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Report of the 12th Baseline Surface Radiation Network (BSRN) Scientific Review and Workshop

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12th BSRN Scientific Review and Workshop

1. Overview of Meeting

The 12th Baseline Surface Radiation Network (BSRN-12) Scientific Review and Workshop was hosted by Marion Maturilli of the Alfred Wegener Institute (AWI) in Potsdam Germany. The AWI currently hosts the BSRN data archive in its Bremerhaven location. The workshop followed the general form and intent of previous workshops and was intended to provide a forum for BSRN participants and user communities to share progress and experiences in the acquisition and application of surface radiation data for climate and related interests. In attendance were many of the current active BSRN site scientists and station managers, BSRN associates who have a long history of cooperative interaction with the BSRN, data users from both the satellite and climate modeling communities, and several local visitors with overlapping interests with BSRN. In addition, several representatives from commercial instrument manufacturers attended as non-promotional observers.

The workshop provides a forum for evaluating the progress and successes of the BSRN network and addressing issues related to the network's activities. The site scientists are reminded of the obligations and requirements for participating in the program, and the BSRN oversight organizations and management are reminded of the valuable and voluntary contributions of each of the field sites and their host sponsors. BSRN continues to strive to address its primary goal of providing high quality, in situ sampled, broadband, surface solar and infrared irradiances on a continuous and long-term basis at a wide climatic variety of sites. The workshop consisted of two and one-half days of oral presentations of scientific results, as well as proposals for new stations, updates and status reports on network activities. The last half-day was spent on group discussions of multiple topics related to the ongoing activities and needs of the network.

Several highlights emerged from the presentations. First, there were proposals for two new candidate sites, with one being in the data poor region of Southwest Africa, which appears to be very appealing as a BSRN site. Several presentations focused on the analyses of long-term data sets and the merits of the BSRN data appear prominently in those analyses. The capable staff of the BSRN Archive provided not only the status of the network from the archive perspective but demonstrated valuable tools being applied to the data that can greatly enhance both the quality and timeliness of data submitted to and retrieved from the Archive. An invigorated interest in surface albedo emerged with two presentations from the satellite remote sensing community demonstrating their interest in the surface-based products. Working Group (WG) reports focused on the more active areas of current interest to the network, while subsequent discussions focused on the areas where additional WG effort is needed. Progress, both in instrumentation and methodology was reported in the area of developing and maintaining thermal infrared (IR) measurement reference standards. Atmospheric constituents play a big role in modulating surface radiation and a number of presentations address related topics of clouds, aerosols, atmospheric absorption, and temperature change. The two most extensive and demanding applications of BSRN data are the satellite and climate modeling communities. Both were well represented at the meeting and provided challenging insights into the needs and specific interests of those communities. It was rewarding for many to see the role that BSRN now plays in refining the Earth mean energy budget through ongoing comparisons of model and satellite results with BSRN data. Appropriately, the final presentation on Friday morning reminded the group of still unsettled instrumentation issues concerning daytime thermal offsets in some unshaded pyranometers.

Below are summaries of the oral presentations made at the meeting in the order listed on the agenda. After the summaries are the expanded notes from the BSRN "business" discussions and the closing of the meeting. Electronic versions of many of the presentations, including posters, are available for a limited time on the GEWEX website at *http://www.gewex.org/bsrn.html*.

2. Opening Session

Dr. Ellsworth Dutton, the BSRN International Project Manager (PM), opened the workshop and welcomed the 60 attendees, and briefly reviewed the purpose of the meeting. Marion Maturilli of the Alfred Wegener Institute (AWI) provided information about the local logistics and the activities planned for the next three days. Prof. Peter Lemke, Head of the Climate Sciences Research Division of AWI, provided an interesting overview of his Division's activities as well as some history of the entire AWI for Polar Research. AWI also has research divisions in Geoscience and Bioscience and this broad range of interests leads to a presence around the world pursuing projects in the Arctic and Antarctic. The Climate Sciences Division has interests in polar meteorology, paleoclimate dynamics, sea ice physics, observational oceanography, and ocean dynamics. Recent studies have focused on Arctic sea ice, and in particular, its thickness variations. AWI not only hosts and operates the BSRN data archive (known as the World Radiation Monitoring Center) from its Bremerhaven location, but also provides the BSRN field sites at Ny-Ålesund in the Arctic and Neumayer on Antarctica. BSRN is very grateful for the many contributions of AWI to its efforts.

The next presentation in the session was by Anna Mikalsen of the Global Climate Observing System (GCOS) office in Geneva, Switzerland. GCOS is one of the two international organizations sponsoring BSRN, along with the World Climate Research Program (WCRP) Global Energy and Water Cycle Experiment (GEWEX). GCOS is focused on the long-term observational needs of the climate research community and in doing so has interests in oceanic, terrestrial, and atmospheric measurements. BSRN exists at the border of all three of these although it is generally categorized under and reports to the atmospheric branch of GCOS. BSRN is considered to be the mid-level network in GCOS three-tier structure for networks, filling the role of the global baseline radiation network. Examples were given that show how BSRN fulfils the GCOS requirements for detection of relevant climate trends, climate model comparisons and validation, and satellite validation. The GCOS program has as one of its objectives assisting existing long-term field programs by matching interested donors with sites having particular needs. Individuals who are aware either of these potential donors or worthy observing capabilities are encouraged to contact the GCOS secretariat to determine if successful connections can be made.

The final presentation of the opening session was by the BSRN International Project Manager (PM) who reviewed the main agenda items and elaborated on the expectations for the meeting. The topical areas for the oral presentations were arranged in broad categories covering the primary current and foreseeable activities of BSRN. These included the presentation of new candidate sites, investigations of surface radiation climatologies, the growing interest in renewable energy applications, UV, surface albedo, radiative forcing by clouds and aerosols, and satellite and climate model applications. Several posters, which were displayed throughout the meeting, provided field site status reports while others touched on many topics as shown on the agenda in this report. In addition to the many interesting presentations on BSRN science, several issues and topics were addressed at the end of the meeting, including: (i) discussion and decisions on newly proposed sites; (ii) review of progress on the establishment of thermal IR calibration reference standards; (iii) understanding and application of the new quality control (QC) procedures at the data archive; (iv) discussion of new and extended interests in surface albedo and in particular, spectral albedo; and (v) revisiting the structure and intent of the Working Groups within BSRN. These working aspects of the meeting were scheduled for the afternoon of the third day of the meeting. The following are brief summaries of the sessions and presentations.

Session 2. Proposals for New BSRN Sites

Two new BSRN sites were proposed at this meeting along with the initial introduction for an upcoming application from a third site. The two proposals and a talk on extending BSRN level solar measurements to the larger area of all of New Zealand for renewable energy applications rounded out this session.

Radiation Measurements in Gobabeb, Namibia (Roland Vogt)

The Institute of Meteorology, Climatology and Remote Sensing (MCR Lab) of the University of Basel, together with the Gobabeb Research and Training Centre and Karlsruhe Institute of Technology (Folke Olesen) installed a BSRN compatible station in Gobabeb, Namibia (*http://www.gobabeb.org*) on the prominent "radiation rock" (S23.5614, E15.04198), where previously, global radiation was measured with an analog Fuess-Robitzsch bimetal radiation recorder. In a memorandum of understanding it was agreed to maintain these measurements for at least six years (ending 2018). The measurements in the Namib Desert will help to close a gap in the global network of BSRN stations. The station was installed in early May 2012 and has been operational since May 15. The instruments for the upwelling components were installed at the 30 m tower in the gravel plains (S23.55095, E15.05139). The instrumentation for downwelling radiation is mounted on a tracker (SOLYS2) consisting of two pyrheliometers (CHP1), a shaded pyranometer (CMP22), two shaded pyrgeometers (CGR4), two pyranometers (CMP22), and all are ventilated except CHP1. Upwelling radiation is measured with a CMP22 and a CGR4 (both not ventilated). Additional meteorological measurements are performed close to the tracker (e.g., ventilated temperature, relative humidity, wind speed, wind direction, air pressure, precipitation).

The Sonnblick Mountain Observatory as a Future BSRN Station? (Marc Olefs)

The Sonnblick Mountain Observatory located in Austria at the Alpine main ridge at an altitude of 3105 m.a.s.l. has the world record for the longest uninterrupted meteorological time-series data since 1886. For two years, a 2AP suntracking device equipped with the standard instrumentation for measuring direct solar, global and diffuse radiation, as well as incoming longwave radiation, has been running and is maintained on a daily basis by two human observers (24/7/365 on duty). Sensors, maintenance work and data quality control algorithms closely adhere to BSRN guidelines. Due to the site's extreme exposure, some special modifications of the measurement equipment were necessary, including the placement of long plastic tubes at the ventilation inlet instead of a grid, to delay rime formation, and the use of a special heating and ventilation unit that allows levelling of the sensors without removal of the housing. Since these modifications were completed, a significant decrease in data quality test failures (e.g., GLOBAL vs. component sum test) has been recorded. Ongoing work includes the increase of the measurement frequency from currently 0.1–1.0 Hz, as well as the storage of the minimum, maximum and standard deviations recommended by BSRN. Additional measurements at Sonnblick include standard meteorological parameters, several automatic webcams, visual cloud observations, a cloud cam, water vapour (GPS), ozone and UV using two spectroradiometers (University of Vienna), as well as aerosol measurements using filter methods.

Extending BSRN Products Across New Zealand (Ben Liley)

This presentation described products that the solar radiation measurement program at Lauder Station used to address a number of questions across New Zealand. The products included the high quality BSRN data for assessing the reliability and utility of other radiation data and using derived tools to make results available to users. For national and regional energy planning, the National Institute of Water and Atmospheric Research (NIWA) has produced maps of available solar energy, including cloud effects for New Zealand. From global irradiance (G) measured at over 100 sites, average values of the "clear-sky clearness index" (CSCI, the ratio G/G_{clear}), were spatially interpolated to map the cloud-corrected global irradiance. The same CSCI parameter can be used to predict the separate direct and diffuse components of G from measurements at hourly or finer time resolution. Testing and refining the prediction algorithm against BSRN data showed that residual error is sufficiently low for many practical applications.

Session 3. Observations and Analyses

Sixteen Years of Surface Radiation Budget Data Over the United States (John A. Augustine)

Results from analyzes of 16 years of surface radiation budget (SRB) measurements (1996-2011) for seven U.S. SRB stations were presented. The primary result showed that the network average of total surface net radiation increased over the entire period at a rate of 8.2 Wm^{-2} per decade. That trend is statistically significant and increases were evident at all stations. An increase in downwelling shortwave (SW-down) of 6.6 Wm^{-2} per decade, also statistically significant, accounted for most of the increase in the total surface net radiation. A network-wide decrease in fractional sky cover is most likely responsible for the shortwave (SW) brightening, and decreasing aerosol optical depth of 0.025 over the entire period has only a minor effect. None of the other components of total surface net radiation budget showed statistically significant trends, but they did contribute mathematically to the trend in total surface net radiation. A slight increase in upwelling shortwave (SW-up) tempered the contribution of SW-down, and was shown to be an inherent consequence of the SW brightening along with anomalous snow cover in 2007 and 2010. An increase in mean surface downwelling longwave (LW-down) of 1.5 Wm^{-2} per decade combined with decreasing upwelling longwave (LW-up) by -0.9 Wm^{-2} per decade produced the observed 2.3 Wm^{-2} per decade increase in total net LW at the surface, but that trend is not statistically significant. The lack of statistical significance in the long-term tendencies of LW-down, LW-up and SW-up is a consequence of large interannual variability that masks ongoing long-term climate processes. It is clear that continued monitoring is necessary to separate out the response of SRB to systematic changes in greenhouse gases from the much larger variability in the LW components of the SRB that we observed.

