Breakout Session Report
ARM/ASR User and PI Meeting
March 16-20, 2015

Session Title: Instrument and Measurement Focus Group for Broadband Radiometric Measurements
Session Date: Monday, March 16, 2015
Session Time: 7:30–9:00 p.m.
Summary Authors: Chuck Long

Description

The Instrument and Measurement Focus Group for Broadband Radiometric Measurements is chartered to address issues related to producing accurate, reliable, and continuous broadband radiation measurements for scientific use. This session focused on the implementation of longwave pyrgeometer calibrations for the ARM Climate Research Facility, progress on addressing noted radiometer ventilation issues, and weather issues detrimental to cold climate radiometry. In addition, discussions were held on suggestions for radiometry deployment for the new Southern Great Plains (SGP) and Oliktok Point configurations and new measurements and impacts.

Main Discussion

Pyrgeometer Calibrations and Reprocessing [ECR-00781]: Ibrahim Reda reported on the second ACP-IRIS comparison. Both designs are absolute longwave (LW) instruments intended to address the need for a world absolute standard for broadband LW radiation measurements. The agreement between the four participating instruments is to within +/- 1 Wm-2 for both the first and second comparisons, which suggests that a world standard may be possible in a number of years' time. Unfortunately, comparisons also show that the current World Infrared Standard Group (WISG) interim standard group of pyrgeometers exhibits an average 4 Wm-2 bias compared to the group of four absolute instruments.

Reports by National Renewable Energy Laboratory (NREL), and also Joe Michalsky, National Oceanic and Atmospheric Administration, show that precision infrared radiometer (PIR) calibrations are highly stable through the years. At the same time, analysis shows that the range of 2 Wm-2 differences (compared to using the 1-second samples) introduced by using the ARM stored 20-second instantaneous samples available to recalculate LW 1-minute averages (using new derived WISG-referenced coefficients in the 3-coefficient formula to be implemented) is significantly less than the uncertainty involved in using the current Albrecht and Cox 2-coefficient formula and the generic "4.0" case-dome temperature term coefficient ARM has used since the beginning.

Given the above, the Broadband Radiometric Measurements (BBRad Group) feels that a reprocessing of historical ARM PIR data is beneficial and warranted. However, the new formula coefficients that will be determined in the upcoming spring/summer calibration season will be based on the WISG and its known bias. This is a significant improvement over the current stored values, but still contains a bias that will not be replaced by a new world standard for several years at least yet. This situation produces a dilemma: Should we expend the time and effort to reprocess the historical PIR data now, significantly improving the accuracy of the measurements, but still containing a bias? Or should we wait for an unknown number of years yet before beginning reprocessing until an absolute world standard may become available, but then leaving the current large-uncertainty data as the only data available for research and publications in the intervening years?

It is the consensus opinion of the BBRad Group that the improvement in the upcoming calibration coefficient determination this year is a significant enough improvement that at least the data from each ARM site central facilities (SGP Central Facility, Barrow, Manus, Nauru, Darwin, and all ARM Mobile Facility (AMF) deployments) should be reprocessed to prevent the further use of the current larger uncertainty data by the user community. All other data, such as all the SGP extended facilities, have typically seen far less use, and could be covered by a "blanket data quality report (DQR)" that would be included in any and all requests for data from these non-reprocessed datastreams. (Of course, in the mean time for the sites that will be reprocessed, the same blanket DQR warning that the historical PIR data includes increased uncertainty due to the 2-coefficient formula with generic "4.0" case-dome temperature coefficient should also be sent out until the reprocessing of that site's data is accomplished.)

In the future when a new world absolute standard is agreed upon and available, a re-calibration can proceed to tie the ARM transfer standards to the new absolute world standard, and new coefficients for each PIR will be determined. At that time, certainly all the extended facilities, etc., data can be reprocessed, along with consideration for again reprocessing all the sites central facilities data.

It is further recommended that given the demonstrated stability of the PIR calibrations, a 3-year recalibration schedule seems adequate to maintain high-quality LW measurements.

Issues

Ventilator Issues [ECO-00991]: Chuck Long briefly presented a review of the issues related to ventilation that were the motivation for ECR-00991. These issues include:

- Directing air flow around the domes (i.e., plugging leaks).
- Assuring adequate unrestricted air flow into the fans
    - Including screening issues
- Switching to 12-volt direct current (DC) high-speed fans
- Daily operations checking.

