Suomi NPP/JPSS Cross-track Infrared Sounder (CrIS): Calibration Validation With The Aircraft Based Scanning High-resolution Interferometer Sounder (S-HIS)

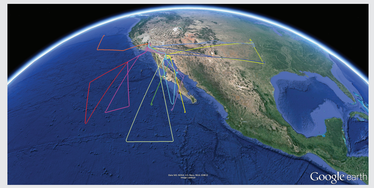
Joe K. Taylor[1], D. C. Tobin[1], H.E. Revercomb[1], F.A. Best[1], R. K. Garcia[1], H. Motteler[2], and M. Goldberg[3]

1. *Space Science and Engineering Center, University of Wisconsin-Madison, 1225 West Dayton St., Madison, WI, 53706*
2. *University of Maryland Baltimore County, Baltimore, Maryland, USA*
3. *Joint Polar Satellite Systems Office, National Oceanic and Atmospheric Administration, Lanham, Maryland, USA*

JPSS Science Team Meeting 2014

Summary

Climate change detection and potential attribution analyses, as well as Numerical Weather Prediction applications, require rigorous uncertainty analyses following established metrological principles. Using satellite radiance observations, these analyses start with understanding the uncertainties associated with the spectral radiance observations and propagate these and other sources of uncertainty into climate change radiance and geophysical product analyses.



Considering the wide range of existing satellite cal/val approaches, the high accuracy of aircraft sensors, combined with the ability to perform pre- and post-campaign calibration tests to confirm the radiometric performance, make satellite underflight comparisons like those presented here uniquely capable of assessing infrared satellite observations with sufficient accuracy and traceability.

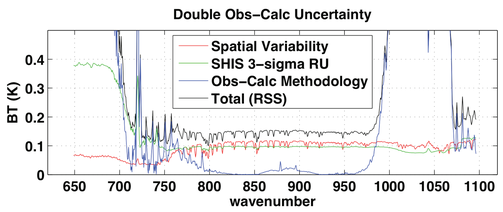
The first Suomi NPP dedicated airborne calibration validation campaign was conducted in May 2013 with a primary objective of providing detailed validation of CrIS radiance observations and meteorological products. During this calibration validation campaign, the NASA ER-2 aircraft instrument payload included the **UW-SSEC Scanning-High resolution Interferometer Sounder (S-HIS)**, the NPOESS Atmospheric Sounder Testbed-Interferometer (NAST-I), the NPOESS Atmospheric Sounder Testbed-Microwave Spectrometer (NAST-M), the NASA MODIS/ASTER airborne simulator (MASTER), and the NASA JPL Airborne Visible / Infrared Imaging Spectrometer (AVIRIS).

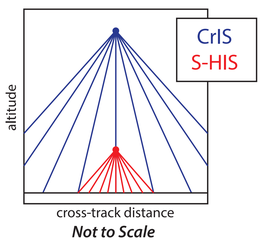
Eleven ER-2 under-flights of the Suomi NPP satellite were conducted during the mission. **The best conditions for radiance validation of CrIS with S-HIS were encountered for the 2013-05-15, 2013-05-30, 2013-05-31, and 2013-06-01 flights.** During each of these flights, the ER-2 flew a straight and level flight leg at ~20.0 km altitude (50 mbar) along the suborbital track of Suomi NPP. **This poster provides an overview of the radiometric calibration, calibration verification, and traceability of the S-HIS validation data. The S-HIS has proven to be a extremely well characterized and understood, carefully maintained, and accurately calibrated reference instrument with a well defined radiometric uncertainty and traceability path.**

A detailed intercalibration assessment between the CrIS and S-HIS instruments for four under-flights from the 2013 SNPP airborne calibration validation campaign have been completed. The radiometric uncertainty contributions from both instruments, along with the radiometric uncertainty contribution associated with the comparison methodology are a critical component of the intercalibration and have been included in the analysis and summary result. **The comparisons show excellent agreement, with residual differences less than 0.1K, and well within the combined radiometric uncertainty estimates.**

Double Obs-Calc Comparison Methodology

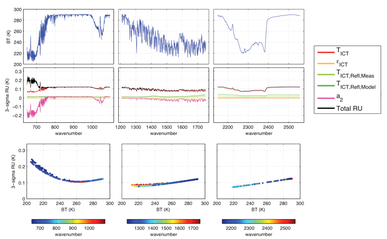
- The resulting residual difference in this method is essentially the difference between the CrIS and S-HIS respective observation minus calculation residuals, reduced to the lowest common spectral resolution for the two instruments.
- The radiance calculations for each instrument assume the same surface conditions, atmospheric state, and forward models. This results in systematic errors that are common to both sets of calculations, and to first order removes the fundamental effects of altitude and view angle differences.
- *For methodology details, refer to: Tobin, David C., et al. "Radiometric and spectral validation of Atmospheric Infrared Sounder observations with the aircraft-based Scanning High-Resolution Interferometer Sounder." Journal of geophysical research 111.D9 (2006): D09S02.*



