Scanning High-resolution Interferometer Sounder (S-HIS) Radiometric Calibration and Performance

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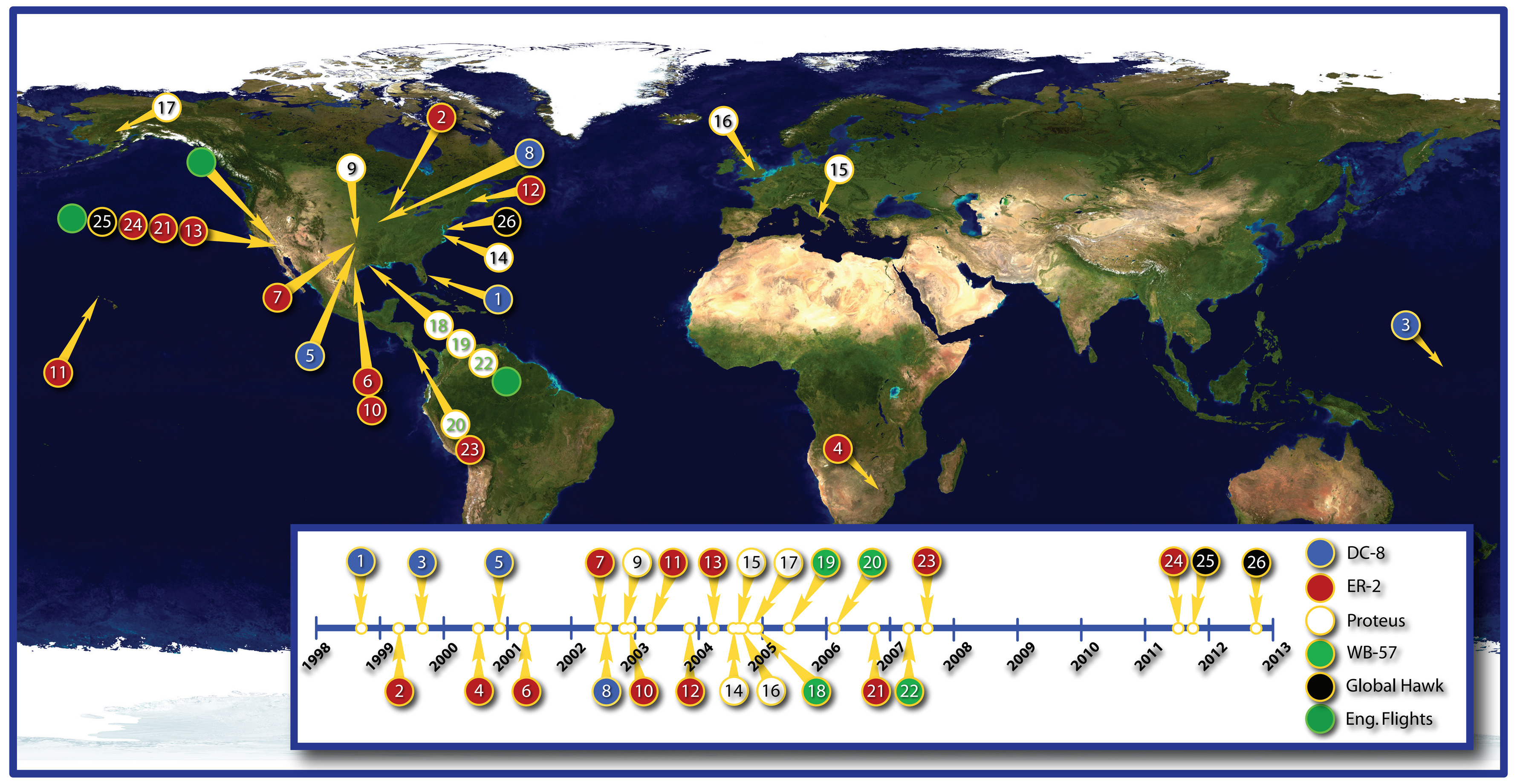
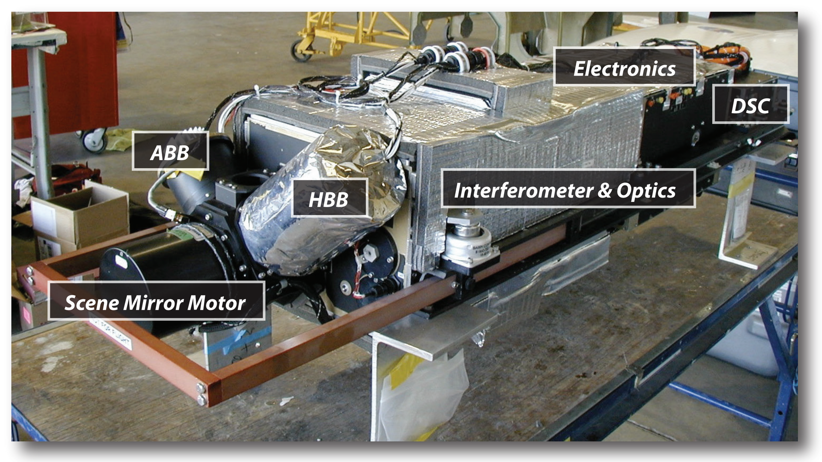
HS3 Science Team Meeting 2013