Mark Kutchenreiter reported on the progress being led by the NREL group under ECR-00991. Several models of DC fans have undergone testing for suitability and a model has been chosen for purchase. These DC fans will be installed for use in the upcoming Broadband Outdoor Radiometer Calibrations (BORCAL) season, with DC fans being installed at each site as the newly calibrated units are swapped in.

A proposed design for replacing the current ventilator fan-mounted screens with a same-sized, but easily removable, foam screen coupled with a 5” diameter hole in the tracker mounting plate drew some lively discussion. Concern was expressed that these new foam screens would suffer the same issues of becoming restricted with build-up of contaminants as the current metal screens due to the small area of the screen with respect to the continuous (and soon to be increased with the 12 DC high CFM fans) air flow. These small fan-mounted screens are in all likelihood designed for indoor rather than outdoor use. As such, we

have the opportunity to increase the screen area to significantly better mitigate the screens getting plugged up by dust, plant matter, and insects, as well as riming and other cold climate effects. It seems logical to perform some investigation to see if increasing the hole on the tracker mounting plate up to the size of the opening in the bottom of the Eppley ventilator might not be feasible without unduly weakening the plate's ability to firmly support the instruments. Having the largest opening possible would be especially beneficial for the North Slope of Alaska (NSA) and AMF cold climate deployments in battling riming and snow deposition issues.

Given the concern that whatever design is implemented be as uniform as possible across the ARM Facility, and be the same in operations as when the instruments are calibrated, one suggested design seemed to best address the needs. The Tropical Western Pacific (TWP) has for many years operated by having removed the fan-mounted screens, and instead RTV'd screening across the opening in the bottom of the Eppley ventilator. This design gives the maximum possible screen area, with a good seal to keep critters out. The main drawback is that the screen needs to be cut out of the way in order to replace the fan, then a new piece of screen RTV'd in place. Instead, a removable screen attachment could easily be designed, giving the large-area benefit without the need-to-cut-away drawback. This screening design would also be the most universal, whether the instrument is mounted on the trackers mounting plate or separately as most of the global shortwave (SW) instruments are. Partnering with the largest feasible hole in the tracker mounting plate (noted above), or having the instrument mounted on a grated stand as in the NSA and TWP, and providing the least restricted air intake possible, this would ease screen inspection and cleaning.

The recommendation at this point is for further investigation and discussion within the current ECO-00991 in order to document the issues and final design decision before moving on with purchasing. The DC fan change-out for the upcoming year can still be implemented using the current fan-mounted screen arrangement, if need be.

With respect to the implementation of operational checks and maintenance as documented in addition to the Solar and Infrared Radiation Station (SIRS) handbook by the NREL personnel, representatives from each site were asked to report on their current status. In a few instances, it is yet unknown if all the changes have been implemented, but assurances were given that the current status would be determined and procedures update as warranted.

One area of concern regarding ventilated instruments that needs to be addressed is with respect to the downward-facing-tower mounted systems. The NSA, and in the case of cold climate AMF deployments, are the only ground radiometer systems that use ventilated (and heated) mounting in the downward-facing units. Currently, there is no uniformity in the design of the downward-facing ventilated paradigm, with each individual site having implemented their own design. It seems time to collaborate amongst these sites to compare experiences and work toward a most optimal design that can be uniformly implemented at the NSA sites and for the cold climate AMF deployments as warranted. Related to design issues are also questions of operational checking of heater and air flow performance given the manually intensive nature of lowering the towers, along with negative impacts of increased traffic on the surface underneath the towers we are trying to measure.

The recommendation is for the NSA and AMF folks to take the lead in collaborating on the cold climate ventilated ground radiometer system design and report back on progress and findings. [Need to identify a lead for this.]

Issues related to cold climate deployments: In a new subject area, Chuck Long introduced the group to the realm of adversity presented by operating in cold climate regimes. Drawing from a report given at the 2012 Baseline Surface Radiation Network (BSRN) Workshop (Potsdam, Germany. 1-3 August 2012) for the BSRN Cold Climate Issues Working Group, a number of examples of riming, snow buildup, frosting, and a few ideas for mitigating these adverse conditions were shown. Included in the presentation were the overarching results and recommendations stemming from the NSA Radiometer Intensive Operational Periods (IOP) activities which included increasing the ventilation air flow with 12V DC fans, and a modification of the heater coils design and placement inside the ventilators. In subsequent discussion, it was determined that these field campaign-generated suggestions have not yet been fully implemented at the NSA sites.