Long-Term Variations of Atmospheric Transmission from Pyrheliometer Measurements (Nozumu OhKawara)

Long-term variations of total zenith transmittance from pyrheliometer measurements at 14 sites in Japan were studied for the period of 1933-2005. From 1933 to the late 1940s, the transmittance remained stable at around 0.74-0.75. This was followed by a decreasing phase in the mid-1980s that reached 0.69, and then an increasing phase until the early 2000s, reach a level of 0.71. The impact on the long-term variation of the transmittance by water vapor in the atmosphere was also estimated using precipitable water vapor from Rawinsonde measurements. The results show that a majority of these variations are caused by aerosols, and that changes in water vapor make only a minor contribution to the variations. The aerosol changes may be related to changes in anthropogenic sources.

Reproducibility of Basic Measurements at the Payerne BSRN Station (Laurent Vuilleumier)

From 15 August to 30 September 2011, an important upgrade to the Payerne BSRN station occurred that integrated the station into the general MeteoSwiss automated network infrastructure. The old infrastructure was completely removed and redone, including the supporting benches, and signal and power cabling. During this period only very partial data was obtained at Payerne.

Quality control is performed daily, thorough verification (quality analysis) of the Payerne station data accuracy (or reproducibility), shortwave (SW) global, direct and diffuse, and longwave (LW) downward irradiance. An analysis shows that the level of reproducibility and stability achieved before the upgrade of the station was maintained, in general, after the upgrade. However, the extremely precise BSRN accuracy target for SW direct irradiance has not yet been fully obtained, although the station accuracy appears to have improved since the upgrade.

Many measurements are made with redundant instruments as well as redundant measurement techniques for the same parameter. This provides many opportunities for quality analysis. Direct SW irradiance measurements are performed at Payerne using both a Kipp and Zonen CHP1 pyrheliometer (previously a CH1 was used) and a PMO6 open absolute cavity radiometer. The PMO6 radiometer used at Payerne has a very low calibration uncertainty of approximately 0.05% and had virtually no change in the calibration constant during the last 10 years (compatible within uncertainty). Monthly comparisons were made between the PMO6 and CH1/CHP1 data using carefully selected events (the

PMO6 long time constant implies that only slowly changing direct irradiance can be used in comparisons). The agreement was on the order of 1% rather than the extremely tight 0.5% BSRN accuracy target for direct radiation in 2004. There have been events where differences up to 2% have occurred (deduced from the monthly analysis) and these could conclusively be related to the imposed efficiency and cost-cutting measures on daily maintenance. Changes have been implemented and a satisfactory situation has been reached. For other analyzed parameters, the level of agreement shown between redundant measurements of the same parameters is compatible with other BSRN accuracy targets. However, this involves measurements that use similar technologies and it should be recognized as reproducibility rather than accuracy checks since similar errors can affect similarly preformed measurements.

Short-Term Solar Irradiance Forecasting for Photovoltaic Energy Applications Based Upon Analysis of Surface Radiation and Meteorological Measurements (Martial Haeffelin)

Solar power can be a significant contributor to the electrical power needs of tropical islands. However, this resource can fluctuate nearly one order of magnitude in short time scales (minutes to hours), making solar power difficult to manage. The objective of our study is to improve our understanding of dynamical and radiative processes that have an impact on solar irradiance variability on La Réunion Island, in order to improve solar irradiance forecasts. Ten years of wind speed, direction, and solar irradiance measurements at 20 stations covering most of Réunion Island were analyzed. We found that wind speed and direction at each station is influenced by large-scale winds (most frequently Easterly trade winds), thermal winds (sea and land breezes), and location with respect to the large-scale wind direction (windward, leeward, lateral sides of the island). A cluster analysis of solar irradiance data was performed and the diurnal cycles were classified in five categories: (i) clear days, (ii) days with a clear morning and cloudy afternoon, (iii) overcast days, (iv) days with highly variable cloudiness, and (v) days with a cloudy morning and clear afternoon. The frequency of occurrence of these parameters was found to be highly dependent on the season, location, wind speed and direction, and vertical profile of humidity. The parameters can be used to perform predictions of the solar irradiance diurnal cycle, both in terms of intensity and variability.

High Density Solar Measurements (Michael Dooraghi)

The U.S. National Renewable Energy Laboratory (NREL) in collaboration with industry partners has deployed multiple networks of spatially and temporally high-resolution solar measurement systems in Florida and Hawaii. These solar measurement networks will continuously provide time-synchronized high-resolution solar (and in one case power) measurements at one-second resolution. The goals of these projects include: (1) understanding the relationship between variability in the solar resource and power production for Megawatt scale PV deployments, and (2) verifying various models used to predict power output, string failures, and direct irradiance based on a global irradiance measurement.

Inferring Ultraviolet Anatomical Exposure Patterns while Distinguishing the Relative Contribution of Radiation Components (Laurent Vuilleumier)

Exposure to solar ultraviolet (UV) radiation is the primary causative factor for skin cancer. UV exposure depends on environmental and individual factors, but individual exposure data remain scarce. UV irradiance is monitored using different techniques, however, it is difficult to translate observations into human UV exposure or dose because of confounding factors (e.g., shape of the exposed surface, shading, behavior). Through multi-disciplinary collaboration a model was developed to predict the dose and distribution of UV exposure on the basis of ground irradiation and morphological data. Standard 3D computer graphics techniques were adapted to develop this tool, which estimates solar exposure of a virtual manikin depicted as a triangle mesh surface. The amount of solar energy received by various body locations is computed for direct, diffuse and reflected radiation separately. The radiation components are deduced from corresponding measurements of UV irradiance, and the related UV dose received by each triangle of the virtual manikin is computed accounting for shading by other body parts and eventual protection measures. The model was verified with dosimetric measurements (n=54) in field conditions using a foam manikin as surrogate for an exposed individual. Dosimetric results were compared to the model predictions. The model predicted exposure to solar

UV adequately. The symmetric mean absolute percentage error was 13%. Half of the predictions were within 17% range of the measurements. Using this tool, solar UV exposure patterns were investigated with respect to the relative contribution of the direct, diffuse and reflected radiation. Exposure doses were assessed for various body parts and for scenarios of a standing person. As input, the model used erythemally weighted ground irradiance data measured in 2009 at Payerne, Switzerland. A year-round daily exposure (8 am-5 pm) without protection was assumed. Results showed that direct exposure was important during specific periods (e.g., midday during summer), but contributed moderately to the annual dose, ranging from 15 to 24% for vertical and horizontal body parts, respectively.

Session 4. Data Archiving and Processing

World Radiation Monitoring Center Archive Overview and Status (Gert König-Langlo)

Beginning in 2008, the World Radiation Monitoring Center (WRMC) has been hosted at the Alfred Wegener Institute (AWI) of Polar and Marine Research at Bremerhaven, Germany (see *http://www.bsrn.awi.de*). The data import is organized in "station-to-archive files" which contain all the data from one station collected during one month. There have been a total of 6806 station-month data sets from the 54 stations available in the WRMC since September 2012. Only nine stations delivered data in 1992. Since 2010 data, seven new BSRN stations have been added.

All submitted station-to-archive files are read-accessible from any user who accepts the BSRN data release guidelines (see *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 (E-mail: *Gert.Koenig-Langlo@awi.de*).

An alternative to the ftp access is a data access via the Publishing Network for Geoscientific and Environmental Data, PANGAEA (see *http://www.pangaea.de/*). Although individual BSRN data sets can be found by using common search engines (e.g., *http://www.google.com/*) or the specific PANGAEA search engine (*http://www.pangaea.de/*), the most direct access is given via pre-compiled PANGAEA search phrases (see *http://www.bsrn.awi.de/en/data/data_retrieval_via_pangaea/*).

Since December 2011 the quality of many BSRN parameters can be checked individually by using Version 2.0 or newer of the BSRN Toolbox (http://dx.doi.org/10.1594/PANGAEA.774827). Currently, the BSRN Toolbox offers the BSRN Global Network recommended QC tests, V2.0 (http://hdl.handle.net/10013/epic.38770.d001). In the beginning of 2012 all data in the WRMC were tested accordingly see: http://www.bsrn.awi.de/en/products/quality_code/physical_possible_limits/. Since December 2011 the WRMC also checks the quality of all incoming data. To avoid too much extra work for the archive the station scientists are recommended to test their data prior to submission.

The plan to calculate centrally AOD data from submitted transmission data following Bruce Forgan's proposal was abandoned. An updated Technical Plan for BSRN Data Management, including some new parameters such as pyrgeometer temperatures, is under construction.

Importing Data to the WRMC (Friedrich Richter)

BSRN station-to-archive files at the Word Radiation Monitoring Center are quality checked before the data are accepted. When data arrives on the ftp-server, an email is sent to the responsible data curator to perform a final test of physical limits and the general format. This is easily done using the BSRN Toolbox, which checks the format of the data in one action and provides an overview of the data availability. In addition to a description of the data upload process to the database, three programs were presented that provide a visual insight of the quality and shape of the data. Data outliers can be easily located and the responsible station scientist informed. Out of the 54 BSRN stations, about 15 stations are uploading their data on a regular monthly basis while the others upload multiple months at a time with several months to a few years delay.

Quality Checks offered by the BSRN Toolbox (Holger Schmithuesen)

The BSRN Toolbox is a software package supplied by the WRMC and is freely available to all station scientists and data users. The main features of the package include a download manager for Station-to-Archive files, a tool to convert files into human readable TAB-separated ASCII-tables (similar to those output by the PANGAEA database), and a tool to check data sets for violations of the "BSRN Global Network recommended QC tests, V2.0" quality criteria. The latter tool creates quality codes, one per measured value, indicating if the data are "physically possible," "extremely rare," or if "intercomparison limits are exceeded." In addition, auxiliary data such as solar zenith angle or global calculated from diffuse and direct can be output. All output from the QC tool can be visualized using PanPlot, which is also freely available. Documentation for the BSRN toolbox can be found at *http://wiki.pangaea.de/wiki/BSRN_Toolbox*.

Metadata at WRDC and it Information has a Key Role in the Analysis of Long-Term Radiation Time Series (Anatoly Tsvetkov)

A metadata database for actinometric stations is being created and archived at the World Radiation Data Center (WRDC). This is in compliance with GCOS Climate Monitoring Principles "…metadata should be documented and treated with the same care as the data themselves" (WMO 202). Metadata related to 1500 stations will be uploaded to the WRDC server soon. The metadata will include changes in conditions of observations (e.g., type of instrument changes, skyline, coordinates of a particular station), which are very useful when analyzing long-term time series of global diffuse radiation.

Session 5. Albedo

Field Measurements of Spectral Albedo: Four Years of Data from the Western U.S. Prairie (Joseph Michalsky)

Albedo measurements are a critical input to radiative transfer calculations. Examples from four years of albedo measurements that began in March 2009 were presented and discussed. It was noted that offset corrections and angular response corrections are not always made and can account for time and solar zenith angle dependencies in the albedo behavior that are contrary to its true nature. One published incorrect example for snow was presented. The spectral albedo is measured at six wavelengths in the visible and near infrared using a multi-filter radiometer and a multi-filter rotating shadowband radiometer. Measurements of vegetative albedo in its green and senescent stages were presented. The changes over time of the vegetative albedos were shown using a normalized difference vegetative index defined by the 673 and 870 nm albedos. The albedo increases with solar zenith angle as expected for vegetation, and a very small slope of the terrain can explain an asymmetry in the morning and afternoon. Measurements of fresh snow albedos indicate almost no solar zenith angle dependence over the small range of incident angles studied. The wavelength dependence depends on the depth of the snow as the surface albedo beneath thin layers of snow may still influence the albedo and its wavelength dependence. Thick layers of snow exhibit the theoretically expected wavelength dependence.