Instrument Overview

The S-HIS is an advanced version of the High-resolution Interferometer Sounder (HIS) NASA ER-2 instrument and was developed between 1996 and 1998 at the UW-SSEC with the combined support of the US DOE, NASA, and the NPOESS Integrated Program Office. It was originally designed for UAV use, which imposed significant constraints on the mass, power, and size requirements.

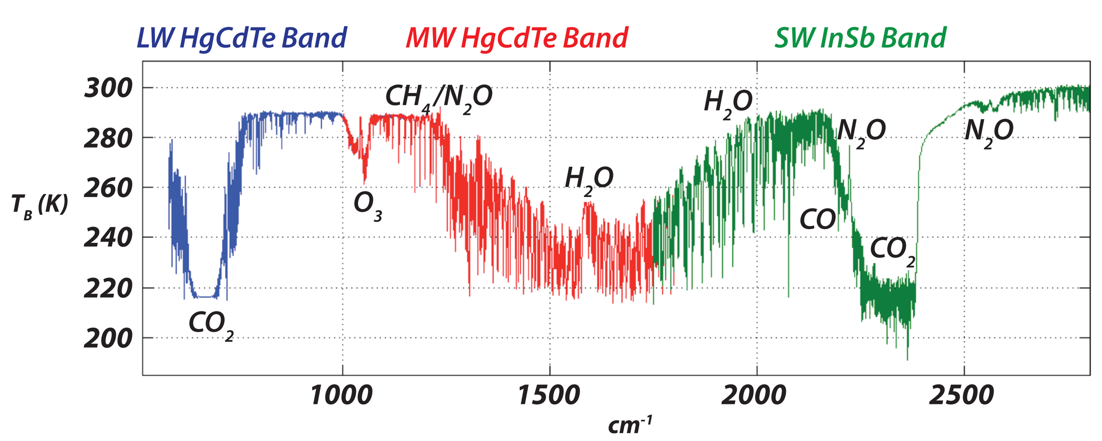


The S-HIS has participated in 26 field experiments on multiple airborne platforms, each with significantly different instrument operating environments. Independent of airborne platform, the S-HIS has provided hyperspectral infrared radiance measurements with high absolute accuracy and low noise.



