Report to the IRC on
Activities of the ASA (Atmospheric Spectroscopy Applications) Working Group

In the past year, dozens of molecular spectroscopists and atmospheric scientists worked on the preparation of the final release of the 2016 quadriennal edition [1] of the HITRAN database, which is a backbone of the interpretation of spectral atmospheric retrievals and is an important input to the radiative-transfer codes. Major improvements were introduced to all sections of the database, namely: line-by-line lists, experimental absorption cross-sections, collision-induced absorption data and aerosol indices of refraction.

The line-by-line lists for most of the HITRAN molecules were updated (and two new molecules added) in comparison with the previous compilation HITRAN2012 [2] that has been in use, along with some intermediate updates, since 2012. The extent of the updates ranges from updating a few lines of certain molecules to complete overhauls of the lists, substantial extension of spectral and dynamic ranges and introduction of additional isotopologues. In terms of improvements to the line lists of the major atmospheric absorbers, several updates can be highlighted:

1. The uncertainties in the intensities of a majority of CO_2 lines have dropped below 1%.
2. The long-standing problem of the consistency between intensities of the 5 µm and 10 µm bands of ozone has been successfully resolved.
3. Addition of substantially more lines for the deuterated isotopologues of water vapor.
4. Major improvements of the methane spectroscopy in all spectral regions.

In addition, the amount of molecules in the cross-sectional part of the database has increased dramatically from nearly 50 to over 300.

A gargantuan article describing the HITRAN2016 database has recently been accepted for publication to the Journal of Quantitative Spectroscopy and Radiative Transfer (JQSRT). It counted 66 pages, 641 references and over 30 figures and about the same amount of tables. It is worth noting that JQSRT featured a special issue devoted to the new edition of the HITRAN database, which included 50 articles in addition to the feature HITRAN paper. Many of these articles were devoted to the detailed description of the database updates or validations of the data that were eventually included.

Taking advantage of the new structure and interface available at www.hitran.org [3] and the HITRAN Application Programming Interface [4], the amount of parameters has also been significantly increased, now incorporating, for instance, non-Voigt line profiles [5]; broadening by gases other than air and “self” [6]; and other phenomena, including line mixing. This is a very important novelty that needs to be properly introduced in the radiative-transfer codes in order to advance accurate interpretation of atmospheric remote-sensing retrievals.

Subsequent to the International Symposium on Molecular Spectroscopy in Champaign-Urbana, IL, USA, a meeting of the HITRAN Advisory Committee was held in Chicago. One of the goals of the meeting was to discuss remaining deficiencies in the HITRAN database, and draw a roadmap for the future improvements that can aid terrestrial atmospheric remote sensing.

Participating in the meeting were the following specialists in the spectroscopy of atmospheric species and atmospheric scientists:

- Iouli Gordon (ASA co-chair and HITRAN project director), Larry Rothman (emeritus ASA co-chair and HITRAN project director), Roman Kochanov, Yan Tan, *Harvard-Smithsonian Center for Astrophysics, USA*
- Jonathan Tennyson, Christian Hill, *University College London, UK*
- Piotr Wcisło, *Nicolas Copernicus University, POLAND*
- Robert Gamache, *University of Lowell, USA*
- Joe Hodges, *National Institute of Standards and Technology, USA*
- Vladimir Tyuterev (through Skype), *University of Reims, FRANCE*
- Brian Drouin, Geoffrey Toon, *Jet Propulsion Laboratory, USA*
- Mary-Ann Smith, *NASA Langely Research Center, USA*
- Peter Bernath, *Old Dominion University, USA*
- Joep Loos, Jonas Wilzewski, *DLR, Germany*
- Alain Campargue, *Grenoble, FRANCE*

Future:

The next ASA/HITRAN meeting will be held in Cambridge, MA 12-15 June 2017.

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Application Programming Interface (HAPI): A comprehensive approach to working with spectroscopic data, J. Quant. Spectrosc. Radiat. Transf. 177 (2016) 15–30. doi:10.1016/j.jqsrt.2016.03.005.

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Brief Report of the IRC Working Group BSRN - Baseline Surface Radiation Network

Amelie Driemel, Chuck Long

- 2017-07-07 -

Current Status/Objectives/Activities

BSRN - a project of the Global Data and Assessments Panel (GDAP, formerly the Radiation Panel) from the Global Energy and Water Cycle Experiment (GEWEX) under the umbrella of the World Climate Research Programme (WCRP) - is aimed at detecting important changes in the Earth's radiation field at the Earth's surface. BSRN is designated as the global surface radiation network for the Global Climate Observing System (GCOS) and contributes to the Global Atmospheric Watch (GAW). Since 2008 the BSRN archive (World Radiation Monitoring Center, WRMC) is hosted by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany (AWI). At the 14th BSRN Workshop held in Canberra, Australia in April 2016 Gert König-Langlo had the pleasure to announce that **AWI** Director Karin Lochte agreed to **continue hosting the WRMC** at the present level. Gert also announced that he would retire mid-2017 and step down as the Director of the WRMC. So since January 2017 Amelie Driemel - the former BSRN data curator at AWI - took over the responsibilities of **WRMC Director**.

