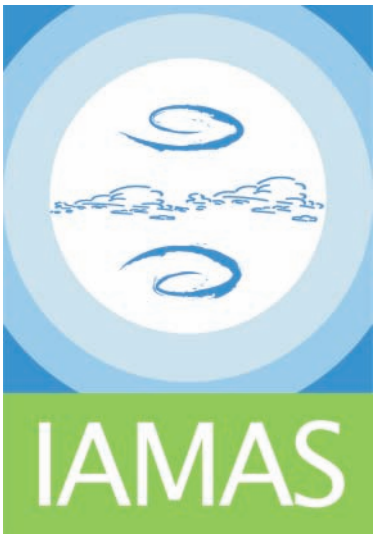

International Association of Meteorology and Atmospheric Sciences

IAMAS Publication Series
No. 1

International Radiation Commissions 1896 to 2008:

Research into Atmospheric Radiation from IMO to IAMAS

compiled by

Hans-Jürgen Bolle

from IRC documents as well as publications and notes by
Fritz Möller and **Julius London**

Oberpfaffenhofen, Germany
May 2008

IAMAS in brief

The International Association of Meteorology and Atmospheric Sciences is one of eight international associations which form the International Union of Geodesy and Geophysics. It exists under changing names since 1919 and promotes research in all topics relevant for the gaseous envelope of the Earth and other planets. Fields of special interest within IAMAS are those addressed by its 10 International Commissions:

- Atmospheric Chemistry and Global Pollution (ICACP)
- Atmospheric Electricity (ICEA)
- Climate (ICCL)
- Clouds and Precipitation (ICCP)
- Dynamic Meteorology (ICDM)
- Meteorology of the Middle Atmosphere (ICMMA)
- Planetary Atmospheres and their Evolution (ICPAE)
- Polar Meteorology (ICPM)
- Ozone (IOC)
- Radiation (IRC)

IAMAS acts globally as indicated in its logo that carries a schematic cyclone in each hemisphere separated by clouds within the tropical convergence zone. A co-operative regular activity is the organization of large international conferences, either as part of the quadrennial IUGG Assemblies (e.g. 2003 in Sapporo, Japan; 2007 in Perugia, Italy; 2011 scheduled for Melbourne, Australia) or in their own right (e.g. 2005 in Beijing, China; 2009 scheduled for Montréal, Canada in conjunction with IAPSO for the oceans and IACS for the cryosphere).

More details can be found on the web-site: www.IAMAS.org

IRC in brief

The International Radiation Commission constitutes the oldest grouping within IAMAS. Its development over more than a century is chronicled in this publication. The role of the IRC is to promote research into atmospheric radiation as well as application of that research to practical problems. This role is part of IAMAS concerning the earth-atmosphere system and the atmospheres of other planets and is performed in co-operation with all the IAMAS Commissions and with other appropriate bodies. Topics of concern to IRC include optical phenomena in the atmosphere, radiative properties of atmospheric constituents and of the earth's surface, radiative properties of planetary atmospheres, radiant energy transfer, radiant energy interaction with other features of the atmosphere (dynamics, climate etc.) and remote sensing of atmosphere and surface.

More details can be found on the web-site: www.IRC-IAMAS.org

IAMAS Publication Series

This publication marks the start of the IAMAS Publication Series. It is intended as a medium for the communication and conservation of material from the Association and its Commissions, which carries sufficient general interest, but is not suited for articles in research journals or scientific monographs. Issues appear when suitable manuscripts are available. Each issue is separately registered with an ISBN from the International Standard Numbering System for Books. Contact the editor for enquiries.

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Foreword

As in many other branches of science, our current advanced state of knowledge of atmospheric processes is the fruit of both outstanding individual inventions as well as international co-operation. More than a century ago far-sighted scientists began to cooperate on a voluntary basis and, supported by their national organizations, founded international bodies to structure their work. Within the framework of the meetings of the directors of national weather services the first Radiation Commission was formed. The current International Radiation Commission (IRC) of the International Association of Meteorology and Atmospheric Sciences (IAMAS) is a direct successor of this early initiative. While the more application oriented part of the initial Radiation Commission became part of WMO, its research oriented members assembled under the International Union of Geodesy and Geophysics (IUGG) where the IRC became part of first IAM, then IAMAP and now IAMAS. The Radiation Commission therefore can be regarded as the oldest, still existing scientific grouping within IUGG. But who of the current generation of active researchers does really know which personalities did actively participate in these continuous research processes, or which topics became attractive and feasible during which periods of time?

In 1980 IAMAP published an informal note written by Fritz Möller about the "history" of the radiation commissions up to 1948. Since that time several presidents of the IRC requested that the further development of the IRC should also be documented. This demand was especially justified as the long existence of the Radiation Commission exemplarily reflects the changes which atmospheric research strategies experienced with time. IAMAS and IRC are happy indeed that Hans-Jürgen Bolle undertook the seemingly dry effort to extract the essence of the documents which he collected during several decades of personal involvement in IRC and IAMAP/IAMAS. He sets off with Möller's shorter account from 1980, then he builds on personal notes inherited from Fritz Möller and Julius London, and extends the survey with his own notes and internal IRC material right to the present time. The inclusion of cuts from photographs, which depict many of the acting individuals and groupings, provides a flavour of the family-type atmosphere that often prevails in (atmospheric) science.

Ordinary historical studies distinguish between editions of source material from archives and monographs providing scholarly conclusions from the source material. For the history of science within the past century readable source material is scarce. This compilation dealing with the different International Radiation Commissions during the 112 years from 1896 to 2008, mainly viewed from the minutes and some presentations given at the regular meetings, is a most valuable attempt to make important parts of source material better accessible.

Browsing through the pages reveals a number of sub-texts, which each reader can construct on his own, *e.g.* how atmospheric radiation research made its way through different wavelength bands having started with solar radiation, how changes of focus came about, and that deep breath combined with patience are necessary to eventually arrive at useful applications of global relevance It is also reassuring to note that individuals were always able to make decisive contributions and that personalities matter as much as strong institutions.

Being still a freshman in my current IAMAS position, I am delighted to contribute to a broader visibility of this exemplary compilation within the entire IAMAS community in both media, electronic storage on the IAMAS web-site for easy access and classical print for computer-independent conservation over longer periods. The German institutions DFG and DLR kindly contributed to the printing costs through their bureaus for international relations. Similar accounts from others of the ten International Commissions of IAMAS are most welcome during the coming years towards the completion of the association's first century (in 2019). On behalf of the entire IAMAS community I am expressing my deep gratitude to Hans-Jürgen Bolle for his initiative and perseverance, and to Jacqueline Lenoble for her editorial support.

Hans Volkert

Secretary General of IAMAS

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Institut für Physik der Atmosphäre
Oberpaffenhofen, G e r m a n y

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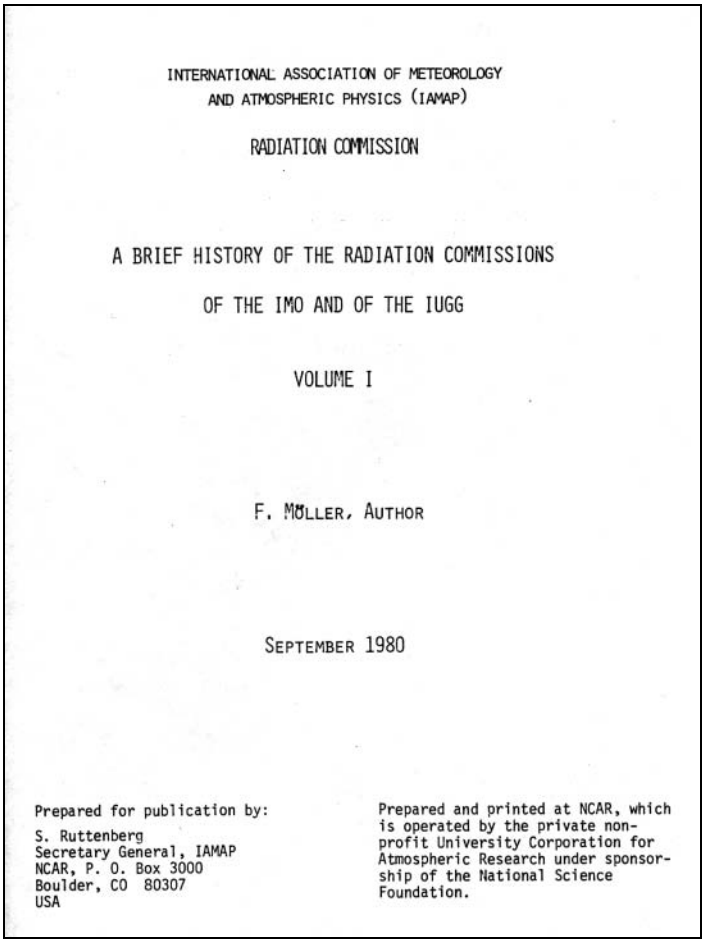
Introduction to the Historical Compilation

Since Fritz Möller, one of the former presidents of the International Radiation Commission of IAMAP, published in 1980 "A *Brief History of the Radiation Commissions of IMO and of the IUGG"* the request to continue his work was repeated by all his successors. Möller himself intended to continue his work in a second volume which he could not finish. He left behind a large amount of documents from the years 1948 to 1980 which nowadays are continuously supplemented by minutes and reports of the Commission and its working groups. After so many years it seems now to be appropriate and timely to continue Möller's work and report on the development of the IRC since 1948 which not only reflects the evolution of atmospheric radiation science but also gives insight into the changes of the research strategies in atmospheric sciences, the work of international bodies and the development of ideas and actions during the second half of the twentieth century.

Möller's "History" starts from the first discussions about a body that would be responsible to foster atmospheric radiation issues in the context of the International Conferences of Directors of Meteorological Services who met the first time in Vienna, 1873. The "History" was prepared for publication by the Secretary General of IAMAP, Stanley Ruttenberg, and published as a IAMAP/IRC report in 1980 (see box). Julius London, Fritz Möller's successor as IRC President, wrote a preface.



INTERNATIONAL ASSOCIATION OF METEOROLOGY
AND ATMOSPHERIC PHYSICS (IAMAP)

RADIATION COMMISSION

A BRIEF HISTORY OF THE RADIATION COMMISSIONS

OF THE IMO AND OF THE IUGG

VOLUME I

F. MÖLLER, AUTHOR

SEPTEMBER 1980

Prepared for publication by:
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Front page of Fritz Möller's "History of the Radiation Commissions"

This documentation of the early stages of the Radiation Commissions may not anymore be available to the interested community. Therefore, the "History" written by Fritz Möller is reproduced as Part 1 of this document. The text follows closely the original. The references of this part of the document can be found in Appendix 4. The officers of the Commissions from 1896 - 1950 are listed in Table 1, the meeting places in Table 2. The lists of membership attached to Möller's document are merged into one single table presented in Appendix 2. As far as they are known also the affiliations of the members are given to indicate which institutions and services were actively involved in the development of an international network of radiation research during the first half of the

twentieth century. The rules for membership have not been recorded. Members seem to have been appointed or re-appointed at each meeting according to the attendance. These were often representatives of weather services.

The IRC of the IUGG started as a small group of scientists who came together to discuss specific questions of measuring techniques, their interpretation and standardization. The members reported their own experiences and recommendations were formulated and released how to use operationally the instruments developed in scientific laboratories. Later on, symposia had to be organized to become acquainted with the research results of a growing community. Problems were not anymore resolved by the whole Commission or parts of it (called "Sub-commissions"), but working groups were established including external scientists to elaborate on solutions which are brought back to the Commission where they are accepted, refused or returned to the working group with new instructions. With the advent of remote sensing devices used from ground or space, the work of the IRC got a new dimension and the number of experts within the IRC had to grow. Finally the global research programmes drew the Commission into their wakes. Working groups to deal with the new challenges had to be established of which some became rather permanent sub-bodies of the Commission acting more or less autonomous. The IRC nowadays functions as a control mechanism to direct research into areas where the improvement of the knowledge about radiation processes is mostly needed and takes care that its now widespread activities are regularly brought together in symposia to exchange the experiences and results obtained in the various fields and to re-directs the goals of its Working Groups.

The development of the Radiation Commission of IUGG since 1948 is dealt with in Part 2 of this document. It is based upon the scientific topics dealt with at the IRC business meetings as recorded in their minutes and annual/multi-annual reports to IAMAP, which was re-named IAMAS in 1995. During the first years after 1948 still internal discussions among the IRC members took most of the room in the minutes. As long as the number of presentations was small and no proceedings were printed, Fritz Möller referred to the scientific papers presented at the meetings and in some cases gave short summaries. His more extensive summaries of the meetings in Rome and Toronto are presented in Appendix 3. When the meetings grew into large symposia, extended abstracts of the papers presented at the International Radiation Symposia (IRS) became available in book format as "Proceedings" (see Appendix 4). At the IRC business meetings in the more recent years the formation and supervision of working groups as well as administrative items such as the organization of future meetings stood in the foreground.

Officers of the IRC between 1948 and 2008 are listed in Table 3. An overview of the working groups established by the commission is given in the section "Working Groups" (Table 5). The list of IRC members since 1948 can as well be found in Appendix 2. For the history since 1948 only a selection of publications is listed in Appendix 4. The provision of a complete list is out of question because also the working groups contribute to a large extent to the literature. Acronyms are explained in Appendix 5.

The editor is deeply indebted to Professor Dr. Jacqueline Lenoble, one of the former IRC presidents, for text improving suggestions and corrections.

It may be useful to precede this document by a short summary how the parent bodies of the Radiation Commissions evolved because this information is scattered throughout the text. The first International Meteorological Conference was convened by Matthew Fontaine Maury of the US Navy and took place in Brussels, Belgium, 23 August 1853. Already at this meeting the seeds were placed for international cooperation in the field of atmospheric radiation. The meeting was followed by the first International Conference of the Directors of Meteorological Services who held their First International Meteorological Congress in Vienna, Austria, September 1873. Here the plan for the non-governmental International Meteorological Organization was developed. At this conference the problem of measurements of solar and sky radiation had been considered. But even at the next conferences in Rome, Italy, 1879, where the International Meteorological Organization (IMO) was officially founded, and in Munich, Germany, 1891, no decisions had been taken in this matter because "research into the subject of radiation was not yet sufficiently advanced". Following a motion of the Deutsche Seewarte the question was again put onto the agenda in 1896 in Paris. Here, the IMO finally established a special *Commission for Radiation and Insolation*. The principal responsibility of the commission was to make recommendations for standardized radiation instruments and methods of solar and sky radiation measurements. Upon request of astronomers the *Commission for the Consolidation and Discussion of Meteorological Observations in the Light of their*

Relationship to the Physics of the Sun ("*Solar Commission*") was founded at the IMO meeting in Southport, 1903. After the first World War the Radiation Commission was re-established 1919 at the *Fourth International Conference of Directors of Meteorological Institutes and Observatories and of the International Meteorological Committee*. The Solar Commission was not re-established because in the meantime the IUGG started to cover this field.

The International Union of Geodesy and Geophysics (IUGG) was formed 1919 in Brussels. At its second General Assembly in Madrid, 1924, the later International Radiation Commission (IRC), was originally formed as the *Solar Radiation Commission (SRC)* of the "Section of Meteorology". The IRC thus is the oldest continuous commission of IUGG. At the forth IUGG GeneraI Assembly in Stockholm (1930), the SRC continued its affiliation with the Union through the newly constituted IAM, the *International Association of Meteorology* (see Ångström, 1949, and also Van Mieghem, 1968)[1]. From the start, the Radiation Commission of IAM and the Commission for Radiation and Insolation of IMO worked in a close relationship that continued for approximately twenty-two years. During that time, the Radiation Commission of IUGG was chiefly concerned with the standardization and development of new methods for the observation of radiation quantities at the ground and in the free atmosphere. The commission under the IMO, however, dealt mostly with providing the basis and administrative structure for routine radiation measurements. Both commissions moved rapidly into the field of radiative transfer in the atmosphere and became in many respects competitors. Close relationships were also established between these two commissions and the Solar Commission of IMO.

Both commissions held meetings (Table 2) and conducted technical and scientific activities until 1939 when all formal activities of the commissions were temporarily suspended. It should be noted, however, that individual commission members and other scientists interested in atmospheric radiation measurements and related radiation problems continued their observations and research work. To resolve the duality of responsibilities for the radiation measurements, the Radiation Commission of the IMO was finally dissolved at the time of the IMO meeting in London in 1946 (Möller, 1980). Instead, a *Sub-commission on Actinometry* was established in August 1947 under the IMO Committee for Instruments and Methods of Observations (CIMO), dedicated entirely to instrumental questions. Two months later, in October 1947, at the eighth Conference of the Directors of the Meteorological Services, IMO was transferred into the World Meteorological Organization (WMO) under which CIMO continues to exist.

In 1957, at the Eleventh IUGG General Assembly held in Toronto, IAM, the parent body of the Radiation Commission, changed its name to the *International Association of Meteorology and Atmospheric Physics* (*IAMAP*). This reflected a broadening of the scope of the association and its commissions to include programs which contribute to all branches of atmospheric physics. A proposal to change its name into International Association of Atmospheric Sciences (Bolle, 1987) with four "divisions" (Weather, Climate, Physical Processes, Chemical Processes) to reflect the importance of atmospheric chemistry and other interrelated sub-disciplines to the association's program was turned down. A new move for a change to *International Association of Meteorology and Atmospheric Sciences (IAMAS)* was made at the Twentieth IUGG Assembly in Vienna (1991) which finally was ratified at the Twenty-first IUGG Assembly in Boulder, in 1995.

[1] References to Part 1 (referred to by: [x]) and selected literature to part 2 can be found in Appendix 4

Part 1: A Brief History of the Radiation Commissions of the IMO and of the IUGG 1896 - 1948

Preface

The energy used for biological and meteorological processes at the ground and in the atmosphere is ultimately derived from incoming solar radiation. Observations of the quantities of available solar energy and determination of how that energy is used in photosynthetic processes, in heating the earth's surface and driving atmospheric motions has been a matter of concern by meteorologists and others for over a century. Thus the recognized need for systematic measurement of various radiation quantities led to the establishment of a Solar Radiation Commission by the International Meteorological Organization (IMO) at its meeting in Paris in 1896. A parallel group, the Solar Radiation Commission, of the International Union of Geodesy and Geophysics, whose major purpose was to bring together active research scientists involved in observational and theoretical studies of the distribution of solar radiation at the ground and in the atmosphere was organized at the IUGG General Assembly in Madrid in 1924. Both groups were combined to a single Radiation Commission as part of the activities of the International Association of Meteorology (IAM, later IAMAP) at the IUGG Assembly in Oslo (1948).

Although, at their inception, the major duties of the Solar Radiation Commissions were to encourage the establishment and maintenance of an international network of solar radiation observations, they were later broadened to include discussions through symposia and scientific reports of varied problems of radiative transfer as well as the development of new methods, and the standardization of these methods for the observations of different radiation quantities at the surface and in the atmosphere.

The present volume (Volume I of a planned two volume set) contains a brief history of the antecedent organizations to the present Radiation Commission (IAMAP) up to the time of their reorganization in 1948. The second volume will cover the Commission activities after 1948.

Prof. F. Möller is an educator and scholar and is well recognized and honored by his colleagues, internationally, for his many important contributions during the past 50 years toward advancing our understanding of atmospheric radiation and its role in the broad problems of atmospheric energetics. He has served the Radiation Commission well as its secretary (1954-57) and president (1957-67). The Radiation Commission is grateful to Prof. Möller for preparing this excellent account of the growth of the Commission activities in response to the needs of the atmospheric science community.

Julius London
Past President
Radiation Commission (IAMAP)

I. The Radiation Commission of IMO

The first International Conference of Directors of Meteorological Services held in Vienna, 1873, had already considered the problem of measurements of solar and sky radiation. However, they postponed the task of finding simple and adequate measurement methods to the Second Conference to be held in Rome, 1879. At this latter Conference it was stated "that the research into the subject of radiation was not yet sufficiently advanced to enable the Conference members to propose a method of observation". The problem was then passed on to the next Meteorological Conference.

The Conference of Directors in Munich in 1891 was of the opinion that no observational method had yet been proposed which could be recommended for general acceptance.

As a result of a motion by the Deutsche Seewarte, the question was again put onto the agenda of the Conference of Directors in Paris in 1896(1). A special commission was established with J. G. Violle as President, with the responsibility of exploring possibilities for uniform instrumentation and observation methods. It was called the Commission for Radiation and Insolation[2], and consisted of 17 members (2).

For about three decades, rather than to have discussion meetings (symposia)[3], the activity of the Commission consisted of discussions of reports drafted by the president and the formulation of resolutions from these draft reports. These resolutions were presented to the next Conference of the International Meteorological Committee for decision. For several decades the Commission discussions were almost exclusively concerned with the problem of measurement methods.

Violle, himself, prepared a comprehensive memorandum for the meeting of the International Meteorological Committee in St. Petersburg in 1899(3) and another one for the meeting of the Committee in Southport, 1903(4).

Violle's report for the meeting of the International Meteorological Committee in St. Petersburg is very detailed and refers back to the work of Bouguer (1760) and Lambert (1760). It gives a thorough description of all known radiation instruments, starting with Violle (1870 and 1897), Crova (1875, 1884, and 1898) including the Ångström Differential-Pyrheliometer (1885), his Recording-Pyrheliometer (1885), the Actionometer developed by Ångström-Chwolson (1892) and the Compensation-Pyrheliometer developed by K. Ångström (1893). He also describes simplified equations for deriving the extraterrestrial radiation (the solar constant), since he considered the correct spectral equations from Langley as much too complicated. He admits, however, that the absorption bands due to water vapor and carbon dioxide, known from the more recent work by Ångström, Julius, Paschen and Rubens, are recognizable in Langley's spectra of solar radiation. In his conclusions, he pleads for a simple instrument, a simple reduction formula and an increase in number of observatory locations in order to recognize the variations which occur on the surface of the sun.

During the same Conference, Hann had a note entered into the minutes that the solar radiation would have to be measured under various conditions in order to learn more about the heat budget of the atmosphere. His attention obviously was not limited to the variations on the sun or in space traversed by the earth in its orbit (Violle).

In his considerably shorter report on radiation for the meeting of the International Meteorological Committee in Southport (1903), Violle points to the great progress in radiation research achieved in the last four years(4): Langley's spectral measurement; the difficulties caused by absorbers present only in the upper layers of the atmosphere; the excellent instrument by Ångström (compensation-pyrheliometer); measurements from balloon-sondes, free balloons, kites and from mountain stations. In conclusion, he again points out the necessity for the use of tested and calibrated instruments only. Since no conclusions were reached at the committee meeting in Southport, Violle urged that a decision would be made at the next meeting of the International Meteorological Committee in Innsbruck in 1905(5). As Item 1 on the agenda, Violle's concentrated requests were considered. Two resolutions were adopted: (1) All central observatories should conduct measurements of the total solar radiation at noon with the compensation-pyrheliometer of Ångström; (2) Irradiation measurements with the compensation-actionometer of Ångström (pyrgeometer) should be made between 10 and 12 o'clock at night.

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[2] Insolation referred to the duration of sunshine as, for instance, measured with a Campbell-Stokes instrument.

[3] This apparently was the working style of Violle, who preferred to write detailed reports instead of having discussions with other scientists. Other Commissions used to have meetings.

Violle submitted his resignation as president of the Commission for health reasons. K. Ångström was elected as the new president.

In the meantime a new development started at the meeting of the Committee in Southport[4]. The meeting of the International Meteorological Committee coincided with a conference of the British Association for the Advancement of Science. The meeting was attended by a large number of physicists and astronomers, among others the director of the Solar Physical Observatory in So. Kensington, Sir Norman Lockyer. He presented a comprehensive "Report on Simultaneous Solar and Terrestrial Changes", in which he showed that, particularly in India, but also in other parts of the world, changes in pressure, temperature, precipitation, and famines, were associated with variations in sunspot activity. He divided the globe into regions where maxima in air pressure seemed to occur simultaneously with small numbers in sunspots and other regions where air pressure showed opposite deviations. Investigations in this matter were obviously what the majority of the directors of the Meteorological Services expected from solar radiation research, and many astronomers nourished the same hope. It was logical that as the result of a proposal by W. N. Shaw a Commission was formed for the *Consolidation and Discussion of Meteorological Observations in the Light of Their Relationship to the Physics of the Sun*, simply called "Solar Commission". Members were Lockyer, Shaw, Pernter and Angot, with the right to coopt additional members (as customary). This new Commission may have been the result of the lack of "conference enthusiasm" of the Radiation Commission under Violle, however, it definitely also followed the general interest which the relationships between solar radiation and meteorology received from meteorologists and astrophysicists. Under the very active President Lockyer, the physical twin sister of the Radiation Commission developed considerable activities and held meetings in Cambridge, 1904; Oxford, 1905; Innsbruck, 1905; and Meudon, 1907. During the meeting of the Committee, a resolution of the Radiation Commission was adopted for the establishment of a radiation station in the Sahara. Resolutions originating in the Committee for establishing meteorological stations in polar regions, on 36 islands in all oceans, named individually, were also presented. In addition, the Committee requested data on the water level and run-off from rivers and lakes, requirements, which to some extent were only fulfilled by the WWW and the International Hydrological Decade (IHD). The International Association of the Academies was made aware of the Solar Commission. The membership of the two Commissions is given in the minutes of the Innsbruck meeting[5] (see Appendix 2).

As President of the Radiation Commission, K. Ångström sent a letter to the International Meteorological Committee in Paris[6] (1907) with proposals for the establishment of the International Radiation Centers for comparison of standard instruments from different countries as well as for national centers for the control of the instruments of the countries with the respective standard instrument. This design was the first development of an instrument to absolutely measure the radiation intensity of the sun under free air conditions and was recommended as standard by the Conference of Directors at Innsbruck, 1905.

The Solar Commission again submitted a comprehensive activity report covering all correspondence since the meeting in Innsbruck. The Commission became more and more a purely meteorological Commission since it requested from all countries in the world monthly averages of air pressure, temperature and rainfall, as well as annual means (for at least a 19 year period, possibly 1881-1905), and also requested installation of new meteorological and radiation stations. In summary, it is likely that the requirements were too comprehensive. No results were reported. The membership list of the Solar Commission for 1907 shows 39 names[6].

In June 1909 the Solar Commission held a meeting in London, at which time the question was discussed in which form temperature reports should be submitted, from how many stations (2 per 10^{o} square field), and how they should be published. These requirements were presented to the meeting of the International Meteorological Committee in Berlin in 1910[7]. The difficulties associated with the requirement to provide standardized data for a Scientific Commission (Solar Commission) and an Operational Commission (The Commission for global network (Reseau Mondial)), were recognized and a compromised proposal was made.

The Chief of the U.S. Weather Bureau, W. L. Moore, had presented a series of proposals related to spectral measurements of solar radiation and evaluation of the ozone concentration. The proposals also dealt with the establishment of a central observatory for monitoring the national sub-standards for solar radiation measurements and questions concerning the uniform reduction of solar radiation measurements.

These questions were referred to the Radiation Commission.

The Commission did not have a meeting in the 14 years of its existence. It was reformed with Maurer (Zürich) as president. The membership list attached to the proceedings of the Berlin meeting still contains some additional names, which however, are no longer mentioned in the membership list of the first meeting of the Commission.

The newly appointed President Maurer called the first meeting of the Radiation Commission in Rapperswill near Zürich in September, 1912[8]. Only three members were present. However, a number of proposals were submitted by correspondence. The first item on the agenda was the proposal by Moore to the Berlin meeting of the International Meteorological Committee. Two central institutes were proposed, one in Europe (Upsala) and one in America. In the meantime, C. G. Abbot at the Astrophysical Observatory of the Smithsonian Institution in Washington had constructed in 1905 and 1912 two novel absolute pyrheliometers and in 1909 a secondary Silver Disc-Pyrheliometer. This led to the need of intercomparison of the two absolute radiation scales. Kimball, for the meeting of the Radiation Commission in 1912, had submitted a report containing the provisional statement that intercomparisons between the Ångström-Pyrheliometer and the Silver Disc-Pyrheliometer, which itself was related to the absolute Waterflow-Pyrheliometer, resulted in 5% smaller values for Ångström. There was, at this time, no further consideration of this question. The dualism of the radiation scales was accepted with a fatalism which cannot be understood today. Following tradition, the different radiation institutes took measurements and published them in the one or other scale partly even without clear designation. Only at a few institutes attempts were made to determine the differences between the two scales as exactly as possible and to seek the reasons for the differences. This double-track was removed only by establishing the International Pyrheliometric Scale in 1956.

Recommendations were made concerning the standardization of sunshine recorders, which showed different values for different manufacturers (this problem was still the subject of discussions 40 years later). The proposals were presented to the International Meteorological Committee, 1913, in Rome[9]. The Committee passed them with the request that a third central institute in the southern hemisphere be added. One must remember here that all travels had to be accomplished by boat and were extremely time consuming. The President of the Radiation Commission was asked to contact the International Solar Research Union for initiating a joint program for the establishment of the comparison center.

The Radiation Commission with 15 members and Maurer as president was reestablished at the Special Conference of the Directors of the Meteorological Services after the end of the first world war[10]. The sister commission (Solar Commission) was not reestablished since the International Union for Geodesy and Geophysics which was formed in 1919 in Brussels was concerned with questions of solar radiation in its "section" for meteorology. A reason for not renewing the solar commission was perhaps the absence of the very active Sir Norman Lockyer who died on 16 August 1920 at the age of 84. Nevertheless, a report on the relationships of solar radiation and various meteorological parameters was submitted to the International Meteorological Conference of Directors of Meteorological Services in Utrecht in September 1923 by Helm Clayton[11] (report Utrecht, 1923, p. 62).

The Commission for Solar Radiation also had its second meeting immediately prior to the Utrecht conference on 5 and 6 September 1923 in Utrecht.

At this meeting Abbot presented a report in which he showed that between November 1921 and September 1922 a significant change in the extraterrestrial solar radiation was noticeable and he called the attention of the Radiation Commission to the effect. Also a proposal by Christoni was submitted to introduce the terms Heliofanie and Heliofanograph for sunshine duration measurements. This subject was postponed until the next meeting. Gorczynski reported on climatological investigations of solar radiation which he had conducted on a six months trip to the tropics. Lindholm and Ångström reported on some steps towards carrying out the resolutions which the International Union for Cooperation in Solar Research, 1907, in Meudon and the same union earlier in Oxford had passed, namely that a compensation pyrheliometer be located as a standard instrument in Upsala.

According to investigations by Marten, Abbot, Ångström, et al., the difference between the Ångström and the Smithsonian scales is 3.5% with only very small variations. The authors recommended the use of both instruments as international standards, however, to add 3.5% to the readings in the Ångström scale. The central station in Upsala was to be instructed to initiate the construction of a standard water-flow-pyrheliometer and to conduct a comparison between it and the Ångström instrument. In another report by

Ångström, the observation station for global and diffused sky radiation in Stockholm and their results were described and the relationship as: $Q = Q_0 (0.25 + 0.75S)$, where S = relative sunshine duration, was established. The same author also reports on measurements of the nocturnal effective radiation and the Gegenstrahlung (infrared radiation from the sky) at valley stations, mountain stations and balloons and explains it by the absorption of water vapor. These reports were recorded in the minutes of the meeting.

As a result of a recommendation by the Radiation Commission, the International Meteorological Conference of Directors passed four resolutions: (1) Establish a central institute; (2) Establish a main measurement station in each country; (3) To have a number of secondary stations. Upon Kimball's recommendation, the conference decided as a fourth resolution, (4) To emphasize the need for additional investigations of the influence of cosmic dust on the changes in solar radiation. The commission was to contact the IUGG in order to secure more complete action.

The Conference of the Radiation Commission in Davos [12], 1925, was attended by eight members and one guest scientist (Linke). The initial discussion was again on the subject of a central institute. Ångström considered attempts to obtain a resolution of this question as untimely since a number of new institutes were also considering this question and hence it would be difficult to select one at this time. It was, therefore, decided: (1) To ask different institutes to address themselves to special tasks. (2) The institutes in Stockholm and Upsala were requested to perform a thorough investigation of the error sources of the Ångström compensation-pyrheliometer. (3) Investigations with spectral filters were assigned to the institutes in De Bilt and Frankfurt/M. (4) Potsdam was requested to develop a new absolute instrument in cooperation with the Physikalisch-Technische Reichsanstalt and to compare it with the Ångström instrument.(5) It was also decided that measurements from aircraft and (6) from mountain stations should be made. Eight scientists had submitted brief accomplishment reports which were attached to the proceedings.

The next meeting of the Radiation Commission was held under President Maurer, 1929, in Copenhagen, simultaneously with the meeting of the International Meteorological Committee and the Conference of Directors of Meteorological Services. The institutes which were assigned special tasks at the meeting in Davos presented detailed reports (Ångström, Linke, Süring, Hergesell, Volochine). Eleven members of the Commission and 10 guests participated in the meeting. The following members were newly elected: G. C. Simpson (to replace the deceased Dines), Lunelund (Helsingfors) and Tichanowsky (Simferopol). Eight resolutions were proposed and accepted by the International Meteorological Committee. Some dealt with organizational, others with scientific technical questions; the problem of the field of view of actinometers; the requirement that mention be made in all publications of solar radiation data as to whether the Smithsonian or the Ångström scale was used, and also to give for all outgoing radiation measurements the value of the solar constant used.

Finally a sub-commission was established to prepare for radiation measurements during the Second International Polar Year; it consisted of Ångström, Kalitine and Linke. Abbot reported on variations of the solar constant with the relative number of sunspots (double wave) and with a 26 month cycle. Dorno and Lindholm reported on the effect of the field of view of solar radiation measurements and requested a set of uniform instructions for the measurements. The same authors presented a detailed discussion on the CD-cell, which was the center of discussion at that time. Hergesell, Büttner and Süring gave brief summaries of their aircraft measurements. Linke reported on the work of Kaempfert and Flach on filters and diffusers. Kalitine and Stenz presented reports on radiation work in the USSR and Poland, and Süring on work in Potsdam.

The meeting in Copenhagen[14] brought a change from the old method of submitting reports by correspondence (unquestionably the result of the difficulties of travel) to the new way of having oral presentations. For instance, General Delcambre reported in writing on a new radiation observatory in Trappes near Paris and Dr. Volochine gave an oral presentation of the research work conducted at that institute.

This new style became quite clear in the unofficial meeting of the Radiation Commission in Potsdam and Berlin from 23-26 February 1931[15] called by request of Süring, Linke and Ångström and which dealt with questions concerning turbidity and the actinometer program for the second polar year. The meeting was conducted by the secretary of the Radiation Commission, A. Ångström, who also acted as president of the Radiation Commission of the IUGG.

Six proposals were passed which dealt with the following subjects: (1) Use of filters for solar radiation

measurements in order to eliminate selective absorption by water vapor from turbidity measurement. (2) Exclusive use of the 1913 Smithsonian scale; an addition of 3.5% was recommended for instrument calibrations based on the Ångström scale and, in addition to the type of instrumentation, the aperture conditions were to be defined as accurately as possible. (3) At polar stations both total irradiance (global radiation) and effective outgoing radiation were to be measured. (4) Various measurements of the air clarity, twilight, etc. were to be conducted as well as (5) of the opalescent turbidity. (6) For the Stefan-Boltzmann constant the value $\sigma = 0.26 \cdot 10^{-10}$ cal cm^{-2} deg^{-4} was recommended[4]. Finally a proposal was submitted to the IUGG, Section on Meteorology, to provide travel funds in the amount of 35 FFr for comparative measurements of various standard and absolute instruments. This was almost immediately approved.

In the following year an official meeting of the Radiation Commission took place in Frankfurt/M, 15-17 September 1932 which had the character of a symposium(16). It was recommended that the two Radiation Commissions of the IUGG and IMO be combined although the IUGG Commission dealt more with scientific and the IMO Commission dealt more with organizational problems. A proposal based on that recommendation was submitted to the International Meteorological Committee.

Subjects of presentations were (1) measurements during the Second International Polar Year, (2) atmospheric turbidity (Linke, Feussner, Ångström, Götz, v. dem Borne), (3) pyrheliometer and standard scale for outgoing radiation measurements (Ångström, Feussner, Mügge, Dubois), (4) cadmium cells (Mörikofer), (5) absolute pyrheliometry (Süring, Volochine, Mörikofer), and (6) instrument aperture (Linke). The printed reports and presentations, as well as the detailed notes on the discussions give an impressive picture of the high standard of the research work and the scientific foresight of the researchers.

At the session of the International Meteorological Committee in De Bilt 1933 the resolutions of Potsdam and Frankfurt were confirmed. A merger of the two Radiation Commissions of IUGG and of IMO had not been concluded because the basis of the two commissions were partly within pure science and partly in practical applications. However, an excellent collaboration appeared possible to van Everdingen, the president of the International Meteorological Committee, even without an official union.

After the meeting in Frankfurt, a sub-committee for absolute pyrheliometry was formed with Süring as president, Mörikofer as secretary and the members Abbot, Ångström, Feussner and Volochine. This subcommittee held its own meeting on 12-13 February 1935 in Potsdam. Prior to that, extensive comparative measurements between the Ångstrom, Silverdisc, and the new Potsdam absolute pyrheliometer were conducted during the last three months of the previous year in Davos. These intercomparisons were conducted between a compensation- and a silverdisc pyrheliometer which had just been newly calibrated at the two institutes of their origin, Upsala and Washington, to the standard instruments there. They showed the interesting result that the difference of the two scales which had been determined as 3.5% at the different institutes at low altitudes was found in the clear air of high mountains as at least 4.5% and sometimes even more. From this it was unequivocally concluded that the amount of this difference depended on the different opening angles of the instruments as well as on the turbidity state of the atmosphere and the sky radiation in a direction close to the solar disc. Detailed reports on the discussions and the comparative measurements in Davos are contained in the minutes of the Oxford Radiation Commission(17) meeting on pages 27-40, with additional reports on the same subject on pages 47-57.

The meeting of the Radiation Commission in Oxford(17) from 12-15 September 1936 was preceded by an International Ozone Conference and it was followed by the meeting of the IUGG in Edinburgh; it therefore was attended by a large number of guests. A. Ångström proposed and it was accepted that the membership should be the same for the two Radiation Commissions (IMO and IUGG) even though there was not yet merger of the two commissions. Discussions during this meeting dealt with a number of old and new problems of which only a few are mentioned here: Absolute pyrheliometry; atmospheric turbidity; a differential-actinometer for skylight measurements (Linke); polarization measurements (Jensen); a new heliothermometer by Ångström; spectral recording of solar radiation (Linke, Hoelper); Cadmium cells (Hoelper); UV-Dosimetry (Götz); the Robitzsch-actinograph (Mörikofer); absolute measurements of UV radiation (Coblentz), and several others. Two new sub-commissions were formed, one to deal with questions concerning the cadimum cell and one with the nomenclature in actinometry.

[4] 1 cal = 4.1868 J

The next meeting of the International Meteorological Committee was held in 1937 in Salzburg[18]. President Ångström read a report which summarized the activities of the Commission in Oxford. The accepted resolutions of the Commission, including one concerning the necessity for frequent comparisons of standard pyrheliometers in different countries, were accepted.

During the meeting of the International Meteorological Committee in Berlin, 1939, only a brief report was read by the president since no sessions of the Commissions had been held in the meantime[19]. The war had started before the next meeting, planned for 1946.

A special conference of Directors was held at the end of the war in 1946 in London[20]. A number of Commissions were not reestablished, one of them was the Radiation Commission of IMO. It had existed for exactly 50 years. It was superseded by the Radiation Commission of the IUGG and by the CIMO within the framework of IMO and later of WMO. Nevertheless, president Ångström gave a report of his Commission which "had ceased to exist". According to his records the Commission had still 35 members. The work of the Commission had almost completely stopped during the war. However, some scientists were still active in research dealing in particular with problems of solar radiation instruments. Feussner and Volochine were still active in the area of absolute pyrheliomeliometry. Mörikofer had tested a number of other instruments: Ångström, Silverdisc, Robitzsch, Bellani, Moll-Gorczynski Solarimeter, and Cadmium-cell.

II. The Radiation Commission of the IUGG (for the period 1924-1948)

The IUGG was formed in Brussels in 1919. The first meeting of the General Assembly of the IUGG took place in Rome in 1922[21]. During the meeting of the Section for Meteorology, 2-9 May, discussions took place on the attenuation on solar radiation by clouds and cosmic dust and a sum of 2500 FFr was approved for the purchase of a number of new instruments. Sir Napier Shaw emphasized the importance of radiation for the general circulation. Kimball talked on the importance of measurements by the Smithsonian Institution. In a special report by Lindholm and Ångström, three subjects were covered: (1) The establishment of radiation measurements in each country; (2) The questionable variation in the solar constant observed by Abbot; and (3) The good agreement in measurements of effective night radiation at different measurement sites. An additional memorandum by Ångström dealt with the heating of the earth's surface and the air under the influence of radiation in connection with eddy conductivity. In another memorandum, Bemporad and Platania mentioned some demands which had been earlier presented for radiation measurements in different altitudes and pointed out, that good conditions for conducting such measurements of the transmissivity of the atmosphere existed in the area of Naples.

Despite this considerable interest in radiation processes, it was only at the Second Meeting of the General Assembly, 1-8 October 1924, in Madrid[22] that a Radiation Commission[5] was formed with Kimball as president. The initial purpose of this Commission apparently was only to monitor the spending of funds approved by the General Assembly. Funding was approved for: (a) pyrheliometers or pyranometers in So. Canada or *Spitzbergen*, New Zealand or *Samoa*, Brazil or Belgium *Congo*, So. Orkney Islands (locations of installations are in *italic*); (b) for Richardson instruments (see below) in four countries which were able to utilize them in aircraft in order to measure the reflected light from below. Furthermore, the desire was expressed that the Meteorological Service of Spain should conduct radiation measurements at the Observatory of Izana (Teneriffa). In Rome (1922), it had already been suggested international studies on the dust content of the atmosphere be conducted with Owens dust counters. The problem of air pollution was formulated. Radiation measurements in two spectral bands were used for this purpose as one can see from a report by Ångström on the measurements in Sweden. It was also requested by the Meteorological Section in Rome in 1922 that Sir Napier Shaw present a comprehensive report on the relationships between radiation and meteorology. This report especially dealt with the basic magnitudes of solar and long wave radiation as well as with the statistical evaluation of data from many stations. Gorczynski presented a series of publications on radiation measurements including spectral measurements for meteorological purposes. Maurain reported on solar radiation measurements at the

[5] The correct name of the IUGG "Radiation Commission" until 1948 was *Commission of Solar Radiation*

Observatory Pare St. Maur near Paris. Richardson demonstrated a newly developed instrument with an Iris aperture for measurements of the albedo from aircraft; the albedo has a considerable effect on the development of different climates.

During the Third Meeting of the General Assembly of the IUGG in September 1927 in Prague[23], the discussions centered around the utilization of funds for the establishment of radiation stations. The Richardson photometer was sent to Italy, Great Britain, France and the U.S.. Volochine reported on a new electric compensation-pyrheliometer. The report by the Smithsonian Institution on the establishment of new observatories in North and South America and Southwest Africa was received with satisfaction and it was recommended that measurements also be made of ultraviolet radiation and total ozone content from high altitude stations. Here the Commission for Solar Radiation was particularly mentioned by name and it was authorized to forward these resolutions. The Radiation Commission was also to cooperate with the equivalent commission of the International Meteorological Committee on comparisons of pyrheliometer scales and the publication of instructions.

President Kimball gave a report for the three years and there were additional reports from many countries. Chapman gave a report as the president of a committee which was established by the International Research Council (ICSU) in 1924 to conduct studies on solar-terrestrial relationships. The committee consisted of Abbot, Chapman, Deslandres, Ferris, Simpson, St. John and Stromer. In addition, the president for the Section of Earth Magnetism, G. Abetti, was elected. A report was printed and distributed in 1926. The Committee dealt with the subject matter of three Unions: astronomy, geodesy and geophysics, and radio telegraphy. The proposal to form a joint committee of the three Unions had certain advantages; however it also had the disadvantage that support funds would be more difficult to obtain than they were from the Research Council directly. At any rate, the committee was to be kept small. It can be considered the successor of the Solar Commission of the International Meteorological Committee and the predecessor of today's Committee for Solar-Terrestrial Physics.

In a special document for the Section of Meteorology[23a] which was published in 1928, L. F. Richardson gave a description and utilization instructions for his albedo measuring device. A collection of reports on dust measurements with the Owens dust counter was also included.

The Fourth General Assembly of the IUGG met from 14-23 August 1930 in Stockholm[24]. The report from the secretary's office contained the accomplishment of the resolutions from Prague. A discussion developed between Kimball and Richardson over the fact that Richardson's albedo meter showed values for the reflection over a snow covered surface of over 100%. The results of this discussion are given in the Monthly Weather Review, 1929, and in the Quarterly Journal of the Royal Meteorological Society, 1930. Volochine continued with the studies which he had begun in Czechoslovakia since the end of 1928 at the Observatory at Trappes; his financial support, however, came from the Czechoslovak Republic. Abbot reported on the continuation of measurements of the Smithsonian Institution and Kimball presented the report of the Commission of Solar Radiation. Kimball requested to be relieved as president, Ångström was elected his successor.

Marvin, Chief of the U. S. Weather Bureau, presented a number of proposals: The differences of the various scales were at the time studied by various institutes so that it did not appear to be necessary that the Section of Meteorology of the IUGG would deal with it any further; the same was true for ozone investigations; however, Marvin expressed a desire that the work by Dobson, Pettit, the Smithsonian Institution and others should be continued; he was the first to propose that measurements be conducted of solar radiation for certain values of the air mass and also measurements of the total irradiance on a horizontal surface, and to publish the results. He also recommended that attention be given to the reduction of solar radiation in various spectral regions. The Radiation Commission prepared a number of recommendations: (1) development of a simple definition of turbidity, to be achieved by cooperation between Linke, Kimball and Ångström; (2) Dobson's program for ozone measurements to be accepted and a *sub-commission for atmospheric ozone* to be formed with the following members: Abbot, Ångström, Chalonge, Dobson (President), Fabry, Götz, Kimball, and Ladenburg[6]; (3) accelerated steps to be taken for the development of an absolute pyrheliometer; (4) joint efforts between the Observatories Trappes, Potsdam, Stockholm, Washington and Parc-Saint- Maur for the development of a normal actinometer were welcomed. All recommendations were accepted by the Section.

[6] This was the nucleus of the later International Ozone Commission of IAMAP (see 1948)

Presentations on radiation were published in thirteen annexes in the Procès-verbaux[24]; they are:

Kimball, H. H., Commission de radiation solaire, p. 45-48

Dobson, G. M. B., Research on atmospheric ozone, p. 49-50

Kimball, H. H., Instructions for obtaining solar radiation intensity measurements, p. 51-63

Ångström, A., On the atmospheric transmission of sun radiation, p. 64, Geogr. Annaler, 1930, p. 130.

Volochine, F., Les travaux du laboratoroire actinométrique international de Trappes, p. 65-72

Volochine, F., Le bulletin actinometrique international de 1'observatoire de Trappes, p. 73-74

Gorczynski, L., Quelque résultats de mesures actinométriques en mer effectuées dans les océans Atlantique et Indien de 1923 à 1928, p. 75-79

Kalitine, N. N., Contribution à 1'étude de 1'intensité de la radiation de la voute céleste au voisinage du soleil, p. 80-87

Brazier, C. E., Rapport sur les travaux actinométriques à 1'observatoire du Parc Saint-Maur de 1927 à 1930, p. 88-90

Lindholm, F., Densité de diffusion optique caractérisant l'atmosphère comme milieu trouble, p. 91-96

Boreema, J., Ultraviolet solar-radiation on Java, p. 97-102

Eredia, F., Rapport sur les mesures photométriques de pouvoir reflecteur du sol, et sur la présentation d'un nouveau photomètre, p. 110-112

Lepetit, Rapport sur les essais en France du photomètre "Richardson" p. 113-119.

Although many papers on radiation were presented and discussed at the Fourth General Assembly Meeting, 1930, at Stockholm, there was little discussion of radiation problems at the meeting of the Fifth General Assembly in Lisbon, 15-23 September 1933[25]. Members of the Geophysical Union, nevertheless, made the remarkable and far reaching proposal that measurements of the amounts of upward and downward directed heat flux above the tropopause be made as a function of geographical latitude and weather conditions; the data to be needed for the theory of the stratosphere and the circulation of the upper troposphere. It appears, however, that this proposal was never further discussed. The report by the president of the Radiation Commission limited itself to the financial support which Volochine had obtained for his Bibliography of Radiation Literature from 1900-1933 and in appreciation to the association and their assistance in the establishment of a pyrheliometric standard scale. Gorczynski presented a report on the determination of precipitable water from spectroscopic measurements of solar radiation. The "Section" Meteorology appeared for the first time in Lisbon as "Association".

The Sixth General Assembly at Edinburgh (17-24 September 1936[26]) resolved: "La Commission de Radiation solaire, le Comité de 1'ozone ... sont accredités à nouveau". In the report of the president of the Commission mention was made of the preceding joint session of the two Radiation Commissions in Oxford and of the resolutions concerning absolute pyrheliometry (a final report was promised for the next meeting of the association) and problems of atmospheric turbidity (proposals by Linke, Hoelper, Götz and Ångström). A report containing an outline of the historical background was given on the status of the development of the new Potsdam absolute pyrheliometer and the absolute ice pyrheliometer by Volochine. Furthermore, a report on the continuation of the actinometric bibliography until 1936 was presented. The following scientific contributions were presented: R. Penndorf, The effect of ozone on the temperature distribution in the stratosphere; O. R. Wolf and L. S. Deming, The absorption of solar radiation in the atmosphere and its relationship to atmospheric temperature and ozone content; R. Trochon, The spectral distribution of atmospheric and terrestrial radiation; N. N. Kalitine, Annual sums of solar radiation (partly as far back as 1913).

The Seventh General Assembly which was held on 15 September 1939 in Washington[27] was under the shadow of the war which had just broken out in Europe and which prevented a number of members and individual scientists from attending. Therefore, purposely no resolutions were passed which might have had far reaching consequences. Also no new elections of officers were held. The report of the president of the Radiation Commission called attention to the community of the work of the two Radiation Commissions which consisted of the same members. These commissions operated within the scope of the two big international meteorological organizations (IMO and IAM). These rather frequent comments about the similarity of the work in the two commissions was perhaps finally responsible for dissolving of the two commissions in 1946. Resolution IV of the association read "The Commission of Solar Radiation is reappointed until the next assembly". Only very few of the presentations given dealt with the subject of radiation. The most important one was probably that by W. M. Elsasser, on a new graphical method

for determining radiative heat transfer in the atmosphere, further H. H. Clayton, solar changes and weather changes, G. W. Kenrick and C. del Toro, Jr., standardization problems in the intercomparison of ultraviolet measurements.

At the Eighth General Assembly of the IUGG, 17-28 August 1948, in Oslo[28], the relationship between the Radiation Commission and the Ozone Commission, which since its founding in Stockholm in 1930 was still a sub-commission of the former one, were resolved: “Le comité recommande la trans- formation de la sous-commission de l’ozone en Commission de l’ozone et le maintien de la commission de la radiation solaire sous le nom de Commission du rayonnement”. The research program of the Radiation Commission was presented to the assembly: (1) investigations of the laws which control the scattering and the absorption of radiation by dust in the atmosphere; (2) collaboration with the subcommission for actinometry of the IMO on questions of standard pyrheliometry; (3) theory of actinometric instruments; (4) development of techniques for investigations of the heat balance at the earth's surface.

Ångström as the President of the Radiation Commission gave a historical overview of the development of the two commissions. The Radiation Commission of the IMO was not reestablished at the Directors’ Meeting (IMO) in London, 1946. However, a sub-commission of actinometry of the CIMO was formed in Toronto in 1948 with Ångström as president with the following tasks: (1) to recommend the best instruments for meteorological studies; (2) the comparability of measurements should be guaranteed by the introduction of a standard scale and by comparisons of the National Substandards; (3) continuous investigations for the conversion of the standard scales and investigations of the errors of routine instruments; (4) investigations of the various recording instruments for sunshine duration, for instance, standardization of the types of paper for Campbell-Stokes; (5) preparation of a list for a terminology; (6) preparation of instructions for the use and normalization of commonly used instruments; (7) recommendations for time, observations and publications of radiation data. With these steps the technique of observations was finally removed from the Radiation Commission of the IUGG, a development which had been apparent and in progress since its foundation. It was not in a position to devote its programs entirely to scientific problems.

The following presentations were given in Oslo in 1948: Deij requested a network of heat balance stations, as they were used by Albrecht in his papers on climatology, general circulation, air mass changes, and long range weather forecasting. Götz reported on the optical properties of the turbid atmosphere, in which he especially emphasized the composition of haze from particles of various sizes. Ramanathan and Karandikar observed an anomalous haze extinction from ozone measurements. Nicolet, Bossy and Pastiels emphasized the importance of the geometry of an actinometer for measurements. Mörikofer presented a written report on the Davos studies of absolute pyrheliometry.

From the above attempts to present some records of the history of the Radiation Commission of the International Meteorological Organization and the Radiation Commission of the International Union for Geodesy and Geophysics, it hardly is possible to obtain a history of the science of solar and terrestrial radiation. For this purpose, it would be necessary to also review the subjects of presentations at the Radiation Symposia, especially after the meetings at Frankfurt and Oxford and after the last world war.

Table 1. Presidents of the Commissions on Radiation from 1896 to 1950

Commission for Radiation and Insolation ("Radiation Commission") of IMO		International Commission for Solar Radiation ("Solar Commission") of IMO *)	
Period	President	Period	President
1896-1905	J.G. Violle	1903-1910	Sir Norman Lockyer
1905-1907	K. Ångström		
1907-1908	J.M. Pernter	Commission of Solar Radiation of IUGG	
1908-1932	J. Maurer	1924-1930	H.H. Kimball
1935-1946	A. Ångström	1930-1951	A. Ångström

*) Initiated as Commission for the Consolidation and Discussion of Meteorological Observations in the Light of their Relationship to the Physics of the Sun

Table 2. Meetings of the Radiation Commissions from 1912 to 1936

Radiation Commission of IMO (1896 - 1946)	Solar Commission of IMO (1904 - 1919)	Commission of Solar Radiation of IUGG (1924 - 1948)
1912 Rapperswil, Switzerland	1904 Cambridge, UK	1924 Madrid, Spain
1923 Utrecht, The Netherlands	1905 Oxford, UK	1927 Prague, Czechoslovakia
1925 Davos, Switzerland	1905 Innsbruck, Austria	1930 Stockholm, Sweden
1929 Copenhagen, Denmark	1907 Meudon, France	1932 Frankfurt (Main), Germany
1931 Potsdam, Germany	1909 London, UK	1936 Lisbon, Portugal
1932 Frankfurt (Main), Germany		1936 Oxford, U.K.
1936 Oxford U.K.		1936 Edinburgh, U.K.
1937 Salzburg, Austria (IMC)*		1939 Washington, USA
1939 Berlin, Germany (IMC)*		

* At these meetings of the International Meteorological Committee only reports of the president of the Radiation Commission were given

Part 2: The International Radiation Commission of IAM/IAMAS/IAMAP - IUGG (1948 - 2007)

The Re-constitution of the IUGG Radiation Commission

The commission was originally called the Solar Radiation Commission because of its preoccupation with instruments and measurements of solar radiation. After more than twenty years, however, it became clear that its area of expertise extends to studies and observations of the entire radiation spectrum, and, when it was reformed in 1948, it was referred to as the Radiation Commission and, subsequently, the *International Radiation Commission (IRC)* when IAM changed into IAMAP. At the same time the Sub-Commission on Ozone was established as a separate commission of IAM. Thus the Radiation Commission could entirely concentrate on questions of radiative transfer and the theoretical background of radiometric systems.

The International Radiation Commission continued first as part of IAMAP and from 1995 on as part of IAMAS. The presently valid regulations for Commissions were released by IAMAS in the year 1999 (see Appendix 1). The principal duties of the IRC were defined to promote, through meetings and discussions (i.e. symposia), the scientific field involving problems of radiation. Its terms of reference were given by J. Bjerknes, General Secretary of IAM, as follows (UGGI 1948a):

- Investigation of the laws governing scattering and absorption of radiation by dust in the atmosphere;
- Collaboration with the Sub-commission on Actinometry of IMO on the question of standard pyrheliometry;
- Theory of actinometric instruments; and
- Development of techniques for investigating the heat balance at the Earth's surface.

The question of the proper task of the Radiation Commission was anew raised in the year 1960, at the meeting in Helsinki, by R. Goody. A long formal discussion developed on the Terms of Reference and their origin. It was explained that each commission of IAMAP, after its constitution, must itself formulate its terms of reference which must then be communicated to, and approved by the IAMAP. It was agreed that a clear distinction should be made between the terms of reference, which embody the permanent tasks of the Commission, and the program of activity which is valid for a period of three (later on four) years. An ad hoc working group was charged with the task to elaborate Term of Reference and the Programme of Activity. It returned with the following proposal which was unanimously accepted: "*The International Radiation Commission is concerned with fundamental research and study in solar and terrestrial radiation*". The program of activity was subsequently developed from internal discussions.

In the years since 1948, the Radiation Commission has played a direct part in the program planning and scientific activities of major international atmospheric programs such as the International Geophysical Year (IGY) and the International Quiet Year of the Sun (IQSY). It has cooperated with the Joint Organizing Committee for the Global Atmospheric Research Program (GARP), the World Climate Research Program sponsored by the International Council of Scientific Unions (ICSU), the World Meteorological Organization (WMO; formerly the IMO), the Committee on Space Research (COSPAR), and other international organizations. Radiation Commission meetings are generally held at the time of IUGG and IAMAP assemblies, sometimes at COSPAR Assemblies or at special conferences and, nowadays quadrennially, at the time of the International Radiation Symposia.

In the now (2008) eighty-four years since it was first formed under IUGG, the Radiation Commission

membership has varied between a size of six in 1924 to approximately forty-five, including honorary members, working group chairs and rapporteurs. Activities of the Commission have been published in UGGI-IUGG News Letters, IAMAP Reports of Proceedings, technical notes, Radiation Symposia proceedings, the open scientific literature and books (examples see Appendix 4). Since 1995 the IRC maintains an internet homepage.

