Overview

The ability to accurately validate infrared spectral radiances measured from space by direct comparison with airborne spectrometer radiances was first demonstrated using the Scanning High-resolution Interferometer Sounder (S-HIS) aircraft instrument flown under the AIRS on the NASA Aqua spacecraft in 2002. Subsequent comparisons in 2004 and 2006 have also demonstrated successful comparisons that now span a range of conditions, including arctic and tropical atmospheres, daytime and nighttime, ocean and land surfaces. These results show brightness temperature differences that often approach 0.1 K over much of the spectrum. This close agreement shows great progress, is encouraging for achieving consistent remote sensing applications, and will even be meaningful for sensitive climate applications. If the absolute calibration of the S-HIS can be convincingly proven to this level, then the Scanning HIS will provide a direct link between NIST and on-orbit observations. With this goal, new tests of S-HIS absolute calibration have been conducted using the NIST transfer radiometer (TXR). The TXR was used to accurately relate the S-HIS radiance to the NIST radiance scale.

The Scanning-HIS continuous spectral coverage from 3.3 to 16.7 μm at 0.5 cm-1 resolution. This coverage is divided into three bands with separate detectors (two PC HgCdTe and one klystron) to achieve the required noise performance. The longwave band provides the primary information for temperature sounding for cloud phase and particle size. The intermediate band provides the primary water vapor information and is used to deduce cloud liquid water content. The shortwave band provides information on cloud reflectance and serves as supplemental information. The 0.1σ absolute radiometric uncertainty for the S-HIS presented in the lower figure.

Two basic tests were conducted: (1) comparison of radiances measured by the Scanning HIS to those from the TXR, and (2) reflectivity measurements of a UW-SSEC blackbody by using the TXR as a stable detector. The radiance comparison involved the Scanning HIS and the TXR each observing a highly stable (and accurate) Atmospheric Emitted Radiance Interferometer (AERI) blackbody over a wide range of temperatures (227 to 290 K). The S-HIS was operated at a typical flight temperature, with the optical bench at about 260 K. Brightness temperature differences between the TXR and the Scanning HIS were found to be, on average, less than 40 mK. The AERI blackbody reflectivity measurement used a heated tube placed between the TXR and the Blackbody (axis co-aligned with the TXR viewing axis and the normal to the center of the AERI blackbody aperture). The tube was heated to about 100 K over the ambient environment of about 225 K. The measured reflectances were better (lower) than predicted, and within the predicted uncertainty of the original estimates. Preliminary results from both tests are very promising for confirming and refining the expected absolute accuracy of Scanning HIS.

NIST TXR Intercomparison Testing at the University of Wisconsin

The upper left plot shows the chamber temperature being held at close to flight ambient levels near 225 K, while the AERI Blackbody is sequentially raised in temperature up to 295 K. The upper right plot shows the Scanning HIS spectra corresponding to the different blackbody temperatures. The spectral response function of the TXR at 3 and 10 μm is also shown.

For the reflectance measurement of the AERI Blackbody, the NIST TXR is a Heated Scene Tube, the Blackbody, and a Radiodetection Spectral Emissivity Comparison Radiometer (DECOR). The DECOR is a one-channel portable cryogenic filter radiometer for providing thermal-infrared spectral calibration benchmarks for large-area calibration sources. The goal is to provide true emissivity measurements of the reference blackbody. The AERI Blackbody is used for TXR calibration in ambient environmental conditions. The results from the UW analysis of these measurements for the 10 μm Channel are presented next, with reflectance from the plotted spectral Scene Tube temperature. The 0.1σ absolute uncertainty in the results from the TXR is shown as solid vertical bars.

The graphs above show the difference between the predicted AERI BB radiance minus the measured S-HIS radiances (at both 3 and 10 μm) and the AERI Blackbody minus the measured TXR radiance at 10 μm. The comparison shows that the differences between the NIST TXR and Scanning HIS are in excellent agreement — on the order of ±0.0053.