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INTERNATIONAL COMMISSION ON ATMOSPHERIC ELECTRICITY (IAMAS/IUGG)

AMS COMMITTEE ON ATMOSPHERIC ELECTRICITY

AGU COMMITTEE ON ATMOSPHERIC AND SPACE ELECTRICITY

EUROPEAN GEOPHYSICAL SOCIETY

SOCIETY OF ATMOSPHERIC ELECTRICITY OF JAPAN

ANNOUNCEMENTS

In order to reduce distribution expenses (as well as deforestation!), the Newsletter is now routinely provided on the web, thanks to Monte Bateman's help. Those individuals needing the mail version should contact Serge Chauzy: (chas@aero.obs-mip.fr) or Pierre Laroche: (laroche@onera.fr). They will receive the Newsletter in its paper version. Those knowing anybody who needs such a paper version are also welcome to contact us. On the other hand, the easiest way to communicate being now electronic mail, we would be grateful to all of those who help us complete the "atmospheric electricity" list of email addresses already available.

Contributions to the next edition of this Newsletter (May 2000) are welcome and should be submitted to Serge Chauzy or Pierre Laroche before April 15, 2000, preferably under word attached documents.

ICAE '99 CONFERENCE (Guntersville, AL)

The 11th International Conference on Atmospheric Electricity has been successfully held in Guntersville, Alabama, June 7-11, 1999. Organized by the International Commission on Atmospheric Electricity and the Global Hydrology and Climate Center, the conference was sponsored by the National Aeronautics and Space Administration (NASA), the Marshall Space Flight Center, and the National Science Foundation. The Conference Chairman, Hugh J. Christian Jr., has performed a great work in hosting this meeting. His contribution, warmly appreciated by the whole community, allowed fruitful discussions between conference attendees. During the conference, some changes occurred within the International Commission on Atmospheric Electricity. Marcia Baker, Phil Krider, and Bill Winn left the commission. Paul Krehbiel, Pierre Laroche, Vlad Rakov, and Dave Rust were elected new members. New officers have also been elected. The new President is now Pierre Laroche (ONERA, Paris, France), and the new Secretary is Serge Chauzy (Laboratoire d'Aérologie, UPS, Toulouse, France). Phil Krider, former President, and Earle Williams, former Secretary, have realized an outstanding work during their presence at the head of the commission. Hearty thanks from the international community!

***THE XIth GLOBAL WARMING INTERNATIONAL CONFERENCE AND EXPO**

This conference, will be held April 25-28 2000, in Boston. The main issues are: Global warming and climate change, Global surveillance: climate future, Education: global change, Human health in a changing climate, Energy and natural resource management, International law and policy making, State and local government actions. 400-word abstracts had to be submitted before October 17, 1999. Other important deadlines: Advanced registration: January 15, 2000; Registration: March 1, 2000. (http://www.GlobalWarming.net).

***AGU FALL MEETING/CASE**

This year AGU Fall Meeting will be held December 13-17, in San Francisco, California. Preregistration deadline: November 9, 1999; Housing deadline: November 12, 1999. Registration can be made electronically through AGU Web site. Don MacGorman (Chair, AGU/CASE) let us know that the AGU Committee on Atmospheric and Space Electricity (CASE) meeting at this year AGU Fall Meeting will be held on Thursday, December 16, at 5:30 pm. The room will be announced later. You do not have to be a CASE member to attend. All who are attending the Fall Meeting are invited. More information on the Web site**:** http://www.agu.org.

***CONFERENCE ON EUROPEAN TORNADOES AND SEVERE STORMS**

This conference, to be held in Toulouse (France) 1-4 February 2000, is intended to be a first step in fostering research coordination in this area. It includes topics like climatology, severe wind, hail, electrical phenomena, synoptic and mesoscale processes, numerical modeling, forecasting. More information on the Web site: http://www.eurotornado.ou.edu.

***EUROPEAN GEOPHYSICAL SOCIETY XXV GENERAL ASSEMBLY**

This annual assembly will be held in Nice (France), 25-29 April 2000. Quite a few sessions of the "Oceans and Atmosphere" division should be of interest for our community members. Abstract deadline: 15 December, 1999. More information on the Web site: http://www.copernicus.org/EGS/EGS.html.

*** NEW EDITORS FOR JGR**

JGR Atmospheres will have four new Editors next year. Two will replace the current editors, Mary Anne Carroll and Roni Avissar, and two new positions are being created. Approximately 1295 articles were processed last year. At least one of the new editors will reside outside of North America. The search committee was formed in early October and consists of eight members, including three from meteorology (Holton-Washington, Hamilton-Princeton, and Orville-Texas A&M). It is anticipated that interviews will begin during the AGU Meeting in mid-December in San Francisco. Members of the atmospheric electricity community are encouraged to consider this opportunity and nominate themselves or colleagues. Further information can be obtained directly from the AGU Headquarters, Washington, DC, or from R. Orville through his email address: rorville@tamu.edu.

***SPECIAL ISSUE "BERNARD VONNEGUT" OF ATMOSPHERIC RESEARCH**

The journal "Atmospheric Research" (Editors in chief: Jean Dessens, Clive P. R. Saunders, and John T. Snow) published, in July 1999, a special issue entitled "The Vonnegut Special Issue", the guest editor being Haflidi H. Jonsson. 11 papers devoted to atmospheric electricity appear in this issue, vol 51, n°3-4.

RESEARCH ACTIVITY BY ORGANIZATION

***AIRBORNE RESEARCH ASSOCIATES (Weston, MA)**

This summer and fall ARA has concentrated on field testing its new ATLAS (Aircraft Total Lightning Advisory System) single station lightning mapping system that has been under development for four years. This system is unique for a single sensor system because it can accurately determine the distance to IC and CG flashes. This is done through measurement of only the initial breakdown into virgin air of the "first pulse" of lightning. This novel patented approach is based on the principle that the first electrical breakdown ("first pulse") of all lightning is essentially invariant in amplitude and vertical -- thus distance is proportional to 1/amplitude and there is no polarization error arising from variations in the relative orientation of the sensor and radiating dipole. For the first time accurate estimates of distance can be obtained with a single sensor, this is possible for IC and CG flashes, and these can be identified.