Use of In Situ and Airborne Multi-angle Data to Assess MODIS, VIIRS, and Landsat Based Estimates of Directional Reflectance and Albedo (Miguel. O. Román)

Data at medium and coarse resolution from the Landsat, Moderate Resolution Imaging Spectroradiometer (MODIS), and Visible Infrared Imaging Radiometer Suite (VIIRS) instruments provide crucial and indispensable time series for the land component global change studies. A summary of the status of the processing, archiving, and early (Launch +6 months) on-orbit evaluation of the VIIRS Land Environmental Data Records (EDRs) was presented, and results from an uncertainty analysis of MODIS- and Landsat-based albedo retrievals, based on collocated comparisons with tower and airborne multiangular measurements collected at the Cloud and

Radiation Testbed (CART) site during the 2007 Cloud and Land Surface Interaction Campaign (CLASIC'07), were discussed.

Session 6. Special Reports

Cabauw: Research and Status (Wouter Knap)

An overview of research activities related to the Cabauw BSRN station in the Netherlands, and results of clear-sky and cloudy shortwave radiative closure were presented. For clear skies there has been excellent agreement between simulated and measured irradiances (mean differences < 2 Wm^2 for direct, diffuse and global). For cloudy skies (single layer water clouds) the simulations tend to overestimate the measurements by 6 Wm^2 on average. The analyses are described in detail in Wang et al. (2009 and 2011, *Journal of Geophysical Research*).

Two satellite applications were discussed: the validation of surface shortwave irradiances (SSI) derived from Scanning Imaging Absorption SpectroMeter for Atmospheric Chartography (SCIAMACHY) and Spinning Enhanced Visible and Infrared Imager (SEVIRI) observations. First order estimates of SSI were made on the basis of effective cloud fractions derived from SCIAMACHY spectra of the O2A bandwidth. A validation of one year of data has been made using data from 20 BSRN stations. Satellite retrievals and BSRN measurements agree very well on average (difference: 4 Wm^2) but the scatter is large (sample standard deviation: ~100 Wm^2). The results are described in Wang et al. (2011, *Atmospheric Measurement Techniques*). Retrievals of direct, diffuse and global irradiances from the ESA Meteosat Second Generation-SEVIRI were also validated by means of a year of BSRN data for different stations. For clear skies, very good agreement is obtained using AERONET aerosol optical properties. Results for all skies appear to be promising. A detailed analysis will be published later (2012, Greuell et al., submitted to the *Journal of Geophysical Research*). The website for MSG products is http://msgcpp.knmi.nl.

The data submission for the Cabauw station is up to date (files are archived from February 2005 until June 2012). In the first half of 2012 there were some tracker problems but the loss of data was limited because of the availability of redundant measurements. A possible offset in the downward longwave irradiance (~3-4 Wm^2) is discussed and a correction is foreseen in the near future. Real time and historical data of the Cabauw station can be found on the web at: http://www.knmi.nl/bsrn. Atmospheric data can be found on the CESAR web portal: http://www.cesar-observatory.nl.

Proposal for Classification of Sky Conditions for Pyranometer Calibration According to ISO 9847 (Xabier Olano)

The pyranometer calibration laboratory of CENER is accredited since 2010 according to ISO 9847:1992 “Calibration of field pyranometers by comparison to a reference pyranometer.” This accreditation´s scope covers calibrations of type Ia for outdoor horizontal calibrations for meteorological and resource measurements (5.2.2, annex B.2). The methodology sets up a criterion for the classification of sky conditions and different data acquisition requirements for each of them. The criteria for classification is based on radiometric conditions, but it is quite underdetermined for this purpose, so the criteria are improved and better defined analyzing estimated measures from different models [ESRA clear sky model and Butt et al. (2010) diffuse radiation and clouds relationship (1)] and experimental measurements from CENER BSRN station (global G, direct Gb, diffuse Gd, diffuse fraction Kd, total sky images of 2011).

For the first sky type, “stable cloudless conditions,” the standard states an upper limit for Kd of 0.2. Apart from that, CENER has added another quality requirement regarding the difference of global irradiance G. This difference shall be (Gmax-Gmin) ≤ 50 W·m-2.

The second sky type covers “cloudy sky conditions.” Different models proposed by Butt et al. (2010) are analyzed looking for a relationship between Kd and cloud cover percentage (CCP). After the adjustment of 3 models, the one that had best results was selected for the analysis. This model takes into account the Sun position (cosθ). According to several sources a CCP of 50% is considered as characteristic for cloudy skies and an input for the model. A lower limit of 0.4 is set for Kd, in addition to the condition established by the standard that G > 100 W·m-2.

Lastly for "unstable sky conditions with some cloud," the standard states that clouds shall be at a distance from the Sun greater than 30º, and recommends an irradiance threshold if data acquisition is automated. To fulfill this goal several conditions are set: Kd ≤ 0.5, Gb ≥ 500 W·m-2, (Gb max-Gb min) ≤ 200 W·m-2, 0.05 < CCP ≤ 0.35. However, these conditions are not enough and a more concrete analysis of the sun region is needed. New conditions for CCP and sunny index are proposed using the sky imager.

[1] Butt et al., 2010: Diffuse radiation and cloud relationships in two contrasting Amazonian rainforest sites. *Agricultural and Forest Meteorology* 150 361-368.

Session 7. Working Group (WG) Reports

Pyranometer Working Group (Chair, vacant)

E. Dutton indicated that the departure of the former WG chair was related to a nationally mandated change in his work assignment. As a result, the work of this group has been minimal. However, there are few pressing issues regarding pyranometers of concern to BSRN at this time. It was noted that there is recent work by non-BSRN participants on the daytime offsets of unshaded pyranometers that has been recently published.

Pyrheliometer Working Group (E. Dutton, Chairman)

The main result for this group was the publication (Michalsky et al., 2011, *Journal of Atmos. Ocean Tech*.) presenting comparison results from an exhaustive yearlong comparison of the then currently available pyrheliometers under all sky and weather conditions. It was acknowledged that windowed pyrheliometers generally do not meet the initial BSRN goal for direct beam. However, several of the newer instruments uncertainties (relative to a reference group of Absolute Cavities) have 95% agreement to within 0.7%, about halving the range of some of the more common older pyrheliometers. Since the report was published some new models of pyrheliometers have become available and a subsequent comparison may be needed in the future. It was also reported that the larger international radiation community is in the process of establishing a new mean extraterrestrial solar irradiance at a level of near 1361 W m^{-2}, which is about 0.36% less than that of the World Radiometric Reference (WRR) to which BSRN solar irradiances are referenced.

Report on Uncertainty in Infrared Radiation Measurements and the IR Working Group (Julian Gröbner)

Since 2009, IRIS Radiometers (Gröbner, 2012) have been deployed on measurement platforms during clear sky nights. A total of 106 measurement nights between 1 January 2010 and 31 December 2011 were analyzed and preliminary results from this intercomparison show a seasonal dependence between the WISG and the IRIS radiometers with higher irradiances in winter, while in the remaining seasons WISG measures on average 4 Wm^2 less than the IRIS radiometers. Furthermore, comparisons between the IRIS, WISG, Eppley PIR and CG4 pyrgeometers show that the results observed between the IRIS and the WISG can be generalized: Eppley PIR and early CG4 pyrgeometers (manufactured before 2003) have a significant seasonal dependence with respect to the IRIS and CG4 pyrgeometers manufactured after 2003 (serial numbers larger than 03xxx), which needs to be corrected in these instruments. While the correction is instrument specific, a generic correction of -0.5 $Wm^{-2}mm^{-1}{}_{IWV}$ is suggested. The determination of an instrument specific correction would require a comparison with the IRIS radiometers during cold (dry) and warm (humid) atmospheric conditions. Work continues on comparisons of IRIS at other sites and an upcoming IR comparison to be held in Davos, Switzerland.

As always, there is a need for more independently designed and built absolute IR sky radiometers to further establish, legitimize and maintain a long-term consensus reference standard.

Cold Climate Issues Working Group (Chuck Long, Chair)

Cold climates are one of most operationally difficult climates for obtaining accurate surface radiation measurements because they are subject to frost, snow, and riming. A number of BSRN stations are located in cold climate environs, and this WG was formed to share experiences and efforts to deal with the detrimental conditions affecting surface radiation instruments. A summary of major results from the ARM North Slope of Alaska (NSA) Radiometer Campaign, surmised that higher speed ventilation fans work better at mitigating frost, riming, and snow build up, but that more slanted sides of the top of ventilator enclosures also help keep the build up out of the field of view. Heating of the ventilated airflow is beneficial, but is inadequate to fully prevent adverse effects at NSA since excessive heating most often introduces enhanced IR loss to pyranometers.

AWI colleagues presented a new ventilator design that actively directs the airflow directly toward the instrument domes, which greatly improves mitigation to the point that heaters are not deemed necessary for their Antarctic sites. Adequate ventilation requires that air intakes remain free of rime and frost build up, and two examples of rime-resistant screening designs were presented for the Jungfraujoch and proposed Sonnblick Mountain Observatory sites. A pyranometer design with built-in internal heaters has been highly resistant to snow, frost, and riming during a winter 2009 deployment at the Storm Peak Laboratory in Colorado.

In summary, some progress toward addressing cold climate issues has been made, but there is much more to be done. Specific sites likely need to adapt strategies to mitigate issues given their own particular issues, and it is likely that there is no one solution for all ranges of conditions everywhere. However, the collaborations and interactions between sites that reside in cold climates has already benefited from the sharing of efforts to date.

Spectral Measurements Working Group [Joseph Michalsky (chair) with contributions from Rachel Pinker, Ain Kallis, and Julian Gröbner]

J. Michalsky reported that R. Pinker provided information on improvements in polar region (60-90ºN) surface albedo estimates from the Moderate Resolution Imaging Spectroradiometer (MODIS) by including better surface characterizations. It is difficult to catch the transitions from snow cover to bare surface back to snow cover in early June and late September time frames, respectively. The University of Maryland (UMD)_MODIS model matched the Atmospheric Radiation Measurement (ARM) Program albedo measurements more closely than other models or estimates from satellite measurements.

Ain Kallis reported that at the Tartu-Tõravere Meteorological Station, solar spectroradiometry (280-400 nm, 1 nm steps) has been performed since 2009 using the double monochromator Bentham DMc150F-U. In 2011 there were 10000 spectra recorded at the rate of one every 15 minutes of daylight. Radiometric calibration is achieved using a standard lamp. There is a nearby AERONET site and a precision filter radiometer (PFR) is expected to be deployed there soon. The data will be used to study the effects of clouds and aerosols on UV.

J. Gröbner reported that a new generation of solar spectrophotometers, the Precision Solar Spectroradiometer (PSR), is being developed at the Physikalisch-Meteorologisches Observatorium Davos (PMOD)/World Radiation Center (WRC) to eventually replace current filter based sunphotometers. It is based on a temperature stabilized grating spectroradiometer with a 1024 pixel Hamamatsu diode-array detector, operated in a hermetically sealed nitrogen flushed enclosure. The spectroradiometer is designed to measure the solar spectrum in the 320 to 1040 nm wavelength range with a spectral resolution of 1–4 nm full width at half maximum. The optical bench with the optical elements was optimized to reduce the temperature dependence of the solar measurements to less than 1% K^{-1} over the entire wavelength range. The design benefits from the experience gained from successive generations of the successful Precision Filter Radiometers (PFR), including: a built-in solar pointing sensor, an ambient pressure sensor and temperature sensors to provide routine quality control information which will allow autonomous operation at remote sites with state-of-the-art data exchange via USB or Ethernet interfaces. The instrument is temperature stabilized to ambient temperatures with a stability of better than 1 K. Initial solar measurements of the PSR beside the PFR-Triad have shown an agreement to within 1% at the common wavelengths 368, 440, 500, and 862 nm.

Long Term Time Series Analysis Working Group (Martial Haeffelin, Chair)

The suggestions and recommendations provided by this group as they pertain to BSRN are:

- Quality control flags must be associated with BSRN data (partially done with BSRN toolbox)
- Uncertainty bars (e.g., instrumental, spatial representativeness) should be included
- BSRN approved and harmonized clear-sky irradiances could be provided. BSRN Clear-sky calculation protocols?
- BSRN protocols should be "diffused" beyond the BSRN network to improve the overall quality of irradiance measurements

A listing of 10 new publications by the WG members was presented that show that BSRN data are being used in the study of decadal scale climate issues.

