WCRP REPORT

World Climate Research Programme

14th Baseline Surface Radiation Network (BSRN) Scientific Review and Workshop

26 – 29 April 2016

Australian Bureau of Meteorology, Canberra, Australia

July 2016

WCRP Report No. 17/2016

Table of Contents

1. Overview of Meeting

Fifty scientists, station managers, and data users presented 44 talks and 32 posters at the 14th BSRN Scientific Review and Workshop held at the Australian Bureau of Meteorology (BoM) offices in Canberra, Australia on 26-29 April 2016. The local host from the Australian BoM was Nicole Hyett, who was ably assisted by a host of other BoM personnel. During the meeting, BSRN observations were reviewed, improvements in instrumentation and data reduction methods discussed, data management and quality control issues considered, and ways the data are used by the larger community were examined. In addition, a total of 12 new sites were proposed for consideration to join BSRN.

The GEWEX Data and Assessments Panel (GDAP), chaired by Jörg Schulz, oversees and gives general guidance to BSRN. The BSRN project consists of volunteers operating stations that measure surface solar and infrared (IR) radiation. Most stations measure the surface radiation by making broadband solar and infrared downwelling and upwelling irradiances according to a set protocol and using highest quality radiometers. Many stations also make ancillary measurements, such as aerosol optical depth (AOD), ultraviolet radiation (UV), photosynthetically active radiation (PAR), and meteorological parameters. A few stations began operating in 1992, and have accumulated over two decades of high-quality data. Currently, 59 stations have submitted data to the BSRN Archive since 1992, of which six have terminated their measurements, two are in the process of restarting their operations after long hiatus, and the rest are operational. The World Radiation Monitoring Center (WRMC) of the Alfred Wegener Institute of Polar and Marine Research (AWI) in Bremerhaven, Germany archives the data produced by the stations (*http://www.bsrn.awi.de*).

Below are summaries of the oral presentations made at the meeting in the order listed on the agenda. After the summaries of the oral presentations there are summaries of the poster presentations. Electronic versions of many of the presentations, including posters, are available for a limited time at:
http://www.esrl.noaa.gov/gmd/grad/meetings/bsrn2016.html.

2. Meeting Sessions

2.1 Opening Session

Dr. Rob Vertessy, the Director of BoM, Canberra, opened the meeting on Tuesday, 26 April 2016, giving an Acknowledgement of Country as well as a welcome address. Nicole Hyett, the meeting host, chaired the opening session and discussed meeting logistics, and BSRN Project Manager, Chuck Long, gave BSRN greetings and the meeting charge.

Tim Oakley, on behalf of the Global Climate Observing System (GCOS) Director Dr. Carolin Richter, added his welcome to the participants of the 14th BSRN Workshop and thanked the Australian BoM for their kind support in hosting the meeting. He provided an update on the status of the GCOS program, which has now moved into its 3rd assessment phase with the publication of its status report in 2015, and is drafting its new implementation plan to be submitted to the United Nations Framework Convention on Climate Change (UNFCCC) at the end of 2016. This was an ideal opportunity for the BSRN community to contribute to the GCOS implementation plan, in terms of the surface radiation measurements, which will be open for public review during July and August 2016. He gave an overview of the GCOS Cooperation Mechanism (GCM), particularly a current project to support a Peruvian observatory in the purchase of suitable instrumentation so that it might be considered a candidate BSRN station. This raised the question of the minimum instrument requirements suitable for BSRN consideration and the information contained in the BSRN operations manual and the Commission for Instruments and Methods of Observations (CIMO) guide. It was agreed that this would be discussed further during the management agenda items at the end of the meeting. He concluded that the BSRN, as a nominated GCOS baseline network, was one of only three networks that he was actively interested in as GCOS network manager, and that he would be looking forward to the presentations and discussions during the week.

Nozomu Ohkawara updated the meeting participants on the status and implementation plan of BSRN in GCOS. Surface radiation budget is a fundamental component for climate monitoring and was designated one of the Essential Climate Variables (ECVs) in GCOS to contribute to the UNFCCC. BSRN has served as a GCOS global baseline network since 2004 and the observation data are effectively used for climate research. Recent progress of surface radiation budget observation was reported in "Status of the Global Observing System for Climate" in 2015 and it was reported that BSRN's total data amount archived at its data center had significantly increased, but data scarce areas also remained in some regions. The new GCOS implementation plan will be updated this year to improve the climate observing system effectively. BSRN is still considered a fundamental network for climate monitoring in GCOS, also in view of the energy cycle, and is expected to continue long-term operation with an expanding network.

The session ended with Gert König-Langlo, Director of the World Radiation Monitoring Center (WRMC) and the BSRN Archive (*http://www.bsrn.awi.de*) at the Alfred Wegener Institute (AWI) for Polar and Marine Research at Bremerhaven, Germany, giving a status update on the current state of the WRMC. Since July 2008, AWI has hosted the WRMC. In April 2016, 59 BSRN stations had submitted their data to the WRMC. The data import is organized in so-called "station-to-archive files" which contain all the data from one station collected during one month. There have been a total of 8761 station-month data sets from 59 stations collected in the WRMC by April 2016. All submitted station-to-archive files are read-accessible for any user who accepts the BSRN data release guidelines (*http://www.bsrn.awi.de/en/data/conditions_of_data_release/*).

The files can be obtained via *ftp://ftp.bsrn.awi.de/* by using a web browser or any ftp tool. The access to the public file archive is password-restricted. Read accounts can be obtained from the WRMC (email: Gert.Koenig-Langlo@awi.de). An alternative to accessing data via ftp is the Publishing Network for Geoscientific and Environmental Data, PANGAEA (*http://www.pangaea.de/*), which offers more user-friendly services. The website *http://bsrn.awi.de/data/data-retrieval-via-pangaea.html* offers an overview and access to all submitted data in PANGAEA format.

Since December 2011, all incoming data are run through a quality control in the WRMC. The station scientists are encouraged to test their data prior to submission using, for example, the BSRN-Toolbox (*http://wiki.pangaea.de/wiki/BSRN_Toolbox*). An updated Technical Plan for BSRN Data Management is available via the BSRN webpage or *www.wmo.int/pages/prog/gcos/Publications/gcos-174.pdf*.

Of particular note was the announcement that Dr. König-Langlo would retire mid-2017 and step down as the Director of the WRMC. The commitment from the AWI Director Karin Lochte that AWI will continue to host the WRMC and BSRN Archive at the present level was heartily welcomed by all participants. Heartfelt thanks were extended to Dr. König-Langlo for his many years of participation in BSRN, and his excellent leadership in establishing and improving the WRMC at AWI. He was also asked to convey the BSRN community's sincere thanks to Dr. Lochte and AWI for their past and continued support of the WRMC.

A video presentation by Jörg Schulz, Chair of GDAP, who could not attend the workshop in person, was given during the afternoon poster session. The presentation reviewed the relationship of BSRN to GEWEX and GCOS, and GEWEX within WCRP. The talk also discussed the WCRP Grand Challenges and the four GEWEX Science Questions underpinning the two GEWEX-related Grand Challenges of Changes in Water Availability and Climate Extremes. The talk concluded by noting that systematic BSRN measurements are needed for monitoring climate variability and change, and for evaluating products based on satellite data (radiation fluxes, surface albedo, AOD) and from reanalyses and climate model runs; that spatial and temporal coverage extension remains an issue; and that continuous calibration of BSRN instruments across the sites and knowledge of uncertainty for the measurements is essential.

2.2 New Site Proposals

Barbados Cloud Observatory (Stefan Kinne)

Stefan Kinne represented the Max-Planck-Institut für Meteorologie, Hamburg proposal for establishing a BSRN site on Barbados (*http://barbados.zmaw.de/*). The Barbados Cloud Observatory site includes a rich atmospheric measurement environment including cloud radars, lidars, ceilometers, and sky cameras and has a sister site at nearby Ragged Point specializing in aerosol measurements that is operated by the University of Miami in collaboration with the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA).

New BSRN Sites in Southeast Asia: From High Elevation (2862 m) to Sea-Level (Carlo Wang)

Four new BSRN sites (Lulin, Yushan, Lanyu, and Dongsha) in Taiwan were proposed by Carlo Wang of the National Central University in Taiwan. These sites have their own uniqueness and scientific implications because of different environment setups. However, considering the historical data availability and current equipment, Lulin and Dongsha were selected as provisional BSRN sites during the workshop.

Solar and Meteorological Monitoring in Newcastle, Australia (Benjamin Duck)

A proposal was made for a new BSRN station located at Newcastle, Australia. This site at 33° latitude is located in a region that is representative of the mid-eastern coastal climate of Australia and has a mean temperature of 20.5°C and an average annual rainfall of 1103 mm. The nearby terrain type is flat coastal and consists of a mixture of urban development and open wetland areas. The site is a hub for energy research operated by the Australian national science agency, the Commonwealth Scientific and Industrial Research Organization (CSIRO), with over 10 years' experience measuring and using solar resource data for solar thermal and solar photovoltaic projects. The current ground station has been operational since December 2013 and measures shortwave and longwave downwelling radiation data as well as meteorological data to a standard that is compliant with BSRN specifications, with redundancy on all radiation measurements. Also measured on the station are solar spectral irradiance and broadband irradiance at 30° tilt as well as horizontal and 30° tilt skycam images. Automatic data collection and quality checking with live view feed has been implemented and instruments are cleaned each weekday. The proposal has been provisionally accepted by the BSRN community, and is contingent on addressing an instrument calibration check with data submission. The station is expected to begin submitting data within three months.

A Suntracker at La Réunion Island for Monitoring Surface Solar Radiation under Tropical Maritime Climate Conditions: Towards a New BSRN Site? (Béatrice Morel)

La Réunion is a small mountainous and volcanic tropical island with very complex terrain and numerous microclimates located at 20.8°S and 55.5°E in the South West Indian Ocean. This site is important because it is in a region not covered by the BSRN network (Southern Hemisphere Tropics, oceanic environment).

The Laboratory of Energy, Electronics and Process (LE2P) of the University of La Réunion, which has an interest in the smart management of solar energy, has been developing an SPN1 radiometric network for the measurement of global and diffuse radiation since 2008. The lab aims at establishing its own center for radiometric calibration, and has been developing data quality control (QC) procedures following BSRN Global Network recommended QC tests.

The lab recently acquired the instrumentation for downwelling radiation: a tracker (SOLYS Gear Drive) consisting of two CMP22 [global-diffuse shortwave (SW)], a CHP1 (direct SW), and a CGR4 (LW) (all ventilated). All these instruments (except the CGR4) were temporary installed on the roof of the Faculty of Sciences Building where the lab plans to build a dedicated platform on top of the lift cage. The measurements have been performed since 8 April 2016. Additional measurements are made close to the tracker: temperature, humidity, pressure, wind direction and speed, rain (Vaisala weather transmitter WXT520), and UVA and UVE irradiance (UVS-AE-T). In addition, the proposed measurement site is collocated with routine upper-air soundings (observations) and basic meteorological instrumentation provided by Météo France and the Observatoire de Physique de l'Atmosphère de la Réunion (OPAR)-Maïdo Observatory, which houses a large variety of atmospheric instruments, including LiDARs, radiometers, and in situ gas and aerosol sensors.