The initial vertical breakdown occurs where electric field intensity maximizes, either at the bottom or top of the horizontal negative charge layer that occupies the middle height range of thunderclouds. Discharges at the bottom of this layer (near 5 km), where the sign of the "first pulse" discharge is positive, occur at the initiation of the downward propagating leader of cloud-to-ground lightning. Similarly, the "first pulse" at the top of the negative layer (near 8 km) is negative, propagates upward, and initiates intracloud discharges.

Previous aircraft lightning detectors operate in the VLF range and mostly detect intense CG discharges. The characteristic "radial spread" phenomena in the displays of these systems (a series of dots along a radial line extending outward from the aircraft position at the center of the display) is caused by detection of the series of return strokes in most CG flashes. They have different intensities and are interpreted as being at different distances. The ATLAS system, which detects only first pulses about 1% as intense as return strokes, only shows one dot per flash at a relatively accurate range. Azimuth is determined through conventional crossed loop/ferrite coil technology, but through detection of only the first pulse. Because an accurate geographic location can be determined for each flash, they can be shown realistically on a GPS/moving map aircraft navigation system. Trying to display lightning flashes with the "radial spread" characteristic from moving aircraft will result in a smear of dots across the screen -- the geographic position will not be known and the cloud of dots can obscure other information on the screen.

With support from NASA, an ATLAS system installed on the ARA TurboBaron aircraft as well as two systems installed on the ground are being tested in Florida. Results show good correlation of ATLAS with NLDN, the KSC LDAR, and radar imagery. Tests are continuing and future plans call for digital signal processing to improve performance. Those interested in the new first pulse total lightning positioning technology, which includes ATLAS and a multistation time-of-arrival system called LASI, should contact Ralph Markson (rmarkson@totallightning.com). Additional details on these systems are in the Proceedings of the 11th International Conference on Atmospheric Electricity, NASA/Marshall Space Flight Center, AL, June1999, p.188.

***AIR FORCE RESEARCH LAB (Boston, MA)**

John Willett (Air Force Research Lab, Boston, MA), Dan Davis (State University of New York at Albany), and Pierre Laroche (ONERA, France)continue analysis of their 1996 triggered-lightning/sounding-rocket experiment at Camp Blanding, FL. The vector, electrostatic-field profiles from the sounding rockets have been "navigated" into an Earth-fixed coordinate system and are being compared with radar data from the Jacksonville NEXRAD. The current and field-change data from the triggered lightning are being analyzed to estimate the propagation velocities of the upward positive leaders that initiated the discharges. Electrostatic models of the corona sheath around these leaders are also being developed to relate leader current and ambient-potential profile to propagation velocity. Anne Bondiou-Clergerie and Philippe Lalande (ONERA, France) are using the experimental data to validate and improve their theoretical model of long positive leaders.

***THE UNIVERSITY OF ARIZONA (Tucson, AZ)**

E. P. Krider and M. J. Murphy are continuing to compare the locations and magnitudes of intracloud (IC) and cloud-to-ground (CG) lightning, as detected by the Lightning Detection and Ranging (LDAR) system, the field mill network, and the Cloud-to-Ground Lightning Surveillance System that operate at the NASA Kennedy Space Center (KSC) and Air Force Eastern Range (ER). The results show that when there is active convection, most CG flashes begin on the lower side of the negative charge region with an initial discharge that propagates downward toward a lower positive charge center (LPCC) near the melting level. Currently, the causes of the LPCCs appear to be both a cloud charging process and IC discharges that effectively deposit positive charge at low altitudes. During the onset of electrification, the LPCC typically appears first at field mill sites that are close to or under the storm.

E. P. Krider and W. J. Koshak are continuing to study the response of the NASA Lightning Imaging Sensor (LIS) when lightning flashes occur over or near the KSC-ER and are within the LIS field of view. Bruce Gungle is examining the relationships between lightning and surface rainfall at the KSC-ER. Scott Handel is studying the behavior of the surface electric field during the onset of isolated thunderstorms and also the surface field just before large, horizontal flashes propagate into the KSC-ER area from distant storms. In the future, an effort will be made to determine if the total light output produced by CG and IC flashes, as inferred from ground and satellite measurements, is proportional to the total charge deposited by the flash.

*CLOUD PHYSICS DEPARTMENT OF VOEIKOV MAIN GEOPHYSICAL OBSERVATORY (MGO, St. Petersburg, Russia)

The group (Dr.Stepanenko V. D., Ponomarev Yu.Ph., Dr.Dovgaluk Ju.A., Pershina T.A) headed by Dr.Sinkevich Andrei had carried out laboratory experiments on studying the influence of electrical discharges on spectrum of fog particles.

Experiments were carried out during the last 5 years. 3 cloud chambers of different volumes were used - 65 m^3, 1 m^3, 0.01 m^3. A Tesla transformer was used to produce electrical discharges in the 65 m^3 cloud chamber. Voltage was equal to 7500000 V. A 3 kV source was used to produce discharges in the 1 and 0.01 m^3 cloud chambers. The results of experiments in the 65 m^3 cloud chamber have shown that there is an increase of cloud particles and electrical field strength due to electrical discharges. Electrical field strength increases to the order of magnitude due to the increase of volume charge. Electrical discharges in the 1 m^3 cloud chamber influence crystal forms which appear in the chamber. Crystals with complex forms appear after discharges. Electrical discharges in the 0.01 m^3 cloud chamber lead to drops freezing at temperature –4 to -6 °C.

Electrical discharges lead to increase of volume charge and hence favorable conditions for further discharges appear. This mechanism of positive feedback can play a significant role in lightning formation. Results of experiments were presented in MGO collection of articles to the 150 anniversary of MGO.

Acknowledgement. We would like to thank Dr Stasenko V.N for his help in transformer Tesla installation in cloud chamber.

*COLORADO STATE UNIVERSITY (Fort Collins, CO)

Department of Atmospheric Science

Timothy Lang and Steven Rutledge are utilizing dual-Doppler and multiparameter radar data, along with electric field change meter and cloud-to-ground lightning detection network data, to examine a broad spectrum of thunderstorm types and intensities. The goal is to better understand how storm kinematic and microphysical structure affect lightning production. Ten case studies have been identified: five mid-latitude thunderstorms observed in northeast Colorado in 1998, and five tropical thunderstorms observed during the TRMM/LBA project, which occurred in early 1999 in the western Amazon of Brazil. These storms vary from weak air mass and monsoonal thunderstorms to intense squall lines and supercells. By examining how variations in lightning patterns and production correlate to variations in the kinematic and microphysical structures within this diverse array of storms, we hope to gain new insights into how storm kinematics and microphysics affect lightning production.

