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Traceable Pyrgeometer Calibrations

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Abstract: The Atmospheric Radiation Measurement (ARM) program provides high quality radiometric data from approximately 150 instruments deployed at Southern Great Plains (SGP), Eastern North Atlantic (ENA), North Slope of Alaska (NSA), Oliktok (OLI), and the ARM Mobile Facilities (AMF) sites. These instruments are deployed on the Solar Infrared Radiation Station (SIRS), SKYRAD, and GNDRAD instrument platforms. In addition to the operational radiometers, there are more than 200 other radiometers that are calibrated and used for instrument swaps and replacements. The National Renewable Energy Laboratory (NREL) and ARM, through the Radiometric Calibration Facility (RCF) at the Southern Great Plains (SGP) site, provides Broadband Outdoor Radiometer Calibrations (BORCAL) for all shortwave (SW) and longwave (LW) radiometers that are deployed by the ARM program. The BORCAL-SW is traceable to the International System of Units (SI), through the World Radiometric Reference (WRR). On the other hand, the SI standard is not yet established for longwave measurements. Both NREL and ARM continue to improve radiometric measurement through the introduction of new methods to reduce uncertainty in calibration and field measurements. A significant part of this effort is to establish the longwave traceability to SI units and deploy the BORCAL-LW using an interim World Infrared Standard Group (WISG) for traceability. Deployment of BORCAL-LW capability has been performed under ARM program ECO-00781, "Establish Pyrgeometer Calibrations Traceable to the WISG". The stated purpose of the ECO is to adopt the consensus WISG for calibrating pyrgeometers used by ARM for broadband longwave irradiance data collected from SIRS, SKYRAD, and GNDRAD instrument platforms. This poster presents the development, implementation, and operation of the LW-BORCAL system at the SGP RCF for the calibration of pyrgeometers that provide traceability to WISG.

Calibration Certificate from BORCAL 2016-02 for PIR 30133F3

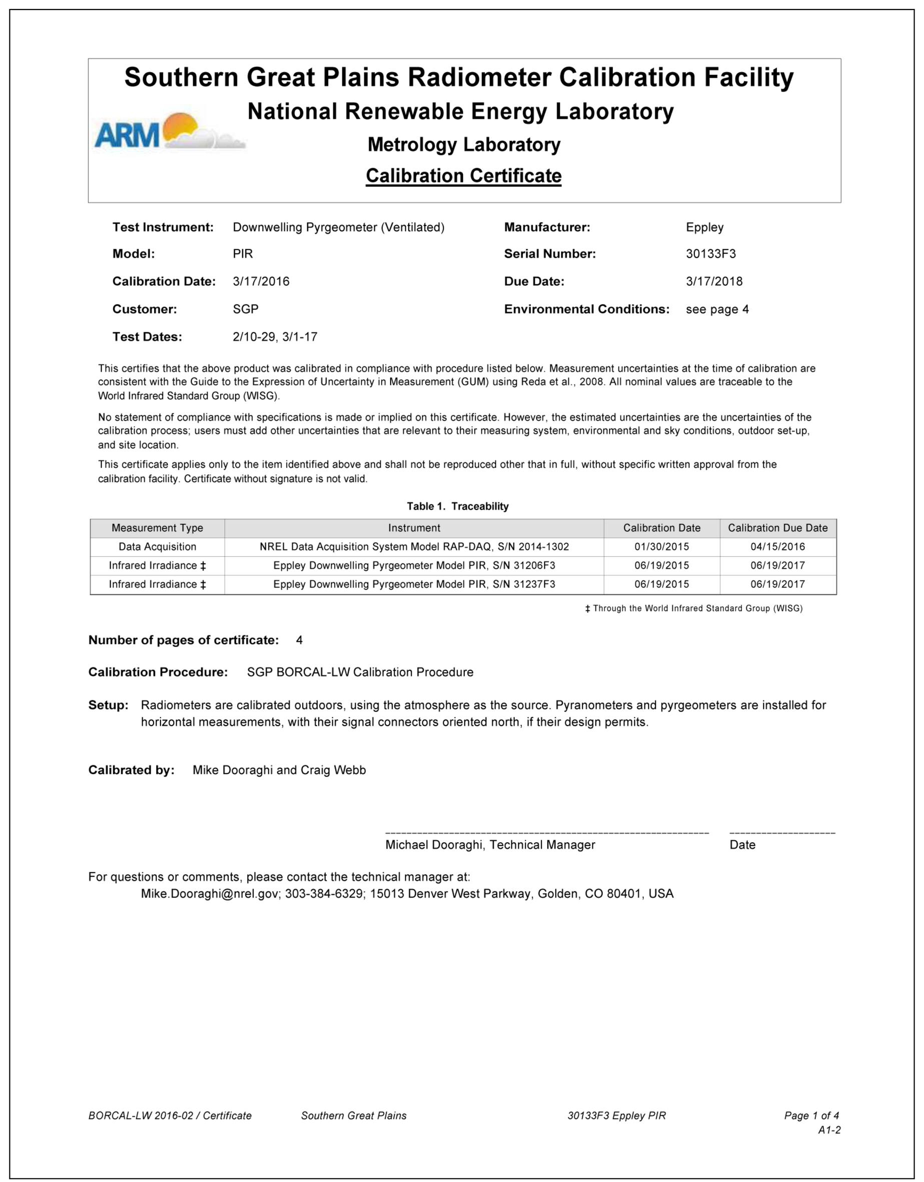
Southern Great Plains Radiometer Calibration Facility
National Renewable Energy Laboratory
Metrology Laboratory
Calibration Certificate

