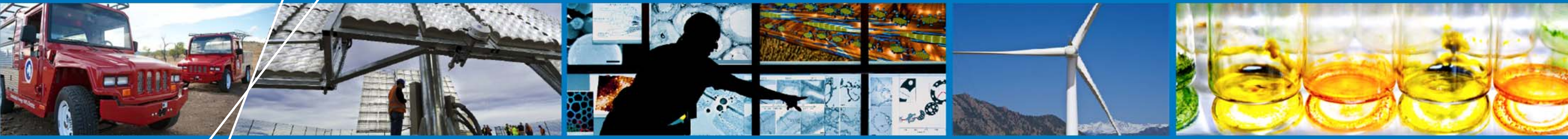
Results of first outdoor comparison between Absolute Cavity Pyrgeometer (ACP) and Infrared Integrating Sphere (IRIS) Radiometer at PMOD



Atmospheric System Research

Science Team Meeting (March 18-21, 2013)

by

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*** = NREL , ** = PMOD/WRC**

NREL/PR-3B10-58121

Outline

The ACP and IRIS are developed to establish a world reference for calibrating pyrgeometers with traceability to SI units. The two radiometers are unwindowed with negligible spectral dependence, and traceable to SI units through the temperature scale (ITS-90).

The first outdoor comparison between the two designs was held from January 28 to February 8, 2013 at the Physikalisch-Metorologisches Observatorium Davos (PMOD). The difference between the irradiance measured by ACP and that of IRIS was within 1 W/m^2.

A difference of 5 W/m2 was observed between the irradiance measured by ACP&IRIS and that of the interim World Infrared Standard Group (WISG).

Absolute Cavity Pyrgeometer (ACP)

- ACP Net irradiance:

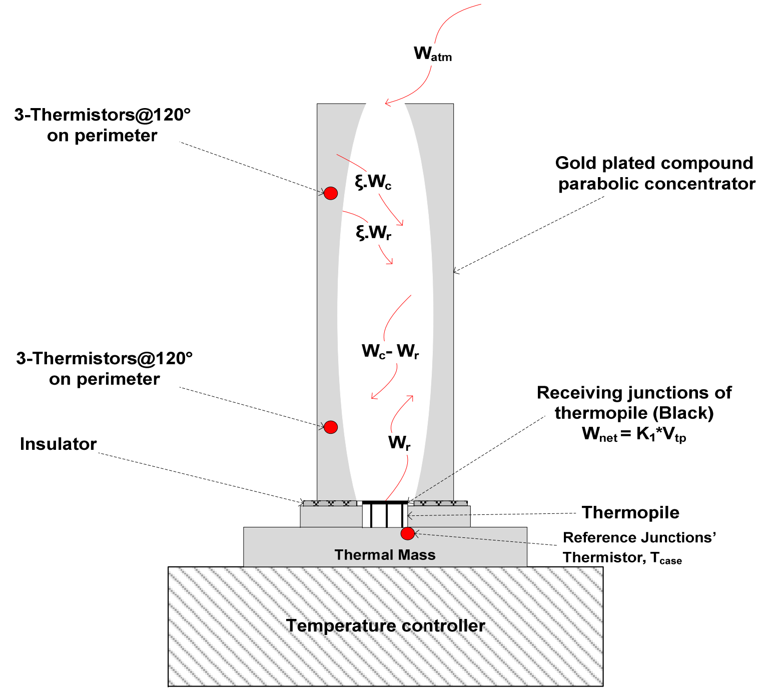
$$K_1 * V_{tp} = \tau * W_{atm} + (1+\varepsilon) * W_c - (2-\varepsilon) * K_2 * W_r$$

- By cooling the ACP case temperature, and since W_{atm} is stable, then,

$$K_1 = \frac{(1+\varepsilon) * \Delta W_c - (2-\varepsilon) * K_2 * \Delta W_r}{\Delta V_{tp}}$$

- Then the atmospheric longwave irradiance is,

$$W_{atm} = \frac{K_1 * V_{tp} + (2-\varepsilon) * K_2 * W_r - (1+\varepsilon) * W_c}{\tau}$$