The Frequency and Distribution of Severe Storms That Produce Predominately Positive Cloud-to-ground Lightning in the Contiguous United States

Although the polarity of most cloud-to-ground (CG) lightning is negative, the ground flashes beneath severe storms are sometimes predominately positive (i.e., > 50%). Occasionally, the +CG lightning flash density is very high (i.e., $\geq$ 0.01 km^{-2} h^{-1}). The existence of predominately positive cloud-to-ground (PPCG) lightning in severe storms evokes fundamental questions regarding thunderstorm electrification mechanisms and raises the possibility of nowcasting severe storms with CG lightning data. Despite their intriguing nature, the regional frequency and % of severe storms dominated by +CG lightning in the contiguous U.S. are not well understood. In addition, little is known about the magnitude of positive peak currents in these storms.

To address this issue, Lawrence D. Carey and Steven A. Rutledge determined the %, flash density, and mean peak current of +CG lightning within the vicinity of every large hail and tornado report during a ten year period (1989 - 1998) during the warm season (April - September). These analyses reveal that PPCG lightning rarely occurs beneath severe storms in the contiguous U.S. Only 15% (5%) of severe storm reports were associated with (high flash density) PPCG lightning. However, there was significant regional variability. The overwhelming majority of +CG lightning dominated severe storms occurred in the central U.S. The Eastern U.S. was nearly devoid of these unique storms; only 3% (0.5%) of severe storms produced (high flash density) PPCG lightning there. In the Central and Northern Plains, about 41% (15%) of severe storm reports were accompanied by (high flash density) PPCG lightning.

Broad frequency and % maxima of severe storms that generate PPCG lightning stretched from eastern CO and the OK Panhandle northeastward through KS and NE to the eastern Dakotas and southern MN. In this southwest-to-northeast tilted region, typically > 30% of severe storms were +CG dominated. Interestingly, this feature is remarkably similar in location and shape to the region of high percentage (e.g., > 10%) of +CG lightning found in the Great Plains and Upper Midwest when analyzing annual NLDN data from 1989 - 1998. This region is also characterized by a relative maxima in the median positive peak current (> 30 kA; Orville and Huffines, Proceedings of the 11th ICAE, 412-415, 1999). Inspection of our results shows that severe storms dominated by PPCG lightning generate a markedly different population of positive peak currents than other severe storms. The mean positive peak current for severe PPCG lightning events typically ranges from 35 kA to 65 kA while it ranges primarily from 10 kA to 30 kA for all other severe storms. Based on these results, we suggest that severe storms that produce PPCG lightning may be largely responsible for the annual maxima in both the percent of positive CG lightning flashes and the positive peak current that is found in the Great Plains and Upper Midwest when analyzing annual NLDN data from 1989-1998. Additional information can be found at the following web site: http://olympic.atmos.colostate.edu/ppcgsvr.html

NWS/VISIT Training Efforts on Lightning

The U.S. National Weather Service (NWS) is offering training on lightning through the Virtual Institute for Satellite Integration Training (VISIT; please see www.cira.colostate.edu/ramm/visit/visithome.asp). Bard Zajac is the producer of lightning training and the point of contact (zajac@cira.colostate.edu). Recent efforts have focused on the development and delivery of a teletraining session on cloud-to-ground (CG) lightning activity in the contiguous U.S. (CONUS) based on research by Zajac and Steve Rutledge at Colorado State University.

The VISIT lightning teletraining session discusses 1) the operation and performance of the National Lightning Detection Network and 2) the spatial, annual, and diurnal variations in total (positive and negative polarity) CG lightning activity over the CONUS and the forecast areas of the participating NWS Weather Forecast Offices (WF0s). This teletraining session takes roughly 90 minutes and is delivered to as many as six WFOs at a time. (VISIT teletraining involves a computer slide show seen by all offices and instructor via the Internet and a conference phone call.) Since the first offering in late-July, the lightning session has been delivered to over 50 WFOs/200 individuals.

Current efforts are focused on the development of a second VISIT teletraining session on lightning. This session will discuss: 1) the spatial, annual, and diurnal variations of positive and negative CG lightning activity, 2) CG lightning activity over the northern Great Plains associated with severe storms and mesoscale convective systems (MCSs), 3) CG lightning activity along the Gulf Coast associated with the sea breeze and cold season baroclinic systems, and 4) the false detection of intracloud lightning as low peak current positive CG lightning over the southeastern U.S.

***UNIVERSITY OF FLORIDA (Gainesvill, FL)**

A total of 30 flashes were initiated during the 1999 triggered-lightning campaign at the International Center for Lightning Research and Testing (ICLRT) at Camp Blanding. Of these 30, 22 contained downward leader/upward return stroke sequences, and 8 were composed of the initial stage only. All triggered flashes effectively transported negative charge to ground. Two triggering attempts under positive electric field conditions (fields at ground were +4.2 and +7.9 kV/m) were unsuccessful, although there was a partial wireburn at a height of about 10 m above ground in the event associated with the higher field. A new experimental installation was used in the 1999 campaign, which included a rocket launcher placed below ground level and surrounded by a 70 x 70 m^2 metallic grid buried at a depth of a few centimeters. This installation was used to minimize the effects of both the triggering facility and the finite soil conductivity on measurements of close electric and magnetic fields and their time derivatives.