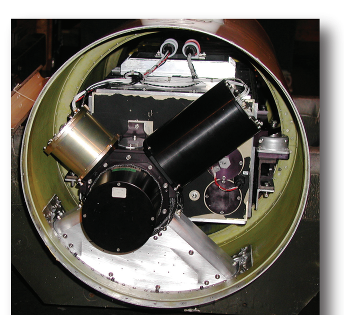
Interferometer Type:	Modified ABB Bomem DA-5
IFOV:	100 mrad (2km @ 20km, nadir)
Scene Coverage:	Programmable 45° scene mirror nadir ± 40° typical
Spectral Coverage:	LW (HgCdTe), 580 - 1180 cm^{-1} MW(HgCdTe), 1000 - 1820 cm^{-1} SW (InSb), 1750 - 3000 cm^{-1}
Spectral Resolution:	0.5 cm^{-1}

S-HIS mounted on AV-6, Zone 25



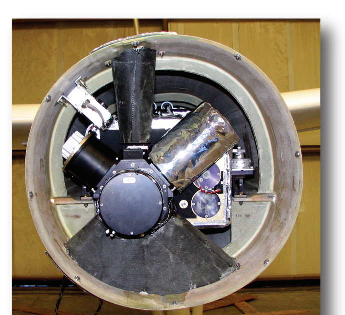
Sample upwelling S-HIS brightness temperature spectra.

Mounted in WB-57 wingpod.



Mounted in ER-2 centerline pod.

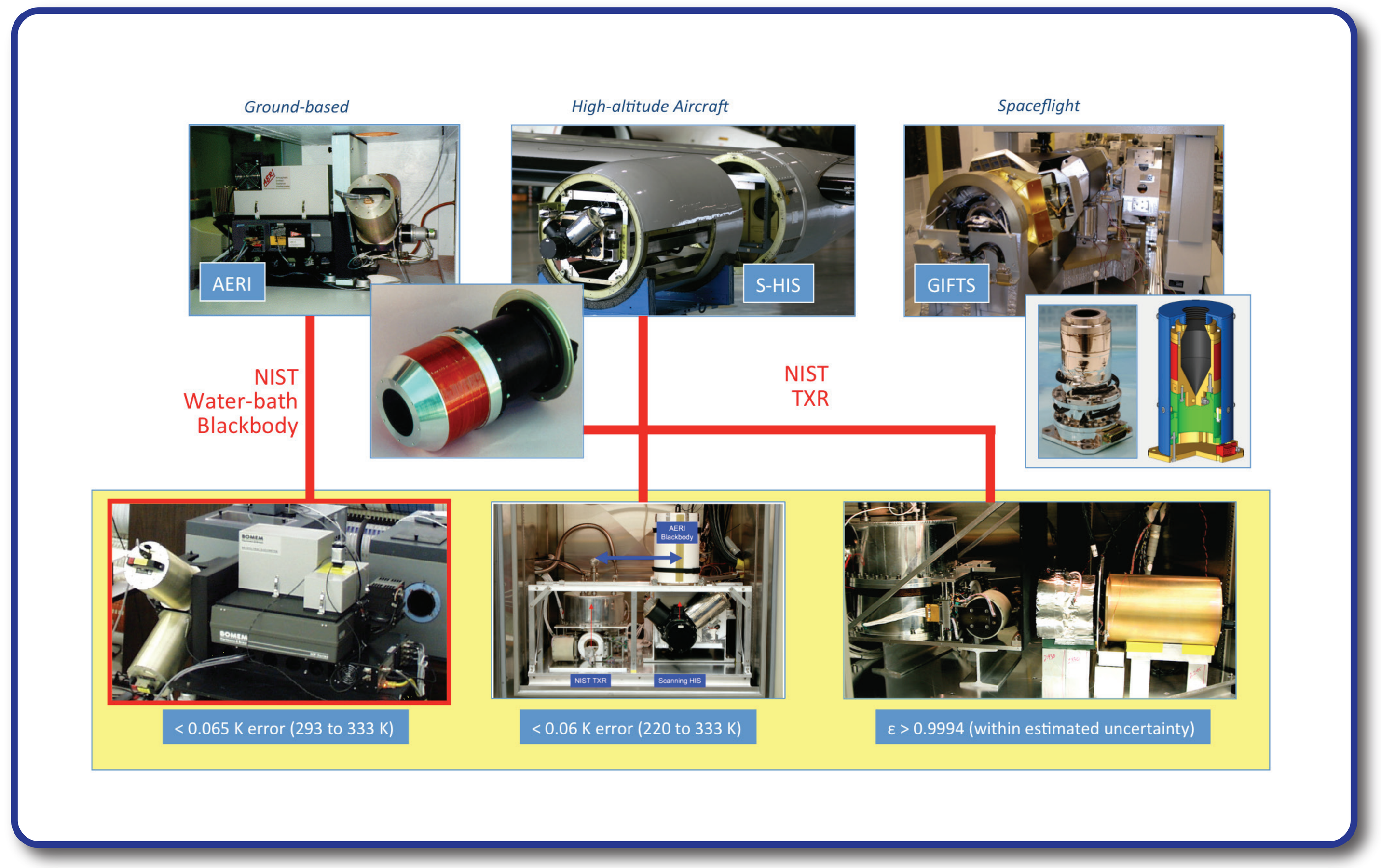
Mounted in DC-8.



