WCRP REPORT

World Climate Research Programme

SUMMARY REPORT
FROM THE

NINTH SESSION OF THE BASELINE SURFACE RADIATION NETWORK (BSRN)

(Lindenberg, Germany, 29 May-2 June 2006)

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9TH BSRN SCIENTIFIC REVIEW AND WORKSHOP

I. OPENING SESSION

The 9th Baseline Surface Radiation Network (BSRN) Scientific Review and Workshop was hosted by Dr Klaus Behrens and the German Weather Service (DWD) at the Meteorological Observatory – Richard Aßmann Observatory in Lindenberg, Germany, from 29 May to 2 June 2006. Dr Ellsworth Dutton, the BSRN Project Manager and Prof. Gerhard Adrian, DWD, provided opening comments, introductions, and general logistics information.

Update on WCRP Developments (Gilles Sommeria, World Climate Research Programme/Joint Planning Staff)

Dr Sommeria gave a brief overview of recent developments in WCRP, including Dr Ann Henderson-Sellers replacing Dr David Carson as Director of WCRP in January 2006, and Dr John Church replacing Prof. Peter Lemke as Chair of JSC in March 2006.

A significant milestone occurred in September 2005 with the publication of the WCRP's new 10-year Strategic Framework 2005-2015 subtitled "Coordinated Observation and Prediction of the Earth System (COPES)." The main aim of this framework is to facilitate analysis and prediction of Earth System variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society. Its goal is to coordinate international cooperation and to respond to the needs of users of climate research and climate forecasts.

In March 2006, the Joint Scientific Committee (JSC) confirmed its support to the COPES strategy and decided to establish a metrics for progress and success for all its elements, in order to increase the visibility of WCRP, strengthen cross-cutting activities, and improve working practices in the various committees starting with JSC. The two COPES panels, on Observation and Assimilation and on Modelling, have started in 2005. In addition, specific coordinated activities have been initiated for Monsoon studies, Atmospheric chemistry and climate, anthropogenic climate change, extreme events, sea-level change, and a new one is suggested on clouds and convection.

WCRP has been an active partner to the GEO initiative from the start, promoting scientific aspects and the development of tasks related to climate and water. Support to the development of global surface networks, including more specifically BSRN, is one important part of GEO's missions. Finally, those attending the meeting were invited to the International Conference "Global Environmental Change: Regional Challenges" to be held in Beijing, 9-12 November 2006, where a number of WCRP topics will be presented.

Review of GEWEX Activities (Dr Peter van Oevelen, GEWEX European Coordinator)

Dr van Oevelen reviewed GEWEX Phase I objectives and accomplishments, and Phase II (2003-2012) objectives and the development of a "GEWEX roadmap" which will provide deliverables and a timeline for accomplishing these. He also reviewed some of the GEWEX Radiation Panel related decisions and actions from the recent meeting of the GEWEX Scientific Steering Group.

Overview of Routine Observational and Research Activities at Meteorological Observatory Lindenberg - Richard-Aßmann-Observatory (Franz Berger, Deutscher Wetterdienst, Richard-Aßmann-Observatorium)

Dr Franz Berger presented an overview of the routine observations and research activities at the Richard-Aßmann-Observatory (RAO), which has been in operation since 1905. It was noted that measurements were taken at RAO using kites from 1905-1932 (record heights for kite measurements at that time). Today, in addition to climate monitoring, RAO instrument data is used for model process evaluations and satellite data calibration. RAO provides quality control reference data sets for many networks, including BSRN, the Coordinated Enhanced Observing Period (CEOP), the GEWEX Water Vapor Project (GVaP), and the GEWEX Atmospheric Boundary Layer Study (GABLS).

GCOS – Update for BSRN (Hans Teunissen, GCOS Secretariat, Switzerland)

Dr Hans Teunissen of the Global Climate Observing System (GCOS) Secretariat presented an overview of the GCOS programme, including: the GCOS mission and strategy; a broad review of the GCOS networks; the interactions between GCOS and the UN Framework Convention on Climate Change (UNFCCC); the completion of the "GCOS Implementation Plan" in response to the findings of the *Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC;* and the relationship between GCOS and BSRN through the formal acceptance by WCRP and GCOS of BSRN as the GCOS global baseline surface radiation network. GCOS welcomed the contributions of BSRN to developing the global surface radiation products identified as part of the Essential Climate Variables defined in the *Second Adequacy Report*, while noting the importance of expanding the network to full global coverage and ensuring the participation of dedicated analysis centres to generate the needed climate products on a continuing basis. It was hoped and intended that formal participation of BSRN in the GCOS programme would provide enhanced visibility of the contributions and importance of BSRN to global climate system observation, thereby strengthening efforts to ensure the long-term support and sustainability of the network as required for all GCOS systems.

The Need for Accurate Ground-based Radiation Data for Establishing a Reliable Radiation Climatology Database (Ehrhard Raschke, ZMAW, University of Hamburg)

Establishing a reliable radiation climatology database is of prime importance for a better understanding of climate changes over all regions of the world. There is no unique method possible for this task. Satellites can measure directly only the fluxes of upward solar (solar radiation) radiation and terrestrial heat (longwave) at the position of their orbit. But excellent techniques are available to derive from such data global fields of both components at a fictitious "Top of the Atmosphere" (TOA), which is possibly a sphere at a mean altitude of about 50 km above ground. There have been flown numerous instruments of different design in single or coordinated satellite experiments since about the year 1960.

The incoming solar radiation at the TOA can be computed accurately on known values of the Total Solar Irradiances – presently assumed to be 1366 Wm^{-2} – and an adequate consideration of the properties of the orbit of our earth around the Sun. However modelers and climatologists use different codes of different complexity for such calculations and obtain often systematic deviations of up to 15 Wm^{-2} over areas of higher latitudes. Thus, Raschke et al., (2005, *GRL*), after comparing various results as obtained in climate models for the purposes of an Atmospheric Model Intercomparison and of the upcoming IPCC-FAR recommended that both communities should base their future work on the same algorithm.

The radiation budget components within the atmosphere and at the Earth's surface cannot be measured from satellites, but again numerous techniques have already been developed during the past 20 to 30 years to compute them from relevant information of the state of the atmosphere and its composition and of the earth's surface as well. Two major data sets have been developed within the scope of GEWEX. One of them – the International Satellite Cloud Climatology Project (ISCCP) FD radiation products – concentrates first in the derivation of cloud field properties over the entire globe and computes in a second step with these cloud data and with many other ancillary data the radiation flux products. The other data set arose from the GEWEX-Surface Radiation Budget (SRB) Project, which takes the ISCCP cloud data but then uses other ancillary data and radiative transfer codes to compute the radiation fluxes at TOA and at the surface. The results at the surface can only be controlled with ground-based measurements of high accuracy and stability. That is why in the early 1980s the existing operational networks of various national weather services were complemented by a world wide network of stations performing measurements with extreme high performance and also providing simultaneous and collocated measurements of relevant atmospheric characteristics. This is the BSRN, which is steadily growing.

The presentation provides results of intercomparisons between data from ISCCP and SRB (see also Raschke et al., 2006, *GRL*), showing non-tolerable deviations which call for further improvements of the codes and input data in both projects. Since various subsets of such data already went into many other studies – including the "calibration" of results from new upcoming data sets of the radiation climatology – the author of this presentation emphasized four major recommendations:

1. The user community should be provided with short and standardized texts on both data sets and instruments.
2. The user community should be encouraged to read the instructions before the data use and discuss open questions with those responsible for the data sets.
3. BSRN should identify those stations which are embedded within a network of high quality radiation stations to overcome the spatial variability of radiations fields due to clouds.
4. GCOS should update its requirements of accuracy and stability for climate data with respect to the spatial and temporal resolution. – This is now being done.

GEWEX Radiative Flux Assessment: Surface Working Group Overview and Update (Paul Stackhouse, Jr., NASA/Langley Research Center)

This presentation informed the BSRN participants of the GEWEX Radiative Flux Assessment Project and specifically the progress made by the Surface Flux Working Group in the Project. First, the objectives and goals of the project were reviewed. These involve the assessment of our current understanding of accuracy of retrieving TOA and surface radiation information from space. Thus, surface measurements constitute a vital part of the effort since these measurements provide the chief benchmark against which surface radiation parameters are evaluated. The definitions of accuracy that the project intends to use were presented in terms of accuracy, precision and stability. This sort of error information is needed from the measurements themselves. The information requested from BSRN and other high quality measurements networks was discussed. For this current assessment, the participants would like use both long-term low temporal resolution data and short-term high temporal resolution. Monthly, daily, and monthly averaged 15 minute data are requested over the length of a particular site's records. Fifteen minute resolution is requested in measured parameters for just the year 2004. A web site has been developed to both accept and deliver such data sets for the assessment activities. The BSRN scientists were invited to participate as possible. The presentation included an overview on how this data would be used in the validation of the satellite and also modeled estimates of the surface radiation parameters. Lastly, it was noted that the activity is ongoing, has already held two workshops and is planning a third one. The goal is to complete the assessment in 2007.

Report on the Commission for Instruments and Meteorological Observations (CIMO) Expert Team on Meteorological Radiation and Atmospheric Composition Measurements (Klaus Behrens, Germany)

CIMO is one of the oldest groups within the Technical Commissions of WMO. For many years the structure of CIMO consisted of an Advisory Group and Working Groups for Surface Measurements and Upper Air Observing Systems. Rapporteurs for special tasks supported the Advisory Group and Working Groups. At the CIMO XIII meeting (Slovak, Republic, 2002), CIMO reorganized its structure into a Management Group and three Open Program Area Groups (OPAG) with a focus on "surface," "upper air" and "capacity building". Three Expert Teams (ETs) work in every program area and will work primarily by e-mail and meet at least once every intercessional period. The ET on Meteorological Radiation and Atmospheric Composition Measurements (ET MR&ACM) consists of four members and representatives of CAS, BIMP, and HMEI, respectively.

The main tasks of the ET MR&ACM) are:

- IPC-X, 2005, WRC, Switzerland
- Liaise with the WCRP on matters related to BSRN and inform members of developments
- Monitor the efforts of the CAS SAG Ozone, UV and AOD measurements on the operational practice
- Update the CIMO Guide
- Develop further the establishment of a World Standard Group of absolute long-wave radiometers
- Coordinate the dissemination of World Radiometric Reference (WRR) factors to regional and national radiation standards
- Coordinate the dissemination of pyrgeometer calibration coefficients
- Provide technical/scientific guidance in the establishment and continuing quality assurance of IRC Davos
- Initiate activities so that high quality solar radiation measurements may be widely guaranteed in all national radiation networks through training courses and in the establishment of networks in areas with a low density of radiation stations
- Status of the traceability of the calibration methods

Three is a close connection between BSRN and ET MR&ACM. During the ET meeting in February 2006 in Davos, Switzerland the following results were achieved:

- A successful IPC-X and conjointly organized RPCs
  - WSG member instruments were well within the long-term stability of 0.2%
- Evaluated status of the Infrared Radiometer Centre (IRC)
  - There is some work to be done to ensure that the Absolute Sky-scanning Radiometer (ASR) is an appropriate reference point for IR measurements
  - The World Infrared Standard Group, consisting of two characterized PIR and CG4, respectively, will provide a very useful interim reference for pyrgeometer measurements until a long-term absolute reference can be established
- Mechanisms and protocols should be introduced to the CIMO Guide to ensure, that to be a RRC or a NRC, it must rather should have effective traceability to the WRR

Furthermore, the ET recommended to CIMO that UV Calibration Centres and a primary WMO reference centre for Optical Depth be created. Because of the importance of infrared measurements to meteorology and climatology, the BSRN community is encouraged to develop absolute IR-Radiometers and also investigate the existing types of pyrgeometers.

Status of the BSRN Archive (Andreas Roesch, World Radiation Monitoring Centre, Switzerland)

BSRN currently runs 38 operational stations. Cabauw, Palaiseau and Plataforma Solar de Almeria have recently started submitting their data to the archive. Xianghe (China) is expected to follow in the near future. The total number of station-to-archive files is approximately 3400. The database currently contains 18 and 4 sites with consistent data for the year 2004 and 2005, respectively.

Thirteen (20) stations provide synoptic observations (e.g., radiosonde measurements). Only seven sites report total ozone amount (Barrow, Boulder, Georg. v. Neumayer, Ny Ålesund, Payerne, South Pole, and Tamanrasset). Reflected shortwave radiation is measured at 15 sites, thus allowing the computation of surface albedo. Global UV-B is observed at 10 sites. Payerne also measures the direct, diffuse and reflected component of UV-B. Both spectral shortwave radiation and aerosol optical depth are not yet reported to the archive. However, comprehensive information on Aerosol Optical Depth (AOD) will be available via the FTP file archive until later.

Since April 2006, applicants for the database and the FTP archive get immediate response and a confirmation email. This has been technically realized by using the scripting language php which will be also applied for further automation of the data transfer, archival and distribution.

The quality control has shown that for 11 (2, 0) sites, more than 30% of global radiation (diffuse radiation and direct radiation) is outside the “extremely rare” limits. The poor quality of global radiation is primarily due to the nighttime offsets. The comparison test between the parameter ‘glob2’ and ‘glob1’ (sum of direct and diffuse radiation) reveals that at nine sites, more than 5% of all available observations are outside the suggested limits. Summarized it can be stated that the data quality is still quite poor at several sites, indicating that the quality of submitted data should be further increased.

The next steps for the improvement of the BSRN archive: (i) Further automation of the insertion procedure; (ii) Supply of value-added parameters such as AOD and clear-sky fluxes through the FTP file archive; (iii) the retrieval of monthly means; and (iv) visual checks of the data quality that should force the users to consider the data quality in their research.

Future at ETHZ (Atsumu Ohmura, World Radiation Monitoring Centre, Switzerland)

Prof. Ohmura, who created the BSRN archive over 15 years ago and maintained it at the World Radiation Monitoring Centre, is retiring. The challenge of supporting and transitioning the archive through its subsequent growth was ably met by Prof. Atsumu and his colleagues. Today, the archive holds data from 36 BSRN sites and has a holding of over 3400 station months of data. Prof. Ohmura’s successor will have a large impact on the future of this archive.

BSRN: Progress and Challenges for the Future (Ellsworth Dutton, National Oceanic and Atmospheric Administration)

With the concept and realization of BSRN now being in existence for approaching two decades (BSRN was proposed in 1988 and archived its first data in 1992) this presentation reviewed some of the major progress of the Network and explored some challenges for the future, as envisioned by the Network’s current International Project Manager. The BSRN concept and data fit into a larger picture of the combined efforts of the surface radiation components of the climate modeling and satellite observations communities. Highlights of the BSRN accomplishments included the growing institutional affiliations and support along with the expanding size of the operations network and resulting data records. Accomplishments also include the many improvements that the group has inspired and otherwise helped to bring into existence for use by the entire ground-based broadband radiation measurement community. In addition, several improvements to the function of the Network and its data archive were noted as were ongoing investigations in areas measurement capabilities not yet fully specified for BSRN level observations, such as the case with UV and PAR where spectral complications are being further addressed by the BSRN working groups. Several examples of highly visible published BSRN data applications both in the area of satellite and model validation and comparison were mentioned along with examples of analysis of the BSRN and related ground based observations provide independent and stand-alone information local and regional radiation climatologies. As one of the more important accomplishments identified is the infusion of new people as BSRN participants and the new ideas and capabilities they bring with them. This is happening both as new stations are included in the Network, and as some people that have been involved in the program move on and their newer replacements are becoming involved.

Challenges ahead for BSRN are many and diverse. Without specific priority a list of challenges was presented that address needs to improve and extend the current and evolved goals and purposes of BSRN. Extension of the BSRN data coverage to data poor regions is of particular note, as the need to perpetuate the organization through a renewal of a commitment to the responsibility for the data archive activities, as well as extending the groups research and analysis activities. The merits of the GCOS Climate Monitoring Principles were stressed as part of BSRN's new set of goals. Also, the potential for the utility of extending the Network observations to include the complete energy balance was also presented.

II. FIELD STATUS AND PROPOSED NEW SITES

Plataforma Solar de Almería Station (Bella Espinar-Frias, Plataforma Solar DeAlmeria)

The *Plataforma Solar de Almería* (PSA) is a large facility which is focused on the study of solar radiation applications, mainly solar power plants and solar chemistry. It is the property of the Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas of Spain and is located in the South Iberian Peninsula, 30 km inland. The PSA is located in a wide valley between two mountain ranges. The most relevant element in the horizon is a 90-m-high tower which has an elevation of 13 degrees from the station. The highest mountain elevation is 5.2 degrees at 339 degrees azimuth. The climate is semiarid Mediterranean with short mild winters and hot summers (temperatures often over 40ºC). Rain in this area is scarce but torrential when it occurs, with an annual average of up to 243 mm. There are almost 3000 hours of insolation and the annual mean temperature is 17ºC.

The station has two parts, the 30-m mast and the shed. The instrumentation installed covers the basic program and part of the expanded one: direct, global and diffuse irradiance, short- and long wave upward irradiance, longwave downward irradiance and spectrum measurements (from 250 to 2000 nm) for the three solar radiation components. Meteorological measurements collected at the station include wind speed and direction (at 30 m, 10 m and 2 m), temperature, relative humidity (at 2 m and 10 m), pressure, and rain amount. A GPS antenna is used as a time server. The electrical signals are stored in the database (as recommended in the last workshop).

The sensor adjustment (e.g., ventilated, inner temperature registration) as well as the maintenance and the cleaning program and the data acquisition system sampling frequency and accuracy are as required and all the filters have been implemented. An on-site instrument calibration program is being set up.
At the last BSRN Workshop in Exeter, the mast was the only thing working. Now, all instruments have been working since October 2005 and these data are accessible on the web at *www.psa.es*. To access the data it is necessary to register as a user. The generation of monthly files in BSRN format is automatic and seven files have already been uploaded to the BSRN archive.

