Understanding Far-Infrared Radiative Processes Using NSA ACRF Measurements

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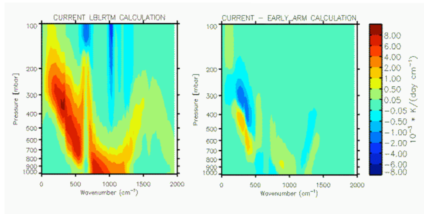
Why Study the Far-Infrared?

- The far-infrared (λ > 15 μm) is an important component of the overall radiation budget of the Earth, accounting for approximately half of the outgoing infrared radiation to space.
- Dominated by the pure rotation band of water vapor, the maximum mid-to-upper tropospheric cooling also occurs in the far-IR (left panel).
- ARM science team research has resulted in enormous improvements in the treatment of radiation in climate models (e.g. Tobin et al. 1999; right panel).



Tropical atmosphere cooling rates calculated using modern LBLRTM calculations(left panel) and differences between current and early ARM (1995/1996) calculations.

At the conclusion of the 1997 SHEBA campaign, some spectral differences between Atmospheric Emitted Radiance Interferometer (AERI) measurements and line-by-line radiative transfer model (LBLRTM) calculations persisted in the far-IR…

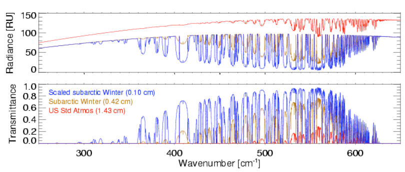
Were these spectral differences attributable to errors in the radiosonde-measured temperature or water vapor profile, to errors in the water vapor spectral absorption properties, or a combination of many parameters?

Far-IR Radiative Closure Experiment Design

- **Objective**: Retrieve water vapor column amount and assess water vapor absorption properties using measurement-model intercomparisons/retrievals
- **Models**
  - LBLRTM/MONORTM: Developed at AER, Inc. to calculate radiance and transmittances at high-resolution for the infrared/solar and microwave, respectively
  - HITRAN 2004 line parameter database; MT_CKD continuum model
- **Data**
  - 183 GHz Radiometers: G-Band Water Vapor Radiometer (*GVR)*
  - AERI: Radiance measurements from 400-3000 cm^{-1} (0.5 cm^{-1} resolution)
  - Vaisala Radiosonde profiles (RS90/92) with surface meteorological data

The NSA ACRF High-Latitude Laboratory

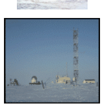
The opacity of the lower atmosphere above most accessible research facilities is a formidable obstacle in evaluating far-IR radiative transfer. Although largely opaque at wavenumbers smaller than 530 cm^{-1} for the US Standard Atmosphere, the transmission increases significantly in the microwindows between absorption lines as the PWV decreases . A radiance unit (RU) is 1 mW / (m^2 sr cm^{-1}).



The ARM North Slope of Alaska Climate Research Facility (NSA ACRF) site is located in Barrow, AK (N 71 ◦ 19.378';W 156◦ 36.934') and approximately 8m above sea level. Racette et al. (2005) demonstrated that the PWV is frequently less than 5 mm; PWVs as low as 0.8 mm have also been measured at the NSA ACRF.

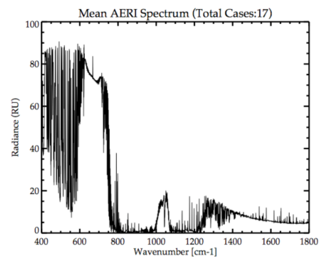
40m Met. Tower

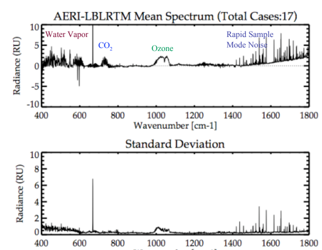
NSA ACRF

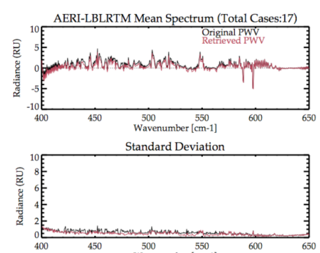


NSA ACRF and nearby NOAA/GMD baseline observatory.

NOAA/GMD

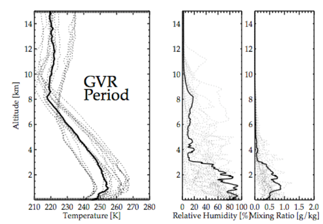




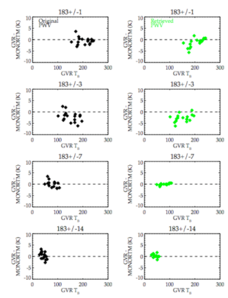


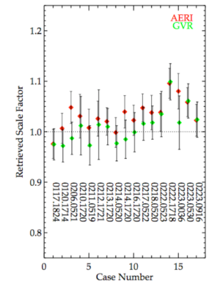
Winter 2007 Comparison

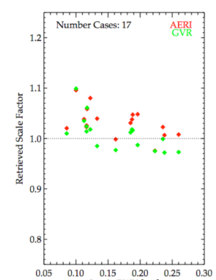
17 radiosonde profiles in conjunction with meteorological tower data were used for AERI - LBLRTM and GVR - MONORTM intercomparisons. Strong temperature inversions were present in most cases and the sonde-derived PWVs were below 0.3 cm. The AERI and GVR data were each offset corrected, and averaged for 30 minutes. Subsequent retrievals of a radiosonde PWV-scaling factor were independently obtained for the AERI and GVR.



- Retrievals of high AERI scale factors may be the result of aerosol or thin cloud layers. Additional scrutiny with the polarized micropulse lidar will be performed.
- Several good cases with robust water vapor profiles have been identified from which water vapor line widths and strengths can be retrieved. Generally it appears that some line widths may need adjustment.







Discussion

- In addition to the GVR comparison presented here, a similar comparison was done for the 2004 Arctic Water Vapor IOP in which another 183.3 GHz instrument was deployed (Ground-based Scanning Radiometer, GSR). This effort showed some unexpectedly large measurement - model differences, and the GSR calibration is being re-examined. The character of the AERI-LBLRTM results were similar to the 2007 period.
- The Radiative Heating in Underexplored Bands Campaign (*RHUBC*) has just wrapped up at the NSA ACRF. During the 3 week campaign the GVR, GSR, and another 183.3 GHz instrument under development were simultaneously deployed, as well as an additional instrument that has extended spectral range into the far-IR. Over 40 additional radiosondes supplemented the twice daily launch schedule currently being used at the NSA site.

References

Racette, PE, EJ Kim, J Wang, ER Westwater, M Klein, V Leuski, Y Han, A Gasiewski, D Cimini, D Jones, W Manning, and P Kiedron. 2005. "Measurement of Low Amounts of Precipitable Water Vapor Using Ground-Based Millimeterwave Radiometry." Journal of Atmospheric and Oceanic Technology, 22, 317-337.

Tobin, DC, FA Best, PD Brown, SA Clough, RG Dedecker, RG Ellingson, RK Garcia, HB Howell, RO Knuteson, EJ Mlawer, HE Revercomb, JF Short, PFW van Delst, and VP Walden. 1999. "Downwelling spectral radiance observations at the SHEBA ice station: water vapor continuum measurements from 17 to 26 um." Journal of Geophysical Research , 104, 2081-92.