At the moment (status July 2017) 59 stations in contrasting climatic zones, covering a latitude range from 80°N to 90°S have provided data to the BSRN archive. In total more than **800 years of radiation data** are available either via PANGAEA (https://dataportals.pangaea.de/bsrn/?q=LR0100) or via the ftp server (http://bsrn.awi.de/data/data-retrieval-via-ftp/). The latter has been reinstalled in June 2017 now using a Secure File Transfer Protocol (sftp). However, all links to the ftp server and the data files stayed the same. To gain access to the data (login info) just contact Amelie Driemel.

In 2016 the AWI homepage was renewed and with it also the **BSRN homepage** (http://bsrn.awi.de/). Although the content is still the same, some of the links might have changed (e.g. the page http://www.bsrn.awi.de/en/data/conditions_of_data_release/ changed slightly to http://bsrn.awi.de/data/conditions-of-data-release/. So if you have links to the BSRN homepage please check if these are still valid.

The 15th BSRN workshop will take place in 2018. The exact date and the venue are still to be determined.

Research Results

A list of **publications related to BSRN** can be found at http://bsrn.awi.de/other/publications/. Within the Web of Science the topic "BSRN" is cited more than 2300 times within 90 articles (statistic from 2017-06-20). See also the figure at http://bsrn.awi.de/other/publications/bsrn-in-web-of-science/. Currently a paper describing the WRMC and BSRN data is prepared by Amelie Driemel (co-authored by all station scientists) and will be submitted to Earth System Science Data at the end of this year.

Plans

Eight stations (1 in Russia, 1 in Australia, 2 in Taiwan and 4 in India) were declared to be **BSRN candidates** at the 14^{th} BSRN Workshop in 2016. As soon as these start submitting data to the WRMC, they will be officially declared BSRN stations.

During the last meeting, it was also decided that any station scientist whose data submission to the Archive lags by two years or more will be contacted by the BSRN Project Manager in order to discuss the issue. At that time, a one year period will be initiated wherein it is expected that the station scientist will make every effort to get the data submission caught up, or at least institute a solid plan to do so within a reasonable time span. At the end of the year following notification the situation will be reviewed, and if no sufficient progress has been made, the station scientist will again be contacted. Dependent on the outcome of this second notice communication, the site may then be classified as "**inactive**" in the BSRN listing of sites.

IRC working group Global Energy Balance (GEB)

Annual Report 2016

Martin Wild and Norman Loeb (WG Co-chairs)

I. Current Activities

In April 2016, in the context of the International Radiation Symposium in Auckland (IRS 2016), WG-GEB Co-Chair Martin Wild together with Peter Pilewskie, Arturo Sanchez-Lorenzo, and Stefan Kinne organized the Session “Radiation Budget and Forcing, which was very well attended with more than 70 submissions.

Unfortunately the IRS 2016 was exactly in the same week as the European Geophysical Union (EGU) 2016 General Assembly in Vienna. Nevertheless it was possible also in 2016 to run the session “Earth radiation budget, radiative forcing and climate change” in its 11th edition, which is very closely related to the working group goals.

In October 2016, Co-Chair Norman Loeb and colleagues chaired an Earth Radiation Budget Workshop held at ECMWF October 18-21, 2016. The workshop consisted of a combination of technical sessions with presentations by the CERES, GERB and ScaRaB science teams and scientific sessions with contributed and invited presentations by local scientists at ECMWF and the University of Reading, and scientists from other institutions within Europe, the US and China. Presentations from the workshop are available on-line at the following website: https://ceres.larc.nasa.gov/science-team-meetings2.php?date=2016-10

In December 2016 at the AGU fall meeting in San Francisco the closely related session “Improved Understanding of the Surface Energy Balance and the spatio-temporal Variation of its Components”, was held for the time, with Martin Wild and WG-GEB member Chuck Long amongst the organizers. WG-GEB Co-Chair Norman Loeb gave an invited talk in this session.

As in previous years, the above activities helped to ensure the availability of appropriate platforms to discuss the various aspects of the global energy balance at the major international conferences in the field.

At ETH Zurich, a project focusing on the temporal variation of atmospheric solar absorption, funded by the Swiss National Science Foundation (SNF) has successfully started (SNF Project: “Towards an improved understanding of the Global Energy Balance: Temporal variation of solar radiation”). This project uses collocated observational data taken from the surface (GEBA/BSRN) with observations taken from space (CERES EBAF, MODIS) to infer quantitative estimates of variation in solar absorption in the atmospheric column. The focus is on the period after 2000, where adequate satellite observations started to become available, and which states a particularly interesting period covering the global warming hiatus.