Session 8. Cloud, Aerosols, and Radiative Forcing

Remote Sensing of Aerosol-Cloud Interactions above an Ocean Platform (Greg Schuster)

Clear sky areas in the vicinity of low-level cumulus clouds are attractive regions for studying the aerosol indirect effect. Passive satellite remote sensing indicates that aerosol optical depth (AOD) and fine mode AOD fractions increase in these areas, but there has been much discussion about whether these retrievals represent true changes in particle microphysics (as opposed to 3D effects not considered in the retrievals). Three-dimensional effects are not an issue for narrow field of view sun photometers and high spectral resolution lidars (HSRL), and limited flight measurements with these instruments also indicate an increase in AOD within 2-5 km of cumulus clouds. The study presented used sun photometer measurements on partly cloudy days from an ocean platform (Chesapeake Lighthouse) located 25 km off the US East Coast. We considered only days when clear-sky and partly cloudy conditions occur on the same day (to limit dynamic meteorological effects), and parse the data set into two populations: "clear" and "partly cloudy." Skies were defined as "clear" when the cloud fraction determined by Geostationary Operational Environmental Satellite (GOES) imagery was less than 5%, and as "partly cloudy" for scenes with single-layer cloud fractions of 0.5-0.8, maximum cloud heights of 2 km, and less than 1% ice. GOES imagery was obtained within 15 minutes of all sunphotometry measurements used in this study, and the differences in surface meteorology (pressure, temperature, wind speed, wind direction, and relative humidity) and aerosol optical depth for the clear and partly cloudy populations were determined.

Climatology of Cloud Radiative Effects at the ARM Tropical West Pacific Sites (Chuck Long)

The US Department of Energy Atmospheric Radiation Measurement (ARM) Program operates three sites in the Tropical Western Pacific (TWP), all of which are BSRN sites. The near-equatorial sites on Manus Island, Papua New Guinea and the island nation of Nauru are tied to the tropical warm pool, which exhibits the warmest sea surface temperatures on Earth. The Darwin site in the Northern Territory of Australia is a tropical coastal site typified by a monsoon climate, with distinct wet and dry seasons.

Overall downwelling surface energy budgets and cloud radiative effects were presented, along with analyses comparing the El Niño and La Niña periods for Manus and Nauru, and the wet and dry seasons for Darwin. Manus and Nauru, and the Darwin wet season, all exhibit average clear-sky downwelling longwave (LW) radiation greater than 400 Wm^2, and clouds add only about 10-15 Wm^2

to this amount for all-sky. The cloud radiative effect (CRE), defined as the all-sky minus clear-sky downwelling irradiances is dominated by the shortwave (SW) radiation. Manus exhibits little variability due to El Niño and La Niña being deeply embedded in the warmest part of the warm pool. Nauru exhibits significant differences due to El Niño and La Niña, especially in the SW. Darwin exhibits the most striking contrast for the surface radiation of the three sites between the wet and dry seasons. While the wet season is similar to Manus at all times and Nauru during El Niño with a SW CRE of about -96 Wm^2, the dry season exhibits small average cloud amounts of only 10-30% and therefore significantly less cloud effects with a SW CRE of only -27 Wm^2. The three ARM TWP sites each exhibit influences from larger-scale regimes that in turn influence the variability of the surface radiative cloud effects.

Disposition of Solar Energy – Towards Estimates from BSRN Surface Measurements and Collocated Satellite Products in Europe (Maria Hakuba)

The quantification of the Earth's Energy Budget components is still afflicted with large uncertainties, in particular, the absorption of solar radiation (ASR) and its partitioning between the Earth's surface and the atmospheric column. Focusing on terrestrial Europe, we made extensive use of BSRN surface solar radiation records combined with collocated satellite-inferred surface albedo and top-of-atmosphere (TOA) net irradiance [MODIS, Clouds and the Earth's Radiant Energy System (CERES) Energy Balanced and Filled (EBAF)] to calculate the solar energy disposition on a monthly mean basis during 2001-2005 for which we calculated the solar energy disposition in terms of annual means, annual cycles and times series of monthly anomalies. The composite annual disposition is:

(i) TOAnet: 185 Wm^{-2}
(ii) ASRsurf: 120 Wm^{-2}
(iii) ASRatm: 65 Wm^{-2} (65, 42, and 23 % of TOA incoming solar radiation)

During 2001-2005 ASRsurf increases significantly by +1.4 $Wm^{-2}yr^{-1}$ and ASRatm decreases by -0.8 $Wm^{-2}yr^{-1}$. Under clear-sky conditions, both TOAnet and ASRsurf are significantly enhanced, whereas ASRatm is reduced. The composite annual cloud radiative forcing on ASRsurf and ASRatm is -28% (of clear-sky) and +8%, respectively. Using the satellite-derived CM SAF surface solar radiation (SSR) product at 0.03- degree spatial resolution, we analyze the sub grid spatial variability and assess the BSRN stations' representativeness for their collocated larger grid cells (1-degree CERES grid). The satellite-inferred surface radiation has the advantage of providing high spatial coverage but is less suitable for investigating temporal variations caused by changes in the atmospheric composition, which are not considered in the retrieval algorithms. The relative mean error between station collocated 0.03 degree grid point and 1-degree mean SSR is 1.3 %, thus, the sites are on average too "sunny" for their collocated 1-degree grid cell, with maximum error at Payerne (5 % or 7 Wm^{-2}).

Kriging of a Global Energy Budget Archive (GEBA) subset (59 collocated 1 degree grid cells covering 76 sites) resulted in a map of annual mean surface shortwave radiation (SSR) that is in very good agreement with the satellite-based spatial pattern (bias: ~ 0.01 Wm^{-2}). The GEBA subset captures the spatial patterns in surface solar radiation, and surface and atmospheric absorbed solar radiation very well. Using both, BSRN and GEBA sites, we will be able to produce a high quality data set of solar energy disposition, both temporally and spatially, that will serve as a reference for the validation of satellite products and climate model performance.

Changes in Temperature and Radiation at the Arctic BSRN Station, Ny-Alesund (Marion Maturilli)

At the Arctic BSRN site, Ny-Alesund, the almost 20 years of meteorological and radiation measurements indicate changes in temperature and radiation. In the annual mean, the surface temperature has increased by about 1.3 K per decade, which is in agreement with the observed general warming of the Arctic region. In Ny-Alesund, the largest temperature increase is found for the winter season, with about 2.9 K increase per decade. At the same time, changes occurred in the radiation observations, with an increase in annual mean net radiation of about 4.2 Wm^{-2} per decade. Looking at the seasons, an increase in the net shortwave radiation is found in spring, most likely related to albedo changes due to an earlier onset of snowmelt. In summer, an increase in global radiation suggests a potential reduction of cloud coverage, while the increase in longwave radiation during winter indicates the presence of more clouds during this period.

Can Aerosols Explain the Decrease in Cloud Cover in China (Xiangao Xia)

Occurrences of clear sky and overcast days were observed to increase and decline by about 2.2 days and about 3.3 days per decade, respectively, which can account for approximately 80% of the decreasing trend of cloud cover. Aerosol effects on decreasing cloud cover in China appear to not be supported by the analysis of the relationship between aerosol optical depth and trends of cloud cover, frequencies of clear sky and overcast days.

Investigations of Dimming/Brightening Trend Differences Using Sum or Global SW (Chuck Long)

Effects of using various permutations of surface-downwelling shortwave (SW) radiation data on dimming/brightening tendencies and trends were presented. Using data from four of the ARM Southern Great Plains (SGP) Extended Facilities network (which were included in the Long et al., 2009 US brightening paper), the original data plus three other forms were used to calculate decadal tendencies from yearly averages. The results suggested that several factors have substantial influence on the resultant slopes of linear fits. The amount of missing data is one significant factor, as is the tendency of IR loss from the global pyranometer time series as indicated from nighttime offsets. The IR loss tendency is imbedded in the overall SW time series if not properly corrected. Another significant factor is whether or not all nighttime data are artificially set to a value of zero, from the notion that there is no downwelling SW at night thus the nighttime SW value should physically be zero. It was shown that this practice masks any ability to detect a significant IR loss tendency. This prohibits the ability to account for that tendency in the analysis to produce decadal changes targeted at the SW from which the IR loss tendency should be removed. It was also noted that the sum of the direct plus diffuse SW also tends to include some typically small amount of nighttime offset from both the direct pyrheliometer and shaded pyranometers as currently used and not normally corrected for the small night time offsets. Finally, the likely inclusion of "bad" data from insufficiently quality assessed time series has an impact.

Recommendations include using a "best estimate" SW time series derived from the sum of direct plus diffuse when available, but filled in with IR loss corrected global SW measurements if the sum is not available, as a means to decrease the amount of missing data in the analysis. Also, quality assessment and control is essential to eliminate the inclusion of "bad" data values. Finally, for the purpose of investigating relative trends, nighttime data should not be artificially set to zero. Rather, the nighttime data should be investigated to assess any tendencies in IR loss, and the IR loss tendency should then be removed from the overall SW time series tendency calculations to more focus the result on the actual changes of downwelling SW over time, instead of a combination of both SW and IR loss changes.

First Results of Measurements with the IRIS Radiometer in Lindenberg (Klaus Behrens)

Since May 2011 the Lindenberg Meteorological Observatory has been operating an Infrared Integrating Sphere Radiometer (IRIS) manufactured at PMOD/WRC, to compare different types of pyrgeometers at clear sky conditions during nighttime. Measurements were made for 25 nights. The Longwave Downward Radiation (LDR) covered a span from about 180 to 340 Wm^2 while the Integrated Water Vapour (IWV) oscillated between 0.2 and 2.0 cm. Results from the Lindenberg site show the same features as reported by J. Gröbner for Davos. These comparisons will be continued in the future to learn more.

VisInfo - Visual Access to Research Data (Oliver Koepler)

The publication of research data in fields such as meteorology, Earth and climate science has become part of the scientific communication. This research data is of great value to current and future research. The German National Library of Science and Technology in Hannover, the Graphic Interactive Systems

(GRIS) Workgroup at the TU Darmstadt and Fraunhofer IGD in Darmstadt presented results of the VisInfo Project, an information retrieval system for visual access to research data.

The VisInfo system applies data visualization to the search process, enabling a content-based search within the data. A web-prototype of the VisInfo system with time-series data from BSRN was presented. In contrast to text documents, research data, with its graphic visualizations, places different demands on indexing, searchability and presentation in the information retrieval process. Using a visual cluster algorithm, a huge amount of scientific research data sets of a digital library can be arranged in a self-organizing map and visualized in one Visual Catalog**.** The Visual Catalog allows instant access to representative curve patterns extracted from the data collection. Using the Query Editor interface the user can modify a given curve pattern or draw a curve by hand and use this visualized curve as query input for a visual search within the data collection. Setting various filter options, the search space can be limited to, for example, time intervals or BSRN stations of interest. Based on predefined similarity notions, similar curves within the search space will be returned and visualized in the Series View. The Series View provides additional metadata information about the corresponding research dataset the curve pattern was found in. Finally, the DOI allows a direct linking to the original data library, hosting the research data set, in our case the PANGAEA data library. The VisInfo system provides a novel, visual approach for a search in research data. Starting from a data overview, the search interface and the search results presentation, all steps use visualized research data. The VisInfo web-prototype will be available by the end of 2012 at *http://www.vis-info.info*.

