Few Week Campaign to Compare Three Absolute Infrared Broadband Radiometers (ASR, IRIS, ACP)

- The current standard is the WISG maintained at PMOD in Davos based on the ASR
- Used the Absolute Scanning Radiometer (ASR) to establish it (Philipona) during IPASRC I
- IRIS (Gröbner) and ACP (Reda) were independently developed absolute radiometers to measure broadband infrared
- IRIS and ACP agree with each other, but not the WISG

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Atmospheric longwave irradiance uncertainty: Pyrgeometers compared to an absolute sky-scanning radiometer, atmospheric emitted radiance interferometer, and radiative transfer model calculations

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Abstract. Because atmospheric longwave radiation is one of the most fundamental elements of an expected climate change, there has been a strong interest in improving measurements and model calculations in recent years. Important questions are how reliable and consistent are atmospheric longwave radiation measurements and calculations and what are the uncertainties? The First International Pyrgeometer and Absolute Sky-scanning Radiometer Comparison, which was held at the Atmospheric Radiation Measurement program's Southern Great Plains site in Oklahoma, answers these questions at least for midlatitude summer conditions and reflects the state of the art for atmospheric longwave radiation measurements and calculations. The 15 participating pyrgeometers were all calibration-traced standard instruments chosen from a broad international community. Two new chopped pyrgeometers also took part in the comparison. An absolute sky-scanning radiometer (ASR), which includes a pyroelectric detector and a reference blackbody source, was used for the first time as a reference standard instrument to field calibrate pyrgeometers during clear-sky nighttime measurements. Owner-provided and uniformly determined blackbody calibration factors were compared. Remarkable improvements and higher pyrgeometer precision were achieved with field calibration factors. Results of nighttime and daytime pyrgeometer precision and absolute uncertainty are presented for eight consecutive days of measurements, during which period downward longwave irradiance varied between 260 and 420 W m^{-2}. Comparisons between pyrgeometers and the absolute ASR, the atmospheric emitted radiance interferometer, and radiative transfer models LBLRTM and MODTRAN show a surprisingly good agreement of <2 W m^{-2} for nighttime atmospheric longwave irradiance measurements and calculations.

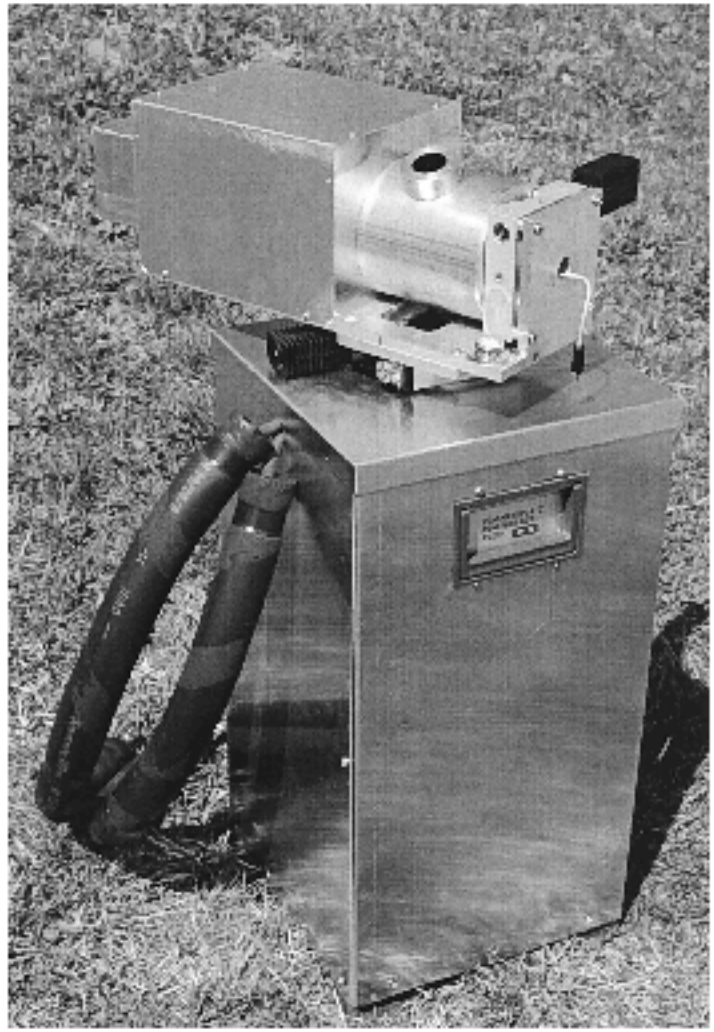

Fig. 2. ASR with reference blackbody (lower part) and rotatable detector head (upper part).