II. Selected Research Results

A perspective letter in *Nature Climate Change* with involvement of WG-GEB Co-Chairs Norman Loeb and Martin Wild of relevance to this working group has been published, emerging from the CLIVAR Research focus “Consistency between planetary heat balance and ocean heat storage”: Von Schuckmann, K., Palmer, M. D., Trenberth, K. E., Cazenave, A., Chambers, D., Champollion, N. , Hansen, J., Josey, S. A., Loeb, N., Mathieu, P.-P., Meyssignac, B., and Wild, M., 2016: An imperative to monitor Earth's energy imbalance. Nature Climate Change 6, 138-144. It argues that the absolute value of Earth Energy Imbalance (EEI) represents the most fundamental metric defining the status of global climate change, and will be more useful than using global surface temperature. EEI can best be estimated from changes in ocean heat content, complemented by radiation measurements from space. Sustained observations from the Argo array of autonomous profiling floats and further development of the ocean observing system to sample the deep ocean, marginal seas and sea ice regions are crucial to refining future estimates of EEI. Combining multiple measurements in an optimal way holds considerable promise for estimating EEI and thus assessing the status of global climate change, improving climate syntheses and models, and testing the effectiveness of mitigation actions. Progress can be achieved with a concerted international effort (von Schuckmann et al. 2016)

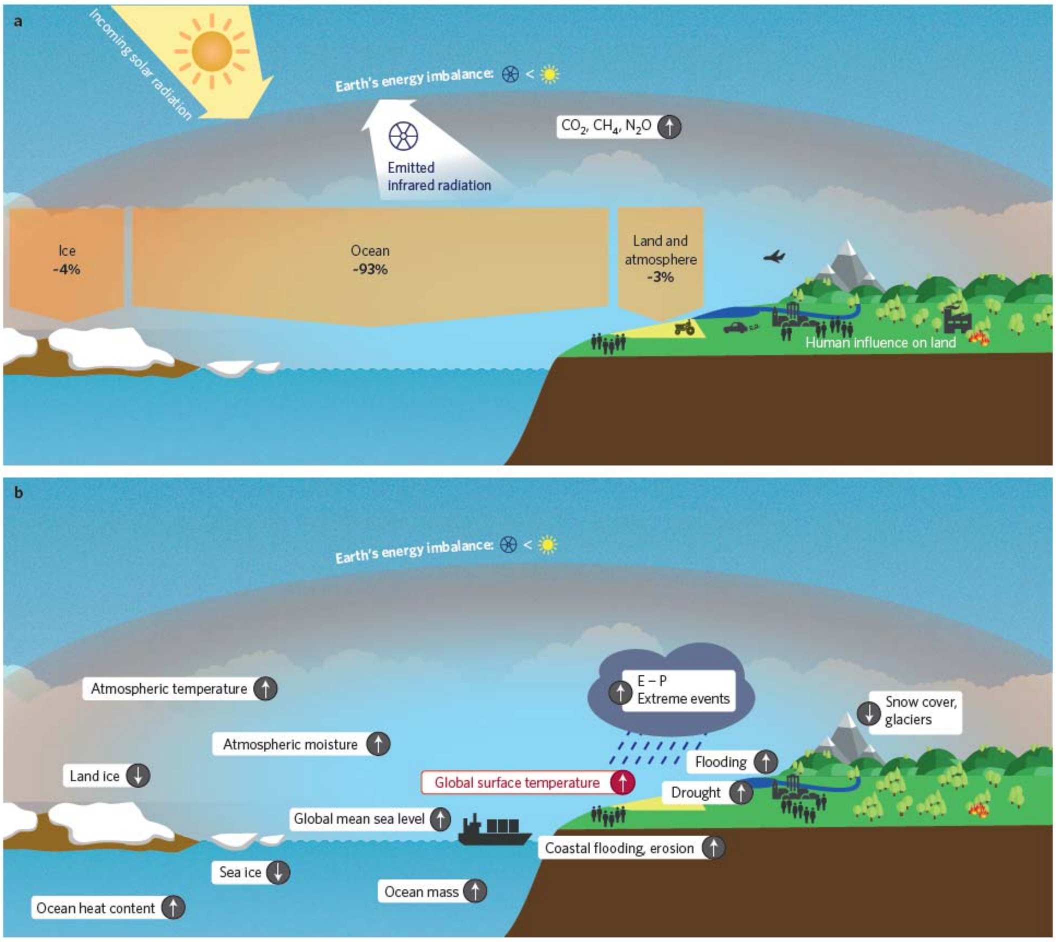

Figure 1: Schematic representations of the flow and storage of energy in the Earth's climate system and related consequences. a, EEI as a result of human activities. The global ocean is the major heat reservoir, with about 90% of EEI stored there. The rest goes into warming the land and atmosphere, as well as melting ice (as indicated). b, 'Symptoms' of positive EEI, including rises in Earth's surface temperature, ocean heat content, ocean mass, global mean sea level, atmospheric temperature and moisture, drought, flooding and erosion, increased extreme events, and evaporation − precipitation (E−P), as well as a decrease in land and sea ice, snow cover and glaciers (from vonSchuckmann et al. 2016).