Martin Uman, Vlad Rakov, George Schnetzer, Keith Rambo, Dave Crawford, and Dick Fisher authored a paper titled “Time Derivative of the Electric Field 10, 14, and 30 m from Triggered Lightning Strokes.” The time derivative of the electric field of triggered lightning strokes was directly measured at distances of 10 m, 14 m, and 30 m. The data were taken in 1998 at the ICLRT at Camp Blanding, Florida. The results were compared with those of similar triggered-lightning measurements made previously at the Kennedy Space Center at distances of 50 m and 5 km and in France at 50 m. A comparison was also made with previous measurements at the Kennedy Space Center for natural lightning strokes over the Atlantic Ocean at distances of the order of tens of kilometers and with overland natural lightning data obtained at 0.7 to 14 km in Germany. The Camp Blanding return-stroke electric field derivative peak values normalized (assuming the inverse distance dependence valid for radiation fields) to 100 km are similar to all previous measurements for both natural and triggered lightning at distances from 50 m to 50 km, all being several tens of volts per meter per microsecond, with the exception of the German overland peak derivative values which are an order of magnitude lower. The 10 to 30 m field derivative zero-to-peak risetimes at Camp Blanding are typically 50 to 100 ns (minimum 30 ns, maximum 180 ns), and widths at half-peak value are typically 100 to 200 ns. There is essentially no difference between field derivative waveshapes measured simultaneously at 10 m and at 30 m, with the closer waveform being about a factor of 2 greater in amplitude. Fourier analysis of field derivative waveforms indicates that the primary frequency content of the electric field derivative waveforms is below about 20 MHz. The Camp Blanding close return stroke field derivative waveforms differ from those of Leteinturier et al. (1990) recorded 50 m from triggered lightning at the Kennedy Space Center in 1985 in that their derivative waveforms typically decrease rapidly after the peak and exhibit zero-crossings. It is argued that the differences between the KSC and Camp Blanding waveforms are related to the relatively large rocket-launching structure used at KSC in 1985. The mean return stroke speed computed from the electric field derivative and current derivative data using the transmission-line model is 2.5×10^8 m s^{-1} with a standard deviation of 1×10^8 m s^{-1}. Some of the Camp Blanding return stroke current waveforms exhibit a pronounced decrease in their rate-of-rise, accompanied by a similar feature in the associated electric field waveform, at the time that the electric field derivative pulse exhibits a transition from a sharp initial spike to a relatively slow tail, typically 100 to 200 ns after the beginning of the waveform. The paper was submitted to the JGR.

Vlad Rakov in collaboration with Richard Kithil of the National Lightning Safety Institute (NLSI) authored an article titled “Small Shelters and Safety from Lightning.” The article will be published in the Golf Course Management magazine.

*LIGHTNING, HIGH VOLTAGE & INSULATION GROUP (University of Queensland, Dept. of Computer Science and Electrical Engineering, Brisbane, Queensland, Australia)

Dave Mackerras and Mat Darveniza are working with the Australian Bureau of Meteorology to produce a thunderstorm and lightning climatology for Australia, based on historical thunderday data, lightning flash counter records, lightning location system records, and satellite observations. An immediate objective is to supplement an existing annual thunderday map with a ground flash density map.

An on-going study of global lightning in cooperation with Richard Orville (Texas A&M University), Earle Williams (MIT), and Steve Goodman (NASA, MSFC) (JGR, Vol. 103, No. D16, pages 19,791-19,809, August, 1998) has been extended in an attempt to model global electric circuit charging. We seek an explanation for the differences between the diurnal variation in universal time of global lightning and the diurnal variation in universal time of the ionospheric potential (Proceedings of the 11th ICAE, pages 634-637, June, 1999).

Observations with CGR3 lightning flash counters in Brisbane and Darwin are continuing. One objective is to determine negative and positive ground flash density, cloud flash density, and total flash density for these areas. The Brisbane CGR3 observations, made in conjunction with electric field change observations, are being used to check earlier estimates of effective ranges, error rates, and correction procedures, for converting CGR3 registrations to flash densities.

*LOS ALAMOS NATIONAL LABORATORY (Los Alamos, NM)

FORTE Radio-Frequency Observations of Lightning (A. Jacobson, P. Argo)

FORTE's RF payload continues to function well and has just reached the 3-million-RF-event milestone. Most of these events are VHF signals from lightning. We are concentrating on coverage of the low latitudes, which generate most of the lightning we see globally. A recent very encouraging development has been the successful implementation of a geolocation (using the

CCD optical imager) for events in which the imager and the RF payloads see temporally-overlapping events. This is now allowing global geolocation of the RF sources.

FORTE Optical Effort: Measurements and Modeling (D. Suszcynsky, T. E. Light, M. Kirkland)

Using FORTE, we have concentrated on studying optical lightning emissions that are simultaneously detected by both the photodiode detector (PDD) and Lightning Location System (LLS) CCD imager. The high temporal resolution (~15 us) of the PDD waveforms and the high spatial resolution (~10 km) of the LLS geolocations combine to give a detailed satellite-based picture of both the spatial and temporal evolution of terrestrial lightning at the stroke level. Concurrently we are developing 3D Monte Carlo simulations of cloud radiative transfer, with emphasis on deducing the temporal structure of the emission from the structure of the scatter-delayed and -broadened observable pulse. The model is capable of handling a variety of cloud/pulse geometries and arbitrary spatio-temporal pulse profiles. Simple test-cases have shown good agreement with simple PDD wave forms, and we are now beginning to consider more realistic scenarios.

FORTE Ground Support: The LANL Sferic Array (D. Smith, K. Eack, J. Harlin, X. Shao)

During 1999 we have operated an array of electric field change sensors that has nominally consisted of 11 stations: 5 in New Mexico/Texas, 5 in Florida, and 1 in Nebraska. We record lightning waveforms with the stations and use cross-correlation and time-of-arrival techniques to locate discharges. The waveforms are used to determine source heights (for intracloud discharges), classify flashes, and determine lightning parameters such as polarity, peak current, and dipole moment change. During the 1999 thunderstorm season, the Florida and New Mexico arrays recorded and located nearly 5000 narrow bipolar pulses (of both positive and negative polarities), which are thought to be produced by compact intracloud discharges. Over 25 percent of these events were produced in a 24 hour period by four thunderstorms over the eastern plains of New Mexico. We are working to analyze these data in context with WSR-88D (NEXRAD) radar and other meteorological data.

Theoretical Work in the Atmospheric and Climate Sciences Group (R. Roussel-Dupre, E. Symbalisty, L. McNair, H. Morris)

Theoretical work in EES-8 at Los Alamos is focused on both intracloud (IC) lightning and high-altitude discharges. First principles modeling of IC lightning has yielded predictions for the optical, radio frequency, and gamma emissions that are in good agreement with observations. Comparisons are made with satellite based optical measurements, ground based slow and fast field change measurements, and aircraft based gamma measurements. Results comparing theory with recent observations of intense bipolar pulses will be presented at the Fall AGU. Simulations of high-altitude discharges using a new, fully electromagnetic code and a new parent discharge model are also yielding interesting results.