Mounted in Proteus wing boom.

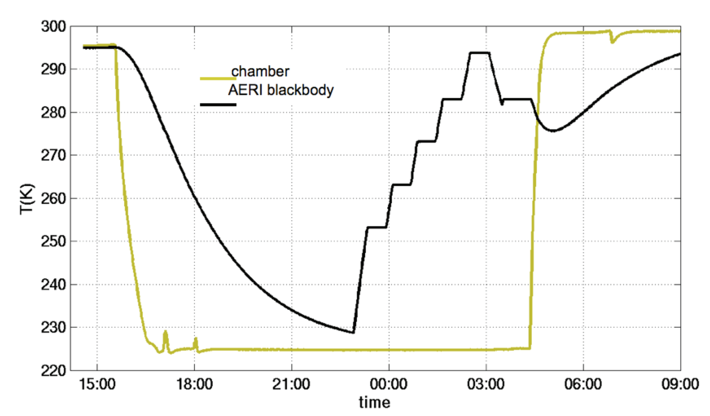
Absolute Accuracy

UW-SSEC Spectrometer and Blackbody Heritage and Ties to NIST

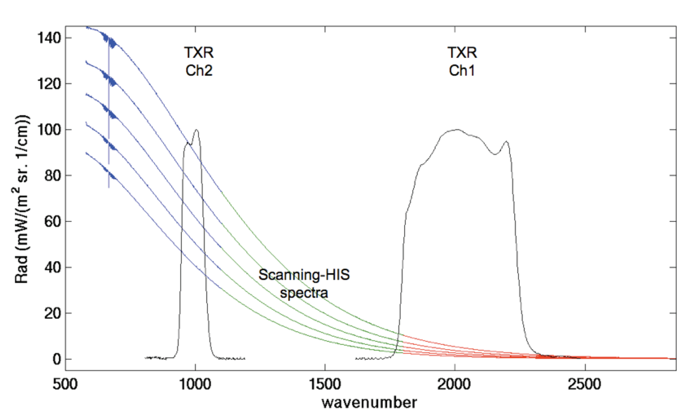


S-HIS / NIST TXR Radiance Intercomparison

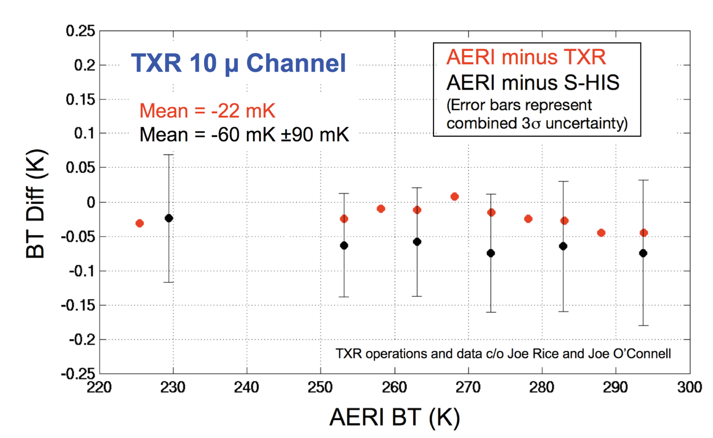
End-to-end radiance evaluations of the S-HIS were conducted at UW-SSEC, under flight-like conditions using the NIST TXR in a thermal chamber. A UW developed AERI Blackbody was run at various temperatures and viewed by the NIST TXR and the S-HIS. Calculated radiances from the AERI BB were compared with measured radiances from the S-HIS and the TXR. These intercomparison measurements provide the basis for satellite validation analyses that are traceable to the NIST radiance scale. A mean agreement between TXR channel 2 and S-HIS of ~40 mK was demonstrated, well less than the propagated 3-σ uncertainties [Best 2007, Taylor 2007]