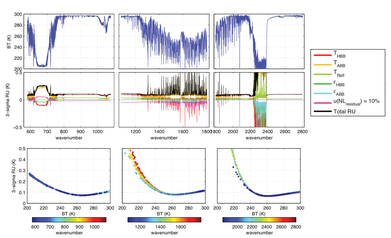


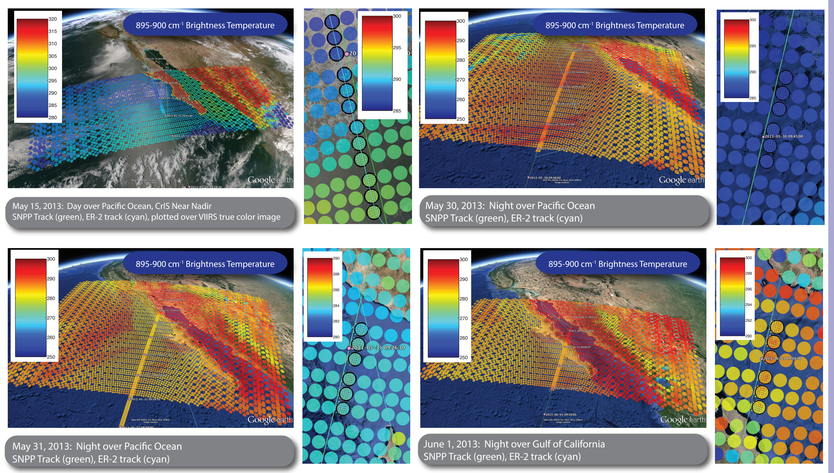
Calibration Verification Results

CrIS Brightness Temperature Spectra and RU
(typical clear sky Earth spectrum)

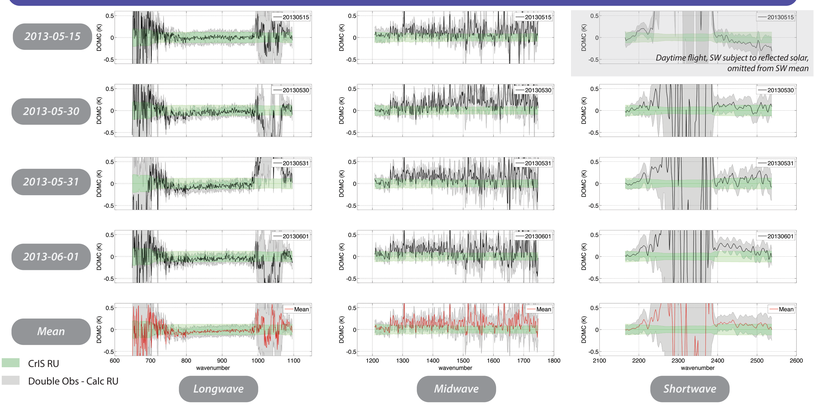


S-HIS Brightness Temperature Spectra and RU
(for flight conditions encountered during the SNPP overpass on 2013-06-01)





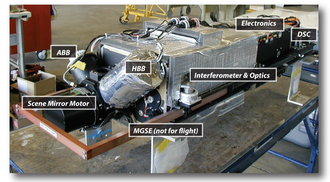
Double Obs - Calc Comparison Results with Radiometric Uncertainty (RU) Estimates



S-HIS

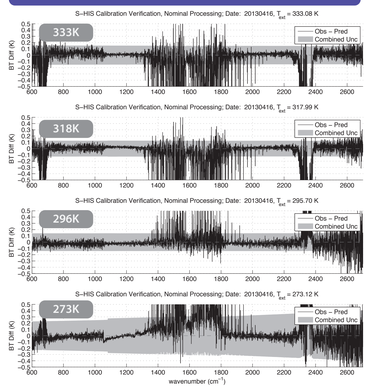
Calibration, Calibration Verification, and Traceability

- Pre-integration **calibration of on-board blackbody references** at subsystem level
- **Pre and post deployment end-to-end calibration verification**
- Instrument calibration during flight using **two on-board calibration blackbodies**
- Periodic **end-to-end radiance evaluations under flight like conditions with NIST transfer sensors.**

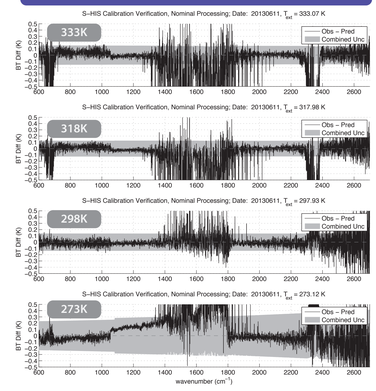


IFOV: 100 mrad (2km @ 20km, nadir)
FOR: Programmable 45° scene mirror nadir ± 40° typical
Spectral Coverage: 580 - 3000 cm^{-1}
Spectral Resolution: 0.5 cm^{-1}

Pre-deployment End-to-end Cal Verification

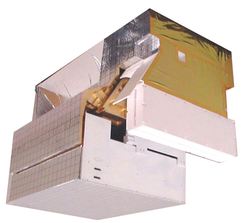


Post-deployment End-to-end Cal Verification



CrIS

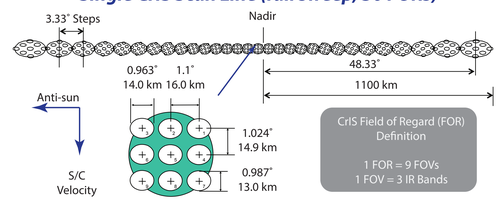
- Infrared **Fourier transform spectrometer** with **1305 spectral channels; produces high-resolution, three-dimensional temperature, pressure, and moisture profiles.** Designed to give scientists more refined information about Earth's atmosphere and improve weather forecasts and our understanding of climate.



CrIS Sensor Features

- 8 cm clear aperture
- 3 spectral bands
- 3x3 FOVs, 14 km diameter at nadir
- PV MCT detectors
- 4-stage passive cooler
- Plane mirror interferometer with DA
- Internal spectral calibration
- Deep-cavity calibration target

Single CrIS Scan Line (full sweep, 30 FORs)



joe.taylor@ssec.wisc.edu, Space Science and Engineering Center, University of Wisconsin-Madison, 1225 West Dayton Street, Madison WI 53706 USA