In the topical collection on “Global Energy Budgets” in *Current Climate Change reports* (edited by Richard Allan), co-chair Martin Wild recently published the paper “Towards Global Estimates of the Surface Energy Budget”. This paper argues that, while global observational estimates of energy fluxes in and out of the climate system at the top of atmosphere (TOA) are now available with considerable accuracy from recent satellite programs, similar reference values are more difficult to establish for the surface energy fluxes, which cannot be directly measured from space. This is reflected in greatly diverging global estimates of the surface energy balance components that have been published over the years, or simulated in global climate models. Since the mid-1990s, accurate direct measurements become increasingly available from the networks of surface radiation stations, which allow to better constrain the energy fluxes at the Earth’s surface. In parallel, satellite-derived products of surface fluxes profit from the great advancement in space-born observation systems that became operational since the turn of the millennium. As a consequence, recent independent global estimates of the surface radiation components based on surface and satellite data sources have converged to within a few Wm^{-2}. This suggests that we are approaching a stage where we are not only confident in the magnitudes of the global energy balance components at the TOA, but increasingly also at the surface. These recent estimates may also be able to reconcile formerly disputed inconsistencies between global energy and water cycle estimates. Remaining challenges include the accurate determination of representative surface albedos and skin temperatures in the calculation of surface shortwave absorption and upward longwave emission, respectively, as well as the partitioning of surface net radiation into the non-radiative fluxes of sensible and latent heat.

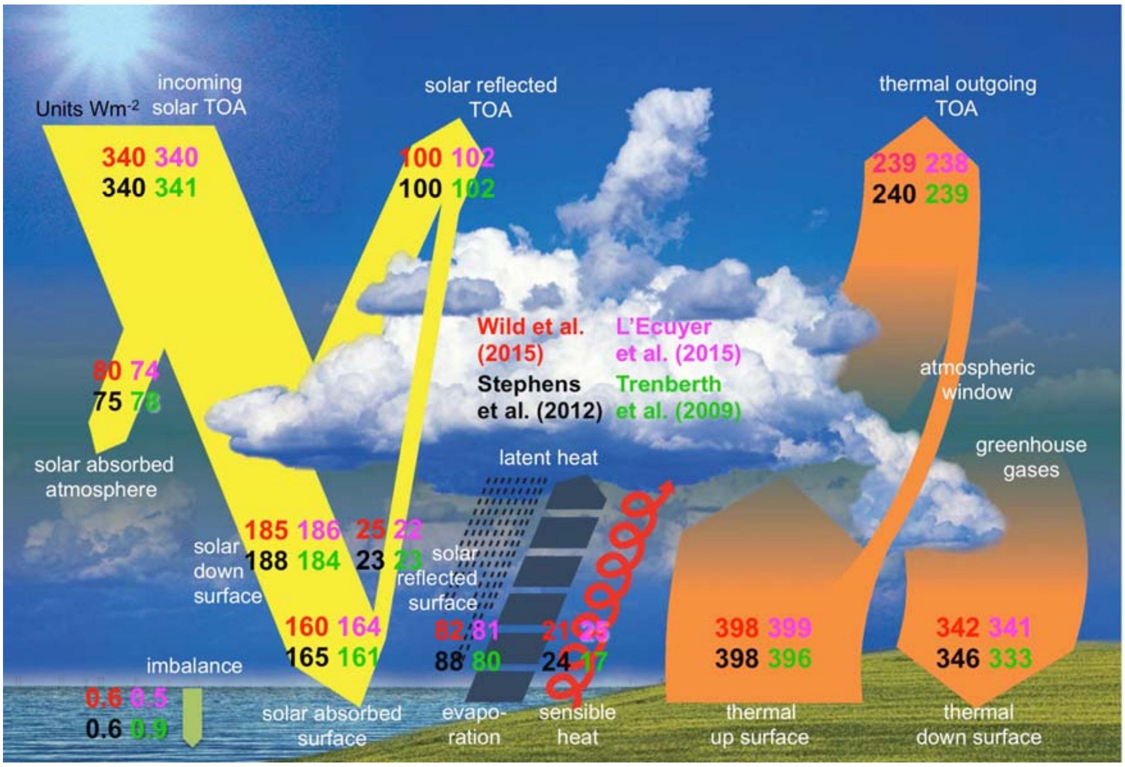

Figure 2: Comparison of different recent global annual mean energy balance estimates for present day conditions as given by Wild et al. (2015) (upper left (red) values), L’ Ecuyer et al. (2015) (upper right (pink) values), Stephens et al. (2012) (lower left (black) values) and Trenberth et al. (2009) (lower right (green) values). Values attached to arrows correspond to energy fluxes in Wm^{-2} in the direction given by the arrows (from Wild et al. 2017)