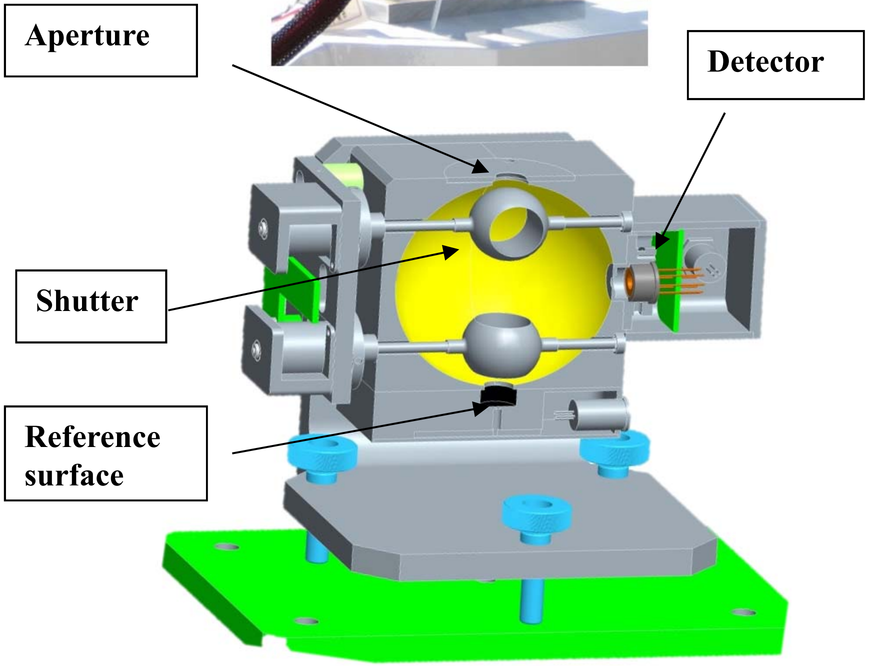


Where,

K_1, V_{tp}, ϵ , K_2, W_r , W_c and τ are the reciprocal of ACP's responsivity, thermopile voltage, gold emittance, detector's emittance, receiver irradiance, CPC irradiance, and throughput (NIST characterization), consecutively.

Reference: Reda, I.; Zeng, J.; Schulch, J.; Hanssen, L.; Wilthen, B.; Myers, D.; Stoffel, T. Dec. 2011. "An absolute cavity pyrgeometer to measure the absolute outdoor longwave irradiance with traceability to International System of Units, SI". Journal of Atmospheric and Solar-Terrestrial Physics, 77 (2012) 132-143. http://dx.doi.org/10.1016/j.jastp.2011.12.011