Figure 1. Page 1 of the calibration certificate contains the customer and pyrgeometer information. It also contains data acquisition and reference pyrgeometer tractability information along with the calibration procedure and the technical manager's signature.

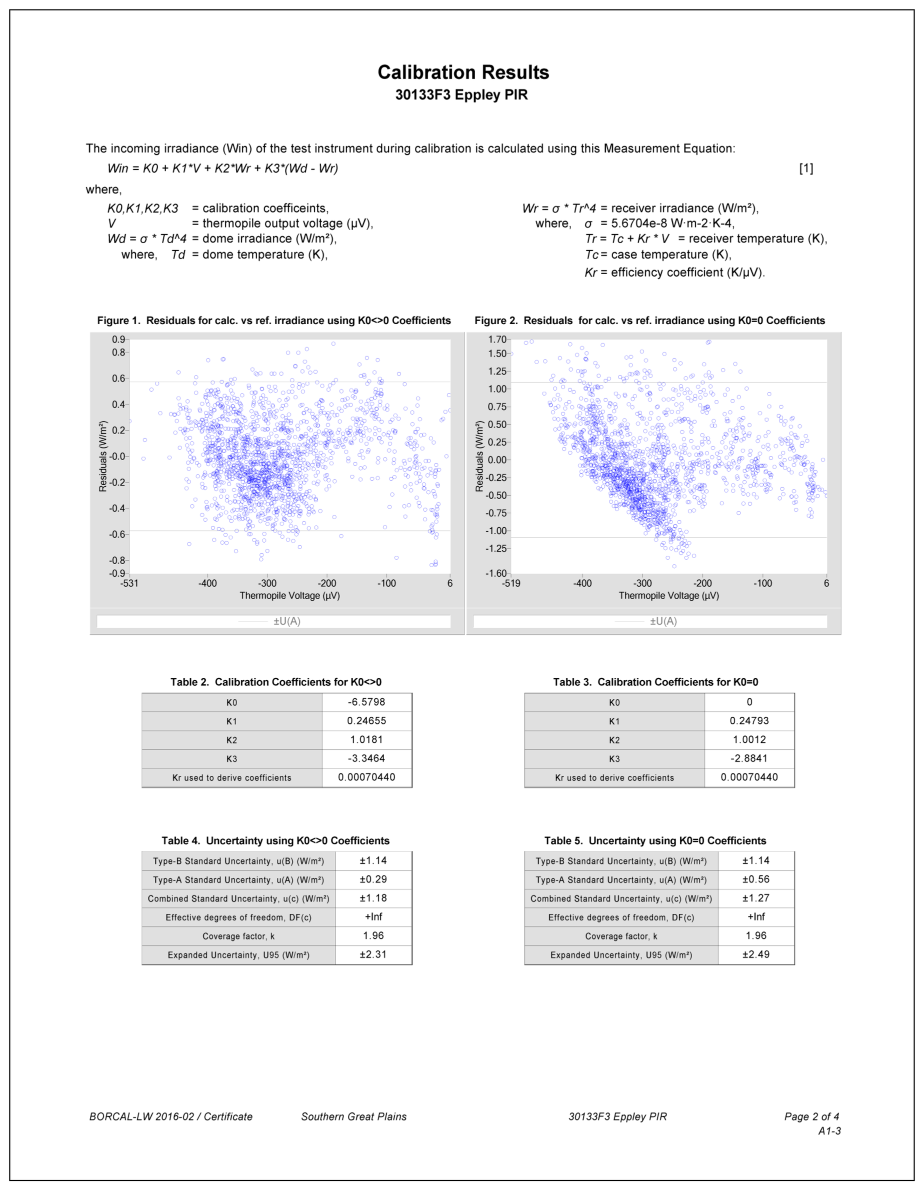
Calibration Results
30133F3 Eppley PIR

Figure 2. Page 2 of the calibration certificate contains the measurement equation with calibration coefficients and constants necessary to calculate the irradiance of the PIR to the sky. Page 2 also contains the residual graphs (as compared to the reference irradiance), calibration coefficients and uncertainty results for both k=0 and k <>0.