New BSRN Sites in Brazil – the SONDA Network (Enio Pereira and Sylvio Luiz Mantelli, INPE/CPTEC)

The SONDA network was devised to improve the national capacity for the assessment of solar and wind energy resources as a tool to assist investors, stakeholders, and the government at the decision level in the development of solar and wind energy projects. The Network provides high quality environmental data from acquisition sites located in the main characteristic climatic regions of Brazil. The project brings together the existing national expertise and infrastructure in meteorology and climatic modeling to develop and validate several atmospheric models. All data from SONDA measurement sites are freely available to the public and it can be downloaded at http://www.cptec.inpe.br/sonda/. With only minor changes and additions on the protocol for data qualification and screening, the five main SONDA sites (Rolim de Moura, Brasilia, Petrolina, Cachoeira Paulista and São Martinho da Serra), are being submitted as new BSRN sites.

Existing sites, Balbina and Florianopolis stations have been included in the SONDA network. Due to previous tracker problems, all sensors and the data acquisition system were replaced and the operator retrained at the Balbina station. The Florianopolis station also had some of the sensors replaced and the data logger changed. Both stations are working, but the data files at the BSRN archive have not been updated. Minor formatting problems with the data files will soon be solved. The delay is due to limited staffing. Qualified data may be downloaded on SONDA home page: *www.cptec.inpe.br/sonda*.

Solar UV Radiation Measurements in Estonia (Ain Kallis, Tartu Observatory)

Solar UV irradiance is measured at Tartu-Toravere BSRN station with five broadband sensors (UV-A, UV-B and erythemal UV) and with a 306 nm narrowband sensor. A new type of UV sensor based on the the solar blind phototube was developed. Since 2004 a computer-aided minispectrometer has been used for solar UV spectrum monitoring. The calibration of UV sensors is based on the tungsten-halogen standard lamp FEL. At Toravere the mean values of the ground-base measured and satellite TOMS-derived doses were in good agreement.

Implementation of the BSRN Station at Dome C (Antarctica) and First Measurements of Radiation Fluxes and AOD (Vito Vitale, ISAC-CNR)

During the austral summer 2005-2006, a BASIC set of radiometers was installed at the new Italian-French station of Concordia (75°S, 123°E). The Concordia station offers a unique opportunity for long-term monitoring of the East-Antarctic Plateau atmosphere. In fact, the South Pole station, which is ~1500 km south of Concordia at lower latitude (90°S versus 75°S) and elevation (2900 m versus 3250 m), is largely affected by air masses of western origin and experiences significantly different weather conditions (e.g., mean temperature is several °C warmer, mean wind is stronger, mean snow accumulation is four times larger).

To assure high quality measurements in a so harsh environment, high-class radiometers, including the pyranometer CM22 and pyrgeometer CG4 were deployed on site for measurements of global, diffuse solar radiation and longwave downwelling radiation. Two pyreliometers (Kipp and Zonen CH1 and Eppley NIP) were installed for direct solar radiation measurements. An 8-channel sun-photometer, based on the Carter-Scott SP02 and realized in the frame of cooperation between ISAC-CNR Bologna and NOAA-CMDL Boulder, will allow obtaining information on the atmospheric turbidity conditions and AOT values. All instrumentation was mounted on a solar tracker model 2AP-Gear Drive completed with a shadow accessory, data recording being supply through two Campbell data loggers. The usual operational range of the tracker was extended by means of extra heating and extra insulation.

Tracker radiometers and sun-photometer are located near the first container of the Concordia Atmospheric Research Observatory (CARO), S-SW of the winter station at a distance of about 700 m from the main buildings, on a platform 2.8 m high so as to have a perfect horizon (only the main station represents an obstruction of 2° in zenith and ~5° in azimuth at about 60° (NE). Row radiation data (1Hz samples) are acquired as differential input and stored in the CR23x data logger, while sun–photometric data are stored as 5 sec averages in a CR10x located near the tracker. Both data loggers are connected to a PC housed in the CARO container and each hour data are transfer from data loggers to the PC and data logger times compared with the station reference to obtain accuracy that is better than 3 seconds. Also the tracker is connected continuously to the PC in order to monitor the internal temperature. Routine operation executed one or more times per day, includes a visual inspection of the instrumentation and radiometer's cups, during which if necessary they are cleaned of ice and snow. The level of radiometers is also checked once a day.

The system can be continuously controlled from the station through a wireless LAN, through which the raw data are regularly transferred from the measurement site to Concordia Station in order to have a backup of at least a daily rate. At the moment raw data are compressed and sent to Italy on a weekly rate (about 7 Mb). In Italy the data are reduced using BSRN protocol and minute averages, standard deviation, maximum and minimum are calculated and stored in daily files. An automatic procedure is being developing to perform in near real-time data processing and quality assurance evaluations.

A potential new BSRN site near Paramaribo, Suriname (Wouter Knap, Royal Netherlands Meteorological Institute)

The radiation site of the Paramaribo station (5.81ºN, 55.21ºW) located at the Meteorological Service of Suriname (MDS) was presented as a possible future BSRN site. The site has been built with support of the EU STAR (Support for Tropical Atmospheric Research) Program and has a significant number of instruments for atmospheric research, such as radiation instruments, sky imager, Brewer, MAX-DOAS, and radiosonde. A basic set of quantities (direct, diffuse, global, and longwave downward irradiance, as well as air temperature, relative humidity and pressure) will be available according to the BSRN standards by the end of 2006.

CHMI - Solar Radiometry, History of Calibrations (Jiri Pokorny, Solar and Ozone Observation, Czech Hydrometeorological Institute)

State of the station presented on several photos of the radiometer tower. History of global radiation measurements at SOO begins at 1953 (daily sums), since 1964 hourly sums. Between 2000 and 2005 instrumentation improved (Global, Diffuse, LW/dnw, Direct, UV-B, Ozone), 1-minute averages. Interest in becoming a BSRN station was expressed. Second part of the presentation shows the method and results of outdoor pyranometer calibration and transfer of the World Radiation Standard by means of the National standard cavity radiometer HF30497.

Status of Candidate Stations from the Last BSRN Meeting (Ellsworth Dutton, NOAA)

Alert, Canada
American Samoa – needs funding
Cabauw Netherlands, accepted and operational
Trinidad, Calif – running, no archival of data
Summatra – no activity
Boreal site – delayed
China – one up and operating; two other being worked to bring online
Sonda network in Brazil – need work for routine processing
Siberia – NSF/NASA Station – probably will be ready in 1-2 years

III. APPLICATIONS – SATELLITES AND RADIATIVE TRANSFER

Systematic Comparison of the BSRN Shortwave and Longwave Downward Radiation Fluxes with their GEWEX SRB Counterparts (Taiping Zhang, AS&M/NASA Langley Research Center)

The most updated BSRN data archive have data worth 2849 site-months retrieved from 35 BSRN ground sites ranging from the South Pole to the vicinity of the North Pole for the period of 1992–2004. The latest GEWEX Surface Radiation Budget (SRB) data (Version 2.5/2.6) of global coverage at 1 x 1 degree resolution covers a period of 21.5 years from July 1983 to December 2004. The SRB data are presented as 3-hourly, 3-hourly monthly, daily and monthly means. To facilitate the comparison, the original BSRN data, which are at 1-, 2-, 3- or 5-minute intervals are processed to generate averages at the same SRB time scales. In spite of occasional outliers, the comparison shows statistically very good agreement between the SRB and BSRN data.

Use of BSRN Data for an Operational CM-SAF Surface Radiation Budget Validation and Inter-comparison with ISCCP-FD and GEWEX SRB Data (Rainer Hollman, Deutscher Wetterdienst)

In the phase of redefinition of the EUMETSAT ground segment, seven Satellite Application Facilities (SAFs), have been established in Europe, each of them a consortia of different national weather services serving dedicated user groups. The SAF on Climate Monitoring (CM-SAF, http://www.cmsaf.dwd.de), hosted by DWD, is delivering a comprehensive set of climate variables, ranging from different cloud products, radiation budget at the top of the atmosphere (TOA), surface radiation budget (SRB), to troposphere humidity. It derives a consistent data set of cloud and radiation products in a high spatial resolution on a uniform grid. Since September 2005 it is producing climate data sets using data from instruments onboard METEOSAT Second Generation. Processing the data from the NOAA polar orbiting satellites began in January 2005. In the future data of different instruments from the European satellite METOP, which is to be launched in the summer of 2006, will be used additionally. The area covered currently is 30° to 80° N and 60° E to 60° W, in October 2006 the area will be extended and will cover as well Africa up to 60° S.

The presentation focused on the surface budget radiation and demonstrated the need and use of BSRN data sets for an operational validation of the derived satellite products. The overall agreement found was within the desired accuracy on daily and monthly mean scales. Also an intercomparison with state-of-the-art satellite products (GEWEX-SRB) was presented. Because of the short overlap time of both product set, only a few months could be compared; the differences are in general within 5 W/m² on monthly and daily means. Some regional differences are observable. From the satellite product point of view the wish was expressed, that surface BSRN sites representing the ocean surface radiation would be of great further help.

Clear Sky Broadband and Spectral Shortwave Radiation Model/Measurement Comparisons (Joe Michalsky)

In the last 10 years some improvements have been made in reconciling the differences in measured diffuse horizontal shortwave irradiance and models of the same for clear-sky conditions (models have been persistently higher than measurements). The problem was initially thought to be the diffuse offset (dark correction) in the PSP pyranometer. After that correction, there was still a 15-20% difference in measurements and models. Further efforts (mainly more realistic specification of aerosol optical properties) reduced the difference to about 10%.

In May 2003 an Intensive Observing Period (IOP) concentrating on the measurement of aerosol properties on the ground and in profiles from aircraft was conducted. 30 clear sky cases were used with a range of air masses and aerosol optical depth to further investigate this problem using the extensive measurements of aerosol properties as input to the models. The results suggest that the average direct model minus measurement values agree to within 1% or below the measurement uncertainty alone. The diffuse results are now within 2%. The probable explanation for this convergence to closure is that better spectral albedo information was used as input to the models and lower (measured) asymmetry parameters were used than the estimates in prior studies.

We are now involved in spectral closure studies to ensure that the agreement in broadband is not the result of a cancellation of differences in different portions of the solar spectrum. Some progress has been made, especially with regard to the issues of using models of sufficient spectral resolution to provide samples within the spectral resolution of the measurements. The other issue, as always, is choosing a correct extraterrestrial (ET) spectrum, which is not a solved problem, and then having high enough spectral resolution for the ET spectrum for the reasons outlined above. We are at the point that we nearly have satisfactory agreement in spectral positioning, but more effort is required to compare several cases and to develop spectral single scattering albedos and spectral asymmetry parameters, as well as spectral optical depth, outside the wavelength range where they are measured.

Cloud-Free Radiative Closure for Cabauw, The Netherlands (Alexander Los, Royal Netherlands Meteorological Institute)

We presented a broad-band radiative closure study for the cloud-free atmosphere at the BSRN site CAB (Cabauw). For this purpose we initialized the MODTRAN radiative transfer model with balloon soundings and AOTs (Aeronet L1.5V2) and compared the calculated to the observed fluxes for the period Feb. – Dec. 2005. More than 50% (60%) of the differences between measured and modelled diffuse (direct) broad-band radiative fluxes agree within 10 W/m2 (20 W/m2). Long tails in the probability distribution functions indicate a possible contamination of the AOT data by (thin cirrus) clouds. As aerosol optical properties other than AOT were not considered we attempted to use the discrepancies between measured and modelled fluxes to derive the absorption properties of the aerosols. This method will be further tested and evaluated using in-situ observations.

Shortwave Surface Flux Trends from Satellite and Surface Site Data -- Preliminary Results from GEWEX-RFA (Paul Stackhouse and Taiping Zhang, NASA Langley Research Center)

In this talk, the more stringent time series analysis of Weatherhead, et al (1998) was applied to the deseasonalized time series of the GEWEX Surface Radiation Budget downward SW radiative flux (SW Vers. 2.5) and Global Energy Balance Archive (GEBA) SW measurements for the time of July 1983 through June 2003. The time series from SRB data at BSRN site measurement site locations were also considered. The method uses a linear deseasonalized model that assumes a residual noise is autoregressive to order one. Using this assumption (which was tested but not shown), expressions were developed to compute confidence intervals of each trend fit and the number of years required to assure 90% probability that the linear change in time (or slope) will satisfy the 95% confidence test. The correlation between GEBA measurements at sites with data gaps no more than 24 months over the time period above and corresponding GEWEX SRB fluxes showed correlations greater the 0.8. It was demonstrated the end points of the time series are very important to the linear change fit. The linear trends were both less than zero and the confidence intervals for both fits included the slopes from each separate data set. However, the confidence also included zero and thus the conclusion is that there is a nonzero probability that the trend was the wrong sign. Due to the high correlation between GEBA and SRB, the SRB data set containing no data gaps was used as a proxy for the GEBA data set to avoid data gaps and to evaluate the relationships between the variations from the measurement locations compared to the globally averaged trends. This gave the following results: 1) the SRB time series did give positive sign to the linear change with a more narrow confidence interval 2) the linear trend from the globally averaged time series was positive and corresponded very well with that from the SRB at just the GEBA sites 3) the positive trend was shown to far larger in the northern hemisphere than the southern hemisphere and the confidence interval did not include 0 and 4) deseasonalized averages of the SRB SW data at the BSRN sites gave similar results and the confidence intervals were about as wide as the those of the global average. This indicates that the BSRN site locations are doing an excellent job representing large scale variability because of their relative wide spread nature. However, it was noted that all the 19-year linear changes here required at least 4 – 20 more years to satisfy the criteria. Thus, we saw that the results indicate the SRB is tending to agree with surface measurement analysis indicating a relative increase in the globally averaged SW irradiance that is most likely dominated by the northern hemisphere. However, the width of the confidence intervals indicate that the noise in the SRB data set either needs to be reduced or the length of the time series be lengthened to provide more confident in the detection of the long-term change. Another note is that the theory can be modified to accept the uncertainty of the measurements and this information would probably increase the uncertainty of the fits and thus the length of time needed to observe the current changes before quantitative confidence in the trends can be established.

Issues Related to Satellite Data Product Comparison and Importance of Ground Truth (Rachel Pinker, University of Maryland)

Discussed were issues related to: evaluation of satellite estimates against ground truth; evaluation of satellite estimates against independent satellite estimates; accounting for aerosols and biomass burning (examples from sub-Sahel).

Used were satellite estimates from the UMD/SRB model driven with: ISCCP D1 at 2.50 spatial resolution; ISCCP DX at 0.50 spatial resolution; GOES data (GCIP/GAPP) at 0.5 and 0.1250 spatial resolutions. It was found that agreement between satellite estimates and ground truth is not always better when the satellite observations match more closely the spatial resolution of the ground truth. Under the CEOP program, capabilities to derive surface SW fluxes from MODIS were developed; this allows sampling satellite products from same satellite. Fluxes were estimated at MODIS scanning time at 10-100 km resolutions. Ground measurement from the ARM central facility and four ARM extended sites and four SURFRAD stations averaged around MODIS scanning time for 15, 30, 45 and 60 minutes. It was found that results at about 30 km spatial resolution yields the highest correlation and lowest RMS for all averaging times of ground observations.

Comparison of the UMD/SRB products with independent satellite estimates (GISS-FD) both available at 2.5 spatial resolution points to the need to understand sources of differences between satellite products. For instance, gap filling methodologies will impact the comparison results between satellite products. Tested were improvements in satellite derived fluxes when aerosols derived from following sources: GOCART model simulations; MODIS retrievals; AERONET measurements. It was found that while new aerosol information improved SW fluxes (total, direct and diffuse) at many BSRN stations, no improvement was found at Ilorin, Nigeria, a sub-Sahel site. Possible explanation: the complexity of aerosol properties when dust and burned biomass are mixed. In summary, an improved evaluation strategy is needed before reliable error estimates of satellite based fluxes can be provided and high quality ground truth is imperative.

IV. APPLICATIONS – CLIMATE OBSERVATIONS AND MODELS

Computation of Monthly Means or the Problem with Poor Data Quality and Gaps (Andreas Roesch, World Radiation Monitoring Centre)

This study investigates the influence of the data quality and the gap length on the computation of monthly means from minute-data. In order to quantify how monthly means are influenced by missing data (data gaps), it is beneficial to present some statistical values: 10 sites have more than 5% missing global radiation. For direct radiation, even 16 (8) sites provide observations with more than 5% (15%) missing data. Eleven (4) sites have more than 5% (15%) missing observation for downwelling longwave radiation. It can be thus concluded that at some sites, a substantial percentage of the observation are missing. The investigation of the distribution function (pdf) of the gap lengths clearly showed that the pdf strongly varies among different sites as well as between different parameters of the same site. This complicates the theoretical investigation of the accuracy of monthly means with respect to the percentage of missing data.

In a second step, seven algorithms for computing monthly means from minute-values were applied to the BSRN data. It was shown that both the gap length and the quality of the data may have an important effect on the computed monthly means. The comparison of mean monthly climatologies for all sites revealed that differences among the investigated methods can be as high as 10 Wm^{-2} (for some cases, differences were even clearly above this limit). For the same percentage of data gaps, the different algorithms generally are in better agreement for the longwave radiation than for the shortwave radiation. This is mainly due to the higher temporal variability in the shortwave than in the longwave. The study showed that the scatter among the methods is rather poorly correlated with the total percentage of missing data and the amount of poor quality data (the data that is outside the extremely rare limits).