III. Recommendations

a) Recommendations with respect to the TOA radiation budget components:

- The international community should urge government agencies responsible for building the next generation of Earth Radiation Budget instruments to include onboard calibration equipment that can detect and correct for on-orbit contamination of optics. Lessons learned from over a decade of in-flight experience (e.g., with CERES FM1-FM4 and the SORCE TIM, Kopp et al. 2005) clearly provide evidence that on-orbit contamination of optics does occur and must be detected and corrected for in order to ensure a robust climate record of the TOA radiation budget.
- The international community should urge government agencies responsible for building the next generation of Earth Radiation Budget instruments to provide sufficient time for ground calibration activities. Ground calibration is the last major test performed prior to shipment, when there are typically no financial or schedule reserves left. Shortening the length of the ground calibration period due to cost/schedule constraints adds uncertainty to the absolute calibration of the instrument.
- The international community should urge government agencies responsible for building the next generation of Earth Radiation Budget instruments to periodically re-verify the traceability of calibration targets on the ground.
- The international community should urge government agencies responsible for building the next generation of Earth Radiation Budget instruments to establish collaborations with other international agencies specializing in calibration standards (e.g., NIST, NRL).

b) Recommendations with respect to the surface/atmospheric radiation budget components:

- A continued and expanded operation and maintenance of a well calibrated network of long term surface radiation stations is required to provide direct observations and anchor sites for satellite-derived products and climate model validation, as well as for the detection of important changes in the radiation fields either not detectable by satellites or anticipated by models. The basic measurements include the four primary components (up and down, longwave and shortwave irradiance) with high temporal resolution (minute values) and known accuracy (BSRN accuracy standards), as well as standard meteorological measurements (Tair, RH, Pressure, Wind speed & direction) essential for radiation quality assessment (Long & Shi, 2008). Funding sources should be ensured that all BSRN sites are able to include downwelling and upwelling SW and LW measurements, along with the direct and diffuse SW, as well as standard meteorological measurements.
- Letters of support from the International Radiation Commission to some of the National agencies funding BSRN stations may help to raise the recognition of the importance of such anchor sites for global energy budget studies. A letter of support from the IRC for the continuation of the radiation measurements at sites operationally struggling and/or at risk of being shut down may therefore be helpful. Contact person for the BSRN sites is GEB working group member Chuck Long (Chuck.Long@pnnl.gov).
- These high accuracy observation sites should be expanded to under-represented regions of the globe (such as many low latitude areas) and particularly oceans where alternate or modified observational strategies might be necessary. The use of newly available shortwave radiometers (SPN-1) that are well suited for use in remote deployments such as on buoys and ships, is recommended. These new radiometers comply with low-power systems measuring both diffuse and direct fluxes, which allows for proper correction of tilt from horizontal (Long et. al, 2010).
- Anchor sites should also include direct and/or diffuse shortwave measurements in addition to total incoming shortwave (SW) along with standard surface meteorological measurements. These measurements are useful for the diagnosis of cloud effects on the radiation budget (Zhang et al. 2010), for the evaluation of satellite-derived products and climate models, and for climate impact research (for example biosphere growth and terrestrial carbon uptake, Mercado et al. 2009).

- To improve surface albedo estimates over various surface types and for the assessment of satellite derived albedo products, high accuracy spectral and broadband measurements from towers are desirable at the anchor sites (Roman et al. 2009).
- Atmospheric spectral optical depths should be observed to infer atmospheric column abundance of aerosol, ozone, water vapor and other atmospheric constituents.
- The spatial representativeness of surface anchor sites needs to be thoroughly assessed (Dutton et al. 2006, Roman et al. 2009). Some of these issues are addressed in Hakuba et al. (2013, 2014) and Riihimaki & Long (2014). The possible "urbanization" effect (impact of local air pollution) in surface solar radiation trends needs quantification.
- Clear sky flux products derived from direct observations should be provided for the validation of corresponding fluxes in the models and satellite derived estimates. An archive should be established that processes and stores such derived quantities and distributes them to the scientific community.
- To achieve progress in the accuracy of satellite-derived surface radiation fields, improved and consistent satellite estimates of vertical distributions of cloud and aerosol radiative properties (size, single scattering albedo, asymmetry parameter) and of water vapor are required

IV. Selected Publications

Dallafior, T. N., Folini, D., Knutti, R. and Wild, M., 2016: Mixed-layer ocean responses to anthropogenic aerosol dimming from 1870 to 2000, J. Geophys. Res. Atmos., 121, 49–66, doi:10.1002/2015JD024070.

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Hakuba, M.Z., Folini, D., Schaepman-Strub, G., and Wild, M., 2014a: Solar Absorption over Europe from collocated surface and satellite observations, J. Geophys. Res., 119, 3420-3437, DOI: 10.1002/2013JD021421.