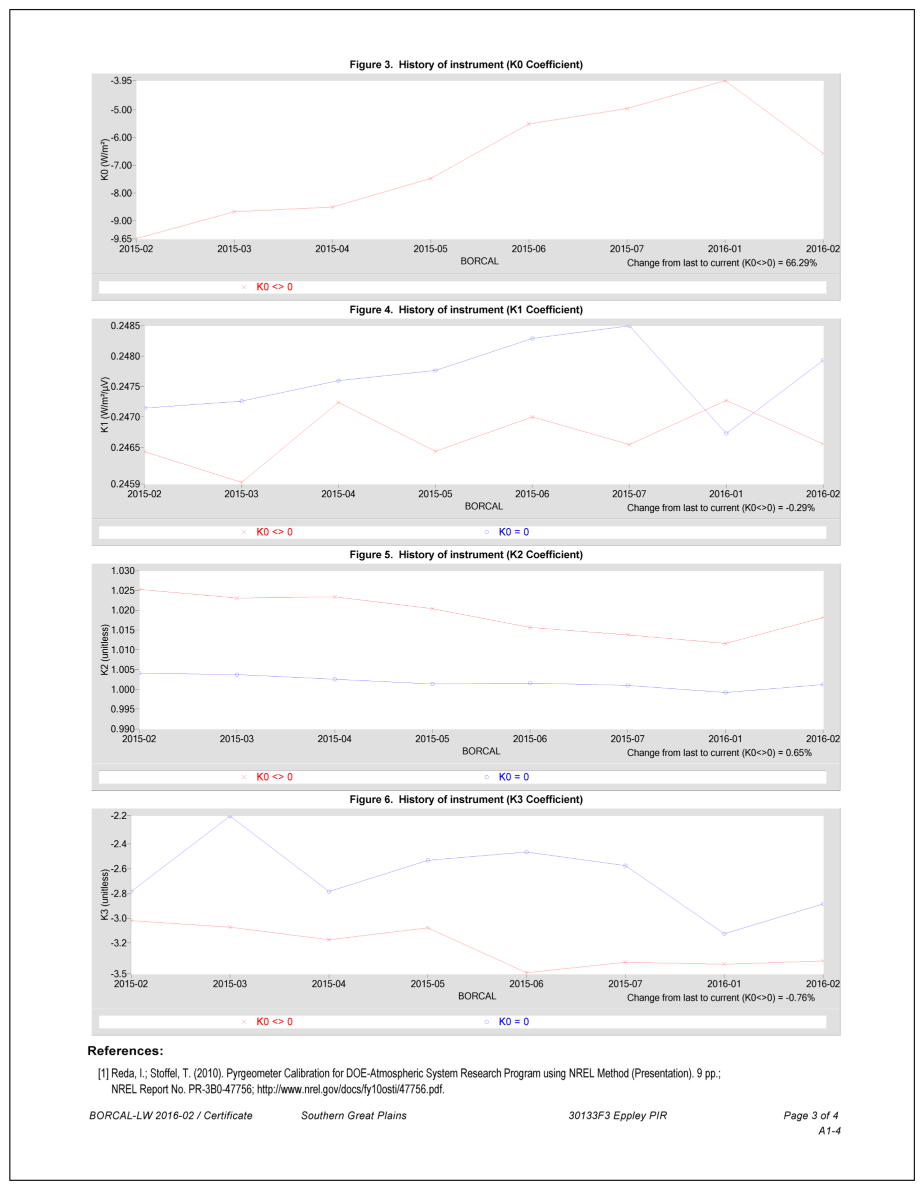

Figure 3. Page 3 of the calibration certificate contains the historical record of calibration coefficient results from BORCAL to BORCAL. The control and measurement assurance standard have been in each of the 8 calibrations so far and thus have 8 results each. The values shown on the left are for the measurement assurance standard instrument 30133F3. The red line represents the traceable coefficient results and the blue line represents coefficient results obtained when forcing the intercept through 0