Aerosol Optical Properties and Aerosol Direct Radiative Forcing in Xianghe (Xiangao Xia, Laboratory for Middle Atmosphere and Global Environmental Observatory, Institute of Atmospheric Physics, Chinese Academy of Sciences)

In October 2004, a set of broadband pyranometers and a CIMEL sunphotometer were installed in Xianghe, a suburban site in North China. Using 15 months of ground-based broadband and spectral radiation data, aerosol loading and its effects on solar radiation were analyzed, which showed that the mean aerosol optical thickness at 500 nm (AOT) is 0.66 and a large day-to-day variation. AOT frequently climbs gradually from background-level to more than 1.0 in 5-7 days, and then breaks down quickly. High AOT greater than 1.0 can occur in all months, however, background-level of aerosol loading mainly occurs in winter season. The high AOT is primarily contributed by anthropogenic fine particles. Aerosols seriously impact the instantaneous downwelling total shortwave radiation (TSW), photosynthetically active radiation (PAR) and total ultraviolet radiation (TUV). The impacts depend on solar zenith angle, aerosol optical thickness and wavelength. Aerosol induced minimum reductions in diurnal mean net solar radiation occurred in winter (35.2, 18.4 and 1.9 Wm^{-2} for TSW, PAR and TUV, respectively). The reductions in summer are more than double those in the winter. The results presented indicate that aerosol effects on human health, plant growth and climate change in China should receive more attention.

Climatic Signals in Time Series of Global Radiation Based on World Radiation Data Centre (WRDC) and BSRN archives (Anatoly Tsvetkov, World Radiation Data Center)

The long-term changes in global radiation measured at the world network of actinometric stations are estimated on the basis of long time series selected from the WRDC archive. It is shown that this signal is small if one considers linear trend component fitted to the yearly data. Sign of 30-years trend in yearly data depends on site location. Examples of such estimates for Europe area are given. If we consider time series built for a particular season combined for all years available in the archive the value of trend with positive or negative sign may be more pronounced.

To describe seasonal signal in global radiation daily data, Chebyshev polynomials were used in the analysis. The order of the polynomial depends on climatic zone considered. The results of analysis of time series for particular stations from the WRDC archive and the BSRN for the latest years give good similarity but there are cases when there is discrepancy between the data.

Means and Trends in Surface Radiation Budgets as Simulated in GCMs and Observed at BSRN Sites (Martin Wild, Institute for Atmospheric and Climate Science, ETH)

Substantial uncertainty still exists regarding the temporal and spatial distribution of surface radiative fluxes and its representation in General Circulation Models (GCMs). To constrain these uncertainties, we use direct observations at the surface from the BSRN and the Global Energy Balance Archive (GEBA) databases located at ETH Zurich. These data are used to systematically assess the performance of a total of 36 GCMs with respect to their surface radiative fluxes. These models represent almost two decades of model development, from the atmospheric model intercomparison projects AMIP I and AMIP II to the state-of-the art models participating in the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR4). Results show that models tend to overestimate the solar irradiance at the surface, due to a lack of shortwave absorption in the atmosphere. The excessive surface insolation is also found under cloud-free conditions in many models, while improvements are found in some of the latest models with higher atmospheric absorption.

Large discrepancies exist also in the longwave downward radiation in the GCMs, both under all sky and clear sky conditions. A comparison with available observations suggests that GCMs tend to underestimate the longwave downward flux. The downward longwave flux at the surface is also a particularly interesting component in the context of climate change, as it is most directly affected by changes in atmospheric greenhouse gases. GCMs predict the downward longwave flux to undergo the largest changes of all energy and radiation balance components, and observed changes at the BSRN sites are in line with the model predictions.

Recent evidence suggests that also the amount of solar radiation reaching the earth surface is not stable over time but exhibits significant decadal variations. These variations, in addition to the changes in longwave radiation induced by alterations in greenhouse gases, cause changes in radiative forcings which may significantly affect surface climate. Observations from GEBA and BSRN suggest that surface solar radiation, after decades of dimming, reversed into a brightening since the mid 1980s at widespread locations. These changes are in line with a recovery of atmospheric transparency, possibly related to reduced aerosol loadings due to air pollution control and the breakdown of industry in formerly Communist countries. Current GCMs typically do not represent aerosol effects with a degree of sophistication to capture these effects. Here we use a special version of the Max Planck Institute for Meteorology GCM (ECHAM5-HAM), which includes aerosol effects in much more detail than in most other GCMs, Due to the improved treatment of aerosol effects, the model is able to reproduce the observed trend reversal under cloud-free conditions realistically.

The transition towards more sunlight at the earth's surface since the late 1980s after decades of decline may significantly affected surface climate. From the 1960s to the 1980s, the dimming may have been large enough to counterbalance the greenhouse-induced increase in downward longwave radiation, so that the available energy at the surface was rather decreasing than increasing. Further, land surface temperatures increased only marginally from the 1960s to the 1980s. Since the mid 1980s, the solar dimming was no longer there to mask the increasing greenhouse effect, so that the greenhouse effect became fully apparent during the 1990s. This is reflected, e.g., in much stronger temperature increase during the 1990s compared to earlier decades, no further decrease in daily temperature range, an intensified global hydrological cycle, as well as a substantial retreat of mountain glaciers, which was suppressed during the prior decades of dimming.

Recent related references:

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Quality Control and Long-term Variation of Surface Shortwave Radiation in China (Tadahiro Hayasaka, Research Institute for Humanity and Nature)

Solar radiation is one of the most important factors affecting the climate and environment. Routine irradiance data is valuable for the research of climate change because of its long-term accumulation and wide space coverage. In this study, a set of quality control (QC) algorithm is used to test the qualities of daily solar global, direct and diffuse radiation data from 122 observatories in China during 1957 to 2000. The QC algorithms include: test of physical threshold (QC1), sunshine duration test of global radiation (QC2), and standard deviation test of time series for averaged annual solar global radiation (QC3). The results show that percentage of global, direct, and diffuse solar radiation data which fail to pass QC1 is 3.07%, 0.01%, and 2.52%, respectively. On the other hand, global solar radiation data failed to pass the QC2 and QC3 are 0.77% and 0.49%, respectively. The Global Energy Balance Archive (GEBA) method is also taken into account to check the data quality of solar radiation in China. There are 84 stations with time series longer that 20 years; for 35 of them, more or less suspected data are found. Based on the tested data, trend of ground solar radiation over China during the past 40 years and the effect of data quality control on it are analyzed. Decreasing trends of ground solar global and direct radiation are not obviously changed by the QC approaches because there are relatively few data that did not pass the quality control. However, the quality control operation still has significant effects on the data of individual station and/or time period.

The ground-based routine irradiance data were compared with two satellite-derived datasets, i.e., International Satellite Cloud Climatology Project (ISCCP) FD data set and GEWEX Surface Radiation Budget (SRB) Project data set. Compared to the routine irradiance data, the satellite-derived data overestimated surface shortwave irradiance, particularly over large cities. These positive biases can be attributed to aerosols with absorptive properties. Satellite-derived radiation datasets are useful. However, aerosols strongly affect surface shortwave irradiance, creating discrepancies between satellite-derived data and ground-based measurements.

Interpreting Surface Radiation and Temperature Trends in Europe (Rolf Philipona, Physikalisch-Meteorologisches Observatorium Davos, World Radiation Data Centre)

From 1980 to 2005 the surface temperature over land in Europe increased about twice as much as the northern hemisphere average. Surface radiation measurements from the Automatic Network (ANETZ) of MeteoSwiss, the Alpine Surface Radiation Budget (ASRB) network and the BSRN station Payerne in Switzerland were used to show how effects of radiative fluxes and forcings on changes of temperature and humidity can be investigated. ASRB stations measuring all radiative components since 1995 allow contrasting changes of the radiation budget to changes of surface temperature and humidity. The measurements show strong correlation between increasing surface temperature and the total absorbed radiation (shortwave net plus longwave downward). Clouds strongly modulate individual shortwave and longwave fluxes with a net cloud effect that is slightly warming on average over the six investigated stations in the Alps. ANETZ measurements show solar net radiation decreasing from 1981 to 2002. In contrast, reconstructed longwave radiation using absolute humidity is increasing. Hence, the temperature rise during this period is likely due to greenhouse warming. From 1981 to 2005 however, solar net radiation is increasing and this mainly due to the heat wave summer 2003 and the sunny 2005. Cloud investigations show that decreasing cloud amounts on the one side let to this increase of solar radiation, whereas on the other side it let to an overcompensating decrease of longwave radiation, leading to decreasing total absorbed radiation and finally to a reduced warming for the period 81-05 compared to the period 81-02. Hence, the investigations so far show no evidence for shortwave nor cloud warming. Instead, temperature in the Alps increases due to longwave radiative forcing, which manifests an increasing greenhouse effect with strong water vapor feedback.

Flux Analysis: On Estimating Continuous Clear-sky Upwelling SW and LW (Chuck Long, Pacific Northwest National Laboratory-PNNL)

A description of the techniques associated with the continuous estimation of clear (i.e. cloudless) sky upwelling SW and LW irradiances was presented. The motivation for this work stems from the need to determine the complete net effect of clouds on the surface radiative energy budget, which must include the upwelling as well as the downwelling components, in order to relate to satellite top-of-atmosphere determinations of "cloud forcing" and compute the energetics of the atmospheric column radiative flux divergence. Results show that the clear-sky upwelling SW methodology now accounts well for extreme changes in surface albedo such as those related to snow fall and melt events. The methodology developed for clear-sky LW shows Very good agreement to the corresponding clear-sky measurements, and appears to give at least qualitatively reasonable results. It is acknowledged that it will be difficult to validate the clear-sky upwelling LW estimations for cloudy periods, primarily due to the lack of accurate enough surface energy model capability to be used for comparative "truth".

Analyses of Flux Analysis Results: Examples from BSRN Sites (Chuck Long, PNNL)

Results from applying the Flux Analysis methodology to two case studies from BSRN data were presented. In the case of the ARM tropical western Pacific Nauru site, a climatological decrease in downwelling SW irradiance occurred starting in December of 2001 when the site experienced a transition from the convectively suppressed to the convectively active regime of the Walker circulation. The actual decrease in SW is shown to be due to a distinct shift in sky cover frequency distribution away from smaller sky cover amounts toward more overcast skies. Additionally, indications are that Nauru has once again entered the suppressed phase at the end of 2005. For the Antarctic, the increase in downwelling clear-sky SW is shown to be a manifestation of the influence of the Mt. Pinatubo aerosols at all three sites in the early years of the time series. The changes in all-sky downwelling SW are shown to be associated not with changes in sky cover frequency distributions (as with Nauru), but rather in changes in the frequency distribution of cloud visible optical depths. In the case of Georg von Neumayer, overcast clouds exhibit a large shift toward optically thinner values, whereas the opposite is true for the South Pole and Syowa. Finally, it is noted that the Flux Analysis methodology significantly increases the value of BSRN-style surface radiation and meteorological measurements above the value of just the measurements themselves. Thus it is strongly recommended that BSRN sites strive to include not only the downwelling radiation, but the surface meteorological and upwelling radiation measurements as well.

V. UV

Spectral Solar Irradiance Measurements in the UV Region and Cloud Documentation at Lindenberg (Uwe Feister, Deutscher Wetterdienst, Richard-Aßmann-Observatorium)

Spectral measurements of solar radiation in the UV region have been carried out at the Lindenberg Observatory since 1995 by a Brewer spectroradiometer of the type MKIV. The UV data base is being used for the validation of UV index forecasts and in the European SCOUT-O3 project together with long-term records of global and diffuse radiation, sunshine duration, column ozone, aerosol optical depths and standard meteorological data such as cloudiness, visibility and snow cover for the re-construction of solar UV irradiation into the past. Additional UV spectroradiometers including fast scanning instruments were installed at the Lindenberg site in 2003 to help improve and extend the UV data base, and make the derived UV doses such as hourly and daily UV irradiation more representative. Improvements in the local facilities for testing and calibrating spectroradiometric instruments together with the additional instruments at Lindenberg have provided better conditions for calibration and measurements.

Clouds play an important role in the radiation balance at the Earth's surface. Using a Whole Sky Imager that was developed and calibrated at the Marine Physical Laboratory (MPL) of the University of California San Diego, cloud cover, cloud distribution and contrails have been documented at Lindenberg since 2003 at short time steps (5 to 10 minutes). In addition to cloud cover, radiances at almost 1 million directions can be derived by post processing of raw images taken in different broadband ranges of the visible and near infrared region. The post processing algorithms in use are being upgraded and improved at MPL using Lindenberg WSI data, and methods for on-site calibration tests are being developed.

Calibration of Erythermal Weighted Broadband Filter Radiometers: News from COST 726 (Julian Gröbner, PMOD/WRC)

The goal of Working Group 4 of COST Action 726 "Long term changes and Climatology of UV Radiation over Europe" is to improve the quality and comparability of broadband UV radiometer networks in Europe. Three tasks were defined which should achieve this goal. First, Standard Operating Procedures for Broadband Instruments to Measure Erythemally Effective Radiation have been written in a joint initiative between COST 726 and the WMO Scientific Advisory Group for UV Measurements. Second, an intercomparison campaign to characterize, calibrate and compare broadband UV radiometers will be held in August 2006 at PMOD/WRC. Third, this intercomparison will be used to assess the calibration capabilities of up to seven European UV calibration laboratories and thus initiate the coordination of their calibration activities for the future. The overall aim will be to standardize and homogenize broadband UV measurements in Europe.

Calibration Checks for UV Erythemal Broadband Radiometers (Laurent Vuilleumier, MeteoSwiss)

In the framework of the Swiss Atmospheric Radiation Monitoring program (CHARM) of MeteoSwiss, UV erythemally-weighted irradiance is measured using SolarLight 501A UV broadband radiometers (biometers) at four stations in Switzerland, including the BSRN station of Payerne. While the global component is measured at all stations, the direct and diffuse components are also measured at Payerne and Davos. Recommendations for measuring UV erythemal irradiance with broadband radiometers require the instruments to be calibrated by comparison to a traceable absolute spectral irradiance reference, taking into account the difference between the instrument spectral response and the theoretical Commission Internationale de l'Eclairage erythemal response. Because such calibrations should be relatively frequent (at least yearly), a method for checking the calibration of a given instrument by comparison with a reference instrument traceable to absolute spectral irradiance has been devised at MeteoSwiss. Issues of instrument stability, inter-instrument reproducibility and operational uncertainty were explored. Three instruments were chosen as reference and were fully calibrated according to the recommendations mentioned above by two different centers and were subsequently measuring side by side in operational mode during several test periods. The reproducibility of observations made according to the recommendations could then be checked, and was found to be compatible with the usually quoted uncertainty. The uncertainty due to the calibration process is usually estimated to be on the order of 5%, but may be slightly in excess of this level. The reproducibility of UV erythemal measurements obtained with the three fully calibrated instruments was found to be just within such limits. Comparison of spectral characterizations of these instruments suggests that a significant part of this uncertainty is linked to such characterization. Inter-comparison of about 20 biometers showed two distinct categories of instruments. While about 15 instruments (including the reference group) had very similar response when measuring concurrently and collocated, the rest of instruments showed significant differences with the reference group. Moreover, for some instruments, the observed differences could not be related to any environmental condition changes (ozone column, solar zenith angle, pressure, humidity, temperature). Excluding the instrument that showed significantly different behavior, the inter-instrument reproducibility is on the order of 2%. In addition an uncertainty depending on the precision of the local ozone total column determination should be added.

Intercomparison of the Solar UV-B Radiation for Jerusalem, Bet-Dagan and Sdom (Dead Sea), Israel (Vera Lyubansky, Israel Meteorological Service)

The UV-B radiation data are being monitored systematically at three meteorological stations situated in different climatic regions of Israel: one located in Jerusalem, in the Campus of Jerusalem University, the second in Bet-Dagan, Israel Meteorological Service, and the third at the western shore of the Dead Sea at a site called Sdom. Jerusalem is located at $31^{0}46^{'}$ N latitude $35^{0}11^{'}$ E longitude and 780m above sea level,

Bet-Dagan is located at $32^{0}00^{'}$ N latitude $34^{0}49^{'}$ E longitude and 30m above sea level, whereas Sdom is located at $31^{0}05^{'}$ N latitude $35^{0}23^{'}$ E longitude and -390 m under sea level. The instrumentation utilized to measure the UV-B radiation consists of a YES UV-B-1 Ultraviolet Pyranometer, thus giving the opportunity to define the UV-B irradiance in two wavelength bands: 280-315nm and 280-320 nm. The intercomparison of the solar UV-B radiation for two wavelength bands is presented for Jerusalem, Bet- Dagan and Sdom utilizing data measured from January 2000 through December 2005. The monthly hourly and daily values for UV-B radiation are reported on the annual average basis. The site altitude has great influence on the UV-B irradiance in Israel. It can be seen very distinctly in yearly means at three stations, and in monthly totals from May to September, the period of high level of UV-B and low cloudiness and also in daily cycle of UV-B radiation The yearly mean of UV-B radiation for 280-315nm was 7.89 Wm^{-2} for Jerusalem, 7.34 Wm^{-2} for Bet-Dagan and 6.99 Wm^{-2} for Sdom. The yearly mean of UV-B radiation for 280-320nm was 15.19 Wm^{-2} for Jerusalem, 14.11 Wm^{-2} for Bet-Dagan and 13.77 Wm^{-2} for Sdom.The intercomparison of the UV-B measurements in summer 2005 for four different stations of Israel (Mizpe-Ramon, Jerusalem, Bet-Dagan and Sdom) was also presented and confirms the results obtained for 6 years period.