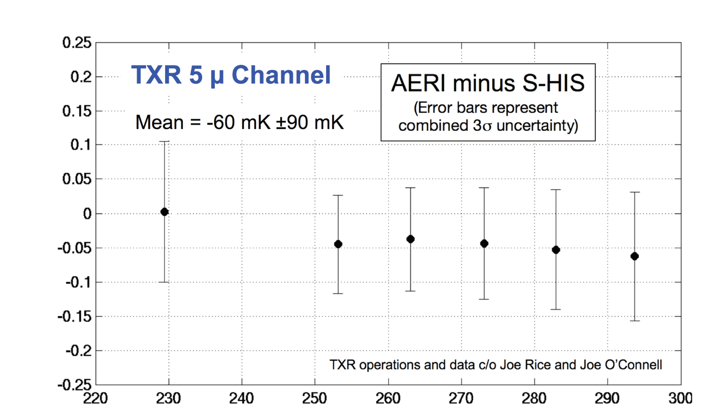


Chamber temperature was held at close to flight ambient levels (~225 K), while the AERI Blackbody is sequentially raised in temperature up to 295 K.



Five Scanning HIS spectra corresponding to five different blackbody temperatures. The spectral response function of the TXR at 5µ and 10 µ is also shown.



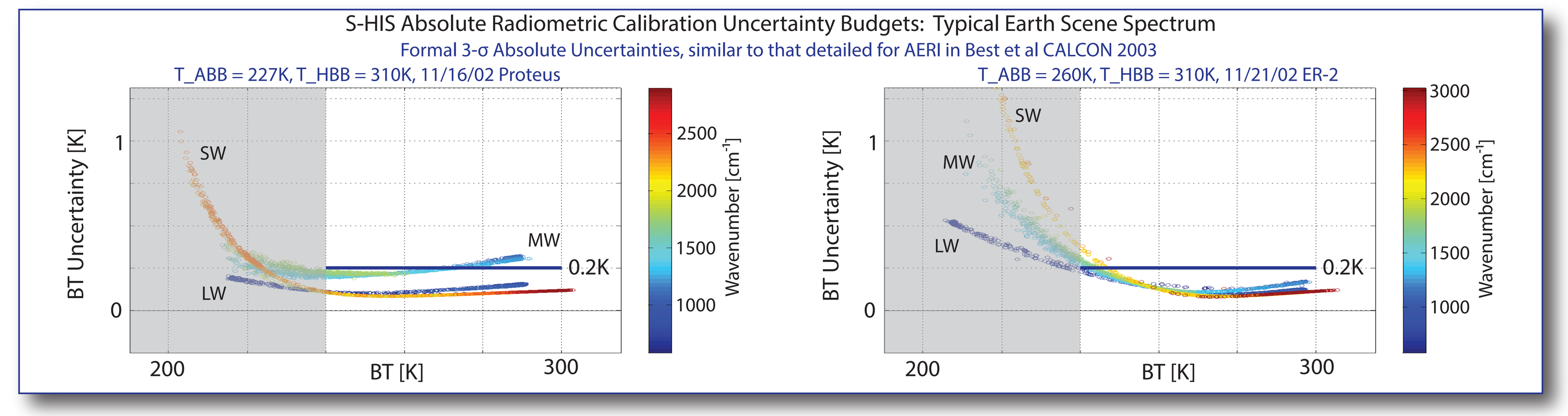


The plots above show the difference between the predicted AERI BB radiance and the measured S-HIS radiance (at both 5µ and 10 µ) and the AERI Blackbody minus the measured TXR radiance at 10 µ (the TXR 5 µ analysis is not yet complete). At 10 µ the differences between the NIST TXR and Scanning-HIS are in excellent agreement - on the order of 40 mK.