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A transfer standard radiometer for atmospheric longwave irradiance measurements

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Abstract
A new reference radiometer for downwelling atmospheric longwave irradiance has been designed and built. The new infrared integrating sphere (IRIS) radiometer is designed to acquire measurements with a time constant of less than 1 s. Based on a thorough characterization, the IRIS radiometer is able to measure longwave irradiance with an expanded uncertainty of $\pm 1.8\,\mathrm{W\,m^{-2}}$ and $\pm 2.4\,\mathrm{W\,m^{-2}}$ in the summer and winter seasons, respectively, which is equivalent to a temperature range between +15 °C and −15 °C for typical conditions at Davos, Switzerland. The long-term stability of the IRIS radiometer was determined over a one year period, yielding a calibration reproducibility in the laboratory of 0.5%. Outdoor measurements with four IRIS radiometers were performed during 13 clear nights in April 2011. The four radiometers measured atmospheric longwave irradiance with differences ranging from $-1.1\,\mathrm{W\,m^{-2}}$ to $+0.7\,\mathrm{W\,m^{-2}}$, which were well within their estimated uncertainties.

(Some figures may appear in colour only in the online journal)

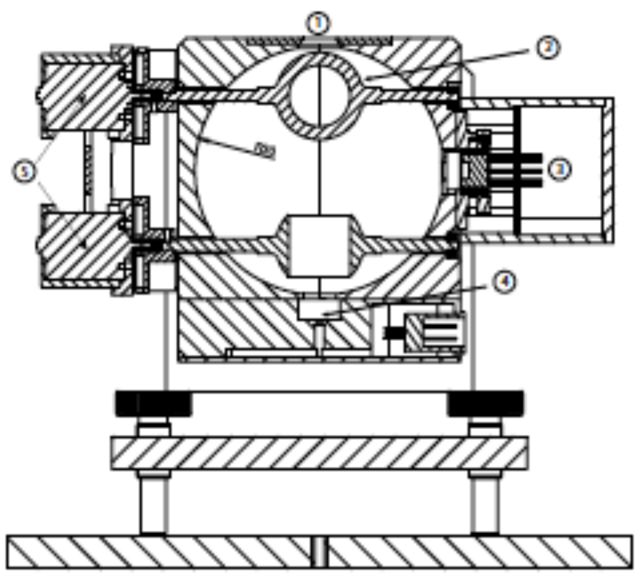

Figure 1. Schematic of the IRIS radiometer. (1) Aperture for longwave irradiance, (2) rotating shutters, 90° out of phase, (3) pyroelectric detector, (4) black coated reference cavity and thermistor, (5) shutter motors.

An absolute cavity pyrgeometer to measure the absolute outdoor longwave irradiance with traceability to international system of units, SI

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ABSTRACT

This article describes a method of measuring the absolute outdoor longwave irradiance using an absolute cavity pyrgeometer (ACP), U.S. Patent application no. 13/049, 275. The ACP consists of domeless thermopile pyrgeometer, gold-plated concentrator, temperature controller, and data acquisition. The dome was removed from the pyrgeometer to remove errors associated with dome transmittance and the dome correction factor. To avoid thermal convection and wind effect errors resulting from using a domeless thermopile, the gold-plated concentrator was placed above the thermopile. The concentrator is a dual compound parabolic concentrator (CPC) with 180° view angle to measure the outdoor incoming longwave irradiance from the atmosphere. The incoming irradiance is reflected from the specular gold surface of the CPC and concentrated on the 11 mm diameter of the pyrgeometer's blackened thermopile. The CPC's interior surface design and the resulting cavitation result in a throughput value that was characterized by the National Institute of Standards and Technology. The ACP was installed horizontally outdoor on an aluminum plate connected to the temperature controller to control the pyrgeometer's case temperature. The responsivity of the pyrgeometer's thermopile detector was determined by lowering the case temperature and calculating the rate of change of the thermopile output voltage versus the changing net irradiance. The responsivity is then used to calculate the absolute atmospheric longwave irradiance with an uncertainty estimate (U_{95}) of ± 3.96 W m^{-2} with traceability to the International System of Units, SI. The measured irradiance was compared with the irradiance measured by two pyrgeometers calibrated by the World Radiation Center with traceability to the Interim World Infrared Standard Group, WISG. A total of 408 readings were collected over three different nights. The calculated irradiance measured by the ACP was 1.5 W/m^2 lower than that measured by the two pyrgeometers that are traceable to WISG, with a standard deviation of ± 0.7 W m^{-2}. These results suggest that the ACP design might be used for addressing the need to improve the international reference for broadband outdoor longwave irradiance measurements.

