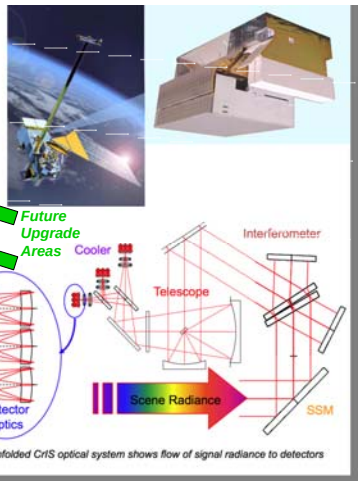
University of Wisconsin-Madison, Space Science and Engineering Center

Expected Accuracy of the Cross-track Infrared Sounder (CrIS) for the US NPOESS

Hank Revercomb, David C. Tobin, Robert O. Knuteson, Joe K. Taylor, Lori Borg, Fred A. Best

CrIS:

- Part of the Crosstrack Infrared and Microwave Sensor Suite (CrIMSS) on NPP and NPOESS to produce all-weather high vertical resolution vertical profiles of temperature, moisture, and pressure
- Plane-Mirror Interferometer With DAPS
- Large 8 cm Clear Aperture
- Three Spectral Bands
  - LWIR: 650-1095 cm^{-1} (0.625 cm^{-1} res.)
  - MWIR: 1210-1750 cm^{-1} (1.25 cm^{-1} res.)
  - SWIR: 2155-2550 cm^{-1} (2.5 cm^{-1} res.)
- 1305 Total Spectral Channels
- 3x3 FOVs at 14 km Diameter for each Band
- Photovoltaic Detectors in All 3 Bands
- 4-Stage Passive Detector Cooler (81K)
- Internal Laser Wavelength Calibration
- Deep-Cavity Internal Calibration Target
- Passive Vibration Isolation System Allows Robust Operation
- Modular Construction

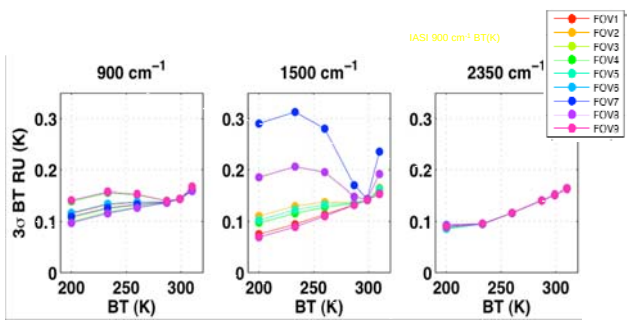


Tobin et al., OSA FTS 2005

Partially unfolded CrIS optical system shows flow of signal radiance to detectors

CrIS FM1 In-flight Radiometric Uncertainty (3-sigma Tb)

versus scene T for all FOVs at ~mid-band

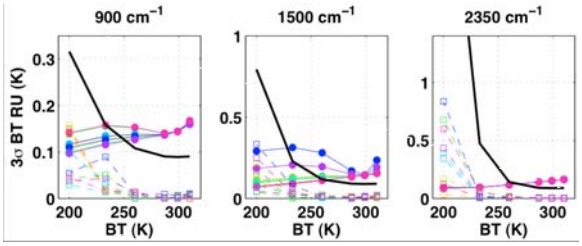


Expected Uncertainty <0.2 K 3-sigma

(larger uncertainty for some MW FOVs from non-linearity will be reduced using in-flight data)

TVAC Testing 3-sigma Radiometric Uncertainty

Compared to CrIS Calibration Uncertainty



- Colored, Filled, Circles = CrIS Inflight Uncertainty
- Colored, Open, Squares = TVAC Residuals (absolute value)
- Solid Black Line = TVAC testing Uncertainty

TVAC validation is generally excellent

(Note that even very small ST emissivity uncertainty causes testing uncertainty to exceed CrIS uncertainty for coldest Ts & SW band)

On-orbit radiometric calibration equation:

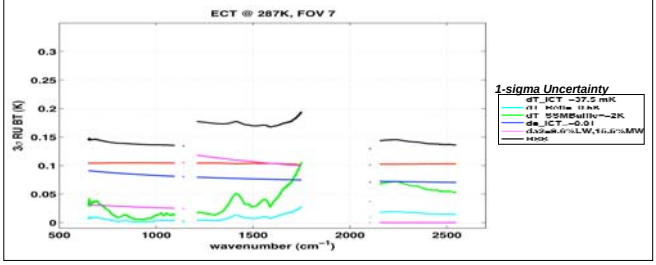
$$R_{Earth} = Re\{(C'_{Earth} - C'_{Space})/(C'_{ICT}-C'_{Space})\}(R_{ICT}-R_{Space}) + R_{Space}$$

with: $R_{ICT} = \varepsilon_{ICT}\, B(T_{ICT}) + (1-\varepsilon_{ICT})\, R_{ICT,Reflected}$

$R_{Space} = B(T_{Space})$

$C' = C\,(1+2\, a_2 V_{DC})$

Parameter	1-σ uncertainty	3-σ uncertainty	Source/Comment
T_{ICT} (K)	37.5 mK	112.5 mK	Bomem/ITT eng. estimate (w/o known readout issue)
ε_{ICT} ( )	0.01	0.03	Independent measurement (TSSR) at 2500 cm^{-1} plus Analysis
$T_{refl,measured}$ (K)	0.5 K	1.5 K	Temperature monitored components (Frame, OMA, BS, ICT Baffle)
$T_{refl,modelled}$ (K)	2 K	6 K	Worst case estimate of unmonitored SSM Baffle T variations
a_2 (1/counts)	9.6% Longwave 15.5% Midwave	28.8% Longwave 46.5% Midwave	DM and ECT view analysis



TVAC calibration equation for ECT view:

$$R_{ECT} = Re\{(C'_{ECT} - C'_{ST})/(C'_{ICT}-C'_{ST})\}(R_{ICT}-R_{ST}) + R_{ST}$$ **Calibrated**

with:

$R_{ST} = \varepsilon_{ST}\, B(T_{ST}) + (1-\varepsilon_{ST})\, B(T_{ST,Relected})$

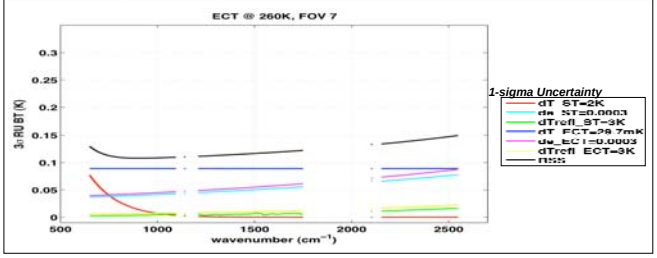
$R_{ICT} = \varepsilon_{ICT}\, B(T_{ICT}) + (1-\varepsilon_{ICT})\, R_{ICT,Reflected}$

$C' = C\,(1+2\, a_2 V_{DC})$

TVAC "truth": ECT view predicted:

$$R_{ECT} = \varepsilon_{ECT}\, B(T_{ECT}) + (1-\varepsilon_{ECT})\, B(T_{ECT,Relected})$$ **Predicted**

Parameter	Value	1-σ uncertainty	3-σ uncertainty	Source/Comment
T_{ECT} (K)	200-310 K	29.7 mK	89.1 mK	Bomem/ITT estimate recent new Hart/UW absolute cal info, and without spatial gradients
ε_{ECT} ( )	0.9995	0.0003	0.0009	Bomem report
$T_{ECT,Reflected}$ (K)	T_{ICT}	3 K	9 K	Conservative estimate
T_{ST} (K)	105 K	2 K	6 K	Conservative estimate
ε_{ST} ( )	0.9995	0.0003	0.0009	Bomem report
$T_{ST,Reflected}$ (K)	T_{ICT}	3 K	9 K	Conservative estimate



Summary of CrIS Accuracy

- The absolute calibration of CrIS Radiance is expected to be better than 0.2 K 3-sigma brightness temperature on orbit for all scene temperatures and wavenumbers
- TVAC testing validates this expectation, except for temperatures below 250 K where the Space Target has larger emissivity uncertainty than a true space view

This poster includes independent analysis of CrIS Flight Model 1 thermal vacuum test data performed by the SSEC/UW-Madison under IPO support, and with the help of ITT, NGAS, & other Government contractors (see also Vancouver OSA, 27-30 April 2009, Tobin et al., HMC1 & Taylor et al., FMA4; Suitland SOAT, 20-21 May 2009, Tobin et al.; SDL SOAT, 9-11 Sept 2009, Revercomb et al.)