VI. IR AND CLOUDS

Responsibilities of the Infrared Calibration Center – Angular Response of Pyrgeometers (Julian Gröbner, PMOD/WRC)

The angular response of several Eppley PIR and CG4 pyrgeometers were measured at the PMOD/WRC. The measurements show that the angular response of PIR pyrgeometers deviate substantially from the desired cosine response and furthermore show clearly the influence of dome thermistors, especially in the case of modified PIRs. On the other hand, CG4 pyrgeometers have a much better angular response, even though asymmetries were observed in one of the three tested instruments. The consequences of these observed deviations will need to be investigated, especially in the presence of varying radiance distributions or in the presence of point like infrared sources. The calibration procedures using in-situ measurements should not be significantly affected since any deviations are taken into account during the calibration, even though blackbody based calibrations might be affected due to differences between the blackbody and atmospheric radiation distributions.

Cloud Effect of Shortwave Radiation on Clouds in Payerne: A Case Study of Surface Radiation Simulation with MODTRAN (Daniela Nowak, ETH Zurich)

The effect of clouds on radiation and the aerosol indirect effect are responsible for large uncertainties in climatology (IPCC, 2001), and better information on these effects are needed. For this purpose, selected stratiform cloud classes are analyzed in this project. A first empirical study of data from the BSRN station in Payerne, Switzerland, showed that different stratiform cloud types have different effect on the net incoming radiation. The effect of stratus clouds is negative (-4.8 W/m2) while nimbostratus clouds have a positive effect (+19.5 W/m2) on longwave and shortwave downward radiation. Ten clear sky and three cloudy sky situations were chosen for detailed simulation with the radiative transfer model MODTRAN. These cases were chosen to demonstrate the validity of the approach, which will be soon extended to a longer period, and the results of this first analysis are presented here. Five clear sky situations in both summer and winter 2003 as well as three cloudy sky situation were chosen. The results in winter and summer clear sky simulations showed a good agreement of the simulated direct, diffuse and global shortwave downward and reflected radiation in most cases (±10 W/m2). Agreement is less good for cases with very low optical depths or few clouds with a higher elevation angle. A very strict selection mode was applied to select cases with 100% stratus cloud cover, thus only 3 cases were found by now within a time period of three months of the COST720 Temperature humidity and Clouds (TUC) profiling experiment (winter 2003/04, Payerne). For these cases the results agree well with the measurements and the differences between the modeled and the observed shortwave diffuse (global) and shortwave reflected radiation are within ±2 W/m2. Clear sky and simple cloud situations (stratiform, single layer) can be well simulated with MODTRAN. Detailed observations of the atmosphere are needed to fit model calculations to observations and especially satellite information is needed for TOA fluxes and cloud information (type and cover).

How to Treat Changes in PIR Pyrgeometer Calibrations? (Gert König-Langlo, Alfred Wegener Institut für Polar- und Meeresforschung)

Within the timeframe BSRN-measurements have already been performed significant improvements in the instruments and calibration procedures have been made. Although these improvements have to be judged as a positive development, they inhomogenize the obtained time series and make the detection of trends in surface radiation fluxes to become a very questionable task.

As an example, the time series of the long-wave downward radiation data obtained at the BSRN-station Neumayer show a decreasing trend of about 10 W/m2 between 1992 and 2005. As can be shown 50% of this trend can be explained as a result of a change in the calibration procedure which took place in 1998.

It is believed a clear coordinated strategy has to be established within the BSRN whether and how such kind of data quality changes should be corrected. Otherwise the BSRN data archive may fail to contribute to detect trends in the surface radiation fluxes.

Radiative Impact of Clouds and Aerosols Based on Multiple Instrument Synergy at the SIRTA Observatory (Martial Haeffelin, Institut Pierre Simon Laplace)

SIRTA is a cloud and radiation observatory located 25 km south of Paris. The research objectives of SIRTA are focused on the study of dynamic, microphysical, and radiative processes of clouds and aerosols. In this presentation we focus on radiative impact of high-altitude clouds. Retrievals of cloud and aerosol properties throughout the troposphere are obtained by combining active (radar + lidar) and passive (sun photometer, IR and microwave radiometers) remote sensing instruments. The BSRN archive contains now almost three years (mid 2003 to 2006) of SIRTA downwelling shortwave and longwave radiation data.

To study cloud and aerosol effects in surface SW and LW irradiances, one must first establish reliable clear-sky references. We use parametric equations to represent downwelling SW clear-sky fluxes as a function of solar zenith angle power law (Dutton et al, 2001) and downwelling LW clear-sky fluxes as a function of the sky emissivity driven predominantly by the integrated water content (Prata et al., 2005).

We compute cloud effect as the difference between the measured flux (SW and LW) minus the clear-sky reference. We show distributions of cloud effect for different types of clouds (low, mid and high-altitude clouds). We find evidence of cloud effect on surface downwelling LW radiation for clouds as high as 11km. We find evidence of cloud effect on surface downwelling SW radiation for semi-transparent high-altitude clouds (optical depth ranging between 0.3 and 0.03). For subvisual clouds (optical depth less than 0.03) the cloud effect is within the uncertainty of the clear-sky reference. The clear-sky SW reference values are strongly sensitive to the aerosol loading used to establish the parametric fit.

Future work will focus on reducing uncertainties in clear-sky references and studying daytime and nighttime SW and LW cloud effects of a few golden days.

Stability of DWD Infrared Standard Group and the Relation to the BSRN Routine Measurements (Klaus Behrens, Deutscher Wetterdienst, Germany)

The DWD Infrared Standard Group, which consists of four pyrgeometers, two PIR and CG4, respectively, were calibrated in June 2004 at the PMOD/WRC in Davos. These pyrgeometers are shaded, so that direct radiation from the Sun cannot heat the domes. Two other pyrgeometers are unshaded. The atmospheric downward radiation is calculated using the Pyrgeometer-Formulae by Philipona for the PIRs and the simple Pyrgeometer-Formulae for the CG4s, respectively. The 1-minute-means for April 2005 to April 2006 were analyzed. During nighttime cloudless cases, the monthly means of the ratio of a single instrument to the mean of all the instruments did not deviate by more than 1%, corresponding to about 2 W/m². Only one PIR oscillated between 1.01 and 1.03 and the reason for that is still unknown. Also during the daytime the averages of the cloudless cases of the Standard Group were within ±2 W/m².

The BSRN routine measurements were compared with the corresponding values of the Standard Group in cloudless nighttime cases. The analysis shows that during the 13-month period the monthly means oscillated within +2 W/m² to -3 W/m². The conclusion is, that between April 2005 and April 2006 the DWD IR Standard Group was stable and the BSRN routine measurement in good agreement with the Standard Group

VII. WORKING GROUPS STATUS AND RELATED ACTIVITIES

Pyrheliometer Thermal Effects (Tom Stoffel, NREL)

The Eppley Normal Incidence Pyrheliometer (NIP) measures direct beam solar irradiance using a thermopile-type detector mounted at the base of a collimating tube providing at 5.7º field of view. Energy from the sun irradiates a black receiver in thermal contact with the thermopile, which in turn produces a voltage proportional to the sun's direct beam energy. Ideally, the thermopile responds only to energy directly from the sun, but for practical reasons, it is impossible to completely isolate the instrument from the ambient temperature and other environmental influences on thermal transfer that can have a small effect on the instrument's response. In this study, we investigate three sources of thermal influence in the environment (temperature gradient, wind, and solar heating) and attempt to quantify their effect on instrument performance. In addition, our work shows that these elements may contribute to a variable, but characteristic bias pattern apparent in diurnal instrument calibration responsivity plots.

Preliminary results of outdoor and indoor experiments at NREL suggest the typical range of NIP responsivity (µV/Wm-2) variation with solar zenith angle, Rs (Z), can be reduced from existing 2% or 3% to less than 1% under clear-sky conditions. Future investigation is planned to evaluate options for reducing thermal effects on NIP calibration responsivity and deployment for routine BSRN measurements.

Oceans Working Group (Ken Rutledge, Climate Sciences Branch, AS&M, Inc.)

This WG was established during the 8th BSRN Workshop and Scientific Review (26-30 July 2004) held in Exeter, U.K. The full report of the WG is in Appendix E.

Transmission and Aerosol Optical Depth Working Group (Bruce Forgan, Bureau of Meteorology Regional Institute Centre)

The progress since the last meeting was summarized as the significant impact on AOD verification by the GAW SAG on Aerosols, the Filter Radiometer Comparison II – Davos Sept-Oct 2005, and the development of a common quality qualifier for assessing the suitability of the transmission signal for AOD calculations. The interaction with GAW also suggested the addition of an intermediary parameter for the AOD derived product, namely AOD + cloud OD. Concern was expressed on the divergence of nomenclature for optical extinction parameters and in particular the divergence from ISO (and WMO) technology. The proposed cloud-filtering algorithm was described. The latest version of the transmission format was distributed, and requests for transmission data to be sent to Bruce Forgan for conversion into (AOD + cloud OD) and AOD. The details on the mode of storage and retrieval from the BSRN ftp archive have yet to be resolved, but should be completed within three months.

Clouds Parameters Working Group (Chuck Long, Pacific Northwest National Labs)

The Cloud Parameters Working Group has come a long way since it's formation at the Melbourne BSRN Workshop. Current retrievals possible include detection of clear-sky periods, continuous estimates of all radiative components (up, down, SW, and LW) and thus the complete net effect of clouds on the surface radiative energy budget, daylight total and 24-hour LW effective fractional sky cover, effective cloud transmissivity, cloud visible optical depth for overcast skies, cloud effective radiating temperature, and crude cloud height estimates. A general discussion by the BSRN membership as a whole ensued, including the topic of what is the scope of the WG charge to address the question: "What simple, affordable, and durable additional instrumentation might be available and deployable for BSRN sites?" It was decided that the WG would prepare and present a Summary Report for the next BSRN workshop, and include a brief discussion of inexpensive instruments that might be of interest as candidates for recommended BSRN measurements.

UV Working Group (Laurent Vuilleumier, MeteoSwiss)

Activities of the UV WG included an intercomparison of SolarLight UV broadband radiometers at the Payerne Station and an irradiance scale intercomparison between the ECUV and the CUCF. The full report and recommendations of this Working Group are in Appendix D.

UV Instrumentation within the WMO and the NDACC (Gunther Seckmeyer, Institute of Meteorology and Climatology, University of Hannover, Germany)

In recent years the requirements on reliable UV measurements have been investigated and standardized by several researchers and scientific committees. Both the network for the detection of atmospheric composition change (NDACC, formerly NDSC) as well as the Scientific Advisory Group (SAG) on UV monitoring within the global atmosphere watch program of WMO have published a series of documents in which the specifications for trend detection instruments as well as instrument characterizations have been described. The presentation illustrates the use of UV instruments in extreme conditions like Antarctica or the tropics. It is concluded that broadband instruments should only be used for specialized investigations and the data should be handled with great care. To reach the goals of the BSRN network it is recommended to measure UV radiation with spectroradiometers.

Further reading:

Instruments to measure solar ultraviolet radiation, G. Seckmeyer, A. Bais, G. Bernhard, M. Blumthaler, C.R. Booth, P. Diesterhoft, P.Eriksen, C.Roy, K.Lantz, M.Myauchi, R.L. McKenzie. Part 1: spectral instruments, WMO-GAW Report No.126, (2001); Part 2: Broadband instruments measuring erythemally weighted solar irradiance, WMO-GAW report No.164, (2005), *http://www.wmo.ch/web/arep/gaw/gawreports.html.*

PAR Working Group (Rachel Pinker, University of Maryland)

The original charge to the Photosynthetically Active Radiation (PAR) Working Group was to investigate what instruments are available to measure PAR and their accuracy, and to decide if PAR should be included in BSRN archive.

About 15 instruments participated in the first PAR instrument intercomparison experiment, which was held in Regina, Canada in July 2002. The instruments compared were manufactured by Li-cor; Kipp and Zonen Par Lite; Apogee; Middleton; and Skye-Probetech. The following spectroradiometers were evaluated: a diode array instrument in the 380-780 nm intervals (1 nm resolution); an Optronics OL754 grating spectrometer in the same spectral intervals. Preliminary results shown at the BSRN meeting in Exeter (2004) indicated that instruments of the same kind tended to give similar results, however, there was a distinct difference between the instruments. An unresolved issue of this evaluation is that a full calibration of the spectroradiometer was not available.

The radiation community recommended looking into the possible use of the MFRSRs to measure PAR. The instrument has seven channels with six pass-bands centered near 415, 500, 610, 665, 862 and 940 nm, an unfiltered silicon pyranometer, and a filter band-pass of 10 nm. It uses an automated shadow-banding technique to measure total and diffuse horizontal and direct normal spectral irradiance through a single optical path.

Efforts were undertaken (B. Forgan) to examine how to establish a direct beam reference for PAR. Data from two Middleton 'absolute' spectral radiometers were used. There are a number of methods to produce a stable reference of the order of 95% uncertainty (<2%) with fairly simple pyrheliometer measurements. This group also was involved in the development of a small spectral radiometer that can measure PAR (or any other spectral range) of interest. It is likely that at least one PAR unit will be deployed at an Australian station together with an 'absolute' spectral radiometer.

PAR related observations and analysis were conducted at a predominantly clear-sky desert site where routine aerosol observations were available from a Cimel instrument [a collaborative effort between the University of Maryland (R.T. Pinker, H. Wang) and the Institutes for Desert Research Ben-Gurion University of the Negev, Israel (A. Karnieli and D. Faiman)]. Several PAR sensors, a Li-Cor spectroradiometer and radiative transfer models were used. Nominal wavelength for conversion from PAR computed in W/m^2 to PAR observations made in PPFD obtained from spectral measurements and spectral irradiance computed by Santa Barbara DISORT Atmospheric Radiative Transfer (SBDART) Code was found to be 548 nm. It was also found that the model output and the spectral measurements are not in full agreement and the need for a spectroradiometer comparison/calibration campaign was recognized.

The working group made the following recommendations:

- Need for additional spectral measurements
- Measurements of PAR direct and diffuse
- Intercalibration of spectroradiometers

BSRN International Project Manager Requests and Suggestions to Site Scientists (Ells Dutton, NOAA, GMD)

The Network manager made a brief presentation on the results of his recent quality assessment of the long-term data records archive by BSRN. In that assessment, time series of deseasonalized monthly averages were visually examined for consistency, continuity and homogeneity. Site scientist with data in question as a result of the inspection had been previously notified and every case the problems had been addressed and solved. The presentation continued with several requests and suggestions for the site scientists from the project manager. These were aimed at addressing issues and concerns that had accumulated since the previous meeting. The list of topics discussed follows where the title of topic is generally self-explanatory but the details of the related presentation and discussion is beyond the scope of this report.

- Your stations, your data, and your organization
- BSRN is constrained not to go where it might naturally be led - this is due to operational/institutions requirements and limitations
- Make timely archive submissions, set goal to improve
- On communications within BSRN: persistence pays, follow-up, be aggressive
- Resubmit corrected data to the archive
- Send upper air data if available
- Send basic met data
- Respond to up-coming solicitation on desired archive features
- Keep making AOD measurements, very valuable in data analysis
- For funding possibilities to maintain sites - leverage off the international contributions BSRN is making
- Keep track of activities that could contribute to your BSRN working group(s)
- Investigate additional, improved, more efficient field site QC
- No net radiometer data should be submitted (field 300) (please, personal request)
- Reporting UV-B and PAR – beware that measurement specifications for BSRN submissions had never been fully established and there are several pitfalls in these quantities.

Spectral Measurements Working Group (Bruce Forgan, Bureau of Meteorology Regional Institute Centre)

There has been little development in low (total) cost spectral sensors in the last two years. However, there has been some work on defining a detector based standard for PAR using existing instruments. Positive developments in low cost CCD array detectors have occurred in the period but putting them in a package fro routine measurements has to be realized, especially as there is a tendency to move away from RS-232 to USB communication protocols as the latter are more suited to laboratory conditions. One problem that has been identified in the last two years has been the sharp change in transmission between 1-3% of Teflon/Spectralon diffusers as about 20 C. As several 2πsr devices use Teflon as the sensor head this potential problem needs to be investigated.

Uncertainties Working Group (Bruce Forgan, Bureau of Meteorology Regional Institute Centre)

There has been steady progress on the development and understanding of uncertainty analysis by the BSRN community and this is reflected in the increased use of uncertainty derivations in presentations. It was pointed out that no one uncertainty analysis can be applied universally across the community for a particular quantity as each quantity is the result of different process, however, the ISO Guide to Uncertainty in Measurement provides a uniform framework for comparison purposes. Work has been done on AOD, direct solar irradiance measurements and pyranometer and pyrheliometer calibration. The effects of using a poorly defined measure and different methods for propagation of errors in constant type B factors was presented using the daily global solar exposure as the quantity but expressed as an exposure (Jm-2) or and irradiance (Wm-2).

Pyranometer Working Group (Joe Michalsky)

The Department of Energy Atmospheric Radiation Measurement (ARM) program has approved and provided funding for the third diffuse intensive observation period (IOP) to be held during October 9-20, 2006. The best performers from the previous two IOPs will be selected for this IOP. Currently the plans are to include a Kipp & Zonen CM21, CM22, and Rolf Philipona's modified CM22. There will also be one or two Eppley 8-48's, the black and white instrument use in ARM for the diffuse horizontal irradiance measurements.

Measurements by an Eppley PIR will be used to correct instrument offsets. The goal is to define a diffuse working standard that may serve the ARM community and, perhaps, the BSRN community for this parameter since the development of an absolute standard for this measurement is unanticipated. The instrument will be calibrated using a cavity radiometer and the shade/un-shade technique during the IOP. Offsets will be determined using nighttime data and extrapolated to daytime values when needed as in the previous IOPs. Geometry is a non-issue since all candidate detectors have the same size, and they will all be mounted and shaded the same way. The Meteorological Service of Canada will provide angular response measurements for all the candidate instruments. The National Renewable Energy Laboratory will provide spectral reflectivity and absorptivity measurements for the instruments' detector surfaces. These latter two measurements are imperative if we are to have a realistic chance of explaining differences that may be measured.