In preparation for the next BSRN workshop and following the BSRN recommendations at this workshop, the lab plans to: (1) send all its radiometers (the two CMP22, the CHP1, the CGR4) to the Physikalisch-Metorologisches Observatorium Davos (PMOD) for traceable calibration in 2016; and (2) be ready to provide one year of data in station-to-archive format to the WRMC-BSRN before the next workshop.

A Proposal to Bring Four SRRA Stations of India into the BSRN Network (Karthik Ramanathan)

Karthik Ramanathan of the National Institute of Wind Energy of India proposed four Solar Radiation Resource Assessment (SRRA) Stations located at Thiruvallur, Gurgaon, Gandhinagar, and Howrah in India. These four sites cover locations in the north, south, east, and west regions of the country, with all the sensors traceable to the World Meteorological Organization (WMO) and World Radiometric Reference (WRR) and possessing well-established quality assurance and archiving procedures. Measurements include both radiation and meteorological variables.

Ice Camp "Cape Baranova" (79°N, 101°E): Possible Candidate for BSRN (Vasilii Kustov)

Vasilii Kustov of the Arctic and Antarctic Research Institute in St. Petersburg, Russia presented a proposal for a new Arctic site at Cape Baranova (79°N, 101°E). The location of the ice base is one of the least-investigated regions of the Arctic Ocean. There are plans for a whole complex of meteorological instrumentation to be installed, similar to the Tiksi location, positioning it as a potential second regional station in the Russian Arctic and a global station in the Global Atmosphere Watch (GAW).

2.3 Instrument Issues

Comparison of Calibration Methods and Resulting Solar Irradiance Measurement Differences (Aron Habte)

The accuracy of solar radiation measured by radiometers depends on the instrument performance specification, installation method, calibration procedure, measurement conditions, maintenance practices, location, and environmental conditions. The study addressed the effect of calibration methodologies and the resulting calibration responsivities provided by radiometric calibration service providers such as the National Renewable Energy Laboratory (NREL) and manufacturers of radiometers. Some of these radiometers were calibrated indoors and some outdoors. To understand the impact of differences in calibration methodology, the study processed and analyzed field measurements from various radiometers. The calibration responsivities were provided by NREL's broadband outdoor radiometer calibration (BORCAL) and a few prominent manufacturers. The NREL's BORCAL method provided outdoor calibration responsivity for pyranometers and pyrheliometers at 45° solar zenith angle and as a function of solar zenith angle determined by clear-sky comparisons with reference irradiance. The BORCAL method also employed a thermal offset correction to the calibration responsivity of single-black thermopile detectors used in pyranometers. Indoor calibrations of radiometers by their manufacturers are performed using a stable artificial light source in a side-by-side comparison between the test radiometer under calibration and a reference radiometer of the same type. In both methods, the reference radiometer calibrations are traceable to the World Radiometric Reference (WRR). These different methods of calibration demonstrated 1–2% differences in solar irradiance measurement. Analyzing these values will ultimately assist in determining the uncertainties in the radiometric measurements and will assist in developing a consensus standard for calibration.

Zenith Angle Bias in Pyranometer Calibration (Michael Milner)

Zenith angle bias is due to the predominance of measurement towards solar noon during pyranometer calibration. The presentation discusses this phenomenon, why it occurs, and includes seasonal and geographic arguments to remove the bias. With the bias towards zenith in mind, the discussion moves on to Pyranometer Cosine Response–Sensitivity versus Zenith Angle. Different cosine responses of several instruments that have passed through the RAV calibration facility are examined. The unique responses of the collection of pyranometers re-enforces why we do not want calibration to be biased upon a particular zenith angle. A mathematical equation for calculating a simple mean sensitivity is introduced. This formula is expanded to introduce the concept of Zenith angle binning to calculate the mean zenith sensitivity at a particular zenith angle for a 1° zenith bin. This is further expanded to a "Mean of Means" method to incorporate all of the zenith bins to generate an overall sensitivity for the instrument with the zenith angle bias now removed. A silicon pyranometer is presented as a case study, and simple mean sensitivity is compared to a zenith binned mean of means sensitivity. The final calibration figure given to the silicon pyranometer is discussed with consideration of its geographic location and cosine response.

An Evaluation of the Delta-T SPN1 as a Sunshine Meter (Nicole Hyett)

The SPN1 sunshine pyranometer is a relatively low cost pyranometer that has several advantages over standard pyranometers: it requires no solar tracker, has no moving parts, and does not need to be adjusted or repositioned to track the sun. It measures global and diffuse radiation as well as recording the sunshine status, which in turn can be used to calculate sunshine duration. The presentation compared sunshine duration calculated using the SPN1 with that derived from a Kipp and Zonen CH1 pyrheliometer. All the data presented were collected at the Bureau of Meteorology site at Adelaide Airport. The ability of the SPN1 to meet the World Meteorological Organization uncertainty target of ± 0.1 h was evaluated.

The 4th Filter Radiometer Comparison of Aerosol Optical Depth Measurements at PMOD/WRC (Natalia Kouremeti)

The fourth Filter Radiometer Comparison FRC-IV was conducted alongside the 12th International Pyrheliometer Comparison (IPC-XII) organized by the World Radiation Center (WRC) at Davos on behalf of the World Meteorological Organization (WMO). The objective of this campaign was to compare different instruments belonging to different global or national networks in order to quantify the main factors that are responsible from possible deviations. The whole activity aims to homogenize AOD measurements on a global scale. Experts from 12 countries participated with 30 instruments and provided their AOD results gathered from 28 September–16 October 2015. Instruments attributed to different AOD networks participated at the campaign, including the Precision Filter Radiometer (PFR) and Precision Solar Spectroradiometer (PSR), CIMEL, POM-2, Multifilter Rotating Shadowband Radiometer (MFRSR), SPO-2, from the GAW-PFR, the Aerosol Robotic Network (AERONET), Skynet, the Surface Radiation Network (SURFRAD), and Australian networks, respectively. A triad of Precision Filter Radiometers (PFR) maintained by the World Optical Depth Research and Calibration Center (WORCC) section of WRC served as reference for this comparison. The results of the FRC-IV have included a large variety of AOD-measuring instrumentation with the participation of reference instruments from global networks and could be considered a starting point for global AOD homogeneity initiatives. The final aim is a unified AOD product to be used for long-term aerosol and radiative forcing studies and satellite validation related activities. The results of the campaign will be published as a World Meteorological Organization report and published in peer-reviewed literature.

The Austrian Radiation Monitoring Network ARAD: Best Practice and Added Value (Ursula Weiser)

The Austrian RADiation monitoring network (ARAD) has been established to advance national climate monitoring and to support satellite retrieval, atmospheric modeling, and the development of solar energy techniques. Measurements cover the downward solar and thermal infrared radiation using instruments according to BSRN standards. A unique feature of ARAD is its vertical dimension of five stations, covering an altitude range between about 200 m a.s.l. (Vienna) and 3100 m a.s.l. (BSRN site Sonnblick). ARAD network operation uses innovative data processing for quality assurance and quality control, utilizing manual and automated control algorithms. A combined uncertainty estimate for the broadband shortwave radiation fluxes at all five ARAD stations, using the methodology specified by the Guide to the Expression of Uncertainty in Measurement, indicates that relative accuracies range from 1.5–2.9% for large signals (global, direct: 1000 W/m^2, diffuse: 500 W/m^2) and from 1.7–23% (or 0.9 to 11.5 W/m^2) for small signals (50 W/m^2) (expanded uncertainties corresponding to the 95% confidence level). If the directional response error of the pyranometers and the temperature response of the instruments and the data acquisition system (DAQ) are corrected, this expanded uncertainty reduces to 1.4–2.8% for large signals and to 1.7–5.2% (or 0.9–2.6 W/m^2) for small signals. Thus, for large signals of global and diffuse radiation, BSRN target accuracies are met or nearly met (missed by less than 0.2 percentage points, pps) for 70% of the ARAD measurements after this correction. For small signals of direct radiation, BSRN targets are achieved at two sites and nearly met (also missed by less than 0.2 pps) at the other sites. For small signals of global and diffuse radiation, targets are achieved at all stations. Some methods and examples of data use were presented. At the BSRN site Sonnblick, some special modifications had to be done to prevent rime and hoarfrost around the sensors that deteriorate radiation signals. Plastic tubes were mounted at the inlet of the ventilation system beneath the instruments to delay rime. The CHP-1 pyrheliometer was replaced by a DR02 with a heated front window that has an ideal heating power between maximal frost removal and minimal offsets.

Reference:

Olefs et al., 2016. The Austrian radiation monitoring network ARAD–best practice and added value. *Atmos. Meas. Tech.*, 9, 1513-1531, *http://www.atmos-meas-tech.net/9/1513/2016/*.

Pyrheliometer Alignment Testing (Michael Milner)

This test method was developed after a RAV transfer standard alignment sight was compromised. It uses programmable tracker offsets to create an 11 x 11 matrix to generate a signal strength contour map. Test method discussion included hardware and software configurations and explanations. The contour plot result of the damaged RAV transfer was discussed and the alignment error identified. Contour plots results and alignments for six different manufacturer/model pyrheliometers were compared and discussed. Individual pyrheliometer error display attributes were also investigated along with a brief insight into pyrheliometer geometry. Finally, photographs of alignment sights for the various pyrheliometers, while misaligned, were presented along with the signal strength contour maps. This provided visual representation of various angular misalignments on the instrument alignment sights and quantified them in terms of percentage signal loss.

Quantifying Spectral Error in Thermopile Radiometers (Aron Habte)

High accuracy radiometric measurements are needed for understanding the radiative impact on climate, development and validation of radiative transfer models, and solar energy system performance. This requires rigorous quantitative evaluation of various sources of uncertainties of measured solar radiation. One potential source of uncertainty is the spectral response of various components of the thermopile radiometers. The focus of this study was to quantify the spectral error of shortwave radiometers due to changes in the optical transmittance of the glass dome and the reflectance behavior of the black detector coating over time. It is known that thermopile-based radiometers have a thermal detector with black coating. The coating has a flat spectral absorption typically ranging from 200–50000 nm. Similarly the precision-ground glass or sapphire domes that protect the detector are supposed to have a flat spectral response (typically 280–3000 nm). The study investigated the spectral mismatch of shortwave radiometers as they age when deployed under various climatic conditions for an extended period. To quantify the impact, it was necessary to evaluate the spectral response of the radiometers under varying air mass in differing climates such as extremely clear and dry conditions occurring at high altitudes and deserts as well as humid and wet environments that exist in tropical settings. This required understanding the stability of the black detector coating to measure spectral changes over time. Further, it was important to understand the spectral impact of degradation of the glass dome due to environmental factors. The presentation demonstrated the measurement set-up in detail and presented preliminary results. The result showed non-flat transmittance of the glass dome and non-flat absorptance of the black coating due to aging contribute to spectral error up to 1.6% for indoor transmittance measurement and up to 1.2% for outdoor transmittance measurement. The presentation discussed a forward plan and use of the study in the development of uncertainty and classification standards of radiometers.