Session 9. Satellite and Climate Model Applications

Surface Radiative Fluxes as Observed in BSRN and Simulated in IPCC-AR5/CMIP5 Climate Models (Martin Wild)
Despite the central role of the Earth's radiation budget in the climate system and in the discussions of climate change, substantial uncertainties still exist in the quantification of its different components, as well as its representation in climate models. While the net radiative energy flows in and out of the climate system at the top of atmosphere (TOA) are known with considerable accuracy from new satellite observations, the energy distribution within the climate system and at the Earth's surface, which cannot be directly measured by satellites, is much more debated, and consensus on reference values is still lacking. In addition to satellite observations, we used the information contained in the direct surface observations from BSRN to provide direct observational constraints, not only for the TOA radiation budget, but also the surface radiative components. BSRN observations were combined with the latest modeling efforts performed by the Coupled Model Intercomparison Project Phase 5 (CMIP5) for the Fifth IPCC assessment report (IPCCAR5) to obtain best estimates of global mean surface radiative components. These analyses suggest that global mean solar downward and absorbed radiation at the surface near 185 and 160 Wm^{-2}, respectively, is very compatible with surface observations. In the thermal range, a downward thermal radiation estimate of 342 Wm^{-2} fits best to the observational constraints given by the BSRN record. Combined with a surface thermal emission of 397 Wm^{-2}, this results in a net surface thermal cooling of -55 Wm^{-2}. A best estimate for the net available radiative energy (surface net radiation) to distribute among the non-radiative surface energy balance components is near 105 Wm^{-2}. The CMIP5 models overestimate on average the downward solar radiation and underestimate the downward thermal radiation at the observation sites on the order of 5-10 Wm^{-2}. This results in an adequate surface net radiation balance by error compensation of 105 Wm^{-2} in the multi-model mean. This suggests that, globally, the simulated sensible and latent heat fluxes, around 20 and 85 Wm^{-2} in the multi-model mean state values, are in line with the surface net radiation estimates presented here and that we may be able to reconcile the current controversy on the closure of the surface energy balance.

With respect to temporal changes in the surface radiative fluxes, significant decadal changes are observed in both downward solar and thermal BSRN records updated to 2011. These BSRN records indicate an increase of downward thermal radiation of 2 Wm^{-2} per decade, which is in line with the latest CMIP5 simulations and expectations from an increasing greenhouse effect. The downward solar radiation also undergoes strong decadal changes (dimming/brightening). A composite of the 23 longest BSRN records suggests an overall increase in downward solar radiation at the Earth's surface of 2.7 Wm^{-2} per decade over the period 1993-2010. None of the CMIP5 models is able to simulate an increase in downward solar radiation of this magnitude at collocated grid points. Thus, while the CMIP5 models are able to reproduce the thermal (greenhouse-gas) induced changes observed overall at the BSRN sites, the solar changes at the Earth's surface (dimming/brightening) are not adequately captured by these models.

Assessing Improvements for the Surface Flux Simulation in the GFDL CM3 as Compared with the CM2.1 General Circulation Model from BSRN Derived Climatology (Stuart Freidenreich)

BSRN shortwave and longwave derived clear-sky and all-sky climatologies have been used to assess the reduction of surface flux biases in a recently developed coupled general circulation model (GCM, CM3) at the Geophysical Fluid Dynamics Laboratory (GFDL) compared with an older model (CM2.1). Advancements have been made in the simulation of clouds and aerosols that have resulted in an overall reduction of the clear-sky flux monthly and annual mean biases (shortwave direct, diffuse, total; longwave) in CM3 as compared with the CM2.1 model. The reduction in the shortwave flux biases is accompanied by a corresponding reduction of the aerosol optical depth biases with respect to AERONET climatology in regions where BSRN sites are located. There is also an overall reduction of the all-sky shortwave and longwave flux biases in CM3 due in part to better determination of cloud water content. Taking all the sites together, there is a modest degree of linkages among the shortwave all-sky flux and cloud amount biases (with respect to BSRN climatology) and among the all-sky longwave flux (with respect to BSRN climatology) and surface temperature biases (with respect to European Centre for Medium-Range Weather Forecasts climatology) in both the CM3 and CM2.1 models. These linkages are less pronounced in assessing the change in the magnitude of these biases between CM3 and CM2.1. Thus, BSRN-derived climatology is shown to be useful tool, both for assessing improvements made in the simulation of surface fluxes, and for validating improvements made in the simulation of clouds, aerosols and surface temperature evident from independent analyses.

Assessment of Modeled Surface Irradiance in CERES Data Products Using BSRN Observations (David Rutan)

This presentation was based on the use of BSRN data in the assessment of data products from the NASA Clouds and the Earth's Radiant Energy System (CERES) satellite instrument program. Along with Top Of Atmosphere (TOA) observations of irradiance, CERES also produces data products that include profiles of calculated irradiance through the atmosphere. These products include calculated irradiance at both the instantaneous (footprint scale), and hourly (one degree grid box scale), time and spatial resolutions. BSRN data is particularly valuable because it provides observations at high time resolution and of reliable (well characterized and calibrated) quality. Methodology using the differing space and time scales of the CERES data products to assess the ability of the various BSRN sites to represent observed surface downwelling irradiance with respect to the approximate equal area grid boxes used in CERES calculations was also discussed.

Processing of the BSRN Data and Its Application in Validating the Satellite-Based GEWEX-SRB Data (Taiping Zhang)

T. Zhang reported on his analysis of original BSRN data, before and after quality checks, and how the data was processed to generate 3-hourly, daily and monthly means. The processed data were then used to validate GEWEX Surface Radiation Budget (SRB V3.0) data, after which any trends present in the data were analyzed. Quality flags were developed using the methodology of ETH and Long and Shi. About 4% of the original records were rejected by quality checks. About 25% of the sites show G2-G1 RMS errors above 25 up to 54 Watts per square meter, where G1 is the Global 1 or the total SW downward flux from the sum of direct and diffuse fluxes, and G2 is the Global 2, or the total SW downward flux from the unshaded pyranometer. After quality checking, all but one RMS error was reduced to below 20 Wm^{-2}. The G2-G1 bias error change was not dramatic except for Ilorin (ILO), Florianopolis (FLO), and De Aar

(DAA). The Ilorin (ILO) site has problems with G1, however its G2 and longwave values appear to be normal and agreed reasonably well with their GEWEX SRB counterparts. Syowa (SYO) and Georg von Neumayer (GVN) stations tend to be outliers in the SRB-BSRN shortwave comparisons. This may be a result of questionable satellite-based cloud identification over snow-covered Antarctica. The G2 values at Ny Alesund (NYA), Payerne (PAY), Kwajalein (KWA), George von Neumayer (GVN) and South Pole (SPO) are continuously available for a 15-year period from 1993-01 to 2007-12. The Weatherhead et al. (1998) method was used to determine the 95% confidence intervals of trends of these sites and of their ensemble average. The time period for trend detection ranged from 2-15 years. Over the 15-year period, the BSRN ensemble average showed no significant positive or negative trends, but its SRB counterpart showed a negative trend of very small magnitude. Considering the uncertainties in the SRB data, no conclusions can be made about these trends.

Using BSRN Measurements to Analyze the Homogeneity of Gridded Data Sets (Jörg Trentmann)

It has been shown in numerous studies already that BSRN data are well suited for the validation of gridded data sets (e.g., derived from satellite observations or from reanalysis). However, assessments of the stability and the homogeneity, thus far have not been the focus of such studies. The stability of four gridded data sets (three of which are satellite-derived and one derived from reanalysis) were evaluated by comparing linear trends calculated from BSRN measurements and others derived from gridded data sets. In addition, the temporal evolution of time series differences between the BSRN and gridded data sets were analyzed using linear trend calculation and inhomogeneity tests (SNHT, PMT). Linear trends in the BSRN data could be reproduced for most stations with their level of significance by the gridded data sets. However, significant non-zero linear trends in the time series of the bias have been detected for some stations. The application of the homogeneity tests led to the detection of shifts, likely present in the gridded data set. However, at this point, it cannot be excluded that also BSRN data set might contain artificial shifts (e.g., due to the relocation of stations).

Investigation of the Daytime Thermal Offset (A) in Pyranometers (Thomas Carland)

Following a recent upgrade of the Swedish radiation network, there was a need to determine the thermal offset due to net IR loss in the new pyranometers and ventilators. A pyranometer capping experiment was therefore performed in Norrköping. In addition to the new instruments also a couple of older sensors and ventilators were tested, as well as some pyranometers without ventilation.
As reported previously, ventilation normally significantly reduces the thermal offset in solid black thermopile pyranometers. Specifically, for the tested CM21 pyranometers in PMOD conditioners (used without air filter) and in the new SMHI ventilators, the thermal offsets as a linear function of the pyrgeometer net IR signal were very similar to nighttime data and the daytime capping results. However, this was not the case for unventilated pyranometers for which the magnitude of the negative offset was considerably higher for daytime capping results compared to nighttime data.

Session 10. BSRN Business

The following items were discussed and primarily focused on the immediate needs and issues of the field observers and the common data flow to the archive at the World Radiation Monitoring Center (WRMC).

Site Scientist Responsibilities

Responsibilities of BSRN site scientists include the following:

- Establishing and maintaining stations to BSRN specifications.
- Collecting, processing and quality control of field data.
- Submitting the highest possible quality data to the BSRN archive in a timely manner.
- Being responsive and accountable to inquiries about the data.
- Attending and participating in BSRN meetings and working groups
- Following the GCOS ten climate monitoring principles
- Always working towards figuring out how to do things better

Most of these responsibilities are reasonably well-defined, except the last, although the definition of “timely manner in the third bullet solicited some comments. About 15 of the present BSRN sites are submitting their data on a monthly basis with delays of little more than a month or two. This is faster than originally expected where a full year was given for stations to retain and process their data. However, user demands for more timely data have steadily increased and current technologies permit faster review and processing of the data than 20 years ago, when the built-in one-year delay was established. Everyone was encouraged to submit their data as soon as they were satisfied with the level of quality, but no new specific requests or requirements were considered. Gert Konig-Langlo, the data archive director, indicated that waiting and sending large volumes of data at a single time places a burden on the archive, which is staffed for regular routine data flow rather than bursts of volume. Some stations have indicated that it is more economical for them to submit many months of data at a time. The seventh bullet was admittedly added to encourage attendee to consider that some improvements were still possible and desirable. However, it is of course important to make the long-term measurements in a consistent and traceable manner such that transitioning in improvements requires some careful planning and overlap to the extent possible, which is the goal of the ten Global Climate Observing System (GCOS) climate monitoring principles.

GCOS Climate Monitoring Principles

BSRN was invited to become a GCOS Global Baseline Network based upon its ability to fulfil the ten GCOS Climate Monitoring Principles given below. It was noted that diligence on the part of the BSRN participants is necessary to assure continued achievement of these.

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.
2. A suitable period of overlap for new and old observing systems is required.
3. The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.
4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.
5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.
6. Operation of historically uninterrupted stations and observing systems should be maintained.
7. High priority for additional observations should be focused on data-poor regions, poorly observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.
8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.
9. The conversion of research observing systems to long-term operations in a carefully planned manner should be promoted.
10. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

These Principles are demanding, but BSRN has come a long ways towards satisfying them. However, practical and economic considerations sometimes require compromise to the extent to which some of the points can be achieved.

Newly Proposed Sites

R. Vogt proposed a new BSRN observing site located near Gobabeb, Namibia. The site is in a data-poor region and remotely located with distinct bimodal representative surrounding surface albedo. Comments will be solicited from the representatives of the satellite remote sensing community as to their impressions of the site. It was noted that there is a small river dividing the two surface types near the site but it is considered of little consequence. C. Long observed that the potential for making measurements over the different surface types extend the ability to more completely analyze the site. The workshop participants voted to accept the station as a BSRN candidate site.

M. Olef proposed a new BSRN station in Sonnblick, Austria. As it is a mountain top facility, it does not fulfil the BSRN requirement for a homogenous surrounding surface area. However, in previous BSRN meetings, the merits of a few high altitude sites had been discussed. Considering the ever increasing resolution of satellite and model data, along with such a site providing some information on the vertical variability of radiation quantities, it was agreed to accept a few mountain sites with the expectation that data users would take the local conditions into consideration in their applications. One such previously proposed site had failed to mature so strong consideration was given to Sonnblick. A vote was taken it was accepted as a candidate site.