Radiometric Calibration

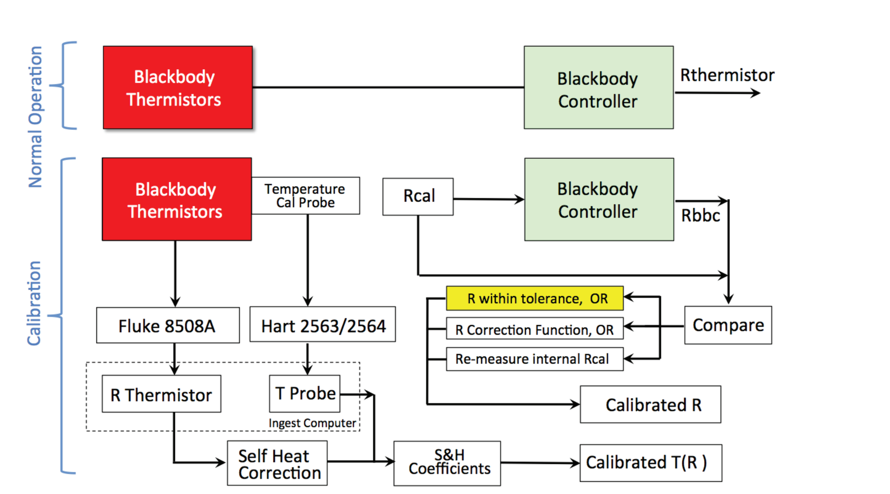
The blackbody reference sources for the S-HIS are high emissivity cavities (normal emissivity ≈ 0.999) carefully designed, fabricated, and characterized at the UW-SSEC. The UW-SSEC AERI, S-HIS, GIFTS, and ARI blackbodies share a common design, with the design scaled to the required aperture for each application. The formal 3-σ (i.e. not to exceed) absolute uncertainties for S-HIS blackbody temperature and cavity emissivity are 0.10 K and 0.001 [Best 1997, 2003], respectively.

Calibration Uncertainty Budget

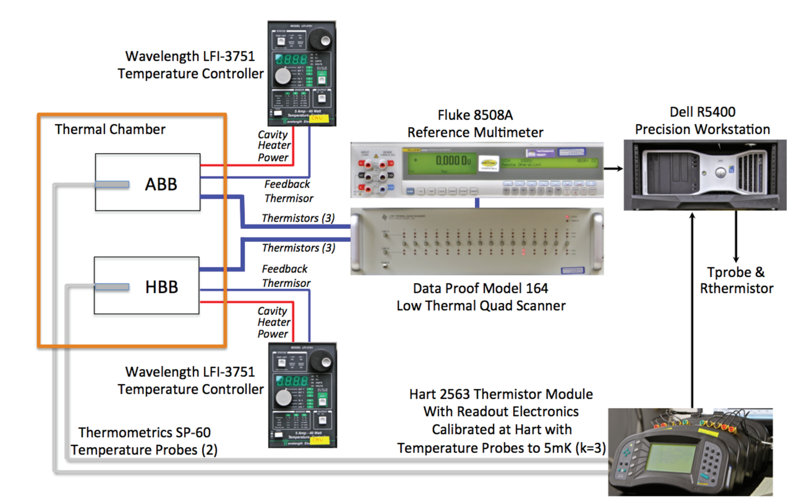


For $T_B \geq$ 220K the design requirement for absolute radiometric accuracy is < 0.5K with reproducibility better than 0.2 K (both 3-σ, not to exceed). An RSS of the error contributors indicates expected uncertainties that are about half of these values over much of the spectrum. Ground tests with a third blackbody confirm this tighter expectation. These are conservative estimates of the uncertainty, with the absolute accuracy representing a not to exceed value.