Measuring Broadband IR Irradiance in the Direct Solar Beam and Recent Development (Ibrahim Reda)

Solar and atmospheric science radiometers such as pyranometers, pyrheliometers, and photovoltaic cells are calibrated with traceability to consensus reference, which is maintained by Absolute Cavity Radiometers (ACRs). An ACR is an open cavity with no window, developed to measure the extended broadband spectrum of the terrestrial direct solar beam irradiance, and extends beyond the ultraviolet and infrared bands; i.e., below 0.2 µm and above 50 µm, respectively. On the other hand, the pyranometers and pyrheliometers were developed to measure broadband shortwave irradiance from approximately 0.3–3 µm, while the present photovoltaic cells are limited to the spectral range of approximately 0.3–1 µm. The broadband mismatch of ACR versus such radiometers causes discrepancy in the radiometers' calibration methods that has not been discussed or addressed in the solar and atmospheric science literature. Pyrgeometers are also used for solar and atmospheric science applications and calibrated with traceability to consensus reference, yet they are calibrated during nighttime only, because no consensus reference has yet been established for the daytime longwave irradiance. In the presentation, a method to measure the broadband longwave irradiance in the terrestrial direct solar beam from 3–50 µm was presented as a first step that might be used to help develop calibration methods to address the mismatch between broadband ACR and shortwave radiometers, and the lack of a daytime reference for pyrgeometers. The described method showed that there is bias in all present shortwave radiometer calibration that might exceed 1.6%, which would cause an error greater than 16 W/m^2 in all historical shortwave irradiance data, and present shortwave irradiance measurement in the field.

Pyrgeometer Uncertainty Calculations (Ian Dollery)

Ian Dollery presented an assessment of pyrgeometer uncertainty calculations, which showed that the largest contributors to uncertainty in the longwave measurements are the thermistors' temperature measurements.

Recovering LW Irradiance Tainted with Bad Thermistor Data (John Augustine)

A large contingent of U.S. BSRN stations (the seven U.S. SURFRAD stations) has been operational since 1995. Measurements of upwelling and downwelling longwave (LW) and shortwave radiation are the focus of the SURFRAD network. Missing any of the four components of the SRB nullifies its primary product until the bad instrument is replaced or repaired, leaving a gap in the SRB time series. Longwave measurements in the SURFRAD network are made with an Eppley pyrgeometer [Precision Infrared Radiometer (PIR) model]. Retrieval of the LW signal from a PIR requires three measurements made by the instrument: (1) the thermopile signal under the filtered dome, (2) the temperature of the instrument body (or case temperature), and (3) the temperature of the instrument's dome. The case and dome temperature measurements are made by thermistors and account for over 80% of the retrieved LW signal because those temperatures are raised to the fourth power in the LW retrieval. For example, an LW error of approximately 22 W/m^2 is produced by a 1°C case temperature error. A method has been developed to correct a bad thermistor measurement that adds only 1–2% extra error to the LW retrieval. It is based on the relationship between the case-dome temperature difference and the thermopile signal. That is possible because the thermopile voltage and dome temperature vary with the character of the LW signal source, but the case temperature does not. If one thermistor temperature is good, the other can be recovered using three linear relationships that relate the case – dome temperature difference to the thermopile signal. The three separate relationships represent clear skies, cloudy skies, and wet conditions (Relative Humidity > 80%) and are derived from a period of good data from the affected instrument at the affected site. Therefore, these correction relationships are site- and instrument-dependent. The method can be applied to both downwelling and upwelling longwave measurements. Thermistor errors of approximately 1°C or less are difficult to perceive in data quality control and can persist for months. These situations have occurred several times during the SURFRAD network's 20-year tenure, and applying this correction method has saved many months of SRB data. Because in both cases the dome temperatures are needed, this method does not apply to pyrgeometers that do not have a dome thermistor.

Long-Term Stability of Two Eppley and Two Kipp & Zonen Pyrgeometers (Klaus Behrens)

Since June 2003, the Lindenberg Meteorological Observatory has been operating a shaded and unshaded PIR as well as a shaded and unshaded CG4 in parallel. Here, we looked at the time series between January 2004 and December 2015. The PIRs (S/N 32800 and 32802) were calibrated at PMOD in the year 2001, while the calibration of the CG4s (S/N 020599 and 000517) was done by the manufacturer in 2000–2002, respectively. Since the start these sensitivities have not been changed. The Combilog 1020 (Fa. Th. Friedrichs, Hamburg) was used as data acquisition system. The data were gathered with a frequency of 1 Hz.

The classical formulas determining LDR for PIRs and CG4 were applied to calculate 1-Min-means for every instrument and minute of the whole time series:

$$A_{PIR} = \frac{U}{C}(1 + k_1\sigma T_b^3) + k_2\sigma T_b^4 - k_3\sigma(T_d^4 - T_b^4) \; ; \qquad\qquad A_{CG4} = \frac{U}{C} + \sigma T_b^4$$

These data are the starting points to calculate 1-Min-means for every record and the deviations from this mean, respectively. In a next step, cloud free records (N=0) were selected from these data. A distinction in night-time (SZA>95°) and day-time (SZA<85°) was carried out. For a further first analysis, these data were condensed into monthly means. The nighttime means of the deviations are stable in time with biases between -0.85 W/m² and -0.3 W/m² for three instruments, while on CG4 has a bias of 1.85 W/m². The 0.1 and 0.9 percentile are within +1W/m² and -2W/m² and show the long-term stability. The daytime values are stable within same bounds, too, while the biases of the unshaded pyrgeometers (-0.35; -0.26) are closer to zero, which can be interpreted a result of the dome heating. A more detailed analysis has to be done in future.

Brief Summary of the IPgC Pyrgeometer Comparison Held during the IPC Last Fall (Julian Gröbner)

The second International Pyrgeometer Intercomparison (IPgC-II) was organized in conjunction with the IPC-XII and FRC-IV at PMOD/WRC from 26 September 26–15 October 2015. Thirty-three Pyrgeometers from 23 institutions and 18 countries were calibrated relative to the World Infrared Standard Group of Pyrgeometers (WISG). In addition, four Infrared Integrating Sphere (IRIS) radiometers and two Absolute Cavity Pyrgeometer (ACPs) were also operated alongside the WISG. The participating pyrgeometers were from three manufacturers: 19 were Kipp & Zonen CG4/CGR4, five were Eppley PIR, and nine were Hukseflux IR20. Even though most pyrgeometers were operated on the data acquisition system of PMOD/WRC, a few groups brought their own data acquisition system and acquired the pyrgeometer signals themselves. Due to the large number of instruments, only a small subset could be mounted on shaded positions, while the large majority was installed on unshaded positions on the roof platform. Nevertheless, all instruments were operated in ventilated units, most of them of the PMOD/WRC type, while a few participants brought their own ventilation units. In view of establishing the traceability of the WISG to the international system of units, four IRIS radiometers and two ACPs were operated during the IPgC on the roof platform during clear nights, with the IRIS and ACP agreeing to +-2 W/m^2, while the WISG measured between 4–5 W/m^2 less. These measurements confirm the results published in Gröbner et al., 2014. The results of the IPgC will be published in a separate WMO report.

Reference:
Gröbner, J., I. Reda, S. Wacker, S.Nyeki, K. Behrens, and J. Gorman, 2014. A new absolute reference for atmospheric longwave irradiance measurements with traceability to SI units. *J. Geophys. Res. Atmos*., 119, doi:10.1002/2014JD021630.

The World Infrared Standard Group (WISG) of Longwave Radiometers: How Can/Should Updated Calibrations Be Transferred to BSRN Records? (Stephan Nyeki)

The BSRN archive of surface observations is used worldwide to validate satellite products and global climate models (GCM). Most BSRN longwave irradiance records are traceable to the World Infrared Standard Group (WISG), hosted by the PMOD/WRC in Davos. However, the WISG has recently been found to underestimate irradiance values. In view of a possible correction to the WISG, this talk examined how this may affect the BSRN longwave irradiance archive. Long-term measurements of downwelling longwave irradiance at PMOD/WRC were discussed, which illustrated two types of possible correction: a scale correction and correction based on the integrated water vapor content of the atmosphere. Statistics gathered from users and the BSRN archive were then presented, showing that the time-series at most stations would be affected. As many of these aspects are a source of current debate, the talk concluded by saying that results from the study would be passed on to CIMO to aid it in its future decisions.

2.4 Observations and Analysis

Cloud Radiative Forcing from Pan-Arctic BSRN Stations: Applications for Climate Monitoring and Seasonal-Scale Sea Ice Forecasting (Chris Cox)

This study analyzes observations of radiative fluxes acquired at the surface from Barrow, Alaska (1993–2015); Alert, Canada (2004–2014); Ny-Ålesund, Svalbard (1993–2015); Summit, Greenland (2010–2012); and Tiksi, Russia (2011–2015). The measurements include upwelling and downwelling longwave and shortwave fluxes, as well as direct and diffuse shortwave flux components and surface meteorology. The observations are post-processed using the Radiative Flux Analysis (RFA) method, which, in addition to basic quality control, provides value-added metrics such as cloud radiative forcing (CRF), optical depth, and fractional sky cover. Here, the seasonal cycle in CRF calculated from the focus observatories is investigated. The importance of surface albedo (a property independent of clouds) is among the largest influences on the CRF, highlighting the need to spatially contextualize surface observations for accurate interpretation of CRF in the Arctic. Subtleties in the factors that control the springtime transition from net cloud warming in winter to net cloud cooling in summer, including influences from the atmosphere, surface, and clouds, are found to be important for the melt season. For example, CRF at Barrow during the spring is well correlated with autumn sea ice extent; thus, Barrow appears to sample cloud anomalies that are responsible for early-season preconditioning of the sea ice surface.

Increasing Carbon Dioxide Cools Antarctica (Gert König-Langlo)

An extract of the paper from Schmithüsen et al. (2015) was given:

> Carbon dioxide is the strongest anthropogenic-forcing agent for climate change since pre-industrial times. Like other greenhouse gases, carbon dioxide absorbs terrestrial surface radiation and causes emission from the atmosphere to space. As the surface is generally warmer than the atmosphere, the total longwave emission to space is commonly less than the surface emission. However, this does not hold true for the high-elevated areas of central Antarctica. For this region, the emission to space is higher than the surface emission, and the greenhouse effect of carbon dioxide is around zero or even negative, which has not been discussed so far. We investigated this in detail and show that for central Antarctica, an increase in carbon dioxide concentration leads to an increased longwave energy loss to space, which cools the Earth-atmosphere system. These findings for central Antarctica are in contrast to the general warming effect of increasing carbon dioxide.

