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Results of Absolute Cavity Pyrgeometer and Infrared Integrating Sphere Comparisons

Ibrahim Reda,[1] Julian Gröbner,[2] Mike Dooraghi,[1] Christian Thomann,[2] Chuck Long,[3] Allison McComiskey,[3] Manajit Sengupta,[1] Emiel Hall,[3] and Stefan Wacker[4]

1. National Renewable Energy Laboratory (NREL) 2. Physikalisch-Meteorologisches Observatorium Davos (PMOD) 3. National Oceanic and Atmospheric Administration (NOAA) 4. Deutscher Wetterdienst (German Meteorological Service)

Abstract

Accurate and traceable atmospheric longwave irradiance measurements are required for understanding radiative impacts on the Earth's energy budget. The standard to which pyrgeometers are traceable is the interim World Infrared Standard Group (WISG), maintained in the Physikalisch-Meteorologisches Observatorium Davos (PMOD). The WISG consists of four pyrgeometers that were calibrated using Rolf Philipona's Absolute Sky-scanning Radiometer [1]. The Atmospheric Radiation Measurement (ARM) facility has recently adopted the WISG to maintain the traceability of the calibrations of all Eppley precision infrared radiometer (PIR) pyrgeometers. Subsequently, Julian Gröbner [2] developed the infrared interferometer spectrometer and radiometer (IRIS) radiometer, and Ibrahim Reda [3] developed the absolute cavity pyrgeometer (ACP). The ACP and IRIS were developed to establish a world reference for calibrating pyrgeometers with traceability to the International System of Units (SI). The two radiometers are unwindowed with negligible spectral dependence, and they are traceable to SI units through the temperature scale (ITS-90). The two instruments were compared directly to the WISG three times at PMOD and twice at the Southern Great Plains (SGP) facility to WISG-traceable pyrgeometers. The ACP and IRIS agreed within +/- 1 W/m^2 to +/- 3 W/m^2 in all comparisons, whereas the WISG references exhibit a 2–5 Wm^2 low bias compared to the ACP/IRIS average, depending on the water vapor column, as noted in Gröbner et al. [4]. Consequently, a case for changing the current WISG has been made by Gröbner and Reda. However, during the five comparisons the column water vapor exceeded 8 mm. Therefore, it is recommended that more ACP and IRIS comparisons should be held under different environmental conditions and water vapor column content to better establish the traceability of these instruments to SI with established uncertainty.

Conclusion

The difference between the irradiance measured by the ACP and the IRIS varied from 0.2 W/m^2 to 2.5 W/m^2 based on the atmospheric conditions, which is within the stated uncertainties of the ACP and IRIS (±3 W/m^2).

The irradiances measured by the average WISG references are less than the average irradiance measured by the ACP and IRIS, varying from 4.4 W/m^2 to 6.6 W/m^2 less, depending on the integrated water vapor, which is in agreement with Gröbner [5].

References

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2. J. Gröbner, "A Transfer Standard Radiometer for Atmospheric Longwave Rrradiance Measurements," *Metrologia* 49 (2012): S105-S111.

3. I. Reda, J. Zeng, J. Schulch, L. Hanssen, B. Wilthen, D. Myers, and T. Stoffel, "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.

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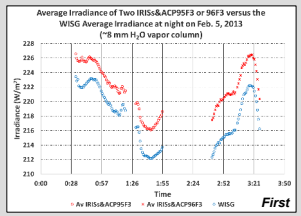
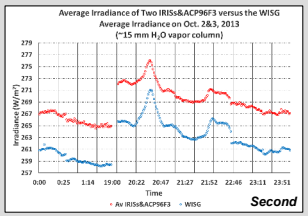
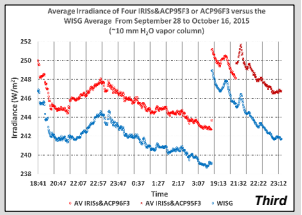
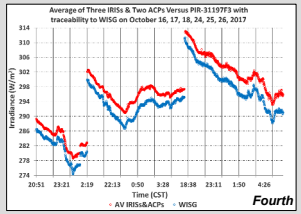
5. J. Gröbner and S. Wacker, "Longwave Irradiance Measurements Using IRIS Radiometers at the PMOD/WRC-IRS," *AIP Conference Proceedings* 1531, no. 488 (2013), doi:10.1063/1.4804813.

Results from Five Campaigns

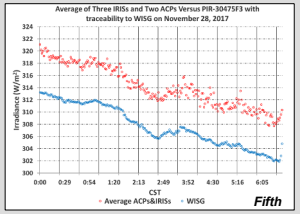






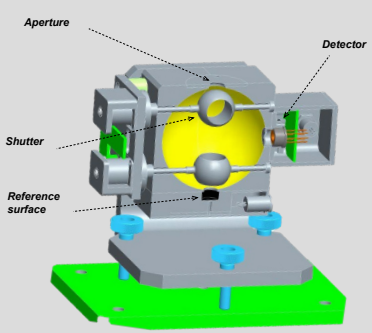


Summary Statitics for Five Comparison Campaigns	Campaign				
	First	Second	Third	Fourth	Fifth
Average Difference (ACPs - IRISs) (W/m2)	0.10	0.31	-1.17	-1.58	-1.77
StDev of Difference	0.08	0.65	0.70	1.15	0.88
Difference within 95%	0.19	1.34	1.82	2.79	2.50
Average Difference (ACPs & IRISs - WISG) (W/m2)	-3.93	-6.14	-3.82	-3.50	-6.50
StDev of Difference	-0.97	-0.76	-0.67	-0.81	-0.66
Difference within 95%	4.38	6.33	4.05	3.86	6.63

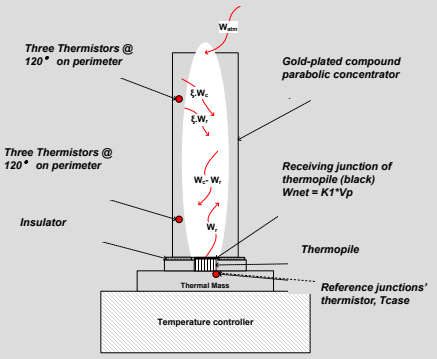


Instrument Description and Characteristics

Infrared Integrating Sphere (IRIS)



Absolute Cavity Radiometer (ACP)



- *Automatic unattended operation*
- *Unwindowed*
- *Traceable to SI units through the temperature scale (ITS-90)*
- *Nighttime measurements only*
- *Negligible spectral dependence*

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