E. Dutton indicated that another new site in southern England, Chilbolton, had asked to be considered as a candidate site and its site team will be encouraged to apply in the future.

Potential Actions for Inactive Sites

E. Dutton pointed out that several BSRN sites have failed to submit data for extended periods of time and that some action concerning the sites is necessary. There was general agreement that instead of suspending such a site, that it be labelled as inactive. The sites where this is a problem are Cambourne, Lerwick, De Aar, Florinopolis, Ilorin, and Solar Village. There was some discussion as to the specifics of each of these sites and in all cases, there is still contact with interested persons who are either trying to re-establish the sites or get the delinquent data submitted. None of the above listed inactive sites were excluded from the project pending further developments. It is the responsibility of these sites and their interested parties to revive these stations since BSRN does not have resources to address individual site operational issues.

Data Archive (WRMC) and Archiving Issues

It has become apparent that some bad data have been placed in the archive. The Archive Director stressed the importance of individual BSRN sites running quality control (QC) on their data before submitting it to the Archive. The Archive supplied "BSRN Toolbox" is an excellent utility for QC that easily detects errors. However, if done by the Archive staff it creates a lot of work for them, as they must communicate back and forth with the sites to address problems. The resources at the Archive are too limited to deal with large numbers of stations not pre-screening their own data. This is the responsibility of the station scientist. It was also noted that in some cases the persons listed as Site Scientists were either nonresponsive to Archive inquires or had little or nothing to do with the data submission. At the very least, the person listed as the Assistant Site Scientist should be familiar with the data submission process and be able to address Archive issues. Konig-Langlo, the Archive Manager, stressed to the members that contact from the Archive to a BSRN site should be taken as assistance and not criticism.

While the commonly applied QC using the BSRN Toolbox (and as formerly applied at the earlier archive in Zurich) has generic limits applied to all stations, it has long been realized and suggested that those limits can be fine-tuned for individual sites or regions. The developer of the ToolBox has plans to allow for user specified limits, however, that product is not expected to be available soon. C. Long pointed out that his published code for QC of BSRN-type data sets is available and that it uses site specific limits and is somewhat stricter than the ToolBox in qualifying data.

The issue of what to do with data flagged by QC programs was discussed. The general feeling of the group was that the data should be manually reviewed to determine if the source of the problem could be identified or if the values are valid but just unusual. Blind or gross elimination of the flagged data may be excessive, but if only a very small percentage of data are flagged it may be okay to automatically eliminate them. In all cases the final data sets with the flagged values are indicated as missing. However, the initial raw data always should be preserved at the originating site, which is a fundamental principle of scientific data collection.

Nighttime Zeros and Offsets

There is no specific BSRN policy for handling nighttime "zero" solar data. G. König-Langlo noted that the most flagged data in the Archive are the nighttime values. Although the issues of night offsets had been previously discussed and our current and former Archives have low-end limits on acceptable nighttime (solar zenith angle greater than ~94 degrees) of -2 to -4 W m^{-2}, participants individually decide if they are going to attempt to correct for offsets, zero-out all nighttime offsets, zero only excessive nighttime offsets, or do nothing and report as acquired. The utilized procedure for each site should be documented in the submitted station-to-archive file and should be apparent in the data if enough is examined. According to K. Berhens, the appropriate ventilation would (or should) eliminate the problem of offsets. When these data are averaged over periods including the nighttime, it is obvious that using negative (or positive) nighttime values in any averaging interval lowers (or raises) the computed average value and is less correct compared to an average that would be obtained if the known correct value of 0.0 were used. Also, setting otherwise missing nighttime data to 0.0 provides for less bias in daily or longer averages than ignoring those missing points. The utility that many people see in retaining all or some of the nighttime offsets is to aid in documenting instrument performance or for monitoring the resulting values after attempting to correct for offsets, either computationally or with ventilation. Various participants express the preference to handling the issue values their own way. It should be pointed out that the issue of whether or not to set nighttime value to 0.0 is related to but a somewhat different topic than addressing thermally induced offsets in daytime data, which was not discussed in any detail.

BSRN Science Objectives Review

Initially, the primary science objective of BSRN was to support the validation of satellite-derived surface radiation products. However, it soon became apparent that BSRN data could be valuable if compared to a full range of models, from simple parametric to all levels of radiative transfer models, and for comparing irradiances generated in the most sophisticated General Circulation and Climate models. In addition, the data is valuable for establishing local to regional radiation climatologies and the nature and extent of variability within those records. Other less common applications were known to exist because the data are available to the entire research community, but would not be considered a science objective for BSRN. More recently, there is a growing interest in renewable solar energy applications and some members of the BSRN are obtaining a larger portion of their resources from that community, which also often utilizes thermal IR observational data. It should therefore be recognized that a significant objective of at least a portion of the BSRN member stations is in pursuit of advances in the area of renewable energy.

Operations Manual

The BSRN Operations Manual (OM) provides all the specifications and recommendations for establishing and operating a BSRN station. The current version (2.1) was published in 2005 by L.J.B. McArthur and is available through the BSRN website. In earlier BSRN meetings, it was decided that the OM should be reviewed and revised as necessary to account for any changes or advances in the BSRN methodology. Considering that the OM author is no longer active in the program, there was a discussion on who should now assume that responsibility and complete the next review/revision. T. Carland asked if there had been any necessary revisions identified. At this time there have been no errors, omissions, or any other apparent changes to the OM identified by the BSRN community. Therefore, the PM will review the manual for the purpose of determining the need for any revisions.

Working Groups Relevance and Structure

The history and intent of the BSRN working groups (WGs) were reviewed by the PM. It was noted that participation and activity has recently been low in many of these. This may be due in part to the fact that the more tractable issues have already been addressed or that various pursuits have stalemated. In addition, several of the active participants in these groups are no longer in the program. The primary intent of the WGs is to address specific issues or problems being encountered by BSRN. The main function of the active WGs is to primarily serve as a collection point for reports on the activities of the individual group members. This is a useful function but shows a lack of coordinated work. The PM expressed a desire to narrow down and consolidate the WGs to those that will be the most useful and effective. The main functions and interests of each of the WGs, as well as their current interests were then reviewed and discussed.

Time Series and Long-Term Analysis Working Group

This relatively new WG has explored and reported on various applications of the BSRN data for time series analysis. The primary utility of this WG is to alert BSRN of the concerns of that community as well as offer the BSRN participants an opportunity to extend their interests into this area. As reported by the WG Chair, M. Haeffelin, the group's current concerns are relative to available data with homogeneity checks and enhancing the network's data QC, including providing guidance as to how to treat flagged data. The group also believes that a clear-sky product would be useful. Also of interest to this group is spreading the BSRN methodology to additional, higher-density networks such as national networks. B. Liley noted that the current existence of BSRN had the effect of generally improving surface radiation observations. The PM suggested that any station following the BSRN specifications could be referred to as BSRN-like measurements. L. Vuilleumier pointed out that costs are our main limitation in the spread of BSRN quality observations. Participants interested in participating with this group were encouraged to contact the WG Chairman.

Aerosol Optical Depth Working Group

The work of this group has virtually halted with the departure of its chairman from an active role within BSRN. The main goal of this group had been the centralized collection and processing of spectral attenuation data into spectral aerosol optical depth (AOD) measurements to be included in the main BSRN archive. It is still highly recommended and encouraged that all BSRN sites acquire spectral solar data for the purpose of deriving AOD because of its immense value in analyzing surface solar irradiance data, although there is now little likelihood of having a central BSRN product. J. Gröbner noted that there are other extensive and growing AOD networks from which these data can be acquired, including the Global Atmosphere Watch (GAW) Programme Precision Filter Radiometer (PFR), Aeronet, and Skynet, as well as many of the individual BSRN sites. There was some discussion as to whether BSRN should still try to centralize its AOD rather than contribute to other databases. D. Rutan suggested that the BSRN website could direct users to the relevant data. J. Michalsky noted that at the latest AOD comparisons in Davos there was close agreement between a large number of participants each doing their own data reduction, thereby suggesting the there may be little need for centralized processing to assure the general availability of consistent AOD data. The responsibility will be left to the individual site scientists to acquire and make available spectral AOD data for their sites. This WG will be inactive until further related pressing issues need to be addressed.

Direct Beam, Pyranometer, and Broadband Albedo Working Group

This group has been reformulated to include the former individually so-named groups because of the commonality of many of the related measurement issues and the fact that much of the recognized necessary work has either been completed or is no longer recognized as pressing or has seen little opportunity for progress. This group will remain dormant under the purview of the PM until such time where there is an interest or there becomes a requirement for activity in one or more of the topical areas. Currently known issues are summarized below.

The direct solar beam data have been recognized as the largest source of uncertainty in the BSRN downwelling shortwave component sum (or total or Global-1) measurement. L. Vuilleumier noted in his earlier presentation, and this has been seen by others and previously recognized by BSRN, that current commercial, all-weather, windowed pyrheliometers do not meet the initial and revised goals of BSRN. The recent comprehensive Variable Conditions Pyrheliometer Comparison (Michalsky et al., 2011) shows the typical performance of virtually all the available pyrheliometers in 2009/2010. This comparison may need to be repeated at a later date as more new instruments become available. No other work on the direct beam has been deemed necessary other than following the potential for a refinement to the mean extraterrestrial solar irradiance from a value near 1365 Wm^{-2} to which the

BSRN pyrheliometers are referenced through the World Radiometric Reference (WRR) to a value nearer 1361 Wm^{-2} as suggested by recent satellite observations from the Solar Radiation and Climate Experiment (SORCE) mission.

Pyranometer performance under all sky conditions was initially recognized as problematic due to numerous angular characterization and thermal effect issues and is operated in BSRN only as a crosscheck on the more accurate component-sum measurement of downwelling solar irradiance. BSRN has given lower priority to further work on the pyranometer as a measure of all sky irradiance. Related work by the former working group was minimal. However, there are ongoing external interests in trying to improve this type of measurement. Also, ventilation issues remain for optimal performance of these instruments

As for the use of pyranometers for diffuse and upwelling measurements, there was no specific discussion on those activities at this meeting nor are there planned BSRN related activities that would be within this WG. However, accurate and representative albedo measurements remain problematic, especially in attempting to match the effective field-of-view of the upwelling irradiance measurements with comparison results from models or satellite products. Given the considerable dearth of these measurements in the world and the relatively few in the BSRN, all current BSRN sites were encouraged by the PM to add suitable upwelling measurements (from at least a 10 m tower over uniform representative nature surface) at their sites if feasible. The presentation this week by C. Schaaf suggested 20 - 30 m towers would be better for many sites.

Spectral Working Group (Includes UV, PAR, and Spectral Albedo)

This working group now covers the areas of interest, which were previously covered by four separate WGs. There is easily an infinite amount of work that could be done under this topic, but most would be fringe to the primary goals and objectives of BSRN. Several early participants in the program had particular interests in PAR and wideband UV. The spectral high resolution WG was formed to investigate the potential eventual need for BSRN to move in that direction, however, this was subsequently deemed impractical from the now well-appreciated operational limitations within BSRN. Research and investigative observational procedures that fall into any of these areas would be of interest to the WG. Julian Gröbner was nominated by J. Michalsky as chair of this WG. Gröbner accepted without objection from the WG members.

IR/Pyrgeometer Working Group

The work of this group has been the subject of several presentations and discussions throughout the workshop, indicating both the important work of the group and its present viability. The current work is focused on the further development of an absolute calibration reference standard for the world, but is also addressing issues with the performance of ordinary pyrgeometers used throughout the network. Fortunately, these remaining uncertainties appear to be within the ±4 Wm^{-2} range, which is considerably less than the ±20 to 30 Wm^{-2} uncertainty that existed when BSRN was formed. The WG Chair, J. Gröbner, noted the extensive use of the BSRN data for model comparisons and the potential impacts of some of those results raise concerns about the traceability of some of the measurements. It was suggested that a traveling standard round-robin intercomparison of IR irradiance measurements, similar to the one conducted in the early days of BSRN, be conducted. There was also a brief discussion introduced by the PM as to the procedure to follow should some adjustment to the current IR reference, WISG, become necessary. It was suggested that a specific correction to existing data be published rather than resubmission of all BSRN data to the archive. However, the group consensus was that it is too early to address this. The PM made a renewed call for more independent absolute IR references to be produced and brought into the discussion. Interested persons, with something to contribute, are invited to join this group by contacting the chairman.