At its meeting in 2004 the IRC decided to award at the IRSs a gold medal for contributions of lasting significance to the field of radiation research and a prize for young scientists who made noteworthy contributions to radiation science. In 2005 the IRS logo was created which symbolizes the sun and its impact upon the atmosphere, the land- and the ocean-surfaces.

After 1948 the former regular meetings of the Radiation Commission at the occasion of IUGG and IAM Assemblies became open symposia at which researchers presented their latest results. These symposia became the focus of scientific discussions. Internal discussions among the members of the Commission on commonly interesting questions, even instrumental ones, gradually receded and organizational matters took their place. This tendency, however, was reverted around 1972 when specific scientific issues were dealt with in working groups. These held separate meetings because also non-members of the Commission were involved. They had and have to report their progress and results back to the IRC which sometimes lead to long discussions during the business meetings. However, later on, with growing specialization and size of the WGs, not involved Commission members felt less competent to interact with the WGs activities.

The growth of the symposia and of the number of working groups broadened the spectrum of topics treated by the Commission which can not in its full breadth be quoted in this historical compilation. For the first decades the papers presented at the still small and mostly internal symposia are quoted. For the time since proceedings of the International Radiation Symposia are published (1972), only items of scientific interest as discussed at the IRC business meetings are reported. Following the change of these themes gives an impression not only how radiation research but atmospheric science as a whole changed during this period of revolutionary developments as there are the advent of satellites, global models, and world wide research programs.

Officers of the International Radiation Commission of IUGG 1948-2008

After the second world war it took a few years until the international scientific organizations recovered from the disruption of their activities. Some of the scientist had the opportunity to continue their research work and as the members of the former Solar Commission met again there was continuation with respect to the acting persons: Anders Ångström was re-appointed 1948 for three years as President and W. Mörikofer as Secretary.

The officers of the IRC used to be elected for a term of four years at the business meetings held in conjunction with the IAMAP Assemblies. Since 1988, however, the elections are shifted by one year to the IRC business meetings at the occasion of the quadrennial International Radiation Symposia. The reason was that more radiation scientists attended these purely IRC gatherings then the symposia attached to the IAMAP and later on IAMAS Assemblies where each Association gets only a smaller fraction of time for themselves.

After 1948 it was generally accepted that the officers could only be re-elected in their office for one additional term of four years. This became the rule in the IAMAS Statutes of 1999 (see Appendix 1). The only exception after 1948 is the three terms presidency of Fritz Möller. In the beginning the “bureau” of the Commission consisted of the President and the Secretary. Then the past president became vice-president (VP) and as such member of the bureau for one term. For Ångström and Mörikofer the title honorary vice-president (HVP) was invented which implied life-long membership. From 1967 on the president became Past-President (PP) for one additional term after his/her presidency and the title of life-long honorary membership (HM) was awarded for outstanding merits for the radiation community. 1983 the bureau was broadened by an elected vice-president (VP) who normally becomes the next president. Since 1996 past presidents are more or less automatically elected honorary members.

The following Table 3 gives an overview of the officers of the International Radiation Commission for the time period of 1948 to 2008.

Table 3. Officers of the International Radiation Commission of IUGG 1948-2008

Period	President	Past President (PP) Vice President (VP) Honorary VP (HVP)	Honorary Members	Secretary
1948-1951	Anders Ångström			W. Mörikofer
1951-1954	Walter Mörikofer			M. Nicolet
1954-1957	Walter Mörikofer			F. Möller
1957-1960	Fritz Möller	W. Mörikofer (VP)		G. D. Robinson
1960-1963	Fritz Möller	W. Mörikofer (VP)		G. D. Robinson
1963-1967	Fritz Möller	A. Ångström (HVP) W. Mörikofer (HVP)		J. London
1967-1971	Kirill Ya. Kondratyev	F. Möller (PP)	A. Ångström W. Mörikofer	J. London
1971-1975	Julius London	K.Ya. Kondratiev (PP)	A. Ångström W. Mörikofer F. Möller	H.-J. Bolle
1975-1979	Julius London	K.Ya. Kondratiev (PP)	A. Ångström W. Mörikofer F. Möller G. Yamamoto	H.-J. Bolle
1979-1983	Hans-Jürgen Bolle	J. London (PP)	A. Ångström (†1981) F. Möller (†21.3.1983) G. Yamamoto (†7.2.1980) K.Ya. Kondratiev	G. W. Paltridge
1983-1988	Jacqueline Lenoble	T. H. Vonder Haar (VP) H.-J. Bolle (PP)	K.Ya. Kondratiev J. London	J. E. Harries G. Paltridge (PS)
1988-1992	Jacqueline Lenoble	J. E. Harries (VP)	K.Ya. Kondratiev J. London R. Goody	W. L. Smith
1992-1996	John E. Harries	J. Lenoble (PP) W.L. Smith (VP)	K. Ya. Kondratiev J. London R. Goody	A. Chedin
1996-2000	William L. Smith	H. Fischer (VP)	K. Ya. Kondratiev J. London R. Goody H.-J. Bolle J. Lenoble J.E. Harries	M. J. Lynch

Table 3 continued

2000-2004	Herbert Fischer	T. Nakajima (VP)	K. Ya. Kondratiev J. London R. Goody H.-J. Bolle J. Lenoble J.E. Harries W.L. Smith	R. G. Ellingson
2004-2008	Teruyuki Nakajima	R. G. Ellingson (VP)	K. Ya. Kondratiev (†1.5.2006) J. London R. Goody H.-J. Bolle J. Lenoble J.E. Harries W.L. Smith H. Fischer	C. Serio

Activities of the Radiation Commission of the IUGG (1948 - 2008)

International Radiation Commission Meetings

The main purpose of the IRC is to organize the international exchange of research results at meetings of which the quadrennial Radiation Symposium presently is the major event. In the years between, the IRC organizes symposia or sessions at IUGG, IAMAS, COSPAR or AMS assemblies, often jointly with other commissions or other scientific bodies. *In connection with the IRS meetings, the Commission held regular triennial business meetings through 1963 and quadrennial business meetings after that year. Business meetings are also due in the years between when the Commission is involved in other mayor symposia.* From the flow of information, recommendations and the agenda for forthcoming activities are formulated at these IRC business meetings. To clarify scientific questions or to promote and organize scientific activities, working groups are appointed which have to report at consecutive business meetings. In the following section the major discussion points and principal presentations at the meetings organized or co-sponsored by the Radiation Commission from 1948 to 2007 are summarized. Until the International Radiation Symposium in Oxford, 1959, the meetings of the IRC had "familiar" character. The number of participants were easily surveyable and the presented papers (in Oxford 46) could almost fully be referred to. Consecutive meetings grew to large conferences with broad scopes, culmination so far in the St. Petersburg meeting of the year 2000 with 550 registered radiation scientists from more than 30 countries who made about 650 presentations printed on 1300 pages in the Proceedings. Under such circumstances it is not anymore possible to refer to single presentations but the general direction which the development of radiation research takes in its various disciplines can be anticipated since 1964 from the terms of reference and activities of the IRC working groups given at the end of this part.

The major meetings in which the IRC was involved since 1948 are described in the following sections, primarily by referring to the scientific discussions in the business meetings. An overview is provided by the Table of Contents. The International Radiation Symposia exclusively organized by IRC are indicated by "IRS" in brackets. If the meetings have been organized by other organizations with IRC participation this is indicated by the acronym of the responsible organization given in brackets. Also some meetings of other organizations in which the Commission was represented by individual members are listed. As a supplement to the information drawn from the minutes of business meetings it is referred to a few circulars of the Commission and reports to IAMAP/IAMAS.

Oslo, Norway, (IUGG) 1948

The 8th General Assembly of IUGG/UGGI, its first meeting after the second world war, took place in Oslo, Norway, in 1948. At this meeting the "Solar Radiation Commission" of IAM was reactivated with A. Ångström as president and W. Mörikofer as secretary.

Only a small number of radiation studies have been presented at the Assembly, discussing actual scientific questions. Some of these presentations were announced as "National Reports".

In a paper titled "Optics of the turbid atmosphere", P. Götz, Arosa, presented spectral extinction measurements which showed a decrease towards shorter wavelengths in the UV. He compared these measurements with the theoretical investigations of Stratton and Houghton who computed the spectral extinction of small dielectric water droplets according to the strict theory of Mie[7]. Götz found that the size of haze particles must have a radius of 0.29 µm. Furthermore he concluded that to determine the sky radiation in the zenith at clear days it is sufficient to consider the Rayleigh scattering. With large zenith distances of the sun, however, in turbid summer days the Mie scattering was to be added. 60 years later, at its Symposium 2008, the IRC celebrated the 100th anniversary of Mie's breakthrough in explaining scattering phenomena of small particles

Deij, de Bilt, reported on Albrecht's investigations of the heat balance of the earth's surface and proposed to arrange a network of radiation balance meters according to Albrecht.

M. Nicolet, L. Bossy, and R. Pastiels talked about "Quelques problèmes fondamentaux pour les ètudes de la radiation" and reported on the area-angle-ratio as a measure to be taken into account in constructing actinometers.

In the British National Report, Sutcliffe reported briefly on sun- and sky radiation as well as on albedo values. In the National Report of the USA similar investigations were mentioned. Likewise, in a paper "Studies on standard pyrheliometry (Rapport National)", Mörikofer and Courvoisier proposed an intensive study on standard pyrheliometry. In the theory of instruments they describe a method of investigating heat resistances rather than heat fluxes and to replace these in a model by electric resistances. This analogy turned out to be very valuable in further investigations.

Brussels, Belgium, (IUGG) 1951

At the 9th General Assembly of IUGG in August 1951 in Brussels, the secretary of the IAM, J. M. Stagg, reported to the Union: "Both the *Ozone Commission and the Radiation Commission have been re-appointed.* The President of the Radiation Commission for the last twenty years, Dr. A. Ångström, has resigned. At that occasion I wish to note Dr. Ångström's important contributions to radiation measuring techniques before the creation of the Radiation Commission and during the whole period of its existence. Dr. W. Mörikofer will be the new President of the Radiation Commission."

Still under the presidency of A. Ångström a proper symposium on radiation took place. In the beginning of the symposium, Ångström made a short statement (see Box at the following page). Then the following papers were presented.

S. Fritz stressed the strong variability of the albedo of clouds but he finds a mean value of 0.50 for all clouds of the earth using the measurements of Danjon for the mean albedo of visual radiation.

Ramdas deduced new constants for the Ångström formula from measurements of infrared radiation by a pyranometer. Further, a new device was developed to record long-wave radiation even during the day. Ramdas also reported on investigations of Momin on a cathode-ray spectrograph for quick records of absorption spectra and an electronically recording solarigraph.

In a paper on "The determination of the radiation balance of the earth", W. Mörikofer first explained the correct definition of the single terms of the radiation balance. He mentioned that the Radiation Commission could not agree with the proposal of the Netherlands made in Oslo to arrange a network to measure the radiation balance with the instruments of Albrecht because these instruments have not yet been tested sufficiently. He mentioned the new development of P. Courvoisier to obtain the wind protection of the receiver plates of a radiation balance meter not by a calotte but by a strong ventilation stream, but he did not explain details of the construction.

[7] Mie, G. (1908) Beiträge zur Optik trüber Medien, speziell kolloidaler Metallösungen. Annalen der Physik 25, Vierte Folge, No. 3, pp 377-445

Commission Internationale du Rayonnement

Président : Docteur A. ÅNGSTRÖM

Secrétaire : Docteur W. MÖRIKOFER

VII Symposium sur le Rayonnement

présidé par Monsieur le Docteur

A. ÅNGSTRÖM

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1. — INTRODUCTION TO THE SYMPOSIUM ON RADIATION,

by

Dr Anders ÅNGSTRÖM.

In introducing this symposium, I wish to make some remarks on the ideas governing its organization. We had the choice either to concentrate on a special limited field of the radiation problems, for instance the radiation balance of the earth's atmosphere and the actinometric methods for determining the turbidity of the atmosphere, or to let a larger field of problems be represented through a number of adresses covering rather different radiation subjects. Both of these schemes had their evident advantages and disadvantages. A limitation of the subjects under discussion would give greater concentration and completeness to their treatment but would at the same time deprive a number of scientists from opportunity to bring their special problems to the attention of an international group of colleagues. Realizing that it was as much as 15 years since the radiation commissions had met to discuss their mutual problems and hear a number of adresses on their field of research, I considered it desirable that the present symposium be open to all the various subjects which the invited colleagues might wish to take up for discussion, without any other limitation than to radiation problems in general and to research of actuality the results of which had not yet been published. In this way it could be expected that personal contacts would be gained along broad lines and that the symposium as a whole would be able to be rather representative of the activity now going on in this branch of atmospheric physics.

This way of organizing the symposium does not, as you will find from the program presented, exclude most of the lectures from grouping themselves in a rather natural way on two or three prominent fields of research, among which I may especially mention *the heat balance of the earth and the atmosphere, the composition of sun light, and the standardization and comparison of actinometric instruments.*

It is my sincere hope that the planned symposium will be able to give you, my dear colleagues, a number of valuable informations regarding the studies going on and the ideas governing them, within our common field of research.

Opening address by Anders Ångström at the Radiation Symposium in Brussels, 1951

Anders Ångström gives a dinner speech. At the right in the foreground David Gates and G. D. Robinson can be seen.

"The blue sun of September 1950" was made the subject of a particular investigation of P. Götz and F. Volz. However, the spectral composition of the direct solar radiation was not the object of their interest, but the very clearly marked Bishop's ring of reddish-brown to ochre-yellow coloration, extending to a distance of 45º from the sun. They could show that the abnormal extinction, already earlier discovered by Götz and so called, also here plays an important role and was easily to be found.

A series of measurements of the "solar radiation in various wavelength ranges" has been made by E. H. Gowan at different places in Canada. He was able to separate short, middle and long UV by different kinds of photocells, to give the results in finsen-hours (1 finsen equals 10 microwatts per square cm of erythemal energy) and obtains so measuring values of that "cheap natural medicine."

The increasing interest of the scientific public in the high atmosphere is reflected in an investigation of Tousay, Johnson, Purcell and Watanabe on "the intensity of sunlight from 2000 to 3400 Å". They photographed solar spectra from rockets at altitudes above the ozone layer. The spectrum between 2000 and 3000 Å is very irregular. The average intensity at 3000 Å was appropriate to a 5500 K blackbody sun and from 2600 to 2200 Å to a 5000 K sun. It is unlikely, however, that the solar continuum was observed, because of the Fraunhofer absorption.

K. Feussner published an investigation with the title "Über die effective Ausstrahlung". In the first part of the work considerations were communicated which point to the fundamental role of the atmospheric downcoming radiation for origin, size and nature of the vertical energy flux and the vertical lapse rate in the troposphere and the stratosphere. The second part dealt with the quantitative representation and gave a new formula for the downwelling radiation. This has a wide range of validity towards low values of water vapour and radiation. The values with very high water vapour content were also discussed.

In the “Rapports Nationaux”, some countries gave reports on radiation research. Japan, among others, reported on the voluminous calculations of Sato on the double and triple scattering in the Rayleigh sky and on Yamamoto's computations of the absorption by water vapour using line measurements of several American authors. Yamamoto also reported on his development of a radiation diagram to determine the nocturnal radiation. Switzerland reported on experiments for absolute pyrheliometry and continued development of the radiation balance meter of Courvoisier. Furthermore, on experiments to construct the spherical pyranometer of Bellani and on studies of Schüepp about turbidity caused by aerosols on the solar radiation. Finally Sweden reported on the development of a new formula for the effective radiation by Lönnqvist.

Rome, Italy, (IUGG) 1954

In the week before the 10th General Assembly of the IUGG in Rome, from 8 to 13 September 1954, there was a meeting of the Radiation Commission at the same place and during the 10th General Assembly two colloquia on radiation were held in the series of symposia (Table 4).

The first one, on "Radiation in the Atmosphere", was chaired by President W. Mörikofer who himself first gave a survey on "The present state of radiation research". He stressed the importance of the different terms for the radiation balance; the direct, the diffuse and the reflected solar radiation, the long wave radiation, as well as the methods and instruments of observation. He further stressed the necessity of publishing all results, particularly with regard of the *International Geophysical Year* now in preparation, for which in fact the Radiation Commission undertook considerable preparation.

Chaired by F. Möller a second symposium took place on "The radiation balance in the lower stratosphere and the sub-stratosphere".

Because of the programmatic aspects of the papers presented at this first larger "colloquium" of the Radiation Commission of IAMAP the contents of the contributions as summarized by Möller are presented in Appendix 3. The speakers are listed in Table 4.

Table 4. Speakers of the two colloquia on radiation at the Xth General Assembly of the International Association of Meteorology, Rome, September 1954

Colloque sur le rayonnement dans l'Atmosphère	Colloque sur le Bilan de rayonnement dans la stratosphere inférieure et la substratosphère
Chairman: President W. Mörikofer.	Chairman: F. Möller
Presentations:	Presentations:
W. Mörikofer	F. Möller
F. Möller	J. Strong
A. Ångström	A.R.Curtis and R.M.Goody
R. Cialdea (1)	A.W. Brewer and J.T. Houghton
R. Cialdea (2)	J.I.F. King
P. Bener	G. Yamamoto
S. Fritz	L.D. Kaplan
G. Yamamoto and T. Sasamori	W.L. Godson
L. Santomauro	
R. Cialdea (3)	

Hamburg, Germany (intercomparison of longwave radiation instruments) 1955/56

In the time between the 10th and 11th General Assembly of the IUGG two events of major importance happened: the two comparisons of longwave radiation instruments at Hamburg, September 1955 and May 1956, and the radiation conference at Davos in September 1956. Both were reported on in the report of the President of the Radiation Commission for 1954 to 1957, which was presented at the 11th General Assembly at Toronto.

Interest in the longwave components of the radiation balance of the earth had much increased in recent years and many different models of longwave radiometers and especially of radiation balance-meters were developed. To examine the accuracy of instruments with such diverse tasks and in order to gain better knowledge of the advantages and drawbacks of the different designs was not easy. The Radiation Commission therefore decided at its meeting in Rome to undertake systematic empirical and theoretical comparisons of all available types of instruments of this kind. These comparisons were carried out during two periods of two weeks each (September 1955 and May 1956) at the Hamburg Meteorological Observatory, and the Commission is indebted to the German Federal Weather Service and especially to Prof. R. Schulze, Director of the Observatory, for their hospitality.

The Hamburg comparisons covered 16 different models of long-wave radiation instruments or radiation

Instruments assembled at the comparisons in Hamburg 1955/56. Instrument characterization by name of their inventors: vertical at the left from top to bottom: Kew, Kreitz, Schulze, Wagner, Hofmann; horizontal towards the right at top: Sonntag, Angström, Georgi; center: Courvoisier, Skeib, Hinzpeter; bottom: Gier and Dunkel, Schoen, Suomi and Franssila.

balance-meters and led to a much better understanding of the requirements for such instruments. Critical points were the temperature coefficients and the blackening of the thermoelements for which "Parsons' Optical Matt Black" was recommended. Although much important insight was obtained of the sources of errors and the physical properties and practical value of the observations, the Commission did not yet feel competent to publish formal recommendations on the reliability and the value of the different designs. Short reports on the program and the results have been published in the WMO Bulletin by Möller (8 January 1957) and by Mörikofer (October 1957).

Davos, Switzerland, (IRC/CIMO-WMO) 1956

The Radiation Commission of IAM and the CIMO/WMO Working Group on Radiation held their meetings in Davos jointly as was usually the case for many years. 36 radiation experts attended the conference which was a working meeting recorded in very elaborate minutes, including the names of the contributors to the discussion, and resulting in one of the largest numbers of most detailed recommendations the IRC ever made (eight, one with six annexes, plus one resolution). It may be of interest to list here the names of the participants of this important meeting:

Members of the Radiation Commission of I.A.M. and of the Working Group on Radiation of W.M.O. (the stars indicate membership on both groups, all members of the WMO group were members of the IAM group as well): A. Ångström* (Stockholm), P. Courvoisier (Davos), R. Dogniaux acting for M. Nicolet* (Uccle), A.J. Drummond* (Newport), F. Möller (Mainz), W. Mörikofer* (Davos), G. D. Robinson (Kew), J. Roulleau* (Paris), R. Schulze (Hamburg).

Other participants were: R. Anderson (Newport), P. Bener (Davos), H.J. de Boer (De Bilt), J. Bricard

(Paris), M. de Coster (Léopoldville), I. Dirmhirn (Vienna), K. Feußner (Berlin), D.M. Gates (London - US Embassy), K. Gräfe (Hamburg), H. Hinzpeter (Potsdam), H. Hoinkes (Innsbruck), H. Kienle (Heidelberg), D. Labs (Heidelberg), H. Masson (Dakar), W. Moller (UNESCO, Paris), H.G. Müller (Munich), E. Nagel (Davos), R. Pastiels (Uccle), H. Schieldrup-Paulsen (Bergen), N. Robinson (Haifa), F. Sauberer (Vienna), S. Schoen (De Bilt), F. Volz (Mainz), H. Wierzejewski (Davos), H. Wörner (Potsdam), Th. Zingg (Davos).

The meeting in Davos was a classical scientific discussion workshop in which top scientists introduced a topic of importance which was in some cases further worked out by an ad hoc working group (called "sub-commission") during the one week long meeting and was then discussed in depth by the plenum. This in most cases resulted in a specific recommendation to weather services, WMO, or the planers of large experiments.

The main theme at this meeting was the definition of the Standard Scale of Radiation, which at that time was a matter of outstanding importance. Extensive inter-comparisons had been made during the years before. These were discussed in detail. The résumé of the IRC, Recommendation 1 (see below), is quoted here at length to document the profound work of the Commission and the invited experts.

As mentioned in Annex 5 of Recommendation 1 (see below), an important point for actinometric measurements is the influence of the circumsolar radiation. R. Pastiels reported about theoretical investigations and F. Volz about experimental work of the influence of the aperture conditions on the measurement of the direct solar radiation. The IRC recommended that pyrheliometers constructed in the future should have an "angle of slope" not less than 1° and not larger than 2° and a ratio of distance between receiver and limiting aperture to radius of receiver equal to or greater than 15. These conditions imply that the "opening angle" must not be larger than 4°. The long list of six Annexes to Recommendation 3 explained in many details how the IRC arrived at this recommendation.

Further topics on the agenda were:

- absolute spectral radiation measurements,
- measurements of the ultra-violet radiation of the sun and the sky,
- the results of the Hamburg comparisons of long wave radiometers,
- the technical application of solar energy,
- radiation measurements during IGY,
- procedure for periodic inter-comparisons of sub-standard pyrheliometers,
- technique for radiation measurement in the free atmosphere,
- actinometric determination of atmospheric turbidity,
- measurements of sky radiation,
- measurement of daylight illumination,
- recording of the duration of sunshine,
- computation of global radiation from records of sunshine,
- experiments with bi-metallic pyranographs and their standardization,
- experience with coloured glass filters,
- measurement of the vertical radiation flux within snow or ice layers,
- instruction for radiation instruments and measurements, and
- radiation terminology.

The possibility of absolute spectral radiation measurements was discussed in the context of the variations of the solar constant. H. Kienle explained which methods are common in astrophysics. Finally it was agreed that this problem could be settled satisfactorily only by measurements outside the atmosphere.

R. Schulze, under the item "measurements of ultra violet radiation of sun and sky", gave a detailed report on his

Walter Mörikofer and Fritz Möller in Davos

investigations of methods to measure UV-radiation. Photoelectric as well photochemical methods were discussed. To fulfill the cosine law, integrating spheres ("Larché spheres") were used with photoelectric detectors. P. Bener reported on measurements with a monochromator equipped with an integrating sphere. Notwithstanding the present difficulties to obtain useful materials (detectors, filters, integrating spheres) the recommendation of the IRC was "that the relations between the ultra-violet radiation, as observed by accurate methods at special institutes, and other meteorological elements be investigated".

Rudolf Schulze, Director of the Meteorological Observatory Hamburg (DWD), host of the longwave radiometer comparisons

At length the radiation measurements during the I.G.Y. were discussed:

- the number of stations,
- the procedure for periodic inter-comparison of sub-standard pyrheliometers,
- the technique for radiation measurement in the free atmosphere,
- the actinometric determination of atmospheric turbidity,
- the measurement of sky radiation,
- the measurement of daylight illumination,
- the recording of duration of sunshine,
- the computation of global radiation from records of sunshine,
- the experience with bimetallic pyranographs and their standardization,
- the experience with colored glass filters,
- other radiation instruments,
- instruction for radiation instruments and measurements, and, finally,
- the terminology of radiation.

A new permanent Sub-commission was set up on the technical application of solar energy to

- investigate the requirement of the user groups interested in the application of solar energy as to solar radiation, instrumentation and data, special attention being paid to the arid zones,
- recommend appropriate means to meet these requirements, and
- to consider the assemblage of existing relevant information on radiation and the means of disseminating this and other information which might be collected in the future.

Much attention were given to the techniques for radiation measurements in the free atmopsphere. H.-G. Müller summarized measurements conducted by W. Pohl with a radiation balance meter constructed by G. Hofmann and comparisons with Möller's radiation chart. G. D. Robinson described aircraft measurements of Houghton and Brewer up to 40.000 feet. D. Gates reported on spectral measurements using PbS cells he had carried out from balloon up to 33 km altitude and filter measurements in the far infrared by J. Strong.

For measurements of the sky radiation the screening of the sun was a matter of discussion as well as the stability of photocells for daylight illumination measurements and the performance of Campbell-Stokes sunshine recorders for sunshine duration measurements. The standardization of four existing types of bimetallic Robitzsch Pyranographs and of spectral glass filters manufactured by Schott (of which a pre-war melt was procured for the RC by the Potsdam Observatory) were other themes.

As a result of the discussions the following recommendations were formulated at the end:

Recommendation 1. The Radiation Commission of IAM and the Working Group on Radiation of WMO, at the joint International Radiation Conference at Davos in September 1956, noting the urgent need of a unique international scale for expressing measurements of solar radiation for the purposes of meteorological radiation research, especially during the International Geophysical Year (IGY), and considering the arguments set out in the following annexe, recommend the *International Pyrheliometric Scale 1956*, before the start of the IGY and preferably by January 1, 1957. Measurements made according to the original Ångström Scale should be increased by 1.5%. As the difference between the Smithsonian Scale of radiation, as revised in 1913, and the original uncorrected Ångström Scale has been found to be 3.5% on the average for measurements of solar radiation, measurements made according to the Smithsonian Scale of 1913 should be reduced by 2.0%.

Annexe to Recommendation 1 of the Radiation Conference, Davos.1956:

1. *Pyrbeliometric scales in current use*

In meteorological services and institutes radiation masurements are normaly standardized by one of two types of instruments, the Abbot silver disk pyrheliometer and the Ångström compensation pyrheliometer. The silver disc instrument is calibrated by reference to a calorimeter maintained by the Smithsonian Institution, the sun being always used as source. Two main types of Ångström instruments are in use, the original type was calibrated at Uppsala, and is now calibrated in Stockholm, by reference to a standard Ångström instrument, used absolutely, always with the sun as source. The other one is calibrated by the Smithsonian Institution, the ultimate reference being the calorimeter, with the sun as source.

In some countries certain measurements of solar radiation are made using radiometers standardized, by reference to other absolute radiometers, on laboratory radiation sources.

2. *The Smithonian Pyrheliometric Scale*

The history of the Smithsonian scale of radiation may be studied in the publications of the Smithsonian Institution. For the present purpose it is important to note that in 1932, following the introduction of an improved calorimeter, the Institution announced that the scale of 1913 was in error, measurements in this scale being high by 2.5%; this has been confirmed in 1934, 1947 and 1952. Nevertheless the Smithsonian Institution has continued to standardize instruments in terms of the scale of 1913, to preserve continuity in series of measurements, and particularly in the publication of its solar constant determinations. The correction of -2.5% has, as far as is known, not been applied in meteorological practice; measurements have always been referred to the scale of 1913.

3. *The Ångström Pyrheliometric Scale*

The Ångstrom scale is based on the compensation pyrheliometer introduced by K. Ångström, which was recommended in 1905 by the International Meteorological Organization for meteorological radiation measurements. The scale is, and has been, embodied in a small group of specimen instruments, other instruments being standards not used absolutely. When the Ångström instrument is used absolutely it is necessary to apply certain corrections to the readings, mainly on account of the so-called “edge effect”. These corrections have been investigated from time to time during the past 40 years. The present estimate, following recent measurements in Stockholm, of the magnitude of the required correction is 2%, measurements on the uncorrected scale being low. This correction has never been applied when sub-standard instruments have been calibrated in Sweden; in meteorological practice measurements have always been referred to the original Ångström scale.

4. *Comparisons of the existing pyrheliometric scales*

The ultimate standards of the Ångström and Smithsonian scales have never been compared with each other, nor with any other absolute radiometer. There have been frequent intercornparisons of the Ångström and Smithsonian 1913 scales, through substandard instruments representing either scale, with absolute radiometers of other types. Many comparisons of substandard instruments have been made with the sun as source. The difficulty of such comparisons is that different areas of circumsolar sky are covered by the different instruments, and the intensity of radiation therefrom is widely variable with time and place, so that the silver disc and Ångström instruments are not strictly comparable if the sun is used as source. A few laboratory comparisons have been reported. The difficulty introduced by the circumsolar sky radiation is eliminated in principle in laboratory comparisons, but other difficulties are introduced, chiefly in dealing with the silver disc instruments, e.g. it is not easy to maintain an even distribution of radiation of sufficient intensity over the comparatively large sensitive surface. One laboratory comparison of a substandard instrument with another type of absolute radiometer has been reported.

5. Summary of results of the comparisons

The generally accepted mean difference between measurements of solar radiation by instruments standardized by the Smithsonian Institution on the 1913 scale and by instruments standardized on the uncorrected Ångström scale is 3.5%, measurements on the Ångström scale being the lower; but individual determinations show considerable scatter. The mean of laboratory determinations of this difference is 2.8%.

A single laboratory determination of the difference between the (british) National Physical Laboratory (NPL) standard scale of radiation and a substandard representing the uncorrected Ångström scale shows readings on the latter scale to be the lower by 0.5%. A series of intercomparisons at Davos (1934) between substandard Ångström instruments and the Potsdam absolute pyrheliometer (a calorimeter), using the sun as source, shows readings on the uncorrected Ångström scale to be the lower by 1%.

The Smithsonian Institution considers the 1913 scale to be in error by +2.5%. Let us designate the Smithsonian Scale of 1913 less 2.5% the corrected Smithsonian scale. On the other hand, the Stockholm Institute considers that a correction of +2% should be made to the Ångström scale. Let us designate the uncorrected Ångström scale plus 2% the Ångström corrected scale. The comparison of substandard instruments using the sun as source suggests that readings on the Ångström corrected scale are in the mean 1.0% higher than on the Smithsonian corrected scale. Comparison on laboratory sources suggests that this figure is 1.7% higher than the measurements on the N.P.L. scale. The Potsdam comparisons show that measurements on the Ångström corrected scale are 1% higher than those referred to the Potsdam absolute pyrheliometer. The mean difference of 0.7% between comparisons using the sun

and those using laboratory sources is of the magnitude to be expected from considerations of the apertures of standard and substandard instruments and an average distribution of circumsolar radiation. Computations by R. Pastiels have shown that the amount of circumsolar sky radiation, which enters through the aperture of the pyrheliometers during measurements of solar radiation, is 2 to 3 per cent in the silver disc and the original Ångström instruments and that the difference between the Ångström and the Smithsonian instruments on account of sky radiation and aperture conditions amounts to about 0.45 per cent.

6. *Conclusions*

Measurements on the uncorrected Ångström scale increased by 1.5% will almost certainly be within ±1% and may be within ±0.5% of the best realization which can at present be made of the true absolute scale of radiation.

This uncertainty is quite acceptable for meteorological purposes, and is in conformity with the present accuracy of meteorological radiation observations.

Recommendation 2. The Radiation Commission of IAM and the Working Group on Radiation of WMO recommend that Meteorological Services and Institutes ensure, before the beginning of the International Geophysical Year 1957-1958, and as soon as is practicable after its closure, that their primary sub-standard pyrheliometer is either re-calibrated against the primary standards in Stockholm, or by the Smithsonian Institution, or compared with sub-standard instruments which have recently been re-calibrated.

They further draw attention to the importance of the re-standardization of the auxiliary electrical apparatus used with pyrheliometers.

Recommendation 3. Pyrheliometers constructed in future should have an "angle of slope" not less than 1° and not greater than 2° ($1° \leq Z_p \leq 2°$) and a ratio of distance between receiver and limiting aperture to radius of receiver equal to or greater than 15 ($b \geq 15$). These conditions imply that the "opening angle" must not be greater than 4° [$Z_0 = \tan^{-1}(R/l) < 4°$; R = limiting aperture, l = distance between limiting aperture and receiver].

This recommendation was followed by six annexes with details of Pastiels's calculations which led to the conclusions of recommendation 3.

Recommendation 4. With respect to turbidity measurements it was recommended that

(i) for pyrheliometric measurements with glass filters the turbidity coefficient ß of Ångström should be computed from the "Kurzstrahlung" - nowadays called shortwave radiation - ($\lambda < 623$ nm),

(ii) in special cases (at radiation observatories with well trained observers) the turbidity parameters B, α, w of W. Schüepp should be determined in addition, and

(iii) in cases when only the total radiation has been measured, the turbidity factor T of Linke (with constants given by Feussner and Dubois 1930) should be calculated.

In an annex explanations are given for the symbols used in this recommendation. The widely unknown quantities mentioned in the recommendation part (iii) are based on the same fundamental assumption as ß and give a more detailed description of scattering by dust and water vapour.

Recommendation 5. In addition to the last recommendation another one was formulated about atmospheric extinction: Meteorological Services and Institutions with appropriate facilities should also pay attention to the investigation of atmospheric extinction by other methods, especially those involving spectroscopy, the use of interference filters, and the measurement of circumsolar radiation at different distances from the sun.

Recommendation 6. Noting that measurements of the ultra-violet radiation of sun and sky are nowadays made by elaborate methods at several well equipped observatories, IRC recommends that the relations between the ultra-violet radiation, as observed by accurate methods at special institutes, and other meteorological elements be investigated.

Recommendation 7. Great attention was devoted to radiation measurements in the free atmosphere. The IRC recommended that Meteorological Services and Institutes should now give all possible attention to the furtherance of investigations of this type (the measurements of radiation components in the free atmosphere).

Recommendation 8. The IRC noted the limited nature of knowledge about the radiation conditions over the oceans and the particular desirability of extending radiation measurements to the oceans during IGY and recommended that all authorities responsible for the operation of weather ships should endeavour to equip their ships to make radiation measurements, particularly for the period of the International Geophysical Year.

Finally, in a **resolution** of "the results of the Hamburg comparison of long wave radiometers", the IRC thanked all participating scientists for the very valuable results obtained.

Toronto, Canada, (IUGG) 1957

At the 11th General Assembly of IUGG in Toronto, September 1957, President Mörikofer gave a survey about the activities of the International Radiation Commission during the years from 1954 to 1957, from the Assembly of Rome to that of Toronto. The activity of the Commission consist in the transactions and discussions at its meetings and in the scientific activity of its individual members. The President had the great satisfaction of reporting that the results of the activity of the Commission in the period under report have been exceptionally successful owing, to a large extent, to the active collaboration of many colleagues. The major points of his report are summarized here.

At its meeting in Rome, the IUGG Committee on the IGY had expressed the wish that not only a program for radiation measurements during the IGY be published but also a detailed instructions for radiation measurements. The President, with the critical help of some members, had prepared the program for radiation measurements during the International Geophysical Year. To respond to the second part of the task, the Commission had nominated a small Sub-Commission to write the manual. The manuscript of these radiation measurement instructions was submitted to the Secretary General of CSAGI in May 1957 and was printed in the Annals of the IGY. The Commission had the opportunity to help the WMO Secretariat in the development of the necessary standard forms for the publication of the main radiation observations of the IGY.

The most important result of the Davos Conference was the creation of the International Pyrheliometric Scale 1956. It lies between the two scales and is used hitherto. Measurements made according to the original Ångström scale should be increased by 1.5 percent, while measurements made according to the Smithsonian scale of 1913 should be reduced by 2.0 percent. Other recommendations of the Davos Radiation Conference refer to the aperture conditions of pyrheliometers, to the use of different turbidity parameters, to the need for inter-comparisons of sub-standard instruments and for radiation measurements in the free atmosphere, over the oceans and especially in the ultra-violet spectral region.

The problem of how to measure the ultra-violet radiation of the sun and the sky had been studied at some Institutes for many years. This problem is as difficult as it is important and the Commission has been able to further several such investigations with the aid of grants from UNESCO. It was a condition for the receipt of such financial assistance that funds from other, non-international, source also be employed in the investigation. During the period of this report, E. H. Gowan (Edmonton, Canada) examined the comparability of the results obtained by means of different kinds of photoelectric cells. R. Pastiels (Uccle, Belgium) had developed a new photoelectric cell with a horizontal receiver surface and had studied the use of interference filters. P. Bener (Davos, Switzerland) dealt with the difficulties of comparability of photoelectric cadmium cells and with the adaptation of a quartz double monochromator to the requirements of routine measurements of the spectral energy distribution in the ultra-violet for total radiation of sun and sky, for diffuse sky radiation and for direct solar radiation.

A discussion took place on the tasks of the Sub-commission for Applied Solar Energy with the result that it should make an inventory of all existing reliable measurements of solar Radiation and of total sun and sky radiation. The collection of references should be used to prepare a radiation climatology suitable to advice designers of solar machines.

A. Drummond submitted a 100 pages draft of the English version of the reports of the Hamburg comparisons of radiation balance meters, which was so far only available in German language.

Fritz Möller, President IRC 1957-1967

A long discussion developed on the future tasks of the Radiation Commission and on its collaboration with the CIMO WMO Working Group on Radiation Measurements. Finally the following program of future activities was developed:

(a) Theory and criticism of radiation instruments, especially
  (i) further study of radiation balance meters,
  (ii) further study of methods for measuring UV radiation,
  (iii) investigation of methods for determining radiation components in the free atmosphere.
(b) Appraisal and interpretation of solar and terrestrial radiation measurements.
(c) Actinometric determination of atmospheric turbidity and its geophysical and climatological applications.
(d) Elaboration of a terminology of radiation fluxes and instruments in collaboration with the CIMO Working Group on Radiation Measurements.
(e) Organization of international symposia on radiation.

The Sub-commission for Radiation Research during the I.G.Y. was disbanded, having fulfilled its task.

W. Mörikofer expressed the desire to retire from the office of President of the Radiation Commission. Mörikofer served the Commission well, first as Secretary, than as President. All member of the Association expressed to him their appreciation for all he had done to further research on radiation.

A nominating committee chaired by A. Ångström proposed F. Möller as new President, G. D. Robinson as Secretary and W. Mörikofer as Vice-President. This was consented by the Commission and the new President was authorized to decide on the tasks of the Vice-President. Six new members were elected (R. M. Goody, H. Hinzpeter, K. Y. Kondratiev, W. Schüepp, Z. Sekera, and G. Yamamoto).

Oxford, UK, (IRC/IOC) 1959

Three years after the meeting in Davos, a symposium on radiation took place at Oxford in the Clarendon Laboratory 20-26 July 1959. A symposium of the Ozone Commission was held at the same place and time.

The Commission held two business meetings at Oxford in which mainly questions were discussed of the publication of radiation data obtained during the IGY.

The IRC discussed the publication of I.G.Y. data by the Meteorological Data Centre on the basis of a resolution of the CSAGI (Special Committee for IGY) Working Group on Meteorology and concluded that the IRC should not comment on the format of the publication but appoint a group to supervise the drafting of a preface for the publication of the radiation data. With respect of the choice of the stations, M. I. Budyko took action.

A draft on “Terminology of Radiation Instruments and Fluxes” was prepared in German by R. Schulze, following a meeting of the IRC officers in Mainz, March 1958. This report was sent to Robinson, who prepared an English version on the same lines, differing to some extent in principle. Dogniaux had taken these documents and prepared a French text, again with differences of principle. The Commission proposed that Dogniaux, Schulze and Robinson, with others interested, should attempt to agree on matters of principle and submit English, French and German texts of their considered version to all members of the Commission and of the Working Group, with which this task is shared. With the help of Sekera and Wierzejewski finally an agreed text was prepared.

The Sub-commission on Applied Solar Energy reported to the Commission that it wished to be reconstituted with revised membership and terms of reference to read:

“The task of the Sub-Commission is to arrange for the preparation of a bibliography of and for the collection and analysis of solar radiation data on a world-wide scale, giving priority to data for the arid regions and proceed on the following lines:

(a) It will prepare a programme indicating the types of data to be collected, and of the countries to be included, ordered according to priority. This programme is to be submitted to the President of the Radiation Commission by 30th November, 1959.

(b) It will seek funds and means to carry out this programme.

(c) It will supervise the preparation of a bibliography of available radiation data, giving preference to data for arid zones.

(d) It will supervise the collection of the data themselves.

(e) It will recommend methods of analysis of the data which are relevant to the problems of applied solar energy.

(f) It will report on the state of its work to the President of the Radiation Commission before the General Assembly of the I.U.G.G., Helsinki, 1960.

The Commission approved these recommendations.

The attendance of the Radiation Symposium was 79 persons. 47 papers were read, including the lecture of the president, which are printed on 41 pages in Monograph No. 4 of the IUGG in January 1960. The papers were grouped into the following sessions: Radiation measurements during the IGY (7 papers); Surface instrumentation (7); Satellite and rocket programs (2); Observation and computation of terrestrial radiation (8); Transmission of solar radiation in the free air and clouds (14); Spectroscopic methods (5); Sub-Commission of applied solar energy (3). The distribution of papers shows that space techniques slowly entered the program of the IRC.

Helsinki, Finland, (IUGG) 1960

In the course of the years a transition of the Commission could be observed from a body occupied with detailed techniques of radiation measurements to one concerned more generally with the study of the role of solar and terrestrial radiation in meteorological processes. As mentioned in the Introduction, R. Goody therefore raised the question of the proper description of the task of the IRC. After intensive discussion it was agreed on the following definition: "*The International Radiation Commission is concerned with fundamental research and study in solar and terrestial radiation"*, but it was also said that the interest in radiation measurements and instruments remains and is manifested in the close cooperation with the Working Group of CIMO. It was expected that, in the future, emphasis in this field will probably be of increasing the number of radiation measurements in the free atmosphere, and securing a more general appreciation of the accuracy attainable in radiation measurements.

Accordingly a *Programme of Activity* was developed for the period 1960-1963 by the ad hoc WG:

1. Organization of scientific meetings of the Radiation Commission;
2. Terminology of radiation components and instruments;
3. Establishment of a Sub-Commission on Instrumentation.

This programme was also accepted unanimously.

The new Sub-commission on Instrumentation was founded under the chairmanship of A. Drummond in which the *first time also a non-member of the IRC participated*. The functions of the sub-commission was defined as follows:

a) to coordinate activities in the development of improved instrumentation, especially in regard to absolute radiometry and spectral radiometry;
b) to ensure the adequacy of intercomparisons and methods of calibration of primary standard instruments.

The sub-commission should attempt to complete task b) and to report its findings to the Radiation Commission within the period of this programme.

The Sub-commission on Terminology of radiation fluxes and instruments met to improve and complete the existing drafts of a terminology of radiation and radiation measurements. The drafts were not discussed in detail. A final discussion, at which members of the Working Group on Radiation Measurement of CIMO should be present, should take place at Vienna and a final resolution should be passed there. The Sub-Commission on Terminology then was disbanded.

The activity of the Sub-Commission on Applied Solar Energy had been hindered by the serious illness of its chairman, W. Mörikofer. In the re-discussion of the tasks of the sub-commission the prevailing opinion was that they exceeded the proper tasks of a commission of IAMAP, particularly because of the great difficulty of building up a suitable machinery to administer any funds received. For this reason the sub-commission was disbanded. The Radiation Commission, however, stated its undiminished interest in the task of elaborating a radiation climatology of this kind, and requested the president to further the task in collaboration with other members of the Commission but without direct involvement of the Commission as a body. It was 32 years later that A. Ohmura reported the first time to the IRC about his efforts to establish as a contribution to the World Climate Research Program (WCRP) a Global Energy Balance Archive (GEBA). Four years later, 1996, he was appointed Rapporteur for the Baseline Surface

Radiation Network (BSRN) which in the meantime was developed for the WCRP and which has similar aims as formulated in Oxford, 1959, for the Sub-commission.

K. Kondratyev proposed that the members of the IRC should present at the occasion of each General Assembly a report on research in the field of radiation carried out in their respective countries and submitted such a report in Russian language. It was agreed that such reports would be very welcome and should be presented at the scientific meetings, not at the business meetings.

It was unanimously agreed to recommend to IAMAP that the total membership of the Radiation Commission be raised to 17 and to elect Professor M. I. Budyko, Leningrad, to become member of the Commission. This was approved when the Commission was reestablished and the membership confirmed in the plenary session of IAMAP. It was recommended that the previous officers be re-elected, which was also approved by IAMAP.

R. Goody put forward the following motion about *Membership Policy* for amendment of the statutes: "The Radiation Commission shall have two classes of membership:

a) Founder Members with unlimited membership;
b) Ordinary members, whose membership will be limited to three terms between the General Assemblies of IUGG ordinary of three years each. After three terms the membership expires; the individual concerned becomes re-eligible only after the lapse of one term during which he is not a member of the Radiation Commission. The officers of the Commission are not subject to this restriction."

It was stressed in the discussion that such a regulation would have the advantage of regularly bringing fresh blood and new ideas to the Commission but that there are some permanent tasks which make longer membership desirable. From the bureau it was stressed that the IRC has no statutes. It is governed by the statutes of IAMAP, which apply equally to all commissions. It is reconstituted and its members are appointed by IAMAP at each General Assembly. The members of the Commission, as appointed at any one General Assembly, can not bind their successors to any course of action. This does not prejudice Goody's motion, or the recording of any agreed recommendation on terms of membership in the report of the Commission to the next General Assembly of IAMAP.

It was agreed that the motion should further be discussed at the next meeting in Vienna.

Only few papers on radiation have been read at the meeting of Helsinki. These were:

Alfuth, Climatology and Missile Problems
S. Fritz, Meteorological Uses of Satellites
L. D. Kaplan, Results of Outgoing Radiation
Conover, Cloud Patterns as Seen from Altitudes of 150 to 1500 km.
Volz and Goody, Optical Measurements of Mesospheric Aerosol.

Vienna, Austria, (IRS) 1961

The Radiation Symposium was held in Vienna, Austria, 14 to 19 August 1961. In the preceding week a session of the WMO (CIMO) Working Group on Radiation Measurement took place.

There was a prolonged discussion of the proposal to compare radiation balance (net flux) meters. The principal types in general use were (a) the shielded type (Schulze), (b) the ventilated type (Kew), and (c) the unshielded, unventilated type (Yanishevski). The Sub-Committee on Instrumentation produced a detailed proposal in which the conditions were defined under which the radiation balance (net flux) meters should be compared under different climate conditions. It also specified which information has to be submitted by the participants to the IRC after the comparison and which radiation data should be published together with meteorological data. The secretary was instructed to determine the terms on which institutes would be prepared to conduct the comparisons.

After it became clear that general agreement on a detailed text of the terminology of radiation fluxes and instruments in the three languages English, French and German was unlikely to be reached, a much smaller document was prepared at a joint meeting with a working group of WMO. A small group was appointed to represent the IRC in the continuing discussions of the CIMO (WMO) Working Group on Radiation Measurements on terminology.

The Commission discussed the decision taken by IAMAP at the Helsinki meeting that special meteorological observations were not called for during IQSY. It was felt that first the possibilities of

radiation measurements from satellites should be explored to the full, which would then in turn call for an extension of radiation measurements at the earth's surface and in the free atmosphere. Resolutions were adopted which were available to subsequent meetings of the appropriate bodies in WMO and CIG (Coordination and Implementation Group), and their substance was then to be incorporated in the IQSY scientific program.

The IUGG/WMO Liaison Officer, W. L. Godson, gave a résumé of the recommendations of the WGs of each organization on meteorological data. There should be two classes of radiation data: daily and monthly totals should be published centrally while hourly and special data should be published locally. In response the IRC adopted recommendation 2.

With respect to the discussion about the membership policy raised at the meeting in Helsinki, sympathy was expressed with the intention to bring new minds regularly into membership. In view of the arguments brought already foreward - that the membership also relies on IAMAP decisions - it was agreed that the question of membership should be considered by exchange of letters before each General Assembly. The President would initiate action by writing in confidence to each member. The President's letter would contain a list of members, with dates of their initial appointment.

Additional information was given in the report to IAMAP for the period 1960-1962:

UNESCO's support for research on the measurement of ultra-violet radiation in the atmosphere ceased in 1958. The residue of the fund was disbursed to I. Dirmhirn, Vienna, to support a project for the recording of ultra-violett radiation with the aid of interference filters.

WMO consulted the IRC in relation to the publication of IGY-IGC radiation data and the Secretary spent two periods in the World Data Center C, Geneva, examining the material and advising methods of publication. An introduction to the data was prepared for WMO and published with the data. Preparation of a digest and discussion of the IGY-IGC surface radiation data, for publication in the "Annals of the IGY", was entrusted to the Commission and discussed at the business meeting. The drafting was left to the secretary, whose manuscript was discussed by designated members before submission for publication.

The following resolutions and recommendations were adopted as a result of discussions:

Resolution 1. Comparison of methods of measuring radiation in the free atmosphere.

The Radiation Commission of the International Association of Meteorology and Atmospheric Physics notes that physically different methods of measuring the radiation flux in the free atmosphere, from sounding balloons, are in use. It strongly recommends that comparisons should be made between the various instruments. These comparisons should be carried out under various weather and climatic conditions: in clear and cloudy skies, during precipitation, and in different parts of the world.

Resolution 2. The publication of radiation data.

The Radiation Commission of the International Association of Meteorology and Atmospheric Physics notes with satisfaction the resolution of the Executive Committee of WMO concerning the collection and publication of data in physical meteorology. It is in full agreement with the proposal to divide radiation data into two classes, the one for central collection and publication, the other for local publication, and trusts that arrangements for central publication will be completed without delay. The Commission urges the authorities responsible for the measurement of radiation to supply promptly to the W.M.O. or the nominated publishing agency the data required for central publication, and to arrange for local publication of the more detailed data if this is not already done.

Resolution 3. Radiation measurements during the International Quiet Sun Year.

The Radiation Commission of the International Association of Meteorology and Atmospheric Physics draws the attention of the authorities responsible for the programmes of scientific work using rockets and artificial earth satellites to the importance of monitoring the solar radiation reaching the earth in all spectral regions, and hopes that all possible efforts will be made to carry this out, particularly during the International Quiet Sun Year. The Commission has also noted the paucity of results obtained during I.G.Y. and I.G.C. on the project to determine the radiation fluxes at all levels in and above the atmosphere. It considers that the period of I.Q.S.Y. offers an opportunity to profit from lessons learnt during I.G.Y. and I.G.C. and hopes that all efforts will be made to measure the incoming and outgoing radiation fluxes, or the net flux, from artificial earth satellites, by means of sounding balloons, and at the earth's surface. Surface measurements are particularly necessary over the tropical and sub-tropical oceans.

Recommendations on Radiation measurements for use in engineering, agriculture, and architecture, with particular reference to arid and semi-arid zones.

The Radiation Commission of IAMAP at its meeting in Vienna in August, 1961, has considered reports by experts on radiation climatology, instrumentation for radiation measurement, and needs of engineers and agricultural scientists, particularly in the arid zones, for radiation data. Its discussions can be summarized in four recommendations:

(a) The "ideal programme" outlined by the UNESCO Group of Experts on Radiation Data for the Arid Zones is a modest and feasible proposal, and should be put into effect by the responsible authorities. It calls for the measurement at each radiation measuring station of the global and diffuse short-wave radiation on a horizontal surface and the tabulation of the measurements in a manner similar to the WMO - IGY form R3; and for the operation of sunshine recorders and the tabulation of sunshine statistics on an hourly basis.

(b) In view of the needs of bioclimatologists and agricultural scientists, increased attention should be given to the measurement of the separate components of the radiation balance near the earth's surface. Where a complete measurement is not possible, computation from partial data is possible and useful, and should be carried out.

(c) The Commission has been impressed by the needs of biologists and agricultural scientists for knowledge of the spectral distribution of the global radiation, and its variations. It draws the attention of suitably qualified services and institutes to the importance of this field of investigation.

(d) The Commission considers that it is now possible to prepare technical guidance on the use of radiation data for practical purposes in the arid zones and urges compilation of such a guide.

At the scientific meeting with 95 participants from 22 countries, 50 papers were presented, mainly following the program which was set up at the Helsinki session. Following the formal opening by F. Steinhauser, F. Lauscher spoke on the “History of radiation research in Austria” and F. Möller delivered his presidential address on “A vertical temperature profile computed assuming combined radiative-convective equilibrium”. Six symposia followed with the titles “The radiative balance and climate of the arid zones and their significance in hydrology and agriculture. Applied solar energy and the arid zones” (chaired by N. Robinson); “Radiative transfer in a medium with scattering and absorption” (Z. Sekera); “Problems of absorptive properties of atmospheric gases” (W. L. Godson); “Interactions of radiation and fluid motion” (F. Möller); “Thermal effects of radiation in the uper atmosphere” (K. Ya. Kondratiev); and “Radiation measurements in the free atmosphere, including the use of rockets and satellites” (D. Q. Wark). Speakers were informed that proceedings would not be published. Most of the papers have been published in scientific journals.

Berkeley, USA, (IAMAP) 1963

At its business meeting during the XIIIth General Assembly of the IAMAP in Berkeley, California, from August 19-31, 1963, the Commission endorsed the proposal made by WMO for regional and inter-regional sub-standard pyrheliometers and noted with satisfaction that after the successful comparison of pyrheliometers at the Davos Observatory under the direction of WMO-CIMO, in August/September 1964, an inter-comparison of radiation flux meters took place in Tartu and another one was in progress at Hamburg, sponsored by the Deutsche Forschungsgemeinschaft. A third series was planned for Taschkent. Also the comparison of radiation sondes was continued.

It was decided that Commission members with nine or more years of service should in general not be re-appointed to the Commission for the period 1963-1966. A. Angström and W. Mörikofer were elected *Honorary Vice-Presidents*.

The Commission found that a “somewhat confused” situation was reported with respect to the terminology of radiation fluxes and instruments and that presently no further action should be taken by the IRC. A terminology was drafted in the three languages, English, French and German. However, it became clear that general agreement on a detailed text was unlikely to be reached. A much shortened document was prepared in a joint meeting of some Commission members with a Working Group of WMO at Vienna in 1961. A modified form of this document is likely to be published by WMO.

The Sub-Commission on Instrumentation reported on investigations about the relationship between the

International Pyrheliometric Scale and the scale maintained in the US National Bureau of Standards. The standard instruments of Davos and Newport (Eppley Laboratory) agreed within 0.1 per cent. The reflectance of Parsons' Optical Black Lacquer recommended as thermopile cover in radiation instruments was investigated at the Satellite Laboratory of the US National Weather Satellite Center over the wavelength range 1 - 40 µm and the transmission of polyethylene and KRS-5 in dependence of weather and temperature was started out to 40 µm at Newport. The IRC decided that the work of the sub-commission was well done, the activity reported would continue without further stimulation by the IRC, and terminated its existence.

The Commission turned down as "in the present state impossible" the proposal made by R. Schulze to designate a specification of the extraterrestrial solar spectrum as the preferred data for use in investigations.

Walter Mörikofer, 1964

The Association endorsed the following recommendation: The Radiation Commission of IAMAP, meeting in Berkeley, California, August 1963, has reviewed the response to its resolutions drawn up in August 1961. These resolutions were accepted by the IUGG and communicated to National Committees and the WMO. The Radiation Commission greatly regrets that no effective action has yet been taken on Resolutions 1 and 2, and recommends that every effort be made to bring to an early and successful conclusion the negotiations now in progress. The Commission notes with pleasure the inclusion of the recommended program by the IQSY of those radiation measurements detailed in its resolution 3, but finds the response of competent authorities disappointing. In particular it has not been informed of any project to monitor solar radiation in all spectral regions from an artificial earth's satellite, a project which should be feasible and which the Commission considers of fundamental importance to the scientific program of the IQSY. It recommends reconsideration by authorities responsible for satellite programs.

At the scientific meeting was one session with scientific papers on radiation with the following contributions:

Mani, Chacko and Desikan, Distribution of Sunshine and Solar Radiation over the Arid and Semi-Arid Regions of the Indian Sub-Continent.

Warner, Some Results of Measurements of Short-Wave Insolation during IGY along the 10th E Merdian and a Comparison with Theoretical Values.

Mani, Chacko and Desikan, Studies on Nocturnal Radiation in India.

Kuhn and Suomi, Effects of Long-Wave Measured Emissivity of High Clouds on Satellite Measurements.

Dietz, Information by Optical Measurements at the Ground of Phenomena in the High Atmosphere.

Paul, Amounts of Gas Encountered in Reaching Different Heights of the Upper Atmosphere Along Vertical and Inclined Directions.

The program and abstracts of the Berkeley symposium on upper atmosphere radiation were published in the IAMAP Proceedings, December, 1963.

Karlsruhe, Germany, (Meeting on Polar Research) 1963

As reported in the Commission Report 1963-1966, a one day conference on "Measurements of the Radiation Balance in Polar Regions" was held on 9 October 1963 in connection with a meeting on Polar Research in Karlsruhe, Germany. Ten scientists took part in the discussion on instruments used and the results obtained in measuring the radiation budget under cold climatic conditions.

Leningrad, USSR, (IRS) 1964

The Radiation Commission held a scientific symposium in Leningrad 5-12 August 1964 on Radiation Processes in the Atmosphere. There were 239 registered participants from 29 countries. 137 lectures were held. These were 25 papers in Session I on "Theory in radiative transfer in planetary atmospheres", 35 in Session II on "Infrared spectroscopy of the atmosphere", 28 in Session III on "Radiation climatology", 14 in Session IV on "Radiation processes as related to atmospheric dynamics and the general circulation", 13 in Session V on "Surface and network instrumentation" and 22 in the Session VI on "Experimental investigations of the radiation field in the free atmosphere". Furthermore, two evening special lectures were held, one by Academician V. G. Fessenkov: "The space dust cloud around the Earth and its penetration into the lower atmospheric layers", and one by W. O. Roberts: "The changing aspect of weather and climate, and the prospects for large scale weather control." The papers are printed in Monograph No. 28 of the IUGG, Paris, Août 1965.