The Infrared Integrating Sphere (IRIS) Radiometer



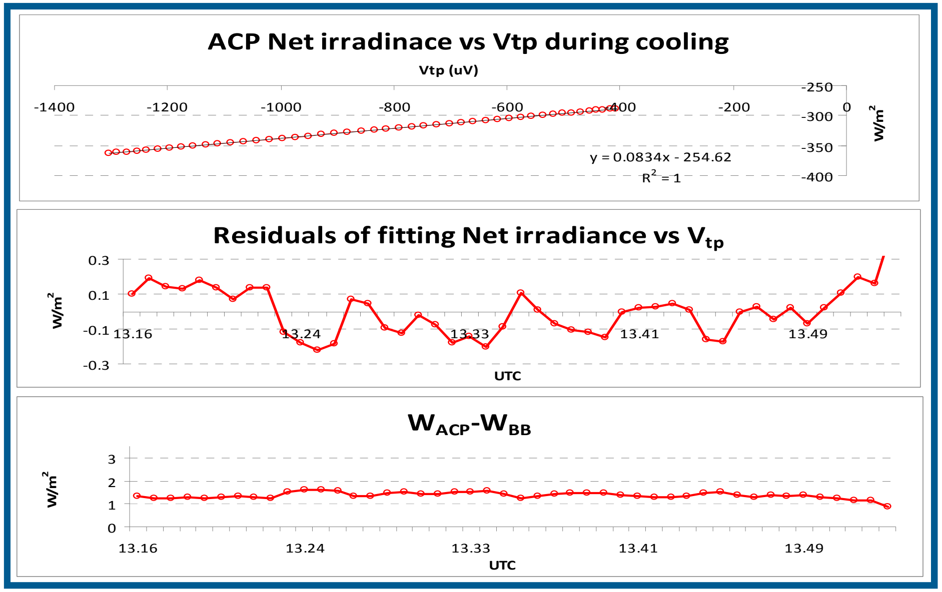
Key features of the IRIS Radiometer

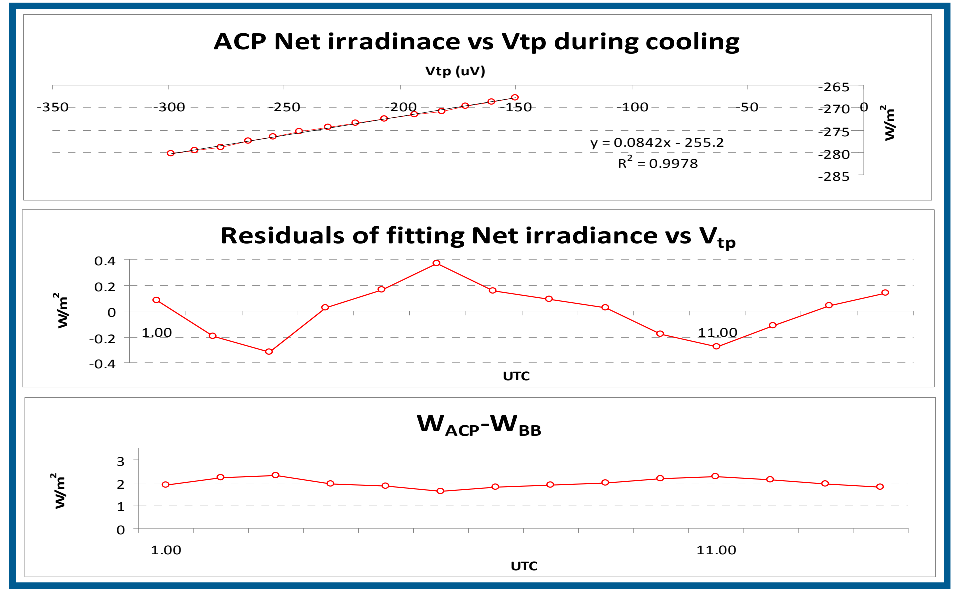
- Windowless
- Irradiance measurement by using a 60 mm gold-plated integrating sphere as input optic
- High sensitivity from a windowless pyroelectric detector
- Flat spectral response
- Measurement frequency 0.1 Hz
- Automatic unattended operation
- Nighttime measurements only

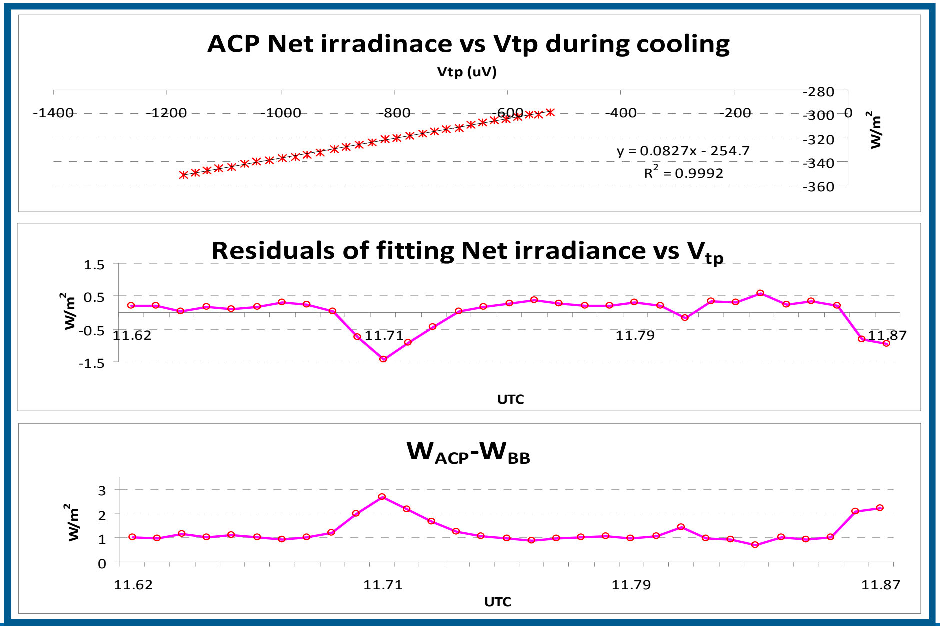
IRIS Uncertainty
U95%= 1.8 Wm^{-2} summer (+15°C)
2.4 Wm^{-2} winter (-15°C)

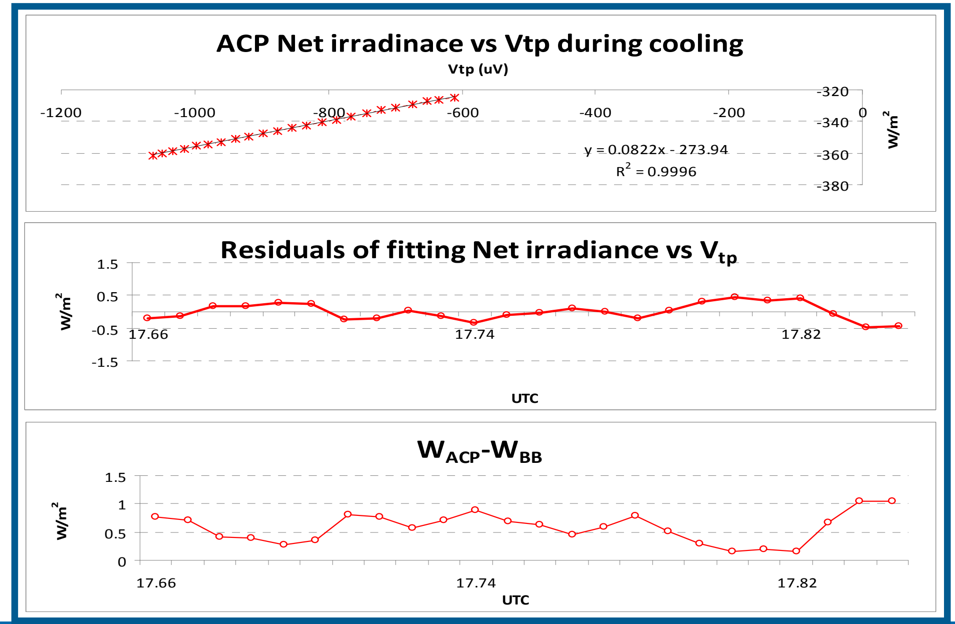
Reference: Gröbner, J., A Transfer Standard Radiometer for atmospheric longwave irradiance measurements, Metrologia, 49, S105-S111,2012.