One possibility for mitigation is a new ventilator design, which could more effectively direct the ventilator air flow directly at and over the radiometer domes. The current, standard designs (e.g., Eppley and Kipp and Zonen) have the air blowing out in the spacing between the sun shield and the instrument at the edge of the sun-shield opening and depend on turbulence to have the air blowing over the dome surface. The resultant air flow is always weakest at the top of the dome in this paradigm, as has often been noted, and is one reason for the recommendation for increased CFM fans to create more turbulence over all the dome area. A far more directed flow design being tested by the group from the Alfred Wegener Institute for Polar and Marine Research in Germany for their Georg von Neumayer Antarctic site was shown. As reported at the 2012 BSRN Workshop, this new design, without additional heating, significantly reduced the occurrence of frost on the dome, though riming was still some problem. However, the design includes the possibility of adding heaters. Discussions by the group revealed that it seems other designs with directed air flow may now be available as well. Thus, the possibility of an NSA IOP aimed at testing this directed air flow idea seems prudent.

Part of the cold climate presentation showed that an internally heated, but non-ventilated, instrument has significant resistance to the cold adverse conditions. As reported in Matsui et al (2012) and by experience gained during the ARM Facility's Storm Peak Lab Cloud Property Validation Experiment (STORMVEX), the Delta-T Devices model SPN-1 total and diffuse SW radiometer has proven to be significantly resistant to riming, frost, and snow because of its internal temperature-controlled onboard heating. By the instrument's design, this heating does not produce an infrared loss effect on the measurements. The SPN-1 is not a secondary standard instrument by design (although it does meet class 1 standards), thus it is not suggested as a primary downwelling SW instrument even though it does produce reasonable measures of the total, diffuse, and (by subtraction) direct SW components. This capability affords an unprecedented possibility for direct comparison and quality control testing of the direct SW normal incidence pyrheliometer measurements, as well as the diffuse and global SW measurements. Currently only being able to compare the global (unshaded) SW to the sum of the direct and diffuse can reveal disagreements, but it does not reveal which of the three components might be the cause of the error. The SPN-1 affords the information needed to directly determine which of the three components

might be problematic. During STORMVEX, when the primary SW instruments were contaminated by frost/rime/snow contamination, then the frost/rime/snow-free SPN-1 measurements become the default "best-estimate" data for those times providing reasonable and scientifically usable measures of the SW components, whereas currently we can only mark them as "bad" data.

Needs

The suggestion was made that an engineering change request (ECR) be submitted to propose adding SPN-1 as official ARM instruments as backup and quality control instruments for all cold climate facilities (NSA and the AMFs). Chuck Long will work with Mark Ivey to draft an ECR.

These cold climate issues are a new topic for the BBRad Group. The brief presentation and brief discussion serves to introduce the group to the breadth of the subject area with the idea that we might work toward addressing these issues in future meetings. This is one area of concern to the community, especially given the recent increased focus on polar regions with respect to climate change. The ARM Facility and ASR program can take a significant lead on this area, which will not only directly benefit ARM cold climate measurement accuracy and continuity, but benefit the wider community as well.

Future Plans

New SGP Megasite Radiometry Recommendations: With time running out, a brief mention was made of whether the BBRad Group might want to devise any recommendations as input to the scheduled May workshop for the ARM Facility's SGP megasite design. Perhaps a recommendation on the density and accuracy of radiometer placement needed for an accurate assessment of the variability of surface fluxes within the proposed 25-30 km grid box, and also including the surrounding area, might be useful in the decision-making process. Joe Michalsky indicated that he had already forwarded some recommendation on instrumentation to Jim Mather, ARM Facility Technical Director, and others, and would forward a copy to BBRad members who are interested. It was noted that a brief 2-pager outlining thoughts on the utility of a logarithmic radial spacing design for the surface radiometry network to document variability had been submitted for consideration years ago during the last rearrangement of the SGP Extended Facility network. Though the idea wasn't acted upon back then, perhaps it might be more relevant to the current design paradigm.

Given the brief time between the ASR PI Meeting and the May SGP design meeting, it was decided that those interested in formulating any recommendations for consideration in May would communicate as warranted via email exchange and telecons to formulate a response.

Reference

Matsui, N., Long, C. N., Augustine, J., Halliwell, D., Uttal, T., Longenecker, D., Niebergall, O., Wendell, J., and Albee, R., 2012: "Evaluation of Arctic broadband surface radiation measurements," *Atmos. Meas. Tech.*, 5, 429-438, doi:10.5194/amt-5-429-2012.