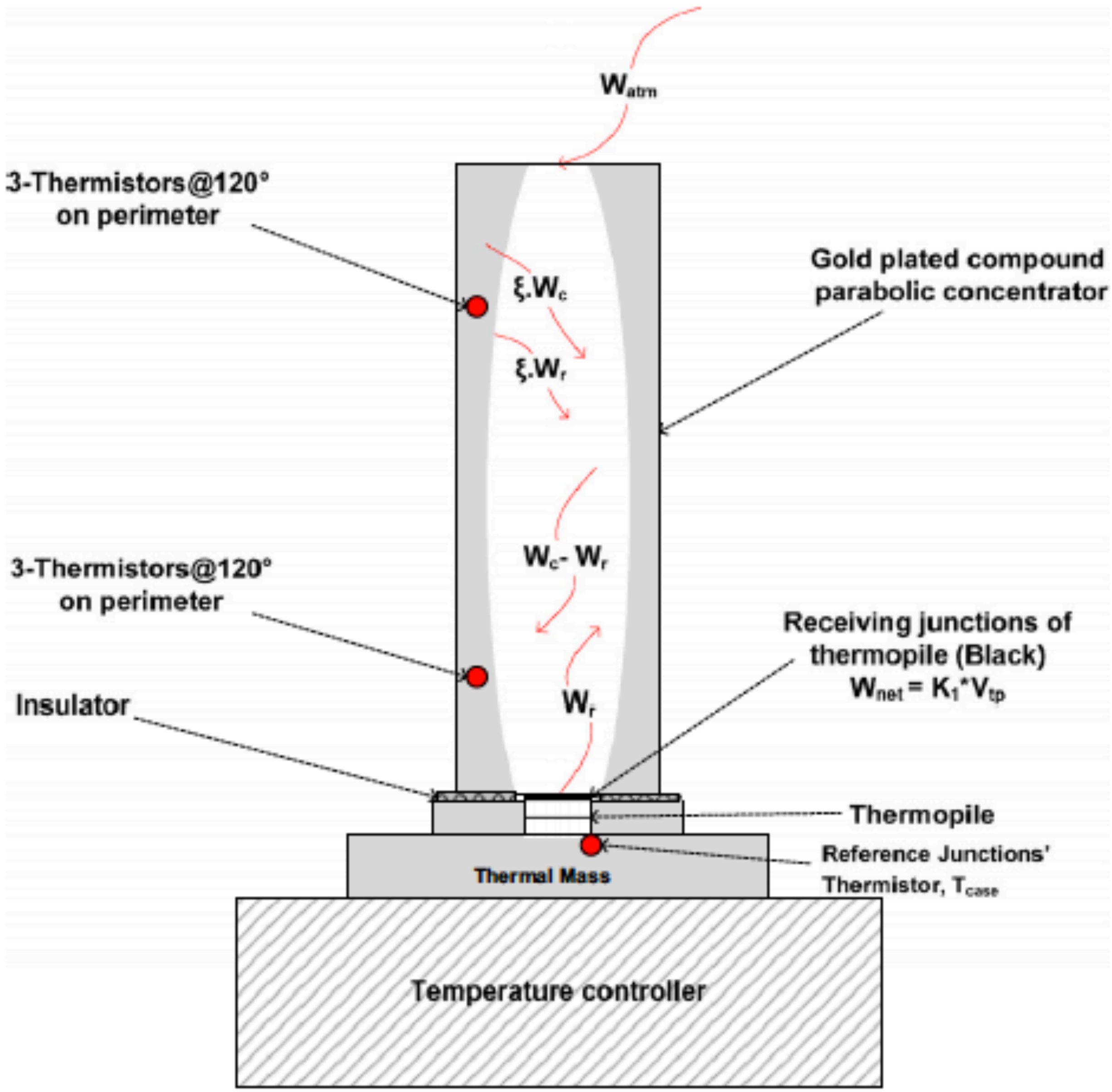


Fig. 1. Simplified diagram for absolute cavity pyrgeometer, ACP.