Reference:
Schmithuesen, H., J. Notholt, G. König-Langlo, P. Lemke, and T. Jung, 2015. How increasing carbon dioxide leads to an increased negative greenhouse effect in Antarctica. *Geophys. Res. Lett.*, 42 (10), pp. 422-428, doi: 10.1002/2015GL066749.

Parameterization of Clear-Sky Surface Irradiance and Its Implications for Estimation of Aerosol Direct Radiative Effect and Aerosol Optical Depth (Xiangao Xia)

Xiangao Xia presented a parameterization of clear-sky surface irradiance and its implications for estimation of aerosol direct radiative effect and aerosol optical depth.

Long-Term Measurements of Solar Radiation and Aerosol Radiative Forcing at Mt. Lulin (2862 m) in East Asia (Carlo Wang)

Aerosol optical properties and aerosol radiative forcing of Mt. Lulin from AERONET and solar radiation flux measurements in cooperation with a radiative transfer model were presented. Their results show strong seasonal variations and particulate high aerosol loading and radiative forcing in March due to transported biomass-burning aerosol. The study demonstrates how an aerosol-radiation-climate study can be carried out by a BSRN-like station.

Determination of Aerosol Optical Depth, and the Required Top Of Atmosphere Values, with a Multi-Filter Rotating Shadowband Radiometer over a Five Year Long Period (Frederick Denn)

This talk focused on calibration for Aerosol Optical Depth (AOD) instrumentation. The instrument used in this study was a Yankee Environmental Systems Multi Filter Rotating Shadowband Radiometer (MFRSR). These calibrations were all based on Langley Top Of Atmosphere (TOA) extrapolations. Calibrations at mountain sites and at the normal instrument measurement location were investigated. Methods of determining mean TOA values were studied including three-month running means, five year fits to daily TOAs, fits to three mountain calibration missions, and a single mountain calibration event that took place in Davos, Switzerland. AODs were determined using each of the calibration methods, and compared to AODs determined by the Davos Precision Filter Radiometer (PFR)-Triad. Using the PFR-Triad as the reference set, it was determined that long-term in place determinations of TOA values are as good as or better than mountain top calibrations.

AOD Estimates from Broadband BSRN Data (Stefan Kinne)

The first afternoon session ended with a presentation on AOD estimates from broadband BSRN data given by Stefan Kinne.

Spectral Irradiance and Optical Depth Retrievals from the Rotating Shadowband Spectroradiometer (RSS) (Joe Michalsky)

The RSS operated successfully between August 2009 and March 2014 after being rebuilt with the Charge Coupled Device (CCD) array enclosed in a vacuum to avoid earlier issues with degassing that caused a film to form on the detector array surface. There are around 1000 useful pixels in this prism spectrograph that span 360–1070 nm with variable resolution from a fraction of a nm to several nm between the UV and near IR. We are using Langley plots to determine the response at the top of the atmosphere, and we have developed a reliable way of estimating top of atmosphere (TOA) response over the strong water vapor and oxygen bands. We use robust estimates of TOA responses and the Gueymard TOA spectrum at RSS spectral resolution to calibrate the instrument in order to estimate global and diffuse horizontal and direct normal spectral irradiances. Calibrations were compared with sparse lamp calibrations of the spectrometer and we find up to 6% discrepancies that are currently unresolved, but suggest lamp overestimated lamp output. We also use the TOA response to calculate aerosol optical depths (AODs). Further effort is needed to reduce the discrepancies; compare AODs with other instruments; generate a database of AODs and spectral irradiances; and produce trace gas retrievals of water vapor, ozone, and nitrogen dioxide. Further, we expect to use the data in concert with other Atmospheric Radiation Measurement (ARM) Program measurements nearby to determine the single scattering albedo and asymmetry parameters of aerosols at the accessible wavelengths.

This addresses the important question of aerosol absorption that has been suggested as higher than previously thought.

15-Year Climatology of BSRN Measurements Made at Chesapeake Light (CLH) Station (Bryan Fabbri)

A 15-year climatology of downwelling longwave measurements collected at Chesapeake Light (CLH) Station shows positive trends for all seasons, with autumn having the highest trend, whereas downwelling shortwave global display seasonally mixed trends. Upwelling shortwave and longwave measurements have a couple issues that have prevented data being submitted to the BSRN archives. They are: (1) in the morning, the shadow of the tower appears on the water where the upwelling instruments are measuring and (2) the tower is in the instruments' field of view. Due to these issues, some data anomalies occur in the data set and can affect trend analysis. Comparing upwelling broadband longwave pyrgeometer (PIR) with an unobstructed narrow field of view infrared radiation thermometer show different results. The magnitude of the PIR data is greater on a clear, summer day than an overcast summer day, and also has greater magnitude than on a winter clear or overcast day. This suggests the PIR is measuring the extra heat signal from the tower, especially noticeable on clear summer days, which are longer and hotter.

The Data from the BSRN Archive and Its Application in the NASA GEWEX SRB and POWER Projects (Taiping Zhang)

By the end of September 2015, there were 8955 site-months of data in the BSRN archive from 60 listed sites, the earliest ones being from January 1992. We have performed quality-check on the original data sets, eliminating records deemed to be in error, and produced hourly, 3-hourly, daily, and monthly means. The results have been extensively used to validate the shortwave/longwave downward fluxes from the GEWEX SRB project up to Release 3.0/3.1 and the direct normal and diffuse fluxes derived therefrom as part of the NASA Prediction Of Worldwide Energy Resource (POWER) project. These satellite-base data sets span a 24.5-year period from July 1983 to December 2007. The FLASHFlux (Fast Longwave And SHortwave Radiative Fluxes) provides rapid release of surface and TOA radiative fluxes from the Clouds and the Earth's Radiant Energy System (CERES) instruments up to near real time. GEWEX SRB and FLASHFlux provide the source data for the NASA POWER project. The validation of FLASHFlux against BSRN was performed from 2008 to 2015. Thus far, all the BSRN data in archive up to September 2015 have been used for validation purposes. The systematic validation found that sites that show unusual patterns in scatter plots are Alert (ALE), Barrow (BAR), Sonnblick (SON), Izana (IZA), Tamanrasset (TAM), Ilorin (ILO), Syowa (SYO), Neumayer (GVN), and South Pole (SPO). High altitudes could contribute to the disagreement with SON and IZA, while snow and ice at high latitudes could partly explain the behavior of ALE, BAR, SYO, GVN, and SPO. In validation of either the GEWEX SRB Global Horizontal Irradiance (GHI), the FLASHFlux GHI, or the model-derived Direct Normal Irradiance (DNI), when just four sites, albeit not all the same sites, are excluded, comparison statistics show significant improvement.

Indian Experiences on Solar Resource Assessment (Karthik Ramanathan)

Karthik Ramanathan gave a talk on solar resource assessment activities and experiences in India.

On the Quality of Solar Irradiance Measurements for Photovoltaic Module Efficiency Studies (Jordi Badosa)

Jordi Badosa gave a talk on the quality of solar irradiance measurements for photovoltaic module efficiency studies.

Validation of the BLR Diffuse Model against BSRN FLO (Sergio Colle)

The BSRN facility has provided qualified data for a long period, about 10 years. The data have been used to check the validity of various known correlations for the diffuse component of IR radiation. In the last few years, Boland et al. (2010) developed a model to estimate the diffuse radiation fraction, validated for Australia. A logistic function is proposed, instead of piecewise linear or simple nonlinear functions, as set forth by Erbset et al. (1982) and other authors. The present work focuses on the validation of the Boland-Ridley-Lauret (BRL) model as a first step to build a model for Brazilian surface stations of the meteorological service. The validation should be completed in the next three months and will be reported in a paper submitted to the *Journal of Solar Energy*.

25 Years of Spectral UV Measurements at Lauder (Ben Liley)

Ben Liley presented a talk on 25 years of spectral UV measurements at Lauder, New Zealand.

Inferring Photolysis Rates from Solar Radiation Measurements at Cape Grim (Stephen Wilson)

The photolysis of ozone to produce the excited oxygen atom (O 1D) is a key process in the chemistry of the atmosphere. This photolysis rate has been inferred from measurements of global and diffuse horizontal irradiance measured at Cape Grim, Tasmania. These measurements span the period 2000–2005 (inclusive) and demonstrate a dependence on ozone column as derived from satellite measurements that is in line with model predictions. They also show that clouds reduce the photolysis rate from the clear sky value by 30–40% over the entire period of measurement.

2.5 Working Group Reports

Infrared Working Group Report (Julian Gröbner)

> Members: J. Gröbner (chair), J. Michalsky (emeritus), K. Behrens, I. Reda, N. Ohkawara, T. Carlund, B. Gorman, B. Forgan, T. Kirk, J. Konings, J. Mes, L. Vuilleumier, J. Celso Thomaz, K. Hoogendijk

The following tasks were discussed during the meeting of the working group for longwave infrared radiation:

- Address the consistency between pyrgeometers under wet climates with regard to high integrated water vapor
- Investigate the use of either WISG or Blackbody based calibrations of pyrgeometers used to measure upwelling longwave irradiance
- Gather information and investigate different methodologies for re-evaluation of BSRN irradiance data sets in view of an eventual recalibration of BSRN radiometers

- Compare pyrgeometer calibrations from different institutes and investigate their consistency
- Investigate the stability of pyrgeometers over time in view of applying recent calibrations to past data sets

Spectral Working Group Report (Julian Gröbner)

Members: J. Gröbner (chair), L. Vuilleumier, B. Liley, R. Pinker, B. Forgan, J. Michalsky, (to be confirmed and completed)

The new Chair of this working group will be Kathy Lantz from NOAA.

The following activities were discussed during the working group meeting and included in the working group's proposed activities:

- Plan a field campaign to compare and calibrate Photosynthetically Active Radiation (PAR) sensors and PAR weighted spectra
- Arrange a UV broadband filter radiometer campaign at the World Calibration Center for UV at PMOD/WRC, Davos, from June–August 2017. Information will be disseminated shortly
- Publish the Filter Radiometer Comparison (FRC-IV) held at PMOD/WRC in October 2015 as a WMO report and condensed in a peer-reviewed publication. Participants in the FRC will be eventually contacted to re-evaluate their data with common parameters supplied by the FRC organizer
- A questionnaire will be circulated to BSRN site operators if it has not been already to obtain information on their AOD products

Cold Climate Issues Working Group Report (Chris Cox)

Members: Chris Cox (Cooperative Institute for Research in Environmental Sciences/National Oceanic and Atmospheric Administration, CIRES/NOAA), Chuck Long (CIRES/NOAA), Gert König-Langlo (Alfred Wegener Institut, AWI), Taiping Zhang (NASA), Vasilii Kustov (Arctic and Antarctic Research Institute, AARI), Jörgen Konings (Hukseflux), Tom Kirk (Eppley), Angelo Lupi (Institute of Atmospheric Sciences and Climate, ISAC), Ursula Weiser (Central Institution for Meteorology and Geodynamics, ZAMG)

The discussion included selection of stations suitable for validation of gridded data products and the complexities of comparisons over snow/ice surfaces, guidelines for averaging data, challenges involved with calibrating radiometers deployed to remote sites and the frequency with which calibrations should be performed, and errors in NIP measurements caused by additional heating to polar-hardened trackers. In preparation for the Year of Polar Prediction (YOPP) (mid-2017 through mid-2019), several BSRN-CCIWG goals where outlined: (1) BSRN Polar sites should be up-to-date in the archive as a service to YOPP and for exposure of BSRN to the international community. (2) Development should continue for a traveling radiometer intercomparison station for validation of remote BSRN stations and a common reference in establishing station intercomparability. (3) BSRN-CCIWG should carry out a radiometer dome icing mitigation strategy intercomparison campaign, which will assess the effectiveness of various designs and identify any adverse effects on the integrity of the measurements; Barrow, Alaska, was identified as a potential location for the campaign.