ACP versus PMOD-BB on Jan 29 to Feb 2, 2013

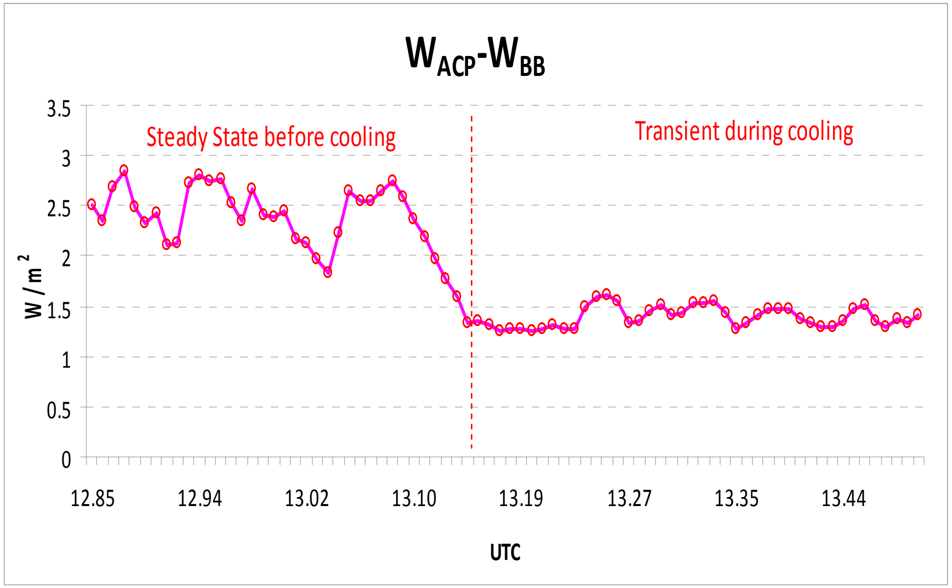


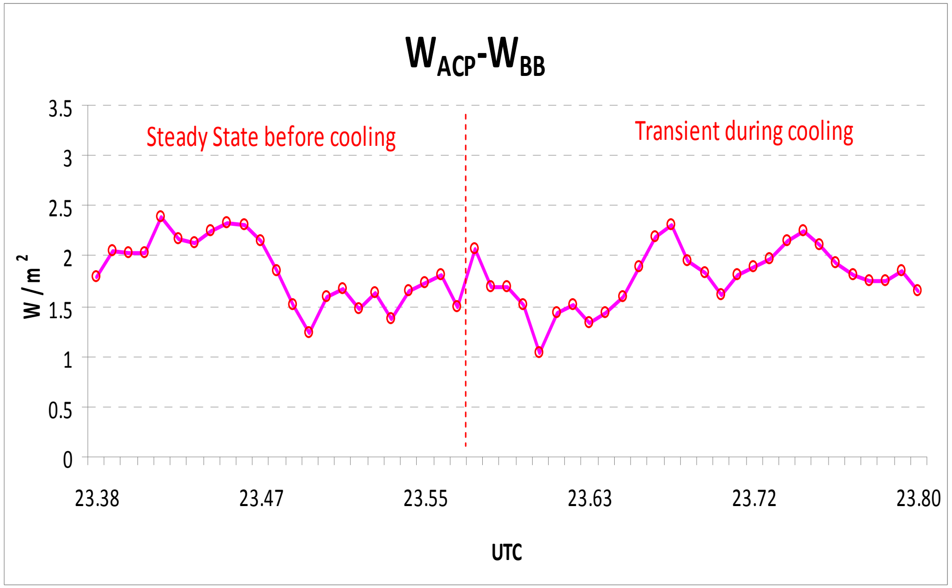


