Establishing the World Reference for Measuring the Atmospheric Longwave Irradiance with Traceability to the International System of Units

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ABSTRACT

Advancing climate change research requires accurate and traceable measurement of atmospheric longwave irradiance. Measurement capabilities are limited to an estimated uncertainty of larger than ±6 W/m^2 using the interim World Infrared Standard Group (WISG). Two independently designed and calibrated absolute radiometers measuring downwelling longwave irradiance were compared during five outdoor comparisons in 2013, 2015, and 2017 at the Physikalisch Meteorologisches Observatorium Davos–World Radiation Center (PMOD/WRC) and the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement program (ARM) in the Southern Great Planes (SGP). Two Absolute Cavity Pyrgeometers (ACPs) developed by the National Renewable Energy Laboratory (NREL) and four Integrating Sphere Infrared Radiometers (IRISs) developed by PMOD/WRC took part in these intercomparisons.

From the five comparisons, the difference between the irradiance measured by ACPs and IRISs varied from 0.2 W/m^2 to 2.5 W/m^2 based on atmospheric conditions, which is within the combined stated uncertainties of ±3 W/m^2. The irradiance measured by the WISG is lower than the average irradiance measured by ACPs and IRISs. The magnitude of difference varied from 0.2 W/m^2 to 6.6 W/m^2 depending on the integrated water vapor. A concerted effort to establish a world reference for measuring the atmospheric longwave irradiance with lower uncertainty and with traceability to the International System of Units (SI) by using the ACPs and IRISs as the reference started at the World Meteorological Organization (WMO). The Commission for Instruments and Methods of Observation Commission (CIMO) Task Team on Radiation References (TT) meeting was held in 2017 at the National Physical Laboratory (NPL), in Teddington, United Kingdom to discuss specific recommendations on the traceability of atmospheric longwave irradiance to the SI.

OVERVIEW

- Results presented on five comparisons between ACPs and IRISs.
- Difference between longwave irradiance measured by ACPs and IRISs versus irradiance measured by WISG.
- Longwave irradiance measured by ACPs, IRISs, and Atmospheric Emitted Radiance Interferometer (AERI) versus irradiance measured by WISG.
- Recommend establishing world reference for measuring atmospheric longwave irradiance with traceability to SI.

Results of First Comparison between ACPs and IRISs–Davos

Average Irradiance of Two IRISs and ACP95F3 or 96F3 Versus the WISG
Average Irradiance at Night on Feb. 5, 2013 (~8 mm H2O vapor column)

October 18, 2017

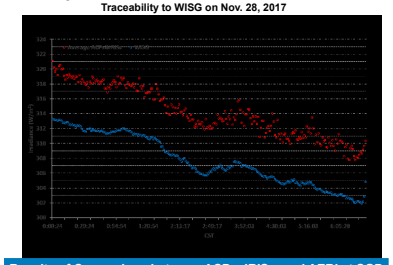
Results of Second Comparison between ACPs and IRISs–Davos

Average Irradiance of Two IRISs and ACP96F3 versus the WISG
Average Irradiance on Oct. 2 and 3, 2013 (~15 mm H2O vapor column)

October 24, 2017

Results of Fifth Comparison between ACPs and IRISs-SGP–Phase 2

Average of Three IRISs and Two ACPs Versus PIR-30475F3 with Traceability to WISG on Nov. 28, 2017



Results of Comparison between ACPs, IRISs, and AERI at SGP

October 26, 2017

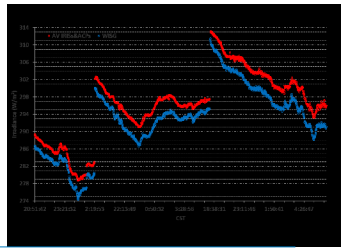
Results of Third Comparison between ACPs and IRISs–Davos

Average Irradiance of Four IRISs and ACP95F3 or ACP96F3 Versus WISG
Average from Sept. 28, 2015 to Oct. 16, 2015 (~10 mm H2O vapor column)

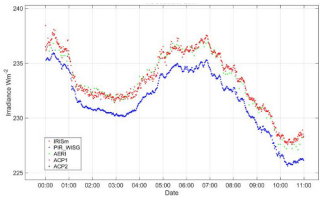
November 28, 2017

Results of Fourth Comparison between ACPs and IRISs-SGP–Phase 1

Average of Three IRISs and Two ACPs Versus PIR-31197F3 with Traceability to WISG on Oct. 16, 17, 18, 24, 25, 26, 2017



December 6, 2017



Summary of the Five Comparisons

W/m^2	First	Second	Third	Fourth	Fifth
Average Difference between ACPs and IRISs	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 of ACPs and IRISs–WISG	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

Meeting of WMO CIMO Task Team on Radiation References

- Focused on traceability of terrestrial radiation measurements. Reviewed and evaluated recent developments of reference instruments for terrestrial radiation, and developed recommendations to the attention of CIMO on the appropriateness, requirements, and timeliness for a possible future modification of the current reference.
- Relevant recommendations from the TT will be submitted to the CIMO MG (March 26–29, 2018), and most likely to CIMO-17 session (October 12–16, 2018, Amsterdam) for endorsement. Report of the TT meeting will encompass all recommendations by end of 2018.

CONCLUSION

- Difference between the irradiance measured by the ACPs, IRISs, and AERI 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 ±3 W/m^2.
- Irradiance measured by the WISG is lower than the average irradiance measured by ACPs and IRISs. The magnitude of the difference varied from 4.4 W/m^2 to 6.6 W/m^2 depending on the integrated water vapor.

ACKNOWLEDGMENTS

We sincerely appreciate the support of the U.S. DOE Atmospheric System Research Program and the Atmospheric Radiation Measurement User Facility, staff at NREL's Metrology Laboratory within the Solar Radiation Research Laboratory (SRRL) for help in setting up instruments and maintaining the quality of SRRL data, and Martina Newman for her continuous support. We thank the U.S. DOE Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Program, and NREL's Environmental, Safety, Health, and Quality Office/Metrology for providing the funds.

AGU 2018 Fall Meeting
Washington D.C.
December 10–14, 2018
NREL/PO-1900-72708