Uncertainties Working Group

The future of the Uncertainties WG is uncertain given the departure of the group's main proponent and Chair since its inception. However, the broadly recognized need for this aspect of a measurement program has never been greater with the generally emerging attitude in some sectors that measurements without these ascribed uncertainties are unworthy. The general mean uncertainties of BSRN data were described in published goals of the organization with specified measurement procedures intended to achieve those goals. Subsequent evaluations have shown the achievement or near achievement of those goals except for the direct solar beam as indicated earlier. The Uncertainties WG focused on developing observation-by-observation instrument uncertainties, however these were not incorporated in the distributed BSRN product. Since few typical BSRN data applications require individual observation instrumental uncertainties, the greater need becomes the total measurement uncertainty over various and extended time averaging intervals, including operational errors and glitches. Although BSRN has prided itself on the high-time resolution at which it has produced data to make it flexible for many applications, the greater value of monthly, yearly and multi-yearly averages has become apparent, and the need for BSRN to address that level of uncertainty remains. It is hoped that current or future BSRN participants will pick up this task. No Chair or membership currently exists for this WG, however the group will be retained as a reminder of this need should adequate interest arise at a later time.

Cold Climates Working Group

This group has been one of the more active groups and was relatively recently formed under the Chairmanship of C. Long. The group has provided useful and interesting reports during past meetings and has attracted a relatively large participation. A large aspect of the work focused on methods and technology for the prevention of condensation on optical surfaces, but the most recent report also emphasized temperature sensitivities of the thermopile instrumentation. There are no specific ongoing activities in this group other than the desire to mutually share experiences and discoveries in the future.

Oceanic Working Group

This WG was formed to address the obviously large gap in BSRN observations over the oceans. Considering that the reason the gap exists in the first place, it has proved very difficult to improve upon it. BSRN has long had four small island/platform sites (Bermuda, Kwajalein, Nauru, and Chesapeake Lighthouse), with another two, Cocos Islands (Northeast Indian Ocean) and Minamitorishima (Northwest Pacific) added since the WG was formed. The full extent of local island effects for each of these sites has not been evaluated, other than at Nauru (Long and McFarlane, 2012). Other efforts to locate available and suitable offshore drilling platforms did not produce new sites. Certain buoys and ocean going vessels are known to carry broadband radiometers but typically do not meet existing BSRN specifications, which are extremely difficult to achieve on a moving platform. The BSRN user community continues to express a desire for more oceanic representative sites to be incorporated into the archive.

The discussion regarding this WG was relatively extensive. J. Michalsky suggested disbanding the group since it was formed to look at options, and no identifiable viable options appear to exist. C. Long indicated that buoys may offer some hope but tilt corrections and cleaning issues have to be addressed. At one time he recalled that there had been a comparison planned between a Woods Hole Buoy and the Chesapeake Light House, but does not know if this ever happened. Long also reported that ARM will be including a radiation package on an upcoming ocean cruise. It is experimental and he will report on it at the next BSRN meeting. Long also suggested that a leader in buoy observations be invited to the next meeting. D. Rutan had looked at buoy data in his CERES/ARM Validation Experiment (CAVE) database at NASA/Langley, and indicated that he has used data from some buoys and found it to be as useful as island sites for his purposes. B. Liley offered to investigate vessels of opportunity. Overall, there was strong consensus to try to expand more into oceanic areas. T. Kirk indicated that he could supply additional information on buoy radiation activities. Everyone was invited to provide the PM with information they could share about known irradiance measurement activities on buoys. This WG is currently without a Chairman.

General Comments

Although not a part of BSRN specifications, the PM commented on the value of redundant measurements, particularly double redundancy, being of value to long term climate monitoring for the purpose of quality control, increased accuracy, and data gap reduction. L.Vuilleumier commented on the practical limitations and existing difficulties of even single measurements.

The PM pointed out that BSRN measurements are being widely used and are making notable contributions as evidenced by a few papers in this meeting as well as many others to be presented the following week at the IRS meeting. Also, review the publications list on the BSRN page to see the extent of applications, followed by a request from the Archive Manager for everyone to inform the Archive (WRMC) of new publications. L. Vuilleumier pointed out that even though people value the good observations, he (and presumably others) get requests to work more efficiently and reduce costs. He had shown in his presentation this week that reducing cost can have serious effects on the data.

Meeting Closing

Posters and presentations from the meeting will be collected and supplied via the GEWEX website, but only for those authors who wish to do so. The PM requested that all presenters send him a brief summary of their presentations to be included in the meeting report. A call for WG member volunteers will be issued in the near future. A call asking for a host for the next BSRN meeting was issued with no immediate responses. A call for suggesting changes or additions to the meeting format was issued by the PM. Marion Maturilli, the host for this meeting, was sincerely thanked by the PM and this was heartily repeated by the rest of the meeting participants. Contributions by Gert König-Langlo to the meeting organization were also acknowledged, as well as his dedication in directing the WRMC for BSRN.

3. Poster Summaries

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

Chesapeake Light (CLH), which is located approximately 25 miles east of Virginia (coordinates: 36.90N, 75.71W), was established in 1999 as a surface validation site for the Clouds and the Earth's Radiant Energy System (CERES) and other satellites. For this reason, Chesapeake Light is also known as the CERES Ocean Validation Experiment (COVE). First data collection for BSRN began in May 1, 2000 and is continuing. Because CLH is a part of the BSRN network, most of the instruments are radiometers that measure both downwelling and upwelling flux at visible and infrared wavelengths. Basic meteorological parameters are also monitored as well as other data collections for aerosol, black carbon, total column water vapor and more (please see the poster presentation which provides a complete list of measurements collected at CLH). Redundancy of data collection occurs for downwelling measurements (global, direct and diffuse) to minimize any data gaps that could occur if an instrument fails.

Chesapeake Light provides a wide range of measurements over an ocean environment with other observations pertaining to aerosol studies, black carbon analysis, a comparison of MFRSR calibrations at Chesapeake Light and at Mauna Loa Observatory (MLO), determination of spectral albedos from Multi-Filter Rotating Shadowband Radiometers (MFRSRs), and a comparison between modeled and actual downwelling shortwave and longwave measurements under three different sky scenarios (clear, partly cloudy and cloudy) over a number of years.

Data for CLH have been submitted through July 2012. This is a total of 146 months of data submitted to the BSRN archive since May 2000. More information about the Chesapeake Light/COVE site can be found via http://cove.larc.nasa.gov/.

Status of the Izaña BSRN Station (Rosa Delia Garcia)

The Izaña Atmospheric Observatory (IZA) is managed by the Izaña Atmospheric Research Center (IARC) belonging to the Meteorological State Agency of Spain (AEMET). In 1984 it was incorporated into the Background Air Pollution Monitoring Network (BAPMoN) and in 1989 it became part of the Global Atmospheric Watch (GAW) programme. It is located in the Tenerife Island (Canary Island, Spain) at 28°18' N, 16°29' W, 2.367 m a.s.l, above a quasi-permanent inversion layer, consequently it offers excellent conditions for *in situ* measurements of trace gases and aerosols under "free troposphere" conditions and for remote sensing atmospheric observations. The environmental conditions (stable total column ozone, very low column water vapour and low aerosols content) and the high frequency of clean and pristine skies, makes IZA optimal for calibration and validation activities. The radiation site in Izaña has been a part of BSRN since March 2009 (www.aemet.izana.org/bsrn_iza). The basic measurements at IZA are global, direct and diffuse radiation and longwave downward radiation. The expanded measurements are total ozone column and the vertical distribution of pressure, air temperature, relative humidity, wind speed and direction obtained with radiosondes launched twice a day (00 and 12 UTC) from the Güimar station (110 m a.s.l.) (WMO, station #60018). Finally the other measurements are short- and longwave upward radiation, UV-A and UV-B radiation.

The measured data are tested against physically possible (Gilgen et al., 1995) and globally extremely rare limits as defined and used in the BSRN recommended data quality control (QC) testing developed by Long and Dutton (2002). The poster shows percentages of data that failed the QC tests in 2009, 2010 and 2011 at the IZA station. In general, the results are very successful with the measurements satisfying the physically possible and globally extremely rare limits. Also, it shows the comparison between measurements and simulations for global, direct and diffuse radiation for clear-sky. There is a good agreement between simulations performed with LibRadtran model and observations for the global radiation with MBE -1.56% and RMSE 2.03%. The differences are very low for direct radiation where MBE is -1.32% and RMSE 1.82%. In the case of diffuse radiation, there is a larger difference between observations and simulations, where RMSE is 6.83% (García, 2011).

Status of the BSRN Stations Alice Springs, Darwin, Cocos Island, and Lauder (Nicole Hyett)

The status of the Australian Bureau of Meteorology BSRN sites was presented, including some details about the types of measurements made at each site. Included were plots of the percentage of data collected for each site from the start of operations of the site. Also included was information on any issues affecting measurements, including information about the difficulty in visiting Cocos Island for calibration and maintenance due to the presence of asylum seekers and the new scheme of calibration for Lauder NZ, made necessary due to NIWA funding cuts.

Status of the Dome Cantarictic BSRN Station (Christian Lanconelli)

Dome-C (3233 m a.s.l, 75°S, 123°E) is a joint Italian French facility on the East Antarctic Plateau, operating throughout the whole year since the winter-over 2005. Dome-C is characterized by an extremely dry (precipitable water < 1mm) and cold climate (temperature ranges between -80°C and -20°C), ~650 mb typical pressure, a strong surface temperature inversion in particular during winter, occasional white-out and diamond dust events, and a relatively calm wind (it does not exceed 15 m/s). The Basic Measurements (LR 0100) were implemented in January 2006 using mostly Kipp and Zonen secondary standards CM22, CH1, and CG4 radiometers, along with a couple of Eppley normal incident pyrheliometers NIP. A set of radiometers is annually calibrated with respect to the WRR (SW) and WISG (LW) hosted at PMOD (Davos). A cold weather adapted 2AP Kipp and Zonen solar tracker is installed.

The base set of measurements is currently operational and archived till February 2010 with 50 monthly archived data. Since April 2007 a set of ventilated secondary standard radiometers (CM22) and a CGR4 operate on a 3-m height "T" shaped albedo rack, to measure respectively the upwelling shortwave and longwave components of surface energy budget (LR 0300). A secondary standard of CM11 pair of pyranometers were installed during the 2009-2010 summer campaign at the level of

32m on the Dome-C scientific tower (h=45m) to obtain an albedo representative of a wider area with the aim to provide valuable data for satellite validation. A custom-built UV-RAD multi-filter ultraviolet radiometer was installed during the 2007-2008 summer seasons and is still in operation during the sunshine periods. It allows retrieval of columnar ozone, surface solar UV spectrum, and weighted dose rates and corresponding daily doses.

Status of Sede-Boker (SBO) BSRN Station (Vera Lyubansky)

The Sede-Boker (SBO) station is located in the Negev Desert and became a BSRN station in 2003. It is operated by the Israel Meteorological Service (IMS) and the Institute for Desert Research (BIDR). In addition to the basic measurements (LR0100), the data of LR1000 and LR1100 (synoptic data and radiosonde data) are transmitted to the BSRN archive on a monthly basis. The basic quantities measured are global, diffuse, direct and atmospheric downward radiation. The instrumentation of the station includes Eppley PSP global pyranometer, shaded Eppley PSP pyranometer, Eppley NIP pyrheliometer and Eppley pyrgeometer. The shaded pyranometer and pyrheliometer are mounted on a 2AP tracker. All instruments are calibrated yearly. In January 2012 we were forced to close the station due to the construction of new homes around the SBO BSRN station. In May 2012 the SBO station resumed its activity from a new location 600 meters north of the old one. The results clearly demonstrate the lack of trend in solar radiation in the period 2003-2011. The smaller variability of global radiation in summer is due to less cloudiness during this season. Hourly data show the well-pronounced daily cycle with daily maximum for January and July respectfully as follows (values in Mj/m^2): global radiation 2.0 and 3.69: direct radiation 2.35 and 3.19; diffuse radiation 0.61 and 0.47.