At the business meeting of the Radiation Commission in Leningrad the following administrative actions were taken:

a) A working group was appointed with Peter Kuhn as Chairman to coordinate an international radiometersonde comparison program. Peter Kuhn, USA, was asked to contact all interested persons who might wish to particpate in. this program and to report back the results to the Radiation Commission.
b) The Commission noted favourably the plans for continued comparison of balance metres under the direction of Miss A. Mani, India, with WMO sponsorship.
c) T. G. Berljand, USSR, gave a report of the plans for the Hydrometeorological Service of USSR to act as the World Data Center for the collection and publication of selected radiation data for the IQSY and subsequent periods. Solar radiation data will include:
   1. Daily and monthly totals of global solar radiation flux;
   2. Hourly, daily and monthly totals of net radiative flux;
   3. Monthly means of hourly data of global solar radiation and net radiation flux.
d) The Sub-Commission on Instrumentation reported about its activities between August 1961 and 1963:
   i) Standards of Radiometry
   The relationship between the International Pyrheliometric Scale and that maintained in the U.S. National Bureau of Standards is under investigation at the-Eppley Laboratory (in close collaboration with the N. B. S.) where, to date, about 50 comparisons have been made. A comparison in March 1963, at Davos, between the primary working standard pyrheliometers of Davos and Newport indicated agreement to within 0.1 per cent of the relationship established in August 1959. These centres have been responsible for the transference of the I. P. S. to a very large number of secondary instruments during this period.
   ii) Optical Properties of Materials
   The Satellite Laboratory of the U.S. National Weather Satellite Center, Washington, D. C., has investigated the reflectance of Parsons Optical Black Lacquer (at 30° incidence) over the wavelength range l - 40μm and has found no significant variation from the data established elsewhere to 25 μm. A start has been made at Newport with the investigation of the transmission properties of polyethylene and KRS-5 out to 40 μm, especially with regard to weather effects and material temperature.

Munich, Germany, (Radiometer Sondes Intercomparison Conference) 1966

The Commission reported to IAMAP (Commission Report 1963-1966) that in June, 1966, a special conference was held in Munich to discuss the results of the comparison of radiometer sondes which were made during the preceding three years. The impetus for this exercise originally came from V. Suomi (USA), P. Kuhn (USA), and H.-G. Müller (Germany) and executed under the direction of the IRC. The first set of ascents was made in Munich (1963). The second set of ascents took place 1965 in the USA at two locations. The second set involved sondes developed by Kuhn (USA), Müller and Fimpel (Germany), Shlyakhov and Kostyanoy (USSR), and Yata, Sekiguchi and Kuwara (Japan). The results of the conference were summarized as follows.

Peter Kuhn at the right in - as usual - intense discussion. John Houghton, at the left, watches with interest

- Each instrument had been improved as a result of the experience gained in the intercomparison program.
- The average difference between the instruments for the absolute downward directed radiation flux values was 0.04 ly min^{-1} [8]at pressures larger than 100 mb. At lower pressures than 100 mb the differences became larger. The average difference of the flux divergence was found to be about 0.010 ly min^{-1} $(100\ mb)^{-1}$ at pressures higher than 100 mb and about 0.020 ly min^{-1} $(100\ mb)^{-1}$ at lower pressures.
- It is probable that with the use of the improved instruments and better transmitting and receiving arrangements, greater homogeneity of the results can be obtained.

It was therefore suggested to make additional intercomparisons over large homogeneous areas, such as the open sea, in different climate zones, particularly in polar regions. The group should maintain close contact with scientists working in theoretical radiative transfer.

The full report by the intercomparison working group was submitted to WMO and IAMAP.

Lucerne, Switzerland, (IAMAP) 1967

The next meeting of IAMAP took place in Lucerne/Switzerland, September/October, 1967. The report of the Radiation Commission contains the following information:

1. All members of the IRC were re-elected for the next term of four years.
2. The following scientists were elected as new members:
   Anna Mani, India
   L. Foitzik, G. D. R.
   M. Migeotte, Belgium
   V. E. Suomi, U. S. A.
3. F. Möller retired from his office as President. K. Ya. Kondratiev, Leningrad, was elected as new President. F. Möller was elected Vice-President, J. London will stay in his office as Secretary for another term of four years according to the by-laws of the Association. A. Ångström and Mörikofer will stay Honorary Vice Presidents.
4. The WG on Radiometersonde Intercomparison was re-established with P. Kuhn as chairman. The group was asked to involve a radiation theoretician in the evaluation of their measurements. W.C. Rodgers was proposed for this task.
5. A. Mani is asked to report to the IRC at its symposium in Bergen, 1968, about the results of the various intercomparisons of surface radiation instruments.
6. The Commission was requested to appoint a representative of IUGG to COSPAR Working Group VI, Panel 2. F. Möller was elected for this office.

The following resolutions were adopted by the Radiation Commission at its meetings of Sept. 27 and 29, 1967, in Lucerne:

(1) The Radiation Commission supports those recommendations of the Global Atmospheric Research Program (GARP) which are concerned with radiation investigation.

(2) In order to check the internal consistency and accuracy of laboratory experiments, radiation theory, and free air observations, it is essential that a program of carefully calibrated observations of infrared radiation fluxes in the free atmosphere be made in different particular spectral regions. It is necessary

[8] 1 ly = 1 Langley = 1 cal cm^{-2} = 41.84 kJ m^{-2}

that accurate vertical distributions of all essential atmospheric parameters, such as: temperature, water vapour, cloudiness, (including water content and drop size distribution), ozone, dust, etc., be determined at the time of the radiation observations. The Radiation Commission recommends that this program should be pursued as completely as possible.

(3) The Radiation Commission recommends that special attention should be placed on experimental studies (including free air observations) and basic theoretical research of the problem of transfer of solar and terrestrial radiation in an atmosphere containing dust, haze and clouds.

(4) The Radiation Commission strongly recommends that the different programs of satellite measurements of cloudiness, radiative fluxes in different spectral regions and total net flux be continued and improved.

(5) Accurate knowledge of the solar constant and the solar radiation reaching the earth's surface in all spectral regions is essential for understanding of the radiation input to the atmosphere. The Radiation Commission recommends that serious efforts be made to monitor the solar constant and the absolute and relative intensities of the solar spectrum from satellite platforms. The Radiation Commission further notes that a similar recommendation was made at its Vienna meeting (1961) and again endorsed at its meeting in Berkeley (1963). Although no such program is presently operational, the Commission regards this problem as one of fundamental importance.

(6) In view of the important progress reported by the working group on intercomparisons of radiometersondes, the Radiation Commission recommends that further intercomparisons among the various radiometersondes be planned and that continuous efforts be made to improve and standardize these instruments.

(7) In the light of existing discrepancies among the different scales the Radiation Commission recommends the study and development of absolute radiometry.

There has been no own symposium on radiation in Lucerne. As part of the IUGG General Assembly a Survey and Specialist Symposium on Radiation was held in Lucerne. Four invited and 15 contributed papers were presented. The abstracts were published in the Report of the Proceedings of the IAMAP Assembly.

Bergen, Norway, (WMO/IAMAP-IUGG) 1968

In response to an invitation of the Geophysical Institute of the University of Bergen, Norway, the next scientific meeting of the Radiation Commission took place in Bergen during the WMO/IAMAP-IUGG Symposium on "Radiation Including Satellite Techniques", 22-28 August, 1968. There were 158 participants and 142 papers were presented. They are reproduced in WMO, Technical Note No. 104, WMO-No. 248, TP.136, 584 pages.

The topics of the individual sessions of the meeting were the following:
1. Satellite instrumentation; 2. Satellite observations and results; 3. Spectroscopy; 4. Radiation climatology; 5. Radiation in clouds and aerosols; 6. Radiation and atmospheric dynamics; 7. Surface and airborne instrumentation; 8. Radiative transfer and planetary atmospheres.

A short business meeting of the Commission was held in Bergen:

The Commission received the report of A. Mani on the results of intercomparisons of sunshine recorders, pyranometers and net radiometers. The Commission recommended that:

1. WMO be requested to continue and extend such intercomparisons and that the activities of the Working Group in this field be encouraged.
2. The Working Group be requested to carry out comparative studies between actual observations and theoretical calculations of net radiation.
3. The development of a precision net pyranometer to serve as a reference standard be encouraged.

The Commission heard a report by T. G. Berlyand and M. I. Budyko on the activities of the Center for Publication of Actinometric Data and the Working Group on Radiation Climatology of WMO.

The Commission received the report of the Sub-committee on radiometersondes and supported the sub-committee's proposal for a third International Intercomparison Program. J. Gille was asked to serve the

WG as expert for radiation theory. The results of this program were reported at the meeting in Moscow, 1971.

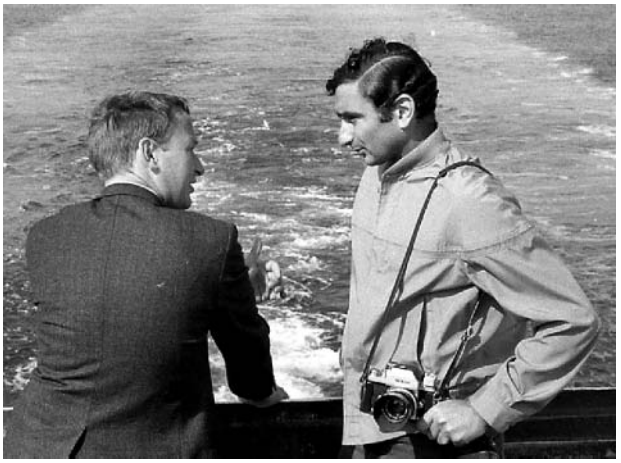
The Commission endorsed the program of cooperation with the Global Atmospheric Rersearch programme and recommended that aid be given in a survey of various types of radiation research programs that are current and would be useful to GARP.

The participants of this meeting enjoyed an extended boot trip in the Fjord of Bergen at which the pictures shown here were taken.

Giichi Yamamoto with H. Schieldrup-Paulsen, the host of the meeting in Bergen

Anna Mani and John Gille

Vladimir Zuev, chairman of the WG on Atmospheric Optics



Heinrich Quenzel and Albert Arking

Julius London, Mikhail Ivanovich Budyko, and Kirill Ya. Kondratyev at the boot trip near Bergen

David G. Murcray who measured spectra from stratospheric balloons and W. S. Benedict, who computed molecular spectra

Leningrad, USSR, (WMO-COSPAR) 1970

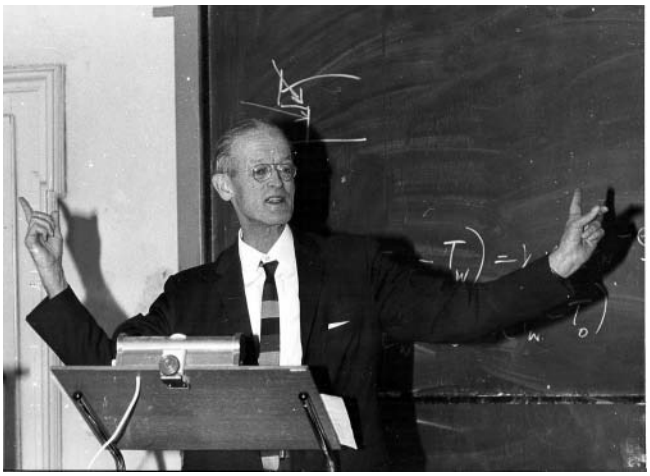
A symposium sponsored jointly by WMO, COSPAR Working Group 6 and the Radiation Commission was held in Leningrad, 22-26 May 1970 in connection with the XIIIth Plenary meeting of COSPAR. 37 invited and contributed papers dealt with the main theme of the symposium: "Remote Sounding of the Atmosphere".

At its business meeting the IRC confirmed its co-operation with the radiation sub-programme of GARP. The IRC took note of the various radiation instrument comparison programs which involved absolute and regional standards of pyrheliometers, surface net radiometers, and airborne net radiometers. R. Dogniaux was appointed by the Radiation Commission as its representative to the third international comparisons of regional working standard pyrheliometers.

Moscow, USSR, (IUGG) 1971

The Commission noted with sorrow the passing of Prof. Konrad Büttner and Dr. Fuad Saiedy who made important contributions to atmospheric radiation science.

The commission was informed about a report of activities 1967-1970 which was submitted to IAMAP to be published as part of the IAMAP proceedings. Beside short reviews of the meetings in Lucerne, Bergen and Leningrad it contained a section on the Radiometer Intercomparison Program on which a decision had been taken in Bergen. The program was co-sponsored by the GARP and executed during May 1970. Radiometersondes of Japan, Germany and the



Konrad Büttner at one of his lively guest lectures in Munich

USA had been launched simultaneously from the NOAA oceanographic research vessel Discoverer on its cruise from Miami to south of Galapagos and back to Panama. Simultaneous measurements were taken of upward, downward and net hemispheric infrared flux. Subsequent intercomparisons were held in Tokio during March, 1971, in which also scientists from the USSR participated. These activities had been organized by P. Kuhn with J. Gille attached as expert on radiation transfer theory. A preliminary report on the first phase of the intercomparison was distributed. The Commission expressed its thanks to its Working Group on Radiometersonde Intercomparisons (P. Kuhn, Chairman) for successfully completing its important program.

Four documents had been submitted to the JOC: one on the radiation sub-program for BOMEX and GATE, an outline of the plans for the Complex Atmospheric Energetic Experiment (CAENEX) prepared by the USSR GARP Commission, a proposal on the determination of atmospheric transmittance characteristics, and a proposal for the further development of the world actinometric network.

The Commission was represented at the 3rd International Pyrheliometric Intercomparison that took place in Davos and Locarno, Switzerland, in 1970. The Commission expressed its thanks to M. Dogniaux for representing the Commission at these intercomparisons.

The Commission heard a brief summary by President Kondratyev on the Soviet GARP sub-program CAENEX. The planned CAENEX five-years program was submitted to the JOC and approved at its 5th meeting (Bombay, 1971). Additional recommendations to JOC on radiation programs for GARP as submitted by Budyko and Wark were discussed and approved at the Bombay meeting. Also, the radiation sub-program for GATE and FGGE were approved in principle.

Nominations for membership were forwarded to IAMAP for election and A. Ångström, F. Möller and W. Mörikofer were elected as *Honorary Members* of the Radiation Commission without term.

The Commission forwarded four resolutions to IAMAP. These resolutions were passed by the IAMAP Assembly in the following slightly edited versions:

1. IAMAP noting
   i) that accurate knowledge of the solar radiation reaching the earth is essential for understanding the radiation input to the atmosphere and
   ii) that, though this problem is fundamental, there is no complete program operational at present, IAMAP recommends that serious efforts be made to monitor the solar constant and the absolute and relative intensities of the solar spectrum from a satellite or from the moon (this recommendation is renewed from Vienna 1961, Berke1ey 1963 and Lucerne 1967).
2. IAMAP noting
   i) the deep concern about the effects of pollution on the climate of the earth and that the climate may be changed by the presence of aerosols and
   ii) our small knowledge of the optical properties of aerosols,
   IAMAP calls attention of laboratory and theoretical atmospheric physicists to the urgent need to determine the optical properties of aerosols and clouds in all relevant parts of the spectrum;
3. IAMAP notes with pleasure the inclusion of the various radiation sub-programs in GARP plans, both for GATE and for the first global GARP experiment. In recognition of the importance of radiation in the GARP concept the Association offers its continued cooperation in GARP and will include one session on "Radiation Problems in GARP" at the International Radiation Symposium to be he1d in Sendai, Japan, 17-24 May 1972.
4. IAMAP expresses its warm congratulations to Professor Fritz Möller on the occasion of his academic retirement and hopes that he will continue to have a happy and active scientific life. IAMAP also expresses its gratitude to Fritz Möller for his guidance while serving as one of the officers of the Radiation Commission for the past 17 years.

At the Symposium on "Energetics and Dynamics of the Mesosphere and Lower Thermosphere in Moscow, 1971, the following papers on radiation were presented:

G. M. Shved: "The role of radiation in the atmospheric heat regime in the mesopause region 60-100 km (Review)". Calculations of the radiative flux divergence suggest that a study of the following dynamic factors of the heat regime should be most fruitful: 1) The tides and internal gravity waves propagating from below are, evidently, (a) a cause of short-term temperature variations (reversible heating) and (b)

ensure, in the dissipation of the above mentioned wave movements (through turbulence as the intermediate form of motions), the heating rate which, by order of magnitude, is not less than the heating due to the solar radiation absorption. 2) The eddy heat transport must be an important mechanism of energy transfer. It may be the only process causing atmospheric cooling at the mesopause. 3) The meridional circulation is an essential feature of the heat regime, in virtue of the adiabatic cooling and heating with vertical motions, and may account for the cold mesopause of high latitudes in summer and the warm one in winter.

M. Ackerman: "Incident solar radiation in the mesosphere and lower thermosphere". Important discrepancies in the ultraviolet solar radiation appear between the data obtained by the different techniques used on different space vehicles. The final answer seems to be available at ground level since the calibration problems appears to be the most important.

A. Drummond: “Measurement of the UV solar radiation incident on the upper atmosphere." A series of filter measurements is described from jet and rocket aircraft and platforms in the stratosphere and mesosphere. The accuracy will approach 1%.

D. Heath: "Satellite observations of the long-term variability and intensity of the near and far ultraviolet solar flux". Measurements in 12 or more wavelengths have been made over 20 solar rotations and show a decline of the variability corresponding the solar 11 year cycle. Similar variations are shown in the solar flux at 1800 in regions of low solar temperatures.

Sendai, Japan, (IRS) 1972

The scientific meeting of the Radiation Commission took place in Sendai, Japan from 26 May to 2 June 1972, on invitation of the Geophysical Institute of the Tohoku University.

The President proposed to send greetings and best wishes of the Commission to Dr. Abbot who just celebrates his 100th birthday, to W. Mörikofer who celebrated his 80th birthday on May 24, and to Z. Sekera, K. Kondratyev and A. J.Drummond who could not attend the meeting because of illness.

The President then opened a discussion on the topic of solar-terrestrial relationships and radiation flux measurements from satellites which at that time was a major issue of COSPAR and UN organizations. A main topic of a recent meeting of the Inter Union Commission on Solar Terrestrial Physics (IUCSTP), in March 1972, was to survey the current state of knowledge in Solar-Terrestrial physics and to identify areas calling for cooperative research in the years immediately ahead. Attention was concentrated on problems of an interdisciplinary character for which inter-union cooperation would appear to be necessary. The most important, as far as the Radiation Commission is concerned, is the proposal to determine the absolute intensity of solar radiation at the top of the atmosphere throughout the entire solar spectrum.

H.-J. Bolle, J. Houghton and K. Sekihara reported on recent activities of the COSPAR Working Group 6 (Application of Space Techniques to Meteorology and Earth Survey). The United Nations Committee on the Peaceful Uses of Outer Space requested a report from COSPAR on the capabilities of space observations for studies of the global environment. This report has in the meantime been prepared by the W.G. 6 and shall be submitted to the United Nations Conference on the Environment to be held in Stockholm in June 1972. It concentrates on a preliminary observing system for monitoring some important climate parameters such as the radiation budget, clouds, particles, trace gases, and surface parameters. The W.G. 6 has invited the IRC to participate in the development of specifications for the parameters to be measured and of an adequate calibration as well intercomparison procedure.

In the following discussion the point was stressed that talks about an observing system of the proposed type are going on for more than 10 years and that the statements of concerned groups have to be very positive in order to get such a project being endorsed by the governments. It was also pointed out that the satellite measurements have to be supported by adequate ground based, aircraft and possibly balloon observations. The need for standardized calibration procedures of very high accuracy becomes more and more urgent in the light of these future plans.

The IRC concluded to take a very active part in these developments since it is understood that one of the functions of the IRC is the promotion of the development of accurate radiation measurement devices. Mr. Marchgraber as representative of the WMO said that WMO already worked on these lines and has set up a WG for absolute measurements.

The IRC set up an ad hoc WG “COSPAR WG 6 - Report” chaired by J. Houghton to prepare a resolution of the IRC on this topic to report at the next business meeting. This group came up with a

statement and recommendations to be sent to the United Nations Conference on the Human Environment in Stockholm. The letter sent to this conference supported the COSPAR initiative, referred to the long concern of the IRC to set up a ground based radiation network and noted three problems to deal with:

- Specification of the radiation parameters and the accuracy with which they have to be measured,
- merging of ground observations with those obtained from aircraft, balloons, and spacecraft,
- calibration in absolute terms as well as intercalibration of different instruments over the wide spectral range involved.

To solve these problems it was proposed to review of the COSPAR WG 6 report and to set up a joint WG to consider in detail the problems of calibration and standardization of both space-borne and ground-based instruments. The IRC endorsed this action and gave consideration to the names of the people who should be members of the WG.

John Houghton, chairman of the WG on the COSPAR WG6 Report, later as Sir John T. Houghton co-chair of IPCC

The President turned to a second important problem which concerned the IRC since some time: He introduced J. Gille who gave a survey on the results and recommendations of the radiation sonde intercomparisons made during the last years. These comparisons show systematic and consistent differences between the different instruments. Upward fluxes are more accurately measured than downward f1uxes. All instruments show deviations from computed radiances. The following recommendations are made:

a) Development of better calibration procedures including vacuum chambers and wind tunnels.
b) Development of a truly accurate aircraft standard.
c) Comparison with satellite and ground measurements.
d) To take aerosol and cloud profiles at the same time with radiometersonde measurements.
e) Application of the present results.
f) Development of new instruments.
g) Continuation of international intercomparisons within an ad hoc group to the JOC.

The RC concluded with regard to the last recommendation to ask GARP to accept further co-responsibility for the group which consists of Fimpe1, Yata, Kuhn, Kuznikov, Müller, Sekiguchi, Shimanzu, and Shlyakov.

The President informed the Commission that P. Kuhn (NOAA) will fund a group of intercomparisons between balloon radiometers and precision bolometers or radiometers at Sterling, Virginia, in April 1973. Invitations have been sent to interested scientists.

The President then introduced Kirby Hanson as guest, who proposed an intercomparison of national working standards for the time of April 24 - May 8, 1973, as radiation activity within GARP. The RC could not recommend these comparisons on an international basis because such comparisons have been made for many years in the past.

An active discussion rose about the radiation sub-program in GARP and GATE. J. Kuettner, from his experience as coordinator for GATE, said that the radiation contribution to GATE has not yet developed to the status of a full program as was shown in the general discussion during the symposium. For comparison he pointed out that an oceanographic research sub-program which was not originally proposed for GATE had been set up very quickly on a national (US) basis and is now in the process to being broadened into an international cooperative program which may eventually merge into SCOR activities. He recommended that the IRC might serve as a coordinating body for the radiation subprogram and endorse a finalized radiation sub-program officially.

The President, F. Möller, G. Yamamoto, and other speakers, however, pointed out that the RC can not serve as coordinator for the radiation sub-program in GATE. The RC could give advice but can not give directives. It is the responsibility of the JOC or JPS to set up an advisory board which also take care of the radiation part in GATE in close cooperation with the general circulation people. It must, however, be left to the responsibility of the single experimenter whether or not he is proposing measurements for

GATE. The interaction between radiation people and the GATE organization is still very informal and lacking in coordination. The President suggested that the IRC should reaffirm its endorsement of GARP and offer its advisary capacity. The RC Bureau would further investigate how the IRC could best serve the program. It was also suggested that perhaps a small Review Committee could be set up to advise the JOC on the suitability of the various radiation sub-programs in GARP.

The IRC received two proposals from R. Dogniaux and D. Wark regarding the calibration of radiation instruments to be used in GATE and other programs about which was voted. It was felt that the proposal of D. Wark was well covered by part of the first proposal and the IRC released the following *Resolution Concerning the Calibration of Radiation Instruments Used in International Programs*:

1. The IRC recommends that the IPS (International Pyrheliometric Scale) 1956 be materialized (or represented) by the set of pyrheliometers selected as reference instruments during the IPC-III, 1970, according to the criteria of selection defined by the CIMO WG on Radiation.
2. The RC recommends also that all the radiometers used for GARP and GATE programs measurements be calibrated according to this IPS (IPC-III, 1970). This implies that the solar radiation pyranometers for use in GATE be calibrated against pyranometric standards, which have traceability to the IPS before and after GATE and under environmental conditions similar to those in the GATE B-scale area in order to minimize relative errors.
3. The RC invites WMO to request the competent CIMO WG to define testing methods for establishing the precision and the accuracy of self calibrating “absolute” radiometers.

A report about the calibration procedure for GATE and the progress in defining testing methods for establishing the precision and the accuracy of self-calibrating absolute radiometers shall be presented at the time of the COSPAR Conference 1973.

J. Lenoble focussed the attention of the IRC at the fact that in the field of radiative transfer studies in scattering media six different methods are in use. In order to facilitate the comparison of results and to minimize the computer time consumption, she proposed that the IRC should explore the possibility of standardization of computing procedures and to set up a program library. S. Rodgers reported that this proposal overlaps with a proposal made by K. Kondratyev to define a standardized "Radiation-Atmosphere". In order to minimize the number of necessary ad hoc groups the RC concluded that these two proposals should be treated by the IRC Bureau with the aim to set up an ad hoc group.

The IRC endorsed the requested cooperation in the URSI-COSPAR-IAGA-IAMAP "Symposium on the Dynamics and Chemistry of the Mesosphere and Lower Ionosphere" in Kyoto, 7 - 21 September 1973, and the IAMAP Assembly in Melbourne, January 1974, with a joint radiation - cloud physics symposium (organized by the IRC) as well as the symposia on "Composition and Pollution of the Stratosphere" and "Radiation and Climate". However, J. Houghton proposed that the President expresses in his letter to the IUGG the deep concern of the IRC about the "crasy situation" that there are two symposia following each other within a few months dealing with very similar subjects. Including the symposia of the RC and the Ozone Commission there are even four partly overlapping international meetings within 1 1/2 years.

Maintaining four years spacing of Radiation Symposia, the IRC concluded to hold its next symposium during summer 1976. It appeared to be advantageous to arrange the symposium approximately contiguous both in time and place with that of the Ozone Commission. The President invited potential host countries to submit proposals in time. A final decision should be made at the Melbourne meeting in January 1974.

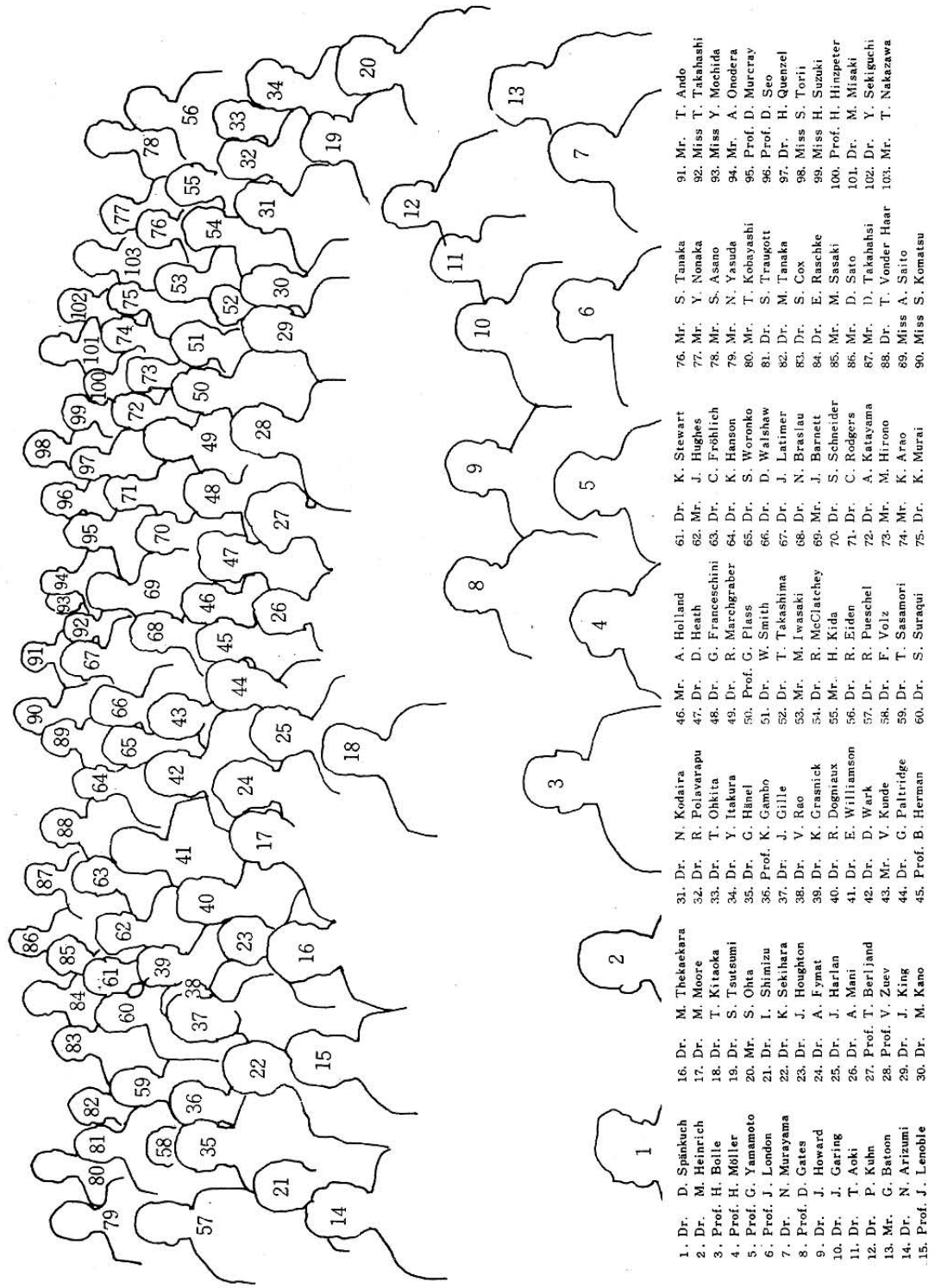
Because of lack of time, three proposals submitted to the IRC could not finally be discussed:

1) Proposal for a resolution on atmospheric transmission functions (D. Wark).
2) Proposal for the constitution of an ad hoc group for review and recommendation of radiation units (J. Howard).
3) Proposal for consideration of sun photometers by the IRC (F. Volz).

The RC strongly supported the initiative of D. Wark regarding the transmission functions necessary for satellite data interpretation and accepted the recommendation without adverse vote. A quick action to establish the proposed ad hoc group shall be taken by the RC Bureau, which will also finalize the version of the recommendation. The two other proposals were transferred to the Bureau for further action.

The symposium dealt with five major topics: radiative transfer in turbid and cloudy atmospheres and oceans; radiation studies applied to the biosphere; radiation factors of climate; cooperative programs in radiation research especially in GARP; and radiation problems related to meteorological satellites and earth survey studies. A review of the Symposium appeared in the IUGG chronicle (no. 89, p 399, 1972).

Participants of the IRS in Sendai, Japan



Name table for the picture of the participants at the IRS in Sendai, Japan

The knowledge of radiation transfer in a turbid atmosphere was summarized in a survey paper by G. Yamamoto and M. Tanaka, who also pointed out that the main problem in determining the climatic effects of aerosols is still the uncertainty with which the imaginary part of the refractive index is known. Contributed papers demonstrated the enormous progress which has been made during the last few years in treating the radiation field of the atmosphere and the system ocean-atmosphere. Plass and Kattawar, for instance, included in their Monte-Carlo computations the spectral effects which water pollution has on the upwelling flux in the atmosphere. Comprehensive computing techniques have been developed by different authors to treat the aerosol influence on the radiative transfer in realistic model atmospheres. So were the results for four types of atmospheres with different gas and aerosol content presented by Braslau and Dave. "We are entering a stage now, where these computing techniques become available for routine computations and it may be the time were some standardization on these methods should be done". However. before this will be effective. a number of comparisons should be made in order to find out more precisely the advantages and shortcoming of the different methods. Another problem is the consideration of clouds in such theoretical models which must probably be done in a statistical way. Some progress has been made in the theoretical treatment of stratified clouds (Heinrich) and very interesting results of new measurements on single clouds have been reported by Paltridge which show still some discrepancies with respect to computed fluxes.

The better understanding of the atmospheric radiation transfer has direct relevance to climatic studies. Walshaw and Sasamori reported on the role of radiation in dynamical models from which climate parameters can be derived. The importance of solar energy input to the oceans for meridional heat transport was pointed out by Hanson.

Of great interest with respect to climatological research are the continuing ground based and airborne efforts of which A. Mani reported from India, which allow conclusions with regard to the transport of aerosols and the determination of the energy budget. Of special concern are in this respect instrumental and calibration problems about which Latimer, Thekaekara, Marchgraber and Fröhlich reported. It was made quite clear to the radiation community that with the new climatological aspects and tighter specifications the old questions of calibration and intercomparison of radiation instruments is far from settled, and this is especially true if satellite instrumentation is included.

Solar radiation which penetrates to the lower levels and the terrestrial emission react with live in the biosphere. It is of vital interest for mankind to understand the mechanism of this interaction. How far this understanding reaches and how many of the questions concerning our immediate environment are still unexplored, became evident in the competent review paper of D. M. Gates about radiation, plants, and photosynthesis. Starting from optical properties of leaves he developed the complete energy balance of plants as well as animals and described the conditions of comfort for different species.

That satellites are already now an integrated but improvable part of the global observation system for the energy budget was convincingly shown by Vonder Haar, Raschke and other speakers. Remarkable results about the variation of the solar uv emission as measured from satellites were obtained by Heath.

Another topic which can not any more thought away from environmental research are meteorological satellites. J. Houghton gave a survey about the recent achievements in this field which range from an extension of the temperature soundings to less than 1 mb, thin cirrus cloud discrimination and determination of mass fields as water vapour and ozone to new experimental techniques as the Pressure Modulator Radiometer. D. Wark in his review talk especially discussed the accuracy of inversion methods and of transmission functions needed in these techniques. Other speakers, including J .I. F. King, V. G. Kunde, R. A. Mc Clatchey and W. L. Smith, contributed to the same or related subjects and an animated discussion arose. V. E. Zuev reported about an extensive research program going on in the USSR to determine the line parameters needed for the derivation of transmission functions both theoretically and by means of a laser spectrometer of very high resolution.

New types of satellite measurements were introduced of which the limb radiance measurements proposed by Gille and Cox are most promising. The recent activities of COSPAR WG 6 about preliminary considerations for an observing system to monitor important climate parameters were reported by H.-J. Bolle. In shorter sessions also radiation problems of the upper atmosphere and of planetary atmosphere were treated. Here V. G. Kunde explained the excellent results of the Interferometer-Spectrometcr Experiment on board of the Mariner 9 mission.

For the next few years the atmospheric research community has to invest major efforts into the

realization of the first GARP experiments: GATE and FGGE. No wonder that the attention of the radiation symposium was also focussed at these future cooperative research programs. The discussion started from the experience made so far with larger national activities. J. Gille reviewed the goals and the achievements of BOMEX. The aircraft sub-program of this experiment and its results were critically analysed by Cox, Harlan, Kuhn, Marlatt, and Vonder Haar. Written statements were available about CAENEX, the USSR Atmospheric Energetics Experiment (Kondratyev).

J. P. Kuettner gave a survey paper about the planning for GATE which was followed by half a day general discussion about the goals, requirements and possibilities for its radiation sub-program.

Beside this very intense scientific program in which also the discussions were given fair room, many personal contacts were possible In a relaxed atmosphere due to the outstanding arrangements of the host country, Japan, and the Local Arrangement Committee, Professor Yamamoto, Dr. Sekihara and their colleagues.

The meeting was co-sponsored by the World Meteorological Organization, the Committee for Space Research, the American Meteorological Society, the Meteorological Society of Japan and supported by the Japan Meteorological Agency. It was attended by 106 participants of 14 countries. Sendai (see figs. on page 46/47) probably was the first of the quadrennial Radiation Commission meetings at which the number of presentations grew beyond that of a mere commission meeting with few focused topics. In the proceedings, a total of 144 papers were published. Only 80 of them were presented, while the remaining could only be read by title because of lack of time. They are published in a bound volume of 565 pages. From here on the meetings grew to the large general International Radiation Symposia with an own series of proceedings in book format.

Melbourne, Australia, (IAMAP) 1974

In reaction to a resolution of the IUGG, not to read scientific papers at the IUGG meetings, a Special Symposium of IAMAP was held in the first days of the year 1974 in Melbourne, Australia. There was no particular session of the Radiation Commission and only a few radiation papers, quoted below, were read and included in more general sessions.

G. I. Kouznetzov presented under the title: “Optical properties of atmospheric aerosol and their significance for the study of trace atmospheric constituents" results of observations of spectral aerosol attenuation and theoretical evaluations. Measurements of continental, oceanic and mountainous regions are compared.

T. Takashima: In the paper “Effect of aerosol size distribution on scattered radiation in the inhomogeneous ozone atmosphere calculated by using the ‘adding’ method” calculations were communicated of the diffuse radiation between 0.30 and 0.34 μm. He shows that the intensity of the upwelling radiation changes only little when the nadir angle is increasing within 60°. When aerosols are doubled in the atmosphere, intensity increases about 20% at $\lambda = 0.34$ μm.

Cohen: "Multiple scattering measurements as a function of wavelength by use of a dye-laser”. He used two different monodisperse aerosol distributions of increasing particle concentrations and optical depth. They showed a slow smoothing of the scattering curve, i.e. the minima and maxima disappeared gradually. From this the value of the multiple scattering could be estimated.

A. Mani and collaborators in "Aircraft measurements of the albedo of the earth and of clouds over India" talked about measurements made with an albedometer in altitudes of 150 to 1500 m. The recorded values of global solar radiation were of the order of 1.60 to 1.80 cal cm^{-2} min^{-1} when there were no clouds. Thin cirrus reduced these values by about 16 to 20%. Reflected radiation was higher over cumulus and cumulonimbus clouds than over any other type of clouds. The value of albedo over sea varied between 4 and 13% and that over ground between 10 and 25%. The albedo over active cumulus clouds was about 40 to 60%. Several other clouds are mentioned. Remarkable appears the albedo of cirrus and remains of dissipating cumulonimbus clouds, with values of 45 to 55%.

Gorelik et al. presented a study on “Measurements of the atmospheric radiance in the 8-12 micron band.” They measured the upwelling infrared radiation and compared it with simultaneously measured temperature and cloud height values. They found good correlation with the cloud temperature but also the values r_{IT} for Sc 0.3l, Sc op 0.53, St 0.66, Ns 0.87, Ac op 0.09 (?), Ci 0.61, Cu hum 0.68, Cu med 0.85, Cu cong 0.88.

Sedunov and Zakhorova in "Radiation effects on radiation fog formation and evolution processes" give a theoretical derivation of fog formation by radiation and turbulent heat exchange. The eddy coefficient is first taken to be an unknown quantity. It can later on be introduced and shows then the influence of wind on the development and formation of fog. There seems to be given a comprehensive theory of fog formation and its further development.

There was another session at the meeting in Melbourne devoted to the general topic "Clouds and Radiation." It contained 17 papers. From the following titles their importance for the at that time ongoing research work can be seen:

Squires: The structure and dynamics of clouds

Twomey: Review paper on the coupling between clouds, radiation fields and dynamic processes.

Fymat: Determination of the complex refractive index and size distribution parameters of clouds and aerosols.

Plass, Kattawar, Hitzfelder: Interior radiances in optically deep absorbing media.

Raschke: Absorption of solar radiation in a cloudy atmosphere above the ocean.

Paltridge: Atmospheric radiation as it affects the character of clouds

Lovill: High resolution global radiation sources and fluxes.

Franceschini: Influence of clouds on solar radiation and it spectral composition.

Fouquart, Pruvost, Lenoble: Accurate computations of fluxes and heating rates for a cloudy atmosphere.

Cox: Effects of cloud patterns on the radiative component of the energy budget.

Hoy: The calculation of infrared radiative cooling rates including the effects of water aerosols.

Mani, Kelkar, Srinivasan: Effect of clouds and particulates on the terrestrial radiative fluxes over India.

Vonder Haar and Ellis: Satellite measurements of the interannual variation of the equator-to-pole radiation gradient, response on the large scale atmospheric circulation, and the effect of clouds.

Platt: High clouds and the climate.

Jayaweera and Wendler: Effect of cloud cover on the winter temperature at Fairbanks, Alaska.

Grenoble, France, (IUGG) 1975

At the IUGG Assembly in Grenoble the IRC had a long, five hours lasting, business meeting with an intensive discussion of the activities of its ad hoc working groups which had been established since the meeting in Sendai.

J. Howard had send a preliminary report defining the work of the Ad Hoc Working Group on Units and Nomenclature and proposed to be replaced by E. Raschke as chairperson. This was endorsed by the IRC which made a number of recommendations for the work. *Inter alia* it urged that the units and definitions to be recommended by this group be in accordance with the S. I. and, as far as possible, with recommendations made by WMO and CIE.

McClatchey, who had been appointed chairman of the Ad Hoc Working Group on the Standard Radiation Atmosphere, submitted a workplan for the group. He proposed six atmospheric models and the LOWTRAN code developed by AFCRL. In close co-operation with R. Fenn at AFCRL aerosol models are under development for a broad range of atmospheric conditions. The IRC endorsed this plan and added a number of precise terms of reference.

The chairman of the ad hoc Working Group on Transmittances, D. Q. Wark, reported that spectral measurements from balloons had been carried out the results of which are compared with line-by-line calculations. Final recommendations would follow after more balloon born observations would have been analysed. The IRC expected that this would be the case at the IRS in Garmisch-Partenkirchen.

The ad hoc Working Group on Calibration, chaired by J. Houghton, encouraged national laboratories with calibration facilities to participate in international intercomparisons and space agencies to facilitate intercomparisons and to communicate their calibration procedures. It gave emphasis to the use of Spacelab for providing a laboratory in which radiation instruments can be calibrated. A recommendation on radiation scales presented by R. Dogniaux was finalized.

T. Vonder Haar reported that the ad hoc WG on the GATE Radiation Sub-Programme works closely together with the GATE Organizing Committee in developing field experiments, evaluation methods, data validation and archiving.

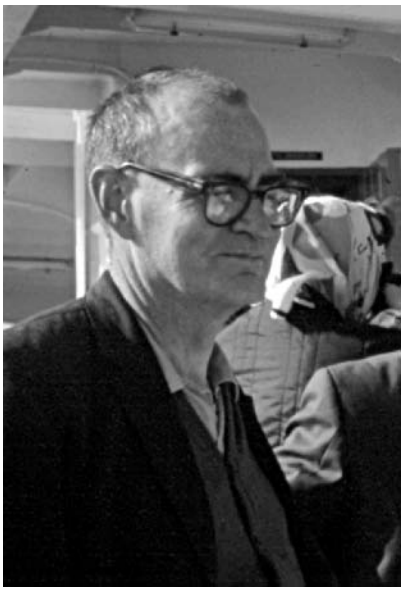
J. Lenoble explained the working mechanism of the Ad Hoc Working Group on Standard Computation

Procedures and announced that the results of the work will be contained in four reports.

A. Fymat had submitted a proposal for a new ad hoc Working Group on Inversion Methods. After an extensive discussion it was concluded to establish the WG under the chairmanship of A. Fymat. The main idea was to clarify whether the inversion methods used in remote sensing are adequate or whether mathematics offer more powerful methods which are not yet used in atmospheric applications.

After having dealt with the WGs, the IRC turned to other radiation activities within GARP.

G. Yamamoto added information about radiation measurements during AMTEX and a longer discussion followed about the role of the IRC in FGGE and the feasibility of Kondratyev's GAAREX proposal (Global Atmospheric Aerosol Radiation Experiment) as part of the FGGE. L. Kaplan was of the opinion that prior to such a large program pilot studies should be made. J. Gille reported that indeed a successful pilot study had been carried out under the name of GAARS, which is an NCAR proposal for global aerosol studies. Inter alia, Dr. Grams runs lidar and laboratory experiments to determine the imaginary part of the refractive index of Mie particles. Finally, the IRC accepted the importance of the GAAREX proposal and recommended to study its feasibility taking into account the existence of equipment, funding, and logistic.



John Howard, pioneer in atmospheric spectroscopy and Editor of Applied Optics, initiator of the WG on units and nomenclature

D. Heath and L. Kaplan reported on a meeting on Solar Constant, the Solar Spectrum and problems of Absolute Pyrheliometry which took place in California. This was a topic on which the IRC had made recommendations since the IAMAP Assembly 1961. The IRC submitted a new recommendation to WMO.

Finally the IRC discussed the increase of the number of commission members and envisaged a number of 20 to 25 as a limit. The limitation of the membership to eight years was an inconclusive issue.

Philadelphia, USA, (COSPAR) 1976

The IRC co-sponsored the Symposium on Meteorological Satellites during the COSPAR General Assembly in Philadelphia, June 1976.

Urbana, USA, (MAP) 1976

With participation of IRC members a meeting on the Middle Atmosphere Program (MAP) took place after the COSPAR meeting in Urbana, Illinois. MAP will be an observative and research program to explore constituent concentrations, atmospheric chemistry, radiative transfer, and dynamics of the stratosphere and mesosphere. The project will be submitted to ICSU through SCOSTEP. The IRC announced to co-operate with MAP if the program is accepted.

Boulder, USA, (COSPAR WG 6) 1976

A special meeting on future programs to observe climate parameters from space was organized by COSPAR W.G. 6 in Boulder, Colorado, 7 - 14 July 1976, in which IRC members were involved. At this meeting the problem of long-term monitoring and necessary calibration procedures had been discussed..

Garmisch-Partenkirchen, Germany, (IRC and ICACGP) 1976

The symposium in Garmisch-Partenkirchen was organized jointly with the IAMAP International Commission on Atmospheric Chemistry and Global Pollution (ICACGP). The emphasis laid on "Structure and Radiation Properties of Aerosols and Clouds Including Remote Sensing and Satellite Measurements". The participation of 300 scientists representing 32 nations reflected the growing interest in the interaction between atmospheric composition and radiative transfer in the atmosphere. The proceedings list 196

papers including the presidential address by J. London on "Observation of the solar flux at the top of the atmosphere". A most remarkable event of the meeting was extensive plenary discussion of the Global Atmospheric Aerosol Radiation Experiment (GAAREX) proposed by K. Kondratyev. Among others, B. Bolin expressed his opinion that the different aspects of the proposal should be further developed under the GARP climate program by the ad hoc GARP working group of the JOC which had been set up to investigate the relationship between radiation and aerosol.

At the business meeting, in memory of W. Mörikofer, the President recalled the devoted and stimulating work which the Past-President of the IRC (1951-1957) had done for the scientific community, and his important contributions to science. W. Mörikofer died on April 14, 1976, at the age of 84.

Professor G. Yamamoto was elected as *Honorary Member* of the IRC.

The President explained that IRC membership must be approved by the IAMAP General Assembly but that the Commission may coopt Interim Members. He proposed Dr. Sayigh of Saudi Arabia as Interim Member to which the Commission agreed.

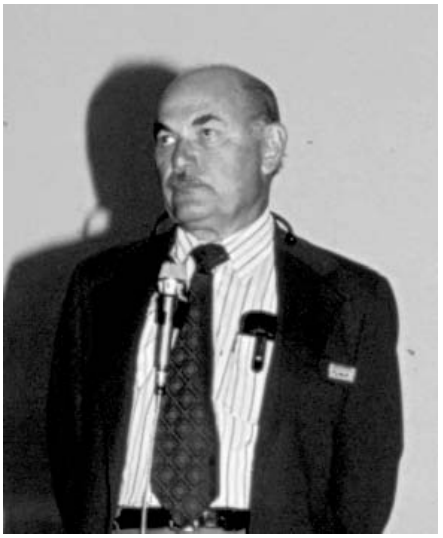
In line with the second main topic of the Symposium the IRC at its business meeting confirmed its further co-operation with COSPAR and discussed in detail with representatives of COSPAR the plans of NASA, presented by M. Tepper, chairman of COSPAR WG 6, and ESA, presented by G. Hunt, to fly instruments to measure the radiation budget from their satellites. The IRC was concerned to hear that a decision about these missions might be taken by NASA already this week and sent supporting statements to both agencies (see box at next page).

Also the interest of the IRC in the newly founded subdivision on geophysical data of the Committee on Data for Science (CODATA) was mentioned.

An item of concern was the critical situation of the Mont Luis Observatory which as well led to a recommendation to continue the high spectral resolution observations of fluorocarbones, nitric acid and other atmospheric constituents. The IRC endorsed the following Recommendation on Mont Luis Observatory:

The solar spectroscopy facility at Mont Luis is an indespensible part of the world-wide meteorological radiation network not only because of its location as an ozone observing station, but even more importantly because the high spectral resolution of the observations has resulted in the first ground-based base-line spectroscopic observation of fluorocarbons and nitric acid. In view of the uniqueness of these observations for a program of monitoring changes of these constituents, the Radiation Commission urges that the Mont Luis operations be continued, and that the continuity be interrupted only as necessary for the re-location of the observatory to a nearby site to allow measurements at greater solar zenith angles and facilitate calibration.

Christian Junge, president of IAMAP, and Edward Martell, president of ICACG, at the IRC-ICACG symposium in Garmisch-Partenkirchen



Morris Tepper, chairman of COSPAR WG 6 and promoter of measurements from space for the World Weather Watch

Finally, O. Avaste invited the IRC for the next Symposium to Tallinin, Estonia, which was seconded by K. Kondratyev. The final decision about the Symposium is to be taken at the next meeting in Seattle.

The chairpersons of the workings groups or their representatives reported on the progress of their work.

E. Raschke informed the IRC that the WG on Radiation Units and Terminology worked towards an agreement with the CIE recommendations and promised a report by the end of 1976, after coordination with CIMO. Some slight changes have still to be made to bring it into agreement with the CIE recommendation. Some members of the Commission objected to the word "exitance" and pleaded for a clearer terminology for the terms ending in -ance respectively -ivity. It was also suggested that concordance be sought by IAU before the final recommendation is adopted. Then the question was raised whether or not the terminology should be multilingual, but it was assumed that there would be a translation into UN languages by WMO if CIMO supports the final recommendations.

The WG on a Standard Radiation Atmosphere had an open meeting at which it was decided to adopt the atmospheric models proposed by its chairman, R. A. McClatchey, though they still had to be checked with respect to hydrostatic consistency. The group was now working on the aerosol models to be included.

A written report was available from the chairman of the WG on Transmission Functions, D. Wark. Spectral transmittances derived from balloon and surface observations in the US are in the intermediate state of reduction. Interim results indicate that satellite observations and theoretically-derived transmittances agree with the observed values to the degree of previous evaluations. Transmittances for the Stratospheric Sounding Unit are to be defined by the British Meteorological Office. Transmittances in the microwave region of the Microwave Sounding Unit will be defined by P. Rosenkranz. All other computations are based upon the AFCRL line parameter compilation. A final report is due in 1977.

The WG on the GATE Radiation Sub-Programme held a meeting in Leningrad in June 1975. Its chairman, T. Vonder Haar, provided copies of the "Report on the Third Meeting on the GATE Radiation Subprogram" in which 30 scientists participated and announced that the work of the group presently concentrates on the preparation of a cloud and aerosol model for the GATE region and the validation of the data stored in Leningrad. Also comparisons with satellite data would be possible and first results are

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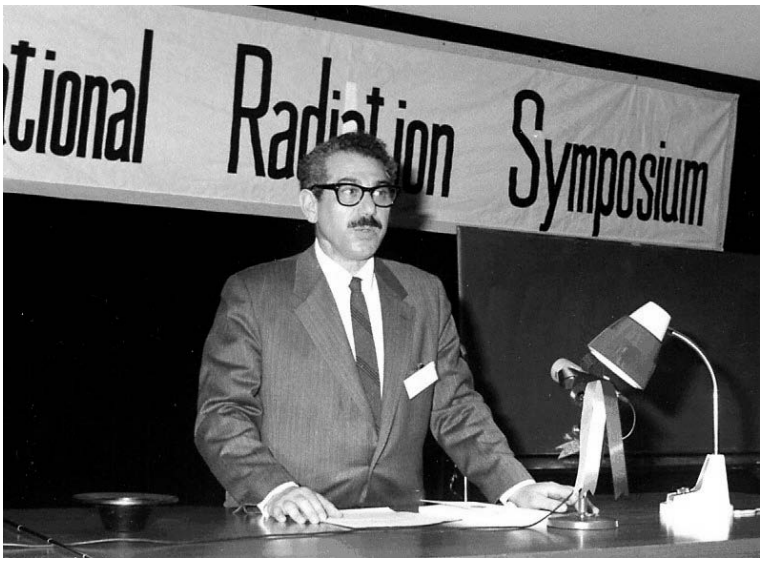
TO: DIRECTOR GENERAL<:
DR R GIBSON<≡
EUROPEAN SPACE AGENCY<≡
HEADQUARTERS<≡
AVENUE CHARLES DE GAULLE<≡
NEUILLY

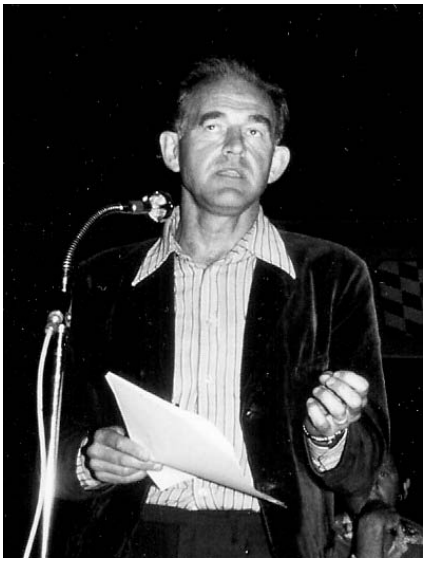
RADIATION COMMISSION OF IAMAP, IUGG
SUBJECT: SATELLITE OBSERVATIONS OF THE EARTHS RADIATION BUDGET FOR STUDIES OF CLIMATIC VARIATIONS

SCIENTISTS PARTICIPATING IN THE SYMPOSIUM ON RADIATION IN THE ATMOSPHERE ORGANIZED BY THE RADIATION COMMISSION OF THE INTERNATIONAL ASSOCIATION OF METEOROLOGY AND ATMOSPHERIC PHYSICS HAVE STRESSED THE NEED FOR LONG TERM HIGH ACCURACY OBSERVATIONS OF EARTHS RADIATION BUDGET. THESE OBSERVATIONS WOUID PROVIDE ESSENTIAL INFORMATION ON ENERGY PARAMETERS ASSOCIATED WITH VARIATIONS IN THE CLIMATE OF THE EARTH-ATMOSPHERE SYSTEM AND THUS MAKE A SIGNIFICANT CONTRIBUTION TO AN OBSERVATIONAL PROGRAM TO MEET THE SECOND SCIENTIFIC OBJECTIVE OF THE GLOBAL ATMOSPHERIC RESEARCH PROGRAMME (GARP), THAT IS, A BETTER UNDERSTANDING OF THE PHYSICAL BASIS OF CLIMATE. WE ARE AWARE THAT PLANS ARE CURRENTLY BEING CONSIDERED BY NASA <USA) AND ESA (EUROPEAN SPACE AGENCY) TO DESIGN AND DEVELOP SATELLITES TO MEASURE THE SEPARATE COMPONENTS OF THE EARTHS RADIATION BUDGET. WE STRONGLY SUPPORT THESE PROPOSED INDIVIDUALLY ESSENTIAL AND COMPLEMENTARY PROGRAMS AND URGE THAT THEY BE PUT INTO EFFECT AS EARLY AS POSSIBLE SO THAT THE RESULTS DERIVED FROM THESE SATELLITE OBSERVATIONS CAN BE INCORPORATED INTO THE INVESTIGATIONS OF IMPORTANT ATMOSPHERIC AND CLIMATE PROBLEMS<=:
PROFESSOR J. LONDON<:
PRESIDENT<
RADIATION COMMISSION OF IAMAP, IUGG+++++

Telegram sent to the Director General of the European Space Agency to influence the decision on flying Earth Radiation Budget missions



Julius London opens the IRS in Garmisch-Partenkirchen



Bert Bolin, initiator of GARP and later on IPCC, contributes to the GAAREX discussion

A business meeting in Garmisch-Partenkirchen (partial view). Standing in front: Julius London; from left to right first row: Fritz Möller, Jacqueline Lenoble, Vladimir Zuev; second row: Gary Hunt, Dominique Crommelynck, Alain L. Fymat, Rumen Bojkov, Dietrich Spänkuch, Ehrhard Raschke; third row: Inge Dirmhirn, at the right, mostly covered by Raschke, Harold Yates

Joachim Joseph, chairman of the WG on aerosols

Ignazio Galindo Estrada, expert on volcaneous aerosols, later WG on World Data Center

Eva M. Feigelson wrote and presented at IRC meetings many basic papers on cloud-radiation interactions

to be reported at the symposium. N. Zaitseva and H. Fimpel reported on the comparison of their radiometersonde measurements during GATE. They had resolved discrepancies prior to the meeting in Garmisch-Partenkirchen. The question was raised about a comparison with satellite data. The WG chairman replied that indeed NIMBUS, NOAA, and SMS data are in the process of evaluation in this direction and that first results are shown in the symposium.

A. L. Fymat distributed a report on the meeting of the ad hoc group on Inversion methods which contained an outline of a major future work program. It was questioned that the whole proposed program could be completed within one to two years. Therefore a final decision about the direction the work of the group should take was postponed to the next IRC meeting which was planned for the IAMAP/IAGA Special Assembly in Seattle, 27 August - 3 September 1977.

At the meeting in Grenoble an Ad Hoc Group on GAAREX was assembled to evaluate this proposal. Some field measurements which can be considered as pre-GAAREX experiments had not been fully evaluated so that priorities could clearly be defined. But the chairman of this group, K. Kondratyev, will present a survey of the project during the plenary (see above).