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Loeb, Norman G.; Manalo-Smith, Natividad; Su, Wenying; Shankar, Mohan; Thomas, Susan (2016) CERES Top-of-Atmosphere Earth Radiation Budget Climate Data Record: Accounting for in-Orbit Changes in Instrument CalibrationRemote Sensing, 8(3), 182. http://dx.doi.org/10.3390/rs8030182

Loeb, Norman G.; Wang, Hailan; Cheng, Anning; Kato, Seiji; Fasullo, John T.; Xu, Kuan-Man; Allan, Richard P. (2016) Observational constraints on atmospheric and oceanic cross-equatorial heat transports: revisiting the precipitation asymmetry problem in climate models Climate Dynamics, 46(9-10), 3239-3257. http://dx.doi.org/10.1007/s00382-015-2766-

Loeb, Norman G.; Wang, Hailan; Liang, Lusheng; Kato, Seiji; Rose, Fred G. (2017) Surface energy budget changes over Central Australia during the early 21st century drought. International Journal of Climatology, 37(1), 159–168. http://dx.doi.org/10.1002/joc.4694

Long CN and Y Shi. 2008. "An Automated Quality Assessment and ControlAlgorithm for Surface Radiation Measurements." The Open Atmospheric Science Journal 2: 23-37. DOI: 10.2174/1874282300802010023.

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Riihimaki, L. D. and C.N. Long (2014): "Spatial variability of surface irradiance measurements at the Manus ARM site." Journal of Geophysical Research, 119, 5475–5491, DOI: 10.1002/2013JD021187.

von Schuckmann, K., Palmer, M. D., Trenberth, K. E., Cazenave, A., Chambers, D., Champollion, N. , Hansen, J., Josey, S. A., Loeb, N., Mathieu, P.-P., Meyssignac, B., and Wild, M., 2016: An imperative to monitor Earth's energy imbalance. Nature Climate Change online

Wild, M., 2016: Decadal changes in radiative fluxes at land and ocean surfaces and their relevance for global warming, WIRES Clim Change, 7, 91–107, doi: 10.1002/wcc.372.

Wild, M., 2017: Towards Global Estimates of the Surface Energy Budget, Curr. Clim. Change Rep, DOI 10.1007/s40641-017-0058-x

Zhu, P., Wild, M., van Ruymbeke, M., Thuillier, G., Meftah, M., and Karatekin, O., 2016: Interannual variation of global net radiation flux as measured from space, J. Geophys. Res. Atmos., 121, doi:10.1002/2015JD024112.

BRIEF REPORT ON ICLAS ACTIVITIES (2015-2017)

BACKGROUND:

The Society, called the International Coordination-group on Laser Atmospheric Studies (ICLAS), is a nonprofit, constituent Working Group of the International Radiation Commission (IRC).

ICLAS works to promote the study of the environment (atmosphere, hydrosphere and lithosphere) including meteorology, pollution, atmospheric physics and chemistry, solid earth, biology, and climate, as elements of Earth and planetary sciences.

ACTIVITIES:

I) CONFERENCES

One of the major activities of ICLAS is to organize the International Laser Radar Conferences (ILRCs). In the reporting period (2015-2017) two (2) ILRCs were organized and held, as follows: New York, USA (2015) and Bucharest, Romania (2017).

Moreover, during these events, ICLAS awards the Inaba Prize and the Lifetime Achievement Awards. The Inaba Prize is awarded to the best oral paper first-authored and presented by an attendee below the age of 40. The prize carries a monetary award of $1200, which is funded by ICLAS through an endowment by the Inaba family. ICLAS's highest honor is the Lifetime Achievement Award (LAA) which honors up to 2 members of the lidar community. Awardees can be selected for outstanding contributions in two areas: 1) for outstanding leadership and service to the international lidar community, supporting, promoting and advocating on behalf of lidar activities around the world; and, 2) for sustained outstanding and innovative scientific or technical achievements in the areas of lidar techniques, technologies, and observations.

- New York, USA (2015)

The 27th ILRC Conference was organized by Professors Fred Moshary and Barry Gross of the NOAA Cooperative Remote Sensing Science and Technology (NOAA CREST) Center and Electrical Engineering Department at the City College of the City University of New York (USA).

It was held on the campus of the City College of New York in New York City from 05-10 July 2015 (http://ilrc27.org). It had 267 participants form 27 countries (211 regular members and 56 students). There were 302 papers presented including 92 oral presentations and 210 posters. The program included the ILRC Summer School organized by Prof. Gary Gimmestad of Georgia Institute of Technology (USA) and offered on 05 July for students and young scientists, also held on the City College campus.

The conference provided a total of 40 students and scholars support to attend the ILRC and present their work.

Four awards were given for the: best oral presentation awarded to Johnathan Hair (USA), best student oral awarded to Monika Aggarwal (Canada), best poster was awarded to Patricia Sawamura (USA) and best student poster was awarded to Willem Marais (USA). Finally, the Inaba Prize was awarded to Dr. Mikkel Brydegaard (Sweden), while LAA was presented to Dr. Pierre Flamant (France) and Jens Bösenberg (Germany).

