FIRST COMPARISION OF RADIANCES MEASURED BY AIRS/AQUA AND HIRS/NOAA-16&17

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1.INTRODUCTION

❑ Cross sensor radiance comparison between the hyperspectral thermal sensor of AIRS/Aqua with the operational multispectral thermal sounders HIRS/NOAA-16 and -17 is highly significant for the validation of instrument performance as well as sounding applications.

❑ Radiance intercomparison between AIRS and HIRS using simultaneous nadir observations allows us to better characterize the instrument performance with minor uncertainties. It also provides us with means for comparing the performance of alternative calibration algorithms.

❑ Using AIRS hyperspectral data considerably reduces the associated spectral and radiometric uncertainties in the comparisons.

2.METHOD

Satellite Data

❑ Simultaneous nadir observations (radiance) between AIRS/Aqua and HIRS/NOAA-16 & 17 from March 11, 2003 to October 1, 2003 in the polar region

❑ AIRS/Aqua Level-1B radiance, and HIRS/NOAA-16 & 17 Level-1B radiance

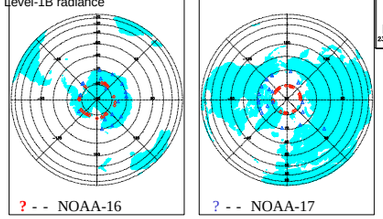


Table 1. Specification of AIRS/Aqua and HIRS/NOAA

	AIRS/Aqua	HIRS/NOAA
Spectral coverage	3.74~4.61μm 6.20~8.22μm 8.88~15.4μm	7 channels:3.70~4.60μm 12 channels:6.5~15.0μm
Scan angle	±49.5 from nadir	±49.5 from nadir
IFOV	1.1°	SWIR: 1.4 ° LW IR: 1.3 °
Earth view coverage	13.5 km at Nadir	20.3 km at Nadir SWIR 18.9 km at Nadir LWIR

Collocating and remapping spatially, and convolving spectrally

▪ Simultaneous nadir overpasses between Aqua and NOAA-16 & -17 occurs every 2-3 days and are predicted using orbital perturbation models (Cao, et al., 2003). Simultaneous nadir observations between AIRS and HIRS are selected based on the following criteria: nadir pixel distance < half the size of the HIRS pixel (~10 km), and solar zenith angle difference <1 °

▪ Convolving the AIRS spectral radiance with the HIRS spectral response:

$$R_{COV} = \frac{\int_{l_1} R_{AIRS}(l) \bullet w(l) \bullet dl}{\int_{l_1} w(l) \bullet dl} \qquad w(l_1) = \frac{\int_{l_1-\Delta l}^{l_1+\Delta l} SRF_{HIRS}(l_1) \bullet SRF_{AIRS}(l) \bullet dl}{\int_{l_1-\Delta l}^{l_1+\Delta l} SRF_{AIRS}(l) \bullet dl}$$

▪ Pixel-by-pixel match by remapping HIRS pixels to AIRS pixels based on ground distance. A small data set near the nadir is chosen (± 50 scanline from the nadir intersection) .

▪ The mean and standard deviation of the radiance difference at the pixel level inside a 4x5 window at nadir are computed.

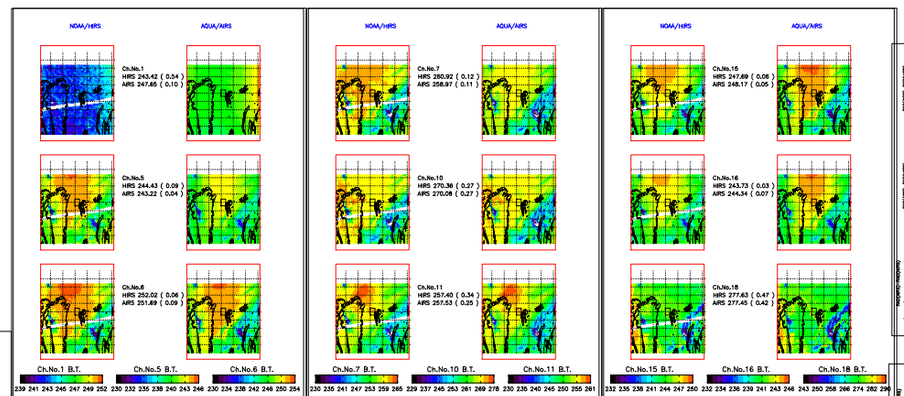


Figure 2. Example data set shows simultaneous nadir observations between AIRS/Aqua and HIRS/NOAA-16 on July 22, 2003. AIRS data are spectrally convolved with HIRS spectral response functions, and HIRS pixels are remapped to AIRS pixels. The black box in the center represents the 4 by 5 pixels window near the nadir intersection of these two satellites, for which the brightness temperature differences (mean and standard deviation) are given in the parenthesis.