The ad hoc working group on Calibration and Intercomparison of satellite and rocket instruments worked together with COSPAR WG 6 and organized a special session on this topic at the meeting in Grenoble. The papers presented at this meeting are published in Applied Optics. The chairman of the group, J. Houghton, proposed to reorganize the group with H. W. Yates as chairman. This was discussed in the presense of M. Tepper, the chairman of COSPAR WG 6, who indicated that COSPAR had been following the work of the joint group closely and appreciated the publication of the Grenoble papers. He continued that he would be unhappy if the entire membership would change with the establishment of a new group.

J. Lenoble reported that the WG on Standard Procedures to Compute Atmospheric Radiation Transfer in an Scattering Atmosphere. Two parts of the report are ready and will be published by IAMAP. No decision about part 3 and 4 were made because they have still to be edited to make them more consistent. It was suggested that more people should run the same methods before part 3 should be published which deals with the comparison of different computation methods.

C. Fröhlich, the chairman of CIMO, and D. Crommelynck gave a survey of the main decisions adopted by the WMO-CIMO Working Group on Radiation Measurement Systems in Geneva, June 1976, of which a written report had been submitted by R. Dogniaux as well. Topic of this meeting was the introduction of the new absolute radiometric scale by 1 July 1980. This “World Radiometric Reference” would be 2.2% lower than the IPS 1956. It should be represented by at least four instruments of independent design which

must have a long-term stability of better than ± 0.2% and should be kept at the World radiation center in Davos, Switzerland. *Inter alia* CIMO proposed a new edition of the WMO Radiation Manual which was developed by members of the IRC for the IGY. Two questions of concern for IRC had been raised by CIMO: the scale (which should be called World Radiometric Reference according to K. Kondratyev) problem and a new edition of the WMO manual for radiation measurements originally produced by members of the IRC.

Tel Aviv, Israel, (COSPAR) 1977

At this COSPAR General Assembly its WG 6 focussed on food production and the monitoring of relevant parameters from space. Jointly with WG 6 the IRC worked on the definition of the space component of GARP.

Seattle, USA, (IAMAP) 1977

A joint IAMAP/IAGA meeting took place in Seattle from 22 August to 4 September, 1977. IAMAP at that time was restructuring its organization to adjust to the changing scientific environment. A new Commission on Climate and an ad hoc Commission on the Development, Chemistry and Physics of Planetary Atmospheres was established. The Joint IAMAP/IAPSO and IAMAP/IAGA groups will be dissolved and replaced by direct contacts between these Associations. SCOSTEP may be continued as a "Special Project"-Bureau and charged with the planning of MAP. The Commissions are requested to involve more scientists and especially to attract young scientists. IRC was of the opinion that it already corresponded to this request by opening its WGs to all scientists who are willing to participate actively and by holding open business meetings. To the foundation of new IAMAP Commissions it responded by appointing members to the new Commission on Climate (Paltridge, Grassl, Ohring, and Vonder Haar) and the Commission on Planetary Atmospheres (Kaplan). The President thanked IAMAP for the offer that Radiation Commission Reports be published through IAMAP.

The President introduced the topic of international programmes. Dr. Dyer gave a short introduction to the Middle Atmosphere Programme (MAP) which should start 1980 and will combine theoretical studies and field campaigns including Space Shuttle, satellites, balloons and aircraft. Contacts with national representatives are planned to stimulate map activities at the national level. Individual scientist were asked by the President to evaluate the MAP proposal for the IRC.

Upon request of JOC the ad hoc WG on Aerosols and Climate had been established and at its meeting in Garmisch-Partenkirchen it was discussed how the aerosol problem can be included in the GARP Sub-programme on Climate. R. J. Charlson handed over a draft report on this topic for evaluation by the IRC.

The JOC of GARP requested to follow up the Aerosol and Stratus Program and nominated G. Paltridge as secretary of an ad hoc working group on the activation of the STRATEX Sub-program of GARP to investigate the climate effects of stratiform clouds. A list of groups working in this area was drafted. JOC will probably follow up the matter of cloud-climate interaction by a cirrus experiment (STRATEX 2). Questioned by L. Kaplan, the President explained that though also other clouds are important, JOC first raised the stratus problem. He proposed to write to the chairman of the GARP Climate Board (JOC) to indicate that there are other important problems to be solved with respect to the interaction between clouds and the radiation field in addition to STRATEX and to ensure that reports on the STRATEX and the Aerosol Sub-programme of GARP will be made available to the scientific community by publication.

C. Fröhlich submitted a document on the "Definition and Maintenance of the World Radiometric Reference" which will be maintained by four instruments and will replace the IPS 1956 after 1 July 1980. The document was circulated to IRC members and approved.

Cooperation with COSPAR was intensified during the meeting 1977 in Tel Aviv. The WG on Calibration was renewed and COSPAR invited the IRC to co-sponsor the symposium on Remote Sounding of the Atmosphere at the COSPAR Assembly XXI in Innsbruck, 1978. The Chairman of the WG on Calibration Standards, H. Yates, had explained that the group will limit itself to the problem of the calibration of instruments designed to measure the radiation budget of the earth. He asked the attendees to respond in written form to the question, how the data of the different types of instruments could be validated without getting involved in a detailed discussion of the sampling problem.

The IRC had obtained two invitations for the next IRS: One from T. Vonder Haar to Ft. Collins, and

one of the Estonian Academy of Sciences presented by O. Avaste. After discussion the IRC voted for the Colorado State University because the Ozone Commission will meet in Boulder, 1980.

Prof. Sayigh invited the IRC to hold a conference and/or a workshop in Saudi Arabia on a topic of interest to the radiation community and be applicable for arid and semi-arid regions. This proposal was welcomed by the Commission but no date was fixed.

J. Lenoble presented the printed version of the report on "Standard Procedures to Compute Atmospheric Radiative Transfer in a Scattering Atmosphere". The printed report can be obtained from the IAMAP Secretariat at a cost of $6.-. Two further parts are still under preparation under the titles:

- Radiative Transfer in Non-parallel Atmospheres, and
- Scattering with Line Absorption.

The new Standard Radiation Atmosphere Model 1977 was since Garmisch-Partenkirchen completed by a number of aerosol models and has now a dryer stratosphere, reported R.A. McClatchey. The atmospheric models had also been checked with respect to hydrostatic consistency. In the discussion it was indicated that in radiative transfer computations easier to handle alternative aerosol models may exist. Also it was questioned that the models cover the full range of observed variations or that the number of models might be too large. The President of IAMAP proposed that this model should also be reviewed by the Commission on Atmospheric Chemistry and Global Pollution. O. Avaste submitted a report of Feigelson "Preliminary Radiation Model of the Cloudy Atmosphere" which went beyond the present scope of the WG by offering mathematical methods to treat radiative transfer in a cloudy atmosphere.

D. Wark reported that the WG on Transmission Functions never met in toto and that the production of a set of standard transmission functions in an absolute sense is not feasible. But a set of standard transmittances computed from line data is under preparation, and a set of observed "reference transmittances" will be established within the following years but may not be ready before 1980. Because of this long lead time, the group should be dissolved and one person be charged to update the material continuously.

Based on an evaluation of their reports and discussions during the business meeting the following *Recommendations with respect to the work of IRC ad hoc WG's* had been formulated by the IRC bureau which were read and endorsed at the meeting:

1. The Radiation Commission would like to thank the GATE Radiation Working Group for the important work it has done in developing the GATE Radiation Subprogram and the subsequent organizational progress involving the problems of data handling, validation and availability of the data set. The RC would welcome a short final report from the GATE radiation working group following its meeting in Leningrad, November 1977, covering a discussion outlining the scientific plans for analysis of the radiation data assembled during GATE.
2. The Radiation Commission recognizes with great satisfaction the excellent work reported by the ad hoc group on Standard Procedures to Compute Atmospheric Radiative Transfer in a Scattering Atmosphere that has led to the publication of Volumes I and II of the final report. The RC recommends that Volumes III and IV dealing with non-parallel atmospheres and scattering with line absorption in plane-parallel atmospheres be prepared with a target date of the end of 1978. It is further recommended that additional computational comparisons, using the basic methods as outlined in the report be made and that their results be published with the full report.
3. The Radiation Commission welcomes the draft report submitted by the ad hoc WG on A Standard Radiation Atmosphere. It is recommended that the draft report be reviewed by appropriate groups and individuals and then submitted to the Radiation Commission in proposed final form for approval by the RC and publication as a Radiation Commission report by mid-1978. It is further recommended that the report be made available to all concerned colleagues. The important contribution by EM Feigelson on a Preliminary Radiation Model of the Cloudy Atmosphere is noted with gratitude. It is recommended that consideration be given to incorporation of the material contributed by E. M. Feigelson in a subsequent report by the Working Group.
4. The Radiation Commission accepts with approval the report of the ad hoc WG on Units and Terminology and recommends its publication as an IRC report. It is recommended that a small ad hoc WG be continued under the chairmanship of E. Raschke for the purpose of subsequent preparation of addenda to the report as required (e.g., nomenclature for polarization parameters, etc.). The RC would

like to thank the ad hoc WG for its important contribution covering this very difficult task.

5. The Radiation Commission welcomes the draft report of the ad hoc WG on Inversion Methods and requests that the report be resubmitted after it has been circulated and evaluated by the full working group. It is recommended that a set of computation be solicited for comparison purposes covering the different computational procedures discussed in the report and based on the proposed Standard Radiating Atmosphere as prepared by the RC working group. A discussion of the progress of the proposed comparison should be prepared for the next RC meeting in Innsbruck 1978 at which time the recommendations contained in the report will be subject to approval.
6. The Radiation Commission expresses thanks for receipt of the preliminary report submitted by the Chairman of the ad hoc WG on Atmospheric Transmittances for Indirect Soundings. It is recommended that the preliminary report be reviewed by the ad hoc WG and a final draft report be transmitted to the RC by the time of the Innsbruck meeting in 1978 for its approval and subsequent publication as a RC report. In preparation of the final draft, it is suggested that some additional information be included in the report concerning the procedure used for computations of the transmissivities, and some additional discussion of how the measured reference transmissivities compare with the transmissivities computed for the standard atmosphere.
7. Through the advent of lasers and new optical filter techniques, a new technology has developed which uses modern optical detectors, both ground based and satellite borne, to transmit, sense, and image information through the atmosphere with high wavelength, time, and space resolution and with high power densities. The research community on these new subjects does not yet have an established international organization within which to interact. Since many problems in atmospheric optics are part of the general discipline of atmospheric radiative transfer it would seem desirable to extend the activities of the Radiation Commission to provide a forum for discussions of research results involving various problems in atmospheric optics (e.g. the transmission of coherent radiation; optical turbulence; refraction and scintillation; non-linear optical effects) and to encourage international cooperation, and the exchange of scientific results in these areas of research.
   Following a proposal by Ruhnke, it was found timely and appropriate to set up an ad hoc working group on atmospheric optics whose first task would be to identify researchers and ongoing research programs and to suggest a list of suitable topics for consideration for the program of the next radiation symposium (1980). V. Zuev was appointed chairman of this group.

The IRC also endorsed the proposal of the President to continue a small ad hoc WG on Units and Nomenclature to incorporate polarization parameters and other items which have been omitted in an addendum of the WG report. A. Fymat and K. L. Coulson offered to assist E. Raschke in this task.

Innsbruck, Austria, (COSPAR) 1978

The IRC was involved in the symposium on Remote Sensing and Inversion Methods of the COSPAR W.G. 6.

The President informed the Commission that A. Ångström had send a note to thank the IRC for its birthday congratulations.

A number of cooperative activities developed during the last time with the advent of global research programmes and the use of satellites:

T. Vonder Haar reported on a workshop for radiation budged measurements held in Williamburg, USA. Six working groups discussed the following topics:

- climate modelling
- climate diagnostics
- radiation modelling
- radiation variability
- cloudiness and radiation budget
- radiation balance measurements for the late 1980's.

This was supplemented by a report of D. Heath about a bilateral USA - USSR activity on radiation measurements and calibration problems.

S. Ruttenberg reported about the outcome of an experts meeting on the measurements of the radiation

balance from space in Alpbach, Austria: "Toward an internationally coordinated Earth radiation budget satellite observing system: Scientific uses and systems considerations" (ICSU-COSPAR, 1978).

J. Gille gave a survey of the planning of MAP. Four projects had so far been selected: coordinated studies of the polar atmosphere in winter; equatorial wave dynamics; processes in the upper stratosphere and in the mesosphere by coordinated experiments of different techniques; presentation of meteorological and chemical variables as monthly and yearly tables.

WMO invited E. Raschke and K. Kondratyev to be rapporteurs for radiation. The WMO Manual on Radiation was to be newly edited in cooperation with CIMO.

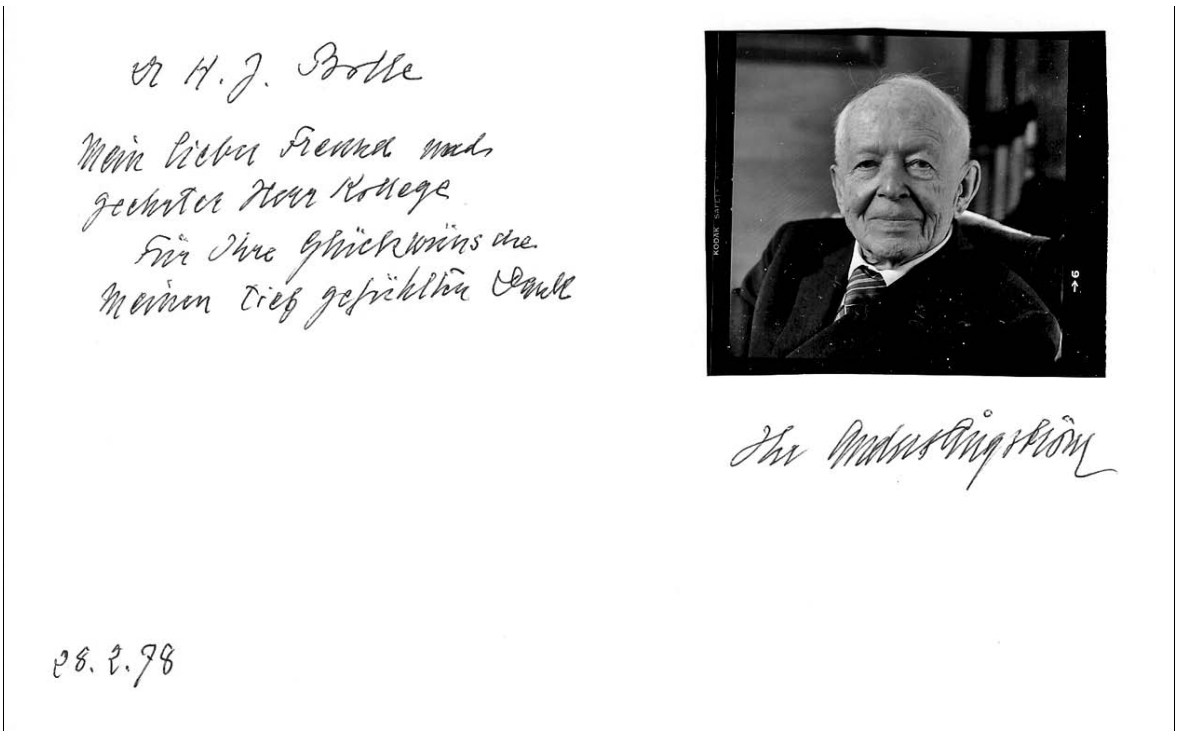
It was observed that more and more other international bodies start radiation sub-programmes within their activities. IAMAP itself had set up new commissions in which problems are to be discussed which were of direct interest for the IRC. Bodies like COSPAR, IAGA and MAP discussed radiation aspects and were elaborating on future perspectives of important research programmes. T. Vonder Haar therefore raised the question of future cooperation with other bodies and the actuality of the terms of reference of the IRC at the advent of new challenges in atmospheric research and specifically in the context of the large international research programmes. The IRC found it timely and opportune to discuss these issues and voted for an ad hoc working group on this matter: the "Ad Hoc Working Group on Future Activities of the Radiation Commission (IAMAP)". T. Vonder Haar was appointed chairman of this group and asked to report back at the next Business meeting.

The existing eight working groups presented the progress of their work. From the discussions following these presentations the IRC Bureau formulated recommendations which were circulated 1979 in the internal report on "Future Perspectives of the Radiation Commission Activities" (see below).

J. Lenoble submitted a third report of the WG on Standard Procedures to Compute Atmospheric Radiation Transfer in a Scattering Atmosphere: "Review of Methods for Horizontally Inhomogeneous Atmospheres and non Plane-Parallel Atmospheres".

The report of the WG on "Units and Terminology" was published by IAMAP. E. Raschke proposed to submit a draft of the nomenclature for reflection quantities at the IUGG meeting in Canberra, 1979. The work on polarization terminology should follow.

The chairman of the WG on the Radiation Sub-programme for GATE, T. Vonder Haar, reported on the fourth meeting of the group in Leningrad, 21-26 November 1977. It was concluded that the WG should



Anders Ångström thanks for the birthday congratulations of the IRC

continue for one year.

New reports of the WGs on the Standard Radiation Atmosphere, Transmission Functions, and the Inversion Methods were not presented.

The WG on Atmospheric Optics had been constituted under the chairmanship of V. Zuev and defines its workplan.

The work of the group on Calibration, Standardization and Validation of Satellite Radiometer Measurements proceeds with a smaller group of active people. The establishment of a "Central Laboratory for Calibration" is under discussion.

The "Future Perspectives of the Radiation Commission Activities" - Memo of August 1979

Prompted by the report of the Ad Hoc Working Group on Future Activities of the Radiation Commission (IAMAP), submitted by its chairman T. Vonder Haar in June 1979, the IRC secretary circulated a somewhat extended memo on this topic in August 1979. In this document the work of the IRC was considered in view of the changing scientific environment and the new horizons of atmospheric research within the framework of the large global research programmes, specifically on climate research. The IRC had invested in the past a good part of its capacity in the co-ordination, unification and stimulation of radiation studies. Some of them, of which the IRC thought that they might be resolved by small committees within two or at most four years, could not be finished satisfactorily within an acceptable time. The introduction of the document therefore concluded with the question: "We have to ask us, whether or not it is still useful and of impact on science to continue with these objectives or whether there are other more pressing problems which have to be tackled" and the opinion was that "numerical modelling is losing its glamour as panacea for all problems - our science is stepping into a phase where the observational systems have to be refined in order to meet the requirements of the models".

As the upcoming new challenges for radiation research the following areas and specific themes were identified:

1. *Climate dynamics*
   cloud-radiation interaction
   energy budget of the "warm-water-sphere", the upper layer of the oceans
   monitoring of aerosols and modeling of its climate impact
   albedo changes of the land surfaces
   radiation effects of increasing minor constituent concentrations
2. *Middle Atmosphere Physics and Chemistry*
   interaction between solar radiation and the atmospheric species
   non-thermal emission
   airglow
3. *Solar energy as an alternative energy source*
   assessment of basic radiation data
4. *Energetics and dynamics of planetary atmospheres*
   radiative transfer and atmospheric dynamics in planetary atmospheres
5. *Environmental conditions in the biosphere*
   radiative transfer in polluted atmospheres
   modelling of the atmospheric boundary layer
   climate of cities
   [not explicitly mentioned here but already discussed at business meetings was the UV-B problem].

The document then discussed how the work of the IRC and its ad hoc WGs fits into this network. Also mutual interactions between the WGs and with other bodies were discussed.

The conclusion, as formulated in this report, was that in the future the IRC should take responsibility and leadership in one central area of the global research programmes to become more visible, to maintain broad cooperation with other bodies in other fields of radiation research, and to elect new members who are active in just these fields. A broad expertise in radiation must be maintained but the central activity could be focussed for an adequate period at one major task such as radiation processes in the earth's climate system. In view of the large structure of the IRC due to the broadening of the themes and memberships of its working groups, an expansion of the bureau by "speakers" for Radiation and Climate

and for Atmospheric Optics and Remote Sensing was suggested as well as a general discussion on the continued existence of the ad hoc working groups.

Also IAMAP discussed to adjust its membership according to the new scientific challenges. This was supported by the IRC bureau.

The report opened discussion on the role and organization of the IRC which took a broad room at the following business meetings.

Canberra, Australia, (IUGG) 1979

The IRC held three business meetings of in total 12.5 hours in Canberra to cope with the new developments in the international scene and the work of the working groups.

The President honoured Prof. Dr. Hans Gerhard Müller, the director of the DFVLR Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany, who died on December 24, 1978. He was very much involved in the comparison campaigns of balloon-borne radiometers.

The membership of the IRC was slightly increased by electing 14 new members and holding open one additional position for the USSR.

By the time of the IUGG General Assembly in Canberra, 29 May to 10 June 1978, IUGG had agreed to establish jointly with WMO the World Climate Research Programme (WCRP) which would start on 1 January 1980. The JOC had been transformed into the Joint Scientific Committee (JSC) for GARP and the WCRP. B. Döös (JSC), who was present as guest, supplemented the report of the President by giving further details of the activities of the Climate Board and its different panels. First activities had already been announced such as the investigation of the cloud-radiation feedback and the role of the upper layer of the oceans in the climate system. Also interest in the investigation of the role of aerosols had been shown. These were clearly fields in which also the IRC was active. Members of the IRC were already involved in the planning of a project on real time cloud statistics by means of satellite data of which G. Paltridge was one of the initiators. In this context the IRC also decided to co-sponsor the 7th International Cloud Conference organized by Soulage in France.

IAMAP had in the meantime modified its statutes. Some of these modifications are of interest for the IRC. More rapid rotation of membership is promoted: The term for Commission members is one full period (four years). They may be re-elected in general for an additional period (only in exceptional cases the possibility should be left open to prolong the membership in excess of two terms). But: Due regard should be paid to geographical distribution. Officers are eligible for re-election in their present position for a second period. “Robert’s rule” should be adopted in which the president has a vote only in case of a tie. The IRC went carefully through the statutes and recommended to take out some unnecessary items to make the statutes as clear and short as possible.

Garry Hunt representative for planetary atmospheres and later on chair of ICPAE

The report of the ad hoc WG for future activities of the IRC and the circular of the secretary on this matter were discussed in detail with many contributions to the discussion:

a) The parameterization of radiation fluxes in the context with dynamical processes and climate research were identified as very urgent (Hunt, Avaste, Bojkov, Fröhlich). The computation of radiation fluxes need prime attention while plans for measurements are made by other agencies. The climatological aspect includes the aerosol question and the radiative transfer in clouds. An efficient feedback with the climate board should be established.

b) Other important problems are in the Middle Atmosphere in connection with photochemical processes and solar irradiance at different levels of the atmosphere (Avaste, Fröhlich).

c) Special attention should be given to calibration of spectral solar measurements (Wark).

d) Of important economical aspect is that of solar energy, its spectral distribution and its modification by economical parameters in the biosphere as well as the radiation balance at the surface. In this case also a standardization of the instruments seems still to be necessary (Raschke, Dogniaux).
e) A long-term measuring network would be needed within the climate program in which the IRC could stimulate the modelling operation while WMO and CAS would be responsible for the measurements (Sekihara).
f) Still unsolved is the important problem of the determination of the albedo from measurements made in space (Wark).
g) Basic problems still exist in the application of spectroscopic techniques and image processing in remote sensing, especially in planetary atmospheres and in relation to photochemistry (Hunt).
h) Also a warning was articulated: The IRC should stick to basic physics and not try to swim with short-living current streams (Paltridge).

It finally was decided that all IRC members should be involved and asked to submit their ideas for future work in written form focussed on the following items. For each of the following topics a referee was nominated (name in brackets) and the discussion should be continued at the meeting in 1980:

- Interaction of radiation and dynamics in planetary atmospheres (Ohring)
- Remote sensing (Kaplan)
- Radiation budget and cloud statistics (Vonder Haar)
- Solar radiation, extraterrestrial and in the biosphere (London)
- Instrumentation (Crommelynck)
- Relations with WMO (Raschke)

The work of the nine existing ad hoc working groups was thoroughly evaluated and for each one recommendations had been formulated.

The report of the WG on Radiation Units and Terminology was published 1978 by IAMAP (without the section on polarisation). The expectation was expressed that also other groups soon come to a conclusion. As E. Raschke explained the WG will still produce a small report on reflection quantities and contacts have been established with IAPSO about the nomenclature of radiation quantities for the ocean. The IRC recommended that the group be dissolved in 1980 after delivering a final report.

J. Lenoble had submitted a written note saying that parts III and IV of the report of her WG, which were edited by Y. Fouquart and W.M. Irvine, are ready for publication and that the published volume I needs an update. The group was congratulated for its outstanding work.

T. Vonder Haar submitted a short report with a review of the GATE RSP (radiation sub-programme) and mentioned a comprehensive report of the Leningrad GATE Radiation Data Center which was submitted to WMO for publication. The IRC did not endorse the proposed self-dissolution of the GRWG at this time because it expected first to see the report in a draft version and a summary of what has been learned from this activity which may be of importance for future tasks in the WCRP and for radiation data archiving in general. Information should also be given on the availability of GATE radiation data.

A few editorial changes are still necessary before the report on the Standard Radiation Atmosphere, submitted by R.A. McClatchey, can be printed, explained the Secretary.

The chairman of the WG on Transmission Functions, D. Wark, promised a pragmatic final report for 1980 though still some discrepancies of the order of 5-7% remain. This was accepted by the IRC.

In a submitted report, A. Fymat proposed comparisons of retrieval methods for the atmospheric vertical temperature profile as the working basis of his WG on Inversion methods. The IRC endorsed in principle this work-plan but recommended that first the WG on Inversion Techniques be consulted. He also had submitted a proposal for publication of a major report on inversion techniques which was nearly finished. The IRC requested first to be informed about the content of the report and the plans for publication before working on this proposal.

The chairman of the WG on Atmospheric Optics, V. Zuev, reported on the preparation of a symposium on laser applications at the IAMAP Assembly in Hamburg, 1981.

There was no new report of the WG on Calibration, Standardization, and Validation of Satellite Radiometer Measurements since the COSPAR report “Towards an internationally coordinated earth radiation budget satellite observing system” (Alpbach 1978). The IRC, however, expected as final report a kind of a manual for calibration procedures and calibration data for the different radiometers. The

vehicle to obtain information about the variety of instruments should be a symposium and eventually a workshop at IAMAP's next Assembly in Hamburg, 1981, co-sponsored by COSPAR.

C. Fröhlich reported that an outline for the Radiation Manual exists which was received with thanks and endorsed by the IRC with the request to include subsections on measurements from ships, spectral measurements, and data archiving. It was the opinion of the IRC that the question of archiving radiation data especially for purposes within the WCRP has to be taken seriously, but the members were at this time not prepared to discuss this mater in depth. Recommendations were expected to come from the GRWG (see above). I. Galindo reminded the IRC that there exists an extended network of radiation measuring sites and data diagnosis in Central America (alone in Mexico 30 automatic Eppley pyranometer stations had been set up with calibration facilities in 3000 m altitude). From WMO came the message that the title of the manual should be "Handbook of Radiation Measurements" to avoid overlapping with other WMO publications.

Ft. Collins, USA, (IRS) 1980

In August 1980 the IRC held its quadrennial meeting in Ft. Collins, USA. The symposium was dedicated to the memory of the late Professor G. Yamamoto, Honorary Member of the Radiation Commission. It was a large event with more than 300 participants.

The IRC held three business meetings of in total 8.25 hours. The first two meetings were 'closed' (i.e. only RC members had access). Many of the matters raised on the full Sunday afternoon meeting were discussed at specially arranged group meetings during the week. At the end a number of action items evolved for further discussion at the next business meeting in Hamburg.

The death of Professor Yamamoto in February of 1980 was commemorated in a speech by the President and by a short period of standing silence.

The President reported on activities of the Commission since the Canberra meeting of December 1979, and in particular described the IRC relation to the JSC of GARP which is addressing the overall climate problem. The RC can expect to be involved in various aspects of the GARP climate programme, such as clouds and radiation, radiatively important gases, aerosols and surface albedo.

Some time was spent on the organization of future meetings such as the symposia at the 1981 Hamburg IAMAP Assembly in which the IRC is involved (Radiative Transfer in the Oceans, Use of Lasers for Studies in the Stratosphere and Troposphere, The Solar Constant and the Spectral Distribution of Solar Irradiance, Calibration of Satellite Radiometers, Session on Satellite Techniques in the "Now-Casting" Symposium of the Cloud Physics Commission, Session on Radiation in the Middle Atmosphere in the MASS-Symposium).

It is expected that the RC will be actively co-operating with COSPAR in organising a symposium on Aerosol Monitoring from Space and on sessions of a symposium on Earth Surface Observations at COSPAR 1982 in Ottawa (G. Ohring and W. Smith have been elected Chairman and Vice-Chairman of COSPAR Sub-Commission A-I). The Validation and Intercomparison component of the topic "calibration" had been deleted from the Hamburg meeting and is now proposed in association with the COSPAR meeting in Ottawa, 1982.

The subject of IRC co-sponsorship of CLAS (Committee on Laser Atmospheric Studies) meetings was discussed, as well as the broader issue of the relation of CLAS to the IRC. The CLAS representative (P. Russell) said CLAS intends to maintain close contact with the IRC, and in particular attempt to schedule *International* CLAS. The IRC agreed to consider favorably the co-sponsorship of *International* CLAS conferences, provided they do not occur too frequently (i.e. not more than perhaps once every three years).

The RC is to organise jointly with JSC (Joint Scientific Committee for GARP and WCRP) an Aerosols and Climate Workshop in late 1980 to be held in Geneva.

It is likely that at the time of the next IUGG in Hamburg, in 1983, the IRC will join with the IUCRM in co-sponsoring a major symposium on Remote Sensing of Climate Parameters with sessions on Cloud-Radiation Feedback. The President will contact IUCRM on this matter.

The President reported that an invitation to hold the next Radiation Symposium (in 1984) in Italy has already been received from G. Fiocco. The final decision on where to hold the symposium will be taken at the 1981 Hamburg IAMAP meeting in the light of invitations received by that time. The President to liaise with Ozone Commission to keep in mind the possibility of back-to-back OC and RC symposia. The

President proposed consideration of a 1984 symposium format whereby summary papers (in the morning sessions) would summarize not only the current state-of-the-art but also introduce the poster to be on display in the afternoon session. There was not overall agreement on this and the subject was deferred.

Then the present status of the WGs was discussed.

The WG on Radiation Units and Terminology chaired by E. Raschke submitted a final report. In the discussion it was suggested that the WG's publication of 1978 may need to be updated, but decision on this was deferred until agreement with IAPSO is reached. For the time being the WG is in standby position.

J. Lenoble submitted the report of the WG on Standard Procedures to Compute Atmospheric Radiative Transfer in a Scattering Atmosphere. The WG has produced two RC published volumes on the subject - Vol. 1 in July, 1977, Vol. 2 in February 1980. It appears that updating of these volumes (particularly Vol. 1) will be necessary in the not-too-distant future. The current status of the WG is standby position until the report of the WG on a Standard Radiation Atmosphere is available, then start with international comparisons of computations in realistic atmospheres. For the further future the topic of Parameterised Procedures to Compute Atmospheric Radiative Transfer in Climate Models is under consideration.

A status report of the WG on Standard Radiation Atmosphere (McClatchey - chair -, Bolle and Kondratyev) was submitted to the Commission after a special mid-week meeting of the group and other interested scientists - mainly to resolve questions concerning aerosol models. The current Status is: Finalization of the "Standard Radiation Atmosphere" to be achieved as early as possible after September 15, 1980 - this being the date of final submission of any suggested modification (the report was finally published as WCP - 112, WMO/TD-No. 24, March 1986, under the title "A Preliminary Cloudless Standard Atmosphere for Radiation Computation").

An oral report of the WG on Transmission Functions was given by the Chairman, D. Wark. The current status is: Final report should be available by December 1980 and the WG is to be disbanded by the time of the next Business Meeting, in Hamburg, 1981.

The WG on Inversion Methods is chaired by A. Fymat, who submitted a proposal for "A Comparison of Retrieval Methods for Reconstructing the Atmospheric Vertical Temperature Profile" which was discussed extensively at a special mid-week meeting. The proposal was approved in principle and the comparison will be organized by A. Fymat. The report on Inversion Methods is to be finalized and should be circulated. The IRC Bureau should request COSPAR co-operation for retrieval comparison. The decision was to continue for the purpose of the above comparison, for which results are expected to be available by the time of the COSPAR meeting in 1982.

The Chairman of the WG on the Radiation Sub-Programme for GATE, T. Vonder Haar, said that the final report has been published as a "white cover" JOC publication. The overall programme was a success. The WG completed its task and was disbanded.

The WG on Atmospheric Optics (Laser Applications in Meteorology) chaired by V. Zuev exists to organize the relevant symposium at the 1981 Hamburg IAMAP meeting and is to be disbanded after the Hamburg meeting.

The Chairman of the WG on Calibration, Standardization and Validation of Satellite Radiometer Measurements, H. Yates, gave an oral report. At this stage the WG has three tasks:

(1) Preparation of a brief for an adequate facility for all countries to use for purposes of instrument comparison and calibration.

(2) Organization of the relevant Hamburg symposium on Instrument Calibration.

(3) Organization of a subsequent-meeting on validation and standardization in conjunction with COSPAR.

The WG continues in existence. The IRC officers are requested to approach COSPAR re joint COSPAR/IRC organizing committee for the meeting on validation.

The Chairman of the WG on the Radiation Manual, C. Fröhlich, reported that, due to late submission by a few contributors to the Manual, the first draft will not be available under September 1980, but with luck should be available for publication (by WMO) at the time of the Hamburg IAMAP meeting of 1981. The WG should continue until the Manual will be submitted for publication (August 1980?).

The WG on Future Activities of the IRC is chaired by T. Vonder Haar. As a consequence of decisions taken at the Canberra Business Meeting, a number of written submissions were available for discussion (i.e. one from L. Kaplan and one from H. Fischer on the future priorities in Remote Sensing and one from

D. Crommelynck on future priorities in Instrumentation). Oral submissions were made by London, Fröhlich and Galindo on “Solar Radiation, Extra-terrestrial and in the Biosphere”. One was made by Ohring on “The interaction of Radiation and Dynamics in Planetary Atmospheres”, and another one by E. Raschke on “relations with WMO”. These topics were discussed and the outcome is reported in various of the items below. The WG was disbanded.

The following summarizes decisions and background with regard to the establishment of *new* Working Groups and the appointment of rapporteurs. These were partly a consequence of the submission of proposals by IRC members with respect to future priorities of the IRC.

It was recognized that the JSC/IRC are organizing an "Aerosol and Climate Workshop" in Geneva in late 1980, and that it would be premature to make decisions on IRC action until the recommendations of that workshop are available. J. Joseph was appointed as a “rapporteur on aerosols” with the brief to prepare for the next Business Meeting (in Hamburg 1981) a list of proposals for action by the IRC - these proposals to take into account the Aerosol and Climate Workshop recommendations.

One of the major recommendations of the JOC Oxford Conference on the parameterization of extended cloudiness in climate models was the encouragement and co-ordination of individual national experiments on various cloud types. The JSC (formaly JOC) wishes to be kept informed of progress in this matter. C.M.R. Platt was appointed rapporteur on this subject, and was asked to provide an initial summary of the work underway around the world for the Hamburg Business Meeting.

A Working Group on Cloud-Radiation Feedback was established to service the JSC request for IRC input to the overall cloud-radiation problem in climate modelling. Its immediate task is to provide advice on steering of the "International Satellite-Derived Cloud Climatology" project, which was suggested originally at the JOC Oxford Conference, and has been endorsed by the JOC (now JSC) as a project of high priority. A work plan was developed at a special meeting in Budapest (June 1980) which work will be continued at another special meeting following the present symposium.

The Commission was informed about two workshops concerned with the question of cloud-radiation feedback, one at GISS and one at the European Center for Medium Range Forecast. G. Hunt was requested to keep the Commission informed about the GISS workshop and E. Raschke about the ECMWF workshop.

An ad-hoc Working Group on Atmospheric Gases was formed in response to a JSC request for advice on the importance of trace gases in the overall climate modelling problem. J. Gille was appointed chairman of the group. A short status report was requested by December 1980, by which time the group will be disbanded.

Arising from the discussion of L. Kaplan's submission with regard to future priorities of the IRC the ad hoc Working Group on Remote Sensing was established. Its brief is to supply for the next Business Meeting (in Hamburg 1981) a review of the problems and recommendations for action by the IRC. The WG is not concerned with remote sensing of clouds or aerosols. The present definition group will be in existence for one year. Further decisions to be taken in Hamburg, 1981.

The Secretary General of IAMAP requested the Commissions to consider a re-definition of the tasks of the World Data Centers in their field of competence. A mid-week meeting on this topic was held between interested members. The Ad-hoc Working Group on World Data Centers under the chairmanship of I. Galindo was requested to elaborate on the ideas which came up during the meeting and to provide a report by the time of the Hamburg meeting in 1981.

The Ad-hoc Working Group on Radiation and Dynamics was established as an outcome of G. Ohring's submission on Future Activities of the IRC and is to supply recommendations for IRC action for the next Business Meeting and will then be disbanded. The group is chaired by G. Ohring.

A WG for Proposals for Action by WMO was established to formulate proposals which might be put to WMO with regard to the following matters raised during discussion:

(1) Development of balloon-borne solar radiometric measurement programme,
(2) Measurement programme of radiation on inclined surfaces,
(3) Network of UV/B monitors - and the problem of calibration of such monitors.
(4) Network of turbidity measurements.

C. Fröhlich and the President are to explore with WMO what the IRC might do with regard to these matters, and to then contact the WG for them to formulate appropriate proposals. C. Crommelynck, J.

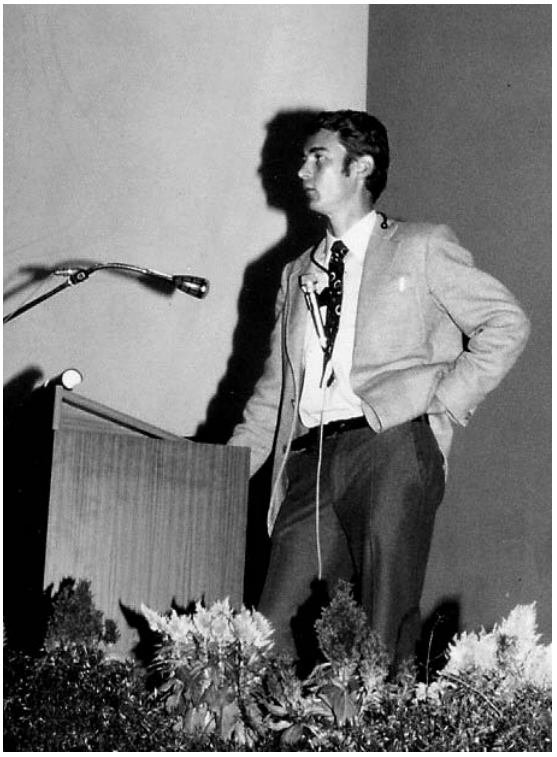
London and E. Raschke to report on desirability of balloon-borne radiometer programme by next Business Meeting.

The President raised the question of the relation with IUCRM and pointed out the likely areas of overlap of the IUCRM proposals and the IRC activities. It was decided that the IRC Bureau should suggest to IUCRM that J. Harris be appointed to their Commission as IRC representative and that the IRC President should ask IUCRM for their proposals with regard to a major symposium at the Hamburg IUGG Assembly in 1983 at which time this matters should be reconsidered.

A suggestion by G. Major that the IRC should consider publishing its own journal was discussed at length but finally rejected as probably impractical from the financial point of view.

Finally, the IRC Secretary, G. Paltridge, was asked to

- develop an initial set of new "RC Terms of Reference" to be circulated for comments prior to next business meeting,
- arrange for sending the report of WG on Units and Terminology to editors of leading relevant journals,
- notify the Secretary General of IAMAP about the IRC decisions re Hamburg Symposia plans (see above),
- draw attention of the Secretary General of IAMAP to the IRC resolution that IAMAP should take steps to announce officially that poster sessions have the same weight as other sessions and that some contributions can be much better presented in posters rather than short contributions. For the future, some symposia are planned which will only have two categories of papers: invited reviews and contributed posters, and
- prepare drafts of the two sections of the "History of the Radiation Commission" handed over by J. London for publication (section 1 deals with the history of the IRC to 1948, Section 2 deals from 1948 onward).



Garth Paltridge, IRC secretary 1979 - 1983

Hamburg, Germany, (IAMAP) 1981

Two invitations were received to host IRS 1984. One for Italy, presented by G. Fiocco and on behalf of the Estonia Academy of Science, presented by Avaste. After a written vote (13 to 8 in favor of Italy, with one abstention) G. Fiocco's invitation was accepted and an organizing committee appointed.

At the suggestion of the IRC President, a somewhat more formal *procedure for the next IRC elections* at the IRC business meetings during IUGG 1983 was agreed upon (see box). A "nominating committee" consisting of J. London, J. Lenoble and K. Kondratiev was appointed . The suggested names should be in the hands of the nominating committee by 1 January 1983.

The secretary agreed to produce draft *terms of reference* for circulation to IRC members before the next business meeting.

O. Avaste was nominated and approved as the IRC representative to be Chairman of the joint 1-day symposium at IUGG on "Upper atmosphere modeling including radiation".

The Co-operation with CLAS (Committee on Laser Atmospheric Studies) was discussed, and it was noted that the IRC expects to endorse co-sponsorship of the next international CLAS meeting in 1984. The co-sponsorship of the 1982 meeting was endorsed if CLAS accepts the IAMAP rules for such co-sponsorship.

The IRC endorsed co-sponsorship of the COSPAR 1983 meeting on measurement of aerosols from space and proposed Y. Fouquart and H. Gerber as the IRC representatives on the organising committee.

Formal Election Procedure Effective 1983

- A "nominating Committee" is appointing consisting of three former IRC Presidents. IRC members may suggest names to this "nominating committee".
- The committee shall assemble an overall list of nominees, attempting to clarify any problems such as double nominations from the same organization, avoiding wherever possible nominations of current ordinary members who have been members for two terms (i.e. 8 years) or more; and attempting to maintain a reasonable balance of the coverage of fields and geographically.
- The list of nominees shall be circulated among IRC members and a vote shall be taken at the next business meeting in a manner to be specified by the nominating committee. Members who will not be able to attend this business meeting should be enabled to indicate their preferences by letter.
- The Total number of ordinary IRC members shall be restricted to that of the present IRC - namely 35.

Election procedure accepted in Hamburg, 1981

The IRC secretary is to write to COSPAR on this matter.

It was pointed out that there are no ERB satellite experiments planned after the current satellite work on the subject. It was agreed that the IRC should take a major role in an attempt to ensure ERB measurements continue to be made. To that end it was agreed that the IRC approach the various relevant international bodies (COSPAR, ESA, WMO, NASA etc.) asking for their participation in (and support for) two symposia within the next 12 months. The first symposium should concern a more accurate definition of the evaluation and the use of radiation budget measurements within the future WCRP and in weather forecasting. The second should concern a new approach to design an improved observation system for the next decade which can meet the newly defined requirements.

In addition to two IRC business meetings there has been also a joint IRC, Ozone Commission, and Climate Commission business meeting during the IAMAP Assembly in Hamburg, 1981. The first item on the agenda of the joint commission meeting was mainly to inform the Commissions about how JSC is dealing with research proposals submitted from scientific communities. The second item was the initial meeting of the Climate Co-ordinating Forum (CCF) by ICSU. Concern was expressed that this forum drains further on ICSU funds; less expensive methods of co-operation exist.

As at the IRS in Ft. Collins, again at the business meeting in Hamburg, 1981, a large evaluation and revision of Working Groups took place, specifically because some had been established as ad hoc WGs in Ft. Collins for one year only. Five WGs/Rapporteurs continued, nine were disbanded and five newly created.

Existing Working Groups and Rapporteurs active beyond 1981:

Working Group on Radiation Manual: The first draft of the manual was distributed and was discussed by the contributors at a special meeting during the week. The chairman of the working group, C. Fröhlich, believed that the final product would be available for printing (by WMO) within six months. It was pointed out that a section on turbidity determination and one on measurements from ships are still missing.

Working Group on Clouds and Radiation: This group, chaired by G. Paltridge, had no action of its own to report except that it is involved in the development of the International Satellite Cloud Climatology (ISCCP) meeting to be held for 3 days after the Hamburg IAMAP Assembly. The working group responsibility is to provide scientific input to the overall clouds and radiation programme which is the responsibility of the Radiation Commission on behalf of the JSC.

Working Group on Standard Procedures to Compute Radiative Transfer: This working group is to continue until a report is available from J. Lenoble.

Working Group on Calibration and Standardization of Satellite Measurements: This working group still has the responsibility for organizing the validation symposium at COSPAR Ottawa, 17 May - 2 June 1982; and for developing a report on calibration procedures.

Rapporteur on Clouds and Radiation Experimentation. The IRC received C. M. R. Platt's excellent report and proposed that it should be published as white cover report in the WCRP series.

The following WGs were disbanded or reformed:

Working Group on Radiation Units and Terminology: This working group was disbanded after the final oral report of its chairman, E. Raschke, at the present business meeting.

Working Group on a Standard Radiation Atmosphere: This working group is to be disbanded by the end of 1981 when the final report is expected to be ready.

Working Group on Transmission Functions: This working group was disbanded at the written suggestion of its Chairman (D. Wark). A short final report from D. Wark was requested by December 1981.

Working Group on Inversion Methods: This working group was disbanded because no indication of further activity was obtained by its chairman.

Working Group on Atmospheric Optics: The President thanked the Chairman and members of the group for the organisation of the Symposium on Laser Atmospheric Studies in Hamburg. No immediate action seemed to be necessary in this field until the relations with CLAS are clarified. This working group was therefore disbanded.

Working Group on Radiation and Dynamics: This working group was disbanded, since no action evolved.

Working Group on Atmospheric Gases: disbanded and reformed (see 3 below).

Working Group on Remote Sensing: The President thanked the Chairman for his report which was positively received by JSC. The working group was disbanded and reformed (see 4 below).

Working Group on World Data Centre: Disbanded and reformed (see 5 below).

Newly established Working Groups

1. Working Group on Remote Sensing (Spectroscopy): The basic task of this new working group is to examine the accuracy of line-by-line calculations of radiances. To this end the group will make an inventory of algorithms for such calculations; it will assemble an inventory of spectra for comparisons; and will arrange for the comparisons to be done. The first report should be available by July 1983. Co-Chairmen: L. Kaplan and A. Chedin. The terms of reference are as follows:

(a) compile all available information on spectral transmission functions and computation procedures in those spectral regions which are of importance for remote sensing;
(b) select well-documented spectral measurements against which computed transmittances (radiances) can be checked; and
(c) organize an international comparison of transmission (radiance) computation algorithms based upon a pilot data set in order to determine the accuracy which can be achieved with the different calculation methods.

2. Working Group on Parameterization of Radiatively Active Trace Gases: This group is to examine the parameterisation schemes for climate models, provide a "state-of-the-art" report and propose future actions by April 1982 for submission to the JSC. Co-Chairmen: V. Ramanathan and H. Grassl, who should co-opt additional members.

3. Ad-hoc Working Group on Aerosols: This group is to evaluate the JSC "Aerosols and Climate" and the Harris reports to propose an order of priority to the various recommendations in that reports and elaborate on the implementation plan. It is proposed that an updated version of the report be published as a WCRP Report. Co-Chairmen: J. Joseph and H. Gerber.

4. Ad-hoc Working Group on Use of TOVS data: This group is to organise a study conference in 1983 on the subject as a joint JSC & IRC effort. Proposal for this study conference to be submitted to JSC via IRC by 1 March 1982. Co-Chairmen: W. Smith and R. Rizzi.

5. Working Group on World Data Centers: This group is to prepare a specific proposal by April 1982, and is to discuss that proposal with the WDC at Leningrad. Chairman: E. Raschke. Members: Galindo, F. Kasten and Major.

Consequently the chairs of the new WGs who were not already members of the IRC were appointed *interim members* of the I RC by virtue of their activities as WG chairpersons on behalf of the IRC. This

status will apply until the next membership election at the Hamburg IUGG in 1983, or at the time their chairmanship of working groups ends. This concerns: C.M.R. Platt - who is the IRC rapporteur on "clouds and radiation experimentation" and who submitted an initial report at the current meeting; R. Rizzi - who is the European co-chairman of the newly established working group on the use of TOVS data; J. Joseph and H. Gerber - who are co-chairmen of the new working group on atmospheric aerosols which is to make recommendations to the JSC.

Resolutions Submitted to IAMAP

A number of resolutions were proposed at the first IRC business meeting, and were passed at the second meeting after thorough discussion and development during the interim. These resolutions were subsequently put to the IAMAP executive and were accepted by IAMAP. The resolutions concern the following:

Resolution on Solar Ultraviolet Measurement

The Radiation Commission of IAMAP,

considering: that solar ultraviolet irradiance and its temporal variations is not sufficiently well-known for middle atmospheric science and that new observations are badly needed to improve the accuracy and the precision of irradiance values;

recognizing: that improvements in calibration procedure are expected to close the gaps between current accuracy goals and achievements;

recommends: the improvement of calibration of new instrumentation by means of:

- the maintenance of synchroton calibration facilities;
- the intercomparison of the different spectral irradiance standards; and
- to study the feasibility of the establishment of a reference to insure the highest possible precision and intercomparability of future observations.

Resolution on Earth's Radiation Budget

The Radiation Commission of IAMAP,

recognizing: the fundamental importance of an accurate knowledge of the Earth's radiation budget and its spatial and temporal variations for understanding the causes of climate variability and change, and considering the recommendations of the JSC concerning the need for radiation budget measurements in connection with the planned major experiments for the WCRP in the late 1980s, and

noting: that the current confirmed plans for Earth radiation budget measurements do not extend beyond 1986,

recommends: that the Earth radiation budget observations be continued via existing and planned programmes for at least a decade, since these will meet some of the most urgend needs, and that continuing studies be encouraged of possible improvements on observing platforms, instrumentation, and data reduction to meet the requirements of the large scale field experiments and global observation systems planned for the last decades of this century.

Resolution on Determination of Aerosol Optical Depth

The IRC endorses the Recommendations made in the JSC Report on Aerosol and Climate and stresses the need for improving on the quality of turbidity measurements within the Background Air Pollution Monitoring Network (BAPMoN) of WMO/UNEP. It urges WMO to establish a mechanism for inspecting regularly the national measuring sites and networks, to look after the maintenance of the instruments, to introduce improved calibration techniques and to standardize the evaluation methods to determine optical depth.

Resolution on World Data Centre for Radiation

The Radiation Commission of IAMAP,

recognizing: the fundamental role which radiation processes play in the climate system and the necessity for radiant exposure data of high quality for climate modelling and climate diagnostics, and

considering: the requirements for radiation data sets in conjunction with the planned major field experiments, within the WCRP,

urges: that all bodies involved improve the assessment, quality control, archiving, and use of radiant exposure data measured at the surface substantially, both in quality and quantity.

For the purpose of this last resolution the IRC recommends strongly that:

1. WMO should establish a regular inspection routine of all national measuring sites and networks to ensure that adequate maintenance and documentation be applied to the instruments, that accurate standardized calibration, interpolation and evaluation procedures be applied, and that all data be shipped without delay to the WDC;
2. The WDC for Radiation be supported to improve substantially on their present archiving and reproducing facilities by converting it to a magnetic tape system as well as by application of advanced validation methods in order to produce useful homogenous data sets which are validated at international standards and archived in internationally compatible magnetic tape formats;
3. The GATE radiation data format as defined in GATE Report No.13 be applied throughout, and the following one-hourly radiant exposure values be archived in Wm^{-2}: global radiation, diffuse radiation, atmospheric long-wave radiation (Gegenstrahlung), sunshine duration, complemented - if possible - by cloudiness, turbidity and net radiation or surface temperature data;
4. IAMAP and WMO request the Main Geophysical Observatory (Leningrad) to produce a report on recent experiences with the available radiation data archive, its benefits and drawbacks, its present use giving examples of the results for radiation climatology studies, the estimated accuracy and precision of the data, and the future needs to improve on the quality of the data to make it more attractive for research studies; and to
5. establish, as soon as this report becomes available and commitments regarding item 2 can be foreseen, a joint WMO/IRC/MGO ad hoc working group to analyze this report, and to elaborate on the implementation of advanced methods for the establishment of a more accurate and useful global radiation parameter climatology for the use in the WCRP.

Annual Reports December 1981 and 1982

Internal and International Aspects

Since the IRC did not meet in 1982, the Bureau analyzed the outcame of the meeting in Hamburg and several events that occurred in 1981/82 which affected the work and meeting aspects of the IRC. It informed the members about these ongoing activities in annual reports of which an excerpt is given here.

Large Assemblies. The President thanked all who were actively involved in the planning and realization of the Radiation Commission Symposia and Sessions at the IAMAP Assembly in Hamburg. At the same time he expressed his concern that these big meetings do not anymore serve fully the personal contacts and scientific discussions which are necessary for thorough transfer of new scientific ideas and international progress. Especially the overlapping of all symposia without the institution of separate review papers which everybody could attend caused disappointment. The Commission has therefore observed discretion in the number of topics to be discussed at the forthcoming large meetings, IUGG 1983 and IAMAP 1985.

Overburdened business meetings. A considerable fraction of the time during business meetings has nowadays to be spent for short term planning discussions and less time remains for the broader perspectives. Scientists and scientific bodies involved in international coordination have moreover to deal with numerous technical details, in which often only few specialists are interested. It has therefore been suggested that the Commission will meet two days prior to the symposium in order to have ample time not only for business but for science. If one or the other Working Group Chairman would like to arrange for a Working Group Meeting prior to the opening of the Symposium he is invited to inform the Bureau.

IRC Involvement in the World Climate Research Programme. The WCRP proceeds in three streams which are developed in parallel but it is assumed that they will end consecutively. Satellite observations play a significant role in all three areas which are with increasing complexity:

1. The physical basis for long-range predictions of weather anomalies.
   The approach is deterministic with specified land- and sea-surface boundary conditions.
2. Interannual variability of global atmospheric climate and the tropical oceans.
   The atmosphere is considered as a stochastic component acting as a forcing factor on the deterministic computation of the ocean evolution from some specific initial state, but including

feedback from the tropical oceans to the atmosphere.

3. Long-term climate and the global oceans.
   Both the atmosphere and the ocean circulation are considered in a self-consistent coupled model simulating the climate regime corresponding to specified external forcing but irrespective of initial conditions.

Cloud-radiation interaction, land surface processes (mainly related to hydrology) and sea-surface fluxes of latent and sensible heat are significant for stream one. In the second stream then the dynamics of the tropical ocean has to be included. For the third stream ocean circulation models have to be developed and the ocean cryosphere processes have to be implemented as well as interactive land surface processes including the terrestrial ecosystem. In this stream then also changes of the concentration of radiative active gases and aerosols play a significant role.

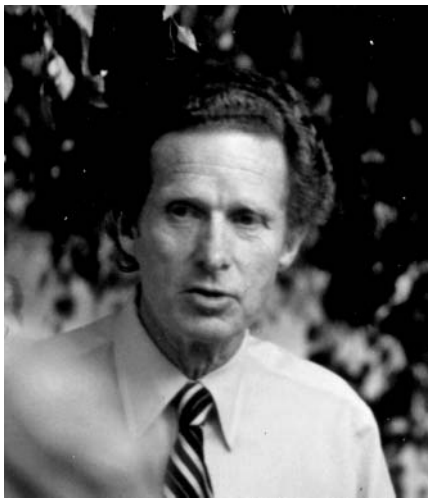
The IRC interlinks in several ways with the WCRP through their working groups (see below). At its business meeting in Canberra, 1979, IRC decided to become more active within the WCRP. The President defined the role of the IRC within the WCRP as follows:
"The Radiation Commission feels responsible to advice JSC on the scientific problems which exist with respect to radiation processes in the climate system, and to assist JSC, WMO and ICSU in the implementation of projects necessary to study these processes. The competence of the Radiation Commission is in the following areas which have so far been identified as being important for climate research: clouds and radiation, atmospheric constituents (gases, aerosols) and radiation, radiation processes at land and ocean surfaces, remote sensing of climate parameters".

The Radiation Commission has in this context either as institution or through individual members so far been involved in the following actions:

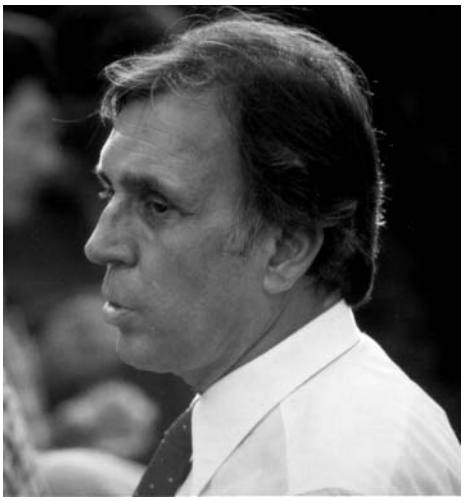
1. Submission of proposal and organization of three scientific meetings on the International Satellite Cloud Climatology Project.
2. Experts Meeting and White Cover Report on Aerosols and Climate.
3. Report on Extended Clouds and Radiation (to be published as White Cover Report).
4. Involvement in the CAGE study group.
5. Report on Climate Effects of Atmospheric Trace Gases to JSC-II.
6. Research on temperature retrieval procedures by establishing the TOVS inversion group and the ad hoc working group on remote sensing (atmospheric transmission functions).
   The following participations in meetings are planned for the next two years:
   a) Co-sponsorship of COSPAR '82 Topical Meetings on
      (i) Measurements of Aerosols from Space
      (ii) Validation of Meteorological Satellite Observing System.
   b) International Laser Radar Conference-11 in 1982 (and -12 in 1984) jointly with CLAS.
   c) Participation in the joint symposia at the IUGG Assembly 1983 (see below).