Uncertainties Working Group Report (Nicole Hyett)

The Uncertainty Working Group met with great enthusiasm, and resolved to provide two documents. The first will provide guidance to new and existing station scientists in the form of a "checklist" document. Several people volunteered to take on different sections. The second document aims to provide an estimate of uncertainties for different BSRN time series. We decided to survey BSRN users on which time series are most commonly in use and to concentrate our efforts in the direction that would provide the greatest value to our users.

Broadband Shortwave Working Group Report (Joe Michalsky)

Attendees: John Augustine, Kathy Lantz, Carlo Wang, Fred Denn, Allison McComiskey, Gary Hodges, Laurent Vuilleumier, Tom Kirk, Joe Michalsky

Possible projects to conduct over the next two years were discussed. Regarding albedo, there was interest in measuring albedos over various heights to determine the effect of height on the broadband shortwave measurements. For example, the use of a pyranometer mounted on "cherry picker" was one suggestion. The possibility of using a sky-blocked, vertically mounted pyranometer to measure one-half of the upward irradiance and then double it to estimate upwelling sparked some interest. Some preliminary data suggest that this would work and allow mountings where the substructure interferes with the nominal measurement protocol. Addressing the heterogeneity issue was discussed, which could be tackled by sampling local spots over a large area to assess the extent of the problem. Regarding pyranometry and pyrheliometry, it was suggested that experiments like the Various Conditions Pyrheliometer Comparison (VCPC) carried out in 2009 be repeated because of the newer pryheliometers and because new comparisons could be performed for diffuse and global horizontal measurements made with pyranometers. These should be carried out in both clean and hazy conditions. It is important to have concurrent measurements of the meteorological conditions and the infrared to make possible corrections to the pyranometers. Allison McComiskey volunteered to take the Working Group chair position.

2.6 Business and Discussions

The final session of the Workshop was comprised of BSRN business and discussions. For the first item of business, several previous Working Groups (WGs) were consolidated into the new Broadband Shortwave Radiometry WG, which was described by Joe Michalsky in the WG reporting, and will be chaired by Allison McComiskey of NOAA Global Monitoring Division.

A discussion of the proposed candidate sites ensued. The candidate sites that were given provisional acceptance were the Taiwan Lulin and Dongsha Atoll sites (Carlo Wang); the Newcastle, Australia site (Ben Duck); the four SRRA [Gurgaon, Howrah, Gandhinagar, and Tiruvallur] Sites in India (Karthik Ramanathan); and the Arctic Cape Baranova site (Vasili Kustov). These eight new sites will be marked with white circles as candidate sites on the BSRN Sites map (*http://bsrn.awi.de/stations/maps.html*), and will be designated as full-fledged BSRN sites upon successful acceptance of quality-assessed data files into the BSRN Archive, the final step in becoming a BSRN station. It was decided that the Barbados site in the western tropical Atlantic, the Taiwan Yushan and Lanyu sites, and the Réunion Island site in the western Indian Ocean all needed further development in areas such as instrumentation, operational paradigm, and calibrations protocols before being accepted as BSRN stations. All were invited to attend the next BSRN meeting to be held in 2018 to present their progress towards becoming BSRN sites.

It was noted that a number of previously proposed candidate sites were still listed, yet had not further interacted or corresponded with BSRN for many years. Two sites had been provisionally accepted as BSRN sites more than a decade ago, but had never submitted any data to the BSRN Archive, which is the final step in becoming a full-fledged BSRN stations. Three other sites proposed joining the network, but never followed up in any way. None of these five sites were ever noted on the BSRN maps or station listings. After discussion, it was decided to drop all five of these sites, and notify their listed contacts that they would be welcome in the future to attend a BSRN meeting and reapply for consideration as BSRN sites.

A related discussion concerned timely submission of data to the BSRN Archive for current listed BSRN sites. It was noted that BSRN has become an internationally recognized and respected resource for the satellite, modeling, and climate communities. Several of the WMO organizations such as GCOS, WCRP, and the GEWEX Data and Assessments Panel (GDAP) depend on BSRN for its reputed high quality surface radiation data. But with this recognition also comes responsibility, as now there are many organizations and efforts depending on the use of BSRN data. Thus we in BSRN have a serious responsibility to make the high quality data we collect available to the community. It does no good to collect data at a site, but then not submit it to the BSRN Archive so that the community of users can have access to it in a standard format, noted as one of the strengths of BSRN. Thus we have a responsibility for not only making high quality, continuous surface radiation observations, but also to submit the data in a timely manner to the BSRN Archive for community access. A tally of the BSRN station data showed that over 25% of the BSRN sites were more than five years behind in their data submission, and many others more than two years in arrears. It was decided that that a new paradigm for monitoring and addressing lagging data submissions to the BSRN Archive will be enacted. Any station scientist whose site data submission to the Archive lags by two years or more will be contacted by the BSRN Project Manager in order to discuss the issue. At that time, a one year period will be initiated wherein it is expected that the station scientist will make every effort to get the data submission caught up. At the end of the year following notification the situation will be reviewed, and if no sufficient progress has been made, the station scientist will again be contacted. Dependent on the outcome of this second notice communication, the site may then be classified as "inactive" in the BSRN listing of sites, and the BSRN web pages and world sites map may be amended to reflect that change in status. A discussion will then ensue at subsequent BSRN meetings as to whether any site should be classified as "closed" should the data submission continue to lag over the years. These sites would always be encouraged and welcome to be classified as “active” again upon successful and timely submission of data to the Archive, and discussion with the Project Manager providing information on how the situation has been addressed with assurance of timely submission in the future.

A recommendation of the 14th BSRN Scientific Review and Workshop is to carry out an intercomparison of IR references so that the problem of the reported observed differences between the newly proposed absolute IR radiometer references [the Infrared Integrating Sphere (IRIS) from PMOD/WRC and the Absolute Cavity Pyrgeometer (ACP) from NREL] and the World Infrared Standard Group (WISG) can be studied more extensively. Joe Michalsky gave a brief presentation titled “Proposal to Compare Three Absolute Broadband Infrared Radiometers.” The current World Infrared Standard Group (WISG) of infrared radiometers is maintained at PMOD in Davos, Switzerland. Most BSRN and manufacturer standards are derived from WISG. The two Eppley PIRs and two Kipp and Zonen CG4s that comprise the WISG were calibrated using the Absolute Sky-scanning Radiometer (ASR) of Philipona. Two new absolute radiometers have been developed since WISG was established. Dr. Groebner developed the IRIS radiometer and Reda developed the ACP. In a comparison in 2013, the IRIS and ACP agreed to within 1 W/m^2 for about 8 hours of measurements. The two disagreed (were higher) than WISG radiometers by about 6 W/m^2. Further, the discrepancy appears to be water vapor column dependent, being smaller when the water vapor is less that 1 cm. We propose to compare the three instruments over a few weeks in mid autumn at the Department of Energy Atmospheric Radiation Measurement (ARM) program site in northern Oklahoma, USA, the site for a previous similar intercomparison in September 1999. The facility has infrastructure to measure needed inputs to model the downwelling broadband infrared and an Atmospheric Emitted Radiance Interferometer (AERI) to measure a significant fraction of the infrared to provide another pseudo-measurement of the broadband infrared. Historically there have been several clear sky days during mid autumn with both moderate and low values of water vapor column at the site. This experiment would shed light on the current differences implied by these results among the three radiometers. The experiment is proposed for October 2017. For the intercomparison to be fully valuable in investigating the reported differences to the current world standard group, it is recognized as critical that the absolute reference in use during the 1999 intercomparison (absolute sky-scanning radiometer - ASR) should also take part in the intercomparison foreseen in October 2017. All efforts are encouraged to make the ASR available for inclusion in the proposed intercomparison.

One final item was discussed in relation to the BSRN Manual. The latest version, primary author Bruce McArthur, was published in 2005 as a WMO Technical Document (WMO/TD-No. 1274). Given the significant progress and advances in radiometric measurements, understanding, and operational and calibration paradigms, an updated version of the manual should be produced. Gary Hodges of the NOAA Global Monitoring Division has volunteered to lead the effort, and will pursue other volunteers from the BSRN membership to assist. This is recognized as involving a significant effort, and the efforts of any who participate are gratefully recognized.

This brief accounting of the 14th Baseline Surface Radiation Network Scientific Review and Workshop hopefully gives a flavor of the breadth of topic areas of the meeting. Once again the level of expertise and enthusiasm of the participants was especially noteworthy. Most of the presentations and electronic versions of posters are available on the web site: *http://www.esrl.noaa.gov/gmd/grad/meetings/bsrn2016.html*.

3. Poster Summaries

Status of Japanese BSRN Stations (Nozomu Ohkawara)

The Japanese Meteorological Agency operates five BSRN stations in Japan (Sapporo, Tsukuba, Fukuoka, Ishigakijima, and Minamitorishima) and one station in Antarctica (Syowa). Observation data are reported regularly to WRMC every month. The exterior of domes or optical surfaces of each instrument is kept clean manually or automatically. The instruments are calibrated at least every five years to be traceable to the world radiation references such as WRR.

Status of Tamanrasset BSRN Station (Lamine Boulkelia)

The Tamanrasset BSRN station (TAM) is part of the GAW Global Station couple site Assekrem/Tamanrasset, which belongs to the National Meteorological Office of Algeria. It is located in the desert rock region between equatorial and mid-latitude (lat. 22° 47'N, long. 5° 31'E, alt. 1377 m.a.s.l.) regions. The site of Hoggar was chosen for the geographical position, altitude, and lack of local anthropogenic pollution. GAW activities began in September 1994 when radiation (with 3 nm step) was one of the main programs measuring solar shortwave radiation including UV-B. Since March 2000, the station has been included in the high-accuracy BSRN network with the support of the NOAA Center for Satellite Applications and Research (STAR) group. Thus, the station is provided with shaded Eppley diffuse PSP and shaded Eppley PIR with CR23X Data logger. In addition to basic measurements (LR0100), ultraviolet data (LR0500), synop (LR1000) with upper air (LR1100) from Airport station (WMO, #60680), and total ozone column (LR1200) are regularly transmitted on a monthly basis to the WRMC-BSRN hosted by AWI in Germany. At present, a total of 193 files have already been accepted (from March 2000 to March 2016). The calibration of solar instruments is done yearly in situ in winter where weather conditions are excellent with an Automatic Absolute Cavity Solar Radiometer Model AHF (#29225). The poster also highlights some results of daily variation of solar and thermal radiation. The graphs show the influence of monsoon flux in dry season on direct and diffuse. In fact, the seasonal variation of global and downward longwave radiation is smaller. The net radiation is frequently in excess in desert region, incoming SW and LW radiation are often greater than outgoing ones. In 2015, the total budget was about 431kWh/m^2 or 1.18kWh/m^2/day and the annual average of albedo is 34%.