VIII. AEROSOLS AND WATER VAPOR

Results of Filter Radiometer Comparison II in Davos, 2005 (Christoph Wehrli, PMOD/WRC)

FRC-II took place from 26 September to 13 October 2005 at Davos with a participation of 15 radiometers from 9 institutions. The comparison aimed to fulfill the specifications set by the WMO GAW program calling for a minimal number of 1000 samples to be collected during at least 5 days of measurements with aerosol optical depths at 500nm between 0.04 and 0.2, and defining a U95 uncertainty within 0.005 + 0.01/m optical depths to be achieved for traceability between radiometers.

Excellent weather conditions permitted to over accomplish the measurement requirements and the traceability criterion was met for 12 radiometers.

In a special exercise, measurements from a single radiometer were evaluated by thee participating experts, using additional data taken by the same instrument at 3 different sites for calibration.
The following conclusions were drawn:

1) Recommendations of WMO for filter radiometer comparisons were fulfilled
2) Ground based AOD measurements can achieve a U95 homogeneity of 0.005+0.01/m between a dozen of representative Sun photometers
3) Algorithms used for calibration and evaluation may contribute a significant part to the observed dispersion in AOD measurements
4) Ångström exponent (500/862) doubtful at AOD<0.1
5) Filter radiometers may have <u>much</u> better stability than 10 years ago

An Operational Aerosol Optical Depth Product from a MFRSR Network, SURFRAD/BSRN (John Augustine, NOAA Earth System Research Laboratory)

Spectral visible data has been measured at SURFRAD BSRN stations in the USA since 1995, but until recently, nothing has been done with the data. The methods used to calibrate MFRSR channels and compute aerosol optical depth (AOD) is similar to traditional methods, but with some nuances. The automated method developed to calibrate the spectral channels cross references MFRSR measurements with times identified as completely clear by the Long and Ackerman clear-sky identification method. This ensures that the MFRSR data used for calibration is not adversely affected by clouds or high atmospheric aerosol content. Langley plots are constructed from the MFRSR data identified, and calibration Vo values are extrapolated on those plots to zero air mass. These Vo values are grouped in one or two month periods, treated statistically to generate meaningful means, and the mean Vo values are plotted in time series over two year periods. The error of the mean Vo values is computed using standard propagation of error methods. The long-term Vo time series are fit to a polynomial that includes sine, cosine, and linear terms so that Vo values may be interpolated to individual days for AOD calculations. The periodic function is necessary because the Vo time series consistently show greater values in summer than winter for all instruments and all stations. Interpolated Vo values for individual days are combined with two-minute MFRSR measurements to generate daily time series of total optical depth for all channels, except 940 nm. Measured station pressure is used to accurately correct the total optical depth for molecular scattering, and total ozone from a NASA web site is used to correct the total optical depth for ozone absorption. The result is daily time series of AOD. A method that tests the stability of the individual daily AOD time series serves to screen out measurements that have been adversely affected by clouds. This AOD method has been operated successfully on four SURFRAD stations and appears to work well. The summertime maximum is apparent at all sites, and the springtime maximum that is presumably caused by Asian dust appears in the time series for the western U.S. stations. A preliminary daily AOD product for SURFRAD BSRN stations has been proposed, however, a transmission file for BSRN input has not yet been formulated.

Aerosol Optical Depth and Integrated Water Vapor Column from Solar Photometry at Swiss Alpine Sites (Laurant Vuilleumier, MeteoSwiss)

At four locations in Switzerland, MeteoSwiss measures atmospheric transmittance at spectral narrow bands with sun photometers including 9 wavelengths between 368 nm and 1024 nm used to infer Aerosol Optical Depth (AOD), and 3 wavelengths in water vapor absorption bands at 718 nm, 817 nm, and 946 nm used to infer integrated water vapor column (IWV). These instruments are Precision Filter Radiometers (PFR) built at the PMOD/WRC at Davos. Currently, in situ calibration by Langley plot analysis has been achieved only at mountain sites. Because of the difficulty of achieving such calibration at the low elevation site in Switzerland, an instrument rotation schedule has been introduced, which will allow using calibration values derived at the mountain sites to be used at the low elevation sites, including re-analysis of the previously recorded raw data at the low elevation sites, including the BSRN station of Payerne.

The Alpine site time series of IWV measured at Davos (1590 m asl) and Jungfraujoch (3580 m asl) were analyzed. At both sites, IWV exhibited a maximum in summer and minimum in winter. Annual mean IWV was 6.7 (±3.9; 1 std) kg m–2 from 1995 to 2005 and 2.2 (±1.5) kg m–2 from 1999 to 2005, at Davos and Jungfraujoch respectively. Co-located GPS measurements exhibited a small positive IWV bias (GPS – PFR) at Davos (0.4 kg m–2) and a large negative bias at JFJ (-1.5 kg m–2). Microwave radiometer IWV at JFJ agreed well with PFR IWV suggesting that GPS IWV suffers from unmodeled effects. Linear IWV trend analysis indicated no significant trend at either Davos or JFJ for clear-sky periods. The GPS-IWV time series is at present too short to determine the trend for all-weather conditions.

Characterization of Absorbing Aerosols and Water Vapor using MFRSR Measurements (Mikhail Alexandrov, Columbia University and NASA/Goddard Institute for Space Studies)

We present new features of our analysis algorithm for Multi-Filter Rotating Shadowband Radiometer (MFRSR) data that include retrieval techniques for spectral aerosol single scattering albedo (SSA) and column amount of precipitable water vapor (PWV). The SSA retrievals employ MFRSR measurements of both direct normal and diffuse horizontal irradiances. We show dependence of the retrieval reliability on aerosol optical thickness (AOT) and discuss possible instrumental problems that may cause it. The algorithm has been tested on a long-term dataset from the local MFRSR network at the DOE Atmospheric Radiation Measurement (ARM) Program site in Southern Great Plains (SGP). Our results are compared to AERONET's almucantar retrievals of SSA from CIMEL sun-photometer co-located with the MFRSR at the SGP Central Facility. A constrained variant of our algorithm, assuming zero nitrogen dioxide column values, has been used for this comparison and to study the influence of the uncertainty associated with this atmospheric gas on the retrieved aerosol absorption properties. Precipitable water vapor column amounts are determined from the direct normal irradiances in the 940 nm MFRSR spectral channel. HITRAN 2004 spectral database has been used to model the water vapor absorption, while a range of other databases (HITRAN 1996, 2000, ESA) has been used in sensitivity study. The results of the PWV retrievals for SGP's MFRSR network were compared with correlative measurements by Microwave Radiometers (MWR), GPS, AERONET, and MODIS satellite product. In the latter case the spatial structure of water vapor field obtained from the MFRSR network data has been compared to the satellite data.

Long-term Observations of Aerosol Optical Depths - A Completion to BSRN (Michael Weller, Meteorologisches Observatorium Lindenberg, Deutscher Wetterdienst)

Integrated in experiments with the Russian space stations Salut and Mir the Meteorological Observatory Lindenberg (founded 1905) started measurements of the aerosol optical depth (AOD) in different regions of the world in 1978.They run routinely in Lindenberg since 1986. The measurements have been gradually expanded to a German monitoring system of the AOD, named ZuZi (**Zu**gspitze -**Zi**ngst). The measuring sites from the Baltic Sea to the Alps cover regions of different aerosol column- concentrations. The time series (1986-2004) of the AOD, including different episodes of interest (Sahara dust, Pinatubo effect redevelopment of industry) are presented. Column related optical aerosol parameters retrieved from the AOD- spectra of all sites are presented and the influence of the optical aerosol parameters on the "top- of -atmosphere" direct radiative forcing, the cloud reflectivity and the radiance field as measured on board of satellite are discussed. Comparisons between the measured AOD and the AOD retrieved by the MODIS instrument/algorithm are shown finally.

IX. CALIBRATION METHODS AND MEASUREMENT UNCERTAINTY

Lindenberg Observatory Reference Station for the Global Water-Vapor Project GVaP (Dirk Engelbart, German Met. Service, Richard Aßmann Observat., Lindenberg)

Under the scope of the Global Water Vapor Project GVaP of WMOGEWEX, the department groundbased remote sensing at the RichardAßmann Observatory Lindenberg operationally runs a full suite of water-vapour and cloudprofiling instruments in order to collect longterm monitoring data of water vapour in all three phases as a reference for intercomparisons, for NWP and satellite validation as well as for climatological purposes. Apart from general information on GVaP, the presentation has given examples on some of the associated measuring systems and has shown selected results from a recent field campaign (LAUNCH2005) using these instruments.

Pyranometer Thermal Offsets (Tom Stoffel, National Renewable Energy Laboratory)

By design, pyranometers with thermopile-type detectors must account for possible thermal offsets, i.e., an undesirable response to infrared radiation fields in the atmosphere or from parts of the pyranometer itself. Thermal offsets are often overlooked because of their relatively small magnitudes when compared to the overall solar signal at higher irradiance. With the demand for lower measurement uncertainty for solar radiation data, recent publications have described a renewed interest in this offset, its magnitude, and its effect on solar measurement networks for atmospheric science and solar energy applications. Recently, it was suggested that the magnitude of the pyranometer thermal offset is the same whether the pyranometer is used for diffuse irradiance (shaded) or total hemispheric irradiance (unshaded). Therefore, calibrating a pyranometer using the shade/unshade method would result in accurate responsivity calculations because the thermal offset error is canceled. When using the component sum method for the pyranometer calibration, the thermal offset error, which is typically negative when the sky is cloudless, does not cancel, resulting in an underestimated shortwave responsivity. Most operational pyranometers that are in use for solar radiation measuring networks are calibrated using the component sum method since it is possible to calibrate many pyranometers simultaneously.

Correcting the component sum method results to account for the thermal offset error is important for reducing measurement uncertainty. The goal of my presentation is to describe a method of using a blackbody pyrgeometer calibration system to determine the net-longwave responsivity and apply this thermal characterization information to pyranometer calibration and field data collection.

Summary of correction method:

1. Determine pyranometer longwave responsivity (R_{bb}) using pyrgeometer blackbody calibration system.
2. Compute the shortwave equivalence of the longwave response ($E = Rs_{bb} / Rs_{mfr}$), using the latest manufacturer's calibration factor (Rs_{mfr}) or other shortwave calibration result.
3. Compute pyranometer responsivity to net infrared (Rs_{NET}) as $Rs_{NET} = Rs_{bb} \times E$.
4. During outdoor calibration of pyranometer(s) by summation method, also monitor the downwelling infrared with a PIR.
5. To determine the pyranometer responsivity (Rs_{COR}, microvolts/Wm^{-2}) as:

   $Rs_{COR} = V_{TP} – (W_{NET} \times RS_{NET}) / \text{Ref Irr}$

   where,
   V_{TP} = Pyranometer thermopile voltage
   $W_{NET} = V_{PIR} / K_1$
   V_{PIR} = PIR thermopile signal (microvolts)
   K_1 = PIR thermopile responsivity (microvolts / Wm^{-2})
   $Rs_{NET} = Rs_{bb} \times E$
   Ref Irr = Direct Normal x Cos(Z) + Diffuse

The results demonstrate that correcting the component sum method to calculate the pyranometer responsivity, using the blackbody net responsivity to correct for the thermal offset error, gave a comparable responsivity to that using the shade/unshade calibration method. The correction method resulted in reducing the difference between the component sum and shade/unshade method from 1.47% to 0.18% for model PSP, and 0.42% to 0.25% for CM22. The 8-48 difference increased from 0.09% to 0.15%, but this is negligible. Even though these differences are small after the correction, they might be attributed to calculating the NET-IR as the difference between the sky and pyranometer case radiation, rather than the difference between the sky and detector surface radiation.

Reference: I. Reda, J. Hickey, D. Myers, T. Stoffel, S. Wilcox, C. Long, E. G. Dutton, D. Nelson, and J.J. Michalsky, *Determination of Longwave Response of Shortwave Solar Radiometers to Correct for their Thermal Offset Errors*, Journal of Atmospheric and Oceanic Technology (JTECH) Vol. 22, No. 10. October, 2005

A Mix of Sun and Cloud: Field Calibrations of Pyranometers Using Natural Variations in Sky Conditions (David Halliwell, Environement Canada)

A new method of determining pyranometer calibration values (responsivtivities) is described, using changes in direct and global solar radiation caused by natural variations in cloud conditions. The method uses normal one-minute field data for direct, diffuse, and global irradiance. Data are analyzed to find periods of time where there are large changes in direct irradiance over short intervals, related to intermittent cloud. The global pyranometer's responsivity is calculated from the instrument's voltage change, divided by the sum of the direct and diffuse irradiance change. By selecting times where the within-minute values are stable (standard deviations < $10 W/m^2$) but the between-minute changes in direct beam are large (> $400 W/m^2$), the method gives pyranometer responsivity values that agree to within ±1% of standard calibration methods. The results can be viewed as a function of solar zenith angle, allowing characterization of the instrument's cosine response. By using field data, responsivtivities can be determined for the complete range of environmental conditions found at a site, and the method requires no special intervention or disruption of normal measurements

Shortwave Global Irradiance Uncertainty: Comparisons of State of the Art Instrumentation at the Payerne BSRN Site (Christian Ruckstuhl, Institute for Atmospheric and Climate Science, ETH)

Shortwave irradiance measurements are widely used in climate research. The applications range from estimations of the radiation budget, of solar radiative forcings as well as evaluations of GCM calculations and ground truthing for satellite measurements. For all this applications it is essential to know the uncertainty of these measurements and this on different time scales. From October 2004 until October 2005 a comparison of different instruments was performed at the BSRN site at Payerne, Switzerland. Eight Pyranometers (two CM22, four CM21 from Kipp&Zonen and two Eppley PSP's) and a Pyrheliometer (CH1) with two different diffuse Pyranometers were compared. Solar irradiance is calculated with the original calibration coefficient (C_{org}) of the instruments and with a field adjusted calibration coefficient (C_{adj}), which is determined from seven clear sky days during the summer half year of the campaign. Among the eight Pyranometers measuring global radiation during the entire year the uncertainty (root mean square error) is for C_{org}/C_{adj} 6.5%/4.7% on hourly means, 3.4%/2.6% on daily means and 3.3%/2% on monthly means. Without considering the two PSP's the error among the six Kipp&Zonen Pyranometers reduces to half or less of the percent numbers above. The cosine error of the PSP is the main contributor of the relative large uncertainty of these instruments. Another source of measurement uncertainty is the Pyranometer offset under clear-sky situations. On all Pyranometers equipped with the Philipona (2002, JGR) heating and ventilation system the night offsets were less than -0.2 Wm^{-2} averaged over the one year campaign. The uncertainty of the direct plus diffuse radiation from the new BSRN diffuse setup is on the same order as the uncertainty of the six Kipp&Zonen Pyranometers. Longtime stability was investigated with two global Pyranometers and a direct plus diffuse setup of the Payerne BSRN site. The global Pyranometers show a non-significant drift of 0.26 Wm^{-2}/decade, whereas the global Pyranometers compared to the direct plus diffuse drift with 1.7 Wm^{-2}/decade.

X. REGIONAL TOPICS

Regional Energy and Water Cycle Components over a Heterogeneous Land Surface – The Lindenberg Contribution to GEWEX Baltic Sea Experiment and Coordinated Enhanced Observing Period (Frank Beyrich, Deutscher Wetterdienst (DWD), Meteorologisches Observatorium Lindenberg)

Land surface - atmosphere interaction processes play an important role in the energy and water cycle over a wide range of scales and exhibit a major influence on the diurnal cycle of near surface values of temperature, humidity, wind, and associated phenomena as well as on the spatial distribution of clouds and precipitation. Among these processes, both radiation and the turbulent fluxes of momentum, heat and water vapour represent the fundamental link between the soil-vegetation system and the overlying atmosphere. Over many continental regions, the land surface is characterised by a certain degree of heterogeneity. An adequate description of the surface - atmosphere exchange processes in numerical weather prediction and climate models taking into account heterogeneity effects is therefore fundamental for a reliable simulation of weather and climate conditions both at the surface and in the free atmosphere.

In 1995, the German Meteorological Service (Deutscher Wetterdienst, DWD) initiated the LITFASS project (LITFASS = '**L**indenberg **I**nhomogeneous **T**errain - **F**luxes between **A**tmosphere and **S**urface: a Long-term **S**tudy') in order to develop and to test a strategy for the operational determination of the area-averaged turbulent fluxes of heat, momentum, and water vapour over a heterogeneous landscape at the meso-γ scale (2-20 km). LITFASS combined measurements in the heterogeneous landscape around the Meteorological Observatory Lindenberg (MOL) with numerical model simulations using a large-eddy-simulation (LES) type high-resolution model. The measurements include the operation of networks of rain gauges and radiation sensors in order to characterise the regional-scale variability of the major atmospheric forcing conditions. A full set of micrometeorological measurements (including upward / downward radiative fluxes, turbulent fluxes, profiles of mean atmospheric and soil state variables) is operationally performed over the two dominant land use classes in the area around the Meteorological Observatory Lindenberg (farmland, forest). Aggregation rules and area-integrating measurements techniques are used to derive the energy fluxes at model grid scale.

Micrometeorological data form the boundary layer field site Falkenberg and from the forest site are regularly submitted to the Central Data Archive of the CEOP project, the BSRN sister activity in GEWEX with respect to the global energy and water cycle.

The presentation will give an overview on the MOL-measurements related to energy and water cycle studies with special emphasis on radiation and turbulent fluxes over the heterogeneous landscape around MOL.