- Bucharest, Romania (2017)

The 28th ILRC Conference was organized by Dr. Doina Nicolae and National Institute of Research and Development for Optoelectronics (Romania).

It was held on the campus of the "Politehnica" University of Bucharest from 25-30 June 2017 (http://ilrc28.inoe.ro). It had 353 participants form 31 countries (259 regular members and 94 students). There were 299 papers presented including 93 oral presentations and 206 posters. The program included the ILRC Summer School organized by Prof. Gary Gimmestad of Georgia Institute of Technology (USA) and offered on 25 June for over 160 students and young scientists, also held at the "Politehnica" University of Bucharest.

The conference provided a total of 62 students and scholars support to attend the ILRC and present their work.

Four awards were given for the: best oral presentation awarded to Jens Reinhard (Germany), best student oral awarded to Moritz Haarig (Germany), best poster was awarded to Volker Freudenhaaler (Germany) and best student poster was awarded to Tomoki Kubota (Japan). Finally, the Inaba Prize was awarded to Dr. Rodelize Mamouri (Cyprus), while LAA was presented to Dr. Upendra Signh (USA) and Dr. Mike Hardesty (USA).

II) ELECTIONS

Another major agenda item of the ICLAS Committee is to organize the elections for determining the new President and Working Group Members.

2015

The three ICLAS members, whom term expired at the 27th ILR, July 2015, were: Andreas Behrendt (Germany), Christoph Senff (USA) and Alex Papayannis (Greece). After nominations, discussion, and voting, the newly elected ICLAS members were: Dimitris Balis (Greece), Andreas Fix (Germany) and Dr. Xinzhao Chu (USA).

2017

The four ICLAS members, whom term expired at the 28th ILR, June 2017, were: Dr. D. Nicolae (Romania), Prof. K. Mizutani (Japan), Prof. Y. Wang (China) and Dr. T. McGee (USA). Also, Dr. F. de Tomasi (Italy) resigned. After nominations, discussion, and voting, the five newly elected ICLAS members were: Dr. Georgios Tzeremes (ESA), Dr. Dave Donovan (KNMI), Prof. Shoken Ishii (Japan), Prof. Fred Moshari (USA) and Prof. Dong Liu (China).

- Presidential Elections

At the site of the 27th ILRC, New York City, July 2015 the ICLAS nominated and discussed possible nominees for the new President, as the term of the outgoing President Upendra Singh had expired. Three nominees were accepted: Andreas Behrendt (Germany), Christoph Senff (USA) and Alex Papayannis (Greece). After voting of all ICLAS members, Prof. Dr. Alex Papayannis was elected the new ICLAS President for a 6 year term (2015-2021).

On behalf of ICLAS

Dr. Upendra Singh	Prof. Alex Papayannis
(Outgoing ICLAS President)	(ICLAS President)

IPRT - International working group on polarized radiative transfer

Claudia Emde and Bernhard Mayer

Meteorological Institute
Ludwig-Maximilians-University Munich
Germany

IRC business meeting, Cape Town, 30 August 2017

International Working Group on Polarized Radiative Transfer

Aims of working group IPRT:

- bring the community together (workshops)
- **compare and improve models**
- **provide benchmark results**
- provide information about free codes
- develop new and faster, publically available codes
- provide input data (scattering matrices, BPDFs – bidirectional polarization distribution functions, ...)

Project website:
www.meteo.physik.uni-muenchen.de/~iprt

Working group activities 2016/2017

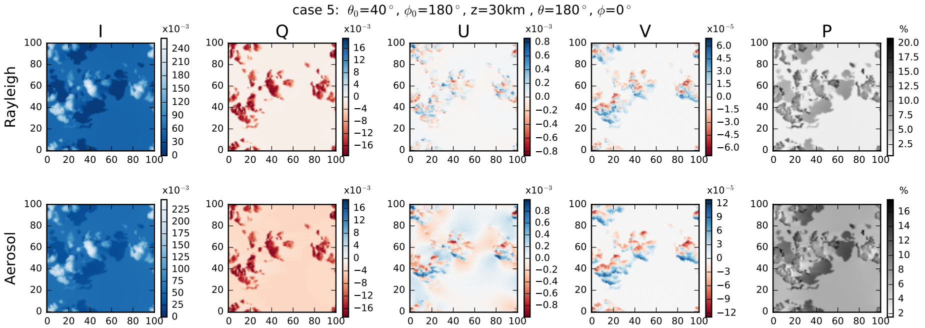
- 3D model intercomparison study for polarized radiative transfer
  - Full Stokes vector (linear and circular polarization)
  - Test cases with various degrees of complexity
  - Contribution of results from 5 vector radiative transfer codes
  - Intercomparison shows generally a good agreement (RMSE $<$ 1% for total intensity, RMSE $<$ 5% for linear polarization, this is within the noise level of Monte Carlo calculations.)
  - Results available on website `www.meteo.physik.uni-muenchen.de/~iprt`
  - Publication currently in preparation