BSRN Station Neumayer (Gert König-Langlo)

Since March 1981, a meteorological observatory program has been carried out continuously at the Antarctic Neumayer Station (70°37'S, 8°22'W) (*http://www.awi.de/nc/en/science/long-term-observations/atmosphere/antarctic-neumayer/meteorology.html*). The program has been amplified over the years; from 1982 onward, it included downward and upward radiation fluxes and synoptic observations. Daily upper air soundings began in 1983, and from 1992 on, weekly ozone soundings were included. Data from other observatories, such as the air chemistry observatory, are available. Neumayer has been a part of BSRN since 1992.

The measurements are ongoing and show the following trends:

- Slightly increasing global radiation
- Slightly decreasing longwave downward radiation
- Strongly increasing sunshine duration
- Slightly increasing surface pressure
- No warming of the surface air temperature
- Most probably minimum of stratospheric spring ozone depletion reached 2006

Solar Resource Assessment Program of India (Karthik Ramanathan)

Karthik Ramanathan presented an electronic poster on Solar Measurement Stations and the Indian Solar radiation Atlas.

Status and Plans for BSRN Stations in the Northern Canadian Archipelago: Alert and Eureka (Chris Cox)

Here we provide an overview of recent work involving the acquisition of radiometric observations from the Baseline Surface Radiation Network (BSRN) stations on Ellesmere Island in the northern Canadian archipelago. The stations are Alert (2004-) (Environment Canada) and Eureka (2007-) [Canadian Network for the Detection of Atmospheric Change (CANDAC)]. The Eureka BSRN station was officially closed in 2011, but was kept operational in collaboration with NOAA. In 2012, Eureka was upgraded to include upwelling measurements. Work is underway to re-establish Eureka as a regularly contributing BSRN member station. Both locations are involved in efforts to increase standardization of data accessibility, metadata documentation, and post-processing for Arctic environments through the International Arctic Systems for Observing the Atmosphere (IASOA). As a result, new, updated versions of the data sets are in preparation. Efforts continue within the BSRN Cold Climate Issues Working Group (CCIWG) to create innovative solutions for problems unique to polar and high altitude environments, in particular frost and rime growth that form obstructions on radiometer domes.

Sonnblick (SON) Site Status Update (Ursula Weiser)

The Austrian RADiation monitoring network (ARAD) has been established to advance national climate monitoring and to support satellite retrieval, atmospheric modeling, and the development of solar energy techniques. Measurements cover the downward solar and thermal infrared radiation using instruments according to BSRN standards. A unique feature of ARAD is its vertical dimension of five stations, covering an altitude range between about 200 m a.s.l (Vienna) and 3100 m a.s.l. (BSRN site Sonnblick). At the BSRN Sonnblick site, some special modifications had to be made to prevent rime and hoarfrost around the sensors that deteriorate radiation signals. Plastic tubes were mounted at the inlet of the ventilation system beneath the instruments to delay rime. The CHP-1 pyrheliometer was replaced by a DR02 with a heated front window that has an ideal heating power between maximal frost removal and minimal offsets.

Status and Operations of the Chesapeake Light (CLH) BSRN Station (Bryan Fabbri)

Chesapeake Light (CLH) has been collecting BSRN data for 16 years with the first data collection beginning on 1 May 2000. CLH is located approximately 25 kilometers (16 miles) east of Virginia (coordinates: 36.90N, 75.71W). Over the past few years, the automatic rinsing system was upgraded. A 757-liter (200 gallon) tank with submersible pump collects rainwater and supplies water to a smaller 132-liter (35 gallon) tank with submersible pump on the tower top where the downwelling instruments are located. Both tanks were painted black to suppress algae formation. The smaller tank is used to spray fresh water on the downwelling shortwave instruments every morning before sunrise. The automatic rinse system is programmed using Campbell Scientific software. The US Department of Energy (DOE), the current owner of CLH, has decided to abandon the project and put CLH up for sale. Due to this proclamation, several instruments had to be removed. However, we were able to petition the DOE to allow a minimal presence while the selling process unfolds. Currently, a suite of downwelling shortwave and downwelling longwave and a suite of meteorological instruments are in place. More information about the CLH BSRN station can be found via *http://cove.larc.nasa.gov/*.

Status and Operations of the NASA Langley (LRC) BSRN Station (Frederick Denn)

The LRC BSRN station located at NASA Langley (37.10N, 76.39W) was established in December of 2014. This is a coastal site with mixed marine, urban, forest, and grassland background scene types. At the time of this writing, the data are available from December 2014 to March 2016. Available data include shortwave and longwave broadband radiometric measurements, as well as standard meteorology.

Status of the Payerne BSRN Station (Laurent Vuilleumier)

The Payerne station has measured the BSRN basic set of parameters since November 1992. In addition, other parameters including longwave (LW) and shortwave (SW) irradiance at 10 and 30m a.g.l., spectral direct irradiance, and UV erythemal irradiance are measured. Many measurements are made with redundant instruments, and there are many opportunities for quality control (QC) checks. These QC checks are applied daily in a first step by an automatic flexible algorithm combining multiple tests. These automatic QC tests single out suspicious data that is afterward assessed visually by a human operator. In 2011, an important upgrade of the Payerne BSRN station occurred, allowing the station to be integrated into the general MeteoSwiss automated network infrastructure. This included completely removing and renewing the old infrastructure such as the supporting benches and signal and power cabling. This was achieved from 15 August 2011–30 September 2011. Beyond quality control that is performed daily, thorough verification (quality analysis or QA) of the Payerne BSRN data accuracy or reproducibility is performed for SW global, direct, and diffuse as well as LW downward irradiance, typically on semi-annual basis. As mentioned in the 2014 report on the status of the Payerne station to BSRN, the QA revealed discrepancies between redundant measurements showing that measurement uncertainty was likely exceeding the strict BSRN accuracy targets. From that time, data submission to the WRMC archive has been suspended. Thorough analysis linked the problem to (1) the sun tracker active tracking system and (2) the data logging system that was changed to match the general MeteoSwiss data-logging infrastructure. A very important effort was devoted to correcting these problems, both for data already recorded since 2011 and for data being recorded currently. Solutions have been developed that result in data recorded since mid-2012 reaching the BSRN accuracy targets without requiring correction, and corrections have been devised that allow most of the data recorded between end of 2011 and mid-2012 to reach the accuracy targets too. Comparisons between the un-windowed absolute cavity radiometer and the pyrheliometer as well as comparisons between the global irradiance measured with a single pyranometer in global mode or inferred from the diffuse and direct measurement show that the stability and accuracy of SW measurements are maintained within 1.5%–2%. Comparisons between redundant LW measurements show that LW downward irradiance is performed with a comparable level of reproducibility.

Solar Radiation Measurements at the Budapest Station (Dénes Fekete)

In our poster, we presented the solar radiation measurements at the Budapest-Lorinc station, the components of the operational measurement program, and calibrating facilities. A short presentation of the pyranometer's thermal offset using automatic capping device was also included. The thermal offset is one of the most significant error sources for pyranometers. One possible method to study daytime thermal offset is to shade the pyranometer periodically, but doing this manually requires significant human activity. To get over this problem, we have built a prototype of an automated "capping machine," which is able to cap periodically two Kipp & Zonen CMP11 pyranometers, where one CMP11 is ventilated, while another one is operated without ventilation. Two CMP11s are capped at every 20 minutes for 5 minutes. After 10 seconds with the caps on, the outputs reach the minima, the values of which are considered the thermal offset. The first results show that daytime thermal offset is more significant than nighttime thermal offset. Daytime thermal offset is more pronounced when the wind speed is low and direct radiation is high.

Status of the Dome C Antarctic BSRN Station (Angelo Lupi)

Located in the East Antarctic Plateau (coordinates: 75 S, 123.45 E), the Dome C station was established in 2007. Data collection for BSRN covers a period starting from April 2007 to mid-2013. Pictures of the BSRN area were shown with the two different albedo racks. A table was provided with information about data submission status. Several plots describe the meteorological conditions (temperature, relative humidity, wind rose, and monthly temperature profiles derived from radiosondes). Monthly mean averages of raw data representing downwelling shortwave global, downwelling longwave, and upwelling shortwave and longwave are also presented. Several plots show the quality check graphs applied to the submitted data (2010 to mid-2013), following Long and Shi (2008). In addition, a pictorial view of percentages of submitted valid data is presented for the different standard components.

Total Solar Eclipse over BSRN Station Ny-Ålesund (Marion Maturilli)

On 20 March 2015, a total solar eclipse occurred over Ny-Ålesund (78.9° N, 11.9° E), Svalbard, in the high Arctic. It was the first time that the surface radiation components have been measured by a BSRN station during the totality of a solar eclipse. The peculiarities of the radiation components and basic meteorology observed during the eclipse event were presented. As the eclipse radiation data will be a useful auxiliary data set for further studies on micro-meteorological surface-atmosphere exchange processes in the Svalbard environment, and may serve as a test case for radiative transfer studies, indications were given to the related data publication and linked supplementary data (doi: 10.5194/essd-2016-2; 10.1594/PANGAEA.854326).

Evaluation of MODIS/VIIRS/Landsat-8 Albedo Products over BSRN Sites (Crystal Schaaf)

The satellite albedo products from the Moderate Resolution Imaging Spectroradiometer (MODIS), the Visible Infrared Imaging Radiometer Suite (VIIRS), and the Landsat-8 Operational Land Imager (OLI) are evaluated using ground-measured albedo over six BSRN sites in the United States supported by the SURFace RADiation Network (SURFAD) throughout the year 2014. All three satellite products agree well with the ground measurements from the towers that serve as spatially representative sites for moderate satellite resolution data (Desert Rock, Fort Peck, and Table Mountain), with root-mean-square errors (RMSEs) of 0.028 for MODIS, 0.031 for VIIRS, and 0.045 for OLI. The daily retrievals from MODIS and VIIRS capture the seasonal variation, ephemeral snow, and snow melt effects on surface albedo, as measured by the tower measurements. However, over somewhat less spatially representative tower locations (e.g., Goodwin Creek, Penn State, and Sioux Falls), the differences can be significant during the dormant season. The daily blue-sky albedo from MODIS and VIIRS are calculated using the 1km MODIS and the VIIRS Bidirectional Reflectance Distribution Function (BRDF) parameters and the MODIS daily aerosol product. The Landsat-8 OLI blue-sky albedo is generated by coupling 30-m Landsat surface reflectance with concurrent MODIS Bidirectional Reflectance Distribution Function (BRDF) Products. The Landsat pixels within the effective field of view of the tower albedometers are averaged for this evaluation. Highly accurate albedo products at both high temporal resolution from MODIS and VIIRS and high spatial resolution from Landsat-8 OLI are critical for future projections of climate and land surface changes.