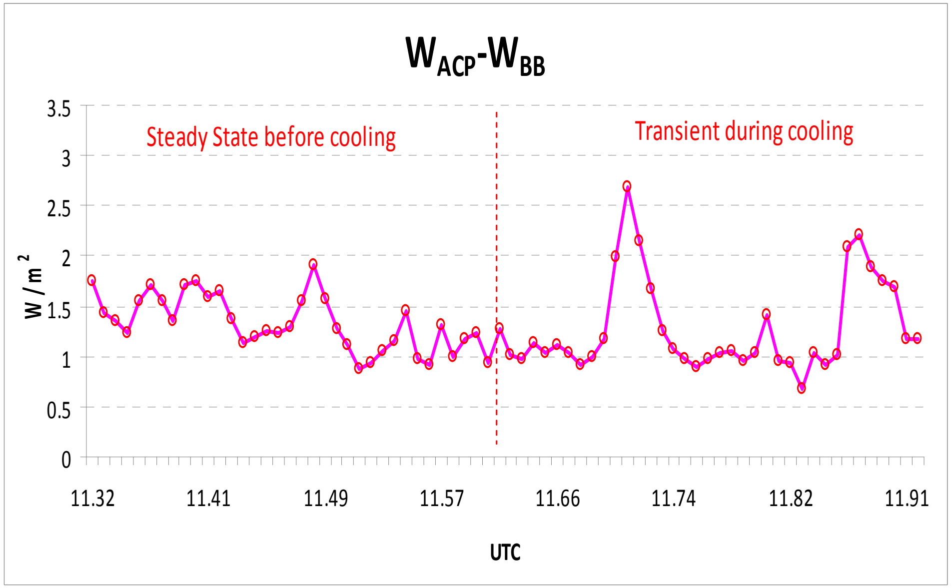


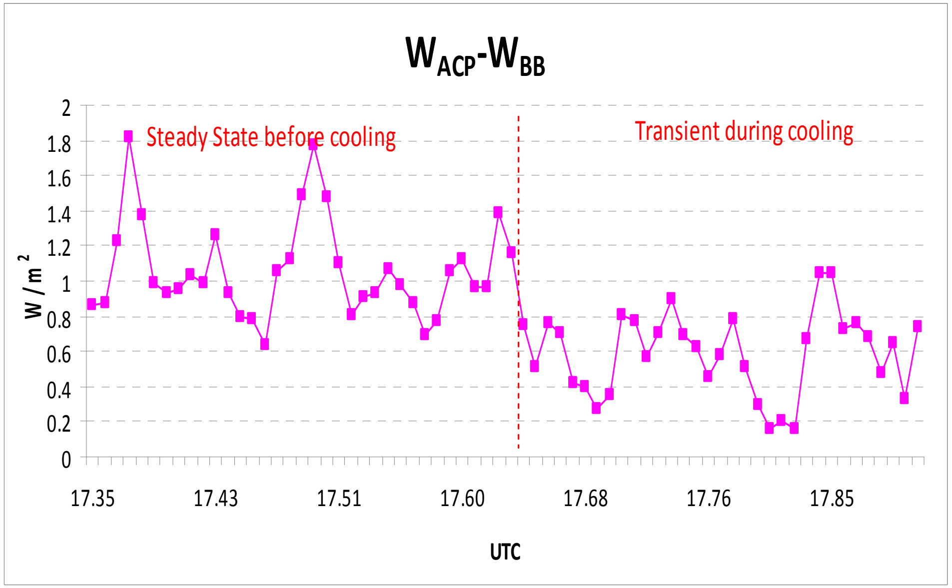


Transient vs steady state in BB, Jan 29-Feb 2, 2013









Outdoor ACP&IRIS at night Feb. 5, 2013