Radiation Budget. In this area the activities developed slightly different from what had been resolved in Hamburg. Due to lack of resources no concerted activity could so far be initiated. For a letter drafted by the President for this purpose according to the decisions taken in Hamburg the expected back up was nor obtained from contacted IRC members. It is hoped that the CAS-Radiation Rapporteurs, with assistance of other IRC members, will be able to produce a guiding report which can serve as basis for future actions. During the ERB Project Team meetings there have been and are continuous contacts between those scientists, who are active in this field. A letter signed by all participants of such meetings and requesting reasonable action would be very helpful for the promotion of such activities through international channels and for raising money to organize workshops or study conferences. In this stage it is of eminent importance that the IRC is endorsed by the whole scientific community concerned with this problem to serve as focal point for the stimulation of the scientific aspects of radiation budget measurements from space.

The IRC has been requested by WMO to define the surface radiation data to be archived and distributed to users by the Radiation Data Center in Leningrad. The President proposed that the following data be archived (after validation): Global Radiation, scattered solar radiation, atmospheric long wave radiation, sunshine duration; instrument type and number; calibration type, dates, and constant.



Richard Goody at the inaugural meeting of the ISLSCP in Innsbruck



Ichtiaque Rasool organized the the saving of Landsat data. Here at the inaugural meeting of the ISLSCP in Innsbruck, 1983

The International Satellite Cloud Climatology Project (ISCCP). Two meetings have been organized by the project manager Bob Schiffer on behalf of JSC with participation of IRC members in order to define the algorithms to be used for the operational extraction of cloud information: the Cloud Algorithm Intercomparison Workshop in Ottawa, 31. May - 1. June, 1982, and the Meeting of the Working Group on Data Management of the ISCCP in New York, 13-17 December 1982. The project is expected to become operational early in 1983. A later revision of the cloud characteristics extraction algorithms is left open as an option. Results of the cloud extraction algorithm intercomparison should be discussed at the IUGG meeting in Hamburg.

The International Satellite Land Surface Climatology Project (ISLSCP). Based upon the overwhelming response of more than 150 scientists from 17 countries to a circular which has been sent out in September, COSPAR SC-A and the IRC have jointly proposed the ISLSCP as a project within the WCP of UNEP and other UN Organizations. Aim of the project is to assess long term albedo and land use changes which might either signalize climate variations or may have an impact upon climate due to a change of soil hydrology. It is planned to focus the project during 1983 by means of two experts meetings, one in the USA (Boulder) at the end of June and one in Europe (Alpbach, Austria) at the end of July, if the necessary funds can be raised.

Saving Landsat Data 1972-1976. Upon announcement by NOAA to save only a limited number of old digital Landsat scenes on CCT, IAMAP and COSPAR organized a small workshop at GSFC in order to advice the EROS Data Center on the selection procedure for Landsat data which might become invaluable for the assessment of land surface changes and climate studies for a period starting with 1972. A report on the results of this meeting with the recommendations of the group was submitted to NOAA. Copies can be obtained from the IAMAP Secretariat.

CLAS joins IRC. The discussion about an "internationalization" of CLAS had resulted in a move to establish a Union Commission on Laser Geophysical Studies. The President of IRC offered the chairman of CLAS that the Radiation Commission is ready to fulfil the role of such a Commission until its official foundation and to respond to such a challenge by extending the IRC membership with respect to the LIDAR community if this charge remains existent for at least six years. The Chairman of the *Committee on Laser Atmospheric Studies (CLAS)* informed the IRC that, at its meeting in summer 1982, CLAS accepted the offer to become part of the IRC until it has established its own international scientific organization. At least for the next term 1983 - 1987 it will act as an IRC group. Five colleagues from the Laser Community will in August 1983 be elected to become members of the IRC in addition to the present number of IRC members. They will then form a working group including some non-IRC members in order

to keep their activities going as an international body (ICLAS).

Contacts with EARSeL. The European Association of Remote Sensing Laboratories held its annual meeting in Igls, Austria, 22-23 April 1982, with two interesting activities, both partly climate relevant:
- Remote Sensing for Developing Countries
- Workshop on Microwave Ocean/Ice.

This meeting as well as a meeting later this year at ESOC Darmstadt with the EARSeL's WG 7 provided an excellent opportunity to discuss problems of mutual interest such as the ISLSCP with this mostly hydrologically and agriculturally oriented community. The Working Group 7 of EARSeL carries out a study to use METEOSAT data for precipitation and radiation budget estimates as input for biomass production and yield assessment models in the Sahel region (Group Agromet Monitoring Project - GAMP).

Symposia with IRC Participation at the IUGG Assembly 1983.
- IUGG Symposium No. 15: Remote sensing for climate studies;
- Interdependence of Clouds, Trace Substances, Radiation and Climate;
- Atmospheric Effects of the 1982 Eruption of the El Chichon Volcano;
- Preliminary Scientific Results of ALPEX;
- Middle Atmosphere Sciences (MUA-1) - IRC Representative J.C.Gille;
- The Seymor Hess Memorial Symposium - Recent Advances in Planetary Meteorology.

IRC Terms of Reference. The Terms of Reference in its second draft form as proposed during the last Business Meeting is up for acceptance at the next Business Meeting in 1983 with the one addendum: Line 3 from the bottom should read: **...** for the *international* scientific community ... ideas, *and to encourage international cooperation* (see box under Hamburg, 1983).

Appointment of a Rapporteur on Ocean Heat Budget Studies. The IRC intends to appoint T. Vonder Haar, who already was involved in the Cage definition studies, as rapporteur on questions related to the radiation budget at the ocean surface at the next business meeting.

Experts Meeting on Satellite Systems to Measure Radiation Budget Parameters and Climate Change Signals. Noting that there are currently no firm plans for complete Earth Radiation Budget observations beyond 1988, COSPAR, WMO and the IRC decided to organize an Experts meeting (Igls, Austria, 29. August - 2. September 1983) on the question how the needs for accurate radiation budget determinations arising from different requirements can be satisfied in the future.

First International TOVS Study Conference. The IRC Working Group on the Use of TOVS Data organizes the first international meeting on *Intercomparison of Satellite Derived Temperature Profiles* in Igls, Austria, 29. August - 2. September 1983 in order to assess the present status of this technique and to work out recommendations for the future. The Study Conference is co-sponsored by COSPAR, IAMAP and WMO.

Workshop on Radiation Effects and Their Implications for Climate Resulting from Desert Amplification and Vegetation Changes in Semi-arid Zones. As one activity within the ISLSCP the IRC has proposed to organize a workshop on the interdependence between land surface transformations and its impact on the radiation budget. This workshop, for which financial support is currently sought, will be held in connection with the Radiation Symposium 1984 in Italy, either the week before or the week after.

Workshop on Radiation Codes for Climate Models. It was proposed to organize an intercomparison of radiation codes used in general circulation and climate models in order to determine their accuracies and to standardize to some degree the procedure to compute fluxes and heating rate in conjunction with the Radiation Symposium 1984.

Workshop on the Modelling of the Cloud Topped Boundary Layer. JSC recommended to organize a workshop jointly with CAS and IRC on the cloud topped boundary layer

- to review critically the present status of research on the cloud topped boundary layer and its modelling
- to identify the outstanding problems
- to make plans for future improvements of the modelling of the cloud topped boundary layer, and
- to develop an optimum strategy for the incorporation of the boundary layer parameterization in a general circulation model of the atmosphere.

The IUGG meeting '83 would provide an opportunity for the organizing committee to meet and to draft an annotated agenda as well as to select the participants. After careful preparations the workshop should take place in spring 1985.

Eighth Session Of WMO Regional Association VI (Rome, 5 - 8 Oct. 1982). WMO announced three priorities of WMO for the next decade:

1. Further implementation of the World Weather Watch (WWW),
2. All components of the WCP, and
3. Transfer of technology (knowledge, methodologies, procedures, hardware)

for which the full support of all member states for the WCP is requested. In view of the uncertainties involved in the continuation of certain satellite system components, it was said that the weather services should demonstrate confidence in the continuation of this observing system e.g. by installing ground stations, and that they have to fight for the continuation of the satellite programs. It was also said that the present system depends very much upon the generosity of only a few nations and that in the future all nations must contribute to the system: Even small financial contributions can have great effect. One possibility would be that the system is paid for by WMO. It must be aimed at an integrated system and not just a combination of the individual components ("The Integrated WWW System Study"). Also the dangerous trend to commercialize satellite information was stressed.

A pressing problem is the limited funds for observation systems. It was proposed to study the possibilities of an optimalization of the observing system which could lead to the deletion of redundant observations. On the other hand new problems like pollution transport require the application of new measuring methods.

The work of the Conference was structured into two Committees of which Committee A dealt with matters of the observation and telecommunication system, Committee B with research aspects. Both met in plenum alternatively. Within Committee B radiation research was discussed. Reference was made to pyrheliometer comparison in Davos, to a planned intercomparisons of sunshine duration instruments, to revisions of the Guide to Instruments and Methods of Observations (Chapter 9, Measurement of radiation, and Chapter 21, Measurement of sunshine duration) and to the publication of an atlas on sunshine duration and global radiation. In a comment to this presentation the IRC President welcomed the instrument intercomparisons as a first step into the direction towards improved radiation data, but stressed the need for data validation and supporting satellite observations.

Status of the Work of IRC Ad Hoc Working Groups

Calibration and Stadardization of Satellite Measurements. The chairman of this WG, which is a joint group with COSPAR, Harold Yates, informed about the successful symposium held at the COSPAR meeting in Ottawa on Validation of Meteorological Satellite Observing Systems. The extended abstracts of this symposium will be published in the COSPAR publication series "Advances in Space Research". It was not possible to combine these papers with those of the Hamburg Symposium on "Calibration" so that the suggested "Handbook on Calibration" will not be complete. But these two symposia on calibration and validation of radiometric measurements from satellites were a big step forward in informing the community about the problems involved and in discussing ways to solve these problems.

Clouds and Radiation. Members of the group are involved in the International Satellite Cloud Climatology Project which is to be launched in 1983. It is further planned to elaborate on the problem to merge satellite observations with surface cloud cover observations. The central task of this group is to stimulate the development of algorithms to model the cloud-radiation interaction. For this purpose a study

on radiation properties of cirrus is presently initiated and a digest of the results to be presented at the IAMAP Symposium on Interdependence of Clouds, Trace Constituents, Radiation and Climate in Hamburg, 1983, is planned and will be submitted to JSC.

Optical Properties of Aerosols. The first meeting of the group co-chaired by H. Gerber and J. Joseph was held at the occasion of the COSPAR topical meeting Measurements of Aerosols from Space in Ottawa, June 1982. The very active group now plans jointly with WMO-CAS a major experts meeting in April 6-8, 1983 in Williamsburg, Virginia, U.S.A., at which aerosol models and the future marching route of aerosol-radiation research within the WCRP will be discussed. Outstanding questions are the inclusion of relative humidity effects, geographical and seasonal variations of aerosol properties, vertical profiles of size distributions, specifications for aerosol properties during special events. With such informations at hand it should be possible to initiate much more realistic advanced sensitivity tests in the future.

The group plans the implementation of an International Satellite Aerosol Climatology Project within the WCRP which has to be supported by related ground-based activities and aircraft measurements.

Parameterization of Radiatively Active Trace Gases. The WG co-chaired by V. Ramanathan and H. Grassl has focussed attention on the radiative most important gases H_2O, CO_2 and O_3. While the WG on remote sensing is concentrating on narrow spectral intervals which are important for atmospheric sounding, here the emphasis lies upon broad band flux and heating rate calculations and appropriate parameterizations which should be checked against line-by-line computations. The WG proposes to hold a workshop on radiation codes for climate models. A WG meeting is scheduled at the occasion of the IUGG meeting in Hamburg.

Remote Sensing. The European wing of this WG started under the active leadership of A. Chedin an International Programme of Comparison of Transmittance and Radiance Algorithms in which also at least one group in the USA already participates. A first report of this group on CO_2 has been submitted with the following preliminary conclusions:

1. Spectra corresponding to relatively weak absorption thicknesses are on the whole correctly reproduced by all groups.
2. Overestimation of absorption at the lower frequency edge of the CO_2 v_2-Q branch is general but can be explained by weak coupling approximation developed by Armstrong (Appl.Optics 21, 2141, 1982).
3. The absorption in the region 710-750 cm^{-1} is almost generally overestimated. This problem can be solved by using sub-Lorentzian line wing profiles.
4. Absorption in the region 600-615 cm^{-1} is overestimated with Lorentzian line shapes and underestimated with sub-Lorentzian line shapes. The half-width temperature dependancies are currently examined.
5. An underestimation of the absorption in the 600 - 615 cm^{-1} region could so far not be resolved.

The results of these careful investigations demonstrate the necessity for this work which had already been pointed out earlier by D. Wark. It is hoped that the number of laboratories contributing to this effort will still increase. Its impact on satellite sounding techniques is obvious.

World Radiation Data Centre Leningrad. An exchange of ideas took place between Professor Borisenkov, WMO, and the IRC about the role of and the expected products from the WRDC in Leningrad. Strong efforts are undertaken by the MGO to adapt the service of the center to the needs of the WCP. A meeting sponsored by WMO is called upon between February 28 and March 4, 1983, to clarify the technical details. The IRC has nominated E. Raschke and F. Kasten to take part in the discussions and to represent the Radiation Commission.

Aerosol Radiation Code in the ECMWF GCM. Chaired by J. Lenoble a group of European scientists from member states of the ECMWF was formed to improve the radiation code of the ECMWF model with respect to more realistic aerosol models and aerosol radiation transfer algorithms and to conduct numerical experiments to estimate the impact of aerosol-radiation interaction on numerical medium and long term weather forecast. This group will exchange first experiences in this field with the WG on Optical Properties of Aerosols at a meeting in December 1982 in Lille.

Hamburg, Germany, (IUGG) 1983

At this meeting a major revision took place of the internal structure of the IRC. G. Paltridge presented the second draft of the revised Terms of Reference of the IRC (see box) which was sent to the IAMAP Executive Committee for approval.

The IRC adopted 10 new members, elected new officers, and introduced in addition the position of a Vice President, known from the sixtieths. The "Bureau" then consisted of:
President (presently J. Lenoble)
Vice President (presently T. Vonder Haar)
Secretary (presently J. Harries)
Past President (presently H.-J. Bolle)
Past Secretary (presently G. Paltridge).
This new structure did not hold for long. It ended 1992 with the presidency of J. Lenoble when Past Presidents more or less automatically became honorable members.
J. London was elected Honorary Member of the Commission.

Jacqueline Lenoble, IRC President 1983-1992

The IRC was involved in the following meetings:
- Laser Symposium 13-18 August (CLAS) - 1984,
- Radiative effects due to desertification and Land transformation - 1984,
- Radiation codes in climate models - 1984, and
- IAMAP/IAPSO Assembly 5-16 August 1985 in Hawaii, USA.

The Commission agreed to name the 1984 symposium the "Möller Radiation Symposium" in honour of Fritz Möller who died during the year.

Status of Working Groups
After some working groups came to an end of their work, it was agreed that the following WGs should continue because of ongoing activities:
- The ad hoc WG on Optical Properties of Aerosols co-chaired by J.H. Joseph and H.E. Gerber. The WG held a workshop in Williamsburg, USA, to take a first step towards the development of an implementation plan for the study of aerosols and climate which should be submitted to JSC.
- The Working Group on Radiation Manual chaired by C. Fröhlich. The report was nearly complete for publication by WMO.
- The Working Group on Remote Sensing (Spectroscopy) chaired by A. Chedin. The group produced a report on the comparison of cell absorption spectra of the 15 μm CO_2 band in which seven laboratories were involved and is planning to study transmittance through inhomogeneous atmospheres for nadir-type viewing, for limb viewing and for microwaves.
- The Working Group on Parameterization of Radiatively Active Trace Gases chaired jointly by Ramanathan and H. Grassl. This group is planning a workshop on results of line-by-line calculations of radiances.
- The Working Group on Use of TOV's data chaired jointly by B. Smith and R. Rizzi. This group organized a study conference under the auspices of JSC and IRC in Igls, Austria, for the week following this IUGG Assembly.
- The Working Group on Clouds and Radiation chaired by G. Paltridge. The WG organized a JSC workshop on the cloud-topped boundary layer in Ft. Collins, April 1983, and plans for the future research with ISCCP data and a report on cirrus clouds as well as co-convening a symposium at the IAMAP Assembly, 1985, about this topic.

INTERNATIONAL RADIATION COMMISSION

New Terms of Reference
(Approved by the Commission on 22 August 1983)

The role of the International Radiation Commission is to promote research into atmospheric radiation as well as application of that research to practical problems. This role is part of the broad charter of IAMAP* concerning the earth-atmosphere system and the atmospheres of other planets and is performed in co-operation with all the IAMAP* Commissions and with other appropriate bodies. Topics of concern to the Commission include optical phenomena in the atmosphere, radiative properties of atmospheric constituents and of the earth's surface, radiative properties of planetary atmospheres, radiant energy transfer, radiant energy interaction with other features of the atmosphere (dynamics, climate, etc.) and remote sensing of atmosphere and surface.

The responsibilities of the Commission include but are not limited to the following:

1. a) To stimulate improvement in the standards for calibration of instruments concerned with measurement of atmospheric radiation;
   b) To encourage the development of new and more accurate instruments which are needed for measurement of atmospheric radiation;
   c) To help develop high quality standards in network measurements of atmospheric radiation;

2. a) To advice other scientific bodies on matters of atmospheric radiation when requested;
   b) To develop when necessary formal recommendations for the promotion of particular aspects of atmospheric radiation;
   c) To join with other scientific bodies in any activity which will promote the discipline of atmospheric radiation;

3. a) To summarize and publish as needed the status, research requirements and measurement requirements of particular aspects of atmospheric radiation;
   b) To provide a forum for the international scientific community to exchange relevant results and ideas and to encourage international co-operation;
   c) To organize the quadrennial International Radiation Symposium.

*renamed as IAMAS in 1999

IRC Terms of Reference released 1983

E. Raschke was appointed Rapporteur on World Data Centers and on Units and Teminology; G. Paltridge was re-appointed as IRC representative on the International Climate Commission, and M. Platt remains rapporteur on clouds and radiation.
The following Working Groups were disbanded:
WG on World Data Centre, and
WG on Radiation Units and Terminology.

Graz, Austria, (COSPAR) 1984

COSPAR organized a major symposium on "Space Observations for Climate Studies" at the end of June 1984 - first week of July in Graz, Austria. The Symposium was co-sponsored by the IRC and was understood as a continuation of the discussions at the Hamburg Symposium on Remote Sensing for Climate Studies. For many IRC members it caused problems to attend both this COSPAR meeting and the Radiation Symposium which started only one and a half months after the COSPAR Assembly. In Graz a more thorough and detailed discussion of experimental methods took place.

Ehrhard Raschke, Multi-Rapporteur on agendas concerning COSPAR's and WMO's relationships with IRC

Perugia, Italy, (IRS) 1984

In Perugia the IRC was confronted with new developments in global science and had to make decisions how to cope with this rapid development.

One of the first items on the agenda was the organization of the IAPSO/IAMAP meeting in Hawaii, 1985. The IRC had been asked to co-sponsor *inter alia* a symposium on "Climate Effects of Nuclear War" wich rose some concern that the IRC may become involved in political topics. At the other side it was said, IRC should accept responsibility to advise on scientific issues relevant to the Commissions interest. In the end, after thorough discussion, the Commission accepted the co-sponsorship on condition that this would be limited to a scientific criticism of the papers submitted.

H.-J. Bolle, in his capacity as President of IAMAP, reported that the President of ICSU, Lal, had advised him that efforts be made to maintain a high standard in papers to be accepted for Hawaii, and had also suggested that the status of poster papers should be made equal to oral papers. He also mentioned that there would be a half-day meeting of IAMAP's Commissions to report on aims of work and to improve interaction between Commissions.

Then, now as a member of JSC, H.-J. Bolle raised the subject of participation in international projects and reported that JSC did not endorse the proposal submitted by the IRC for an International Aerosol Climatology Project. Instead, the new version of the WCRP Plan includes the statement that the IRC should take primary responsibility for aerosol research: This needed to be discussed by the IRC. With respect to ERB, the WGGCOS of the JSC recommended that the HIRS instrument be complemented by a wide band channel and to fly improved instrumentation at a later stage. He regreted that the Igls workshop on the ERB did not have stronger impact. The IRC should therefore decide whether it would be necessary or not to push for a further ERB initiative.

On cloud research it was expected by JSC that the IRC through its WG on Clouds and Radiation assists JSC in developing a research strategy. This did not yet happen, and again this needed to be discussed by the IRC.

H.-J. Bolle went on to point out the pressure from other organizations - e.g. URSI - in the remote sensing field. IRC needed to decide whether or not it wished to play a major role. Other programmes such as the the International Geosphere-Biosphere Programme represented potential new opportunities for IRC involvement.

After discussion of these topics an ad hoc working group was set up (chaired by E. Raschke) to elaborate on an initial set of recommendations for the involvement of IRC in international programmes and to report at the second business meeting. The group was seen as a first step in the re-formulation of IRC's future role and activities. The group deferred part of the questions to the respective WGs and concluded with respect to IGBP that no clear aims could yet be seen. Remote sensing was seen as a major topic at the IRS 1988 and that it would be necessary to clarify the interests and spheres of both bodies.

A. Chedin, who is as well member of one of URSI's Commissions, agreed to act through that route as a representative of IRC interests.

Also the Asian region got more into the focus of scientific activities: China proposed a meeting on "Atmospheric Radiative Properties of East Asian Region and its Application to the Global Climate and Remote Sensing". It was agreed to co-sponsor this meeting.

At the end of two business meetings the President summarized that two opposing views on IRC's function were presently discussed:

- IRC should respond only when requested from outside to become involved in major programmes by providing expertise in atmospheric radiation, and
- IRC should seek to impose its influence on all maters involving atmospheric radiation.

The President's view was that neither extreme would be valid but if a task was taken on, then IRC needs to have the capability through its members to do *real work*.

The WG's reported extensively about the progress of their work.

C. Fröhlich reported that the work of the WG on the Radiation Manual was nearly done, the manual would be published by the end of 1984.

The WG on Remote Sensing, chaired by A. Chedin, was expanding its activity and formed three sub-groups on nadir, limb, and microwave sounding. These three sub-groups are chaired by D. Spänkuch, H.

Fischer, and K. Künzi respectively).

The Intercomparison of Transmittance and Radiation Algorithm (ITRA) project was proceeding well. Line mixing problems needs to be attacked. It was agreed that the name of the WG should be changed into "Direct Problems in Remote Sensing".

The "loose definition" of the tasks of the WG on Clouds and Radiation chaired by G. Paltridge, led to a diffuse program with five tasks: (i) Parameterisation of cirrus clouds for climate, (ii) statistics of cloud base height (in cooperation with CLAS), (iii) cooperation with WGNE, (iv) cloud climate feedback and sensitivity, and (v) definition of research uses for ISCCP data. Little progress could be reported for some of these tasks so that a decision about its continuation was envisaged for 1985 when most of the tasks should be finished.

Considerable progress was reported by J. Joseph for the WG on Aerosols. The results of the Williamsburg meeting were published in the WCP-55 report. The importance of satellite observations of tropospheric aerosols was emphasized together with ground based monitoring and an adequate library data base. Consequently it was proposed to disband the WG after the submission of the full report and to establish an ad hoc WG to take care of the creation of a global data base. For this purpose the WG should be transformed according to this task.

W. Smith presented three conclusions of the TOVS Data WG as result of its Igls meeting:

- The physical approach is superior to the statistical approach;
- availability of good surface data can improve soundings dramatically;
- differences in temperatures are of the same order as between ECMWF predictions and sonde data.

The main question was how to use and to improve direct read-out data software. Two publications were produced at Wisconsin on temperature profiling. A second TOVS workshop was planned for 1985 at Innsbruck where two aspects would be considered - the use of 1 km AVHRR data to improve boundary conditions and H_2O retrievals.

In the Annual Report of 1982 the President announced a workshop on Radiation Codes for Climate Models in conjunction with the IRS in 1984. This workshop was proposed by Y. Fouquart and J. F. Geleyn, G. Stephens and G. Paltridge and supported by the WG on Parameterization of Radiatively Active Trace Gases. The ad hoc WG on Radiation Codes in Climate Models and the WG on Radiatively Active Gases held this joint meeting in Frascati. It could be shown that different line-by-line models agree well but narrow band models showed errors up to 20%. It was agreed that both working groups should consider to join under the title of Radiation Codes in Climate models chaired by Y. Fouquart and F. Luther.

The rapporteurs reported about the Leningrad World Data Centre on Radiation (E. Raschke) and Cloud and Radiation Experiments (Platt) about which an extensive report was distributed. E. Raschke was asked to report on post-ERBE projects at the next meeting as well.

Because there had been little participation of the radiation community concerned with spectroscopy at the Symposium, R. Zander, H. Fischer and J. Harries were asked to prepare a specific proposal on this topic for the 1985 meetings.

As announced in the Annual Report 1981/1982 the negotiation with the CLAS community had successfully accepted to become a WG of the IRC. was warmly welcomed as a new WG within the IRC firming now under the name International Committee on Laser Atmospheric Studies (ICLAS). Its task is to coordinate the international lidar program. The terms of reference and the planed sub-committee structure were formulated. ICLAS became an import and as far as can be seen a truly permanent component of IRC.

Honolulu, Hawaii, USA, (IAMAP) 1985

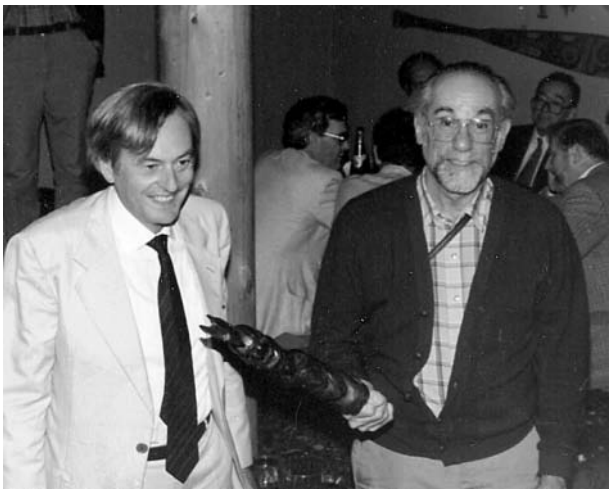
The chairpersons of the WGs gave their annual progress reports of which the following statements were discussed at the business meeting:

The chairman of the WG for the preparation of the Radiation Manual, C. Fröhlich, announced that the 134 pages manual had been sent to WMO for printing. The WG consequently was disbanded.

The WG on Clouds and Radiation submitted its report which, according to the opinion of its chairman, G. Paltridge, and the WG members ended its mandate so that the WG could be abandoned. Since, however, the scope of clouds/radiation research had expanded considerably, G. Paltridge presented six areas of topics for further special attention to the IRC:

(a) Surface radiation budget,
(b) Cloud Base Climatology,
(c) International Satellite Cloud Climatology Project,
(d) Use of Satellite Measurements of Radiation Budget,
(e) Radiation and Microphysics of Clouds,
(f) Sea Surface Temperature Variations Coupled to Cloud Base.

IRC considered to address the items (a), (c), (d), and (e) in the framework of WGs but no direct action was taken. Item (b) was transferred to C. M. R. Platt who had already put forward the proposal to implement worldwide a network of eight lidar and some ceilometer stations to begin collecting data on cloud bases for ISCCP. Item (f) was taken under study. With respect to item (c) it was explained that the advisory actions of the ad hoc WG on ISCCP would be completed with the implementation of an ISCCP validation and research plan. The IRC approved this as the final action of this WG: to complete the ISCCP validation and research plan for the JSC.



Stanley Ruttenberg, Secretary General of IAMAP for many years, after having received the indian "talking stick" from President Hans-Jürgen Bolle

The IRC formally endorsed C. M. R. Platt's plan for a worldwide network of eight lidar and some ceilometer stations to begin collecting data on cloud bases for ISCCP. This recommendation will be forwarded to IAMAP for endorsement.

J. Joseph submitted a written report of the WG on Optical Properties of Aerosols. A collection of selected papers presented at an experts meeting in Williamsburg, 1983, had been published. J. Lenoble and A. Deepak reported on discussions regarding the compilation of a library for aerosol data and a re-arrangement of the objectives of this WG.

H. Fischer, J. Harries, and R. Zander presented their ideas to promote spectroscopy. They proposed that the ad hoc WG on Atmospheric Spectroscopy Applications be formed into a permanent WG. G. Hunt expressed interest in a joint WG between IRC and the Planetary Commission. The IRC agreed in principle and asked President Lenoble to discuss the matter with other Commissions such as IOC and ICPAE. D. Wark proposed to summarize the work of an earlier IRC WG related to spectroscopy.

An increasing number of meetings with radiation topics and requests for co-sponsorship required the nomination of IRC representatives for each of these meetings.

Toulouse, France, (COSPAR) 1986

Discussions at the business meeting in Toulouse give rise to the following analysis of the status of the IRC within a rapidly developing environment of world-wide research programs. Working Groups under dynamic chairpersons develop more and more their own momentum in organizing workshops or meetings and co-operation with other organizations, the IRC providing the international legitimation for their activities. For example: TOVS holds regular workshops nearly every year; ITRA reports about a workshop in Maryland; ICRCCM held one in Frascati concerning longwave clear sky cases and one at the University of Maryland including shortwave and cloudy cases; it also considers field experiments to measure spectral longwave radiances. ICLAS joined the IRC already as an very active organization (CLAS) holding meetings with nearly 200 attendees every second year. Through the WGs the IRC expands its influence in international programs and in joint ventures with other scientific bodies. While, in the beginning, Working Groups were set up as *ad hoc* groups to solve a specific problem for the Commission, some of the groups now become more permanent institutions with long lifetimes which are in some cases determined by the duration of the major international research programmes. The WG reports to IRC consequently grow voluminous and the presentation of these reports at the business meetings replace the scientific discussions among the members of the IRC as it was usage thirty years ago. Another item of the

agenda which takes increasing room is the organisation of forthcoming large meetings or small workshops and the nomination of representatives for cooperative actions.

A. Chedin reported for ITRA that 30 scientists participated in the workshop at the University of Maryland. Future plans include the comparison between codes and real satellite data.

As Y. Fouquart reported, ICRCCM held its first workshop at Frascati, 1984. It was dedicated to longwave radiation in clear sky cases. The second workshop which took place at the University of Maryland, 1986, included shortwave and cloudy case comparisons. The discrepancies are particularly large for solar radiation with scattering. Further calculations are planned and the idea of a field experiment to measure spectral longwave radiances is under discussion. For this experiment a location would be preferable with more total atmospheric water vapour content than would be available in Boulder.

T. Menzel reported on behalf of W. Smith and R. Rizzi that the TOVS WG holds regular workshops about every 18 months (Igls, 1983; Madison, 1985, Madison, 1986). Reports of these workshop can be obtained from W. Smith.

P. McCormick reported for ICLAS that the last ILRC was held in Aix en Provence, 1984, with 180 participants. The next is planed for Toronto, 1986. An WMO/IRC experts meeting in Geneva, 1985, investigated the possibility of lidar networking for aerosol, ozone, cloud and other constituents. A report of this meeting being in preparation. The application of lidar from space is studied in the USA and Europe.

J. Lenoble presented written reports from M. Platt (ECLIPS) and E. Raschke (World Radiation Data Center and ISCCP). With respect to the WRDC, Y. Fouquart, H. Grassl and G. Ohring commented that not only the access to its data but also the station network needs to be improved. This was supported by the Commission. A recommendation to be prepared by E. Raschke will be sent by the IRC Bureau through IAMAP to WMO.

A. Deepak gave a historical background for the International Aerosol Climatology Project (IACP) and presented a work plan for a WG on this topic. The International Commission on Cloud Physics had requested that this could be a joint WG between IRC and ICCP. After some discussion it was decided to establish this Joint WG with G. Vali co-chairing it as representative of ICCP. A. Deepak was appointed chairman for the IRC in a closed Commission session.

Another proposal for a new WG was put forward by R. Zander on Atmospheric Spectroscopy Applications (ASA). It will be a joint WG with the International Ozone Commission (IOC) and the International Commission on Planetary Atmospheres and their Evolution (ICPAE). The WG plans to organize a workshop on non-LTE and continua problems in mid 1987. A. Barbe was nominated as co-chairman by the Ozone Commission. The IRC agreed to establish this WG. In a closed Commission meeting R. Zander was appointed chairman of the WG.

G. Stephens urged by telex to establish a WG on Clouds and Radiation jointly with ICCP to organize a symposia on Cloud Physics and Radiation in 1988. The IRC hesitated to establish the group at once because of a lack of information.

At the business meeting in Honolulu it had been planned to establish one WG concerned with the Earth Radiation Budget at the top of the atmosphere (proposed by T. Vonder Haar) and another one for the surface (proposed by G. Ohring). After discussions and contacts during the last year it was decided to combine both WGs under the Co-Chairs T. Vonder Haar and G. Ohring. They were requested to prepare joint terms of reference and a working program.

Vancouver, USA, (IUGG) 1987

At the beginning of the year 1987 President Lenoble circulated a summary of the IRC work since the meeting in Toulouse in which she highlighted the following events:

- Several members of the IRC visited the Beijing International Radiation Symposium (BIRS) which for several participants was the first time to meet Chinese colleagues.
- The International Geosphere-Biosphere Programm (IGBP): A Study of Global Change was launched at ICSU's General Assembly in Bern, Switzerland.
- A first International AVHRR workshop under IRC auspices was held in Melbourne, Australia.

In Vancouver, the President opened the business meeting with a commemoration of F. Luther, D.

Deirmendjian, and R. Preissendorfer who died since the last business meeting.

The President then continued with a statement on the value and importance of the IRC as an independent means of bringing pressure to bear on scientific decision makers and recalled basic principles concerning membership and working groups:

- A Working Group is established for a limited duration with a well defined task and must provide a written report every year.
- The chairperson of a Working Group is an "ex officio" member of the IRC. This means
  - if a chairperson is chosen from outside the IRC, she or he becomes automatically a member;
  - the same is applicable when the chair is changed at the request of the WG (although this has to be approved by the IRC);
  - when a WG is disbanded the chairperson ceases from being an IRC member, unless regularly elected;
  - the WG should be limited to one chairperson each, an exception to be made in particular cases.
- The members of WGs may or may not be members of the IRC. As soon as the WG is established a membership list must be drawn up (the number of members is not limited). WG members are responsible for informing the rest of the community of their activities. All those, who contribute to the WGs should become full members of those groups. The membership list should be revised every two years and those members be asked to step down who have not participated or contributed during that time.
- All reports and publications must have the agreement of all participants and the approval of IRC Officers before submission. Reports published by WMO must be edited before submission by the chairperson and must contain a complete list of all members of the WG. In publications in journals all authors must be named with their affiliation, i.e. IRC, IAMAP/WG.

D. Deirmenjian who developed aerosol models for typical atmospheres

Details of the WG reports were this time given in an Annex. But in the minutes it was recorded that the WDC WG was disbanded, and that the terms of reference of the Cloud-Climate Sensitivity WG were limited from a full treatment of cloud-radiation physics to cloud-climate sensitivity only.

At the meeting in Toulouse the proposal had been made to set up jointly with the Cloud Physics Commission a WG on Clouds and Radiation. This was now endorsed and G. Stephens was elected chairman of the group. G. Paltridge put forward a proposal for an AVHRR working group but the Commission agreed for the time being only to co-sponsor a second AVHRR workshop. G. Fiocco suggested that the Commission should form a WG on Radiation in Polar Regions.

The CACGP launched an initiative to create an International Global Atmospheric Chemistry Program (IGAC). H. Fischer was asked to continue to attend planning meetings on behalf of the IRC.

ISLSCP was developing well. In France and the USA experiments on land-surface properties are conducted and also in other countries experiments are planned.

Lille, France, (IRS) 1988

In Lille the IRC again had three business meetings of long duration with up to 50 attendees.

An important decision was made with respect to the election of new members: To ensure a stronger participation of radiation scientists, J. London proposed to elect the IRC officers and members in the future at the Commission Symposia and not at the IUGG meeting. This proposal was accepted and the next election date be fixed at 1992.

Richard Goody was elected Honorary Member of the IRC by an unanimous vote of the Commission following a recommendation of J. London.

The work of the WGs was thoroughly reviewed and discussed.

The ITOVS group had made important contributions to the implementation of vertical soundings in

weather prediction models and anticipated a full report, covering the science of sounding, software, and application to weather prediction. Its chairman, A. Chedin, nevertheless identified a long term task because the demand for higher accuracy will continue with forthcoming missions such as AMSU, TIROS NEXT, EOS. He proposed that the Commission should support a recommendation to IAMAP that a combined microwave and IR microwave sounder should be placed on future operational Meteosats. This issue was discussed with the result that A. Chedin was asked to bring forward a written draft recommendation.

A. Chedin and N. Scott gave verbal introductions to their written reports on the work of the WG and the results of a recent symposium. The initial task of the ITRA group was completed but the Commission decided that in view of future programs the group should continue with extended objectives.

Upon recommendation of its chairman, G. Ohring, the ERB group was disbanded because it was duplicating the work of other groups. E. Raschke was asked to serve as rapporteur on ERB matters of the joint JSC-IRC-WMO group on radiation fluxes chaired by T. Vonder Haar.

Also the ICRCCM group had completed its initial task, the comparison of radiation transfer codes. Its chairman, R. G. Ellingson, proposed a second phase to provide for WCRP a library of line-by-line test cases, periodically update assessments for climate research, and specifications for measurement requirements. Furthermore, for IRC, line-by-line calculations should be compared with climate models and ERB data, band models should be intercompared, and other greenhouse gases then CO_2 should be studied. This was accepted by the Commission.

A discussion arose about the WG on Cloud Climate Sensitivity. Its chairman, G. Ohring, suggested to wind up the group because of duplication of the work of other groups but A. Arking disagreed and came forward with an own report. On the basis of this report the Commission decided to continue the group.

The Commission was very satisfied with the work of the Atmospheric Spectroscopy Applications group under its chairman R. Zander and recommended its continuation and appealed to funding agencies to support the work.

The IACP group chaired by A. Deepak constituted five sub-groups and was now in the process to form a sixth one on stratospheric aerosol. A IACP “Report 88-2" was submitted to IGBP under the title: “Global Aerosol Climatology and Effects Programme (GACEP): A Plan Outline.

McCormick, the chairman of ICLAS highlighted the recent International Laser Radar Conference and announced that the next meeting will be in Tomsk, USSR (1990). The membership of the group had been revised.

G. Stephens, chair of the Clouds and Radiation group, jointly with A. Heymsfield (NCAR), explained that its major and successful aim is is to bring together cloud physicists and radiation specialists.

The Rapporteurs informed the Commission about other ongoing international activities. H. Fischer reported that a meeting proposed by ICACGP is planned in Melbourne to consider the future programme of the International Global Atmospheric Chemistry Programme (IGAC). J. London suggested that a more appropriate way forward would be to create an IAMAP WG with ICACGP, IRC and other interested Commissions on this topic. This proposal was to be presented to IAMAP at the Reading meeting in 1989. E. Raschke reported on ISCCP and drafted a recommendation to IAMAP suggesting a continuation of ISCCP and the importance of validation. A short report was telexed by M. Platt on the Cloud Base Measuring Programme.

The suggestion to found a new WG on AVHRR was turned down because the Commission questioned the need to have a working group dedicated to a specific instrument. The Commission also decided to postpone the decision about a WG on Radiation in Polar Regions until the Secretary has consulted the Committee on Arctic Research and the Commission on Polar Meteorology about this matter. The Commission took note of a suggestion of D. Crommelynck that radiation divergence represented a basic topic across many subjects and microscale radiation divergence might be a future topic.

Information was also presented on ISLSCP, IGBP, COSPAR, GEWEX and the International Ozone Symposium. ISLSCP had published a brochure about its research goals. M.-L. Chanin noted that a proposal was submitted to IGBP on Middle Atmospheric Responses to Changes (MARC). Four symposia of COSPAR had been supported by IRC at its meeting in Finland including one on microwave remote sensing and one on the middle Atmosphere after MAP. With respect to the WCRP M.-L. Chahine noted that there were no formal links yet between IRC and GEWEX, but that this new sub-programme is dealing with energy fluxes and water distribution, model development for prediction of the distribution of water

energy fluxes as well as the development of remote sensing and surface measurement capabilities.

At the International Ozone Symposium tropospheric ozone as well as the polar ozone problem had emerged as important issues. Its chairman G. Megie mentioned also that the IOC discussed the establishment of a WG on the impact of trace gases on climate. IRC recommended to make a joint proposal from IRC, IOC, and the Climate Commission on this topic in Reading, 1989.

From this time on the situation of the working groups became more consolidated and this historical outline should be complemented by those of each individual working group. Because of the huge amount of knowledge accumulated by the WGs due to their entrainment into large global programmes this would blow up the frame of this document. Consequently, the reports about the WGs are kept short here.

Reading, UK, (IAMAP) 1989

At the business meeting during the IAMAP Symposium at the University of Reading primarily the reports of the Working Groups were considered.

A. Chedin reported that a marked increase of interaction between TOVS and forecasters have been noted. In June 1989, a successful workshop of the WG on International TIROS Operational Vertical Sounder (ITOVS) had been held, with 75 participants from 25 countries. Four sub-working groups had been set up on the following subjects: Quality of TOVS Products, TOVS Applications, Algorithm Review, and Future Instrumentation.

A. Chedin as well reported on the progress of the WG on Intercomparison of Transmittance and Radiance Algorithms (ITRA). Three sub-groups had been maintained during the year focussed on Nadir, Limb Sounding, and Microwave Observations. For each group a number of observational data sets had been identified.

A written report of the WG on Atmospheric Spectroscopy Applications (ASA) had been submitted by R. Zander containing the announcement of the second ASA Workshop to be held in Moscow in 1990. It was noted that the ASA WG ought to focus on basic problems of atmospheric spectroscopy, since applications were dealt with by several other groups.

T. Von der Haar reported about a meeting of the Joint JSC - IRC - WMO Group on Radiation Fluxes which was held in December 1988. New members for the Group were being sought.

P. McCormick reported on the work of the International Co-ordinating Group on Laser Atmospheric Sensing (ICLAS). The group published the 2nd edition of the LIDAR researchers Directory (August 1989). Plans for the next LIDAR conference were moving forward: this would be the 15th International Laser Radar Conference, to be held in Tomsk, Siberia, USSR, July 23-27, 1990. The LITE project, to be flown on Shuttle in May 1993, had passed a Critical Design Review in April 1989, which confirmed the design of a 3-wavelength LIDAR experiment.

R. G. Ellingson reported and presented the written report of the WG on International Comparison of Radiation Codes in Climate Models (ICRCCM). No further WG meetings had been held since the last report, but activities continued into the 2nd phase, to obtain data to validate radiation models.

A. Deepak reviewed the activities of the WG on the International Aerosol Climatology Project (IACP) since its formation in 1987, and submitted a written report. L. Stowe reported on a planned meeting of its Sub-Group 4 to discuss space measurements of aerosols.

On behalf of the WG on Cloud Climate Sensitivity, A. Arking submitted a paper to the Commission, giving a status report on the sensitivity of model climate predictions to assumed cloud models. A special symposium was being organised to highlight the cloud-climate problem. Commission members felt the paper to be most valuable, and suggestions were made as to its publication as an IRC or as a WCRP/IRC document.

No report was obtained from the WG on Clouds and Radiation.

M. Platt submitted the written report on the Experimental Cloud Lidar Pilot Project Study (ECLIPS) to which A. Chedin added that the TOVS WG might wish to add a member to this group. It was also suggested that the Commission should ask G. Fiocco to comment on the ECLIPS proposal. W. Smith suggested that ground based passive spectrometers should be better co-ordinated with the active sensors.

H. Fischer, acting as rapporteur to the IRC for the International Global Atmosphere Chemistry Programme (IGAC), presented a report of this approved core project of the International Geosphere-

Biosphere Programme (IGBP).

IRC rapporteur E. Raschke submitted the written report on the International Satellite Cloud Climatology Project (ISCCP). In this connection he also raised the question of the formation of a new Working Group, tabled 'Intercommissions Working Group on Climatic Impacts of Trace Constituents', of which a written description was submitted. It was agreed to establish a group temporarily under the Chairmanship of J. London, for one year, and to receive a progress report at the COSPAR Assembly in the Hague.

Beside the reports of the WGs the President reported that T. Vonder Haar had submitted his resignation as Vice President, due to pressures of other work. The Commission recorded its thanks to T. Von der Haar for his contributions.

As new VP and Secretary J. E. Harries and W. L. Smith were elected. These appointments will terminate at the same time as the Presidency, in Summer 1992.

Tallinn was accepted to host the next IRS.

Den Haag, The Netherlands, (COSPAR) 1990

The Business meeting during the COSPAR Assembly was probably one of the most informative one. IRC Secretary William L. Smith wrote, as in the following years, detailed minutes and added fourteen Appendices with additional information. At the end he wrote: "The meeting closed at 7:30 p.m. with adjournment to a local Italian restaurant for an enjoyable dinner." The Commission received a complete overview of the work of the WGs and ongoing global as well as topical research programmes.

A. Chedin reported that the Technical Proceedings of the 5th ITOVS meeting held in Toulouse are published and available. LMD (Paris) and CIMSS (Madison) have formulated a common policy regarding TOVS software distribution for their products ITPP (CIMSS) and 3I (LMD). The software will be distributed to research institutions for an initial fee of $ 3000. Updated versions will then be provided for $ 1000.

He also reported that under the WG on Intercomparison of Transmittance and Radiance Algorithms (ITRA) a valuable data set has been assembled by the Nadir and Microwave Subgroups. It consists of high spectral resolution Interferometer Spectrometer (HIS) and Microwave Profiler data obtained during the Ground-based Atmospheric Profiler Experiment (GAPEX) performed during October 1989 in Denver, Colorado. The infrared radiance spectra and seven spectral channel microwave brightness temperature data are tabulated together with Crosschain Loran Atmospheric Sounding System (CLASS), balloon-borne temperature, water vapour, and wind data, Radar Acoustic Sounding System (RASS) temperature profiles, and operational weather service radiosonde data. The ground- based data set is to be supplemented by several sets of HIS and microwave radiance spectra collected from the NASA ER 2 aircraft at a pressure altitude of 55 mb in order to be able to verify transmittance and radiance computation algorithm with both upward and downward propagating radiance data.

A written report had been submitted by R. Zander of the WG on Atmospheric Spectroscopy Applications (ASA). Over 50 scientists participated in an ASA workshop in Moscow and presented papers on atmospheric spectroscopy and data bases for atmospheric remote sensing. The meeting concluded with an open discussion about how to best enhance the efficiency of ASA in its key areas. R. Zander suggested to step down as chairman of ASA with L. Rothman replacing him. This was approved by the Commission and J. Lenoble thanked R. Zander for his excellent leadership.

A. Deepak was not present but L. Stowe presented the activities of the International Aerosol Climatology Project (IACP) on which a written report was available. The WG formed a sub-group on the Global Aerosol Data Base Development chaired by R. Husor. The plan for the International Global Aerosol Program (IGAP) presented at the meeting in Reading, 1989, was updated and made available to the Commission. Two Experts meetings have been conducted, one on stratospheric aerosols measurements, properties and effects, and the other one on Space Observations of Tropospheric Aerosols and Complementary Measurements. Additional workshops of IACP include the topics: Global Aerosol Data System (GADS), Interactions Between Aerosols and Clouds, Physics and Chemistry of Aerosols, and General IACP Workshop on IGAP (IUGG, Vienna 1991). A disturbing information was that NOAA planed to discontinue its program on surface turbidity measurements of aerosols. Because these

measurements are a crucial component of the global aerosol data base, President Lenoble, following a suggestion of G. Ohring, agreed to write a "letter of concern" to NOAA on behalf of the IRC. A lively discussion followed. J. London proposed that the Air Force Geophysical Laboratory (AFGL) might be willing to act as the archive center for the global aerosol data base with electronic data management accessibility by IACP, NOAA, and other users. J. Lenoble suggested that the cloud and global aerosol data bases need to be brought together for the study of the climate effects of cloud/aerosol interactions. A further discussion of these issues was planned for the next IRC Business Meeting to be held at the IUGG in Vienna.

It was noted that there had been no report of the WG on Clouds and Radiation for the past two years. After considerable discussion it was resolved that this group should be reformed taking on the added responsibility of the IRC representation on the Joint JSC/IRC/WMO Group on Radiation Fluxes. Furthermore, that G. Ohring replaces G. Stephens as Chair of the Clouds and Radiation Working Group.

G. Ohring, who is one of the IRC representatives on the Joint JSC/IRC/WMO Group on Radiation Fluxes then led a discussion on the activities of this group, which met in Ft. Lauderdale, Florida. Topics are presently *inter alia* ISCCP results and GEWEX plans. Under the leadership of J. Deluisi a plan for the establishment of a Global Baseline Surface Radiation Network (GBSRN) of 20 - 30 stations was developed. W. Smith proposed exploring the possibility of including measurements of downwelling infrared spectra with high spectral resolution now available with low-cost Fourier transform interferometer technology.

The major activity of the International Coordination Group on Laser Atmospheric Sensing (ICLAS) was to ensure the organization and implementation of the 15th International Laser Radar Conference in Tomsk, July 1990. Other items reported by M. P. McCormick were: WMO published a report on "Aerosols, Clouds, and Other Climatically Important Parameters: Lidar Applications and Networks" (WCRP-9, WMO/TD-No. 233, May 1988). An Experimental Cloud Lidar Study Program (ECLIPS) has been formed in which 11 groups cooperate worldwide (WCRP-14, WMO/TD-No. 251, September 1988). The development of the shuttle-based NASA LITE (Laser in-Space Technology) continues on schedule.

On behalf of the Rapporteur for ECLIPS, M. Platt, who could not attend, W. Smith added some information on this item. ECLIPS had successfully conducted a field program in October-December 1989. Its results were made public at the meeting of the Optical Society on remote sensing at Lake Tahoe, early 1990. The discussions about another field campaign in 1991 took place in relation to FIRE, ICE, and SPECTRE.

The Rapporteur for ISCCP, E. Raschke, had submitted a written report in which he also pointed at the interactions between various activities. He stated that ISCCP's operational activities are in a good shape, its Data Management WG is now also taking care of the Global-SRB-Project which is centralized at NASA-LRC and plans a JSC sponsored workshop on "Sea Ice and Surface Radiation Budget" in Bremerhaven, Germany. J. London added that a two-day workshop on ISCCP is planned in September in New York.

R. G. Ellingson submitted a written report on behalf of the WG "International Comparison of Radiation Codes in Climate Models (ICRCCM) in which he drew the attention of the IRC at the Spectral Radiation Experiment (SPECTRE) by which a number of the problems uncovered by IRCCM and ITRA will be addressed. The experiment will take place as part of FIRE Cirrus II in Kansas, fall 1991. R. G. Ellingson and Y. Fouquart, the co-chairs of ICRCCM, developed a format for radiation flux calculations which should facilitate the intercomparison of results of radiative transfer modellers.

A. Arking, the chair of the WG on Cloud Climate Sensitivity, informed the IRC that a revised version of his report presented in Reading has been submitted to the Bulletin of AMS for publication.

The International Global Atmospheric Chemistry Program (IGAC), was launched as part of IGBP in 1989. In his report about the program H. Fischer noted two publications describing the activities of the programme: "International Global Atmospheric Chemistry Programme. A Plan for International Cooperation During the Next Decade" and the IGAC Newsletter recently launched as a regular communication chanel for atmospheric chemists concerned with global problems.

J. London reported on the activities of the IAMAP Intercommission Working Group on Trace Constituents (CITC) since its formation a the IRC Business Meeting in Reading, UK, summer 1989. The terms of Reference of the group were developed and finalized at the groups first meeting here in Den Haag. A second meeting is planned for the Radiation and Cloud Physics Symposium to be held in San

Francisco during July. A major initial activity of the CITC is the preparation of model atmospheres of the various trace constituents. This and similar activities require close collaboration with other groups of related interest, particularly the International Satellite Greenhouse Gas Project (ISGGP) which was planed during the COSPAR Assembly by representatives of COSPAR Sub-commission A-2, WMO, ESA, ISY, and CITC.

Short information was given by R. G. Ellingson about the Atmospheric Radiation Measurement (ARM) Program which was being developed by the US Department of Energy (DOE) following an initiative of US scientists involved in ICRCCM and ITRA. NATO was going to sponsor a course on "Atmospheric Radiation and Climate Change" under the leadership of J. Deluisi to be organized in Europe. P. Simon summarized the activities related to the International Geosphere-Biosphere Programme (IGBP). H.-J. Bolle had submitted by mail an extensive report on the status of ISLSCP. M. Chahine provided an overview of the Global Energy and Water Cycle Experiment and the planning of an Continental Scale Project from 1991-1997 in the U.S. with the objective of validating macroscale hydrological/atmospheric models of energy and water cycles over extended land areas with *in-situ* and satellite data.

Finally, John Harries proposed that the "History of the IRC" originally prepared by the deceased past president F. Möller be brought up to date. J. London proposed that this be done through contributions from the various Presidents of the IRC since Möller and agreed to organize the effort.

Vienna, Austria, (IUGG) 1991

The business meetings in Vienna were opened with the sad message that O. Avaste passed away recently. The President suggested that the next meeting be dedicated to him in his honor.

Beside the planning of the Symposium in Tallinn, 1992 and the reports of the WGs there were only few business items. J. London was appointed to chair the nominating committee to recommend new members and officers for the IRC. NASA Langley extended an offer to sponsor IRS '96 in Williamsburg, Virginia. The radiation measurement archive in Leningrad has recently been compiled. H.-J. Bolle noted that A. Ohmura uses the archive to study the global radiation budget at the surface and suggested to invite him to report to the IRC about his results. H.-J. Bolle also suggested that the past years' achievements of the IRC WGs be published. This sugestion was tabled to the next meeting to give the president the time to discuss this matter with the chairs of the WGs.

The reports of the WGs were distributed as appendices of the minutes and only shortly commented in the minutes itself.

Adarsh Deepak jointly with Gabor Vali presented the complete report of the IACP WG and proposed the dissolution of the group because its task to develop an implementation plan for the International Global Aerosol Program (IGAP) was done. The recommendation to establish (for one year) a WG IGAP on the implementation of the plan was unamimously approved by the Commission and P. McCormick and R. Jaenicke were appointed to co-chair the group.

E. Raschke reported on ISCCP and its relevance for GEWEX and the Polar Radiation Budget. He noted that more validation by research groups is necessary.

The WG CITC held a workshop in Vienna as J. London reported. He sugested to continue the WG as an inter-commission (ozone, chemistry, climate, clouds, and radiation) WG (IWGCITC) and that R. G. Ellingson be the IRC representative. An extensive "Summary Report of the IUGG/IAMAP Workshop MW5: Climatic Effect of Atmospheric Trace Constituents" (Vienna, 19-20 August, 1991) is attached to the minutes.

G. Ohring announced that the ICCP/IRC WG on clouds and radiation, formed in January 1991, holds its first meeting in Vienna. He also reported that the meeting of the JSC/IRC/CAS

Olev Avaste, Head of the Chair of Geophysics at the University of Tartu

Joint WG on Radiation Fluxes planed for January had to be shifted to later this year because of the Gulf War.

The meeting of the Joint WG on Radiation Fluxes (WGRF) was held in September in Palm Springs. An impressive structure had been set up for this radiation-climate oriented component including an own WRCP Radiation Projects Office (R. Schiffer). The report of the meeting in Palm Springs was attached to the minutes of the IRC business meeting. Many ideas developed within the IRC has been implemented:

- Surface Radiation Budget Projects and Related Programmes
  - development of the WCRP Surface Radiation Budget Climatology Project (SRB)
  - implementation of the WCRP Baseline Surface Radiation Network (BSRN)
  - planning and status of the Experimental Cloud Lidar Pilot Study (ECLIPS)
  - US Department of Energy Atmospheric Radiation Measurements Programme (ARM)
- Top-of-the-atmosphere Earth Radiation Budget
  - Status report on ERBE and planning of CERES
  - The ScaRaB project
  - Survey of recent Earth radiation budget results
- Cloud/radiation observational studies
  - International Satellite Cloud Climatology Project (ISCCP)
  - Requirement for a Global Water Vapour Climatology Project
  - Proposed studies: cloud observations from operational satellites, dedicated satelites for monitoring clouds, radiation, and aerosol, new approaches to remote sensing of clouds
  - Toga Coupled Ocean-Atmosphere Response Experiment (TOGA-COARE)
- Clouds and radiation in climate models
  - Recent developments in modelling cloud and radiation in climate models
  - Comparison of observed and model simulated seasonal cloudiness variations
  - Intercomparison of Radiation Codes in Climate Models (ICRCCM) - including plans for a spectral radiance experiment
  - Polar surface radiation fluxes and sea-ice modelling
  - WCRP Symposium on clouds and climate
- Aerosols, cloud condensation nuclei and climate

The report on Cloud Climate Sensitivity of A. Arking was published in the WRCP Tech series as well as an article in BAMS.

The ITOVS group proposed new chairpersons: John Eyre and Michael Uddstrom. This was approved by the Commission. An extensive report containing 18 items had been submitted in which *inter alia* concern about the progress of the ATOVS software development was expressed.

The ITRA WG, so far led by A. Chedin, elected N. A. Scott as new chair which was approved by the Commission.

For ICRCCM R. G. Ellingson sumarized the completed tasks and resulting publications and provided details of the SPECTRE project.

P. McCormick presented a written report of the ICLAS in which he mentioned that the Pinatubo eruption has served to increase communication between lidar groups worldwide.

The ECLIPS activities were reported by M. Platt. Co-chair R. G. Ellingson gave the report of ICRCCM, and the IGAG activities were summarized by H. Fischer.

Tallinn, Estonia, (IRS) 1992

As decided in 1988 the first time elections took place at the occasion of the Radiation Symposium. The change of membership and of officers is, as always, documented in Appendix 2 and Table 3 respectively. Beside organisational questions about forthcoming meetings and a few announcements the main task of the business meeting was again the review of the reports of the WGs.

On behalf of the chairs of the group, J. Eyre submitted the draft document "International TOVS Working Group: A Strategy for the 1990's" and solicited the views of the commission. Of particular importance to the Commission is the proposal to change the status of the ITOVS-WG to that of a working group of the WMO Commission on Global Meteorological Satellites (CGMS). The IRC members felt that

this change of status was appropriate and would support this change if approved by the ITOVS-WG members at its next meeting in February, 1993, and the CGMS. Once this change of status takes place, the ITOVS-WG would cease to exist as a working group of the IRC but it was felt that the IRC should have an official representative who would report on the CGMS/ITOVS-WG activities at future IRC business meetings (in fact, the TOVS group remained in existence beyond 1993).