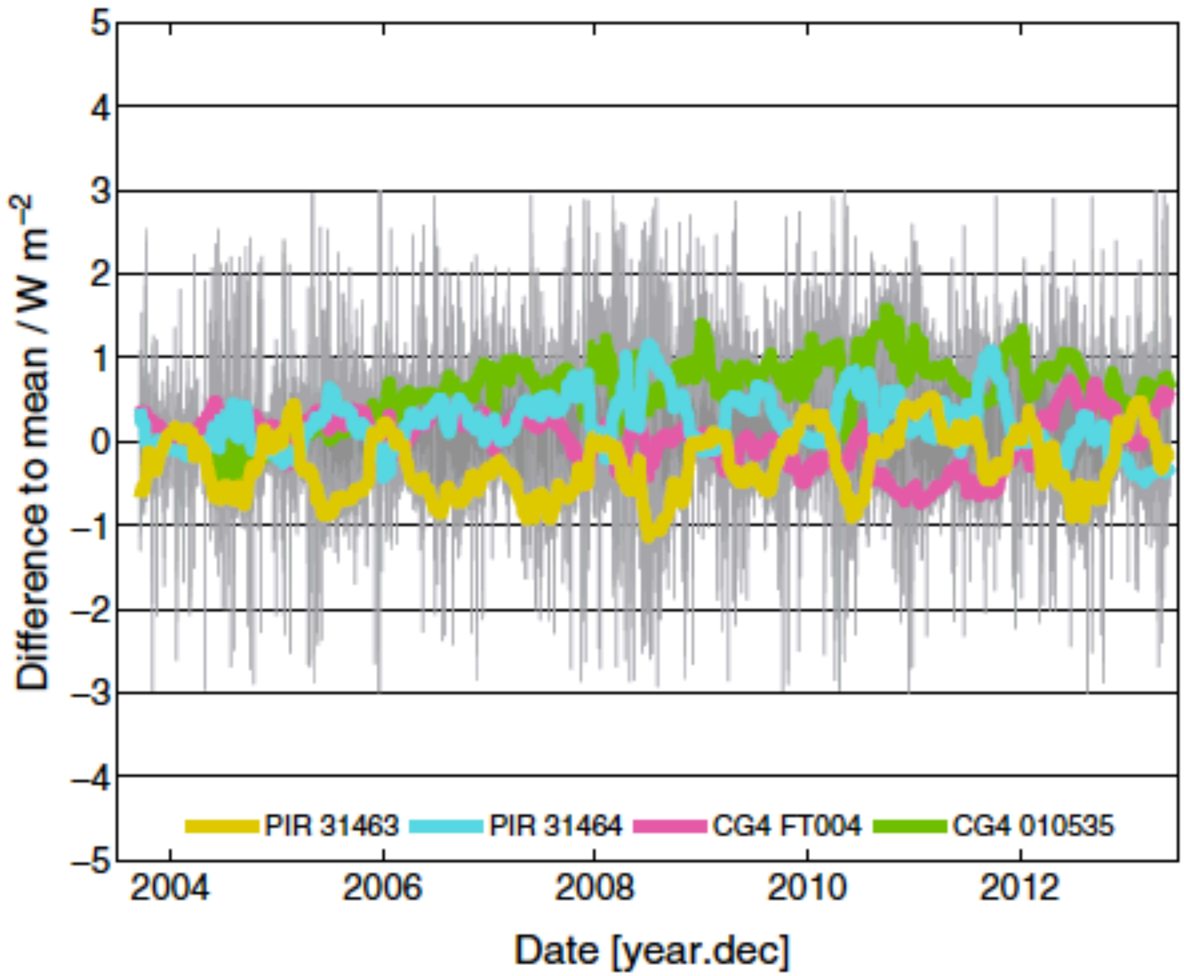


Figure 1. Residuals of downwelling irradiance measurement with respect to the average of the four pyrgeometers forming the World Infrared Standard Group. The thick curves represent the monthly moving average from daily pyrgeometer averages (shown in grey). Only nighttime data were used.