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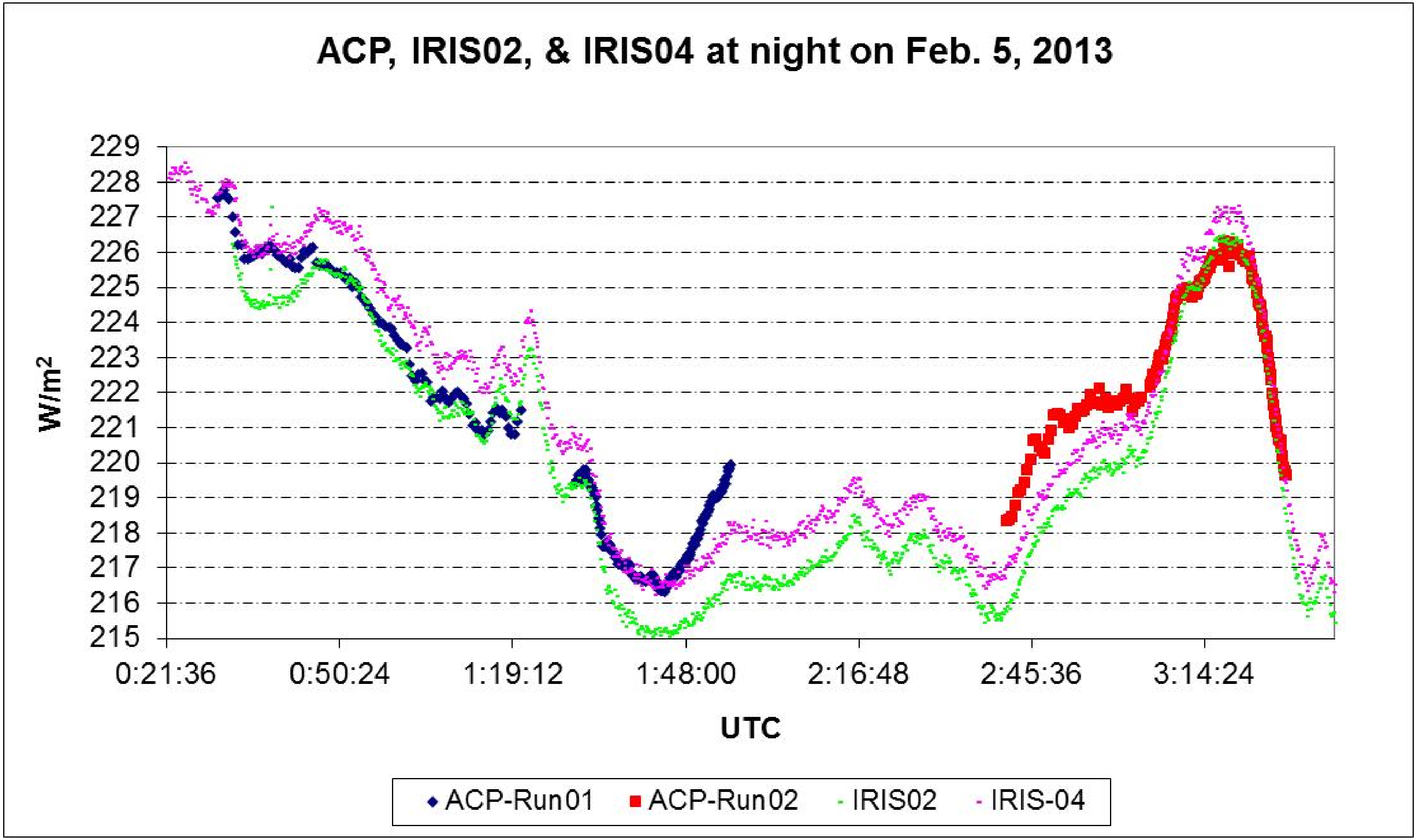
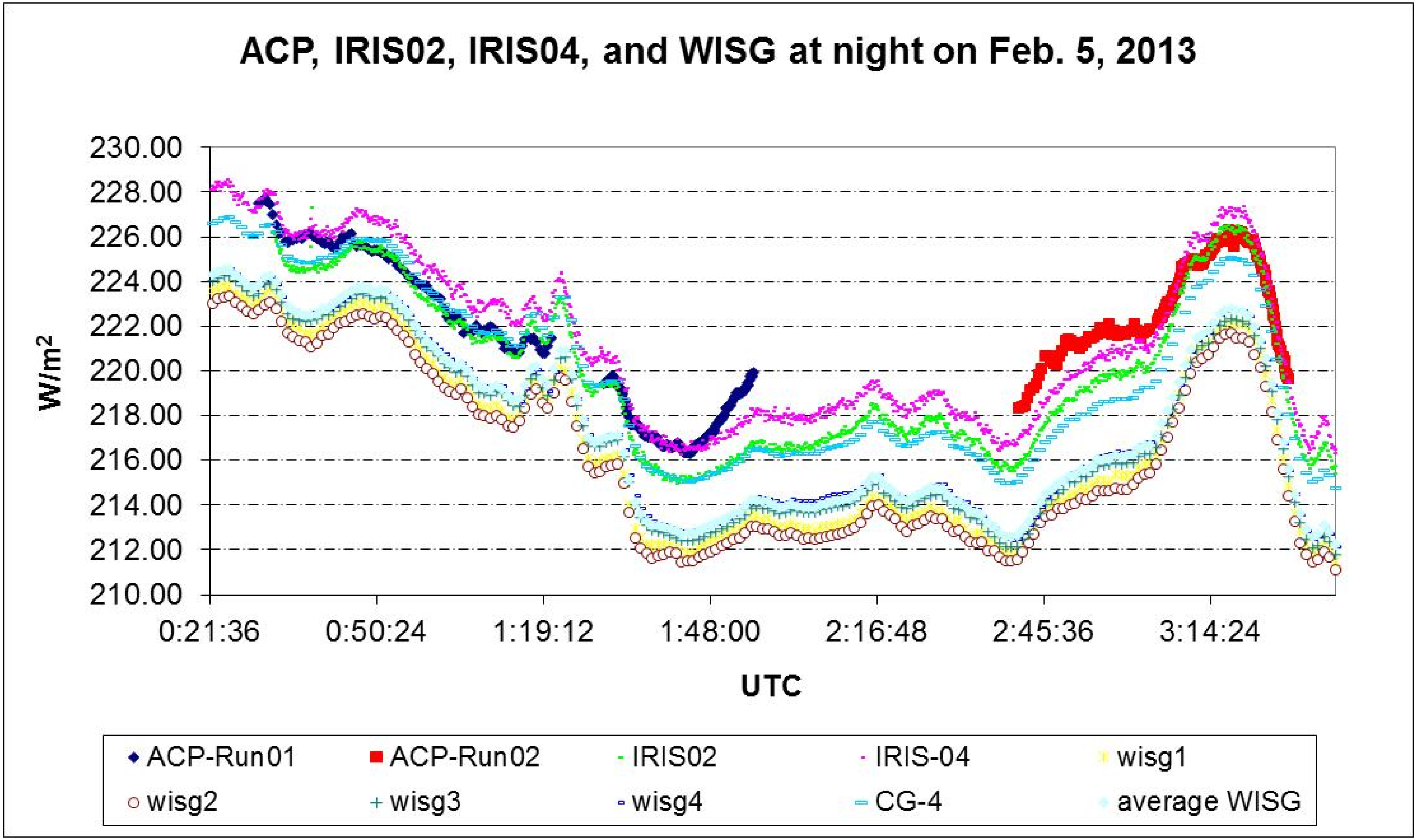


