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
Ibrahim Reda*, Julian Gröbner**, Stefan Wacker**, and Tom Stoffel*

* = NREL, ** = PMOD/WRC

NREL/PR-3B10-58121
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 Physikalisches-Meteorologisches Observatorium Davos (PMOD). The difference between the irradiance measured by ACP and that of IRIS was within 1 W/m².

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

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)

ACP versus PMOD-BB on Jan 29 to Feb 2, 2013
Transient vs steady state in BB, Jan 29-Feb 2, 2013

\[ W_{ACP-WBB} \]

- Steady State before cooling
- Transient during cooling
Outdoor ACP&IRIS at night Feb. 5, 2013
Outdoor ACP&IRIS at night Feb. 5, 2013

ACP, IRIS02, & IRIS04 at night on Feb. 5, 2013

UTC

W/m²


ACP-Run01 ACP-Run02 IRIS02 IRIS-04
Outdoor ACP, IRIS & WISG at night Feb. 5, 2013

ACP, IRIS02, IRIS04, and WISG at night on Feb. 5, 2013

UTC

W/m²

ACP-Run01 ACP-Run02 IRIS02 IRIS-04 wisg1
wisg2 wisg3 wisg4 CG-4 average WISG
Irradiance difference (WISG minus IRIS) at PMOD

From Julian’s presentation, IRS2012-Germany

(Data from 180 nights)

Results

Average Offset \((\text{IWV}>10)\) \(-4.1 \pm 1.5 \ \text{Wm}^{-2}\)

Gradient \((\text{IWV}<10)\) \(-0.45 \pm 0.1 \ \text{Wm}^{-2}\text{mm}^{-1} \ \text{IWV}\)
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/m²
• Irradiance measured by WISG is ~4 W/m² 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.