EKO New "High-end" Secondary Standard Pyranometer Called MS-80 (Kees Hoogendijk)

For roughly 100 years, the development of pyranometers has been slow with minor deviations from the original architecture and detector technology. EKO Instruments recently developed the MS-80 Secondary Standard Pyranometer with a unique detector technology providing substantial performance improvements. Embedding the 1 s response detector inside the sensor body now allows for an isolated detector as well as an environment that makes the sensor immune to offsets and aging effects caused by humidity, changes in barometric pressure, and UV radiation.

65 Years of Radiation Measurements in Tartu-Tõravere Station (Kai Rosin)

Tartu-Tõravere station maintains the longest time series of radiation measurements in Estonia. The actinometric station at Tartu, in the eastern part of Estonia, was established in 1950. That was also the beginning of regular measurements of global radiation and direct irradiance. The measurements of diffuse irradiance were added in 1954 and reflected irradiance in 1955. Radiation measurements were moved to Tõravere, 20 km from Tartu, in 1965. The station became a BSRN candidate in 1993, and since 1999 it has operated as a BSRN station and measurement data are transmitted to the BSRN archive on monthly basis. In addition to basic quantities, net radiation, downward and upward longwave irradiance, UVA, UVB, UV erythemal radiation, photosynthetically active radiation, and total ozone measurements are carried out. Aerosol optical depth measurements with precision filter radiometer are the latest addition to the observation program. All instruments are calibrated yearly. The condition of sensors is checked several times a day. In 2015 a web-based solar radiation atlas was born as a joint initiative of Latvia, Lithuania, Poland, and Estonia. The atlas is comprised of satellite-based solar surface irradiance, direct irradiance, and direct normalized irradiance maps covering the period 1991-2014. A new surface solar radiation data set called

SARAH (Surface Solar Radiation Data Set – Heliosat), based on observations of the Meteosat Visible and InfraRed Imager (MVIRI) and the Spinning Enhanced Visible and Infrared Imager (SEVIRI) instruments on board Meteosat satellites, was used. Satellite data were first validated against time series of in situ solar radiation measurements from Kaunas, Šilutė, Dobele, Zīlāni, Tartu-Tõravere, and Vilsandi. Comparison of satellite data with ground-based observations show that the average monthly solar surface irradiance and direct irradiance values of satellite data are somewhat lower than those measured in meteorological stations.

An Automated Cleaning System for Pyranometers (and Other Solar Instruments) (Frederic Jobin)

The Bureau of Meteorology is developing an automated cleaning system for the cleaning of a wide variety of solar instrumentation. A brief overview of the design methodology and software control/monitoring was explained and the current state of the prototype was displayed.

A BSRN Station in a Developing Country: Need, Challenge, Effort, and Progress (Clement O. Akoshile)

Ilorin is located in a region of Nigeria that is affected by biomass burning and dust outbreaks that have a strong effect on surface radiative fluxes. Accurate information on such fluxes is needed for a wide range of environmental applications. The site has a long history of monitoring geophysical parameters with instruments that meet the requirements of the Baseline Surface Radiation Network (BSRN). The radiation measurement record has been interrupted; however, monitoring of aerosols as part of the Federated AERONET network has continued. Ilorin records the highest aerosol optical depth measured at AERONET sites and measurements of radiative fluxes are needed to quantify such effects on solar resources. Consistent power supply shortages affected the site operation but recently, the University of Ilorin addressed this problem by obtaining powerful generators and by installing solar panels. Data transmission has been improved by using the Internet while instrument calibration will be feasible through collaboration with the Nigerian Meteorological Agency (NIMET) and Nigeria Air Space Research and Development Authority (NASRDA), Centre for Atmospheric Research (CAR). Ilorin is also hosting the Surface PARTiculate mAtter Network (SPARTAN) to measure and identify the temporal variation of particulate matter. The staff at Ilorin is trained in the maintenance and operation of instruments required by BSRN and is hopeful that with appropriate assistance the station will be able to join BSRN.

Surface Based Cloud Radiative Forcing Assessment at Dome-C Antarctic (Angelo Lupi)

Since April 2007, the BSRN basic set of parameters has been continuously measured at the Dome C station (DOM). Less than a decade of measurement is now available and suitable to define a statistically significant climatology for the radiation budget of Concordia, including eventual trends, by specifically assessing the effects of clouds on SW and LW net radiation. To define SW and LW clear sky fluxes, various parameterizations were adopted. A well-known and robust clear sky algorithm has been operationally applied on the downwelling SW components to identify cloud free events and to fit a parametric equation to determine clear-sky curve along the Antarctic daylight periods (September to April). Concurrently, a LW clear sky algorithm, based on downwelling LW absolute value and standard deviation thresholds, was used to infer LW downwelling clear fluxes. In addition, an empirical model to represent a clear sky surface albedo is introduced to represent the asymmetrical diurnal behavior. The upwelling LW flux is indeed obtained using a linear relationship between Tskin and Tground. The results confirm a positive cloud radiative forcing (10–17 W/m^2), with a significant positive trend.

Two Years of BSRN Measurements at De Aar, South Africa (Katlego Ncongwane)

The South African De Aar (30.66°S, 23.99°E, 1287 m) BSRN station provides accurate monitoring of short and longwave radiation in the region. The station was reinstated in April 2014 through the Solar Resource Mapping for South Africa (SRMSA) project, which aims to develop a high resolution solar atlas that will provide precise knowledge of the geographical spread and temporal variability of solar resources in South Africa. The De Aar BSRN station measures Global Horizontal Irradiation (GHI), Diffuse Horizontal Irradiance (DHI) and Direct Normal Irradiance (DNI), Downward Longwave, Ultraviolet radiation-A (UVA), and Ultraviolet radiation-B (UVB) as well as basic observable weather parameters such as temperature, relative humidity, wind speed and direction provided by the Automatic Weather Station (AWS). Frequent and consistent maintenance of the De Aar BSRN station and the post quality control of the data results in high quality and low uncertainty of ground-based measurements that are important in the validation of satellite derived solar resources and ultimately the development of high resolution solar maps. In this poster, hourly satellite-based irradiance (GHI and DNI) measurements from the Surface Solar Radiation Data Set - Heliosat (SARAH) were compared to ground-based (GHI and DNI) measurements at the De Aar BSRN station. At the time the comparison was performed, there was only data available for 2014. Since De Aar BSRN station data are available from April 2014, the comparison was done from April to December 2014 for which the data are available. The analysis shows an overall agreement between CM-SAF SARAH and ground-based measurement, in particular the GHI parameter. This is anticipated for a site such as De Aar that often experience cloudless conditions and less pollution for most part of the year.

Facilities for Pyranometer and Pyrheliometer Calibration at BSRN FLO (Sergio Colle)

The poster reports the current status of the BSRN Florianopolis (FLO) station concerning data collection, data qualification, data archiving, and radiometer calibration. Data archiving at the BSRN archive is currently updated. However, the cavity radiometer HF requires calibration in order to reach the traceability to calibrate the station pyranometers and pyrheliometers.

Validation of CM SAF Satellite-Derived Surface Radiation Data Records Using BSRN Measurements (Jörg Trentmann)

The EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF, www.cmsaf.eu) generates and distributes climate data records based on satellite instruments onboard geostationary and polar-orbiting satellites. Two regional (SARAH, SARAH-E) and one global [CLoud, Albedo and RAdiation (CLARA)] climate data records of surface solar radiation are currently provided via the CM SAF Web User Interface. By using the high quality, globally distributed data from the BSRN archive, the accuracy (between 5 and 10 W/m^2 for the monthly averaged solar radiation data), the decadal stability (between 0.5 and 2 W/m^2/dec), and the ability to detect monthly anomalies (correlation around 0.9) of the satellite-based data records are regularly assessed. Besides the high quality and the global coverage of the BSRN data, the continuous updates of the database, the joint data format, the common archive, and the very active scientific community are good reasons to use BSRN for the validation of satellite-based data records. We encourage the BSRN team (and its supporters) to continue the excellent work; additional BSRN stations in data sparse regions and a higher timeliness in data delivery to the archive would be appreciated.

4. Participants

First name	Last name	Email
John	Augustine	john.a.augustine@noaa.gov
Kenrick	Anderson	Kenrick.Anderson@csiro.au
Lamine	BOULKELIA	lamine.boulkelia@gmail.com
Klaus	Behrens	klaus.behrens@dwd.de
Christopher	Cox	christopher.j.cox@noaa.gov
Matthew	Carr	m.carr@bom.gov.au
Sergio	Colle	sergio.colle@ufsc.br
Ian	Dollery	i.dollery@bom.gov.au
Benjamin	Duck	benjamin.duck@csiro.au
Bryan	Fabbri	bryan.e.fabbri@nasa.gov
Bruce	Forgan	bwforgan@bigpond.com
Paul	Freeman	p.freeman@bom.gov.au
Godugunur	Giridhar	ggd_cdp@yahoo.co.in
Julian	Gröbner	julian.groebner@pmodwrc.ch
John	Gorman	j.gorman@bom.gov.au
Nicole	Hyett	n.hyett@bom.gov.au
Kees	Hoogendijk	kees.hoogendijk@eko-eu.com
Alexis	Heintz	alexis.heintz@univ-reunion.fr
Gary	Hodges	gary.hodges@noaa.gov
Patrick	Jeanty	patrick.jeanty@univ-reunion.fr
Frederic	Jobin	f.jobin@bom.gov.au
Gert	König-Langlo	gert.koenig-langlo@awi.de
Jörgen	Konings	jorgen@hukseflux.com
Vasilii	Kustov	kustov@aari.ru
Tom	Kirk	info@eppleylab.com
Chuck	Long	chuck.long@noaa.gov
Chulkyu	Lee	chulkyu.lee@korea.kr
Kathleen	Lantz	kathy.o.lantz@noaa.gov
Joseph	Michalsky	joseph.michalsky@noaa.gov
David	Mathias	adm@middletonsolar.com
Beatrice	Morel	beatrice.morel@univ-reunion.fr
Stephane	Mevel	stephane.mevel@meteo.fr
Michael	Milner	m.milner@bom.gov.au
Allison	McComiskey	allison.mccomiskey@noaa.gov
Stephan	Nyeki	stephan.nyeki@pmodwrc.ch
Katlego	Ncongwane	katlego.ncongwane@weathersa.co.za
Tim	Oakley	toakley@wmo.int
Nozomu	Ohkawara	ohkawara@met.kishou.go.jp
Steve	Rhodes	s.rhodes@bom.gov.au
Karthik	Ramanathan	karthik.niwe@nic.in