Electronics and Thermistor Calibration

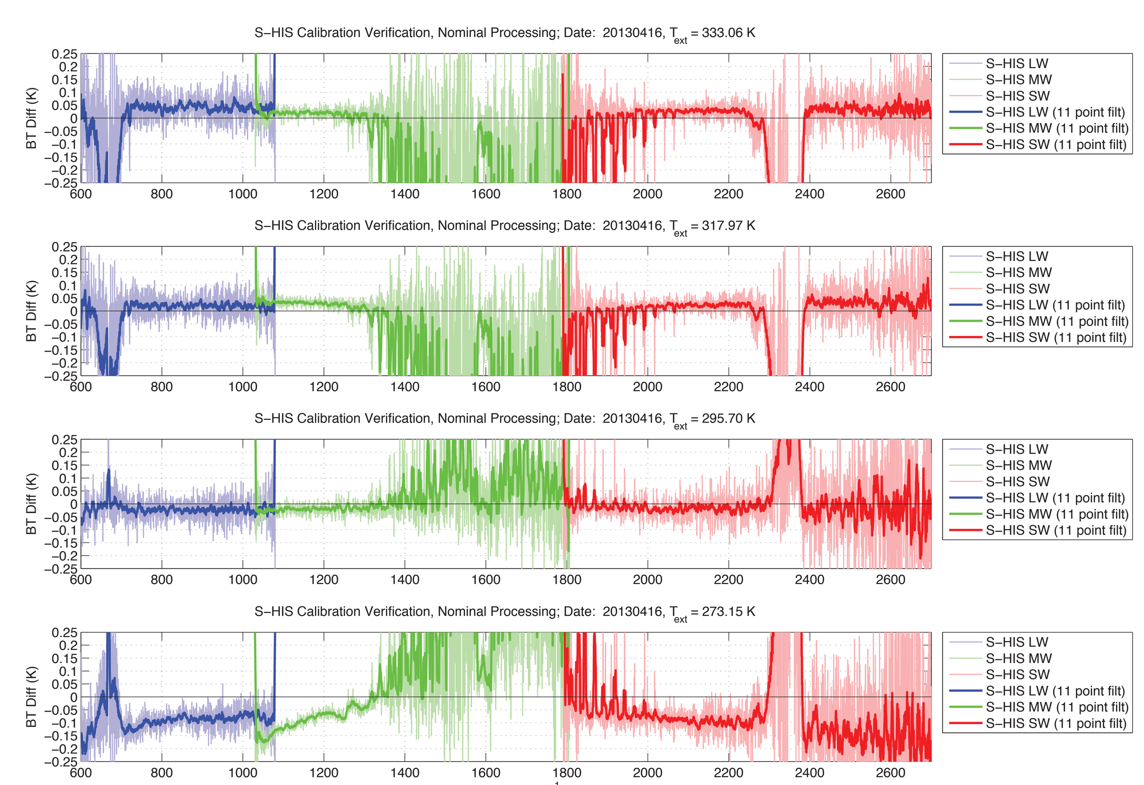


Calibration Overview



Calibration Configuration -60C - 60C

End-to-end Laboratory Calibration Verification



Example laboratory end-to-end calibration verification. Calibration verification is completed in the lab pre and post mission.

The plots show the difference between the predicted target blackbody radiance and the S-HIS measured radiance for 4 blackbody temperatures (273.15 K, 295.70 K, 317.97 K, 333.06 K).

The nonlinearity coefficients are optimized for the flight environment and instrument temperature; residual nonlinearity effects are evident in the brightness temperature differences.

Residual nonlinearity is the dominant contributor to the difference for the 273.15K target observation in the lab config.

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