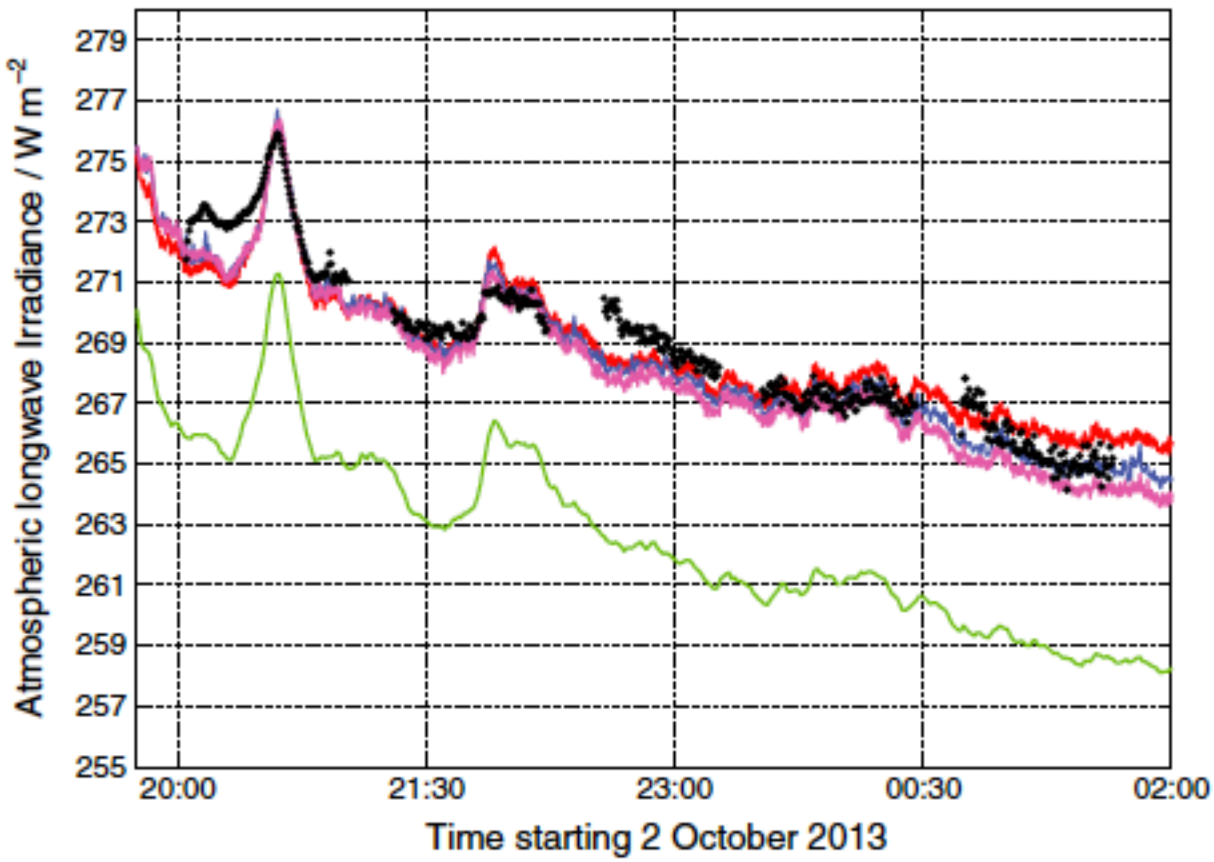
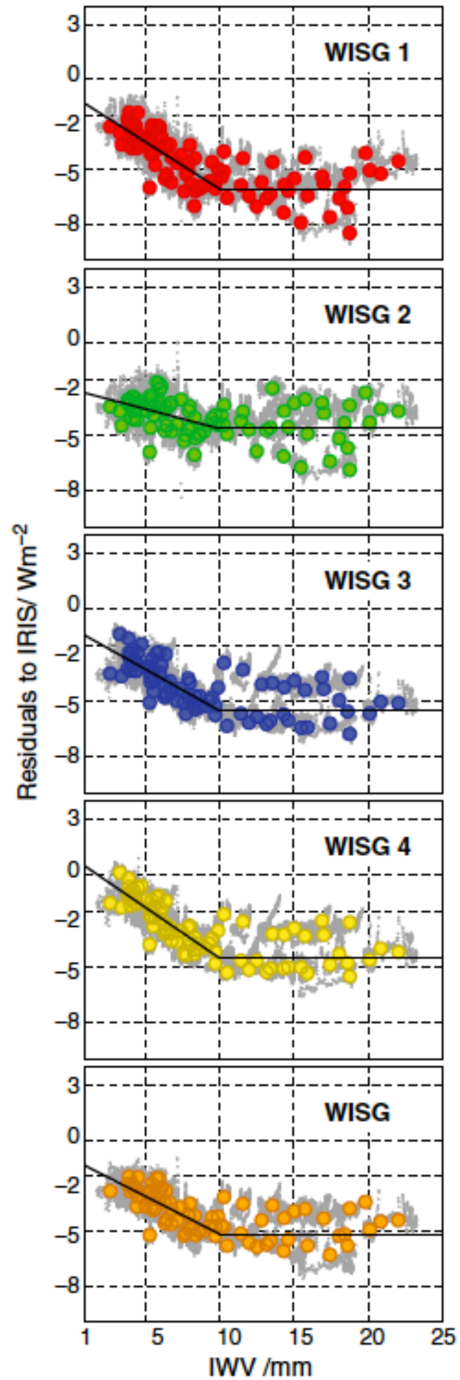