Secretary W. Smith noted that the next International TOVS Study Conference (ITSC-VII) will be held in Igls Austria, February 1993. Emphasis will be given to improved processing algorithms, applications to climate and global change studies, and preparations for ATOVS.

N. Scott summarized the structure and activities of the ITRA working group, including the Helsinki workshop held just prior to this Tallinn IRC-92 symposium. N. Scott wished to acknowledge the important support provided by Dr. Sakkari Uppala of the Finnish Meteorological Service for handling all the local arrangements for the highly successful Helsinki meeting. A major conclusion of the Helsinki ITRA workshop was the need to expand the current data set to include SSMI observations to cover the low frequency end of the microwave spectrum. There is also consideration for ITRA to evaluate the performance of very fast transmittance models (e.g., the RITOVS) being used to process spectral radiances from current satellite radiometers and airborne interferometers (e.q. TOVS and HIS) and possibly future advanced satellite sounders (e.g., AIRS, IASI, and ITS). N. Scott noted that the ITRA-WG is working towards the publication of its results in a major journal.

R. G. Ellingson provided both a written report and an oral summary of the activities of the International Committee for Radiation and Clouds for Climate Models (ICRCCM). He noted that there has not been a formal working group meeting since Vienna 91 but that the working group members have participated in a major field campaign called SPECTRE. Ellingson noted that a workshop was to be held early next year to discuss the SPECTRE results. A workshop report of the sensitivity of radiation flux calculations to trace gas concentrations was published in the Bulletin of the AMS (BAMS), June 1992 issue.

President Lenoble asked whether the ICRCCM-WG should be continued as an independent entity or combined with the ITRA and ASA. There was general support for the consolidation of the three working groups into a single body and the working group chairs Ellingson, Zander, and Scott were given the task of developing a plan for future consolidation.

G. Ohring submitted a written report of the Clouds and Radiation activity and noted that there are five formal members of the working group with approximately twenty other scientists participating in the planning activities. Working group activities include the organization of sessions at the IRC- Tallinn, ICCP-Montreal and the International Workshop on Cloud-Radiation Interactions and Their Parameterizations in Climate Models - Princeton, N.J. (April 93).

E. Raschke presented an oral report on the current status of ISCCP. In particular, he noted the need for a detailed study of all available cloud and radiation climatologies with the objective of publishing a report stating their characteristics and where they can be accessed. A working group was established under his leadership to conduct the study which will be reported at the next business meeting at Yokohama, Japan in July, 1993.

R. McClatchey, on behalf of ICLAS, provided an oral report on the activities of the International Coordination Group for Laser Atmospheric Studies (ICLAS). He noted the 1992 meeting held at MIT where discussions focussed on Mt. Pinatubo, Clouds, Moisture, as well as LIDAR and spaceborne LIDAR concepts. R. McClatchey noted forty five poster presentations on these topics. The next meeting is proposed to be held in Japan during 1994.

President Lenoble summarized the ECLIPS Experiment report provided by M. Platt. Noteworthy are the ECLIPS workshops held, participation in TOGA COARE, and the participation in ECLIPS II.

L. Rothman reported that the Atmospheric Spectroscopy Association (ASA) will hold a three day meeting in France with a continued focus on spectroscopy ranging from the ultraviolet throughout the microwave region of the spectrum. In particular four areas will be discussed; (1) Data Bases, (2) Non-LTE Processes, (3) Continua, Line Mixing, and Line Shapes, and (4) Atmospheric Measurements .

H. Fischer reported on the International Global Atmospheric Chemistry Programme (IGAC) which became a core project of IGBP. The first IGAC Scientific Conference will take place in Eilat/Israel between 18 April and 22 April 1993. Conference foci are regional as well as global studies and fundamental laboratory investigations. One of the IGAC projects related to scientific work within the IRC is GLOCHEM (Global Atmospheric Chemical Survey). The goal is to establish a global picture of the

spatial and temporal distributions of key chemically reactive species and photochemically active solar radiation. In 1991 a preliminary program has been drafted containing chapters on stationary surface measurements, ship-borne observations as well as aircraft and satellite measurements. National research programs are in a planning status.

R. G. Ellingson presented a written report and an oral summary of the Trace Gas Working Group activities. He noted his work with W. C. Wang to identify trace gas related topics of mutual interest to the Ozone and Radiation Commissions including the intercomparison of line-by-line and band model calculations. The SPECTRE data set which provided ozone sondes and flask sample profiles of CO_2, CH_4, N_20, CO, F11 and F12 has been identified as a basic data set for use by the working group. J. London noted that the Trace Gas working group was originally established to provide (1) a trace gas concentration climatology and (2) results of model calculations.

No report was available of the International Global Aerosol Program (IGAP)

A discussion took place about the Global Energy Balance Archive (GEBA) which was presented by A. Ohmura. The archive, developed under the World Climate Research Program (WCRP), is summarized in two reports:

1. Global Energy Balance Archive GEBA. World Climate Program-Water; Project A 7. Report I: Introduction, 62 pages with 15 figures and 5 tables, 1989. ISBN 37281 16793; and
2. Global Energy Balance Archive GEBA. World Climate Program - Water; Project A7 Report 2: The GEBA Data Base: Interactive Applications, Retrieving Data. ISBN 3 7281 1859 I.

Global Radiation at stations in Europe exist since 1922 and there are over 150,000 station-months available. The data are available to Climate Modellers and other researchers via Electronic Mail.

It is interesting to recall that the Sub-commission on Applied Solar Energy in 1959 discussed "to arrange for the preparation of a bibliography of and for the collection and analysis of solar radiation data an a world-wide scale" but did not succeed at that time because of a lack of funds to start the work.

J. London furthermore noted that fifty years ago a network of instruments was established for measuring the ultraviolet radiation reaching the ground. Today, because of the increased UV health hazard resulting from decreased ozone, it is important to monitor UV-B radiation reaching the ground. It was suggested that a new Working Group be formed to deal with this problem. P. Simon agreed to organize an interim working group under his chairmanship. The working group will prepare proposals to IAMAP to look at instruments, scientific programs, networks, etc. to deal with the UV-B radiation monitoring and warning problem.

At the end J. London raised the problem of an excessive number of "no-shows" at the IRC Symposium in Tallinn. It was suggested (by W. Smith) that this might be avoided by requiring that a portion of the registration fee be paid prior to the scheduling of the presentation in the meeting program. There was general support for this proposal.

Yokohama, Japan, (IAMAP) 1993

President Harries sugested that a leaflet be prepared to explain the charter of the IRC. This leaflet would be helpful to inform new members and agencies supporting its meetings and working group activities.

WG reports, partly written, were available for ITOVS, ICRCCM, Clouds and Radiation (JWGCR), ISCCP, ICLAS, ECLIPS, Trace Gases, WCRP WG on Radiative Fluxes, and WVCR.

The focus of the last ITOVS meeting in Igls, Austria, was on climate application of TOVS data rather than of retrieval methodology. Also discussed were new versions of the International TOVS Processing Package (ITPP-5), the 3I processing package, and their applications to the forthcoming improved TOVS with the AMSU on NOAA K, L, and M satellites. Considerable progress was also reported on the direct assimilation of TOVS radiances in the numerical weather analysis/prediction process with consistent positive impact of the data being demonstrated for both hemispheres. The next ITOVS WG meeting is planned for New Zeeland in 1995.

Improvements of the water vapour retrievals are to be achieved from a combined SSM/I (ocean) and TOVS (land) system combined with NMC global analysis products, reported the WVCR WG. A cloud radar is being planned for the TRMM2 mission as defined at a recent workshop at JPL.

Also the WG on Clouds and Radiation was working on the parameterization of cloud-radiation interactions in climate models.

The written report of the Trace Gases WG noted that there was considerable interest in including model intercomparisons for methane and nitrous oxide in addition to ozone, the original charge to this working group.

ISCCP is reprocessing the 1983-1993 data set with improved algorithms. E. Raschle sugested that an ISCCP results session be sponsored by the IRC for the IUGG meeting in Boulder, 1995.

This point was treated in more detail in the extensive report provided by T. Charlock on the activities associated with the WCRP. The version 2 of the ISCCP data set is forthcoming with charges in the processing procedures regarding polar clouds and cirrus, improvements in the calibration, and the alleviation of the scan angle bias. Two algorithms for estimating the surface radiation budget from ISCCP data are being intercompared. One of these will be selected for future processing. There is also good progress on the enhancement of the Baseline Surface Radiation Network (BSRN). Considerable attention is given to improved longwave radiation instruments.

A. Chedin proposed that a new working group on “High Spectral Resolution Remote Sensing for Weather and Climate Studies” may replace the ICRCCM, ASA, and ITRLA WGs. He was requested to solicit the support of the chairs of these groups before coming to the IRC with a formal proposal at its next meeting in Hamburg, 1994.

Hamburg, Germany, (IAMAP) 1994

At the Business meeting in Hamburg the following reports of the WGs were received:

J.Eyre and M. Uddstrom submitted a written report of the activities of the International TOVS Working Group (ITWG). They noted that the ITWG should retain its status in relation to the IRC and will interact more strongly with WMO. Three members of ITWG (LeMarshall, Menzel, and Eyre) have been appointed as "Rapporteurs on Soundings" of the new WMO CBS Working Group on Satellites. The next conference ITSC-VIII will be held in Queenstown, New Zealand, 5 - 11 April, 1995.

Noelle Scott reported that the ITRA WG is now analyzing results from twenty-three scientific groups from eight countries. She noted that there have been no formal meetings of ITRA since the 1992 Helsinki meeting but that numerous informal meetings are continuing. ITRA will sponsor a symposium “Spectroscopy and Radiative Transfer” at the IUGG-'95 meeting in Boulder, Colorado.

R. G. Ellingson reported that no ICRCCM international working group meetings were held during 1993-94, but that a U.S. member meeting was held October 28, 1993, at the University of Maryland. He noted that a joint ICRCCM-ITRA workshop would be held at the University of Maryland in January 1994 to discuss comparisons of calculations with observation obtained during SPECTRE. An e-mail to participants of the SPECTRE intercomparison study which explains this activity is included in Ellingson’s written report.

A. Barbe and L. Rothman reported that the main focus of the WG on Atmospheric Spectroscopy Applications was on the third conference of ASA held 8 - 10 September, 1993, at Reims, France. The proceedings will be published in a special issue of the Journal of Quantitative Spectroscopy and Radiative Transfer.

M. Platt submitted an extensive report of international activities in the field of Clouds and Radiation. He highlighted activities of the FIRE, ASTEX, GEWEX, ARM, ECLIPS, JACCS, LITE, and SOCEX programs. His report provided an excellent survey of C & R activities underway around the world. George Ohring noted that a major WG activity was the International Workshop “Cloud Radiation Interactions and Their Parameterization in Climate Models” held in Washington, D.C., during October, 1993. He noted that a complete workshop report has been prepared and is to be published as a WCRP report.

E. Raschke informed the IRC about activities of the ISCCP and noted that radiation budget components computed from the ISCCP data are in close agreement with those derived from ERBE data. Improvements in the interpretation of ISCCP data are being made through the use of 6.7 μm water vapor band measurements now available from all geostationary satellites being used for ISCCP. He also noted a symposium entitled “Clouds, Convection, and Land Surface Processes”, to be co-sponsored by the IRC at IUGG-'95.

A. Omura presented an overview of the Baseline Surface Radiation Network (BSRN) at the World Climate Research Program (WCRP). He noted that considerable progress has been made in the area of IR

measurements. The target accuracy of 10 Wm^{-2} had been achieved. Efforts are now underway to push this limit of accuracy to 3 Wm^{-2} to permit the detection of the growing "Greenhouse Effect".

Short presentations of new developments in the DOE-ARM, GOES-8, the ERS-1, and VARS were presented by Ellingson, Smith, and Harries, respectively.

Knute Stamnes offered to be the host and the primary organizer of the venue for IRS '96 in Fairbanks at the University of Alaska. He highlighted that this would be an ideal location for this next IRS considering the new research focus on polar radiation processes and the forthcoming SHEBA measurement program planned for the north slope of Alaska beginning in 1997. Fairbanks was unanimously approved for the next International RadiationSymposium to be held in August, 1996.

President Harries reported that he is working on a leaflet describing the activities of the IRC.

Boulder, USA, (IUGG) 1995

The minutes of the business meeting reflects that the Commission was intensively discussing the work of their WGs though not all of them reported at the meeting in Boulder.

W. Smith provided an overview of the development in the vertical sounding area (ITOVS). The TOVS Study Conference - VIII had been held in Queenstown, New Zealand. Recommendations regarding the new ATOVS, direct assimilation of radiances in NWP, and the advancement of high spectral resolution infrared sounders were noted.

G. Ohring presented a written report of the WG on Clouds and Radiation. At the same time he suggested that a new WG be formed which includes aerosol-radiation as well as well as clouds and radiation (see below).

E. Raschke reported on ISCCP activities and noted that the Working Group on ISCCP should continue for at least five more years. A parallel effort will begin to produce ISCCP data sets at higher space and time resolution. Workshops are being held to discuss the added value of cloud information derived from future satellite missions. ISCCP data at higher space and time resolution are envisaged and improvements are needed in diagnosing optically thin cirrus clouds and low level stratus clouds in polar regions.

ICLAS anounced a meeting at the Free University in Berlin.

ICRCCM held a workshop in Maryland at which model calculations have been compared with observations from SPECTRE. Activities included flux calculations for climate models, line-by-line and broadband models. 22 participants compared 29 sets of calculations. These comprised 10 line-by-line, 12 narrow band, and 7 broadband calculations in the spectral regions 500 - 2000 cm^{-1} or 4 - 20 µm. The average rms error of the models is about 3 Wm^{-2}. Only six climate people contributed their climate data. Over the next few years ICRCCM would give emphasis to trace gas sensitivity studies and the IR continuum.

R. Kandel gave a report on the WCRP activities. SCARAB, ERBE, ISCCP, SBRN and GPCP products become available. More interaction is needed with modelling groups and in particular more focus on validation. GEWEX support for these activities was discussed. The cloud profiling radars needs coordination. It was feared that the current suite of papers in *Science* on anomalous cloud absorption might, through the funding agencies, have a negative impact on the field. An ISCCP funding cut would mean that little will be implemented in Phase 2 of the program. The group, chaired now by G. Stephens, felt that it would progress through its activities more efficiently if it addressed just one goal at a time.

M. Platt noted that the major ECLIPS activities include ground based LIDAR operations and data collection under overpasses of the Space Shuttle LITE. Excellent LITE data sets have been acquired and are being analysed to diagnose cloud properties globally. Relatively inexpensive micropulse LIDAR can be operated in unattended fashion and should become part of the world's "Baseline Surface Radiation Network (BSRN)".

No reports were given for ITRA, ASA, IGAC, and Trace Gases though these groups were still active, the trace gas group announced a meeting in fall.

New activities were discussed:

1. G. Ohring and M. Lynch made a plea for a WG on Aerosol-Radiation as well as Clouds and Radiation formed jointly by the IRC and the ICCP. The members of the group should be selected by both

commissions as well as others active in the community. Action on this item will take place before the IRC meeting in Fairbanks, Alaska. G. Ohring and M. Lynch were asked to form a "Task Force on Aerosols" to support the establishment of this new group.

2. A proposal for "The Inverse Problem" was submitted and attached to the minutes. The Commission members were asked for reactions.
3. P. Simon made a formal proposal for a UV Network to be established and coordinated by WMO. A Science Steering Committee should oversee the network as well as the application of and access to the data. Presently, is was the perception that stratospheric and tropospheric ozone, clouds, and aerosol would be the prime data sources. Activities would include the comparison of radiative transfer models and the refinement of numerical procedures, the comparison of scalar and vector models, as well as the validation against measurements derived from both intensive study periods and climatological data.

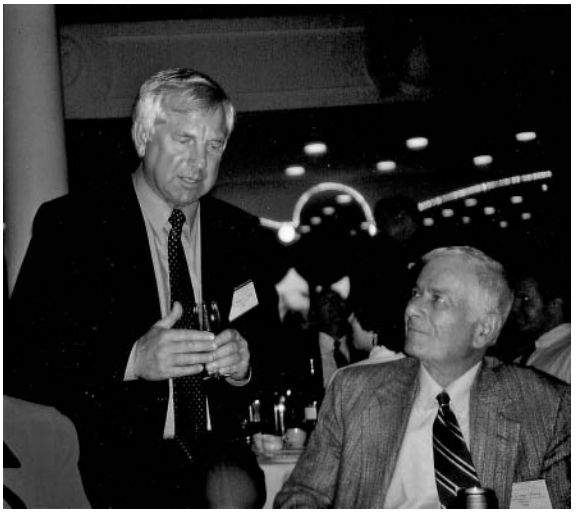
Internet Reports

At this time the IRC started to distribute minutes and documents through the internet: www.irc-iamas.org/

Fairbanks, USA, (IRS) 1996

A paper of the Secretary M. Lynch reflected upon the extended dialogue that occurred during the formulation of the Scientific Program for International Radiation Symposium '96. The large number of abstracts (in excess of 500) meant that most of the Sessions had little choice but to schedule short oral presentations associated with poster paper presentations. A range of opinion was received on the topic. It was agreed that the *IRS had a role of reviewing recent progress in the discipline and the formulation of key directions for future scientific effort.* It was suggested that parallel scientific sessions be avoided and that a *strong preference be given for a workshop format to permit a focus on the science problems.* It was also favoured that the IRC give attention to opportunities to link its meetings with other like groups, such as those involved in the role of vegetation in radiative transfer. There should be more attention to dissemination of information on IRC activities including more use of the IRC membership regionally. R. G. Ellingson and H. Fischer spoke in favour of the use of more extensive review papers by key researchers with greater integration of topics. After some discussion it was generally agreed that presentations should be restricted to just one paper per principal author and that the 10 sessions in IRS'96 were too many. K. Stamnes indicated interest in more integration of IRS topics with other scientific groups who had a keen interest in radiation processes such as the ocean, vegetation, land and snow/ice communities. J. Schmetz viewed heterogeneity of radiation science as part of the source of the present problem; it impacted many research areas and, by its nature, was prone to diversity. He also supported 30 minute review papers and felt that the audience appreciated such reviews and really sought them out to keep them abreast with developments in related areas of the discipline. Major reviews should be supported by a limited selection of 15 minute duration reviews with the remainder of papers presented as posters. T. Nakajima supported the inclusion of environmental topics because these had strong appeal to younger people. He also questioned whether the four year interval between IRS was too long.

Generally, it was agreed that the poster sessions were an important component of the meeting and that their scheduling in a prominent place in the program (as was achieved at the Fairbanks' meeting) showed that they were strongly supported by delegates. A large meeting room to accommodate the plenary sessions was important but the availability of several adjacent smaller rooms would aid the conduct of more specialist sessions and workshops. The clustering of meeting rooms and the associated poster display area being in close proximity was a



William L. Smith, IRC president 1996 - 2000, and George Ohring

significant element in the successful conduct of the Fairbanks meeting.

Also the reports of the WGs evoke lively discussions:

In addition to the annual ITOVS report (J. Eyre / M. Uddstrom) the Commission was informed that an important development had been that the National Center for Environmental Prediction (NCEP - formerly NMC), which had implemented 4D assimilation of TOVS radiances, now had advised of strong evidence of significant impact of satellite soundings in the northern hemisphere. The impact on northern hemisphere forecasts, due to the incorporation of the TOVS sounding radiances, was reported to be more significant than any other single improvement in NWP during the history of NMC/NCEP. It was noted that significant impact was demonstrated a number of years ago for the southern hemisphere. The Advanced TOVS (inclusive of the 20 channel AMSU) was scheduled for launch on NOAA K in the Spring of 1997. In view of the exciting developments ahead in advanced sounding (IASI, AIRS GHIS), the continuation of the active ITOVS Working Group was endorsed by the IRC.

A report on ITRA activities had not been received. T. Clough advised that the microwave subgroup of ITRA did not appear to be active. With the ARM program now well established it had become a focus for improvements to radiation code, and it may not be essential that ITRA continue in its present form. H. Fischer declared that there were a range of subgroup activities including: (a) vertical, (b) limb, and (c) microwave applications. The limb subgroup (chaired by H. Fischer) was no longer active because the intercomparison between calculations and measurements did not reveal any significant problems to be addressed by this group.

R. G. Ellingson advised that he had finalised the report on ICRCCM which was available as a draft in May 1995. An ICRCCM Workshop was held in Maryland on evaluation of water vapour in the infrared in climate models. The intention was to extend its work into the tropics and polar regions. Mention was made of a meeting on Trace Gases held the very next Saturday which was being led by Dave Cross. Dr. Ramaswami of GFDL was recommended as a possible person to lead the efforts in the shortwave radiation area. There was concern in the community about the accuracy being claimed in the shortwave code of climate models. R. G. Ellingson reported that spectral data would become available within the next year or so to permit testing of climate models and for comparison of observations and calculations. E. Raschke questioned whether ICRCCM planned to devote enough effort to absorption in clouds and was advised that there were still problems in the clear region as well as in cloudy fields. J. Harries felt that the ICRCCM Group and the Clouds and Radiation Working Group would benefit from coordination of effort and that this would be assured by cross representation of membership of the two Groups. It was recommended that the excellent work of this Group be continued.

No written report was provided by the WG on Clouds and Radiation and no member of the Working Group was present who could deliver a verbal report. R. Kandel suggested that the relationship of this Working Group to the Working Group on Radiative Fluxes (WGRF) should be clarified. At one point there had been a proposal to include aerosol effects in the Working Group. The meeting agreed that the area covered by the Working Group was a topic of key interest to the IRC. It was resolved to write to G. Ohring to seek identification of the issues and activities currently being addressed by the Working Group and to determine whether or not to continue this working group in its present form, given that there might be significant overlap with the WGRF.

E. Raschke reported that the ISCCP was active, and outcomes to date were beneficial. Data sets had been revised and some 4 1/2 years of data were now available. Expectations were that 13 years of data would be available next year. He complimented the efforts of W. Rossow's group in putting the data sets into good order.

P. Flamant had been elected Chair of the ICLAS WG and was congratulated by the meeting chair. A report had been provided in advance by P. McCormick and had been distributed. P. Flamant paid tribute to the leadership and stimulation that P. McCormick had provided for ICLAS. With respect to activities of ICLAS, it recently had held the International Laser Radar Conference in Berlin which had an attendance of 310 people. Further, the Coherent Laser Radar Conference, held Keystone, Colorado in 1995 had been very successful. The next coherent meeting was to be held in Linkoeping in June, 1997. The multiple scattering lidar experiment had been completed. Further, there was active participation in the Detection of Stratospheric Change activity. Airborne campaigns included LITE. The Earth Radiation Mission and the Atmospheric Dynamic Mission of ESA are planned missions presently at a very early

stage of formulation. P. Flamant reminded the meeting that the 17th ILRC was held Sendai, Japan (July 25-29, 1994) and the 18th ILRC 22-26 July, 1996.

At the address http://arbs8.larc.nasa.gov/lidar/directory.html, ICLAS had mounted a lidar home page on the WWW. Funds provide the Working Group with considerable flexibility to support student attendance at meetings, prizes for best conference presentations and to schedule two international meetings and workshops. The President thanked ICLAS for its vigour and stated that it stood out as one of the most active and effective working group of the IRC.

The report for ECLIPS was delivered by M. Platt. The activities of ECLIPS III was essentially a validation exercise with aircraft support for LITE measurements. The aim was to obtain a 9 day cloud climatology starting from the tropical western Pacific. An important outcome was that high clouds showed no significant multiple scattering. It was clear that benefit would be gained from increased networking of groups particularly for the acquisition of lidar cloud data, products and supporting information. ARM sites were very much a key component of the program and an important part of the network. There was a need to combine data sets such as lidar and passive radiometry in projects such as ECLIPS and PICASO. T. Nakajima indicated the strong interest by other groups and researchers in obtaining radiatively important quantities such as cloud base from micropulse lidars. W. Smith raised the prospect that networking might be enhanced if some working groups combined to pursue specific goals (e.g. ICLAS/ECLIPS/Clouds and Radiation) such as cloud base impact on the surface radiation budget.

The meeting was advised that L. Rothman was not able to attend the IRC to report on ASA WG activities. There was however a Conference to be held in Reims in two weeks time. It was agreed the activities of the Group would be reviewed prior to next year's Business Meeting.

H. Fischer reported that a trace gas sub-group of the International Global Atmospheric Chemistry Program (IGAC) had formed under Dr. Atlas of NCAR. It appeared to be primarily focussed on the troposphere which, of course, posed many scientific challenges.

R. G. Ellingson reported that the WG on Trace Gases had met informally over the last year but there was no priority task under active investigation. Its role could be reviewed; one option for the Group was that it could be merged with part of IGAC.

T. Nakajima reported that the WCRP Working Group on Radiative Fluxes met in July in Dublin and was scheduled to meet in Geneva in November. Many successful activities had been undertaken. There had been some emphasis on aerosols and radiation and the links to biomass burning using TOMS and DMSP. Recommendations had been made on the surface radiation budget and the problem in the shortwave involving aerosol forcing of the order of 20-30 Wm^{-2}. The recommendation of the Group was to process some eight years of surface radiation budget data as well as to research how to approach the proper handling of the aerosol problem. The Group would not produce an equivalent LW data set but probably select an appropriate algorithm for use. There was an intention to use these experiences to assist in defining a project, possibly with IGAC and ISCCP, on aerosol links using data from ADEOS I and II as well as CHEMSAT. R. Kandel commented that the Group also appeared to have similar membership to the GEWEX Radiation Panel and some clarification of which role it was serving would be beneficial.

Y. Timofeyev provided advice on the progress of the group on NLTE - Remote Sounding of the Middle Atmosphere. Being a new Group which was relatively recently endorsed, it was really only now starting its activities. There was considerable interest in the non-local thermodynamic equilibrium (LTE) effects in the middle atmosphere which was a substantial topic to progress.

A formal report by the UV-B Group was not available. It was noted that P. Simon was heading the WMO IGAC Group and that there might be benefit in clarifying roles and links to the UV-B. Discussion with P. Simon would be beneficial.

A. Ohmura advised that within BSRN there were 11 stations in the network ranging from Spitzbergen in the high northern latitudes (80 N) to the South Pole station (90 S). The operational plan was that data would be available for release no later than 6 months after acquisition. Because aerosols and the UV demand spectral data, there was a strong interest in acquisition of spectral observations to assist in studying the performance of GCMs. Plans included expansion of the network to more than 11 stations. In particular there were none over the oceans, none in the boreal region, nor in South Africa or desert regions. It also would be highly desirable to collocate the BSRN facilities with ozone sonde stations. E. Raschke recommended that many national weather stations, in principle, could join the BSRN providing that stations were representative of conditions in the region. He also stressed the need to consider less

ambitious BSRN stations because many countries could not afford the initial high cost of establishing stations but were interested in participation. Further issues were that information needed to be disseminated of the mechanism of bringing stations into the BSRN and also how to achieve intercalibration of station measurements. Many universities might also be interested in contributing, but they would need funds to do the task satisfactorily. For the ocean regions, it would be beneficial to explore the prospect of using oil platforms. For example, in the north sea, if it were possible to equip just 10 of the 70 or so stations, this would be a tremendous assistance. It might also be possible to locate small stations on ships, specifically research vessels. The precise requirements for establishing a station needed to be disseminated more widely - both for existing stations and for the small stations suggested by E. Raschke. It was agreed the latter would be taken up at the BSRN Group meeting during the week and station measurement protocols (held by T. Charlock) would be sought. The question of the existence of a protocol for field experiments would be raised with T. Charlock as well. The Chair expressed his appreciation to the Working Groups for their efforts in progressing the important issues in radiation science and for the presentation of their reports at the meeting.

After some discussion of the question, how to cope with the growing number and activities of the WGs, the meeting endorsed the view that IRC should undertake a review of the activities and plans of all Working Groups for the period 1996-2000 and ask them to report formally on these matters. It was agreed that Working Groups should be established to address specific issues and report on them after due consideration or appropriate research. Accordingly, the Working Groups should expect (and welcome) to be wound up on completion of their work, unless they identified significant issues or extensions of the original brief. Membership of Working Groups is a significant demand on time and it was agreed that all would benefit from that time commitment being of limited duration. Only through adopting this process would new Working Groups form and key concerns to the IRC be resolved.

Melbourne, Australia, (IAMAS) 1997

The Commission discussed the forthcoming meeting at the IUGG Assembly in Birmingham, 1999.

G. Paltridge spoke on the matter of paleo-UV. Specifically, he pointed to the increased UV via the ozone hole that was impacting the level of microbes in ice. This could be demonstrated through sampling of past cores for algae in sediments. It was agreed that “clouds and UV in polar regions” would cover this topic. Several other suggestions from the floor addressed forthcoming experiments that would have been completed by July 1999. The list included TRMM, MODIS, ACE -2 (off African west coast), atmospheric correction to radiances (e.g. SeaWiFS, OCTS), validation of remotely sensed products (e.g SST) from new sensors (MODIS, ASTER, AATSR), and TARFOX. Other suggestions were biomass estimation and biomass burning, radiative transfer/spectroscopy of ice clouds, the retrieval of radiative, optical and microphysical properties, the missing forcing in the climate system, maybe also the indirect aerosol effect, and trace gas profiling.

Some time was dedicated to the proposals for IRS 2000. Four proposals for IRS 2000 had been received. E. Raschke suggested that each proposer should be asked to provide a theme and a strong scientific reason for the venue they proposed. He also suggested that the IRC should consider conducting a summer school associated with the IRS. T. Nakajima advised that the International Ozone Symposium was to be held in Japan in the first week of July. The IRS could be scheduled the second week in July. He expressed support for an Asia-based venue with Korea and Thailand as possibilities, as well as Japan. A further suggestion was that sponsorship to support young scientists attending should be added to the matrix. M. Platt recommended attention being given to avoiding overlap with the ICCP "clouds" meeting. It was also advised that if the St Petersburg proposal failed it was possible that a "Kondratyev Workshop" might be held.

Regarding the International Program for Validation of EOS - AIRS, the Chair advised that George Aumann, Program Manager for AIRS, was seeking access to high quality sonde data for the AIRS validation program. The interest was primarily in research grade sonde data sets. E. Raschke indicated that the Vaisala sonde correction scheme meant that those sondes could produce high quality data. J. LeMarshall mentioned the Baseline Upper Air network (BUAN) as another alternative for validation because the BUAN sondes were scheduled off synoptic times.

Written reports had been received from ITOVS, ICRCCM, Clouds and Radiation, Remote Sounding of Middle Atmospheres and BSRN.

A verbal report on ISCCP was delivered by its chairman. The Meeting was advised that a well calibrated radiance data set was available from 1983 onward. The real need was for experienced people to research the data. Plans include using an overlap period to test the new algorithm prior to its incorporation. These data are currently used in a number of GEWEX experiments (e.g. BALTEX). With respect to ISCCP-2 the point was made that improved temporal, spatial and spectral data were required, particularly to support research proposals involving clouds and radiation and the hydrological cycle. ISCCP-2 would have more spectral bands and would be at 10 km resolution. The 3.7 micrometer spectral band is not available. INSAT still had not contributed data. There had been no information on the Chinese satellite Feng Yun 2. The Russian satellite GOMS had been on-orbit for two years but had been experiencing difficulties. The Chair mentioned the cirrus problem with ISCCP and the advances that the second generation METEOSAT and the new GOES sensor would offer to ISCCP-2.

M. Platt introduced the ECLIPS report and advised that the data from ECLIPS were archived at NASA Langley. Comments were made by W. Smith that the next steps in lidar would require spectral radiance data to be collected simultaneously to support determination of particle size. Another possible direction was millimeter radar with spectral radiometry. T. Nakajima advised that a m-pulse lidar was available in Thailand and that ice-water content, lidar optical depths and size distribution were goals to identify. It was agreed generally that it was timely for the Working Groups to endeavour to focus on the identification of new directions.

The President introduced the written Report of BSRN that had been received from A. Ohmura. E. Raschke made the point that BSRN global coverage was far from adequate. If we were to find answers to the heating of the oceans, the resulting climate change etc, then our models needed validation with data sets over the oceans as well as the land. Also, stations do break down. The concept of a single station in a region is also inadequate because of issues such as periodic cloud cover, effects of mountains etc. Comment was made that ARM stations for Indonesia and Manus Island were being established to provide oceanic data.

The Chair asked the Vice - Chair, H. Fischer, to undertake a review of the IRC Working Groups during the period 1997 - 2000. The purpose was to seek to have the WGs solve/report on existing problems that they had taken on previously. If the work of the WG was then completed, the WG should dissolve. If new problems were identified, then it might continue or be re-formed with an appropriate membership and new title to address the new issues. The IRC needed to view the WGs as transient. If they dragged on too long, people would refuse to participate. It was also felt that the WGs should have more of a role at the IRS. For example, special reporting sessions or workshops depending on needs, problems or purpose.

Nagoya, Japan, (COSPAR) 1998

In these years the IRC showed much concern about the efficiency of its Working Groups. Its members urged to disband them as soon as their initial tasks are fulfilled and to establish new WGs on specific tasks rather than to let a WG slowly fade out by generating follow-on activities for sub-groups. In Nagoya, H. Fischer repeated what had been resolved the preceding meeting: The intention was that IRC Working Groups were created from time-to-time and assigned tasks to be undertaken. Once the WG had addressed the issues and reported satisfactorily, the expectation should be that the WG be closed down. If WGs became standing committees they would become too numerous and the IRC too cumbersome to function. Consequently he advised the IRC President to close down the IGAC WG. Also R. G. Ellingson advised that there appeared to be no outstanding issues assigned to the Trace Gases WG and he recommended that it be closed.

The meeting was further informed that the Report of the IXth International TOVS Study Conference (ITSC-IX, Feb 20-26, Igls, Austria) had been published. The Technical Procedings of the same meeting was also available. ITSC-X had identified sponsors and would be held in Boulder, CO, USA. The Advanced TOVS (inclusive of AMSU) and AVHRR Processing Package (AAPP) was under development and would be released to the International TOVS Working Group (ITWG). Other activities included an expression of concern for the protection of the microwave frequency bands important to satellite sensor operation. WWW pages existed for ITWG and ITSC-X.

The ICRCCM group was establishing its Home Page in the current year. Its chairman reported that the limitation to model comparisons was the lack of quality observational data. The Group had assembled some 200 sets of downwelling spectral LW spectra from an interferometer and the associated broadband LW flux. It was his opinion that the visible field was where the LW was in about 1988. In a similar fashion to the LW, comparisons of clear sky, cloudy sky and broken cloud were being undertaken with the WCRP Radiation Panel.

Discussion arose as to whether the WG on Clouds and Radiation ought to be expanded to include aerosols as well as clouds and radiation. However, an alternate view had been put forward that extending the scope of the WG in this way would duplicate activities of ICCP Working Groups. At a later date G. Ohring was planning to report on the outcome. He also had indicated previously that he would like to step down from Chair of the WG.

Several comments were made on the ISCCP database. Data sets, additional to the 250 km by 250 km resolution were now available. A 14 year record of 30 km data was to be available in mid to late 1998. J. Schmetz advised that Eumetsat had moved a geostationary satellite to 63° east until the end of 1999 to close the data gap over the Indian Ocean.

A complete volume of the J. Quant. Spect. and Rad. Transfer had been devoted to the key science issues embraced by the ASA WG. There was also a Fall 1998 meeting of this WG that had been reported.

The WCRP Working Group on Surface Radiation Budget operated under GEWEX was examining the anomalous absorption issue. It was producing 2.5° by 2.5° and also 1° by 1° gridded data sets. The WG was planning to meet at the end of August 1998 in Scotland.

The WG on Remote Sounding of Middle Atmospheres addressed the issue of non-LTE impact on remote sounding in the middle atmosphere and the potential for increased information being gained from spectral measurements (e. g. MIPAS for non-LTE research). Members were asked to provide any contributions they might have to a report that he was preparing for the IRC.

A. Ohmura, Rapporteur on BSRN, reviewed activities reported at previous meetings of the BSRN at Fairbanks and Budapest. Of the 70 stations reporting continuous observations, 15 had been identified for special attention requiring a scientist's involvement with a brief to improve quality control. Without a specification of accuracy, based on a detailed characterisation of errors, this goal was difficult to achieve. The data objective was, to reduce the time between observation and release of products to 3 months, but many stations will not be able to meet this objective. Future plans included the use of an ECMWF “fast radiance” to improve site control. Data products were available as one minute statistics (see <http://www.geo.umnw.ethz.ch/urmc>). For access to data users should go via the BSRN site administrator (<bsrnadm@geo.umnw.ethz.ch>).

Achievements of the BSRN were:
- all climatic zones are covered
- improvements to instrumentation
- standardisation of data reduction methods
- publication of two manuals
- establishment of a central data archive
- formulation of a data release policy.

Tasks for the future included:
- network extension (oceans, deserts, tropics, high latitudes)
- need for improved coverage
- need for simultaneous and collocated BSRN and upper air data
- to encourage spectral observations - UV, PAR, aerosol, enhanced greenhouse signature.

Problems that remain to be addressed are:
- effect of LW radiation on SW radiation
- establishment of a standard for LW radiation (prescribed for the SW)
- identification of representative sites for monitoring the Earth's surface albedo (so-called 1 km farms).

In the following discussion, A. Ohmura added in response to questions that the UVB situation is progressing with the approach drawing on synchrotron radiation as the calibration standard.

The President advised that the next business meeting of the IRC would be during the IUGG’99, Birmingham (July 19-30). He also indicated that the IRC active Working Groups would have been

confirmed by then. Members with suggestion on new IRC Working Groups should contact him.

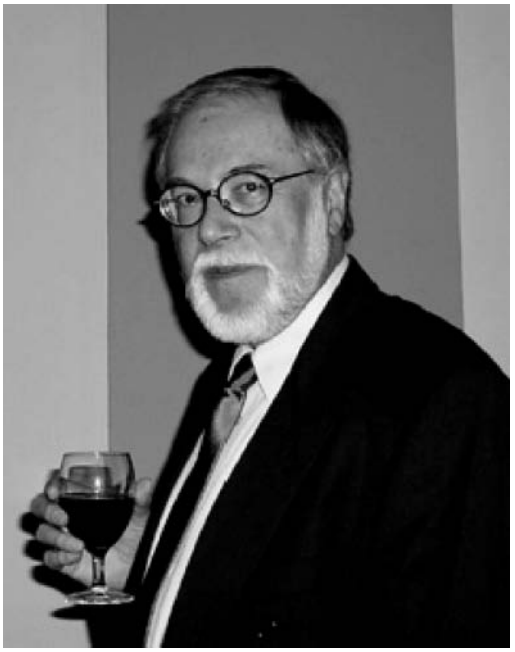
The Vice President, H. Fischer, outlined the planning for the next IRS2000. Proposals for the Symposium venue had attracted four submissions all of which were very appealing and of a high standard. The venue for the year 2000 had been selected via ballot of IRC members. St Petersburg was the successful bid. H. Fischer recorded the appreciation of the IRC to the unsuccessful bidders and encouraged them to resubmit at a future opportunity. Plans were that the IRC President, W. Smith, would visit Y. Timofeyev in the following May to review meeting plans, to assemble a Program Committee and to consider the balance of poster papers and parallel sessions. While plans were very preliminary, eight topics/themes were under consideration. Suggestions made from the floor were to (i) include climate change within the Earth radiation budget topic and, (ii) highlight recent concerns about the solar constant; in particular, the fact that SOHO was presently off-line and the Lagrange radiometer was emerging as an issue.

R. G. Ellingson commented that he was of the view that the IRS should commit to an Asian meeting because it was some 30 years since the last Asian meeting. The IRC needed to restore a better balance between meeting frequency and the scientific effort from that region.

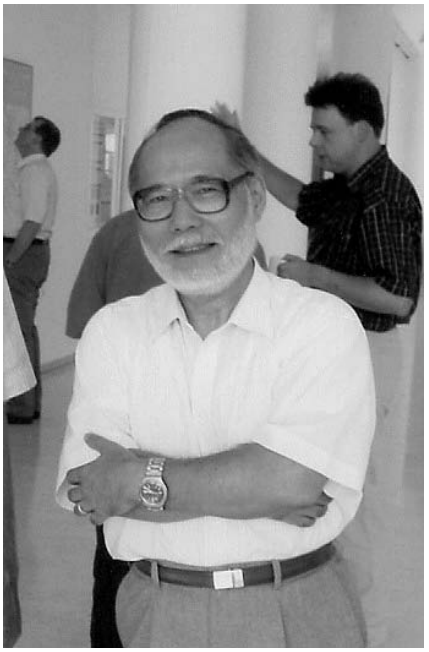
J. Le Marshall reported that the Australian Bureau of Meteorology, JMA, Scripps and CSIRO had selected one year of data to undertake a GMS Pathfinder that covered noise, calibration and destripping in a cross-calibration with AVHRR for coincident date, time and look angles. The work had progressed well and would be completed before the end of 1999.

R. G. Ellingson raised a concern, brought to his attention by E. Raschke, about the increasing effort to discredit the enhanced greenhouse issue. He sought suggestions on the best arguments the science community might use to demonstrate the impact on the radiation budget of increasing CO_2. There were questions raised in this debate about whether we knew the line-by-line transmission in the LW sufficiently accurately. H. Fischer indicated that, in his view, it was not a case of requiring new measurements - we knew CO_2 extremely well - but more one of convincing such people of this. H. Fischer agreed to discuss the issue with the IRC President W. Smith. There was, of course, the prospect that the debate might die away within a short period because the issues being promoted could not be sustained on scientific grounds.

B. Barkstrom advised that it was 100 years ago that Langley's book "New Astronomy" reported on the measurement of the solar constant and its relevance to life on Earth. He encouraged members to access the Langley DAAC and discover the schools project that had been initiated to celebrate this centenary.



Herbert Fischer, IRC president 2000 - 2004, inventor of the MIPAS instrument



Atsumo Ohmura who developed the world wide radiation data base BSRN

Birmingham, UK, (IUGG) 1999

The main topic of discussion was the agenda and plans for IRS-2000 being held in St. Petersburg next July. There were also working group reports from current working group chairs, or their representatives, plus a discussion of the re-organization of working groups in order to better satisfy the dealing with current challenges and problems, such as the global validation of new, and forthcoming, satellite radiation measurements and remote sensing products.

St. Petersburg, Russia, (IRS) 2000

The International Radiation Symposium in St. Petersburg stood in the light of Academician Kirill Ya. Kondrayev's eighties birthday which was celebrated at a big party. The symposium was also one of the largest, the IRC ever had with a record number of over 550 radiation scientists from more than 30 countries. 650 presentations were given and the book of proceedings amounted to 1311 pages. A "Past Presidents"-Session was organized in honour of Kirill Kondratyevs contributions to radiation research.

The membership of the IRC was reviewed, some members ended their term and new members have been elected.

E. Raschke started a discussion to propose prominent scientists from outside of the IRC as honorary members. A move was put forward to solicit one-page bios to aid in the selection of new members.

Herbert Fischer was nominated as the new president. This nomination was seconded, and H. Fischer was voted in as new president. Teruyuki Nakajima was voted in as vice president and Bob Ellingson as secretary.

Bill Smith, the immediate past president, was elected *Honorary Member*.

A discussion was started about the invitations for hosting IRS 2004. W. Smith suggested favouring locations in Australia or Asia. G. Partridge agreed to propose Hobart, Tasmania. E. Raschke suggested to include Korea and China in the consideration. Daren Lu agreed that China might be a good candidate. W. Smith restated that IRC will formally solicit proposals and that the membership would then vote on them.

Vic Delnore briefed the IRC about the planned CRYSTAL field campaigns, with emphasis on opportunities for international cooperation. The president pointed to a possible conjunction of CRYSTAL's main campaign (Tropical Western Pacific in 2004) and IRS2004. E. Raschke suggested the need to coordinate CRYSTAL with several European efforts, most notably one being planned by Dr. Lammerer of KNMI.

Plans were made for IAMAS-2001 in Innsbruck The president noted that the IRC homepage was not up-to-date and suggested that a history of the IRC be written and posted.

A discussion arose about poster sessions and the sequence of IRS symposia but without any new conclusion.

The efforts of the local committee in hosting the present symposium were recognized. Y. Timofeyev modestly accepted the unanimously expressed appreciation for a highly successful symposium and especially for the outstanding cultural program.

H. Fischer repeated the rules for activities of *Working Groups*, as initially presented last year in Birmingham: Short annual report; longer report at Commission

Svetlana Kondratyev, Yuri Timofeev, Bill Smith, Kirill Kondratyev, Richard Goody

Meetings; Commission to decide if each Working Group should be continued. Not all Working Groups provided reports.

Richard Goody, Marie L. Chanin, and Kirill Kondratyev

Working Group Reports:
The chairman of the International TOVS Working Group (P. Menzel) distributed written copies of his report.A meeting was held in Boulder in February 1999 and the Working Group will get together at the ITSC-XI meeting, 20-26 September, in Budapest. Approval was requested and granted for continuance of this working group.

A written ICRCCM report from B. Ellingson was submitted by R. Cahalan; approval was requested for continuance and granted.

Clouds and Radiation: E.Raschke suggested that Graeme Stephens be contacted to coordinate this Working Group; this would afford the IRC with an association with Dr. Stephens' research.

ISCCP: E. Raschke explained the ISCCP's operational mission of data acquisition and accumulation, cited 16 years of global radiances started by Bill Rossow, and pointed out that it is a rich source of data for students to work on. The president noted that this long-term record establishes a baseline, but asked how the baseline will be maintained through changes in processing algorithms. In response, E. Raschke stated that ISCCP doesn't tamper with internal calibrations, but acknowledged that this is a concern and will get a fuller answer later. P. Menzel mentioned that the coordinating group for meteorological satellites is the catalyst to do this. The president wants the IRC to know if there is any doubt about the continuance of this. E. Raschke noted that NASA, being a research agency, is not the proper agency to support a continuing, operational effort like ISCCP. Having accompanied ISCCP for many years, E. Raschke finally withdrew as chairman of the ISCCP Working Group.

E. Eloranta reported that ICLAS will hold an international radar/laser meeting every two years. They are the interface between gadget makers and the people who want to make water vapour and other measurements. H. Fischer suggested combining active and passive instruments in some of the new ESA missions.

T. Clough stated that support for ASA is marginal, but there has been lots of activity. H. Fischer mentioned that both line and continuum data are needed. T. Clough responded that a small (3-person) ad hoc group is recommended, to work with L. Rothman. H. Fischer agreed to establish this group later.

Y. Timofeev said that the report of the W.G. on Remote Sensing of the Middle Atmosphere (RSMA) is identical with his paper presented in the symposium. A short written summary will be provided later. No evidence is known of problems with the forward models; only some minor discrepancies occurred which are summarized in the Proceedings. The Working Group is active and will be continued.

UVB: Nothing new is to report since the Birmingham meeting, announced P. Simon. No meetings occurred since then. A three-page report is submitted, the working group will be continued.

A. Ohmura explained that the BSRN W.G. has three objectives: 1) to promote spectral measurements, 2) to resolve calibration uncertainties, and 3) to observe important changes in radiation climate. The activity is in need of an organization to support the measurements. So far eight years of data are compiled. Biannual workshops are organized. Spectral measurements should be intensified. 21 sites are included worldwide, but most are at established national meteorological sites. E. Raschke noted gaps in Chile and other areas and specifically expressed concern about the apparently big gaps in Asia, but the president pointed out to about the six new radiometer sites in China. D. Lu, of the Institute of Atmospheric Physics, China, said that the University of Maryland is installing four sets of aeromet instruments to fill some of the gaps in Beijing, Tibet, and other locations. A. Ohmura noted to make sure that D. Lu will be invited to future BSRN meetings.

P. Simon reported on Total Solar Irradiance Monitoring Group and that C. Crommelink lacks funding

and can therefore not chair the W.G. A new chairperson is sought. R. Cahalan suggested to include L. Rothman in this group.

Working Groups for 2000-2004:

The Validation Working Group (VWG) proposed in 1999, in Birmingham, did not deliver a report. The purpose of VWG would be to organize validation of new satellite measurements. The membership is fixed. Topics are: Aqua satellite, advanced IR sounder in polar orbit (AIRS), EOS (AIRS/MODIS) validation. Potential domestic and international validation sites for radiosondes are required. Sondes with spectroscopic capability launched at specific times would be useful. David Tobin is the co-author of the sonde launch procedures. H. Fischer suggested to establish a net of sonde launch sites for all sensors useful in the validation of radiance measurements. W. Smith noted that terrain is a consideration for these downward looking instruments; and also that the effects of cirrus clouds and local weather need to be considered. This new WG was approved to start work and W. Smith will get into contact with N. Pougatchev to furnish a report.

A discussion arose about the proposed WG for multispectral methods for cloud height aIlocation from satellites. J. Schmetz submitted notes. Some colleagues centred on stereo looks, side looks, and multispectral measurements and independent validations. This new WG was recommended and approved as a formal Working Group.

Innsbruck, Austria, (IAMAS) 2001

At the business meeting in Innsbruck again the Working Groups stood in the centre of the discussion. Most of their reports were made available at the IRC homepage. Few comments were made: P. Koepke added additional information which is not included in the UVB written report, namely that UV forecasts require O_3 and cloud forecasts. In particular cloud forecasts must be done at very high temporal resolution - the order of minutes at a given hour. J. Joseph pointed out that forecasts of desert dusts are also required for accurate UV forecasts, and with view to BSRN, H.-J. Bolle noted the pressing need for aerosol data, particularly aerosol optical depth, at all sites.

Discussion of proposals for new IRC working groups focussed on the intercomparison of 3-D Radiation Codes (I3RC) and the Height Assignment of Semi-transparent Clouds. As part of the report from ICRCCM, R. Cahalan summarized the progress made in I3RC and proposed that for I3RC a separate IRC working group be established, primarily because 3-D effects are now more obvious in remote sensing and dynamics. There was general IRC consensus that such an IRC working group should be established. R. Cahalan was instructed to expand his proposal to include the goals and terms of reference of I3RC and submit it to the IRC bureau in advance of the next IRC meeting. Action on the proposal is tabled pending receipt of a more detailed proposal.

Time was also allocated for a Validation Working Group as proposed by Nikita Pougatchev, but no representative was present.

On behalf of its chairmen J. Schmetz and P. Menzel, R. Davies summarized the plans of the proposed Working Group on Height Assignment of Semi-transparent Clouds. There appeared to be general agreement that this would be a fruitful activity, but the proposal needs additional information, particularly goals and procedures for the next four years. R. Davies was encouraged to prepare a more specific proposal following IRC guidelines.

It followed a general discussion of the requirements for IRS 2004 and on the need for geographic equal opportunity; the desire to move to different parts of the globe in a quasi-systematic fashion to ensure the opportunity for all interested scientists to participate in the proceedings during their career lifetimes. Two tentative proposals were made: Seoul, Korea, by B. J. Sohn, and Salt Lake City, Utah, USA, in conjunction with the University of Utah and the ARM program by Th. Ackerman.

Two proposals for IRC-sponsored symposia for the 2003 IUGG were discussed, namely: Cloud-Aerosol-Radiation Processes in the Climate System, and Variation of the Solar Spectrum and Its Impact on Climate.

J. Joseph gave a short presentation on the Mediterranean Israeli Dust Experiment MEIDEX.

Houston, USA, (COSPAR) 2002

In his quadrennial report the President, H. Fischer, had appraised the success of the St. Petersburg Symposium 2000. He also highlighted the considerable significance the work of the RSMA WG on the inclusion of non-LTE effects in radiation codes has on new satellite experiments with high spectral resolution.

Beside with organizational matters the Commission dealt with reports of WGs and Rapporteurs. The IRC bureau accepted a new charter for the I3RC group and appointed R. Cahalan as Chairman. Its primary objective is to promote and to coordinate improvements in accuracy, applicability, and availability of three-dimensional radiation transfer codes for use in remote sensing and climate models. William Rossow, GRP Chair, was asked to be the rapporteur to the IRC on clouds and radiation. It also was recommended that perhaps the IRC should have a rapporteur from Aeronet. Recommendations and/or volunteers for such a position are welcome.

T. Nakajima reported on plans for the Asian Pacific Radiation Symposium. Rationale: There are many more people now, particularly in Asia, studying radiation and there are few opportunities for them to attend organized symposia. The first APRS will be held in China in 2003. Thereafter the meetings will be every four years, separated by two years from the IRS.

Sapporo, Japan, (IUGG) 2003

The IRC business meeting in the Royton Hotel, Sapporo, Japan, during the IUGG General Assembly was opened by the President H. Fischer. He, *inter alia*, explained the steps that he had taken so far on compiling the history of the IRC. He will keep on trying to collect available material from J. London and other former IRC presidents.

The IRC Vice President, Terry Nakajima, then highlighting the following points of the IRC activities in the 2002/03 time frame:

For the next IRS an official proposal was made from Korea for which the majority of the IRC members voted. Thereby, Korea was elected as the next IRS location.

The Vice-President brought forward the proposal to install an IRC Award including a medal. His idea for such prices, to be awarded at each IRS, is, to increase the IRC's visibility through the following rationale:

a. To honour scientists who made a large contribution to the radiation research community,
b. To encourage young scientists,
c. To strengthen IRC activities.

In the following discussion it was suggested to have one prestigious price of the order of $2000, which should be called "IRC medal". In addition, 2 young scientists should be awarded about $200. Poster awards might be set. The details of the selection criteria and procedures have still to be worked out. The first ceremony is to be held on the first (senior scientist medal) and last (young scientist medal) day of IRS 2004.

The president sent a letter to the working group chairs, in which he explained the general rules and duties for the working groups.

Initiated by colleagues from Asia, the IRC supports the "Asian-Pacific Radiation Symposium (APRS)" on 25-27 Aug. 2003 in Xian, China, as a new capacity building activity in East Asia.

The IRC web site has been refurbished and is now considered to contain all relevant material. IAMAS is asked to give the top level page the official layout and to crosslink with the official IAMAS site, which is planned for the near future. Another link to the GEWEX/GRP site should be included. (This action item was closed with establishment of the formal link between IAMAS and IRC in September 2003). A use of the IRC website was later on discussed to display or link useful information of the atmospheric radiation processes for general users. One example is to show the ICRCCM table for radiation code comparisons.

IRC has contributed to IUGG General Assembly 2003 in Sapporo, Japan by holding two symposia: Variation of the solar energy output and its influence on climate (Symposium MI01; IRC, ICCI, ICACGP), and Clouds, Aerosol, and Radiation (Sympoisum MI02; ICCP, IRS, ICACGP). The MI02 symposium had 143 papers; 60-100 participants were counted at each of four days.

IRC Awards

The IRC awards are established to recognize scientists who have made extraordinary contributions to radiation research.

1. **Types of awards**
Awards will be presented every four years to one senior and to one or two young scientists with the following designations:

a) IRC Gold Medal: This award is designed to honour a senior scientist who has made contributions of lasting significance to the field of radiation research.

b) IRC Young Scientist Award: This award consists of a $ 1000 cash award to a young scientist who has made recent noteworthy contributions to radiation studies and is regarded as becoming a leading radiation scientist in the future.

2. **Nomination**
Candidates for the awards are to be nominated by IRC members. The nomination package is to consist of the candidate's CV and a letter of recommendation from the proposing IRC member.
A condition for the young scientist award is that the candidate must be within 10 years of having received the PhD degree at the time of nomination.

3. **Selection**
The selection of the prize winners is performed by the IRC Awards Committee consisting of the IRC officers, two former IRC presidents and two senior scientists. The Committee is chaired by the IRC president. IRC members can propose members for the Awards Committee to the IRC president. The members are appointed by the president who will be supported in this decision by the two other IRC officers. Expertise and geographical distribution of committee membership will be taken into account when making the selections.

4. **Awards Ceremony**
An Awards Ceremony will take place during the quadrennial International Radiation Symposium. The awardees will be expected to present a lecture as part of the ceremony.

5. **Scheduling**
Recommendation letters should be sent to the IRC president (copy to the IRC secretary) not later than 1 March in the year of the IRS, and the IRC Awards Committee will complete their selections by 15 April. The awardees will be notified of their selections during the second half of April.

Rules for IRC Awards

Several new directions of radiation studies were partly controversially discussed:

The President proposed, that the IRC should release a recommendation for the optimal description of the water vapour continuum to be used in radiative transfer models.

A. Ohmura proposed to compile a concise but yet accurate handbook on high quality radiation measurements.

T. Nakajima proposed the themes
- Radiative forcing due to aerosol-cloud interaction, and
- Reflectance/emissivity of land surfaces

No final conclusion could be drawn due to the limited time. The President indicated, that new topics can only be introduced, if there are scientists available who are willing to take the lead in such a topic.

W. Schmutz of the WRC, Davos, reported that his institution has been selected to become the world standard institute for thermal infrared measurements, for which a scientific advisory board will be installed. He asked, whether the IRC would be willing to name a person for this committee. H. Fischer accepted for the IRC and promised to make an appropriate proposal within due time.

Few reports of the working groups and rapporteurs have been presented at this meeting:

The President took the role of the Rapporteur for several WGs of which nobody could make it to the

business meeting. Thus the ITOVS WG was and is still active. ICLAS is active and has sent occasional reports in the past but he promised to send out a letter to inquire the actual state. ASA, which used to be very active, is facing difficulties: L. Rothman changed his affiliation and is missing support. The President will contact L. Rothman and offer to write a support letter from IRC to NASA (finally the report was sent to the President from L. Rothman in August.).

According to the President also the ICRCCM WG has been very active in the past. He hinted at the available short report in which new activities are outlined. Comments proposed to provide in future comparison data for higher atmosphere levels than now, to put a link to the ICRCCM web site from the IRC website, and to ask anybody who uses the data from this site for model comparison to give his/her coordinates to R. G. Ellingson for reference.

The RSMA WG is very active and an extensive report is available. Dr. Kostsov presented on behalf of Y. Timofeyev the working group's report to the meeting, in which he outlined the topics, activities and achievement of the three subgroups.