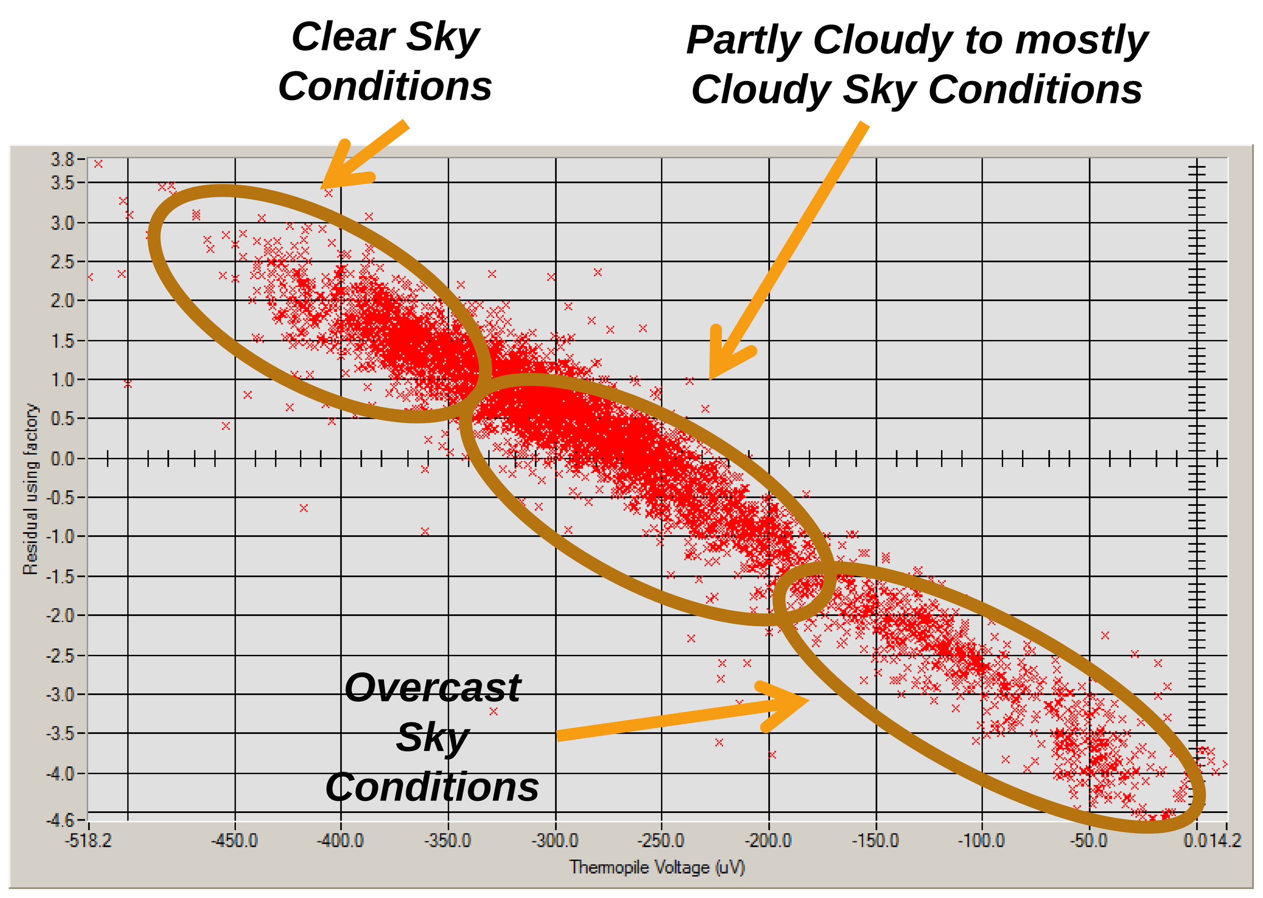

Figure 4. The LW BORCAL can be concluded once data has been collected under all sky conditions. This allows for calibration over the full voltage output range. The above graph shows the residuals in the between the reference irradiance and the instrument irradiance using the factory calibration.