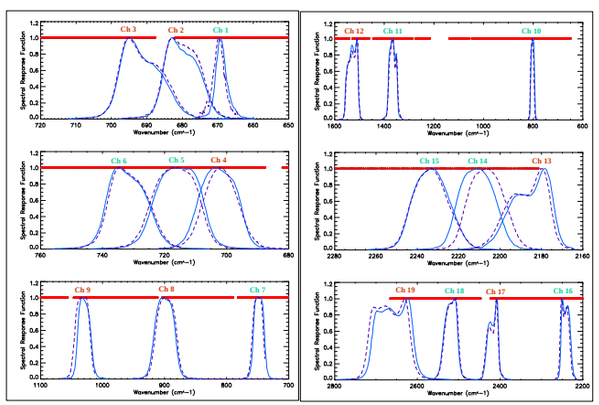
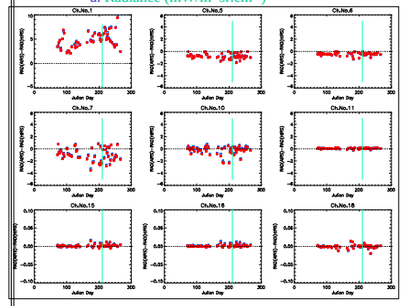


Figure 1. HIRS spectral response functions for the 19 IR channels (solid line for NOAA-16; dashed line for NOAA-17). Red lines show the corresponding AIRS spectral channel coverage. Only 9 HIRS IR channels are fully spectrally overlapped by AIRS, shown as green color.

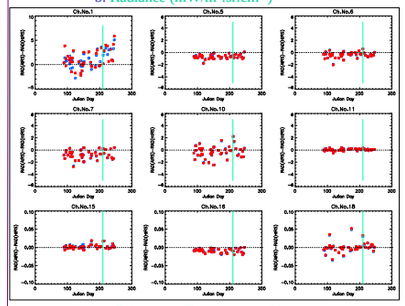
HIRS/NOAA-16 vs. AIRS/Aqua

a. Radiance ($mW/m^2.sr.cm^{-1}$)

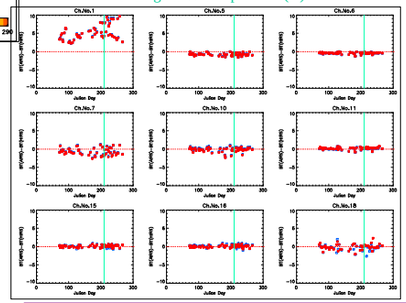


HIRS/NOAA-17 vs. AIRS/Aqua

b. Radiance ($mW/m^2.sr.cm^{-1}$)



c. Brightness Temperature (K)



d. Brightness Temperature (K)

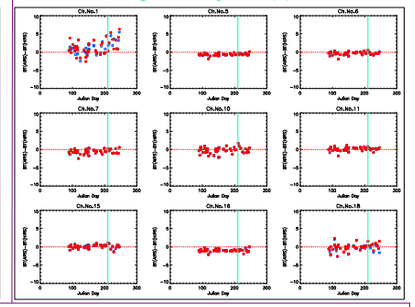


Figure 3. Difference between AIRS (spectrally convolved to match HIRS) and HIRS are given in radiance (a and b), and brightness temperature (c and d). The green line indicates the date when AIRS L1B data changed from version V. 2.7 to V. 3.05.

a. and c. - NOAA-16; b. and d. - NOAA-17; ? - HIRS calibration algorithm 3; * - HIRS calibration algorithm 4

Table 2. Brightness temperature comparison summary. $?BT_1$ and $?BT_2$ represent the difference (AIRS – HIRS) for HIRS calibration algorithm 3 and 4 respectively.

AIRS-HIRS			Ch. 1	Ch. 5	Ch. 6	Ch. 7	Ch. 10	Ch. 11	Ch. 15	Ch .16	Ch. 18
NOAA-16	$?BT_1$	mean	5.1	-0.8	-0.5	-0.7	-0.1	0.04	0.02	0.1	-0.4
		Std	2.1	0.4	0.2	0.9	0.6	0.3	0.4	0.4	0.8
	$?BT_2$	mean	5.0	-0.8	-0.5	-0.8	-0.3	0.1	0.02	-0.01	-0.2
		std	2.0	0.4	0.2	0.9	0.6	0.3	0.3	0.3	0.8
NOAA-17	$?BT_1$	mean	1.0	-0.7	-0.4	-0.7	-0.3	0.07	0.08	-1.0	-0.3
		std	1.6	0.3	0.4	0.6	0.8	0.5	0.5	0.3	0.9
	$?BT_2$	mean	1.0	-0.7	-0.4	-0.7	-0.3	0.07	0.05	-1.0	-0.1
		std	1.9	0.3	0.4	0.6	0.8	0.5	0.5	0.4	0.9

3.Summary

1. Overall, HIRS/NOAA-16 and -17 observed radiances are in good agreement with those of AIRS/Aqua. The differences are within ~0.8K for eight out of the nine channels compared, with AIRS observations being slightly warmer.
2. Large difference (>5.0K) are observed for HIRS/NOAA16 channel 1, probably due to calibration uncertainties and large noise in HIRS channel 1. It is reduced substantially (to 1.0K) for NOAA-17
3. AIRS radiances are consistent with both HIRS/NOAA-16 and HIRS/NOAA-17
4. HIRS calibration algorithms 3 and 4 produced similar results for most channels, however, with a better agreement for algorithm 4 in shortwave channels, such as channel 16 and 18.

Acknowledgements:

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References:

Cao, C., M. Weinreb, and H. Xu, 2003, Predicting simultaneous nadir overpasses among polar-orbiting meteorological satellites for the inter-satellite calibration of radiometers, Journal of Atmospheric and Oceanic Technology, in press.