R. Cahalan gave an overview of the work of the 3DRT group, outlining the group's structure, activities, methodologies, products, and future plans. He was asked to hand in a written version of his report.

The ISCCP Rapporteurs' report was missing. Dr. Bakan volunteered to contact E. Raschke in this respect.

B. Ellingson is looking for a successor as a rapporteur on Clouds and Radiation, a report is not available so far.

P. Simon reports shortly that nothing new happened in the UV-B area since the last meeting and promised to turn in a written statement. He mentioned, that his retirement could make a change in his role as rapporteur necessary, but promised to discuss this issue with his successor.

A. Ohmura reported on the present status of the BSRN data base and on future plans.

Busan, Korea, (IRS) 2004

The president had already in his New Year's letter addressed the novel idea to honour distinguished scientists by an IRC Award. From now on, the IRC will confer a Gold Medal to senior scientists who rendered outstanding merits to atmospheric radiation science, and a Young Scientists Award (see box). At the business meeting he reported on the procedure to select recipients of the IRC Awards. Two senior scientists, two former presidents, and the IRC officers form the Award Committee.

The 2004 Award Committee dedicated the Gold Medal to *Richard Goody* and the Young Scientists Award to *T. Takemura*.

T. Nakajima discussed the IRC desire to have a permanent logo. It was agreed to have an IRC logo competition. All IRC members were requested to send ideas to T. Nakajima.

Again the organization of future meetings was a large item at the business meeting. Since the attendance of IRC scientists at the COSPAR meeting 2002 was marginal, it was considered to replace COSPAR by another organization to hold meetings between the quadrennial Radiation Symposia.

The IRC received WG reports from TOVS, ICRCCM, 3D Radiation, and RSMA, and the rapporteurs for UV-B, BSRN, and Clouds and Radiation. Written reports were posted on the IRC web site.

New WGs were proposed:

T.Hayasaka proposed a WG on "Long Term Analysis of Surface SW Radiation Budget (LASR)". He was advised to submit a proposal according to the IRC guidelines to the 2005 business meeting.

A. Ohmura proposed a new WG or a rapporteur on "Total Irradience".

P. Köpke reported about a new COST activity on UV climatology which is addressing the effect of changing UV irradiance on biological systems.

Finally the IRC was informed that IAMAS was building up an activity for the Polar Year and had requested nominations for IPCC reviewers.

Bejing, China, (IAMAS) 2005

President T. Nakajima welcomed participants and informed about the nomination of IPCC technical reviewers:

1. Thomas P. Ackerman, DOE/Pacific Northwest National Laboratory
2. Chris Folland, UK Met Office

3. John Harries, Imperial College
4. Robert Gurney, The University of Reading
5. Atsumu Ohmura, Institute for Climate Research ETH
6. Didier Tanre, U.S.T. de Lille
7. Tatsushi Tokioka, Japanese Meteor. Soc. Japan
8. Guang-Yu, Chinese Academy of Sciences

The President briefly summarized the new IRC plans for the 2005-2008 term and reported on the election process of new IRC members for this term. Information on these points is available at the IRC website, http://www.irc-iamas.org/. Discussion was opened about the formal invitation to host IRS 2008 from France (Lille), Italy (Matera), and Brazil. Suggestions were put forward by attendees to consider geographical balance (the IRS already has visited areas such as North America, Europe, and Asia; therefore, other areas should now have a priority) and possible synergy with other symposia, such as the International Ozone Symposium and the Cloud Symposium.

T. Hayasaka (RIHN, Japan), A. Ohmura (ETH, Switzerland), G.-Y. Shi (IAP, China) had submitted the requested proposal for a new working group on *Long-term Analysis of Surface SW Radiation Budget (LASR)*. The argument for this new WG is that little is known about the radiative forcing at the surface while many evaluations of radiative forcing at the top of the atmosphere have been performed. T. Hayasaka presented a number of maps showing linear trends of the SW radiation at stations in China as compared to the ISCCP-FD data. The trend 1971 - 2000 differs in some regions considerably from the trend 1991 - 2000 (this corresponds to observations made in Switzerland and presented at the IUGG meeting in Perugia, 2007, showing a "solar dimming" from 1960 - 1980/90 and a "brightening" afterwards). The objectives of the WG is to collect existing operational pyranometer and related data world wide and to apply a comprehensive analysis to the collected data which may also include surface SW data derived from measurements made from satellites. After the presentation, IRC members recommended the proposers to establish synergy and contacts with other IRC working groups. The new working group was accepted.

As a general remark it was stressed that the working group chairs should use the IRC home page to distribute their conference information. The IRC web page can also be traced from IAMAS homepage.

The IRC contributions to the IAMAS meeting were on the following topics:

- Clouds, aerosol, radiation, and climate, together with the ICCP;
- Advanced remote sensing of trace constituents in the atmosphere;
- Satellite derived (surface) radiation budget components – validation aspects;
- Solar variability and climate change.

Madison, USA, (AMS) 2006

The business meeting planed for Beijing, China, (COSPAR) 2006 was finally held in Madison, USA, at the occasion of the AMS meeting. President T. Nakajima reported that since the last IRC business meeting during the IAMAS Conference in Beijing two IRC members passed away, Guy Rochard, December 2005, and Kirill Kondratyev, May 2006. The President took actions in order to prepare appropriate tributes, which now can be found at the IRC web site. An obituary notice has been prepared for Kirill Kondratyev, which will be sent for publication to an appropriate science magazine (finally selected was BAMS).

The main topics of the sessions within IUGG to be held in Perugia, in 2007, in which the IRC will be involved are: "3D Radiative Transfer in Complex Geophysical Media Including Clouds, Vegetation, Ice and Snow", "Satellite Observations: Products and Applications", "Aerosols, Radiation and Clouds", and "Solar Activity and its Influences on the Earth's Weather and Climate" .

At the last Business Meeting in Beijing it was decided to consider the following criteria for the final venue decision:

- Geographical balance. IRS already has visited areas such as North America, Europe, and Asia; therefore, other areas should now have a priority.
- In the past, possible synergy with other symposia, such as the International Ozone Symposium and the Cloud Symposium, have been considered. Although it is understood that the present busy situation of many conferences makes it difficult to take this arrangement into consideration. To help and guide IRC members for their future decision about the various proposals, a list was made about

the past IRS venues.

- In addition, at the meeting in Beijing it was agreed to go through the following process for organizing IRS2008:
  - Presentation and discussion of final proposals at the 2006 IRC business meeting.
  - Final decision for the site venue just after the 2006 business meeting by voting.
  - Session organization and IRC gold medal and young scientist award selection process to begin after the venue decision.

President Nakajima invited members to present their proposal for the venue of IRS2008. By a short round among the attendees it was realized that there was no new proposal in addition to the three from France (Lille), Italy (Matera), and Brazil.

For the French proposal, Michel Legrand made a very comprehensive presentation which was congratulated from the attendees.

The Italian proposal was updated by Carmine Serio. He said that the proposal is suffering from the lack of main sponsors, such as the Italian Space Agency and the National Research Council. This is because most of the Italian Agencies, acting in contexts close to atmospheric sciences, are in the process of renewing their officers and Council Boards. This situation will put some risks on a successful definition of the Italian proposal. Because of these risks and because it would be not appropriate, at this stage, to potentially penalize proposals, which as that presented by France, are really in good shape, Carmine Serio announced that the Italian proposal was withdrawn.

On behalf of J.V. Martins the Brazilian proposal was presented by R. Cahalan who made a very detailed presentation.

Both remaining proposals were congratulated by the President and attendees. From the general discussion, the need of a better harmonization between the two proposals was felt to be desirable. Then the two proposals would be compared on a sort of common basis. For this purpose President Nakajima and others among attendees asked Brazilians to conform their proposal to the French one, as far as the breakdown structure of the estimated spending was concerned. In the end it was agreed to allow both promoters to have some further iterations on their proposals before presenting them for the final vote to the IRC community.

Moving ahead in his report, President Nakajima encouraged Working Group (WG) Chairs and Rapporteurs (RP) to link their web-page to the IRC web-page for a better circulation of information. He also summarized that presently there are six WGs and five RPs acting within IRC.

After that, President Nakajima informed members that the publication of the Proceedings of IRS 2004 by Deepak Publishing Co. is in its last stage. Finally, because of the evident closeness to IRC, he announced that the next three Business Meetings will be held during

IUGG 2007, Perugia, Italy

IRS 2008, venue to be decided

IAMAS 2009, Montreal, Canada

The Secretary reported that after the last call for the present Business Meeting there have been only three WG chairs replying positively, which in addition to W. B. Rossow, who was attending the meeting, summed up to a potential of four presentation for the day.

W. B. Rossow reported on the GRB working group activity. The presentation was appreciated and congratulated from the attendees. He was also asked to produce in the near future a written version of his report, to be uploaded on the IRC website.

Three more activity reports were given which should become available at the IRC website: R. F. Cahalan's report on the activity of the 3DRT working group, Th. Achtor's report on the ITWG working group, and T. Hayasaka's report on the LASR activity.

As a general remark it was stressed that working group chairs should use the IRC home page to distribute their conference information. The IRC web page can also be traced from IAMAS homepage.

Perugia, Italy, (IUGG) 2007

The meeting was opened by President T. Nakajima who welcomed the participants. Upon his proposal the Commission appointed R. F. Cahalan acting Vice President because R. G. Ellingson presently was not in the position to fulfill the position. T. Nakajima presented a brief report about the financial status, recent

IRC activities and new publications (see Appendix 4).

Among the activities were the IRC participation in the IAMAS 2005 Assembly in Beijing and the sponsorship of the Asian-Pacific Radiation Symposium, July 2006, Kanazawa, Japan, which underscores the increasing interest in the Asian area.

The IRC president, T. Nakajima, and the chair of the GEWEX Radiation Panel, William B. Rossow, sent a letter supporting the climate sensors for the NPOESS satellite to John Church, Chairman of the Joint Scientific Committee, and Ann Henderson-Sellers, Director of the Joint Planning Staff for the World Climate Research Programme. This reminds of the similar action from the meeting in Garmisch-Partenkirchen.

To the IUGG assembly in Perugia, the IRC contributed the following four sessions which were attended by a large number of persons, in some cases more than 100:

President Teruyuki Nakajima, Director Center for Climate System Research, The University of Tokyo, talking with Jean-Louis Brenguier, Centre National de Recherches Meteorologiques, CNRM/GMEI,

- 3D Radiative Transfer in Complex Geophysical Media Including Clouds, Vegetation, Ice and Snow (IAMAS, IAHS, UCCS); IRC conveners: Robert F. Cahalan, Bernhard Mayer.
- Satellite Observations: Products and Applications (IAMAS, IAG, IAGA, IAHS, IAPSO, UCCS); IRC conveners: Hung Lung Allen Huang, Michael D. King.
- Aerosols, Radiation and Clouds (IRC, ICCP, ICACGP); IRC conveners: T. Nakajima, G. Isaac, G.-Y. Shi, and L. Barrie
- Solar Activity and its Influences on the Earth's Weather and Climate (IRC); IRC convener: Werner Schmutz

The President also informed the Commission about the most relevant outcomes from the IUGG/IAMAS business meetings. These were the IAMAS officer nominations:

President: G. Wu, China

Vice presidents: M.A. F. da Silva Dias, Brazil; A. Thompson, USA

Secretary General: H. Volkert, Germany

Two important IUGG/IAMAS resolutions should be worked out very soon (after the business meeting the second resolution has been made available at the IAMAS web site) on:

Aerosol Pollution and Precipitation and on

The Urgency of Addressing Climate Change.

The President also informed the Commission about dates, locations and format for the proposal of sessions, of IAMAS 2009, 19-29 July, in Montreal. After discussion, the following sessions and conveners were proposed:

- Link among aerosols, clouds, and Radiation (IRC, ICCP, ICACGP); IRC conveners: T. Nakajima, G. Isaac, G.-Y. Shi, and L. Barrie
- 3D Radiative Transfer in the atmosphere (IRC); IRC conveners: R. F. Cahalan, B. Mayer.
- Satellite Observations of the atmosphere (IRC); IRC conveners: H. L. A. Huamg, M. D. King.
- Solar Activity and its Influences on the Earth's Weather and Climate (IRC); IRC conveners: W. Schmutz

The conveners were encouraged to submit as soon as possible their proposal according to the format above. It was also decided to inform IRC members and ask for contributions.

After the President's presentation and the discussion of IAMAS 2009 the Commission moved to discuss the venue site, dates and organization of IRS2008. A presentation was given by Marcia Yamasoe which will also be made available at the IRC web site. The presentation was welcomed and highly appreciated from IRC Commission. It was decided to have IRS2008 in Brazil, according to venue and dates proposed by the LOC committee. The main organization aspects of IRS 2008 can be summarized as follows:

- Venue IRS2008: Brazil, Iguaçu, 3-8 August
- LOC: Marcia Akemi Yamasoe (University of Sao Paulo); Maria Assunção F. Silva Dias (CPTEC/INPE); Paulo Artaxo (University of Sao Paulo); Pedro Leite Silva Dias (University of Sao

Paulo); Luiz Augusto Machado (CTA – CPTEC/INPE); Regina Alvalá (INPE); Juan Carlos Ceballos (CPTEC – INPE); Alexandre Correia (CPTEC – INPE); Karla Longo (CPTEC – INPE); Marcelo Corrêa (Federal University of Itajubá); Aline Procópio (Federal University of Rio de Janeiro); José Vanderlei Martins (IRC Representative, UMBC, NASA/GSFC).

- Program committee: IRC officers and conveners.
- Book publication (Nakajima and Yamasoe)
- IRC gold medal award committee and IRC young scientists award committee (IRC officers+ senior scientists)
- Young scientist award recipient: one or (possibly) two scientists

During the discussion it was decided following the IRC rule that two former presidents, H. Fischer and W. Smith, will act as members of the committees for the IRC awards. Two other senior scientists will be appointed by the President at earliest timing. H. Fischer recommended to the IRS2008 LOC to select Hotels capable to propose cheap accommodations for young people and/or students. The discussion then moved to the organization of the programme, sessions and sub-sessions of next IRS 2008. It was remembered to the commission that the past IRS Conference adhered to the following main topics:

Session A: Topical Union Session

Session B: Radiative Transfer Theory and Modelling

IRC Business Meeting at the IUGG Assembly in Perugia, 2007. From left to right, first row: Herbert Fischer and Carmine Serio; second row: Bernhard Mayer, Werner Schmutz, and Robert F. Cahalan; third row: Mario Blumthaler, Nataly Ye. Chubarova, and Teruyuki Nakajima; fourth row: Guang-Yu Shi and Peter Köpke; fifths row (see upper figure): Marcia Akemi Yamasoe, José Vanderlei Martins, Alexander Marshak, Paolo Di Girolamo, and Allen Larar.

Session C: Molecular Radiative Properties
Session D: Particle Radiative Properties
Session E: General Remote Sensing
Session F: Satellite Measurements
Session G: Surface Measurements and Field Experiments
Session H: Radiative Budget and Forcing
Session I: Weather and Climate Applications

Although the above Format was appreciated from the Commission, there were comments regarding how to update the various topics: On behalf of LOC scientists, M. Yamasoe proposed to have a session or subsession able to deal with Energy issues and Amazon basin studies; H.-J. Bolle proposed to have a topic on radiation and climate in Megacities; A. Larar proposed to not predefine Session titles at this time but, rather, to identify topical areas in the Call for Papers and then use the submitted abstracts to best optimize conference session/program formulation; he also suggested the topical area list include new satellites/missions, such as CloudSat/Calipso and Metop/IASI. In the end, it was recommended to have as soon as possible an e-mail exchange among IRC members in order to have feedback suggestions and comments.

The next item was the reports of Working Groups.

H. L. A. Huang reported on the activity of the ITWG working group. His power point presentation will be soon available on the IRC website. The presentation was appreciated and congratulated from the attendees. In particular, the President praised the high efficiency and intercommunication with other bodies of the ITWG as a model for other WGs. H.-J. Bolle remarked with respect to the direct interaction between ITWG and other bodies that recommendations to international organizations would have to be channelled through IRC and IAMAS.

R. F. Cahalan reported on the activity of the 3DRT working group and G.-Y. Shi presented a brief report on the workshop “From Dimming to Brightening and its Climate Implications”, which was held in Nanjing, China on May 20-21, 2007. Both power point presentation should be made be soon available on the IRC website. The presentations were appreciated and congratulated from the attendees.

Finally the Vice President, R. Cahalan, introduced to the assembly the new IRC member Alexander Marshak, who works with NASA/GSFC. He was congratulated from the Commission.

Outlook

With the meeting in Perugia the 1948 reformed International Radiation Commission of IUGG is approaching its 60th birthday and came back to the country where it held its first Symposium in connection with the IUGG Assembly, 1954, in Rome. From a small group of scientist dedicated primarily to the question how to make accurate measurements of the solar radiation or, as we would say nowadays, to determine accurately the solar input to the Earth’s climate system, it has grown to a large organization with quasi-permanent Working Groups and Rapporteurs who keep contacts to world-wide research programmes which determine the scientific landscape since the last third of the twentieth century. The range of its research area has grown from individual ground based measurements to global networks and remote sensing from space, from pyrheliometers measurements to lidar and microwave sounding, from clear sky observations and simple models to 3D radiative transfer through turbid atmospheres and clouds, including, for a limited time, atmospheres from other planets. From a group originally dominated by European scientists, the IRC has reached out to all continents and especially during the last few years became very active in Asia and will celebrate in front of the breathtaking scenery of Iguaçu in Brazil its 60th birthday and the 100th anniversary of the publication of Mie’s paper on the optics of turbid media which has so much stimulated aerosol research.

The minutes of the IRC business meetings, on which this compilation is based, do not anymore reflect the full extent of progress in the widespread field of radiation research. A large fraction of the time of business meetings has to be spent on organisational matters since the IRC is responsible for regular meetings of the scientific community to exchange and to interlink the obtained results and to direct the Working Groups into the most challenging areas, thus assisting the global research programmes in solving

the overriding problems of our time. Or as M. Lynch formulated it in 1996 in his paper on the IRS format: *IRS has a role of reviewing recent progress in the discipline and the formulation of key directions for future scientific effort*. The scientific progress is found in appendices to its earlier minutes and nowadays in the internet. This information results from the work of its members and adopted scientists in various groupings. Most of the discussions about scientific details and scientific progress take place in workshops of the Working Groups who directly interact with the wider scientific community, submitting their reports to the IRC, publishing them in international series, in the open literature, and - more recently - at the IRC home-page. As a consequence the IRC recently has published less commission recommendations and resolutions than in its earlier times. The history of the IRC is developing into the history of its Working Groups.

IRC Working Groups

The first time it was mentioned that the members of the IRC delegated work among themselves was at a business meeting in Rome, 1954. The IUGG Committee on the IGY expressed the wish that not only should a program for radiation measurements during the IGY be developed and published, but that detailed instructions for radiation measurements would also be of great value. The Commission undertook this task and nominated a small *Sub-commission for radiation research during IGY*. There was not much formality involved at that time, such as for the appointment of a chairperson, formal terms of reference or formal decisions to dissolve such a group which sometimes only worked during the time of the meeting. These groups were called Sub-commissions because only Commission members worked on them. Later on such groups were called *ad hoc Working Groups* if they had been established for a limited time to respond to a request from other organizations or to work on the solution of a matter that just came up during a meeting or simply *Working Groups* if there was a longer research strategy behind their terms of reference. These "working groups" were open for non-members of the Commission. Chairpersons were appointed by the Commission, sometimes following recommendations of the involved scientists. A third category of contributors came later, the *Rapporteurs*. These are single scientists who are asked to follow specific radiation-relevant scientific developments which happen outside the Commission but in which the Commission is interested, to keep the IRC informed by annual reports about how these develop and to alert the Commission if official interaction becomes necessary.

1956 a Sub-commission worked on an *Instruction Manual for Radiation Instruments and Measurements* (Chairman A. Drummond) and another one on the *Preparation of A Terminology of Radiation Fluxes and Radiation Instruments* consisting of R. Dogniaux, R. Schulze, and G. D. Robinson. A. Drummond gave a survey of his plan for the instruction handbook. The sub-commission on terminology met several times before the meeting in Davos, 1956. Here they presented three versions, in English, French and German, which diverged from each other. The commission urged the authors to unify the terminology in which they succeeded with the help of two other commission members.

A temporary working group was appointed in Davos to obtain a recommendation on the best turbidity measure which did not arrive at a general recommendation.

Also a new *permanent Sub-commission* was formally set up with precise "terms of reference" to examine questions connected with the technical utilization of solar energy of which P. Courvoisier was appointed Chairman. This *permanent* Sub-commission was already disbanded 1960 but revived with more focused terms of reference in 1963 as a Sub-commission on Applied Solar Energy which also did not survive for long.

With the progress of GARP the simulation of the vertical distribution of heating rates by atmospheric forecast models became an important issue. To test the theoretical formulations, radiometers were developed to measure the vertical distribution of radiation fluxes from balloons and aircraft. Soon it became necessary to test the accuracy of these new devices. For this purpose inter-comparison campaigns were organized. The first one took place on invitation of H. G. Müller in Munich, in December 1963. At the meeting in Leningrad, 1964, a report of these activities was given and P. Kuhn was asked to form a working group to coordinate this program. This was the formal birth of ad hoc IRC working groups with external members. The motivation for a second working group inaugurated at this meeting arouse from the cooperation with COSPAR WG 6 (Application of Space Techniques to Meteorology and Earth

The following rules for IRC-Working Groups were valid in 2004:

1. Scientific Objective of the WG: The scientific objectives of a WG should be clearly defined at the beginning, and in case of prolongation in a more or less modified form, and should be part of actual research areas in atmospheric radiation.

2. Duration of a WG: The WG should define activities which can be treated in a limited time frame (about 4 years). See also point 5.

3. Chairperson of a WG: The chairperson of a WG is normally a member of the IRC (exceptions are possible). At the IRC business meetings the chairperson or a representative of the chairperson will speak to the WG written report and answer questions raised by the audience.

4. Reports: The chairperson of a WG delivers a brief written annual report to the IRC president (about 2 pages) before an announced IRC business meeting. After 4 years the WG completes a reasonable report about the scientific objectives achieved during this time period for the IRC.

5. Continuation of a WG: The IRC will consider a continuation of a WG after a 4 year period If the WG has delivered a reasonable report about the results and the planned future WG activities, and the chairperson or a representative attends the corresponding IRC business meeting for discussion.

Rules for IRC Workingn Groups

Survey), which was concerned about the accuracy of absolute measurements made from satellites. This group in the beginning firmed as "COSPAR WG6 - Report" because it was asked to review this report with respect to calibration problems and to recommend actions for the improvement of absolute measurements.

With the growing complexity and diversity of research into radiative processes in the atmosphere and remote sensing it became necessary to involve more scientists in the work of the IRC. Rather than to expand its membership considerably, the IRC decided in the following years to set up ad hoc working groups on specific themes in which also scientists are involved who are not members of the IRC. By the time some WGs became more independent and organized own meetings in cooperation with other international bodies. The chairpersons of these working groups, if appointed from outside the IRC, got the status of "*ex officio members*" for the time of the existence of their working group. Sometimes, when the task came to an end but the topic needed further observation, a working group was dissolved but a *Rapporteur* was appointed to report back to the IRC e.g. how the scientific community dealt with the outcome of the work.

Always at its business meetings the IRC is obliged to discuss the reports received from its WGs and to decided about their continuation. Sometimes the IRC found it necessary to remind the WGs about the rules under which they were established. The last time this was the case in 2004 (see box). Especially at the meetings in Melbourne, 1997, and in Nagoya, 1998, the continuity of WGs was questioned. In Melbourne the President W. Smith charged the Vice-president H. Fischer to undertake a review of the WGs - which lead to the disbandment of some of them. The IRC at that time concluded that "IRC Working Groups being created from time-to-time and assigned tasks to be undertaken. Once the WG had addressed the issues and reported satisfactorily, the expectation should be that the WG be closed down. If WGs became standing committees they would become too numerous and the IRC too cumbersome to function. .....The IRC needed to view the WGs as transient. If they dragged on too long, people would refuse to participate ". In 1983 the ICLAS was accepted as an own entity within the IRC (though originally only for a couple of years) but some WGs which started out with limited briefs exist now for almost 25 years. It therefore seems to be overdue to review the conclusions drawn by the IRC in 1998 and, maybe, to consider to go back to its beginning and establish permanent sub-commissions. It was also felt that "the WGs should have more of a role at the IRS. For example, special reporting sessions or workshops depending on needs, problems or purpose." The proposal should therefore earnestly be considered to allocate time for the WGs to present at least from time to time the *scientific results* of their work and where science stands at that time at the open sessions of the IRSs. WGs generally produce remarkable and important results which often disappear in the grey literature or become part of reports of other organizations. Even if there are publications in the referenced literature it is sometimes difficult to track

them to the IRC. As repeatedly requested at business meetings (see e.g. Sapporo, 2003), the information of the interested scientific community about reports and publications written as an outflow of the work of the IRC and its WGs needs to be improved (e.g. by disseminating relevant information through the internet). For administrative purposes it is necessary to report - as it is the case in the minutes of business meetings but unfortunately also in some WG reports - which items have been discussed and that results have been obtained. But it would be of more value to find a way to inform the interested scientific community more continuously as well about *which* scientific results are obtained and what is their impact on the progress of science. This unresolved item was already raised - but tabled - at the business meeting in 1991.

Table 5 contains a list of the Radiation Commissions working groups, the period of their existence, and the name of their chairpersons, as well as of the IRC Rapporteurs.

Table 5. Working Groups of the Radiation Commissions of IMO (1929 - 1936) and IUGG (1954 - 2008) and IRC Rapporteurs (1980 - 2008)

Period of existence	Title of the Working Group	Name of the chairperson(s)/members
1929 (- 1931?)	Sub-commission to prepare for radiation measurements during the Second International Polar Year	A. Ångström, N. N. Kalitine, and F. Linke
1930 - 1948	Ssub-commission for atmospheric ozone	G. M. B. Dobson (President), C. G. Abbot, A. Ångström, Chalonge, C. Fabry, F. W. P. Götz, H. H. Kimball, E. Ladenburg
1932 (ceased by world war II)	Sub-commission for Absolute Pyrheliometry	R. Süring (President), W. Mörikofer (Secretary), C. G. Abbot, A. Ångström, K. Feussner, O. Hoelper, F. E. Volochine
1936 (ceased by world war II)	Sub-commission for the Cadmium Cell Problems	A. Ångström, W. W. Coblentz, O. Hoelper, F. Linke, W. Mörikofer
1936 (ceased by world war II)	Sub-commission for Nomenclature in Actinometry	W. Mörikofer (President), R. Süring, F. J. W. Whipple
1954-1957	Sub-commission for radiation research during I.G.Y.	Members: A. Angström, A.J. Drummond, F. Möller, W. Mörikofer, and G.D. Robinson
1956 - 1959 1959 - 1960	Sub-commission on Technical Application of Solar Energy Reconstituted as Sub-commission on Applied Solar Energy	P. Courvoisier W. Mörikofer
1956 - 1960	Sub-commission on Terminology of radiation fluxes and radiation instruments	R. Dogniaux
1956	ad hoc WG on Recommendation on the Best Turbidity Measure	Menbers of the IRC
1954 - 1957	Sub-commission on an Instruction Manual for Radiation Instruments and Measurements	A. Drummond
1960	ad hoc WG on IRC Terms of Reference and Programme of Activity	Members: A. J. Drummond, S. Fritz, R. Goody, K. Ya. Kondratyev

Table 5 continued

Period of existence	Title of the Working Group	Name of the chairperson(s)/members
1960 - 1963	Sub-commission on Instrumentation	A. J. Drummond
1964 - 1972	Radiation Sonde Intercomparisons (in co-operation with GARP)	P. Kuhn P. Kuhn and J. Gille
1972 - 1982	Standard Radiation Atmospheres (SRA) Report 1981: WCP-112/WMO/TD#24	R. A. McClatchey
1972 - 1980	Radiation Subprogramme for GATE	T. Vonder Haar
1972 - 1981	Units and Nomenclature Continued 1973 as: Radiation Units and Terminology (Report printed by IAMAP April 1978)	J. Howard and E. Raschke 1973: E. Raschke
1972	ad hoc WG on Evaluation of the COSPAR W.G. 6 - Report Continued as:	J. Houghton
1972 - 1973	Calibration and Inter-Comparison of Rocket and Satellite Radiation Instruments Reconstituted as:	
1973 - 1984	Calibration, Standardization and Validation of Satellite Radiometer Measurements (specifically those designed for the measurement of the radiation budget of the earth)	H. Yates
1972 - 1981	Atmospheric Transmittances for Indirect Soundings (Transmission Functions)	D. Wark
1973 - 1983	Standard Procedures to Compute Atmospheric Radiation Transfer in a Scattering Atmosphere Report published 1985 under the title: "Radiative Transfer in Scattering and Absorbing Atmospheres: Standard Computational Procedures", A. Deepak Publishing, Hampton, Virginia, USA	J. Lenoble
1975	ad hoc WG on the Global Atmospheric Aerosol Radiation Experiment (GAAREX)	K. Ya. Kondratyev
1975-1981	Inversion Methods	L. Fymat
1976-1984	Radiation Manual	C. Fröhlich, J. London
1977-1981	Ad Hoc Working Group on Atmospheric Optics	V. Zuev
1978 - 1982	Aerosols and Climate	Joachim Joseph
1979 - 1980	Ad Hoc Working Group on Future Activities of the Radiation Commission (IAMAP)	T. Vonder Haar
1980 - 1983	World Data Centers continued as Rapporteur E. Raschke	I. Galindo 1982: E. Raschke

Table 5 continued

Period of existence	Title of the Working Group	Name of the chairperson(s)/members
1980 - 1985	Clouds and Radiation (started as Joint IRC-ICCP WG on Cloud Radiation Feedback) Report 1984	G. Paltridge
1980 - 1981	Radiation and Dynamics	G. Ohring
1982 - 1986	Optical Properties of Aerosols (WGOPA) (1984: Discussion about re-naming in Global Data Library; continued as IACP)	J. H. Joseph and H. E.Gerber
1981 - 1986	Use of TOVS Data (planning and conference 1983 in Igls, Austria) Continued as ITWG	W. Smith and R. Rizzi
1981- 1998	Parametrization of Radiatively Active Trace gases (also named Radiatively Active Gases) Merged into Radiation Codes in Climate Models	V. Ramanathan (1981 - 1987) and H. Grassl (after 1987 at business meetings represented by R. G. Ellingson)
1981- 1984	Remote Sensing (Spectroscopy) continued 1984 as Direct Problems in Remote Sensing and 1988 as ITRA	L. Kaplan and A. Chedin
1983 - present	International Coordination Group on Laser Atmospheric Studies (ICLAS)	P. McCormick 1997: P. Flamant 2006: R. Menzies
1984 - 1988 1988 - 1998	Direct Problems in Remote Sensing continued 1988 as Intercomparison of Transmittance and Radiance Algorithms (ITRA)	A. Chedin A. Chedin 1991 - 1993: N. A. Scott
1984	Ad hoc WG on IRC involvement in international programmes	E. Raschke
1984 - present	Inter-Comparison of Radiation Codes in Climate Models - Joint WMO-IRC WG (ICRCCM) Continued 1988 with new mandate 1991 addressed as International Committee for Radiation and Clouds for Climate Models (ICRCCM)	Y. Fouquart and H. Geleyn 1986: Y. Fouquart 1987: Y. Fouquart and R. G. Ellingson 1992: R. G. Ellingson
1985	International Satellite Cloud Climatology Project (ISCCP) IRC advisory action	H.-J. Bolle, G. Paltridge, E. Raschke, T. Vonder Haar
1986 - 1993	Atmospheric Spectroscopy Applications (ASA) Joint WG with international Ozone Commission (IOC) and International Commission on Planetary Atmospheres and Their Evolution (ICPAE).	R. Zander and A. Barbe (Ozone Commission)
1993 - present	Continued 1993 as Joint IRC/IOC/ICPAE WG Atmospheric Spectroscopy Association (ASA)	1994: L. Rothman and A. Barbe

Table 5 continued

Period of existence	Title of the Working Group	Name of the chairperson(s)/members
1986 - 1991	International Aerosol Climatology Project (IACP), Joint WG with ICCP	A. Deepak and G. Vali 1987: A. Deepak
1986 - present	International (A)TOVS Working Group (ITWG)	1987 - 1991: A. Chedin and P. Menzel 1992 - 1997: J. Eyre and M. Uddstrom 1997 - 2006: J. Le Marshall and G. Rochard 2006 - 2008: T. Achtor and R. Saunder
1986 - 1988	Earth Radiation Budget (ERB) continued as Rapporteur	G. Ohring and T. Vonder Haar 1987: Ohring
1987 - 1991	Clouds and Climate Sensitivity (Report 1991 in BAMS)	G. Ohring and A. Arking
1987 - 1990	Clouds and Radiation, Joint WG with the Cloud Physics Commission	G. Stephens
1990 - 1998	Reformed WG on Clouds and Radiation with added responsibility of IRC representation on the joint JSC/IRC/WMO-CAS group on Radiative Fluxes Continued 2001 as Rapporteur	G. Ohring
1989 - 1996	IAMAP Intercommission Working Group on the Climatic Impact of Trace Constituents (CITC)	J. London and Wei-Chyung Wang 1993: R. G. Ellingson
1991 - 2000	ICCP/IRC WG on Clouds and Radiation inclusive representation in the Joint JSC/IRC/WMO Group on Radiation Fluxes which was formed in January 1991	G. Ohring
1991 - 1992	IGAP Implementation of the Plan	P. McCormick and R. Jaenicke
1996 - present	Remote Sounding of Middle Atmosphere (RSMA)	Y. M. Timofeyev
2002 - present	3D Radiative Transfer (3D RT)	R. F. Cahalan
2005 - present	Long-term Analysis of Surface SW Radiation Budget (LASR)	A. Ohmura & G.-Y. Shi 2006: T. Hayasaka
Rapporteurs:		
1980 - 1998	1980 - 1983: Cloud-Radiation Experiments 1983 - 1988: Cloud Base Measurement Programme 1989 - 1998: Experimental Cloud LIDAR Pilot Study (ECLIPS)	C. M. R. Platt
1983	Radiation Units and Terminology	E. Raschke

Table 5 continued

Period of existence	Title of the Working Group	Name of the chairperson(s)/members
1983	Ocean Heat Budget Studies	T. Vonder Haar
1983 - 1987	World Data Centers (started as Leningrad World Data Centre on Radiation)	E. Raschke
1985 - 2001	International Satellite Cloud Climatology Project (ISCCP)	E. Raschke
1988 - 1998	International Global Atmospheric Chemistry Program (IGAC)	H. Fischer
1988- 1991	Earth Radiation Budget continued by JSC/IRC/WMO-CAS Joint Working Group on Radiative Fluxes	E. Raschke
1991 - 1998	JSC/IRC/WMO-CAS Joint Working Group on Radiative Fluxes (incl. Clouds and Radiation)	T. Vonder Haar 1993: G. Ohring
1993 - present	UV-B	P. Simon
1996 - present	Baseline Surface Radiation Network (BSRN)	A. Ohmura
2001 - present	Clouds and Radiation	R. G. Ellingson 2003: Th. Ackerman
2005 - present	GEWEX Radiation Panel (GRP)	W. P. Rossow

Appendix 1: Excerpt of IAMAS Statutes

Excerpt of IAMAS Statutes and Regulations (01. 08. 1999) concerning Commissions and Joint Comittees:

XI - Commissions

31. Commissions for the study of particular questions may be constituted by the General Assembly.
    31.1 The objectives of the Commissions will be reviewed every four years by the Executive Committee. This will make appropriate recommendations at a Plenary Session of each Ordinary General Assembly, which decides on the continuation of the research and works of the Commission or on its termination.

32. The members of these Commissions will be recognized and interested scientists.
    32.1 The Commissions may elect new members by a simple majority vote of the members voting in the election. These members must be from Adhering Countries. Members may also be appointed from non-Adhering Countries by the President of a Commission, after consultation with members of the Commission. Due regard should be paid to geographical representation in the composition of the Commissions. The terms of Commission members will normally be for two full periods. The results of membership elections and appointments will be reported to the General Assembly.

33. Each Commission will elect a President and a Secretary from among their membership; and a Vice President may also be elected if the Commission desires; their terms of office will normally be for one four year term. They will be eligible for re-election for one additional term. Officers will be from Adhering Countries, except Associate Countries.

34. When a new Commission is constituted, the first President will be appointed by the Executive Committee. The Commission President will invite appropriate scientists to be members. These appointments will be voted upon by the Commission at its first meeting.

35. The Commission should, in general, conduct their elections of officers and members at the times of the Ordinary General Assemblies of the Association. In this case these elections should be held prior to the final Plenary Session of the General Assembly so that the results, along with other business conducted by the Commissions, may be reported to the General Assembly. Alternatively, Commissions may decide to elect their officers at a Commission meeting/ symposium that is independent of the Ordinary General Assembly, or by correspondence. The General Assembly will have the right to comment on the work of the Commission, which the Commissions may wish to consider at subsequent business sessions.

36. The Commissions may meet and have symposia when convened by their President outside the meetings of the General Assemblies. Such symposia may be arranged jointly between interested Commissions, or jointly with other appropriate bodies of the International Council of Scientific Unions, or with other relevant organizations (e.g., the World Meteorological Organization).

37. A Commission may, at the discretion of its President, appoint Sub-Commissions, Committees, or Working Groups, to undertake special studies or to devote specialist attention to a part of the general area of concern. The members of such sub-bodies need not be members of the Commission. They should be appointed by the President of the Commission, after due consultation with members of the Commission. Findings or recommendations of such sub-bodies must be approved by the parent Commission before promulgation.

38. All decisions of Commissions will be taken by a simple majority of votes of the members voting (individual votes). In case of equal votes for and against, that of the President will decide.

XII - Joint Committees

39. Joint Committees between the Association and other Associations on scientific questions of mutual interest may be constituted by the Associations concerned. In the case of IAMAS, formal approval will be given by a General Assembly, although approval in principle may be granted at an earlier date by the Executive Committee.

40. The members of the Joint Committee will be appropriate scientists nominated by the respective Associations, each of which will normally nominate the same number of members.

41. The Joint Committees may propose new members whose nomination must be ratified by the respective Association at the occasion of their General Assembly. The term of office of members will be for one period. They will be eligible for re-appointment.

42. Each Joint Committee will elect a President and Secretary who will not both have been appointed by the same Association, and whose term of office will be for one period. They will be eligible for re-election once.

43. The Joint Committees will formulate their program of work and will organize their meetings, insofar as possible, during the course of the sessions of the General Assembly of the Union. The proceedings of the Joint Committees will be appended to the minutes of the Associations concerned.

43.1. The Joint Committees may meet when convened by their President outside the meetings of the General Assemblies, on condition that the Bureaus of the respective Associations are advised beforehand. They may meet at the same time as related Commissions or Joint Committees constituted by other Associations of the Union or by other Unions, in order to study and resolve together problems which interest more than one Association of the Union or more than one Union.

44. Requests from a Joint Committee for subsidies must be presented and supported by the Associations concerned.

45. Every Joint Committee may refer in a consultative capacity to experts who are not members of the Joint Committee.

46. All decisions of Joint Committees will be taken by a simple majority of votes of the members present (individual votes). In case of equal votes for and against, that of the President will decide.

47. The IAMAS Executive Committee will review the continued participation of IAMAS in each Joint Committee every four years.

Appendix 2: Radiation Commission Members

Members of the Radiation Commissions 1896 - 1948

The following abbreviations are used for the Commissions:
RC Radiation Commission of IMO founded as Commission for Radiation and Insolation (1896 - 1946)
ISC International Solar Commission of IMO founded as Commission for the Consolidation and Discussion of Meteorological Observations in the Light of their Relationship to the Physics of the Sun (1905 - first world war)
CSR Commission of Solar Radiation of IUGG 1924 - 1948 (no member lists are available for the time 1932-1936, the last meetings before the second world war).
The years given for the end of memberships refer to the last year when the name is mentioned. The membership could have lasted longer e.g. until the next meeting respectively throughout the war were the activities were practically ceased. If only one year is given, this could imply membership until the following meeting.

Name and Affiliation	Commission and Years
Abbot, C. G., Smithsonian Institution, Washington, D. C., USA	RC 1919 - 1936
Åkerblom, F., Observatoire Meteorologique de 1'Universite, Upsala, Sweden	RC 1910 - 1936
Albrecht, F., Meteorologisches Observatorium, Potsdam, Germany	RC 1936
Angot, A., Directeur du Bureau Central Meteorologique de France, Paris, France	ISC 1907- 1910 RC 1919 - 1936
Ångström, A., University, Upsala, Sweden, (Secretary RC 1919, 1929) Statens Meteorologisk-Hydrografiska Anstalt, Stockholm, Sweden (President RC pro tem 1932, President RC 1936)	RC 1919 - 1936 CSR 1924 - 1930
Ångström, M. K., University of Upsala, Sweden	RC 1896 - 1905 ISC 1905 - 1907
Bigelow, Frank H., Officina Meteorologica Argentina, Buenos Aires, Argentina	RC 1910 - 1925 ISC 1910
Birkeland, K., Prof., Dptm. of Physics, University of Christiana, Norway	ISC 1907 - 1910
Boerema, J., Prof. Koninklijk Magnetisch en Meteorologisch Observatorium, Weltevreden, Dutch Indies (1929), Batavia (1932, 1936)	RC 1923 - 1936
Boutaire, A., Faculte des Sciences, Lyon (1929), Universite de Dijon, Dijon (1932, 1936), France	RC 1929 - 1936
Boutaric (eventually printing error, see Boutaire)	RC 1923 - 1925
Braak, C., Koninjlijk Nederlandsch Meteorologisch Instituut, de Bilt, Netherlands	RC 1929 - 1932
Brazier, C. E., Observatoire du Parc Saint-Maur, Seine, France	RC 1932 - 1936
Chistoni, C., Dptm. di Fisica Terrestre nell'Universite, Naples, Italy	RC 1896 - 1925
Chwolson, O. D. Dptm. of Physics, University, St.Petersburg, Russia	RC 1896 - 1923
Cirera, R., Rev./Padre, S. J., Director del Observatorio del Ebro, Tortosa, Spain	ISC 1907 - 1910
Coblentz, W. W., Council on Physical Therapy, Washington, D. C., USA	RC 1936
Davis, W. G., Officina Meteorologica Argentina, Cordoba, Argentine Republic	ISC 1907
Deslandres, H., Directeur de l'Observatoire d'Astronomie Physique, Meudon, Seine-et-Oise, France	ISC 1907 - 1910

Name and Affiliation	Commission and Years
Dobson, G. M. B., Dr., Watch Hill, The Ridings, Shotover, Oxford, England	CSR 1927 - 1930 RC 1936
Dongier, R., Prof., Institut de Physique du Globe de 1'Universite, Paris, France	RC 1923 - 1929
Dorno, C., Prof., Observatoire pour 1'Etude de la Radiation solaire, Davos, Switzerland	RC 1923 - 1929
Eliot Sir John (Secretary), 79, Alleyn Park, Dulwich, London; Bon Bon Porteau, Cavalaire, Var, France.	ISC 1907
Evershed, J., Kodaikanal Solar Physics Observatory, Madras	RC 1919 - 1936
Exner, Franz, Prof., Institut für Radiumforschung, Wien, Austria	RC 1923 - 1925
Fabri, France	CSR 1927 - 1930
Gorczynski, L., Dr., Subdirector for the Meteorological Bureau, Wasaw, Krakauer Vorstadt Director, Meteorological Service, Warsaw, Poland Societe des Sciences, Warsaw, Poland	RC 1910 RC 1919 - 1936 CSR 1924 - 1930
Götz, F. W. P., Dr., Lichtklimatisches Observatorium, Arosa, Switzerland	RC 1932 - 1936
Hale, G. E., Prof., Director of the Solar Observatory, Carnegie Institution, Pasadena, Calif., USA.	RC 1905 - 1910 ISC 1905 - 1910
Hann, J., Hofrat Prof. Dr., XIX, Hohe Warte, Vienna	ISC 1907 - 1910
Hepites St. C. Hepites, Directeur superieur honoraire de 1'Institut Meteorologique de Rumania, Bukarest-, Rumania	ISC 1907 - 1910
Hergesell H., Prof., Siegmundshof 10 (1929) Kaiseralle, 171, Berlin-Wilmersdorf, Germany	RC 1923 - 1936
Hinks, A. R., Chief-Assistant, The Observatory, Cambridge, England	RC 1905 - 1910
Hoelper, O., Dr., Meteorologisches Observatorium, Potsdam, Germany	RC 1932 - 1936
Hunt, Egypt/Australia	CSR 1927 - 1930
Hurst, Egypt	CSR 1930
Innes, R. T. A. Director of the Transvaal Meteorological Department, Johannesburg	RC 1905 - 1910
Janssen, Observatoire d'Astronomic Physique, Meudon, Seine et Oise. Paris, France	ISC 1907
Jaumotte, Commandant Comm., Director, J. Institut Royal Meteorologique de Belgique, Uccle pres Bruxelles, Belgium	RC 1919 - 1936
Julius, W. H., Prof., Dptm. of Physics, Rijks Universiteit, Utrecht, Holland	ISC 1907 - 1910
Kalitin, N. N., Prof., Observatoire Geophysique Central, Vassili Ostrov (1923-1929); Institut de'Actinometrie, Leningrad, USSR	RC 1923 - 1936
Kimball, H. H., Prof., Mount Weather Observatory, Va. (1910), Mount Wilson Solar Observatory, Pasadena, Calif. (1919), U. S. Weather Bureau, Washington, D. C. (1929), USA	RC 1910 - 1936 CSR 1924 - 1930
Knox-Shaw, H., Director, Meteorological Section, Physical Service, Dawawyn, Cairo, Egypt	RC 1919 - 1929
Köppen, W., Admiralitatsrat Prof. Dr., Abteilungsvorstand an der Deutschen Seewarte, Hamburg, Germany	ISC 1907 - 1910
Kuhl, W., Prof., Meteorologisches Observatorium, Potsdam, Germany Ruschenstrasse 14, Hameln, Germany	RC 1932 - 1936

Name and Affiliation	Commission and Years
Lejay, Pére P., Rev., S.J., Observatorium Zi-ka-wei, Shanghai, China	RC 1932 - 1936
Lindblom (eventually typing error, see Lindholm)	RC 1925
Lindholm F., Dr., University, Christiania, Norway (1919) Statens Meteorologisk-Hydrografiska Anstalt, Stockholm, Sweden	RC 1919 - 1936
Linke, F., Prof., Universitäts-Institut für Geophysik and Meteorologie, Frankfurt/M., Germany	RC 1925 - 1936
Lockyer Sir Norman (President), Solar Physics Observatory, South Kensington, London S.W.	ISC 1907 - 1910
Lockyer W. J. S., Dr., Solar Physics Observatory, South Kensington, London	ISC 1907
Lunelund, H., Dr./Prof., Universite de Helsingfors, Helsinki, Finland	RC 1929 - 1936
Lyons, H. G. R. E., Captain, Survey Department, Cairo, Egypt (1907) Professor of Geography at the University, Glasgow, Scotland	ISC 1907 - 1910
Marchand, E., Directeur de l'Observatoire du Pic du Midi, Bagneres-de- Bigorre, 9, rue Gambetta, France	RC 1905 - 1910 ISC 1907 - 1010
Maurain, Ch., Prof., Institut de Physique du Globe de la Faculte des Sciences de l'Universite, Paris, France	RC 1923 - 1936 SRC 1924 -1930
Maurer, J., Dr., Federal Meteorological Institute, Zurich, Switzerland (President RC 1910 - 1929)	RC 1910 - 1936
Mercaton, Switzerland	CSR 1927 - 1930
Messauger, Spain	CSR 1927 - 1930
Mohn, H., Prof. Dr., Direktor des Meteorologischen Instituts, Christiania, Norway	ISC 1907 - 1910
Moll, W. J. H., Prof., Driebergsche Weg 16 A Zeist (1929), Huize Heuvelheide, Soesterberg, Netherlands (1932)	RC 1925 - 1936
Mörikofer, W., Dr., Physikalisch-Meteorologisches Observatorium, Davos, Switzerland (Secretary pro tern)	RC 1932 - 1936
Nell, M. Ch. A. C. Veursche Weg 35a, Roorschoten (1929), Wijngaardenlaan, Voorscholen (1932), Papelaan 118, Voorsehoten, (1936), The Netherlands	RC 1929 - 1936
Normand, India	CSR 1927 - 1930
Patterson, J., Meteorological Service of Canada, Toronto, Ontario, Canada	RC 1936 CSR 1927 - 1930
Pernter, J. M., Hofrat Prof., Hohe Warte, Vienna, Austria	RC 1905, ISC 1907
Plaskett, M. J., Victoria, Canada	RC 1919 - 1936
Platania	CSR 1924 - 1930
Puppo, A. R., Prof., Osservatoirio Meteorologico di Conegliano, Conegliano, Italy	RC 1936
Ramanathan, K. R., Dr., India Meteorological Department, Poona (1932), Colaba and Alibag Observatories, Colaba, Bombay India	RC 1932 - 1936
Rey, P., Insp.-Gen., Institut de Recherches agronomiques, Paris, France	RC 1923 - 1936
Ricco, A., Prof., Direttore dell'Osservatorio Astrofisico, Meteorologico e Geodinamico, Catania, Sicily	ISC 1907 - 1910
Rimmer, W. B., Prof., Commonwealth Solar Observatory, Mount Stromlo, Canberra, Australia	RC 1936

Name and Affiliation	Commission and Years
Rotch, A. L., Prof., Director of the Blue Hill Meteorological Observatory, Hyde Park, Mass., USA	ISC 1907 - 1910
Rucker, Sir Arthur, 19 Gledhow Gardens (1907), London, S.W.Newbury, Everington House, Berkshire,	ISC 1907 - 1910
Rykatschew, M., Generalleutnant, Direktor des Physikalischen Central-Observatoriums, St. Petersburg, Russia	ISC 1907 - 1910
Scheiner J., Prof. Dr., Königl. Friedrich-Wilhelms-Universität (1907), Hauptobservator am Astrophysikalischen Observatorium, Potsdam, Germany	ISC 1907 - 1910
Schmidt W., Prof., Adjunkt an der Zentralanstalt für Meteorologie and Geodynamik (1910), Hochschule für Bodenkultur, Hochschulstrasse (1929), Zentralanstalt für Meteorologie and Geodynamik(1932), Vienna Austria.	RC 1910 - 1932
Schoute, C., Dr., Koninjlijk Nederlandsch Meteorologisch Institut, de Bilt, Netherlands	RC 1923 - 1936
Shaw, W. N., Dr., Director of the Meteorological Office, London, S.W.South Kensington, England	ISC 1907 - 1910
Silvado, A., Capitao-Tenente Direction de Meteorologia, Morro de St. Antonio (1907), Director da Marinha no Ministerio, Rio de Janeiro, Brazil	ISC 1907 - 1910
Simpson, Sir George C., London, England Meteorological Office, Air Ministry, Kingsway,	RC 1929 - 1936 CSR 1924 - 1930
Snellen	RC 1896
Steen, A., Meteorological Institute, Christiania (1907), Vice-Direktor des Norwegischen Meteorologischen Instituts,Christiania, Norway	ISC 1907 - 1910
Stenz, Edward, Dr., Instytut Geofizyki, Uniwersyletu Jana Kazimierza (1929), Poland Sulejowek k. Warsaw, Poland	RC 1929 - 1936
Steward, South Africa	CSR 1927 - 1930
Störmer, C., Prof., University, Christiania (1919), University, Oslo (1929), Huitfeldtsgate, Oslo (1932), Institute for Theoretical Astrophysics, Blindern, Norway	RC 1919 - 1936
Stupart, R. F., Canadian Dominion Meteorological Service (1896, 1907), Director of the Meteorological Service of Canada, Toronto, Canada	RC 1896 ISC 1907 - 1910
Süring, R., Prof., Meteorologisches-Magnetisches Observatorium, Potsdam,Germany	RC 1923 - 1936
Sverdrup, H. U., Prof., University of Bergen, Norway (1927); Scripps Institution of Oceanography, La Jolla, Calif., USA (1936)	CSR 1927 - 1936
Tacchini	RC 1896
Taylor, S. Griffith, Dr.,Commonwealth Meteorological Service, Melbourne, Australia (1919), Prof., University of Chicago, Chicago, Illinois, USA (1932), Geographical Institute, Toronto, Ontario, Canada (1936)	RC 1919 - 1936
Teisserenc de Bort, L., Observatoire de Mété0rologie Dynamic, Trappes, Seine-et-Oise, pres Paris, France	ISC 1907 - 1910
Thege von Konkoly, N., Hofrat Dr., Direktor der Ungarischen Reichsanstalt für Meteorologie and Erdmagnetismus, Budapest	ISC 1907 - 1910
Thomson, Prof., Andrew Meteorological Service of Canada, Toronto, Ontario, Canada	RC 1936
Thomson, Samoa	CSR 1927 - 1930

Name and Affiliation	Commission and Years
van Everdingen, E., Prof. Dr., Chef-Direktor des Meteorologischen Instituts, de Bilt, The Netherlands	ISC 1910
Violle, L. Jules G., Dr., Professeur de Physique au Conservatoire des Arts of Metiers, Paris, France	RC 1896 - 1910 ISC 1907 - 1910
Volochine, F. E., Dr., Laboratoire Actinometrique de 1'Observatoire de Trappes, Trappes,Seine-et-Oise, France	RC 1925 - 1936 CSR 1927 - 1930
von Bezold, W., Geheimer Oberregierungsrat, Berlin, Germany	ISC 1907
Walker, Gilbert W. Superintendent of the Observatory Eskdalemuir, Langholm, Scotland	RC 1910
Whipple, F. J. W., Dr., Kew Observatory, Old Deer Park, Richmond, Surrey, England	RC 1936
Wind, C. H., Prof. Dr., University of Utrecht, Holland	ISC 1907
Wojcikow, A., Dr., Professor der Physikalischen Geographie an der Universität, St. Petersburg, Russia	ISC 1907 - 1910
Wolf, Max, Prof. Dr., Geheimer Hofrat Grossherzogl. Ruprecht-Karls-Universität (1907), Direktor des Astrophysikalischen Instituts, Heidelberg, Germany	ISC 1907 - 1910
Wolfer, A., Prof. Dr., Direktor der Sternwarte, Zürich, Switzerland	ISC 1907 - 1910

Members of the International Radiation Commission of IUGG 1948 - 2008

HVP = honorary vice president, HM = honorary member, interim member = member elected by the IRC between nomination terms and therefore not confirmed by IAMAP/IAMAS, *ex off.* = *ex officio* member (chairpersons of Working Groups and Rapporteurs, who are not elected IRC members but have the same status for the time of their appointment). The ICLAS WG got the privilege 1983 to nominate five additional IRC members, which is indicated by 'ICLAS'.