Appendix A

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BSRN-9

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9th BSRN Scientific Review and Workshop, 2006 - Lindenberg, Germany
(all times – local, with AM/PM inferred)

Agenda

29 May, Monday 2006 <u>Opening and</u> <u>Overviews</u>

8:15 – 8:45	Registration and set up for first talks
8:45 – 8:50	Announcements – Klaus Behrens and Ellsworth Dutton
8:50 – 9:00	Opening remarks – Prof. Gerhard Adrian, German Weather Service
9:00 – 9:20	Franz Berger – Overview of Routine Observational and Research Activities at Meteorological Observatory Lindenberg - Richard-Aßmann-Observatory
9:20 – 9:35	Gilles Sommeria – Update on WCRP Developments
9:35 – 9:55	Peter van Oevelen – GEWEX Activities
9:55 – 10:05	Hans Teunissen – Global Climate Observing System (GCOS) -- Update for BSRN
9:50 – 10:20	Break
10:20 – 10:40	Ehrhard Raschke – The need for accurate ground-based radiation data for establishing a reliable radiation climatology database
10:40 – 11:00	Paul Stackhouse – GEWEX Radiative Flux Assessment: Surface Working Group Overview and Update
11:10–11:30	Klaus Behrens – Report on the CIMO Expert Team on Meteorological Radiation and Atmospheric Composition Measurements
11:30 – 12:00	Andreas Roesch – Status of BSRN Archive Atsumu Ohmura – Future at ETHZ
12:00 - 1:15	Lunch
1:35 – 1:50	Ells Dutton – BSRN: Progress and Challenges for the Future
	<u>Field Site Status and Proposed New Sites</u> (15-minute overview talks)
1:50 – 2:05	Bella Espinar-Frias – Plataforma Solar de Almería Station (Spain)
2:05 – 2:20	Enio Pereira - New BSRN sites in Brazil – the SONDA network
2:20 – 2:35	Ain Kallis - Solar UV Radiation Measurements in Estonia
2:35 – 2:50	Vito Vitale – Implementation of the BSRN station at Dome C (Antarctica) and first measurements of radiation fluxes and AOD
2:50 – 3:05	Wouter Knap – A potential new BSRN site near Paramaribo, Suriname

3:05 – 3:20	Jiri Pokorny – CHMI - Solar Radiometry, History of Calibrations
3:05 – 3:45	Discussion on proposed and desired stations, and other topics
3:45 – 5:30	Posters (Will be displayed for the entire week)

30 May, Tuesday **<u>Applications – Satellites and Radiative Transfer</u>**

8:30 – 8:50	Taiping Zhang - Systematic Comparison of the BSRN Shortwave and Longwave Downward Radiation Fluxes with Their GEWEX SRB Counterparts
8:50 – 9:10	Rainer Hollman – Use of BSRN data for an operational CM-SAF surface radiation budget validation and inter-comparison with ISCCP-FD and GEWEX SRB
9:10 – 9:30	Joe Michalsky – Clear Sky Broadband and Spectral SW Radiation Model/Measurement Comparisons
9:30 – 9:50	Alexander Los – Cloud-Free Radiative Closure for Cabauw, The Netherlands
9:50 – 10:10	Paul Stackhouse and Taiping Zhang – Shortwave Surface Flux Trends from Satellite and Surface Site Data--Preliminary Results from GEWEX RFA
10:10 – 10:30	Break
10:30 – 10:50	Rachel Pinker – Issues Related to satellite Product Comparison and Importance of Ground Truth

<u>Applications – Climate Observations and Models</u>

10:50 – 11:10	Atsumu Ohmura – Surface Radiation and Energy Budget
11:10 – 11:30	Andreas Roesch – Computation of Monthly Means or the Problem with Poor Data Quality and Gaps
11:30 – 11:50	Xiangao Xia – Aerosol optical properties and aerosol direct radiative forcing in Xianghe
11:50 – 12:10	Anatoly Tsvetkov - Climatic Signals in the Time Series of Global Radiation based on the World Radiation Data Centre and BSRN Archives
12:10 – 1:30	Lunch
1:30 – 1:50	Martin Wild – Means and variations in surface radiation budgets as simulated in GCMs and observed at BSRN sites
1:50 – 2:10	Tadahiro Hayasaka – Quality control and long-term variation of ground solar irradiance in China
2:10 – 2:30	Rolf Philipona – Interpreting surface radiation and temperature trends in Europe
2:30 – 2:50	Chuck Long – Part I) Flux Analysis: On estimating continuous clear-sky upwelling SW and LW and Part II) Analyses of Flux Analysis results: examples from BSRN sites
2:50 – 3:20	Break
3:40 –	Posters and/or Tour of Lindenberg Facility

31 May, Wed.	**UV**
8:30 – 8:50	Uwe Feister - Spectral solar irradiance measurements in the UV region and cloud documentation at Lindenberg
8:50 – 9:10	Julian Groebner - Calibration of erythermal weighted broadband filter radiometers: News from COST 726
9:10 – 9:30	Laurent Vuilleumier - Calibration checks for UV erythemal broadband radiometers
9:30 – 9:50	Vera Lyubansky - Intercomparison of the Solar UV-B radiation for Jerusalem, Bet-Dagan and Sdom (Dead Sea), Israel
9:50 – 10:10	Break
	IR and Clouds
10:10 – 10:30	Julian Groebner - Responsibilities at the Infrared Calibration Centre--Angular Response of Pyregeometers
10:30 – 10:50	Daniela Nowak - Cloud effect on shortwave radiation on clouds in Payerne
10:50 – 11:10	Gert Konig-Langlo - How to treat changes in PIR pyrgreomter calibrations
11:10 – 11:30	Martial Haeffelin - Radiative impact of clouds and aerosols based on multiple instrument synergy at the SIRTA observatory
11:30 – 11:50	Klaus Behrens – Stability of DWD Infrared Standard Group and the relation to the BSRN routine measurements
Wednesday PM	**Excursion**
1 June, Thursday	**Working Groups and Related Activities**
8:30 – 8:50	Tom Stoffel – Pyrheliometer thermal effects
8:50 – 9:00	Discussion on Direct Beam Measurements
9:00 – 9:30	Ken Rutledge - Oceans Working Group
9:30 – 9:40	Bruce Forgan - Transmission and Aerosol Optical Depth Working Group
9:40 – 10:10	Break
10:10 – 10:40	Chuck Long - Clouds Properties Working Group
10:40 – 10:50	Laurent Vuilleumier – UV Working Group
10:50 – 11:20	Gunther Seckmeyer - UV Research from the WMO and the NDACC (former NDSC)
11:20 – 11:50	Rachel Pinker - PAR Working Group
11:50 – 12:10	Ells Dutton -- BSRN International Project Manager Requests and Suggestions to Site Scientists

12:10 – 1:10	Lunch
1:10 – 1:25	Bruce Forgan – Spectral measurements Working Group
1:25 – 1:40	Bruce Forgan – Uncertainties Working Group
1:40 – 2:10	Rolf Philipona - Pyranometer Thermal Offsets - (*review of presentation made at last meeting)*
2:10 – 2:30	Joe Michalsky - Pyrameter Working Group
2:30 – 2:45	Dutton/Michalsky/Philipona/Groebner – Hibernated Pyrgeometer Working Group
2:45 – 3:00	Discussion on Working Groups
3:00 – 3:15	Break
	<u>Aerosols /Water Vapor</u>
3:15 – 3:25	Christoph Wehrli – Results of Filter Radiometer Comparison II in Davos, 2005
3:25 – 3:45	John Augustine – An operational Aerosol Optical Depth Product from a MFRSR network, SURFRAD/BSRN
3:45 – 4:05	Laurant Vuilleumier – Aerosol Optical Depth and Integrated Water Vapor column from solar photometry at Swiss Alpine sites
4:05 – 4:25	Mikhail Alexandrov – Characterization of absorbing aerosols and water vapor using MFRSR measurements
4:25 – 4:45	Michael Weller – Long-term observations of aerosol optical depths - a completion to BSRN
4:45 – 5:15	Bruce Forgan - Determination of longwave response of SW solar radiometer to correct for the thermal offsets
2 June, Friday	**<u>Calibration Methods and Measurement Uncertainty</u>**
8:30 – 8:50	Dirk Engelbart – Lindenberg Observatory - WMO Reference Station for the Global Water-Vapor Project GVaP
8:50 – 9:20	Bruce Forgan – Determination of LW response of SW solar radiometers to their thermal offset errors (*withdrawn*)
9:20 – 9:40	Tom Stoffel – Pyranometer Thermal Offsets
9:40 – 9:50	David Halliwell – A Mix of Sun and Cloud: Field Calibrations of Pyranometers Using Natural Variations in Sky Conditions
9:50 – 10:10	Christian Ruckstuhl – Shortwave global irradiance uncertainty: Comparisons of state of the art instrumentation at the Payerne BSRN site
10:10 – 10:30	Break

Regional Topics

10:30 – 10:50	Frank Beyrich - Regional energy and water cycle components over a heterogeneous land surface – the Lindenberg contribution to GEWEX-BALTEX and CEOP
10: 50 – 11:10	Ulrich Leiterer - GCOS Surface Network
11:10 – 12:00	General Discussion on BSRN Network Activities
12:00 – 1:00	Lunch
1:00 – 2:00	Workshop wrap-up
2:00 –	Separate Working Group meetings as practical – establish work plans and schedules for next 2 years.

Posters

Klaus Behrens – Status Report of the Lindenberg BSRN Station

Lamine Boulkelia – 10 Years of radiation measurements at Tamanrasset.

Martial Haeffelin and Jean-Charles Dupont – CIR – A Range Cloud Infrared Radiometer for Remote Sensing of Properties: Application for the BSRN Cloud Community

M. Haeffelin and co-authors – Measurements and status at the SIRTA (Palaiseau, France) BSRN station.

Andresa Herber – Aerosol Optical Depth Measurements as part of the BSRN station Ny-Alesund, Spitsbergen at AWIPEV Research base.

Yvonne Hinssen and Wouter Knap – Pyranometric and Pyrheliometric Sunshine Duration

Gary Hodges – Status and Updates of the U.S. SURFRAD BSRN sites

Gary Hodges – Status and Updates of the ARM Data Submitted to BSRN

Wouter Knapp – Status of BSRN Cabauw

Gert Konig-Lango – Status of the Two German Polar BSRN stations

Dave Longenecker et al – Status of NOAA baseline BSRN sites.

Jean-Philippe Morel – Comparison between the atmospheric irradiance measurements obtained at Carpentras from two pyrgeometers: a PIR and a CG4

Hiroshi Naganuma – Comparison of CG4 with PIR

Ormanda Niebergall, David Halliwell, Bruce McArthur, and Ihab Abboud – Status of Radiation Measurements in Canada

Jean Olivieri – Photosynthesis is probably the most important biological process on Earth

Ken Rutledge – Status of the CERES Ocean Validation Experiment (COVE) BSRN Site

Tom Stoffel – Pyrgeometer Calibrations for the ARM Program: Updated Approach

Shawn Smith – Progress of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative

U.Veismann, I.Ansko, A.Kallis and E.-M. Maasik – Solar UV radiation measurements in Estonia

Laurent Vuilleumier – Status of the Payerne (Switzerland) BSRN Station

Robert A. Weller – Surface Radiation Observations in the Open Ocean

Hiroshi Naganuma – Status of BSRN Syowa, Japan

Hiroshi Naganuma – Status of Tateno, Japan

Rachel Pinker – Ilorin Station Visit Report

BSRN Working Group Structure and Status

Obligations and duties of the WG Chairs and members (this is a somewhat new guidance so please read and digest.)

Chair - Responsible for establishing the group's work plan based on his/her knowledge of the needs in the topical area and based on the suggested activities provided during the previous general BSRN meeting. The Chair also collects and incorporates the contributions of the WG members and provides an oral and written report at the next biennial meeting.

WG Members – It is expected that the WG group members will work, either under direction from the Chair or corresponding to the member's individual activities and expertise. The members will provide appropriate results from their work to the Chair for inclusion in the WG's report.

Current proposed membership of BSRN Working Groups based on previous membership and adjustments from the Lindenberg meeting:

PAR - Rachel Pinker (Chair), Bruce McArthur (co-chair), Bruce Forgan, Ain Kallis, Kevin Rutledge

Pyranometer (total and diffuse) - D. Halliwell (Chair), Rolf Philipona, Joe Michalsky, K. Behrens, C. Long, M. Haeffelin, L. Vuilleumier,

Pyrgeometer - Rolf Philipona (Chair), Joe Michalsky, Julian *Gröbner*, K Behrens, T. Stoffel, A. Los

Oceanic – Ken Rutledge (Chair), Gary Hodges, Robert Weller, C. Long, M. Wild, H. Diamond, Oystein Godoy, Shawn Smith

Direct Beam - Ells Dutton (default-Chair) - Tom Stoffel, Dave Haliwell, Donald Nelson

Cloud Parameters - C. Long (Chair), M. Haefflelin, D. Nowak, B. Forgan, R. Philipona, Sylvio Mantelli

Aerosol Optical Depth - B. Forgan (Chair), J. Michalsky, C. Wehri, V. Vitale

Upwelling Irradiances – Bruce McArthur (Chair), K Behrens, R. Pinker, R. Stone, A. Roesch, Crystal Schaaf

Spectral Measurements - Joe Michalsky (Chair), Rachel Pinker, Alex Manes, B. Forgan, L. Vuilleumier, B. McArthur, A. Kallis, R. McKenzie

Uncertainties - B. Forgan (Chair), K. Behrens, D. Halliwell, T. Carlund, C. Long, L. Vuilleumier

Report of the BSRN UV-B Working Group (A. Manes)
Submitted to the 9th BSRN Meeting in Lindenberg, 2006

Members of the UV WG: B. Forgan, K. Lantz, A. Los, B. McArthur, R. McKenzie, A. Manes, J. Olivieri, R. Philipona, L. Vuilleumier (Chair)

History

The UV-B WG was established at the 5th BSRN meeting in Budapest, Hungary, 18-22 May 1998. Although, it was generally agreed that monitoring the UV-B surface fluxes should be part of the measurement suite of BSRN stations, it was also recognized, however, that the accuracy and stability of the commercially available broadband UV radiometers did not match the accuracy requirements at BSRN stations. In defining the tasks of the WG the majority of participants did not support any active engagement of the WG in research activities aimed to reduce the uncertainty of broadband UV radiometers, but merely to monitor the progress made in the field of broadband UV-B radiometry by other agencies (i.e., by GAW, CUCF and ECUV), and report the results to the BSRN Scientific and Review Workshops. In our Report to the BSRN Meeting in Regina, Canada, in 2002, we have recommended to BSRN stations Managers to carry out broadband UV-B measurements routinely, and the BSRN Archive administration was requested to make provisions for inclusion of UV data in the archive. These recommendations, adopted by the participants of the Regina meeting, were based mainly on the reported considerable progress achieved in the accuracy and stability of broadband UV-B measurements, mainly by the US networks (i.e., SURFRAD and USDA), in close cooperation with the Interagency Central UV Calibration Facility (CUCF) of SRRB, NOAA.

UV data in the archive as of February 2006

As of February 2006 (Andreas Roesch, private communication), 872 station months of UV data from 9 stations, out of 35 operational BSRN stations, have been acquired, submitted to and accepted by the archive. This is only a minor change with respect to the figures reported in 2004. The updated values are shown in Table 1. As can be seen, the only European station submitting UV data to the archive is the Payerne station. All the others are from the US networks, SURFRAD and ARM (Atmospheric Radiation Measurement Program) networks. UV is measured by a number of European networks (currently within COST-726). Collaboration with them could facilitate the implementation of UV measurements at some BSRN stations.

Table 1. BSRN Stations Reporting UV-B to the Archive

Station	State/Country	Acronym	Organization	Period of Record
Boulder	CO, USA	BOS	SURFRAD	1995 - 2003
Goodwin Creek	MS, USA	GCR	SURFRAD	1995 - 2003
Fort Peck	MT, USA	FPE	SURFRAD	1995 - 2003
Bondville	IL, USA	BON	SURFRAD	1995 - 2003
Rock Springs	PA, USA	PSU	SURFRAD	1998 - 2003
Desert Rock	NV, USA	DRA	SURFRAD	1998 - 2003
Momote, Manus Is.	Papua New Guinea	MAN	ARM	1996 - 2004
Nauru Island	Tropical Western Pacific	NAU	ARM	1998 - 2004
Payerne	Switzerland	PAY	MeteoSwiss	1998 - 2004

Highlights of the UV WG recommendations adopted at the Exeter BSRN meeting in 2004

- In the absence of a recognized UV World Calibration Center, it will be in the best interests of the BSRN network, as well as other networks, that SSRB/CUCF and ECUV/PMOD establish a framework of cooperation and coordination, including joint intercomparison campaigns, and a reference group of broadband UV radiometers common to both centers.

- BSRN station managers should make the necessary arrangements with the existing, recognized by WMO/GAW Regional UV Calibration Centers, SRRB/CUCF and ECUV/PMOD, to get their good services in providing characterization and calibration of the broadband UV radiometers, deployed or to be deployed at their stations.

Activities Relevant to Precision UV Radiometry: 2004 – 2006

A number of activities undertaken by L. Vuilleumier (MeteoSwiss) [1], J. Groebner (PMOD/WRC) and L. Vuilleumier [2], J. Groebner and P. Disterhoft (CUCF/SRRB) [3], seem to match the above mentioned recommendations as adopted at the BSRN Exeter Meeting.