Sunshine Duration Measurements Using the Carpentras Method (Jean-Philippe Morel)

The A and B coefficients of the Carpentras formula that were used to estimate the sunshine duration (SD) from pyranometer measurement results are given for nine BSRN Stations where Global (G) and Direct (I) solar reliable irradiation measurements are available. The measurements from these worldwide stations are shared and correctly measured.

The Carpentras Method: We consider that SD = 1 if the global measurement result G (W/m^2) sampled every one minute is superior to the following function:

$G > Gmod \times Fc$ with:

$Gmod = 1080 (\sin h)^{1.25}$

$Fc = A + B \cos (2\pi d/365)$

where:

d is the number of the day,

h is the sun elevation.

We compare the total SD obtained every day by adding all the minute results of the preceding method (SD = 1 or SD = 0), to the SD reference obtained in the same way from the moment that: $I > 120\ W/m^2$.

For all the Stations, the coefficients A and B were selected in order to obtain the smallest difference between annually calculated SD and reference SD. The challenge also consisted in obtaining the smallest variation (amplitude) of the function of the time: (SDminute-calculated – SDminute-reference).

The selected stations were: Boulder (Colorado, USA), Cabauw (Netherlands), Carpentras (France), Momote (New Guinea), Palaiseau (France), Payerne (Switzerland), Tamanraset (Algeria), Tateno (Japan), and Toravere (Estonia).

We conclude that:

- Coefficients 77<A<67 and –0,02<B<0,08
- The determined coefficient A is the same every year
- The determined coefficient B is very similar every year

- Error Max<1% by year (except Toravere 2009)
- Possible correlation with type of climate
- No correlation with latitude

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 LW and SW irradiance at 10 and 30 m 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 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, which allowed integrating it into the general MeteoSwiss automated network infrastructure. This upgrade, which included complete removal and renovation of the old infrastructure (e.g., supporting benches, signal and power cabling), was performed from 15 August 2011 to 30 September 2011. Only partial data was available during this period.

Beyond the daily quality control, thorough verification (quality analysis) of the Payerne BSRN data accuracy (or reproducibility) was performed for shortwave (SW) global, direct and diffuse irradiance, as well as longwave (LW) downward irradiance. This revealed that the level of reproducibility and stability reached before the upgrade of the station was maintained in general. Although, the extremely tight BSRN accuracy target for SW direct irradiance seems to have not been obtained, the situation seems to have improved since the upgrade. Errors and inhomogeneities in the old data submitted to WRMC in the LW, diffuse SW and UV have been identified and are being analyzed. However, the important work load involved in renewing the BSRN Payerne station delayed correction of old un-homogenized values in the WRMC database.

4. Participants

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5. Agenda

Twelfth BSRN Scientific Review and Workshop
AWI, Potsdam, Germany 1-3 August 2012

31 July, Tuesday

18:30	AWI hosted reception at Hotel Mercure 'Cinebar'

1 August, Wednesday

08:30 – 09:00	Registration and begin poster set-up
	<u>**Opening Session**</u>
09:00 – 09:10	Ellsworth Dutton and Marion Maturilli – Meeting opening and logistics
09:10 – 09:25	Peter Lemke (AWI Climate Sciences Research) – Welcome and AWI Overview
09:25 – 09:35	Anna Mikalsen – An update from the GCOS Secretariat
09:35 – 09:45	Ellsworth Dutton – Meeting overview and expectations
	<u>**New and Proposed BSRN Measurement Sites**</u>
09:45 – 10:00	Roland Vogt – Radiation Measurements in Gobabeb, Namibia
10:00 – 10:15	Marc Olefs – Sonnblick Mountain Observatory as a Future BSRN Station?
10:15 – 10:30	Ben Liley – Extending BSRN Measurements throughout New Zealand
10:30 – 11:00	**Break (finish poster set-up and poster viewing)**
	<u>**Observations and Analysis**</u>
11:00 – 11:20	John Augustine – 16 Years of Surface Radiation Budget Data Over the U.S.
11:20 – 11:40	Nozomu OhKawara – Long-Term Variations of Atmospheric Transmittance from Pyrheliometer Measurements
11:40 – 12:00	Laurent Vuilleumier – Reproducibility of Basic Measurements at the Payerne BSRN Station
12:00 – 12:20	Martial Haeffelin – Short-Term Solar Irradiance Forecasting for Photovoltaic Energy Applications Based on Analysis of Surface Radiation and Meteorological Measurements
12:20 – 12:40	Michael Dooraghi – High-Density Solar Measurements
12:40 – 13:00	Laurent Vuilleumier –Inferring Ultraviolet Anatomical Exposure Patterns while Distinguishing the Relative Contribution of Radiation Components
13:00 – 15:00	**Lunch (also, poster viewing and AWI campus tour)**
15:00 – 16:00	Julian Gröbner – Uncertainty of Long-wave Irradiance Measurements & WG Report
16:00 – 16:30	**Break (with poster viewing)**
	<u>**Data Archiving and Data Processing/Review**</u>
16:30 – 16:50	Gert König-Langlo – Archive Overview and Status
16:50 – 17:10	Friedrich Richter – Importing Data into the WRMC
17:10 – 17:30	Holger Schmithüsen – Quality Management Included in the BSRN Toolbox
17:30 – 17:50	Jordi Badosa – Irradiance Measurements at the SIRTA Observatory: Revisiting Quality Control Procedures

17:50 – 18:10 Anatoly Tsvetkov – Metadata at WRDC and its Information has a Key Role in the Analysis of Long-Term Solar Radiation Time Series
18:10 – 19:00 Posters available for viewing

2 August, Thursday

Albedo

09:00 – 09:20 Crystal Schaaf - The Role of BSRN in Validation of Moderate Resolution Satellite Albedo Products
09:20 – 09:40 Joseph Michalsky - Spectral and Broadband Albedos near Boulder, Colorado
09:40 –10:10 Miguel Román - Use of In situ and Airborne Multi-angle Data to Assess MODIS, VIIRS, and Landsat Based Estimates of Directional Reflectance and Surface Albedo

Special Reports

10:10 – 10:30 Wouter Knap - Cabauw: Research and Status
10:30 – 10:50 Xabier Olano – Proposal for Classification of Sky Conditions for Pyranometer Calibration According to ISO 9847

10:50 – 11:20 Break (with posters)

Working Group Reports

11:20 – 13:00 (10 to 20 minutes each)

13:00 – 14:00 Lunch

Clouds, Aerosols and Radiative Forcing

14:00 – 14:20 Markus Rex – Polar Ozone and Climate Change
14:20 – 14:40 Christoph Ritter – Observations of Arctic Aerosol
14:40 – 15:00 Greg Schuster – Remote Sensing of Aerosol-Cloud Interactions Above an Ocean Platform
15:00 – 15:30 Chuck Long – A Climatology of Cloud Radiative Effects at the ARM Tropical Western Pacific Sites

15:30 – 16:00 Break (with poster viewing)

16:00 – 16:20 Maria Zyta Hakuba – Solar Absorption in the Atmosphere – Towards Estimates from BSRN/GEBA Surface Measurements and Collocated Satellite Products
16:20 – 16:40 Marion Maturilli – Changes in Temperature and Radiation at the Arctic BSRN Station Ny-Alesund
16:40 – 17:00 Xiangao Xia – Can Aerosol Explain Decrease of Cloud Cover in China?
17:00 – 17:20 Chuck Long – Investigations of Dimming/Brightening Trend Differences Using Sum or Global SW
17:20 – 17:40 Klaus Behrens – First Results of Measurements with the IRIS-Radiometer in Lindenberg
17:40 – 18:00 Oliver Koepler – VisInfo – Visual Access to Research Data

19:00 – Group Dinner

3 August, Friday

Satellite and Climate Model Applications

09:00 – 09:30 Martin Wild – Surface Radiative Fluxes as Observed in BSRN and Simulated in IPCC-AR5/CMIP5 Climate Models
09:30 – 10:00 Stuart Freidenreich – Assessing Improvements for the Surface Flux Simulation in the GFDL CM3 as Compared with the CM2.1 General Circulation Model from BSRN-Derived Climatology

10:00 – 10:50 Break (with poster viewing)

10:50 – 11:10 David Rutan – Assessment of Modeled Surface Irradiance in CERES Data Products Using BSRN Observations
11:10 – 11:30 Taiping Zhang – Processing of the BSRN Data and its Application in Validating the Satellite-Based GEWEX-SRB Data
11:30 – 11:50 Jörg Trentmann – Using BSRN Measurements to Analyze the Homogeneity of Gridded Data Sets
11:50 – 12:10 Erhard Raschke – GEWEX Radiation Flux Assessment: The role of ground- based data
12:10 – 12:30 Thomas Carlund – Investigation of Daytime Thermal Offset (A) In Pyranometers
12:30 – 13:00 Poster viewing

13:00 – 14:00 Lunch

14:00 – 17:00 **BSRN Business (all site scientists and active BSRN participants should attend)**
Discussion on proposed new stations and additional needs
Data archiving and QC
Calibration requirements and needs
Review of BSRN science goals
Operations Manual updates
Discussion on working group structure and membership
Other items as they may come up during the meeting
Next meeting
Wrap up
Adjourn

6. List of Poster Presentations

Posters will be on display the entire meeting in the break area and will be accessible daily 08:00 to 19:00. Poster boards are 90 cm wide by 120 cm high.

Badosa, Jordi – Analysis of 18-Month SPN1 Irradiance Measurements at the SIRTA Observatory

Becker, Ralf – BSRN Station Lindenberg: Current Status

Donkers, Chiel – Modeling the Spectral Behavior of Pyrgeometers During Calibration

Fabbri, Bryan – Status and Operations at the Chesapeake Light (CLH) BSRN Site

Gacia-Carbrera, Rosa Delia – Status of Izaña BSRN Station

Haeffelin, Martial – Solar and Infrared Irradiance Measurements at SIRTA Observatory: New Instruments and Evaluations

Hodges, Gary – Status and Updates of SURFRAD BSRN Sites

Hodges, Gary – Status and Updates of ARM BSRN Sites

Hyett, Nicole – Status of BSRN Stations: Alice Springs (AU), Darwin (AU), Cocos Island (AU), and Lauder (NZ)

Kallis, Ain – Solar Radiation Network in Estonia

König-Langlo, Gert – Status of the BSRN Station Georg-von-Neumayer

Konigs, Jörgen – Measurements with Pyrgeometers, the Clean Way

Kustov, Vasilii – Comparison of AT-50 and M-80 Russian Radiation Instruments to Modern Sensors Specified by the Baseline Surface Radiation Network (BSRN) Program

Lamine, Boulkelia – Status of Tamanrasset BSRN Station

Lanconelli, Christian – Status of the Dome C Antarctic BSRN Station

Lyubansky, Vera – Status of SBO BSRN Station

Mair, Martin – A New Radiation Monitoring Initiative in Austria

Maturilli, Marion – Status of the BSRN Station Ny-Alesund

Morel, Jean-Phillipe – Sunshine Duration Measurement Using Carpentras Method

Olano, Xabier – Status and Updates of CENER BSRN Station

Schukurov, Karim – Influence of Smoke on Both Ground-level Air Temperature and Downwelling Long-wave Radiation Flux During Forest Fires in Moscow Region in Summer 2010

Vuilleumier, Laurent – Status of the Payerne BSRN Station

Wang, Ping – Shortwave Flux Profile Analysis for the Cabauw BSRN Site