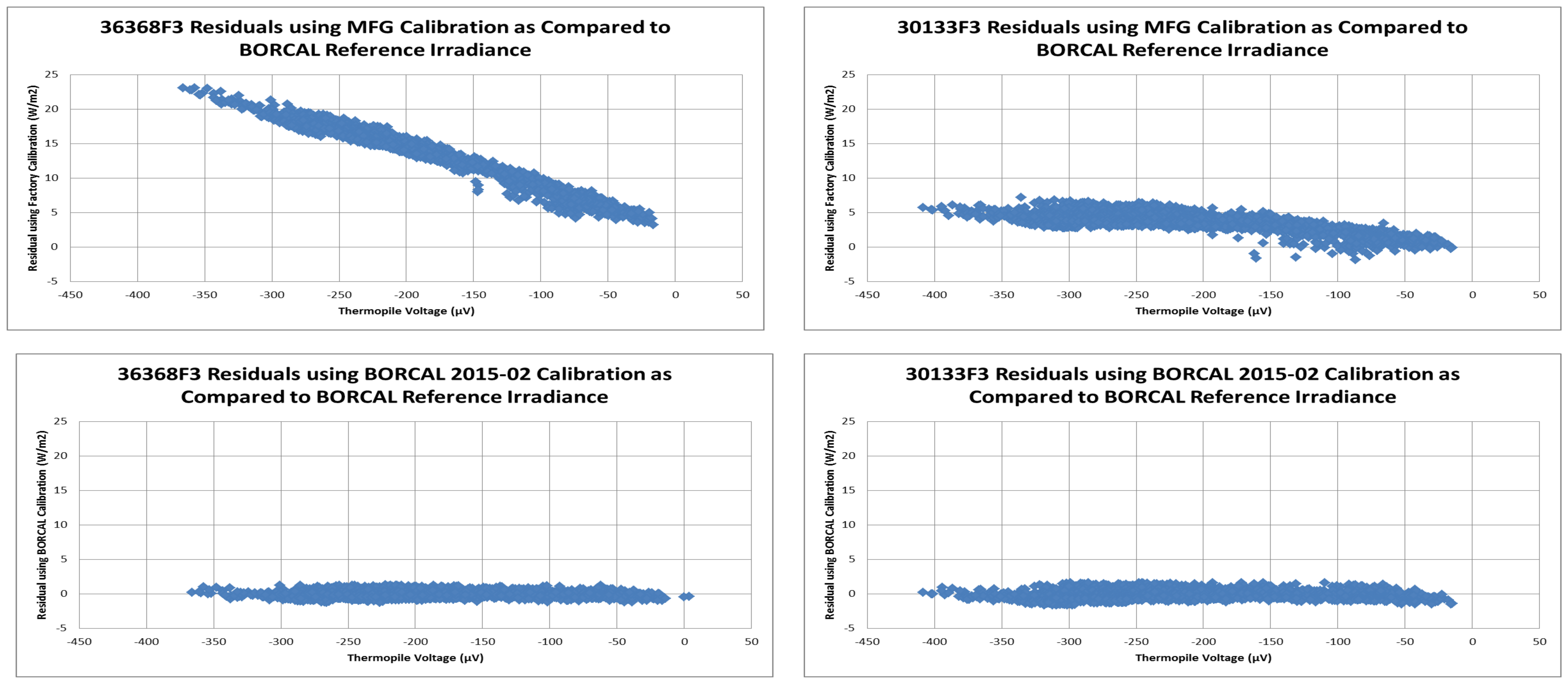

Figure 5. The residual in W/m^2 as compared to the reference instruments ranges from 3.2 to 23.1 for the control instrument (36368F3) and from -1.8 to 7.2 for the measurement assurance standard (30133F3) when using the manufacturer's calibration. The residual in W/m^2 as compared to the reference instruments ranges from -1.3 to 1.3 for the control instrument (36368F3) and from -1.6 to 1.6 for the measurement assurance standard (30133F3) when using the BORCAL-LW calibration.