*<u>INSTITUTE OF METEOROLOGY AND GEOPHYSICS (Frankfurt, Germany)</u>

Martin Füllekrug reports:

Three GPS synchronized measurement stations recorded horizontal magnetic field variations in the ULF/ELF transition range 4-200 Hz at Silberborn, Germany (51.8°N, 9.5°E), and 4-19 Hz at Hollister, California (36.8°N, 121.4°W), and Lameroo, Australia (35.5 °N, 140.6 °E), during April 1998. The three station records exhibit simultaneous discrete excitations of Earth-ionosphere cavity (or Schumann) resonances which result from the constructive interference of electromagnetic waves which propagate with little attenuation in the spherical Earth-ionosphere waveguide (Schumann, 1952; Sentman, 1995). These Earth-ionosphere cavity resonances are mainly excited by particularly strong lightning flashes which can be triangulated by use of the orientation of the Poynting vector along the great circle path of propagation.

The great circle path crossing points of the three independently observed Poynting vector orientations determine two best fitting lightning flash locations on the Earth. The time of arrival difference between two stations is used to resolve the hemispheric ambiguity. The derived lightning flash locations are validated with lightning flash locations reported by the VLF time of arrival difference system of the British Meteorological Office (Lee, 1986). The lightning flash location accuracy by use of Earth-ionosphere cavity resonances is on the order of several hundred kilometers. The physical reason for the location error is threefold (Füllekrug and Sukhorukov, 1999). First, the alignment flash bearing deviation exhibits a rotational dependence at coastal stations as a result of the excitation of higher order modes in the vicinity of the sharp conductivity contrast between the ocean and the Earth's crust. Second, the bearing deviation exhibits a diurnal variation which results from the anisotropic contribution of the ionosphere to the wave propagation, mainly apparent during night time conditions. This bearing deviation Äö can be estimated: Äö = arctan ($1/2k_0 n_E h_E$), where k_0 is the free space wave number, h_E is the height of the ionosphere E-region (90 km), and n_E is the refractive index of the nocturnal E-region. Third, random occurrences of sporadic D-Layer ionization patches result in a statistical variability of the source triangulation accuracy (Pappert, 1985).

All triangulated lightning flashed represent an estimate of the global lightning activity. Since the horizontal magnetic field variations can easily be monitored continuously, it is possible to determine the temporal evolution of particularly interesting thunderstorms, for example in Central Africa, North America, and Australia. The thunderstorms in North America and Australia exhibit a sharp rise of the flash rate and a decay within one day, while the high flash rate in Africa persists for 3-4 days and may be associated with a mesoscale convective system (Laing and Fritsch, 1997) or many individual thunderstorm cells.

*<u>UNIVERSITY OF MISSISSIPPI (University, MS)</u>

During July and August, 1999, Tom Marshall and Maribeth Stolzenburg conducted Studies of the Electrical Evolution of Thunderstorms (SEET) at Langmuir Lab in New Mexico. Twenty-nine balloon soundings of electric field and thermodynamics were acquired in six different storms, with as many as seven soundings per storm. Terry Hock and colleagues at NCAR/ATD developed a full-GPS system for the Vaisala dropsondes as part of SEET; this technology greatly improved balloon tracking within the thunderstorms. Also new for this study were narrowband transmitters for the electric field meters, provided through NCAR/ATD, which made it possible to successfully receive data from as many as four balloons (eight instruments) at one time. During several of the storms studied the New Mexico Tech Lightning Mapping System of Paul Krehbiel, Bill Rison, Ron Thomas, and colleagues detected numerous lightning flashes in the vicinity of one of more balloons. Additional data for these storms were collected with the Langmuir Lab 3-cm Doppler radar (Steve Hunyady and Graydon Aulich) and with the multiparameter radar operated by Paul Krehbiel in Socorro. The ballooning portion of this project was accomplished with the assistance of Dave Rust (NSSL), Terry Hock, Dean Lauritsen, and Errol Korn (all of NCAR/ATD), as well as five students from the University of Mississippi and two students from the University of Oklahoma. Data processing and analysis are now underway.

Analysis of data from the 1998 MEaPRS experiment, based in Oklahoma, is continuing. There are fourteen balloon soundings of electric field in mesoscale convective systems and convective squall lines as a result of that project, which was performed in collaboration with Dave Rust and many others at NSSL. An additional five soundings were made into supercells and convective storms producing a high percentage of positive cloud-to-ground flashes; analysis of these data is continuing in collaboration with Don MacGorman, Dave Rust, and Bill Beasley (NSSL/University of Oklahoma).

*INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (INPE) (Sao José dos Campos, Brazil)

The Lightning Triggering Experiment in Brazil (LTEB) is an international collaboration project involving Brazil, France and Canada with the main goal to study the physics and related technical phenomena associated with triggering lightning. The project is the first to consider this phenomenon in the tropical region of the world, where most lightning does occur.

The institutions involved in the project are: in Brazil, the Instituto Nacional de Pesquisas Espaciais (National Institute of Space Research, INPE) and the University of Campinas (UNICAMP); in France, the Centre d'Etudes Nucléaires de Genoble (Center of Nuclear Studies of Grenoble, CENG), the Laboratoire d'Aérologie of the University of Toulouse, and the Company INDELEC; and in Canada the company Hydro Quebec Utility (IREQ).

The project should be developed in the installations of INPE in Cachoeira Paulista, São Paulo, Brazil. This site was chosen considering the high lightning activity in the region, determined through electric field measurements, performed using field mill, during the summer season of 1999, and its facilities. The project is divided in two phases: in the first, to occur between December, 1999 and March, 2000, the technique to trigger lightning with small rockets will be used; in the second phase, one year later, the technique of laser triggering will be also attempted. During the first phase, it will be launched about 50 rockets in Cachoeira Paulista from the beginning of January to the end of March 2000, using both classical and altitude techniques. Electric field (from quasi DC to VHF) and current measurements will be performed. For additional information, please contact in Brazil Dr. Osmar Pinto Jr. (osmar@dge.inpe.br) and in France Dr. Serge Chauzy (chas@aero.obs-mip.fr).