Model intercomparison studies
Participating vector radiative transfer models

model name	method	geometry	references
3DMCPOL	Monte Carlo	1D/3D	Cornet et al. (2010), Fauchez et al. (2014)
MSCART	Monte Carlo	1D/3D	Wang
IPOL	discrete ordinate	1D	Korkin
MYSTIC	Monte Carlo	1D/3D[a]	Emde et al. (2010), Mayer (2009)
Pstar	discrete ordinate	1D	Ota et al. 2010
SHDOM	spherical harmonics discrete ordinate	1D/3D	Evans (1998)
SPARTA	Monte Carlo	1D/3D	Barlakas (2014)

[a]MYSTIC includes fully spherical geometry for 1D and 3D.

Example for nadir geometry, 3D LES cloud field



Stokes vector (I,Q,U,V) and degree of polarization P.

3D LES cloud field in pure Rayleigh atmosphere (top) and atmosphere including aerosol (bottom).

Summary of 3D intercomparison

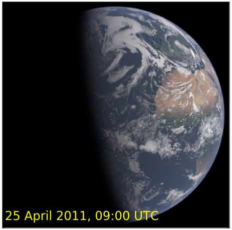
- Comprehensive test cases in 3D for:
  - Step cloud
  - Cubic cloud
  - LES cloud scene
- Results:
  - Models agree mostly within expected accuracy
    (i.e. standard deviation for Monte Carlo codes)
  - Differences at cloud boundaries due to definitions of model grids
  - Comparison of Monte Carlo forward and backward tracing method
  - Evaluation of variance reduction techniques

Previous work – Summary of 1D intercomparison

- Comprehensive test cases in 1D for:
  - Rayleigh scattering (with non-zero depolarization factor)
  - Surface reflection (Lambertian, reflectance matrix)
  - Spherical and non-spherical particles
  - Large size parameter
  - Coupling of layers with different optical properties
- Achieved very good agreement on high accuracy level (mostly better 0.1–1%)
- Benchmark data available on IPRT website
  `www.meteo.physik.uni-muenchen.de/~iprt`
- Publication:
  C. Emde, V. Barlakas, C. Cornet, F. Evans, S. Korkin, Y. Ota, L. C.-Labonnote, A. Lyapustin, A. Macke, B. Mayer, and M. Wendisch.
  IPRT polarized radiative transfer model intercomparison project – phase A.
  J. Quant. Spectrosc. Radiat. Transfer, 164(0):8-36, 2015.

Future plans – Polarized radiative transfer in fully spherical geometry

- Model intercomparison study in fully spherical geometry
- Particularly challenging for vector radiative transfer models using explicit methods (e.g. discrete ordinate or doubling-and-adding)
- Investigate accuracy of approximations
- So far no benchmark results exist!



Earth as seen by the moon, simulated with MYSTIC in fully spherical geometry.

Report from Jean-Luc Widlowski on RAMI:

Completion of the analysis of the second set of test cases in RAMI-IV

Conformity testing methods, as defined by the Joint Committee for Guides in Metrology, were applied to the evaluation of canopy RT models over six highly realistic virtual plant environments in RAdiation transfer Model Intercomparison (RAMI) - IV. The structural, spectro-directional and illumination related properties of these 'actual canopy' scenarios were based on detailed field inventories collected from forest stands. The resulting 1 hectare RAMI scenes contained between 90 and 890 million geometric primitives and specifes-specific optical properties in 18 different spectral bands. Twelve RT modelling groups provided simulations of canopy scale (both directional and hemispherically integrated) radiative quantities. The simulation results showed much greater variance than those recently analysed for the abstract canopies of RAMI-IV. Canopy complexity is among the most likely drivers behind operator induced errors that gave rise to the discrepancies. A shared risk conformity testing approach was used to evaluate the compliance of RT model simulations on the basis of reference data generated with the weighted ensemble averaging technique of ISO-13528. However, using concepts from legal metrology it was shown that the magnitude of the uncertainty associated with this reference was preventing a confident assessment of model performance with respect to the selected tolerance intervals. As an alternative, guarded risk decision rules were introduced that account explicitly for the uncertainty of both the reference and the candidate simulation methods.

Report by Alexander Marshak on I3RC:

- During the past year (7/19/16 - 7/18/17) we gave the I3RC community code to 12 people who requested it. 6 were from the US (including 2 from private companies), 3 from China, and 1 each from India, Japan, and Argentina.

- We keep all publications about 3D radiative transfer in cloudy atmospheres on the I3RC website.

- UMBC will be hosting parts of the I3RC project that involves 3D online calculator. We move it away from the NASA/GSFC site (https://i3rc.gsfc.nasa.gov)