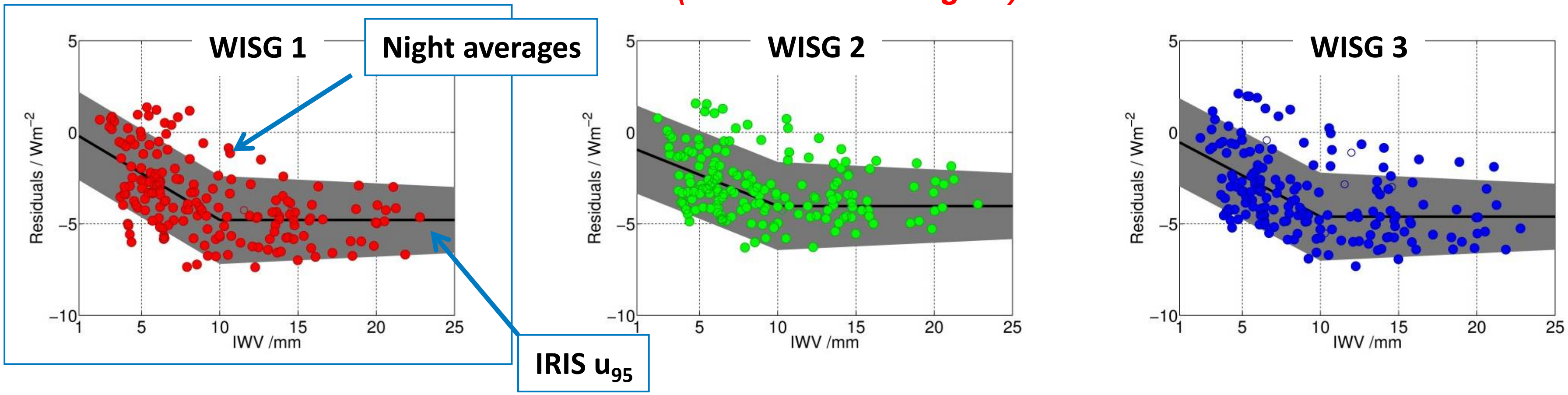
Outdoor ACP, IRIS & WISG at night Feb. 5, 2013

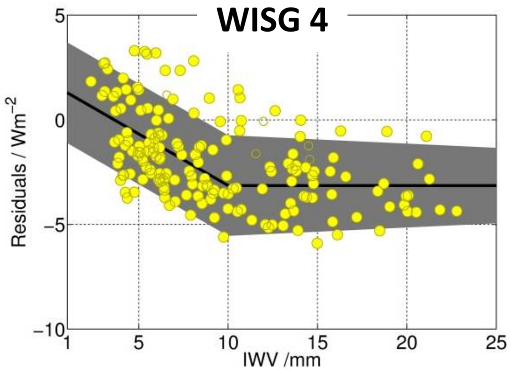


Irradiance difference (WISG minus IRIS) at PMOD

From Julian's presentation, IRS2012-Germany

(Data from 180 nights)