Payerne experiment: Comparison of UV-B SL radiometers calibrated at CUCF and ECUV [1]
In the framework of the Swiss Atmospheric Radiation Monitoring program (CHARM) of MeteoSwiss, UV erythemally-weighted broadband irradiance is measured, including the Payerne BSRN station, using Solar Light 501A UV broadband radiometers. Three SL instruments were chosen to serve as reference at MeteoSwiss, based on the availability of past characterizations and stability. One instrument was sent for characterization to the ECUV, while the two others were sent to the U.S. Central UV Calibration Facility (CUCF) at Boulder, U.S.A. According to Cathy Lantz of CUCF (personal communication) the radiometers sent to the CUCF were a courtesy calibration because the CUCF was not calibrating SL UV-B radiometers during this period. The calibration supplied to MeteoSwiss was based on an absolute comparison with CUCF's unmaintained triad of SL 501A's. The calibration factors given to Meteoswiss used generic correction factors for ozone and solar zenith angle for the triad. The CUCF's experience is that SL 501A's spectral and angular responses are not reproducible from instrument to instrument and that the differences in Fig. 2 could easily be expected from the application of these generic correction factors. After characterization and calibration at the two calibration centers, the three radiometers were installed in parallel at the Payerne site (see Fig. 1) for measurement of global UV radiation between 31 August and 5 October 2004.

Figure 1. UV biometer testing site at Payerne.

The results from the comparisons between the three radiometers for 14 clear-sky days showed an agreement that is compatible with the stated uncertainty of well characterized broadband UV-B radiometers, estimated to be on the order of 5-10% (Lantz et al, 1999) [2]. A detailed study of the uncertainty of UV irradiance with well-calibrated spectro-photometers estimated the k=2 uncertainty for erythemally weighted UV irradiance to 6.1% (Bernhard and Seckmeyer, 1999) [3]. Since such a quantity is used in the calibration procedure for broadband UV radiometers, it is likely that the uncertainty of such calibration is in excess of these 6.1%.

Comparisons of the raw data signals for a range of solar zenith angle and total ozone column suggest that the three tested instruments have very similar spectral characteristics. The respective calibration functions for the reference UV radiometers as determined by the two central calibration facilities, ECUV and CUCF are shown in Figure 2.

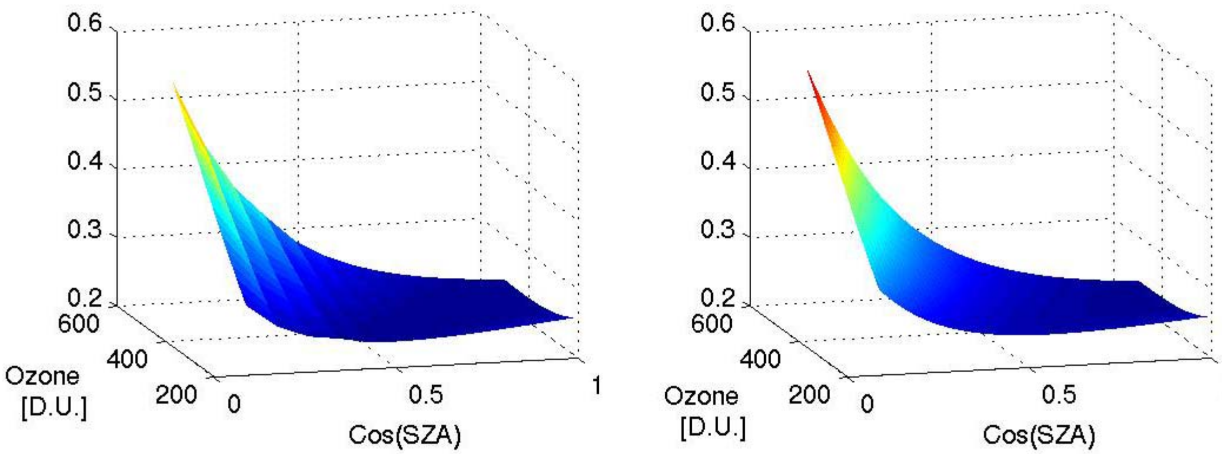

Figure 2. Calibration functions (in Wm^{-2} per V) for reference UV radiometers determined by ECUV (left), and by CUCF (right).

As expected, the calibration functions for the two reference radiometers are similar. However, inspection of their ratio reveals some significant differences of up to 7% for some values of SZA and O3. While the largest differences occur for large SZA and have therefore little consequences, differences on the order of 5% still occur for SZA between 50 and 60º. Furthermore, there is a distinct hump in the calibration function ratio at SZA = 70º. Separate comparison of the raw data signals from both biometers, and the corresponding calibrated data (UV erythemal) show that the raw data signals are more in agreement than the calibrated data.

Irradiance scale intercomparison between the ECUV and the CUCF [4]

The Irradiance scales of ECUV and CUCF were compared during an intercomparison held at ECUV in 2004. They are traceable respectively to PTB (Physikalisch-Technische Bundesanstalt) and NIST. The final result of the intercomparison, the ratio between the CUCF and ECUV Irradiance scales is shown in Figure 3.

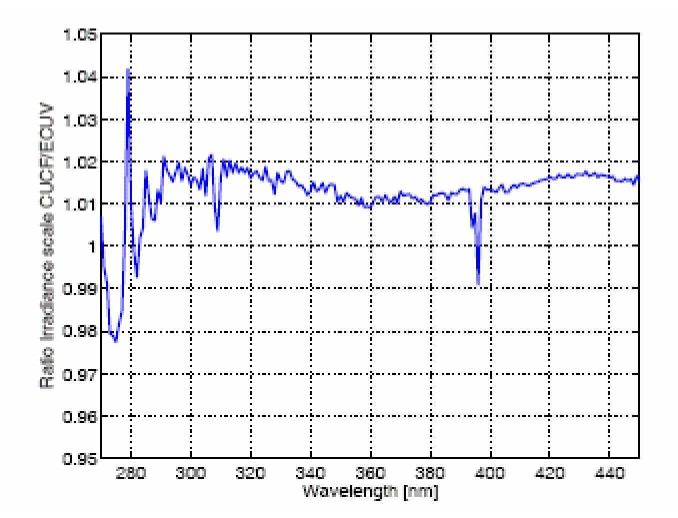

Figure 3. Irradiance scale intercomparison between CUCF and ECUV.

Several interesting features can be observed in this figure. First of all, the CUCF irradiance scale is on average between 1 and 2% higher than the ECUV irradiance scale. The mean offset between the two irradiance scales is 1.3%. Some larger discrepancies can be seen between 270 and 290 nm, where the ECUV and CUCF irradiance scales progressively diverge by about 4% relative to the values at longer wavelengths.

According to Patrick Disterhoft (personal communication) prior to the above intercomparison there was also a bi-lateral intercomparison of spectral irradiance between the NIST and PTB (the reference labs for the CUCF and ECUV, respectively). Although, the results of that intercomparison have not yet been formally published, according to Patrick Disterhoft, those results (through personal communication) would bring the CUCF and ECUV irradiance scales closer together.

Summary and Conclusions

- The continuing reluctance of the majority of BSRN Station Managers to acquire and submit broadband UV-B data to the archive stems from the relatively high uncertainty of such measurements, which is estimated to reach up to 10%. Such high uncertainty seems to be hardly compatible with the primary aims of the BSRN: climate change, trend analyses and ground truth for the satellite community.

- The manufacturers of broadband UV radiometers have done little during the past years to increase the accuracy and calibration stability of these instruments. Moreover, they provide a calibration factor (CF) rather then a calibration function. The CF is given, either for a fixed SZA and total ozone (like in case of SL 2.7 mm ozone, 30^o SZA [5]), or with a table correcting for the SZA (UV-B1, YES).

- It is conceivable that the uncertainty can be reduced, not to exceed 5%, under condition that each BSRN station will keep a secondary reference characterized and calibrated by one of the recognized calibration centers (CUCF or ECUV). The calibration function should be tested for stability at least once per year.

- WMO/BSRN, GAW and COST should provide financial assistance and encourage the two central calibration facilities, CUCF and ECUV, to continue their efforts in coordinating and unifying their characterization and calibration procedures.

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Ocean Observations Working Group Report
9th BSRN Scientific Review and Workshop
Lindenberg, Germany

Origin:

Established during the 8th BSRN Workshop and Scientific Review (26-30 July 2004) in Exeter, U.K.

Members:

Howard Diamond	US NOAA	U.S. Global Climate Observing System
Ellsworth Dutton	US NOAA	Surface Radiation Research Branch
Oystein Godoy	NO NMI	Norwegian Meterological Institution
Gary Hodges	US NOAA	Surface Radiation Research Branch
Chuck Long	US DOE	PNNL Atmospheric Remote Sensing Lab
Ken Rutledge (chair)	US NASA	Climate Sciences Branch, AS&M, Inc.
Bob Weller	US WHOI	Woods Hole Oceanograpnic Institution
Martin Wild	SW PMOD	Physikalisch-Meterorolgisches Observatorium Davos
Shawn Smith	US FSU	Center for Ocean Atmospheric Prediction Studies

OOWG charged with determining and reporting to the BSRN Science Committee:

A - Which broadband radiation measurements are presently being made over the oceans, what are their observational uncertainties

B - The acceptable uncertainties as defined by climate science and satellite remote sensing communities

C - What advances in ocean radiometry need to be made should the existing uncertainties not meet the community goals

D - The feasibility of BSRN organizing inter-comparison activities for observation groups which perform broadband radiometry on the oceans' surface

E - A categorization of sites on the oceans according to the climate scientists', and remote sensing specialists' priorities so limited resources may be allocated optimally

F - Optimal and sufficient network designs for sampling the oceans

G - Identify candidate ocean sites

Progress for 2004-2006 Period

(Charge G) contacted member companies of the oil industry to discuss access to ocean plat-forms as possible radiation monitoring sites, four companies contacted, two responded:

1) Connoco Phillips - brief discussion, negative response

2) Shell Oil – gave thoughtful consideration, turned down platform access because of cost of transportation, offered ship access

(Charge B,E) developed, distributed and began summarizing a community survey on ocean observations, only 14 of 82 surveys returned, summary of acceptable uncertainties for ocean radiation surface radiometry reported during meeting

(Request for Institutional Support / Clarifying Research Issues) US National Research Council decadal survey, white paper submitted: "*Surface Shortwave and Longwave Broadband Network Observation*

Uncertainty for Climate Change Research, Verification is Needed", May 2005, emphasized the need for ocean surface radiation research funding for satellite validation and climate observations

(Charge F) optimal/sufficient network design using SRB 21-year archive, correlation/EOF maps. Presented applications of Zhang's correlation analyses maps for investigating time/space correlations with demonstration of how this information may be used for buoy selection for optimal / sub-optimal sites

(Charge D) CHL/buoy radiometer inter-comparison, we initiated observations which will eventually allow a side-by-side comparison of ocean-platform and buoy based radiometers to assess the buoy affects on the observational uncertainties

(Charge G) ships of opportunity, NOAA SAMOS project presented to plenary session to introduce Voluntary Observation Ships (VOS) program to BSRN. SAMOS looks to BSRN for guidelines to improve their radiometry packages so that progress towards climate quality observations is achieved

(Charge G) geophysical observation buoys, Ocean cites project presented to plenary session to introduce buoy observations program to BSRN. Weller looks to BSRN for guidelines to improve his radiometry so that progress towards climate quality observations is achieved.

POSTERS

Status Report of the Lindenberg BSRN Station (Klaus Behrens)

Since 15 June 2003, measurements have been carried out on the roof of the new laboratory building, which is equal to the old site (φ= 52,21° N, λ= 14,12° E, h = 121 m). The measurements of all quantities (global, diffuse, direct and atmospheric downward radiation) are duplicated to ensure data quality. Two CM22 and CM21 are used for measuring global and diffuse radiation, respectively. Furthermore, atmospheric downward radiation is recorded using shaded PIR and CG4 pyrgeometers. Two CH1 and an AHF are measuring direct radiation. The shaded pyranometers and pyrgeometers as well as the pyrheliometers are mounted on two 2AP Kipp and Zonen trackers. All 2π instruments are ventilated by a heated air stream. The data are recorded by COMBILOG data logger of T. Friedrichs, Hamburg.

The good agreement of measured global radiation and from the vertical component of direct radiation and diffuse radiation calculated global radiation was demonstrated on a day which started with cloudless and finished with totally overcast conditions

10 Years of radiation measurements at Tamanrasset (Lamine Boulkelia, National Meteorological Office, Algeria)

As a part of the Saharian Meteorology Research Centre of the National Meteorological Office, the GAW activities began in September 1994. Radiation is one of the main programs with measuring solar shortwave radiation including UV-B. With the sponsor of STAR/CMDL-Boulder, the station has been included in BSRN since March 2000. The station is located at about 2000 km south of Algeria in the desert region between equatorial and mid-latitude (latitude 22^{o} 47'N, longitude 05 ^{o} 37'E, altitude 1377 m.a.s.l). It is provided with shaded Eppley diffuse PSP and shaded Eppley PIR with CR23X data logger. Except PIR and UV-B, SW instruments are regularly calibrated and data submitted to WRMC in Zurich, Switzerland and WRDC in St. Petersburg, Russia via NREL, Golden, USA. To date a total of 69 months have been accepted in the BSRN archive.

CIR, a range Cloud Infrared Radiometer for remote sensing of cloud fraction and cloud base height : application for the BSRN community (Jean-Charles Dupont, ATMOS, Le Mans, France; Martial Haeffelin and Philippe Drobinski, Institut Pierre Simon Laplace, Paris, France)

Up to now measurements of cloud fraction have been conducted by human observers at low frequency acquisition (every 3 hours) or with a ceilometer (ASOS algorithm). In parallel, new challenges in meteorology, climatology and environmental protection require day and night values of the cloud fraction upgraded every few minutes with a convenient accuracy.

The thermal infrared technology of the CIR range and in particular CIR-4, fully matches these requirements. The CIR technology uses thermal infrared radiation in the spectral range of 9 to 14 µm. The CIR 4 is composed of four pyrometers aligned following the main directions of the wind rose (North, South, East and West). The CIR 4 provides through time series total nebulosity in percentage or in octa, nebulosity by class of cloud altitude, as well as the cloud base height by class of altitude. Three cloud layers are considered: 0-2 km, 2-6 km and 6-8 km. The accuracy in the retrieval of cloud fraction is +/- 6% and for ceiling +/- 200 m in the range of 0 to 8000 m. The CIR-13 is a scanning instrument providing the same set of instruments as the CIR-4 in addition to day and night sky dome imagery.

To provide cloud fraction, CIR algorithms use *brightness temperature of the sky*. Currently, the threshold between clear and cloudy sky is carried out with a fixed temperature. Parametric models show relationships between clear sky longwave radiation and atmospheric conditions near the ground. In this work, we try to optimize threshold temperature by linking clear sky longwave radiation in the spectral range of 9 to 14 µm with temperature near the ground, relative humidity and/or Integrated Water Vapor. Cloud base height is provided by an *adiabatic profile of temperature*.

To evaluate and optimize CIR algorithms, some comparisons with Lidar results and statistics during a period of four months have been performed. There is a good coherence for statistic cloud fraction results but there are some inaccuracies for ceiling height. In fact, when we have broken clouds days or high thin clouds there are discrepancies between Lidar and CIR measurement.

Future work will include the study cloud emissivity impact on cloud base height measurement, quantify the impact of vertical profile of temperature on ceiling height measurement (improve the current adiabatic profile) and finally apply variable threshold brightness temperature to CIR algorithms to improve results provided by CIR technology.

Measurements and Status at the SIRTA (Palaiseau, France) BSRN Station (Martial Haeffelin, Institut Pierre Simon Laplace, and Jean-Charles Dupont, ATMOS)

SIRTA is a cloud and radiation observatory located 25 km south of Paris. The research objectives of SIRTA are focused on the study of dynamic, microphysical, and radiative processes of clouds and aerosols. In this presentation we focus on radiative impact of high-altitude clouds. Retrievals of cloud and aerosol properties throughout the troposphere are obtained by combining active (radar + lidar) and passive (sunphotometer, IR and microwave radiometers) remote sensing instruments. The BSRN archive contains now almost three years (mid 2003 to 2006) of SIRTA downwelling shortwave and longwave radiation data.

To study cloud and aerosol effects in surface SW and LW irradiances, one must first establish reliable clear-sky references. We use parametric equations to represent downwelling SW clear-sky fluxes as a function of solar zenith angle power law (Dutton et al, 2001) and downwelling LW clear-sky fluxes as a function of the sky emissivity driven predominantly by the integrated water content (Prata et al., 2005). We compute cloud effect as the difference between the measured flux (SW and LW) minus the clear-sky reference. We show distributions of cloud effect for different types of clouds (low, mid and high-altitude clouds). We find evidence of cloud effect on surface downwelling LW radiation for clouds as high as 11km. We find evidence of cloud effect on surface downwelling SW radiation for semi-transparent high-altitude clouds (optical depth ranging between 0.3 and 0.03). For subvisual clouds (optical depth less than 0.03) the cloud effect is within the uncertainty of the clear-sky reference. The clear-sky SW reference values are strongly sensitive to the aerosol loading used to establish the parametric fit.

Future work will focus on reducing uncertainties in clear-sky references and studying daytime and nighttime SW and LW cloud effects of a few golden days.

Pyranometric and Pyrheliometric Sunshine Duration (Yvonne Hinssen and Wouter Knap, Royal Netherlands Meteorological Institute)

Comparisons of sunshine duration (SD) derived from measurements of direct and global solar irradiance are made for BSRN Cabauw, the Netherlands for the period March 2005–February 2006. The cumulative and daily mean differences between the pyrheliometric and pyranometric methods are +191 h and 0.59±0.04 h/d, respectively. By means of tuning the pyranometric method these differences can be reduced to +7 h and 0.02±0.04 h/d. Similar results can be obtained by directly correlating SD to the measured global irradiance.