*NATIONAL LIGHTNING SAFETY INSTITUTE (NLSI) (Louisville, CO)

The NLSI High Altitude Lightning Observation Station (HALOS) – 4083 m elevation in the Rocky Mountains – completed year one of a five year study of comparative air terminal tip geometries. Results are posted in Chapter 6 (NLSI Research) of the WWW site: www.lightningsafety.com Many thanks to our mentors at New Mexico Tech for valuable guidance and suggestions.

Five Chicago hotel sites were investigated for lightning disturbances. One electrical event caused some 130 hotel guests to check out due to loss of the telephone system. NLSI conclusions centered mostly around non-lightning power quality issues such as poor electrical equipment installation practices, and defective surge protection products. Dependence upon UPS equipment for transient protection also was noted in our recommendations.

A site study to a lightning-initiated failure of transformer insulators at an eastern USA nuclear power was conducted. From GAI data, we concluded that a (low amplitude) 3.6 kA flash by-passed shield wires. Shield wire configurations had not been upgraded to the latest IEEE recommendations found in IEEE Std 1243-1997 "IEEE Guide for Improving Lightning Performance of Transmission Lines" and IEEE Std 1410-1997 "IEEE Guide for Improving Lightning Performance of Electric Power Overhead Distribution Lines." Abdul Mousa of BC Hydro participated in the NLSI contract.

NLSI distributed more than 200 copies of its 10 minute "Lightning Safety 101" video during the 1999 lightning season. The focus of the video is personnel safety in both work and recreation situations.

At the 1999 ICAE Huntsville meeting NLSI presented results of a study of annual USA lightning costs and losses. The US Gummint reports the figure to be $35 million: NLSI has evidence the real costs are in the $5 billion plus range. See NLSI WWW site, section 3.2, for summary information.

At two meetings (American Nuclear Society meeting in Santa Fe NM and the Range Commanders Council, White Sands Missile Range NM), NLSI presented results of 8 years of lightning incidents to Department of Energy facilities around the USA. Nature of damage, type of lost equipment, and distribution of events were discussed. Conclusions as to similar lightning consequences here might be applied to other organizations with multiple facility locations across the USA. The paper is at NLSI's WWW site section 5.11.

With co-author Vlad Rakov, NLSI prepared a paper on golf course shelters and lightning safety. It will be published in Spring 2000 in Golf Course Management magazine.

The "Certified Lightning Safety Professional" workshop series graduated 82 students in 1999. The intensive 2-3 day class proposes to create subject matter experts in issues related to lightning hazard mitigation. Air terminals, grounding, bonding, shielding, surge suppression, lightning detection and personnel safety are some of the topics discussed. Graduates become leaders and trainers about lightning safety issues for their organizations. The year 2000 class schedule is posted on the WWW site in section 2.2.3.3, and the course outline is posted in section 2.2.3.2. Note the winter classes will be held in Breckenridge CO, a ski resort located two hours from Denver.

*NATIONAL SEVERE STORMS LABORATORY, NOAA (Norman, Oklahoma)

Ted Mansell and Jerry Straka of the University of Oklahoma and Don MacGorman and Conrad Ziegler of NSSL have been examining model simulations of a spectrum of severe storms that use one of three different parameterizations of noninductive graupel-ice charging (Takahashi 1978, Gardiner et al. 1985, and Saunders et al. 1991) modified to use rime accretion rates), along with a single inductive charging parameterization for graupel/hail and droplets. Most simulations have produced appreciable lightning flash rates, including cloud-to-ground lightning, and some have produced extremely large flash rates. Successive model runs of the same storm simulation with the three different noninductive parameterizations typically produce significant differences in the magnitude and distribution of thunderstorm charge and in the resulting flash rates of various types of lightning.

David Schultz (NSSL) authored "Lake-Effect Snowstorms in Northern Utah and Western New York With and Without Lightning" (http://www.nssl.noaa.gov/~schultz/light/mss.html). He found that lake-effect snowstorms with lightning have significantly higher temperatures and dewpoints in the lower troposphere and significantly lower lifted indices than lake-effect snowstorms without lightning. In contrast, there is little difference in dewpoint depressions between events with and without lightning. Nearly all events have no convective available potential energy, regardless of the presence of lightning. The results from this paper are then discussed in the context of current models of storm electrification. This proposed forecast methodology will be tested this winter during the Intermountain Precipitation Experiment (http://www.nssl.noaa.gov/mag/ipex.shtml), a field project designed to improve understanding of orographic and lake-effect snowfall in northern Utah.

John Cortinas and Ron Holle have started a study that will investigate the climatological occurrence of winter lightning across North America. The study uses 15 years of data from the United States' and Canada's surface observing networks, which include human reports of thunder, dry-bulb and dewpoint temperatures, wind direction and speed, visibility, and type of weather occurring at the observation time. Holle and Cortinas are examining these data to learn about the meteorological conditions that typically accompany reports of winter thunder, the frequency of thunder reports, and any relationship between reports of thunder and precipitation intensity.

Ivy Winger (NSSL and Univ. of Oklahoma School of Meteorology) is analyzing microphysics data from the NOAA P-3 acquired during MEaPRS 1998 for her M.S. research. These analyses will eventually be combined with electric field profiles (whose analysis is being led by Maribeth Stolzenburg, Univ. of Mississippi) for an MCS observed near Russelville, Arkansas. Providing guidance to Ivy on the microphysical data analysis are Terry Schuur (NSSL/CIMMS) and Bob Black (Hurricane Research Division).

Don MacGorman and Dave Rust of NSSL and Tom Marshall and Maribeth Stolzenburg of the University of Mississippi are working to finalize analysis and interpretation of the electric field soundings they acquired from storms that produced positive ground flashes in 1998.

Ron Holle and Raúl López of NSSL, and Christoph Zimmermann of Global Atmospherics, Inc. published "Updated Recommendations for Lightning Safety-1998" in the October 1999 issue of the Bulletin of the American Meteorological Society. This article consists mainly of the text of the recommendations developed by the Lightning Safety Group that met in Phoenix, Arizona in January 1998.