Figure 3. Downwelling atmospheric longwave irradiance measured during the night of 2–3 October 2013 at PMOD/WRC. The red, blue, and magenta curves represent the measurements from IRIS#2, IRIS#3, and IRIS#5, respectively; the black dots represent the measurements from the ACP, and the green curve shows the average irradiance measured by the WISG.


WISG 1
WISG 2
WISG 3
WISG 4
WISG
Residuals to IRIS/ Wm^{-2}
IWV /mm

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Downward longwave irradiance uncertainty under arctic atmospheres: Measurements and modeling

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[1] Measurement and modeling of downward longwave irradiance are a special challenge in arctic winter due to its low water vapor content and the extreme meteorological conditions. There are questions about the representativeness of the instrument calibration, the consistency and uncertainty of measurements and models in these environments. The Second International Pyrgeometer and Absolute Sky-scanning Radiometer Comparison (IPASRC-II), which was conducted at Atmospheric Radiation Measurement (ARM) program's North Slope of Alaska (NSA) site in Barrow provided a unique opportunity to compare high accuracy downward longwave irradiance measurements and radiative transfer model computations during arctic winter. Participants from 11 international institutions deployed 14 pyrgeometers, which were field-calibrated against the Absolute Sky-scanning Radiometer (ASR). Continuous measurements over a 10-day period in early March 2001 with frequent clear-sky conditions yielded downward longwave irradiances between 120 and 240 W m^{-2}. The small average difference between ASR irradiances, pyrgeometer measurements, MODTRAN and LBLRTM radiative transfer computations indicates that the absolute uncertainty of measured downward longwave irradiance under arctic winter conditions is within ±2 W m^{-2}. *INDEX TERMS:* 0360 Atmospheric Composition and Structure: Transmission and scattering of radiation; 1610 Global Change: Atmosphere (0315, 0325); 3309 Meteorology and Atmospheric Dynamics: Climatology (1620); 3349 Meteorology and Atmospheric Dynamics: Polar meteorology; *KEYWORDS:* longwave radiation, pyrgeometer, MODTRAN, LBLRTM

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Proposal for Some Fall in Oklahoma

- Bring all three together for 2-3 weeks, starting mid October (best chance for clear weather and both low and moderate water vapor)
- ARM site has AERI to derive approximation for infrared irradiance (kind of an independent 'measurement')
- ARM site has infrastructure (may want to add some CG4's)
- ARM has measurements needed for first principles modeling of downwelling IR