Ibrahim	Reda	ibrahim.reda@nrel.gov
Kai	Rosin	kai.rosin@envir.ee
Mi-Jeong	Shim	mjshim@korea.kr
Seungjoo	Song	sjtomato@korea.kr
Laurent	Vuilleumier	laurent.vuilleumier@meteoswiss.ch
Ursula	Weiser	ursula.weiser@zamg.ac.at
Sheng-Hsiang	Wang	carlo@cc.ncu.edu.tw
Stephen	Wilson	swilson@uow.edu.au
Xiangao	Xia	xxa@mail.iap.ac.cn
Taiping	Zhang	Taiping.Zhang@NASA.gov

5. Agenda

14th BSRN Scientific Review and Workshop **Canberra, Australia, 26-29 April 2016**		
Monday, April 25		
17:00	**Ice Breaker (cash bar)**	**University House** (short walk from BoM offices)
Tuesday, April 26		
	Opening, Welcome	**Chair: Nicole Hyett**
9:00	Dr. Rob Vertessy	Acknowledgment of country
		BoM Director, greetings and welcome
09:30	Nicole Hyatt	Meeting logistics
09:45	Chuck Long	BSRN Greetings and meeting charge (show of hands for WG attendance)
10:00	Tim Oakley	Welcome on behalf of Director GCOS and update on the status of GCOS
10:20	Nozomu Ohkawara	Status and implementation plan of BSRN in GCOS
10:40	Gert König-Langlo	Current state of the WRMC
11:00	**Break (30 minutes)**	*Poster Group 1 put up posters*
	New Sites Proposals 1	**Chair: Chuck Long**
11:30	Stefan Kinne (Hauke Schulz)	Barbados proposal as a BSRN site
11:50	Carlo Wang	New BSRN sites in Southeast Asia: from high elevation (2862 m) to sea-level
12:10	Benjamin Duck	Solar and Meteorological monitoring in Newcastle, Australia (new site proposal)
12:30	**Lunch**	
	New Sites Proposals 2	**Chair: Chuck Long**
14:00	Béatrice Morel	A suntracker at La Réunion Island (20.8°S; 55.5°E) for monitoring surface solar radiation under tropical maritime climate conditions: towards a new BSRN site?
14:20	Karthik Ramanathan	A proposal to bring four SRRA stations of India into the BSRN network
14:40	Vasilii Kustov	Ice camp "Cape Baranova" (79N, 101E) - possible candidate to BSRN
15:00	**Break (30 minutes)**	
15:30	***Poster Session 1***	
16:00	Jörg Schulz	Overview of GDAP
16:30	**Adjourn**	
Wednesday, April 27		
Instrumentation Issues		**Chair: Gert König-Langlo**
09:00	Aron Habte, Manajit Sengupta	Comparison of Calibration Methods and Resulting Solar Irradiance Measurement Differences
09:15	Michael Milner	Zenith angle bias in Pyranometer calibration
09:30	Nicole Hyett	An evaluation of the Delta-T SPN1 as a sunshine meter

09:45	Natalia Kouremeti	Fourth Filter Radiometer Comparison (FRC-IV)
10:00	Ursula Weiser	The Austrian radiation monitoring network ARAD - best practice and added value
10:15	Michael Milner	Pyrheliometer Alignment Testing
10:30	**Break (30 minutes)**	*Poster Group 1 take down posters*
Instrumentation Issues (Cont.)		**Chair: Laurent Vuilleumier**
11:00	Aron Habte, Manajit Sengupta	Quantifying Spectral Error in Thermopile Radiometers
11:15	Ibrahim Reda	Measuring Broadband IR Irradiance in the Direct Solar Beam
11:30	Ian Dollery	Pyrgeometer Uncertainty calculations
11:45	John Augustine	Recovering LW irradiance tainted with bad thermistor data
12:00	Klaus Behrens	Long term stability of two Eppley and two Kipp & Zonen pyrgeometers
12:15	Julian Gröbner	Brief summary of the IPgC pyrgeometer comparison held during the IPC last fall
12:30	Stephan Nyeki	The World Infrared Standard Group (WISG) of longwave radiometers: How can/should updated calibrations be transferred to BSRN records?
12:45	**Lunch**	*Poster Group 2 put up posters*
14:00	***Poster Session 2***	
16:00	**Adjourn**	
Thursday, April 28		
09:00	**Working Group Breakouts**	Times (TBD)
	Julian Gröbner	Infrared Working Group
	Chuck Long	Cold Climate Issues Working Group
	Julian Gröbner	Spectral Working Group
	Nicole Hyett	Uncertainties Working Group
10:30	**Break (30 minutes)**	
11:00	**Working Group Breakouts (Cont.)**	
	Gert König-Langlo	Training: how to use the BSRN-Toolbox, PanPlot to handle BSRN data before submission and as user
12:00	**Lunch**	
Observations and Analysis		**Chair: Joe Michalsky**
13:30	Chris Cox	Cloud Radiative Forcing from pan-Arctic BSRN stations: Applications for climate monitoring and seasonal-scale sea ice forecasting
13:45	Gert König-Langlo	Increasing carbon dioxide cools Antarctica
14:00	Xiangao Xia	Parameterization of clear-sky surface irradiance and its implications for estimation of aerosol direct radiative effect and aerosol optical depth
14:15	Carlo Wang	Long-term measurements of solar radiation and aerosol radiative forcing at Mt. Lulin (2,862m) in East Asia

14:30	Frederick Denn	Determination of Aerosol Optical Depth, and the required Top Of Atmosphere Values, with a Multi-Filter Rotating Shadowband Radiometer, Over a Five Year Long Period
14:45	Stefan Kinne	AOD estimates from broadband BSRN data
15:00	**Break (30 minutes)**	
Observations and Analysis (Cont.)		**Chair: Julian Gröbner**
15:30	Joe Michalsky	Spectral Irradiance and Optical Depth Retrievals from the Rotating Shadowband Spectroradiometer (RSS)
15:45	Bryan Fabbri	15 Year Climatology of BSRN Measurements made at Chesapeake Light (CLH) Station
16:00	Taiping Zhang	The Data from the BSRN Archive and Its Application in the NASA GEWEX SRB and POWER Projects
16:15	Godugunur Giridhar, Karthik Ramanathan	Indian Experiences on Solar Resource Assessment
16:30	Jordi Badosa	On the quality of solar irradiance measurements for photovoltaic module efficiency studies
16:45	Sergio Colle	Validation of the BLR diffuse model against BSRN FLO
17:00	Ben Liley	25 years of spectral UV measurements at Lauder
17:15	Stephen Wilson	Inferring photolysis rates from solar radiation measurements at Cape Grim
17:30	**Adjourn**	
Friday, April 29		**Chair: Chuck Long**
Working Group Reports		
09:00	Julian Gröbner	Infrared Working Group
09:15	Julian Gröbner	Spectral Working Group
09:30	Chris Cox	Cold Climate Issues Working Group
09:45	Nicole Hyett	Uncertainties Working Group
10:00	Joe Michalsky	Broadband Shortwave Working Group
Business and Discussions		**Discussion Lead: Chuck Long**
10:15	Chuck Long	Need chair for Broadband Shortwave WG?
	Chuck Long	New sites discussion
	Chuck Long	Delinquent data submissions discussion
	Joe Michalsky	SGP IOP; comparison of the 3 instruments that are considered absolute, & WISG versus IRIS & ACP
	If time:	Instrument specifications against a minimum requirement for BSRN site (WMO Requirements for Instrument Purchase)
		Minimum requirements for a BSRN site (Do we have enough just downwelling SW, ask for down & up SW & LW?)
13:00	**Adjourn**	

6. Listing of Posters

Poster Session 1		
	Electronic:	
1	Nozomu Ohkawara	Status of Japanese BSRN Stations
2	Lamine Boulkelia	Status of Tamanrasset BSRN Station
3	Gert König-Langlo	Neumayer BSRN Station
4	Jordi Badosa	PAL BSRN Station at SIRTA, Paris Region: Status and News
5	Karthik Ramanathan	Solar Resource Assessment Program of India
6	Chris Cox	Status and Plans for BSRN Stations in the Northern Canadian Archipelago: Alert and Eureka
	Hard Copy:	
7	Ursula Weiser	SON Site Status
8	Klaus Behrens	Status of the Lindenberg BSRN Station
9	Bryan Fabbri	Status and Operations of the Chesapeake Light (CLH) BSRN Station
10	Frederick Denn	Status and Operations of the NASA Langley (LRC) BSRN Station
11	Gary Hodges	ARM BSRN Sites Update
12	Gary Hodges	SURFRAD BSRN Sites Update
13	Laurent Vuilleumier	Status of the Payerne BSRN Station
14	Stephane Mevel	Status of the Carprentras (CAR) BSRN Station
15	Dénes Fekete	Budapest Station Solar Radiation Measurements
16	Angelo Lupi	Status of the Dome-C Antarctic BSRN Station
Poster Session 2		
	Electronic:	
17	Marion Maturilli	Total Solar Eclipse over BSRN Station Ny-Ålesund
18	Crystal Schaaf	CEOS Land Product Validation (LPV) Subgroup
19	Crystal Schaaf	Evaluation of MODIS/VIIRS/Landsat-8 Albedo Products over BSRN Sites
20	Kees Hoogendijk	EKOnew "High-end" Secondary Standard Pyranometer Called MS-80
21	Kai Rosin	65 Years of Radiation Measurements in Tartu-Tõravere Station
22	Frederic Jobin	An Automated Cleaning System for Pyranometers (and Other Solar Instruments)
23	C.O. Akoshile	A BSRN Station in a Developing Country: Needs, Challenge, Effort and Progress
	Hard Copy:	
24	Seungjoo Song	Quality Control of Surface Atmospheric Radiation Data Measured at Anmyon and Gosan, Korea
25	Stefan Kinne	Radiative Energy Flows in the Atmosphere: (Satellite) Observations vs Modeling
26	Stefan Kinne	BSRN as Reference Revealing Biases of CERES, ISSCP, SRB data and CMIP3 Modeling
27	Vasilii Kustov	Shortwave and Longwave Radiation Balance in Tiksi (2010–2016)

28	Angelo Lupi	Surface Based Cloud Radiative Forcing Assessment at Dome-C Antarctic Station (75°S) Using BSRN Data
29	Katlego Ncongwane	Two Years of BSRN Measurements at De Aar, South Africa
30	Kenrick Anderson	The Application of Solar and Meteorological Data at the CSIRO National Solar Energy Centre
31	Sergio Colle	Facilities for Pyranometer and Pyrheliometers Calibration at BSRN FLO
32	Jörg Trentmann	Validation of CM SAF Satellite-Derived Surface Radiation Data Records Using BSRN Measurements
33	Stephan Nyeki	The GAW-PFR Aerosol Optical Depth Network: 2008–2013 Time-Series at Cape Point Station, South Africa

Participants of the 14th BSRN Meeting