Mary Ann Cooper of the University of Illinois at Chicago's Dept. Of Emergency Medicine, and Ron Holle and Raúl López of NSSL published "Recommendations for Lightning Safety" in the September 22/29, 1999 issue of the Journal of the American Medical Association. This one-page letter summarized the recommendations developed by the Lightning Safety Group.

Raúl López retired from NSSL in April 1999 to his new home in Simpsonville, South Carolina after 20 years with NOAA's Environmental Research Laboratories. His colleagues continue to work with him on a variety of lightning studies that he initiated during the six recent years at the National Severe Storms Laboratory.

OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES – ATMOSPHERIC ENVIRONMENT RESEARCH GROUP (Paris, France) www.onera.fr

The preparation of ORAGES microsatellite experiment is in progress under the effort of Anne Bondiou-Clergerie (PI of the experiment, bondiou@onera.fr), Philippe Lalande

(lalande@onera.fr) and Patrice Blanchet (blanchet@onera.fr). ORAGES is a space VHF lightning mapper which will localize intra-cloud and cloud-to-ground lightning flashes on the earth surface. The antenna system is currently under definition and will be experimented on a stratospheric balloon flight at the end of 2000. ORAGES will be a low orbiting experiment. The "Laboratoire d'Aérologie" is collaborating on the scientific definition of the experiment (Serge Chauzy and Franck Roux).This experiment is funded by the French Space Agency (CNES).

Claire Théry and Pierre Laroche carry on working on the evaluation of NOx production by lightning from total lightning observations obtained during the European campaign EULINOX (European Lightning NOx production) and Colorado campaign STERAO-A. Those analysis are conducted in collaboration with Hartmut Hoeller from DLR (Germany) and Jim Dye from NCAR. Eric Defer presented his Ph.D. memo on the total lightning mapping by VHF interferometry in June. Those interested to get is memo can contact Claire Théry (thery@onera.fr) or Eric (defer@ucar.edu). He is currently achieving a post-doctoral position at NCAR with Jim Dye on a similar topic. Our approach consists in evaluating the length of the discharge including positive and negative leader components as well as return stroke and recoil streamers.

A collaboration between John Willett at Air Force Research Lab, Dan Davis at SUNYA and Pierre Laroche is in progress on the analysis of simultaneous triggered lightning and electrostatic atmospheric field profile.

Monique Petitdidier(monique.petitdidier@cetp.ipsl.fr) from CETP, a Ph.D. student, Eric Boyer, and Pierre Laroche are working on simultaneous observations with an electrostatic field meter and the HF radar of Arecibo at Porto-Rico during the storms associated with hurricane GEORGE in September 1998. The effort goes on the analysis of HF emission from lightning flash as detected by the radar receiver and the radar detection of the plasma channel.

The study of the effects of lightning on aircraft and helicopter is currently under investigation as one of the major goals of the Atmospheric Environment Group. Work is on lightning effect on radome and on the sweeping mechanism on the fuselage. Those type of studies are done within large European Program like Fulmen DG7 and EM-Haz DG12 (http://dbs.cordis.lu).

LABORATOIRE D'AEROLOGIE, UNIVERSITE PAUL SABATIER (Toulouse, France)

The group of Atmospheric Electricity of the Laboratoire d'Aérologie (Serge Chauzy, chas@aero.obs-mip.fr, Sylvain Coquillat, coqs@aero.obs-mip.fr and Serge Soula, sous@aero.obs-mip.fr) has been involved in the MAP field experiment in Northern Italy during the months of September and October 1999. The MAP (Mesoscale Alpine Programme) is devoted to the study of the effects of orography on the atmospheric processes. The heavy rain caused by thunderstorm developments is part of these processes and one of the scientific aims is the understanding of the electrical mechanisms and their links with microphysics and dynamics.

A few electric field soundings were performed, using a newly designed sensor devoted to the detection of the vector electric field. Corresponding in situ measurements of meteorological parameters (pressure, temperature and humidity) were carried out, associated with a GPS localization of the system. Some soundings have been realized within structures producing stratiform rain. Surface measurements (electric field, precipitation current, raindrop net charge, rain size spectrum) have also been performed during several storm events. The characteristics of the precipitation current will be studied in relation with the thundercloud development and its evolution, as it is described by doppler and polarimetric radars detection.

As part of the project ORAGES developed by ONERA (Anne Bondiou-Clergerie) correlation studies between lightning and precipitation activities are carried out (Serge Soula). The main goal consists in finding a relevant parametrization of the correlation in order to estimate the rain amount from lightning observations by satellite and to characterize the specific lightning activities in strong thunderstorms for applications in flood nowcasting. A specific aim about storm activity evolution across water/land border is considered from these correlation studies in collaboration with Henri Sauvageot, from the radar group of the Laboratoire d'Aérologie.

The interactions between microphysics and thunderstorm electrification are continuously studied within the group by Sylvain Coquillat. We focus on the natural conditions of lightning triggering. Previous numerical studies have shown that corona emission can be emitted from raindrops falling in a vertical electric field provided they are highly charged or when they interact with each other. The subsequent question that arises is whether the corona emission is favored in a horizontal field configuration since raindrop disruption field is lowered in such a situation. In order to answer this question, we developed a numerical modeling of the behavior of an uncharged raindrop falling in a horizontal electric field. We simultaneously performed an experimental study used to validate the modeling at sea level pressure. It is found that corona emission is more easily triggered in a horizontal than in a vertical electric field. We expect this result to be reinforced when considering charged raindrops.

*DEPARTMENT OF PHYSICS - UNIVERSITY OF PARMA (Italy)

Albino Carbognani reports on his article entitled "An Introduction to ball lightning", and available on the Web site: http://www.ufodatanet.org.

Among the phenomena known to geophysicists, that of ball lightning (BL) is one of the least understood, even though it has been studied for more than a century and a half. Precisely because of the nature of the phenomenon, the data gathered come exclusively from eye-witness observations. However, in recent years the BL phenomenon has been "rediscovered" by the scientific community, and greater efforts are being made to understand it. The article examines the main physical properties of BL, and illustrates the results of visual observations taken from current scientific literature. Physical parameters are discussed, as are similarities and differences between meteorites and BL, which can be mistaken for one another. In conclusion, the main theories suggested to interpret the BL phenomenon are reviewed, together with the partially successful attempts made to replicate BL in laboratories. An extensive bibliography of recent articles published in major international scientific journals is also given. (in italian language).