Status and Updates of ARM BSRN Sites (Gary Hodges, CIRES/NOAA)

The five Atmospheric Radiation Measurement Program (ARM) monitoring sites that are included in the BSRN archive were presented. Three are located in the Tropical Western Pacific and two are collocated at the ARM Climate Research Facility in Oklahoma, USA. Data for all five stations have been submitted through November 2005. This is a total of 484 months of data submitted to the BSRN archive. Darwin Australia is the newest ARM station to be included in the archive. It was commissioned March of 2002 and was accepted as a BSRN site at the 2004 Exeter meeting.

Status of BSRN Cabauw (Wouter Knap, Alexander Los, Cor van Oort, Jacques Warmer, Ed Worrell Royal Netherlands Meteorological Institute)

Since January 2005 radiation measurements have been recorded in Cabauw, the Netherlands, according to the standards of BSRN. Thus far, 15 months of basic radiation measurements have been submitted to the central BSRN archive in Zürich. Measurements of upward and spectral fluxes are planned to be submitted as well. The development of a pyrheliometer ventilation/heating unit, in order to prevent the formation of condensed water on the instrument window is ongoing.

Status of the Two German Polar BSRN stations (Gert Konig-Lango, Meteorologische Observatorien, Alfred-Wegener- Institute)

The Alfred-Wegener-Institute for Polar and Marine Resarch runs the Neumayer BSRN station (70º39'S, 8º15'W, Antarctica) and the Ny Ålesund BSRN station (78º56'N, 11º57'E, Spitzbergen). Neumayer is situated on the Ekstrøm Ice Shelf at a distance of about 10 km from the shore line. The Ekstrøm Ice Shelf has a homogeneous, flat surface always covered with snow. Ny Ålesund is situated directly on the shore line of the Kongsfjorden, surrounded by mountains with heights up to 700 m. The ground is snow-free from about midsummer to early winter.

Both stations are equipped with identical instruments. The continuous measurements started at Neumayer in 1982 and at Ny Ålesund in 1992. All measurements are ongoing and available via the BSRN archive. More information and on-line data are additionally available via http://www.awi-bremerhaven.de/MET.

The comparable long time series from Neumayer and Koldewey make first trend analyses possible. The most striking feature is an increase of the annual sunshine duration at Neumayer from about 1300 hours/year at the beginning of the BSRN-measurements to nowadays values around 1900 hours/year. This trend is associated with increasing global radiation and a decreasing to the long-wave downward radiation.

Status of NOAA baseline BSRN sites (Dave Longenecker)

Five active and three candidate BSRN sites are currently being run by the NOAA former Climate Monitoring and Diagnostics Laboratory radiation group. The candidate sites are Trinidad Head California, American Samoa, and Alert Canada. The Alert site is being cooperatively operated by the NOAA and Canadian EC groups. The poster presented the extent of the data currently collected and submitted to BSRN along with examples of extended time series of individual radiative quantities. Also the status and extent of specific measurement programs at the different sites was displayed.

Comparison between the atmospheric irradiance measurements obtained at Carpentras from two pyrgeometers: a PIR and a CG4 (Jean Philippe Morel, Carpentras-Météo-France)

The comparison took place during all the year 2005. When the skies are clear, the mean values of the difference between the ***CG4*** and the ***PIR*** measurement results are lower than |0.5%| as long as the meteorological temperature of the day – ***t*** – is higher than about 10°C. The higher differences: $>$ 2%, correspond to ***t*** ≤ 5°C.

It seems that these differences are mainly due to:

- The spectral transmissions of the silicon domes of the pyrgeometers that are not “flat” (as they are for the glass or the quartz of the pyranometer domes,
- The spectra of the atmosphere radiation, notably when the sky is clear and cold, and the atmosphere is dry.

The differences are also extremely small when the sky is overcast.

Comparison of CG4 with PIR (H. Naganuma, Japan Meteorological Agency)

When calibrating CG4 by downwelling comparison with PIR as a reference, a clear difference is seen in hourly sensitivity between nighttime and daytime, and it is especially large in summer. This difference in apparent sensitivity, perhaps caused by window heating effect due to solar radiation, means that time zone and season for comparison affect the calibration. On the other hand, when calibrating CG4 by upwelling comparison, change of sensitivity at daytime is small. But there is large discrepancy in sensitivity between results of upwelling comparison and that of downwelling comparison. Conclusion: the calibration by downwelling comparison is not adequate to the instrument for upwelling measurement.

Status of Radiation Measurements in Canada (Bruce McArthur, David Halliwell, Ihab Abboud, James Morley and Ormanda Niebergall, Environment Canada)

Environment Canada continues to operate its BSRN station at Bratt's Lake, Saskatchewan, and has also established a program to install BSRN-level radiation measurements at several locations across Canada, as part of its CORE site initiative. One set of instruments has been added at the Bratt's Lake site, and another is operational at the CARE site near Toronto. Several sites to be installed in 2006-7, are linked to research on photovoltaics, with Natural Resources Canada, and will include spectral radiation measurements (direct beam, global, diffuse, and reflected) in the UV, visible, and near-IR wavelengths. In 2004, resources contributed by NOAA enabled the addition of BSRN radiation measurements to existing air quality programs at Alert, in Canada's high arctic. There are plans to develop a BSRN site in Eureka for the International Polar Year. Environment Canada is also expanding its network of Cimel sun photometers within AeroCan, and developing systems for real-time transfer of this data into the forecasting system. This growing network will require increased calibration services, and a new calibration lab will be constructed in 2006 at the Bratt's Lake Observatory. This new facility will also include provisions for LIDAR installation at the site.

Status of the Clouds and the Earth's Radiant Energy System (CERES) Ocean Validation Experiment (COVE) BSRN Site (K. Rutledge[1], G. Schuster[2], B. Fabbri[1], F. Denn[1], J.Madigan[1]Analytical Services and Materials, Inc., Hampton, Virginia; [2]NASA Langley Research Center, Climate Sciences Branch)

Over 5 years of basic radiation observations performed at the ocean platform site (CHL) have been inserted into the BSRN archive. During the past year, a second tracking device was deployed to assure optimal tracking at the site. The remote nature of the site and the associated limited access makes dual tracking systems attractive so that continuous high quality observations may be achieved. Other types of instruments have been deployed over the past 2 years to capture signals associated with aerosol microphysical characteristics, cloud and aerosol layers, water leaving radiances, water vapor and liquid water profiles.

Comparisons of shortwave (SW) and longwave (LW) CERES Surface and Radiation Budget model results to surface observations performed at the site show very favorable agreement. Cloud conditions are conservatively estimated using both the Long/Ackerman cloudiness indices in conjunction with spatial statistics from the MODIS imager instrument. Clear sky biases for the SW and LW comparisons are -0.7 and -1.0 W/m^2 respectively. The dispersion for both the SW and LW comparisons are greatest for the partly cloudy skies but the biases are largest for the overcast sky periods.

Data quality assessments based on cross-instrument observation comparisons are shown to result in approximately a 1% relative uncertainty for upwelling longwave instruments (pyrgeometer and pyrometer). This result effectively compares the LW calibration techniques from a commercial lab against the World Radiation Center. Downwelling SW data quality was assessed using over 5 years of clear-sky global irradiance as compared to summed global irradiances (cos(SZA)*direct + diffuse). A mean of approximately 3% relative uncertainty for these two methods resulted. Recent problems with solar tracking systems are suspected to explain this sub-optimal comparison.

Pyrgeometer Calibrations for the ARM Program: Updated Approach (Tom Stoffel and Ibrahim Reda, National Renewable Energy Laboratory)

The U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Program uses more than 100 pyrgeometers for longwave irradiance data supporting climate studies. Since 1995, the calibration of these pyrgeometers has been a topic of intense research to achieve the goal of accurate field measurements that are traceable to a recognized reference. The original EPLAB factory calibrations (with dome correction factor = 4.0) were used for all Model PIR deployments. The development of a world reference for infrared radiation measurements began with two International Pyrgeometer and Absolute

Sky-scanning Radiometer Comparisons (IPASRC-I and II) in 1999 and 2001. Beginning in 2002, after determining improved measurement precision was possible, all ARM pyrgeometers were calibrated using a newly-developed EPLAB/NREL Pyrgeometer Blackbody Calibration System designed to meet BSRN protocols for controlling pyrgeometer and blackbody temperatures. In 2005, results of clear-sky data analyses from ARM's Broadband Heating Rate Profile (BBHRP) and Longwave Quality Measurement Experiment (LW QME) comparisons indicated a significant measurement bias of -12 Wm^{-2}. This prompted recent investigations summarized here, including several pyrgeometer calibrations at the Physikalish-Meteorologisches Observatorium Davos, World Radiation Center (PMOD/WRC).

Results from blackbody calibrations based on various means of determining the reference blackbody temperature are applied to several weeks of outdoor measurements conducted at the PMOD/WRC in 2005. Analyses confirm the new blackbody system is about 1.5ºC *colder* than expected when the circulating fluid temperature is less than -15ºC due to stratification. Mechanical mixing of the fluid reduces this temperature bias representative of clear sky conditions, but also reduces the measurement precision. A suggested approach to pyrgeometer calibrations is presented based upon the development of reference and transfer standards traceable to the World Infrared Standard Group (WISG) under development at PMOD/WRC. Results from an alternate calibration approach based on blackbody and outdoor characterizations are also presented.

After a thorough evaluation of available options for pyrgeometer calibrations, ARM will adopt the best method consistent with and traceable to an accepted World Infrared Standard Group (WISG). Currently, all ARM broadband longwave measurements are based on the most recent EPLAB calibrations and the dome correction factor has been set to 4.0 for historical consistency.

Progress of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative (Shawn R. Smith, Center for Ocean-Atmospheric Prediction Studies, Florida State University)

Recent progress of the SAMOS Initiative will be provided. The poster will include a report by the SAMOS data center will on results of the 2005 pilot project, including updates on vessels contributing observations, the ship profile database, and issues that arose during initial implementation. The data center will outline plans to recruit additional vessels, expand data distribution, and advance data quality evaluation. An update from NOAA ESRL/PSD and WHOI will describe the development status of the portable standard instrument system. Progress on accuracy standards for marine meteorological observations will also be discussed. A draft of the "Guide to making climate quality meteorological and flux measurements at sea" is currently undergoing review and this guide will be outlined. Additional information related to radiation measurements will be provided by Ken Rutledge during his working group report.

Solar UV Radiation Measurements in Estonia (Uno Veismann, Ilmar Ansko, Kalju Eerme, Ain Kallis, Enn Maasik, Tartu Observatory)

Solar UV irradiance is measured at Tartu-Toravere BSRN station with five broadband sensors (UV-A, UV-B and erythemal UV) and with a 306 nm narrowband sensor. A new type of UV sensors on the basis of solar blind phototube was developed. Since 2004 a computer-aided minispectrometer has been used for solar UV spectrum monitoring. The calibration of UV sensors is based on the tungsten-halogen standard lamp FEL. At Toravere the mean values of the ground-base measured and satellite TOMS-derived doses were in good agreement.

Status of the Payerne (Switzerland) BSRN Station (L. Vuilleumier, A. Vernez, Federal Department of Home Affairs FDHA, Federal Office of Meteorology and Climatology, MeteoSwiss)

The Payerne station has measured the basic BSRN set of parameters since November 1992. In addition, other parameters including LW and SW irradiance at 10 and 30m a.g.l., spectral direct irradiance and UV erythemal irradiance are measured.

A new shading system for diffuse measurements (as well as for shading pyrgeometers) was installed because the old system did not fulfill BSRN requirements. Specifically, the shading disk was too large and too close to the pyranometer for reproducing the field of view and slope angle of the direct measurement. A transition system for a pyranometer was installed in 2003, while a carefully designed system including five-shaded position on a Brusag tracker was built and installed in 2005. Following GCOS principles the old shading system is still operating for characterizing the changes between the old and the transitional system, and between the transitional system and the final one. Since the old system is still operational, the old and the final system can also be directly compared. Comparisons revealed very significant differences between the old and both the transitional and the final system, especially in cases with thin clouds or haze when an important halo can be detected around the sun. While the distribution peaks around zero an important tail in the positive direction (when analyzing the difference between the transitional and old system: transitional-old) is present well beyond 10 W/m2. Comparison between the transitional and the final system revealed only small differences. The comparison will be further analyzed to check how homogenization of data measured with the old system can be achieved.

All of the UV erythemal broadband radiometers (biometers) in operation at MeteoSwiss (including at Payerne) are now yearly undergoing a calibration check by comparison to a well-calibrated reference. The estimated uncertainty for such a method is a little in excess of 5% for the calibration of the reference and on the order of 4% for inter-instrument reproducibility. This uncertainty is compatible with the observed difference between redundant measurements of UV global erythemal irradiance with several biometers. Errors and inhomogeneities in the old data submitted to WRMC in the long-wave, diffuse SW and UV have been identified and are being analyzed. However, correction of old incorrect values in WRMC database is still pending.

Surface Radiation Observations in the Open Ocean (Robert A. Weller, Woods Hole Oceanographic Institution)

The ocean research community needs surface shortwave and longwave radiation to use together with latent and sensible heat flux to quantify the surface heat flux that couples the ocean and atmosphere. The accuracy goal is 10 W m^{-2} in net heat flux at daily and longer time scales. Surface buoys moored to the sea floor are being deployed in characteristic climate regimes (e.g., stratus clouds, trade winds, tropical convection) and where ocean-atmosphere process studies are to be conducted. A number of buoys are in place now; more are planned. Future buoys may provide more stable, powered platforms. The moored buoys are supplemented by observations from cross-basin ship tracks by Volunteer Observing Ships (VOS). One goal is to use these in-situ surface radiation observations together with satellite or model-based surface radiation fields to develop ocean surface flux fields gridded at 1°x1° with daily resolution. A second goal is to build up sustained ocean surface radiation time series at key locations for use in calibrating/validating model or remote-sensing based surface radiation fields and to provide local ocean surface forcing to process studies and ocean modelers.

The poster reviews the methods used to make the observations on the surface buoys and VOS, shows the present locations of observations, explains our calibration procedures, and summarizes the biases we find between our in-situ observations and surface radiation from ISCCP, NCEP1, NCEP2, and ERA40. These fields have significant biases. The challenge remains of developing gridded surface radiation fields over the ocean that have the accuracy required to allow us to meet the accuracy of 10 W m^{-2} in net heat flux. We seek advice and collaboration on in-situ radiation observations and on developing gridded surface heat flux fields for the global ocean.

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Status of the Syowa, Japan BSRN Station (H. Naganuma, Japan Meteorological Agency)

As one of the Antarctic Research Activities by the National Institute of Polar Research (NIPR), the Syowa Antarctic Station is operated by an expedition party from the Japan Meteorological Agency. Radiation data have been transmitted to the BSRN data archive from Syowa since 1994. Because of the technical and training support provided by the Tateno BSRN station, measurements at Syowa have been upgraded continuously over the past 10 years.

Due to ice melt over the past few years, the solid tower housing upward components, which is built on the ice bay, sometimes becomes unstable. A pergola structure with thin poles is under study as a more practical housing for these instruments. Data up to 2003 have been accepted in the BSRN data archive. Thanks to great improvements in the communication capabilities of Syowa, radiation data transmission is now possible on monthly basis. Monthly submission of Syowa data from Tateno to the BSRN archive will soon be available.

Status of the BSRN Tateno, Japan (H. Naganuma, Japan Meteorological Agency)

During the 1957 International Geophysical Year (IGY), the Aerological Observatory (Tateno) of the Japan Meteorological Agency began making global solar, direct solar and longwave radiation (nighttime only) measurements. Reflected solar radiation was added in 1961, followed by diffuse solar radiation in 1962. In 1976 continuous daylong downward and upward longwave radiation measurements became possible by utilizing radiometers with polyethylene dome. After years of preparation in instrumentation and software to meet the BSRN technical requirements, Tateno began data transmissions to the WCRP World Radiation Monitoring Center (WRMC) in 1996. To date, a total of 122 months of basic and partial measurements including surface and upper air meteorological data have been accepted in the BSRN data archive.

Based on radiation data spanned almost 50 years, some distinct temporal trends have been clarified at Tateno. Global solar radiation showed gradual decreasing between the late 1950s and around 1990. After 1990 the trend turned afterwards. To see the trend avoiding the effect of weather, quasi cloud free sky conditions were statistically constructed using maximum hourly totals in a month. The result was almost the same as the former trend. Longwave radiation continues to increase almost linearly from the mid 1970s up to 2005. Daily total of downward longwave radiation indicates about 0.38MJ/m2 (4.4W/m2) increase per decade. On the other hand, upward longwave radiation shows about 0.22MJ/m2 (2.5W/m2) increase per decade during these thirty years. As the combination of solar and longwave radiation trends, net total radiation showed nearly counterbalanced around 1980. In 1990s it began to rise with the rate of about 0.6MJ/m2(7.0W/m2) per decade.

Photosynthesis is Probably the Most Important Biological Process on Earth (Jean Olivieri, Carpentras-Meteo-France)

Photosynthesis is the process by which green plants, algae and certain bacteria use the solar light to convert carbon dioxyde and water into glucose. In so doing, photosynthesis provides the basic energy for practically all living things. The quantity of solar light reaching the Earth’s surface is almost constant (solar constant). The total amount of solar energy fixed by the plants during the photosynthesis process represents about 0.06% of this quantity. The cost of plant respiration (lost during metabolic activity) is about 0.05% of the same quantity. Consequently the photosynthesis has an upper limit. Humans eat almost exclusively the plants they grow in their cultivated fields, or meat from animals they rear in permanent pasture. Now we must ask ourselves whether photosynthesis resources are sufficient to feed human beings. Calculations show that these resources will be sufficient until 2050 to feed about 10 billions human beings.