Control Instrument History

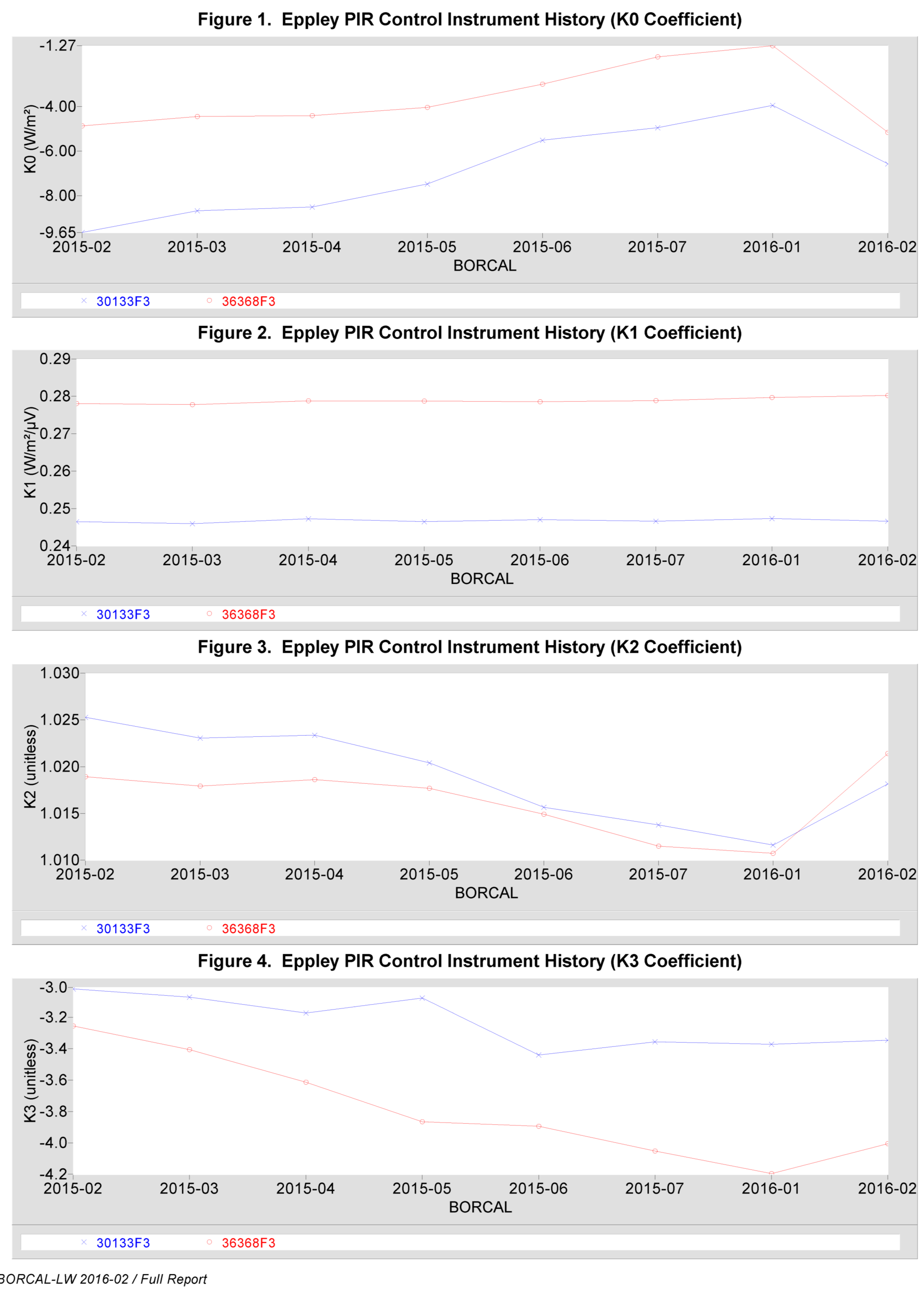

Figure 7. Results are from 8 LW BORCAL events for the control instrument (36368F3) and the Measurement Assurance Standard (30133F3) are shown above.

Figure 6. Craig Webb installing Pyrgeometers on one of the LW trackers at the SGP RCF.

Metrics for LW calibrations from July 2015 to March 2016

- **Total number of Instruments : 92**
- **Total individual Instruments : 81**
- **Total failed calibrations: 8 (Most of these were later linked to a failed channel)**
- **Average Uncertainty: ± 2.31 W/m2**
- **Highest Uncertainty: ± 2.59 W/m2**
- **Lowest Uncertainty: ± 2.26 W/m2**
- **Average number successful calibrations per session: 11.75**
- **Average length of time for BORCAL-LW to complete: 30.6 days**
- **Shortest BORCAL-LW event: 17 days**
- **Longest BORCAL-LW event: 44 days**
- **Current range of K0 values for all successfully calibrated instruments: -9.6467 to 4.0452**
- **Current range of K1 values for all successfully calibrated instruments: 0.2152 to 0.34601**
- **Current range of K2 values for all successfully calibrated instruments: 0.9929 to 1.0253**
- **Current range of K3 values for all successfully calibrated instruments: -5.1028 to 0.00087**

Documentation of the longwave and shortwave BORCAL processes conducted at SGP can be found here: http://www.nrel.gov/docs/fy15osti/65035.pdf
Documentation of the Radiometer Calibration and Characterization (RCC) software can be found here: http://www.nrel.gov/docs/fy16osti/65844.pdf

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(If needed, use this space to credit NREL Center and/or DOE program that supported the work.)

Conference Title
Conference Location - city, state
Conference Dates
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