Results

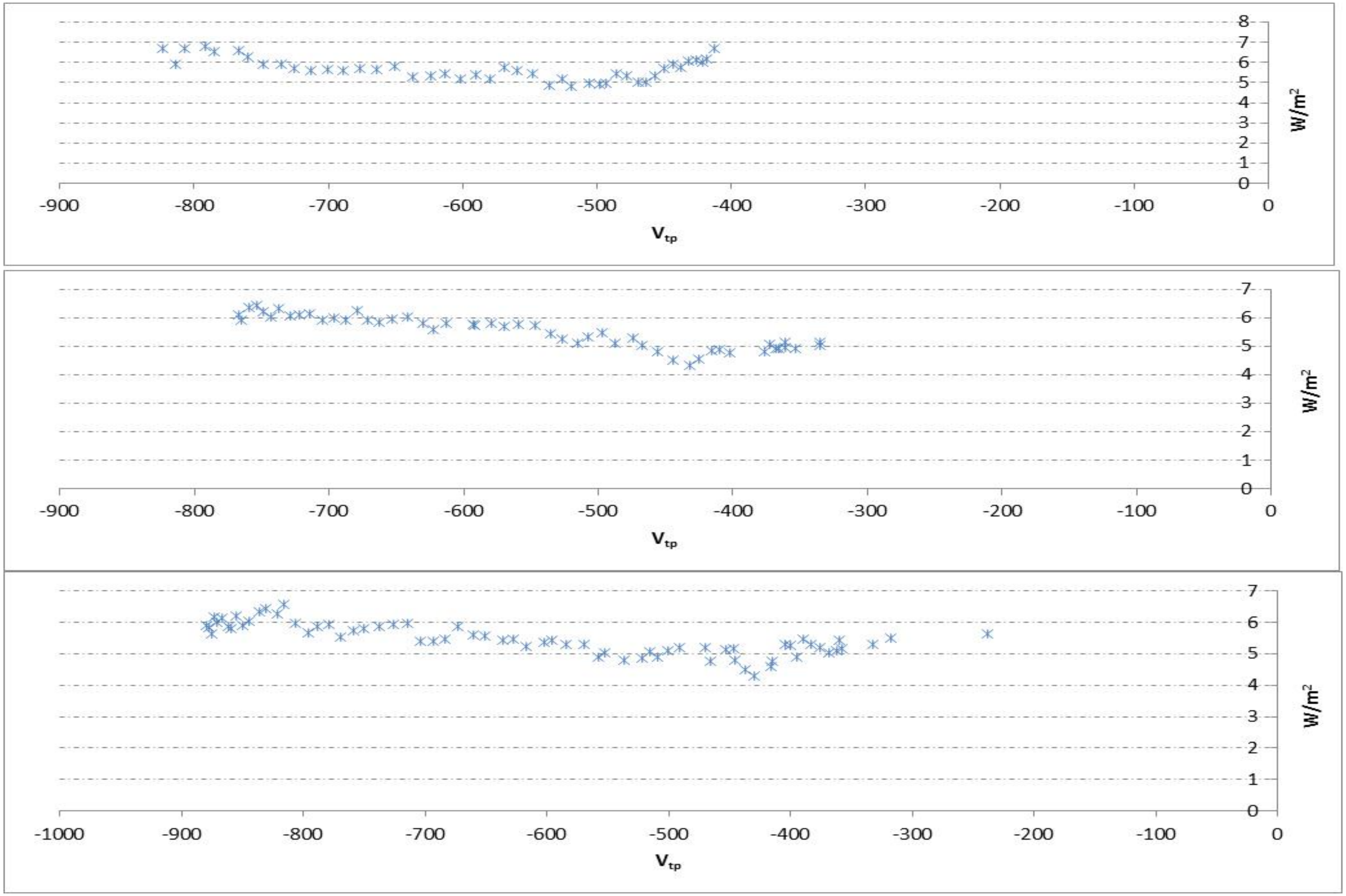
Average Offset (IWV>10) **-4.1 ± 1.5 Wm^{-2}**

Gradient (IWV<10) **-0.45 ± 0.1 Wm^{-2}mm^{-1}$_{IWV}$**

Irradiance difference (ACP minus WISG) at NREL

Three cooling cycles on November 18 and 21, 2012 with 40% RH at SRRL
Consistent with Julian's observation with high water vapor*

* Algebra is reversed for consistency with NREL's historical files



Preliminary Conclusions

- **Special set-up of ACP in BB due to unknown gradient in CPC**
- **Outdoor agreement between ACP & IRIS to within 1 W/m^2**
- **Irradiance measured by WISG is ~4 W/m^2 lower than that measured by ACP&IRIS. Is Consistent with a Water Vapor Column of 8 mm. This was also observed at NREL/SRRL at RH = 40% (on November 18, 2012 at NREL/SRRL: Water Vapor Column from 7 mm to 9 mm during cooling cycles)**
- **Future comparison with higher/lower water vapor to resolve observed spectral effect on outdoor pyrgeometer calibrations**
- **A 3rd design might increase confidence in establishing a consensus reference with traceability to SI units.**