*SOUTH DAKOTA SCHOOL OF MINE AND TECHNOLOGY (Rapid City, SD)

Andy Detwiller reports:

The T-28 armored aircraft research group at the South Dakota School of Mines and Technology has been working on better arrangements of field meters on the aircraft that will yield more robust estimates of ambient electric field components. An analysis of this system has appeared in the October 27, 1999, issue of Journal of Geophysical Research - Atmospheres. General information about the T-28 can be found at http://www.ias.sdsmt.edu/institute/t28/ .

In addition, we have recently acquired a High Volume Precipitation Spectrometer (HVPS) probe from SPEC, Inc., which soon will be outfitted with a particle charge-measuring sensor array developed by Bill Winn and Clifton Murray at the New Mexico School of Mining and Technology. We are looking forward to unique charge and image data of precipitation particles in severe storms to be acquired with this probe during the Severe Thunderstorm Electrification and Precipitation Study (STEPS) next season.

Arrangements for STEPS are still being made and funding is still pending as of the beginning of November. Information about STEPS is available at :

http://www.mmm.ucar.edu/community/field.html

***STANFORD UNIVERSITY: STARLAB (Stanford, California)**

The VLF Group at STAR Laboratory of Stanford University is actively involved in experimental and theoretical work targeted on understanding of strong upward electrodynamic coupling of tropospheric thunderstorms to the mesospheric and lower ionospheric regions and associated optical and electromagnetic effects.

This past summer, graduate students Elizabeth Gerken, Timothy Chevalier and Maria Salvati fielded Stanford's optical experiments for studying sprites and elves at the Langmuir Laboratory (New Mexico). This consisted of the Fly's Eye photometric experiment, the Dobsonian Sprite Experiment (DSE) telescopic imager, and a broadband VLF system. The Fly's Eye had new triggering capabilities and was able to automatically find elves for both positive and negative cloud to ground lightning discharges. A red-filtered photometer was added to the DSE to allow for high temporal resolution of sprite intensities in addition to the high spatial resolution of the telescope. Another graduate student Robert Moore completed software to automatically capture sprite events as a video tape is being digitized, greatly reducing the time needed to process the sprites data. Our group collaborated with scientists at Kitt Peak to successfully triangulate on sprites and a paper will be given under the direction of Steve Mende (University of California, Berkeley) at the Fall 1999 meeting of American Geophysical Union (AGU). Umran Inan and Elizabeth Gerken are working to publish a paper on the fine structure of sprites seen in the DSE results. A paper based on the 1999 data set will be given by Elizabeth Gerken at the Fall AGU meeting. Mike Johnson, Umran Inan, Sean Lev Tov, and Tim Bell used simultaneous observations of early/fast Very Low Frequency (VLF) events at nine closely spaced (similar to 65 km) sites and a numerical model of the propagation and scattering of VLF signals in the earth-ionosphere waveguide to directly measure the scattering pattern of associated ionospheric disturbances (GEOPHYSICAL RESEARCH LETTERS, v. 26(#15), pp. 2363-2366, AUG 1, 1999). In cases when the causative lightning is within 700 km of the north-south array of observing sites, early/fast VLF events are typically observed at no more than 2 or 3 sites, which indicates a narrow beam of the scattered signal in the forward direction. In the different cases studied, forward scattering patterns exhibit 15 dB beamwidths of less than 30 degrees consistent with horizontal extent of 90 +/- 30 km.

Victor Pasko, Umran Inan, and Tim Bell reported results of quantitative two-dimensional electromagnetic modeling of mesospheric electric field transients produced by cloud-to-ground (CG) lightning discharges with short duration currents (<0.5 ms) (GEOPHYSICAL RESEARCH LETTERS, v. 26(#9), pp. 1247-1250, MAY 1, 1999). The range of applicability of existing quasi-electrostatic models of sprites and the physical conditions under which relatively weak CG lightning discharges (thundercloud charge moment changes less than 50Cx10 km) may initiate sprites are discussed in the context of recent experimental findings.

Georgios Veronis, Victor Pasko, and Umran Inan employed a new two-dimensional cylindrically symmetric electromagnetic model of the lightning-ionosphere interaction, which includes effects of both the lightning radiated electromagnetic pulses (EMP) and the quasi-electrostatic (QE) fields, to study effects of lightning-ionosphere interactions on time scales ranging from several microseconds to tens of milliseconds (JOURNAL OF GEOPHYSICAL RESEARCH-SPACE PHYSICS, v. 104(#A6), pp. 12645-12656, JUN 1, 1999). The temporal and spatial evolution of the electric field, lower ionospheric electron density, and optical emissions calculated with the new model are used to investigate theoretically the effects of the lightning return stroke current waveform (i.e., the current rise and fall timescales) and of the observational geometry on the optical signals observed with a photometer. For typical lightning discharges of ~100 microsecond duration the ionospheric response is dominated by the EMP-induced heating leading to the highly transient and laterally expanding optical flashes known as elves. For cloud to ground lightning discharges of ~1 ms duration removing substantial amount of charge (i.e., ~100 C from 10 km altitude), heating and ionization changes induced by the QE field lead to the mesospheric luminous glows with lateral extent < 100 km, referred to as sprites.

*UNIVERSITY OF WASHINGTON (Seattle, WA)

A theory for the microphysical mechanisms involved in collisional charging of ice has been developed by Greg Dash and John Wettlaufer at the University of Washington, with Brian Mason, presently at North Carolina State University. The model is centered around recent experimental observations of collisional charging and mass transfer, and provides semi quantitative explanations fore several observations made in these and earlier experiments: (1) particles growing more rapidly from the vapor are charged positively; (2) charge transfer is proportional to growth rate; (3) during impacts the colliding surfaces exchange amounts of liquid-like mass, with thicknesses and temperatures far outside the limits of equilibrium surface melting; (4) charge transfer tends to saturate at high rates.

The theory predicts trends and amounts of charge and mass transfer in rough agreement with measurements.

Mason, B. L., 1998. An experimental investigation of charge transfer during ice contact interactions. PhD Thesis, University of Washington (unpublished).

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Mason, B. L. and J. G. Dash, 1999. Charge and mass transfer in ice-ice collisions: a mechanism for electrification of thunderstorm. Submitted.