Name	First Name/ Initials	Country	Period
Achtor	Thomas	USA	2004 - 2008
Ackerman	Thomas P.	USA	1992 - 1996 2004 - 2008
Alhefud	H.	Iraq	Interim Member 1991? - 1992
Ångström	Anders Knutsson	Sweden	1924 - 1948 - 1967 HVP 1963, HM 1967, †1981
Annegarn	Harold	South Africa	2004-2008
Arking	Albert	USA	1992-1996
Arriaga	A.	Portugal (EUMETSAT)	1992 - 1996
Avaste	Olev	USSR	1975 - 1983 (†1991)
Bakan	Stephan	Germany	1996 - 2004
Barker	Howard	Canada	1996 - 2004
Barton	Ian	Australia	2000 - 2008
Blumthaler	Mario	Austria	2004 - 2008

Name	First Name/ Initials	Country	Period
Bojkov	Ruman D.	WMO representative	1975 - 1988
Bolle	Hans-Jürgen	Germany/Austria	1971 - 1987, HM 1996
Budyko	Mikhail Ivanovich	USSR	1960 - 1979
Cahalan	Robert F.	USA	2000 - 2008
Carli	Bruno	Italy	1992 - 1996
Carswell	A.	Canada	1983 - 1992 ICLAS
Cess	Robert	USA	1988 - 1992
Chanin	Marie Lise	France	1992 - 1996
Chedin	Alain	France	1979 - 1988 and 1992 - 1996
Chen	Hong-Bin	China	2000 - 2008
Chubarova	Nataly Ye.	Russia	2000 - 2008
Clough	Shepard A.	USA	1996 - 2004
Courvoisier	P.	Switzerland	1954 - 1967
Crommelynck	Dominique A.	Belgium	1979 - 1987
Dahlback	Arne	Norway	1996 - 2004
Davies	Roger	Canada	1992 - 1996
De Zafra	R.	USA	1992 - 1996
Deepak	Adarsh	USA	1986 - 1992
Derr	V.	USA	1983 - 1992
Di Girolamo	Paolo	Italy	2004 - 2008
Dirmhirn	Inge	Austria	1963 - 1971
Dogniaux	R.	Belgium	1957 - 1979
Drummond	Andrew J.	USA	1954 - 1963
Ellingson	Robert G.	USA	*ex off.* 1988 - 2000 2000 - 2008
Eyre	John		1992 - 1996
Feigelson	Eva M.	USSR	1979 - 1987
Fiocco	Giorgio	Italy	1979 - 1992
Fischer	Herbert	Germany	1979 - 2004, HM 2004
Flamant	Pierre	France	*ex off.* 1996 - 2006
Foitzik	L.	German DR	1967 - 1971
Fomin	V.	USSR	1983 - 1987
Forgan	Bruce	Australia	2004 - 2008
Fouquart	Yves	France	1979 - 1992
Fritz	Sigmund	USA	1948 - 1957
Fröhlich	Claus	Switzerland Representative of WMO-CIMO WG System Radiation	1975 - 1983 *ex off.* 1983 - 1987 1992 - 1996

Name	First Name/ Initials	Country	Period
Fymat	Alain L.	USA	*ex off.* 1976 - 1980
Galindo Estrada	Ignacio	Mexico	1979 - 1987
Geleyn	Jean François	France	1983 - 1992
Gerber	Hermann	USA	Interim Member 1981 -1982 *ex off.* 1982 - 1988
Gille	John C.	USA	*ex off.* 1977 - 1979 1979 - 1987
Godson	W. L.	Canada	1954 - 1963
Gonima	L.	Columbia/France	1987 - 1996
Goody	Richard	USA	1957 - 1963, HM 1992
Götz	F. W. P.	Switzerland	1948 - 1951
Grassl	Hartmut	Germany	*ex off.* 1981 - 1987 1987 - 1996
Haigh	Joanna	UK	1992 - 1996
Hansen	James E.	USA	1975 - 1983
Harries	John E.	UK)	1979 - 1996, HM 1996
Hayasaka	Tadahiro	Japan	2000 - 2008
Heerdon, van	Johan	Republic of South Africa	1996 - 2004
Herman	Benjamin	USA	1983 - 1992 ICLAS
Hinzpeter	Hans	FR Germany	1957 - 1975
Houghton	John T.	UK	1963 - 1975 *ex off.* 1976
Howard	John N.	USA	*ex off.* 1976 - 1980
Huang	Hung Lung Allen	USA	2004 - 2008
Hunt	Garry E.	UK	1975 - 1983
Jayararnan	S.	India	1992 - 1996
Joseph	Joachim	Israel	*ex off.* 1981 - 1988 1996 - 2004
Kandel	Robert	France	1987 - 1996
Kano	M.	Japan	1979 - 1983 - 1987
Kaplan	Lewis D.	USA	1975 - 1983 *ex off.* 1983 - 1987
Kärner	Olavi	Estonia	1992 - 2000
Katsaros	Kristina	France/USA	1992-1996
Kawata	Yoshiyuki	Japan	2000 - 2008
Keevallik	Sirje	Estonia	1983- 1992 and 1996-2004
King	Michael D.	USA	2000 - 2008
Kondratyev	Kirill Ya.	USSR/Russia	1957 - 1979, HM 1979, †1.5.2006

Name	First Name/ Initials	Country	Period
Köpke	Peter	Germany	2000 - 2008
Künzi	Klaus	Switzerland-Germany	1987 - 1992
Larar	Allen	USA	2004 - 2008
Laszlo	Istvan	USA	1987 - 1992
Legrand	Michel	France	2000 - 2008
Leighton	Henry	Canada	1996 - 2004
LeMarshall	John	Australia	*ex off.* 1997 - 2006
Lenoble	Jacqueline	France	1963 - 1979 *ex off.* 1979 - 1983 1983 - 1996, HM 1996
Liou	Kuo-Nan	USA	1992 - 1996
Liu	Changsheng	China, Nanjing	1987 - 1996
London	Julius	USA	1963 - 1983, HM 1983
Lu	Daren	China, Beijing	1987 - 1996
Lybovtseva	Yu.	USSR	1987 - 1992
Lynch	Mervin	Australia	1992 - 2000
Major	Gyorgy	Hungary	1979 - 1987 and 1996 - 2004
Mani	Anna M.	India	1967 - 1979
Martins	Jose Vanderlei	Brazil	2000 - 2008
Marshak	Alexander	USA	2007 - 2008
Mayer	Bernhard	Germany	2004 - 2008
McArthur	L.J. Bruce	Canada	2004 - 2008
McClatchey	Robert A.	USA	*ex off.* 1976 - 1980
McCormick	Patrick	USA	1983 - 1992 ICLAS
Meggie	Gerard	France	1983 - 1992 ICLAS
Menzel	Paul	USA	*ex off.* 1987 - 1991 2000 - 2008
Menzies	Robert	USA	2002 - 2008
Migeotte	M.	Belgium	1967 - 1971
Morcrette	Jean Jacques	France/UK (ECMWF)	1992 - 1996
Möller	Fritz	Germany	1954 - 1967 HM 1971 †21.03.1983
Mörikofer	Walter	Switzerland	1929 - 1948 - 1967 HVP 1963, HM 1967 †14.04.1976
Nakajima	Teruyuki	Japan	1992 - 2008
Newson	R.	Switzerland (WMO Representative)	1988 - 1992
Nicolet	Marcel	Belgium	1948 - 1957
Ohmura	Atsumu	Switzerland	1992 - 2008

Name	First Name/ Initials	Country	Period
Ohring	George	Israel/USA	1975 - 1987 *ex off.* 1987 - 2000
Paltridge	Garth W.	Australia	1975 - 1996
Plana-Fattori	Artemio	Brazil	1996 - 2004
Platt	C. Martin R.	Australia	Interim Member 1981 - 1982 *ex off.* 1982 - 2000
Pollack	J.	USA	1983 - 1992
Prokrovskij	O.	USSR	1987 - 1996
Ramachandran	S.	India	2000 - 2008
Ramanathan	Veerabhadran	USA	*ex off.* 1981 - 1987
Ramdas	C. A.	India	1948 - 1957
Raschke	Ehrhard	Germany (FR)	1975 - 1983 *ex off.* 1983 - 2004
Reiter	Reinhold	Germany (FR)	1983 - 1992 ICLAS
Rizzi	Rolando	Italy/UK (ECMWF)	Interim Member 1981 - 1983 *ex off.* 1983 - 1987 1992 - 1996
Robinson	G. D.	UK	1948 - 1963
Rochard	Guy	France	*ex off.* 1996 -2004
Rodrigo	R.	Spain	1987 - 1996
Rodgers	Clive D.	UK	1975 - 1983
Rozenberg	G. V.	USSR	*ex off.* 1967 - 1976
Rossow	William B.	USA	*ex off.* 2004 - 2008
Rothman	Laurence S.	USA	1992 - 2008
Roubleau	R.	France	1948 - 1957
Rozenberg	G. V.	USSR	1967 - 1976
Russell	James	USA	1987 - 1996
Saunders	Roger	USA	2004 - 2008
Sayigh	A.A.M.	Saudi Arabia	1976 - 1979 interim member
Schmetz	Johannes	Germany	1992 - 2000
Schmutz	Werner	Switzerland	2000 - 2008
Schüepp	W.	CH/Congo	1954 - 1967
Schulze	Rudolf	Germany	1954 - 1963
Scott	Noelle	France	*ex off.* 1992 - 2000
Sekera	Zdenek	USA	1957 - †1972
Sekihara	Kyo	Japan	1971 - 1979
Serio	Carmine	Italy	2000 - 2008
Shi	Guang-Yu	China	2000 - 2008
Shine	Keith	UK	1992 - 2000
Sikka	D. R.	India	1979 - 1983

Name	First Name/ Initials	Country	Period
Simmer	Clemens	Germany	2004 - 2008
Simon	Paul C.	Belgium	*ex off.* 1987 - 2008
Sklyarov		USSR	1983 - 1987
Slingo	Anthony	UK	1987 - 1992
Smith	William L.	USA	1979 - 2000, HM 2000
Sohn	Byung-Ju	Korea	2000 - 2008
Spänkuch	Dietrich	German DR	1971 - 1992
Srinivasan	V.	India	1983 - 1987
Stammes	Knut	USA	1996 - 2004
Stuhlmann	Rolf	Germany	2000 - 2008
Suomi	Verner E.	USA	1967 - 1971
Takashima	Tsutomu	Japan	1992 - 1996
Tanaka	Masayuki T.	Japan	1975 - 1983
Tanre	Didier	France	2004 - 2008
Taylor	Fred	U.K.	1983 - 1992
Timofeyev	Yuri M.	Russia	1992 - 2008
Uspensky	Alexander B.	Russia	2000 - 2008
van Heerden	Johan	South Africa	1996 - 2004
Vonder Haar	Thomas H.	USA	1975 - 1988
Wark	David Q.	USA	1963 - 1979 *ex off.* 1979 - 1981
Wendling	Peter	Germany	1992 - 2000
Yamamoto	Giichi	Japan	1957 - 1975, HM 1976 (†07.02.1980)
Yaamanouchi	Takashi	Japan	1987 - 1996
Yates	Harald	USA	*ex off.* 1977 - 1983
Zaitzeva	Nina	USSR	1983 - 1992
Zander	Rudolphe	Belgium	*ex off.* 1986 - 1992 1992 - 1996
Zhou	Xiuji-J.	China	1979 - 1992
Zuev	Vladimir E.	USSR	1971 - 1983

Appendix 3:
Summaries of Papers Presented 1954 and 1957 in Rome and Toronto

Papers Presented At the Xth General Assembly of the International Association of Meteorology, Rome, 8 to 13 September 1954

Papers presented at the "Colloque sur le rayonnement dans l'Atmosphère" after the introductory talk of President Mörikofer:

The second paper was presented by Möller on "The actinometric determination of the atmospheric turbidity." He extended the paper of Götz at the Oslo meeting where Götz used one size of the aerosol to interpret the sky radiation. "We now know from the investigation of Junge that there is quite a spectrum of aerosol particle sizes". By means of the studies of Volz, Möller demonstrated how the scattered light from the sky is composed of effects of different particle sizes. This can be shown for the radiation loss of direct solar radiation as well as for the origin of the diffuse sky light. Different types of scattered light exist and the frequency and importance of these types are estimated. A view of similar interpretations of the polarization was given.

Under the title "Actinometric measurements - performance and application", Ångström gave a survey on measurements by pyrheliometers with and without glass filters with the intent of making measurements for biological applications.

Two papers of Cialdea followed: 1) "Un néphoscope photographique pour la polarisation de la lumière du ciel". An apparatus is described to take pictures of the total sky vault in a metal convex mirror over 3 polarization filters and to determine from these the degree of polarization of light from every single sky point. 2) "La polarisation de la lumière du ciel diurne". The speaker showed the investigation of the sky radiation by a photoelectric polarization meter and discussed the influence of different cloud forms.

P. Bener reported on "Measurements of natural ultraviolet radiation by meansof methods with spectral integration". Instruments with spectral integration might be represented by photobiological processes. The author mainly considers instruments as for instance cadmium cells with a filter cutting off towards the shorter wave lengths (minox-glass) and he defines calibration factors. He could show that even a calibration in absolute units is possible by use of these filter factors. This given, an essential progress in the measuring technique as long as one does not want to use spectral intensity measurements directly.

A paper of S. Fritz, "Scattering and absorption of solar energy by clouds of large water drops," had already been published in J. of Met., 11 (1954) 291.

Yamamoto and Sasamori spoke about "Measurements of atmospheric radiation". They found a very fine correspondence between their measurements and computations by the Yamamoto chart. An additional radiation which has been attributed by Robinson to the atmospheric dust could not be discovered in the pure Japanese air.

Santomauro reported on "Une method systematique d'emploi du nomogramme d'Elsasser pour la recherche de la variation du flux". He used the Elsasser diagram to evaluate the longwave radiation in the Po plane because relatively fast changes of weather occur there. The aim of his studies was an investigation of synoptic changes.

The last paper was given by Cialdea on "Les expéditions de l'I.N.G. pour les observations géophysiques pendant less eclipses totales de soleil". He mainly performed polarization measurements and measurements of the "virtual" temperature of the sky with a solarigraph of Gorczynski, but he also had made measurements of magnetism and atmospheric electricity in solar eclipses at Khartoum and at Löttorp (Sweden).

Papers presented at the "Colloque sur le Bilan de rayonnement dans la stratosphere inférieure et la substratosphère":

The first lecture was somewhat outside of the proper topic and given by Möller on "A simplified method of computing the radiation balance in the troposphere". He developed a formula for the vertical radiation flux at the pressure of 400 mb and another one for the radiation flux at the surface both formed in principle analogously to Ångström's formula for the radiation flux at the surface. One obtains the heat loss of the layer 1000 - 400 hPa as difference of the two radiation fluxes and from that easily the cooling rate of that layer, which is between -0.10 and -0.22 cal cm^{-2} min^{-1} (- 70 – -153 J m^2 sec^{-1}) in two given examples. This was planned as a pre-study for a physical weather forecasting.

The next paper was given by J. Strong on "New facts on planetary atmospheres". He observed spectra of planets with a resolving power of 0.08 µm at 10 µm and an area resolution of 1.5" diameter. The measurements were made between the lines of the water vapor spectrum and then viewed alternatively the planet and the sky. Venus had a temperature in its center of 232 K, the difference between noon and midnight was only 5 K. At Mars a daily variation of the temperature was observed with a maximum half an hour after local noon. Small variations are probably consequences of local changes of the albedo; a strikingly cold spot was at a place where optically a yellow cloud could be seen.

Curtis and Goody presented the paper: “The effect of departures from Kirchhoff's law on stratospheric radiation calculations”. For any given absorbing gas there is a height above which collisions are too infrequent to maintain a Boltzmann distribution of energy among the vibrational states. Above this height Kirchhoff's law ceases to hold. The actual heating rate is then given by $H(z) = R[J(z')]$, where R is a linear operator and $J(z') = B(z') + \{\lambda(z') H(z')/2\theta\}$ the source function. $B(z')$ is the black body source function for local thermodynamic equilibrium (LTE), $\lambda(z')$ a vibrational relaxation time, inversely proportional to pressure, and θ the natural lifetime of the excited state. The authors found a way to solve the equations by successive approximations, assuming that $R[J(z')]$ tends to zero for $z' \rightarrow \infty$. When applied to a band of the type of the 15 µm CO_2 band, with stratospheric temperature data taken from rocket soundings, this reduced the extremely high cooling rates above 80 km which would be obtained by using just $B(z')$ as source function.

Brewer and Houghton spoke about “Observed radiation fluxes in the atmosphere at levels up to 12 km”. The authors built a very light electrical resistance thermometer which was suspended thermally isolated in a high vacuum and could look through a KRS5 window. They measured from a Mosquito aircraft the radiation coming from below and from above. Some corrections were necessary. Remarkable results are that the earth's surface irradiated only 90% of the black radiation at air temperature. Clouds of the lower layers can be considered as black radiators. Cirrus clouds often have emissivities essentially lower than blackbody radiation; a dense Cirrus cloud had only 80%, a thin one only 5% of black body radiation, as it would have for a water content of 10 µm thickness.

In a theoretical investigation on “The radiation equilibrium of a non-grey terrestrial atmosphere” J. I. F. King investigates the effects of line structure of bands of an absorbing gas. In general the configurations of the radiation equilibrium are solutions of a non-linear integral equation, the generalized Milne-Schwarzschild equation. For only two simple cases, it is possible to obtain a closed solution of this equation. This is first the almost trivial case of the grey atmosphere. The other closed solution was obtained for a Lorentz-line-absorbing model atmosphere. Recently the method of discrete ordinates has been devised by Chandrasekhar for the solution of stellar radiative equilibrium problems. As band absorption he chooses the Elsasser band model of equally spaced equidistant lines. The mechanism for the solution of these equations is extremely tedious but reasonably straightforward.

A similar paper was presented by Yamamoto, “Radiative equilibrium of the Earth's atmosphere: line absorption case”. Assuming the Elsasser line shape, Chandrasekhar's and Rosseland's mean absorption coefficients were obtained for the case of a finite atmosphere. The combination of these mean absorption coefficient with the radiative equilibrium source function for the finite atmosphere in the grey case gives new source functions. By this procedure he obtained source functions for both pressure-independent and pressure-dependent lines. Numerical computation of the values of source functions was carried out for carbon dioxide lines using appropriate data for the earth's atmosphere; also the constancy of flux was examined by numerical computation. As a result, Chandrasekhar's mean seemed to give better results than Rosseland's mean for the case of a line-absorbing atmosphere of finite thickness.

L. D. Kaplan presented a paper on “The infrared spectrum of the lower stratosphere and its importance in the heat balance”. Characteristics of the infrared spectra of ozone, water vapor and carbon dioxide under stratospheric conditions were discussed from the point of view of the role of these gases in the heat balance of the lower stratosphere. Spectral details that are of minor importance for nocturnal radiation or radiative loss to space are critical for the stratospheric heat balance. Neglect of these details invariably leads to overestimation of cooling rates. The relative spectral distribution of position of the principal absorption bands is of great importance because of the marked differences in variation with height of the concentrations of the principal absorbents, and is probably the major factor in the maintenance of the troposphere.

A last paper was presented by Godson: “The computation of infrared radiative transfer by atmospheric water vapor”. In the spectrum of water vapour the most striking pictures are the apparently random distribution of lines and line distances and of the intensities. It is well known that with a random distribution of lines the spectrum mainly with large water vapour masses is more transparent than with a regular distribution. The author tested some models of the distribution of lines, investigated different distributions of intensity and line shape and was convinced that the best approximation for the absorption function was given by the random distribution of distances and a distribution of intensities according to a logarithmic ogive (this paper was published in Journal of Meteorology).

Papers Presented At the Symposium on Atmospheric Radiation in Toronto, 7th September 1957

The following papers were presented at the Symposium on Atmospheric Radiation, Toronto, 7th September 1957:

F. Möller, “The synoptic distribution of the tropospheric radiation balance”. The distribution of the tropospheric radiation balance and its components were calculated and mapped for several synoptic situations over Europe. Whether these distributions are controlled by simple dependencies upon observed meteorological elements was considered.

J. Van Mieghem, "Radiation data needed in dynamic meteorology." In order to be able to account for non-adiabatic effects on atmospheric processes, the geographical and vertical distributions of actual values of the radiation balance must be known in the atmosphere and at its boundaries. As for synoptic data, the representativeness of radiation data is an essential requirement.

S. Fritz, “Seasonal heat storage in the oceans and heating of the atmosphere”. An estimate of the amount of thermal energy stored in the oceans is useful in estimating the amount of energy available for heating the atmosphere. From bathythermograph data in a few places, the monthly heat storage in the oceans was related to changes from month to month of the ocean surface temperature. With the aid of this relationship the monthly latitudinal heat storage in the oceans was computed. Gabites (1950) estimated the radiative and evaporation-condensation heating terms; addition of the heat storage computed as above, yields the net seasonal heating of the atmosphere. In the middle latitudes the near balance between large numbers often leaves even the sign of atmospheric heating in doubt. In tropical and polar latitudes, atmospheric heating is more closely as expected.

J. London, “The radiation balance and total energy flux in the atmosphere”. New values for seasonal variation of net radiation excess in the troposphere have been computed. These values lead to a new distribution of the total energy flux as required by the radiation balance. For the Northern Hemisphere the maximum flux is northward at latitude 30°N during February ($6.8 \cdot 10^{16}$ cal min^{-1}) and at latitude 40°N during August ($3.1 \cdot 10^{16}$ cal min^{-1}). The annual balance shows a maximum required flux at about 40°N ($4.8 \cdot 10^{16}$ cal min^{-1}). The required fluxes are smaller than most previous estimates but are consistent with recent observations of the mechanics of the general circulation.

A. J. Drummond, “The spectral distribution of energy in sunlight as received on the high plateau of Southern Africa”. This paper presents the principal results of 30 months' records derived from a series of six pyrheliometers exposed continuously to the sun, at Pretoria, and registering on an automatic multi-channel potentiometer. The spectral regions sampled were the blue-green (actually $\lambda<490$ nm), green (490-524 nm), yellow-orange (525-535 nm), red (635-690 nm) and infra red ($\lambda>690$ nm). The dependence of the distribution of intensity with wavelength upon the air-mass (i.e. the optical path length) during the contrasting dust-free but moist summer season and the dusty dry winter season was discussed.

A. J. Drummond, “The luminous efficiency of daylight”. Representative values of the luminous flux through a horizontal surface were given, both for cloudless and overcast skies which were obtained in South Africa (Pretoria). Comparisons were made with similar series for certain locations in Europe and North America. The luminous efficiencies of total daylight and also of skylight (expressed in the form of lumens per watt) were derived for Pretoria and compared with other records where such values can be extracted. The effect exercised upon the natural luminous efficiency by varying water and dust atmospheric conditions was illustrated.

J. T. Houghton, “The absorption of solar radiation by the upper atmosphere”. A grating infra-red spectrometer capable of a resolution of ~2 cm^{-1} was installed in a Canberra aircraft and records of the sun's spectrum in the 1-3 μm region were obtained at altitudes up to 45,000 ft over England. The 1.9 μm vapor band and the carbon-dioxide bands at 2 μm were clearly resolved. The water vapour present in the atmosphere above 45,000 *ft.* gives approximately the same absorption as a path of laboratory air containing about 5 μm of precipitable water vapour. This is considerably more than would be expected if the measurements of Murgatroyd, Goldsmith and Hollings (1955) are extrapolated at constant mixing ratio to the top of the atmosphere. The infra-red absorption measurements at lower altitudes are not inconsistent with the data the above workers obtained using a frost-point hygrometer. A preliminary report of these infra-red absorption measurements has been made by Houghton, Moss, Sealey and Hawkins (1957).

J. Lenoble, “Etude du rayonnement ultraviolet atmospherique”. The terrestrial atmosphere modifies the solar ultraviolet radiation by absorption and by scattering. The radiation scattered once or several times arrives at the ground level from the whole sky. The equation governing the sky radiance is easy to established for a plane-parallel homogeneous atmosphere. We discuss the various assumptions made, in particular the influence of the ozone vertical profile. The solution of this equation by an approximate iterative method is in good agreement with Chandrasekhar's results. This method permits to evaluate the relative importance of the orders of scatterings; they roughly decrease according a geometrical progression; higher orders have to be considered for shorter wavelengths. A recording spectrometer has been built to study the sky radiance; the measurements have shown the major role of haze and clouds, depending on the wavelength.

S. Y. Kogan, M. S. Malkevich and E. M. Feigelson, “The approximate methods of evaluating the light intensity for the case of non-spherical scattering in the earth's atmosphere and the results of calculations”. To make the theoretical analysis of the laws governing the light scattering in the Earth's atmosphere and to calculate its intensity, the radiative transfer equation must be solved for the case of perfect scattering in the atmosphere of a finite optical thickness, provided a parallel beam of light is incident on the upper boundary of the atmosphere. The following approximate methods of solving the radiative transfer equation have been suggested for the case mentioned above:

1) the method of approximating the kernel of the integral equations which are equivalent to the equation of transfer by the kernels, admitting accurate solutions;

2) the method of spherical harmonics with the resolution of the ambiguity in boundary conditions arising if this method is used to solve the equation of transfer;

3) the iterative method at a specially selected first approximation that guarantees a rapid convergence.

The intensity of the scattered light in a two layer atmosphere has been determined with values of optical thickness of the atmosphere of $\tau^* = 0.1; 0.2; 0.3; 0.4; 0.6; 0.8$, the albedo values, q, of the earth's surface equal to 0.1; 0.2; 0.3;

0.4; 0.6; 0.8, the zenith angle of the sun $\zeta = 30, 45, 60, 75°$, and a scale of scattering functions of various stretch degrees ("Richtungsquotient" as defined by L. Foitzik and H. Zschaeck). For the lowest layer the scattering functions with a stretch equal to 1.3; 1.8; 2.5; 4.7 and 8.4 have been taken in different variants of calculation. For the upper layer the stretch degree of the scattering functions is supposed to be equal 1.3. All the scattering functions have been presented as a series in Legendre polynomials using 10 terms in a series. The computations have been made by means of the third method mentioned above. The intensity values of the scattered light have been obtained as functions of height and direction and the physical parameters mentioned above. The maps of isophot brightness of the day sky and that of the light leaving the atmosphere through its upper boundary have been compiled. The laws governing the intensity variations of the light depending on the physical parameters have been investigated. The errors of evaluations are not higher than 5-6 percent excluding the case of $\tau^* = 0.8$ when the error may reach 10 percent.

J. I. F. King, "A universal transmission function for far-infrared radiation: the line cluster model". A Universal Transmission Function (UTF) is developed for determining thermal penetration through absorbing media which can be applied to any atmospheric band or window system regardless of its complexity. The critical parameter shaping the character of the transmission is found to be the degree of regularity of line spacing within the band. Baffling cases of unusually high transmissivities are shown to be due to the clustering of the individual lines. All parameters appearing in the UTF are physically related to the absorption spectrum in a calculable way rather than being "fitting factors" as is generally the case.

S. I. Rasool, "Solar radiation in Pakistan". Four years' data of the measurement of the global radiation received on a horizontal surface and direct sun radiation on a normal surface have been analysed and studied along with sunshine duration records for the same period. The various formulae proposed by Nicolet and Dogniaux have been put to the test and new values of the correction factors obtained. A Solar Radiation Observation network has started functioning in West Pakistan. A brief account is given of the distribution of solar energy in this country and the prospects of its utilization for domestic purposes are discussed.

K. Ya. Kondratyev, "Transference of heat radiation in the atmosphere and associated problems". The problem of the transference of heat radiation in the atmosphere is of serious importance for solving many practical problems on the thermal or radiation balance of the earth's surface and atmosphere.

One of the fundamental problems in the transference of heat radiation is the determination of the integral function of absorption in the atmosphere. This problem can be solved from evidence on infra-red spectra of absorption of gases composing the atmosphere as well as indirectly, from data on the angular distribution of intensity of heat radiation in the atmosphere. The determination of the absorption function gives rise to some important problems. Among them the most essential are the following: the contribution of various gases of the atmosphere to the general heat radiation; the scheming of the infrared spectrum of the atmospheric absorption; the influence of a non-homogeneous medium (temperature and pressure fluctuations) upon the absorption and radiation of heat; the relation between leakage functions in the directional and diffusion radiation; the applicability of Kirchhoff's law under the conditions of the earth's atmosphere. When all the above problems are solved, one can pass over to another investigation state -- the deduction of approximated equations of the transference.

The investigation of the approximated equations of the heat radiation transference solves some important practical problems, first of which is the problem of computing fluxes of heat radiation in the atmosphere. In this connection much attention is devoted to the computations of effective radiation and of fading radiation. Of special interest is the problem of investigating laws of the angular distribution of the intensity of atmospheric heat radiation. This part of the work contains both theoretical and experimental results which enable us to solve some interesting practical problems. Some of the them are considered here, namely: the influence of cloudiness on effective radiation and anti-radition, a change of the effective radiation with height under a wood canopy, the effect of slopes on radiation. The above results deal with the problems of computing the intensity and fluxes of thermal radiation under certain conditions. Besides these, the flux of heat radiation is of great interest.

The approximate method of computing a flux of heat radiation requires considerable attention to the analysis of the applicability of diffusion conceptions in solving this problem and to the special investigation of pecularities in computing the ground atmospheric layer. The investigations have yielded positive results in the form of a new, sufficiently simple and accurate graphical method of computing a radiant heat flux in the boundary layer. The use of the approximated method of computing the flux of heat radiation makes it possible to arrive at important conclusions on the relations of a radiant and a turbulent heat exchange in the boundary layer.

Appendix 4: IRC Publications

References of Part I, Radiation Commissions 1896 - 1948

1. Bericht über die Internationale Meteorologische Conferenz zu Paris 1896. Kgl. Preuss. Meteor. Institut, Berlin, 1899.
2. Canegieter, H. G., The History of the International Meteorological Organization 1872-1951. Annalen der Meterologie, Neue Folge Nr. 1. Offenbach 1963. App. E, The Commission for Solar Radiation, pp. 175-182.
3. Bericht des Internationalen Meteorologischen Komitees. Versammlung zu St. Petersburg, 1899. Kgl. Preuss. Meteor. Institut, Berlin 1903.
4. Bericht des Internationalen Meteorologischen Komitees. Versammlung zu Paris 1900 and zu Southport 1903. Kgl. Preuss. Meteor. Institut Berlin 1905. Specifically Anhang VII, Sir Norman Lockyer, Report on simultaneous solar and terrestrial changes, pp. 37-50 and Anhang XIII, J. Violle, Rapport sur la radiation, pp. 65-70.
5. Bericht über die Internationale meteorologische Direktorenkonferenz in Innsbruck, September 1905. K.k. Zentralanstalt f. Meteor. u. Geodynamik, Wien 1906. Specifically Appendix I. J. Violle and Appendices VIIIa and VIIIb, J. M. Pernter, Über die Beobachtung der atmosphärischen Lichterscheinungen (d.i. Halos, Kränze, Regenbogen, Himmelsfarben), pp. 87-92.
6. Bericht über die Versammlung des Internationalen Meteorologischen Komitees, Paris 1907. Veröff. Kgl. Preuss, Meteor. Instituts Nr. 191, Berlin 1908. Specifically Anhang VI, Sir Norman Lockyer, Report of the Proceedings of the Solar Commission, pp. 28-42; Appendix XII, Brief des Herrn K. Ångström, pp. 53-54.
7. Bericht über die Versammlungen des Internationalen Meteorologischen Komitees und dessen.., Berlin 1910. Specifically Anhang IV, Sir Norman Lockyer, Report of the Proceedings of the Solar Commission, p. 26, and Appendix XIX, W. L. Moore, Proposals submitted to the International Meteorological Committee, Berlin 1910, pp. 57-59.
8. Bericht über die erste Tagung der Strahlungskommission des Internationalen Meteorologischen Komitees in Rapperswil, 2. and 3. September 1912. Schweizerische Meteor. Centralanstalt. Zürich-Selnau, 1912, 22 pp.
9. Bericht über die Versammlung des Intern. Meteor. Komitees Rome 1913. Veröff. Kgl. Preuss. Meteor. Instituts Nr. 260, Berlin 1913.
10. Report of the proceedings of the Fourth International Conference of Directors of Meteorological Institutes and Observatories and of the International Meteorological Committee, Paris 1919, M.O. 239, London, 1921.
11. Report of the International Meteorological Conference of Directors and of the Meeting of the International Meteorological Committee at Utrecht, September 1923. Kon. Nederl. Meteor. Instituut, No. 112, Utrecht 1924, pp. 23-24, p. 62, and App. B. Commission Internationale de Radiation Solaire, pp. 69-78.
12. Procès verbaux de la conference de la commission internationale de radiation solaire a Davos 31/8 - 2/9 1925. Stockholm 1926, 22pp.
13. Bericht über die 12. Versammlung des Internationalen Meteorologischen Komitees in Wien, September 1926. Zentralanst. f. Meteor. u. Geodynamik, Publ. Nr. 130. Wien, 1927, 54 pp.
14. Procès-verbaux des séances de la conference internationale des directeurs du comité météorologique international et de diverses commissions à Copenhague septembre 1929. 2 parties. Sécr. Com. Mét. Intern. No. 3, Utrecht. 1929. Espec. pp 30-31, pp. 105-106 and Appendice W, pp. 181-214.
15. Comité Météorologique International. Procès-verbaux des Séances de De Bilt, 4-7 octobre 1933. Secretariat de 1'O.M.I. No. 17, Utrecht, 1934, p. 20 and App. VI, Rapport du Président de 1a Commission de Radiation Solaire (Bericht über Berlin 1931), pp. 63-71.
16. Internationale Strahlungskommission. Protokolle der Sitzungen in Frankfurt a/M., 15-17 September 1932. Secr. O.M.I., No. 15, Utrecht 1933, p. 80.
17. Strahlungskommission. Protokolle der Sitzungen in Oxford, 12-15 September 1936. Sécr. O.M.I., No. 33, Leyde 1937, p. 97.
18. Comité Météorologique International, Procès-verbaux de la session de Berlin 21-25 septembre 1937. Leyde 1938. pp. 14-16, 112-113. Secr. O.M.I. No. 40.
19. Comité Météorologique International, Procès-verbaux de la session de Berlin 21-25 juin 1939. Sécr. O.M.I., No. 45, Lausanne 1941, p. 86 et p. 175.
20. Conférence extraordinaire des Directeurs, Londres, 25 février - 2 mars 1946. O.M.I. Publ. No. 52. Lausanne 1946, pp. 95-96 et pp. 222-223.
21. UGGI, Première Assemblée Générale Rome, mai 1922. Procès-verbaux des Séances de la Section de Météorologie. Rome 1922. Annexés 1, 3 et 4, pp. 18-25.

22. UGGI, Deuxième Assemblée Générale Madrid, octobre 1924. Procès-verbaux des Séances de la Section de Météorologie. Rome 1925, pp. 6, 9-10, Annexe VI: Sir Napier Shaw, Radiation in relation to meteorology, pp. 85-121; Annexe VII: La radiation solaire, pp. 122-128.
23. UGGI, Troisième Assemblée Générale Prague, septembre 1927. Procès-verbaux des Séances de la Section Météorologie. Rome 1928, pp. 7-8, 24-25, 28-33, 43-44; Annexe IV: H. H. Kimball, Report of the special commission appointed by the meteorological section of the IUGG at its meeting in Madrid in October, 1924, to promote pyreheliometric and other specified observations; pp. 63-65; Annexe V: Radiation solaire pp. 66-72; Annexe VI: S. Chapman, Report of the Committee appointed by the International Research Council to further the study of solar and terrestrial relationship, pp. 73-74.
23a. Richardson, L. F., Report on photometers for a survey of the reflectivity of the earth's surface. Cambridge 1928, 18 pp.
24. UGGI, Quatrième Assemblée Générale Stockholm, aout 1930. Procès-verbaux des séances de la section de Météororologie.
I. Actes de la Section (pp. 10-13; 21-23)
III. Procès-verbaux des seances (pp. 44-47)
IV. Liste des Résolutions (pp. 59-61)
Annexes (pp. 45-102, 106, 110-120, 159-160)
25. UGGI, Cinquième Assemblée Générale Lisbonne, septembre 1933. Procès-verbaux des séances de l'Association de Météorologie
I. Actes de 1'Association (p. 1 and p. 12)
III. Rapport de la Commission de Radiation Solaire (pp. 33-36)
II. Mémoires et Discussion (pp. 287-290).
26. UGGI, Sixième Assemblée Générale Edinburgh, septembre 1936. Procès-verbaux de séances de 1'Association de Météorologie, Paris 1937, 1939:
I. Actes de 1'Association
III. Rapport de la Commission de Radiation Solaire (pp. 35-41)
IV. Rapport sur la bibliographie actinometrique (pp. 43-48)
II. Mémoires et discussions (pp. 287-290).
27. UGGI, Septiéme Assemblée Générale, Washington, D. C., U.S.A., septembre 1939. Procès-verbaux des Séances de 1'Association de Météorologie
I. Actes de 1'association. Washington, 1939 (pp. 13-14, 23)
II. Memoires et discussions. Bergen, 1940 (pp. 53-54, 59-60, 67)
28. UGGI, Huitième Assemblée Générale, Oslo, Norvège, aout 1948. Procès-verbaux des Seances de 1'Association de Météorologie
I. Actes de 1'Association (p. 11), Uccle 1948
II. Mémoires et Discussions, Uccle 1950 (pp. 30-48, 65-66, 89-90, 156-157).

Selected Literature of Part II, IRC activities after 1948, ordered according to the year of publication

UGGI, Assoc. de Météorologie, Réunion d'Oslo (1948), Publ. IAM No. 8a., Programme et Resume des Memoires. Los Angeles, 1948, pp. 25-27, 17-18, and 34.

Ångström, A. (1949) Survey of the Activities of the Radiation Commissions of the International Meteorological Organization and of the International Union of Geodesy and Geophysics (Note). Tellus 1, No. 3, pp. 65-71.

UGGI, Huitième Assemb. Générale Oslo, Norvège, Aout 1948. Publ. No. 8d. Procès verbaux des Séances de 1'Assoc. de Météorologie III Rapports Nationaux, Uccle, Belgique, Nov. 1950, pp. 216-226.

Stagg, J. M. (1953) UGGI, IUGG Newsletter, 2^{e} Année, No. 1, Janv. 1953, p. 89. A report of the 9. Gen. Ass. of the Union, held in Brussels 21st August - 1st September 1951.

UGGI, Neuviéme Assemblée Générale Bruxelles, Aout 1951. Procès-verbaux des Séances de 1'Association de Météorologie. Memoires et Discussions. Bruxelles - Decembre 1953, pp. 199-231.

UGGI, Assoc. de Météorol., Réunion de Bruxelles, Aout 1951. Publ. AIM No. 9/d, Rapports Nationaux, Bruxelles 1952, pp. 24-27, 39-40, 50.

UGGI-IUGG News-Letter. 3^{e} année-No. 6, Juillet 1954. AIM Rapp. Nation. Prés. À l'occasion de la X^{e} Ass. Générale Rome, 14-25 Sept. 1954, p. 234, 265, and 276.

IUGG, Tenth general assembly, Publ. AIM No. 10/c. Scientific proceedings of the International Association of

Meteorology, Rome, September, 1954, London, 1956, pp. 521-594.
IUGG, XIth Gen. Assembly, Toronto, Sept. 1957. IAMAP Report of Proceedings. Publ. IAMAP No. 11/b, London, May 1958, pp. 26-36, 76-82; Reconst. of Commissions and Committees, p. 125.
Mö11er, F. (1957) Radiation comparisons at Hamburg, WMO Bulletin, January 1957, pp. 13-15.
Mörikofer, W. (1957) The Hamburg Comparisons of Long-Wave Radiometers. WMO Bulletin 6, pp. 139-143.
IUGG, XIth Gen. Assembly, Toronto, Sept. 1957. IAM programme of meetings, Publ. AIM No. 11/a. London, 1957. pp. 32-34 and IAMAP Report of Proceedings, Publ. IAMAP No. 11/b, London, 1958, pp. 76-82.
IUGG, Monograph No. 4. Symposium on Radiation, Oxford, 20-25 July 1959, Paris, Janvier 1960, 43 pp. Imprimé par l'Institut Géographique National, Paris, 43 pages.
IUGG Chronicle, No. 32, Dec. 1960, pp. 244-246.
IUGG, XIIth General Assembly, Helsinki, 26 July - 6 August 1960. IAMAP Programme of Meetings. Publ. IAMAP No. 12/a, pp. 38-40, 68.
IUGG Chronicle, No. 43, May, 1962, pp. 98-99.
IUGG XIIIth General Assembly Berkeley, August 1963. IAMAP report of proceedings. Pub. IAMAP No. 13. Toronto, December 1963, 183-186, pp. 4-9.
IUGG Monograph No. 28. Symposium on radiation processes in the atmosphere, Leningrad, 5-12 August 1964. Paris, Aout 1965.
Van Mieghem, J. (1968) International cooperation in meteorology: An historical review. Report of the proceedings of the XIVth assembly of the International Association of Meteorology and Atmospheric Physics (IAMAP), Lucerne, Sep-Oct 1967, pp. 109–128.
Anonymous (1968) Symposium on Radiation including Satellite Techniques, Bergen-Norway, 22. - 28. August 1968, Abstracts, 74 pp.
IUGG XIVth General Assembly, Lucerne, September - October 1967. IAMAP Report of Proceedings. Publ. IAMAP. No. 14, Toronto, April 1968, pp. 4-12.
IAMAP Proceedings of the International Radiation Symposium, Sendai, Japan, May 26 - June 2, 1972, 565 pp.
IUGG Chronicle No. 89, December 1972, pp. 399-400.
IAMAP (IUGG) Report of Proceedings First Special Assembly, Melbourne,Australia, January 1974. IAMAP publ. No. 15a, Toronto 1974, pp. 67-72, 81-90.
Bolle, H.-J., ed. (1977) Proceedings of the Symposium on Radiation in the Atmosphere with special emphasis on Structure and Radiation Properties of Aerosols and Clouds including Remote Sensing and Satellite Measurements, Garmisch-Partenkirchen, FRG, 19-28 August 1976. IAMAP Radiation Commission and Commission on Atm. Chemistry and Global Pollution. Science Press, 8 Brookstone Dr., Princeton, NJ 08540, USA, 630 pp.
Raschke, E., ed. (1978) Terminology and Units of Radiation Quantities and Measurements. IAMAP Radiation Commission, Boulder, Colorado, USA; April 1978, 17 pp.
Möller, F. (1980) A Brief History of the Radiation Commissions of the IMO and of the IUGG. IAMAP Report, 45 pp.
Anonymous (1980) IRS1980: International Radition Symposium; August 11 - 16, Volume of Extended Abstracts, Colorado State University, Fort Collins, Colorado, USA, 575 pp.
Fiocco, G., ed. (1984) IRS'84: Current Problems in Atmospheric Radiation. Proceedings of the International Radiation Symposium, Perugia, Italy, 21-28 August 1984. A. Deepak Publishing, Hampton, Virginia, USA, 438 pp.
Lenoble, J., ed. (1985) Radiative Transfer in Scattering and Absorbing Atmospheres: Standard Computational Procedures. A. Deepak Publishing, Hampton, Virginia, USA, 300 pp. Translation into Russian Language by K. S. Shifrin published 1990 in Leningrad.
Fröhlich, C. and London, J., ed. (1986) Revised Instruction Manual on Radiation Instruments and Measurements. WCRP Publication Series No. 7, WMO/TD-No. 149.
WCRP/IAMAP/RC (1986) A Preliminary Cloudless Standard Atmosphere for Radiation Computation. WCP 112, WMO/TD-No. 24.
Becker, F., Bolle, H.-J., Rowntree, P. R. (1988) The International Satellite Land-surface Climatology Project. COSPAR/IAMAP/UNEP/WMO/ICSU, ISLSCP Secretariat, Berlin, pp. 100.
WMO/ICSU (1988) Aerosols Clouds and Other Climatically Important Parameters: Lidar Applications and Network. WCRP - 9, WMO/TD-No. 233.
WMO/ICSU (1988) An Experimental Cloud Lidar Pilot Study (ECLIPS). WCRP - 14, WMO/TD-No. 251.
Lenoble, J. and Geleyn, J.-F., eds. (1989) IRS'88: Current Problems in Atmospheric Radiation. Proceedings of the International Radiation Symposium, Lille, France, 18 - 24 August 1988. A. Deepak Publishing, Hampton, Virginia, USA, 653 pp.
Arking, A. (1991) The Radiative Effects of Clouds and Their Impact on Climate. Bull. Amer. Met. Soc. 71, pp. 795-

813.
Keevallik S. and Kärner, O., ed. (1996) IRS '92: Current Problems in Atmospheric Radiation, Proceedings of the International Radiation Symposium, Tallinn, Estonia.A. Deepak Publishing, Hampton, Virginia, USA.
Smith, W. L. and Stamnes, K., eds. (1996) IRS '96: Current Problems in Atmospheric Radiation. Proceedings of the International Radiation Symposium, Fairbanks, Alaska, August 1996.
Smith, W. L. and Timofeyev, Y. M., eds. (2000) IRS 2000: Current Problems in Atmospheric Radiation. Proceedings of the International Radiation Symposium 2000, St. Petersburg, Russia, 24-29 July. A. Deepak Publishing, Hampton, Virginia, USA, 1311 pp.
Fischer, H. and Sohn, B.-J., eds. (2004) IRS 2004: Current Problems in Atmospheric Radiation, Proceedings of the International Radiation Symposium 23–28 August 2004, Busan, Korea. A. Deepak Publishing, Hampton, Virginia, USA.
Nakajima, T., Ellingson, R. and Serio, C. (2005) Featured Commission: The International Radiation Commission (IRC). IAMAS Newsletter, July 2005, pp 3-4.
Cahalan R.-F., Oreopoulos L., Marshak A., (incl. Macke A.) et al. (2005) The International Intercomparison of 3D Radiation Codes (D3RC): Bringing together the most advanced radiative transfer tools for cloudy atmospheres. Bull. Amer. Met. Soc. 86, pp. 1275-1293.
Nakajima, T., Bolle, H.-J., Smith, W., Lenoble, J., and Timofeev, Y. (2006) Obituary: Kirill Kondratyev, Bull. Amer. Met. Soc. 87, pp. 1420-1421.

Appendix 5: Acronyms

AATSR	Advanced Along-Track Scanning Radiometer
ACE -2	Aerosol Characterization Experiment (-2 North Atlantic Regional)
ADEOS	Advanced Earth Observing Satellite
Aeronet	Aerosol Robotic Network
AFCRL	Airforce Cambridge Research Laboratory
AFGL	Air Force Geophysical Laboratory
AGI	International Geophysical Year (French)
AIRS	Atmospheric Infrared Sounder
ALPEX	Alpine Experiment
AMS	American Meteorological Society
AMSU	Advanced Microwave Sounding Unit
AMTEX	Air-Mass Transportation Experiment
APRS	Asian-Pacific Radiation Symposium
ARM	Atmospheric Radiation. Measurement (Program of the US Department of Energy)
ASA	Atmospheric Spectroscopy Association
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ASTEX	Atlantic Stratocumulus Transition Experiment
BALTEX	Baltic Sea Experiment
BAMS	Bulletin of the American Meteorological Society
BAPMoN	Background Air Pollution Monitoring Network
BIRS	Beijing International Radiation Symposium
BOMEX	Barbados Oceanographic and Meteorological Experiment
BSRN	Baseline Surface Radiation Network
BUAN	Baseline Upper Air network
CACGP	Commission on Atmospheric Chemistry and Global Pollution - IAMAP
CAe	Commission on Aerology - WMO
CAENEX	Complex Atmospheric Energetics Experiment
CAGE	Cage shaped GATE experiment west of Dakar
CAS	Committee on Atmospheric Sciences - IUGG (ICSU)
CBS	Commission for Basic Systems (WMO)
CCF	Climate Coordinating Forum
CCP	Commission on Cloud Physics - IAMAP/IAMAS
CERES	Clouds and the Earth's Radiant Energy System
CGMS	Coordination Group for Meteorological Satellites
CHEMSAT	small special-deployable satellites for upper atmosphere research
CIE	International Commission on Illumination
CIG	International Geophysical Committee - ICSU/WMO
CIMO	Committee for Instruments and Methods of Observations - WMO
CIMSS	Cooperative Institute for Meteorological Satellites
CITC	Climatic Impact of Trace Constituents
CLAS	Coordination Group on Laser Atmospheric Studies
CLASS	Crosschain Loran Atmospheric Sounding System
COARE	Coupled Ocean-Atmosphere Response Experiment
CODATA	Committee on Data for Science and Technology
COPUOS	(United Nations) Committee on the Peaceful Uses of Outer Space
COSPAR	Committee on Space Research - ICSU
CRYSTAL	Cirrus Regional Study of Tropical Anvils and Layers
CSAGI	Special Committee for IGY (from French)
CSR	Commission of Solar Radiation of IUGG 1924 - 1948
DMSP	Defense Meteorological Satellite Program
EARSeL	The European Association of Remote Sensing Laboratories
ECLIPS	Experimental Cloud LIDAR Pilot Study
EOS	Earth Observing System
ERB	Earth Radiation Budget
ERBE	Earth Radiation Budget Experiment

EROS	(Center for) Earth Resources Observation and Science
ESA	European Space Agency
ESMWF	European Center for Medium-Range Weather Forecast
ESOC	European Space Operations Centre
Feng Yun	Feng Yun (FY-x) - China's Earth Observation Systems “Wind and Cloud”
FGGE	First GARP Global Experiment
FIRE	First ISCCP Regional Experiment
GAAREX	G1obal Atmospheric Aerosol Radiation Experiment
GAARS	G1obal Atmospheric Aerosol Radiation Study
GACEP	Global Aerosol Climatology and Effects Programme
GAMP	Group Agromet Monitoring Project
GOMS	Geostationary Operational Meteorological Satellite
GAPEX	Ground-based Atmospheric Profiler Experiment
GARP	Global Atmospheric Research Program
GATE	GARP Atlantic Tropical Experiment
GBSRN	Global BSRN
GEBA	Global Energy Balance Archive
GEWEX	Global Energy and Water Cycle Experiment
GFDL	Geophysical Fluid Dynamics Laboratory
GHIS	GOES High-Resolution Interferometer Sounder
GISS	Goddard Institute for Space Studies (NASA)
GLOCHEM	Global Atmospheric Chemical Survey
GOES	Geostationary Orbiting Environmental Satellites
GPCP	Global Precipitation Climatology Project
GRP	GEWEX Radiation Panel
GRWG	Gate Radiation Working Group
GSFC	Goddard Space Flight Center
HIRS	High Resolution Infrared Radiation Sounder
HIS	High-spectral resolution Interferometer Sounder
IACP	International Aerosol Climatology Project
IAF	International Astronautical Federation
IAGA	International Association of Geomagnetism and Aeronomy (IAMAP)
IAM	International Association of Meteorology
IAMAP	International Association of Meteorology and Atmospheric Physics (IUGG)
IAMAS	International Association of Meteorology and Atmospheric Sciences
IASI	Infrared Atmospheric Sounding Interferometer
IAU	International Astronomical Union
ICACGP	International Commission on Atmospheric Chemistry and Global Pollution
ICCP	International Commission on Cloud Physics
ICE	International Cometary Explorer
ICLAS	International Committee on Laser Atmospheric Studies
ICLAS	International Coordination Group on Laser Atmospheric Studies
ICMUA	International Commission of Meteorology of the Upper Atmosphere
ICPAE	International Commission on Planetary Atmospheres and Their Evolution
ICRCCM	Inter-Comparison of Radiation Codes in Climate Models
ICRCCM	International Committee for Radiation and Clouds for Climate Models
ICSU	International Council of Scientific Unions
IGAC	International Global Atmospheric Chemistry Program
IGAP	International Global Aerosol Program
IGBP	International Geosphere-Biosphere Programme
IGC	International Geophysical Co-operation
IGY	International Geophysical Year
IHD	International Hydrological Decade (1965-1974)
IMO	International Meteorological Organization
INSAT	Indian National Satellite (System)
IOC	(or IO_3C) International Ozone Commission
IPCC	Intergovernmental Panel on Climate Change

IPS	Intemational Pyrheliometric Scale
IQSY	International Quiet Year of the Sun
IRC	International Radiation Commission (formerly RC)
IRS	International Radiation Symposium
ISCCP	International Satellite Cloud Climatology Project
ISLSCP	International Satellite Land Surface Climatology Project
ISMG	International Scientific Management Group
ISY	International Space Year
ITPP	International TOVS processing Package
ITRA	Intercomparison of Transmittance and Radiance Algorithms
ITSC	International TOVS Study Conference
ITWG	International (A)TOVS Working Group
IUCRM	Inter Union Commission of Radio Science
IUCSTP	Inter Union Commission on Solar Terrestrial Physics
IUGG	International Union of Geodesy and Geophysics (also UGGI)
JACCS	Japanese Cloud Climate Study
JOC	Joint Organizing Committee - GARP
JPL	Jet Propulsion Laboratory
JPS	Joint Planning Staff
JSC	Joint Scientific Committee - WCRP
KNMI	Het Koninklijk Nederlands Meteorologisch Institut
LASR	Long-term Analysis of Surface SW Radiation Budget
LITE	Laser In-Space Technology
LMD	Laboratoire de Météorologie Dynamique
LOTRAN	Low Resolution Transmittance Code
LTE	local thermodynamic equilibrium
MAP	Middle Atmosphere Programme
MARC	Middle Atmospheric Responses to Changes
MEIDEX	Mediterranean Israeli Dust Experiment
MGO	Main Geophysical Observatory
MIPAS	Michelson Interferometer für Passive Atmosphärische Sondierung
MODIS	Moderate Resolution Imaging Spectroradiometer
NBS	National Bureau of Standards
NCEP	National Center for Environmental Prediction (formerly NMC)
NIMBUS	first three-axis stabilized meteorological satellites in sun-synchronous orbit
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite
OC	Ozone Commission
OCTS	Ocean Color and Temperature Scanner
OPA	Optical Properties of Aerosols
PBL	Planetary Boundary Layer
PICAS(S)O	Pathfinder Instruments for Cloud and Aerosol Spaceborne Observations
POESS	Polar Orbiting Environmental Satellite
RASS	Radar Acoustic Sounding System
RC	Radiation Commission - IAMAP
RITOVS	very fast TOVS transmittance models
RSMA	Remote Sounding of Middle Atmosphere
RSP	Radiation Sub-Program
RT	Radiative Transfer
S-HIS	Scanning HIS
SCOPE	Special Committee on Problems of the Environment
SCOR	Scientific Committe on Ocean Research
SCOSTEP	Scientific Committee on Solar Terrestrial Physics
ScaRaB	Scanning Radiometer for Radiation Budget Measurements
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SHEBA	Surface Heat Budget of the Arctic Ocean Project

SI	System International d'Unités
SMS	Synchronous Meteorological Satellite
SOCEX	Southern Ocean Cloud Experiment
SOHO	Solar and Heliospheric Observatory
SPACELAB	Space Laboratory
SPECTRE	Spectral Radiation Experiment
SRA	Standard Radiation Atmosphere
SRB	Surface Radiation Budget Climatology Project
SSM/I	Special Sensor Microwave/Imager (on board of DMSP)
SST	Sea Surface Temperature
STRATEX	Aerosol and Stratus (Sub-program of GARP)
TARFOX	Tropospheric Aerosol Radiative Forcing Observational Experiment
TIROS	Television and InfraRed Operational Satellite
TIROS NEXT	Next-generation of the TIROS (from TIROS-N, NOAA 6-7 on)
TOGA	Tropical Ocean Global Atmosphere
TOGA-COARE	TOGA Coupled Ocean Atmosphere Response Experiment
TOMS	Total Ozone Mapping Spectrometer
ITOVS	International TIROS Operational Vertical Sounder
TOVS	TIROS Operational Vertical Sounder
TRMM	Tropical Rainfall Measuring Mission
TROPEX	Tropical Experiment
UGGI	Union of Geodesy and Geophysics International (see IUGG)
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UV-B	Ultraviolet-B
VARS	Vertical and Azimuth Reference System
WCP	World Climate Program
WCRP	World Climate Research Program
WDC	World Data Center
WG6	Working Group 6 of COSPAR (App. of Space Techniques to Met. and Earth Survey)
WGGCOS	Working Gtoup on Global Climate Observation System
WGNE	Working Group on Numerical Experimentation
WGOPA	Working Group on Optical Properties of Aerosols
WGRF	Working Group on Radiation Fluxes
WMO	World Met.eorological Organization
WRDC	World Radiation Data Center
WRR	World Radiation Reference
WWW	World Weather Watch

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International Radiation Commissions 1896 to 2008: Research into atmospheric radiation from IMO to IAMAS. Compiled by Hans-Jürgen Bolle with contributions by Fritz Möller and Julius London.
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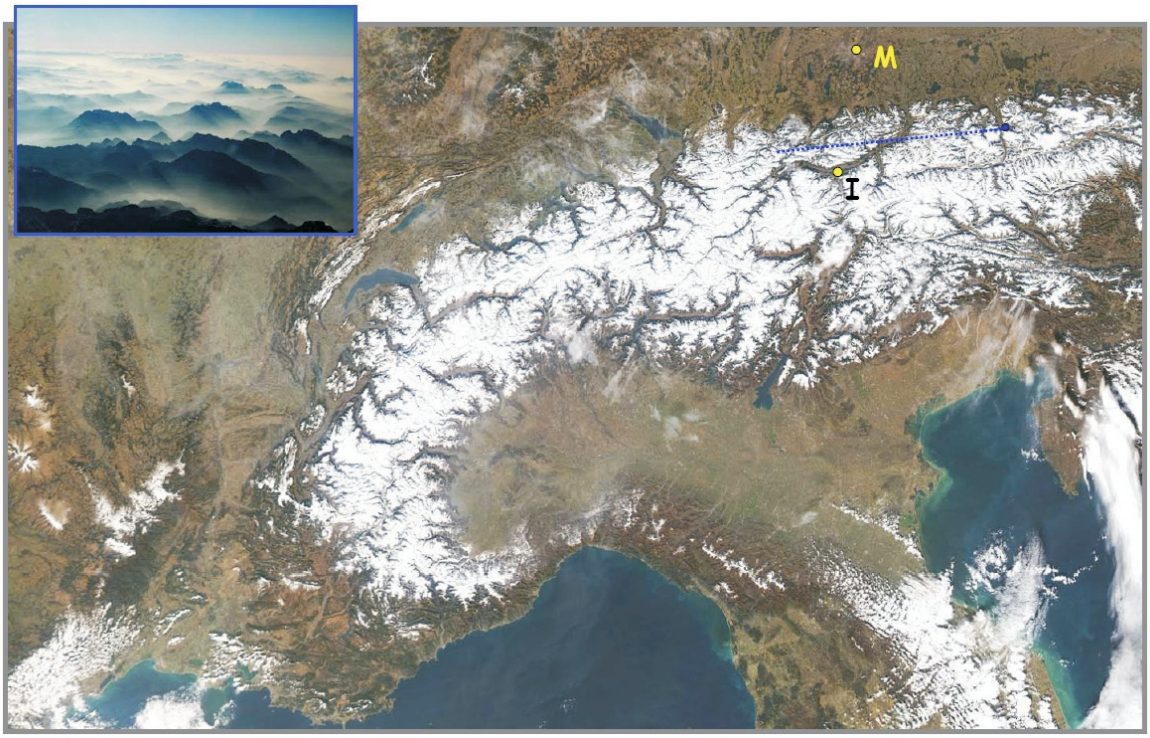
Information about the authors

Hans-Jürgen Bolle (*1929), prof. em. of the Freie Universität Berlin, obtained his PhD from the University of Hamburg under the tutelage of Rudolf Schulze. He became scientific assistant of Fritz Möller at the university of Mainz in 1958 and taught throughout his career at the universities of Munich, Innsbruck and Berlin. He was president of the IAMAP-IRC (1979-1983) and of IAMAP (1983-1987) as well as vice-chairman of the JSC-WCRP (1982-1986), chairman of the BAHC-IGBP Scientific Steering Committee (1990-1993), and member of COSPAR Working Group 6 (1971-1987). His main research areas were atmospheric spectroscopy and the application of satellite data for climate research. In the 1990s he coordinated several major projects of the European Commission in the Mediterranean area related to atmospheric radiation, remote sensing and land-surface processes. Fritz Möller and Julius London also served as presidents of the IRC.

Illustration of the topic



Much of the work of the IRC is dedicated to the quantitative assessment of the Earth's climate state variables. The images illustrate some of the phenomena which complicate the sounding of the atmosphere from satellites and the determination of the Earth's energy budget: Scattering of solar radiation by aerosol and clouds - which requires three- dimensional radiative transfer modelling - and the variable albedo and surface properties. The complex structure of land and sea surfaces as well as the cloud pattern over central Europe reflect radiation in several wavelength-bands to the MODIS instrument on the AQUA satellite (12 February 2008, 1205 UT). ***M*** *and* ***I*** *denote the locations of Munich and Innsbruck, where Fritz Möller and Hans-Jürgen Bolle spent long periods of their research careers. The inset depicts an airborne westward perspective across the Alpine massifs from Watzmann to Wetterstein across the curved Inn valley (the central view is along the dark blue dotted line; 11 Oct. 2007, 14:30UT). Intense forward scattering of sunlight caused by aerosol, which filled the valley atmospheres, helps to distinguish the multitude of mountain chains.*

Satellite image: courtesy of MODIS Rapid Response Project at NASA/GSFC; insert: Hans Volkert

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