INTERCALIBRATION OF GEOSTATIONARY IMAGERS VIA HIGH SPECTRAL RESOLUTION AIRS

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CALCON

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INTRODUCTION

Purpose

• Global applications of weather/environmental satellites require comparisons of the outputs from the various operational instruments.

• Radiance validation of new instruments during post-launch checkout provides confidence in instrument performance or could provide an indication of a problem.

Radiometric Accuracy

• AIRS on Aqua has become the desired standard to compare to all GEOs.

• AIRS calibration accuracy is believed to be within 0.1 K for most of the spectra.

• Knowing the limits of calibration accuracy makes satellite data more useful for a wide range of applications and products.

Data Collection

• Geo/Leo within +/- 30 Minutes

• Leo within +/- 10 degrees Lat/Lon of geostationary satellite nadir viewing location

Spatial Averaging

• Geo and Leo data smoothed to 100 km (effective resolution) using a moving average.

• Smoothing and averaging reduces the effects of possible navigation errors and the differences between instrument resolutions.

• The Mean Radiance inside the Intercalibration Area is calculated from the spatially averaged data.

METHODS

"Original" Intercalibration Equation

• Geo minus Leo

• Forward model calculated radiances are subtracted from measured mean radiances. This is necessary when comparing two broadband instruments to account for differences in their spectral response functions.

• LEO = Low Earth Orbiting Instrument (HIRS or AVHRR)
• GEO = Geostationary Orbiting Instrument
• Mean = Measured Mean Radiance in Intercalibration Area
• Clear = Forward Model Calculated Clear Sky Radiance
• R = Radiance (mW/m²/ster/cm⁻¹)
• T = Temperature (K)
• ΔT_{CAL} = Brightness Temperature Difference
• B^{-1} = Inverse Planck Function Conversion From Radiance to Temperature

$$R_{Cal} = \left[R^{GEO}_{Mean} - R^{GEO}_{Clear}\right] - \left[R^{LEO}_{Mean} - R^{LEO}_{Clear}\right]$$

Convert to Brightness Temperatures

$$T_{CAL} = \left[B^{-1}_{Mean}{}^{GEO} - B^{-1}_{Clear}{}^{GEO}\right] - \left[B^{-1}_{Mean}{}^{LEO} - B^{-1}_{Clear}{}^{LEO}\right]$$

Intercalibration Equation Applied to AIRS

• AIRS radiances are convolved with GEO spectral response functions.

• Spectrally convolved AIRS radiances are compared with measured GEO radiances.

• $\Delta T = B^{-1}_{Mean}{}^{GEO} - B^{-1}_{Mean}{}^{AIRS}$

• AIRS replaces the broadband HIRS or AVHRR and provides a more accurate comparison

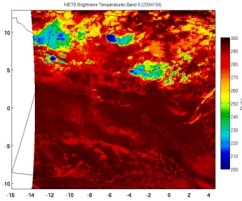
Should Differences with AIRS be expected?

• When AIRS radiances are convolved with GEO spectral response functions, any substantial gaps in the AIRS spectra creates some "convolution error." The magnitude of this error increases as the gaps in the AIRS spectral coverage increase and with more variable spectra.

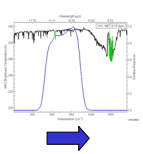
• Convolution error is small for some channels, such as the IRW, but large in others, such as the water vapor channels.

• In addition to convolution error, other contributions to the difference can come from temporal, field of view size and shape, viewing angle differences and navigation differences as well as GEO spectral response function uncertainty.

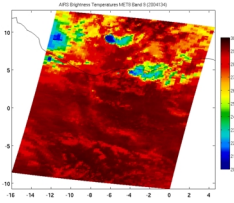
Convolution Example With MET-8 IR Window



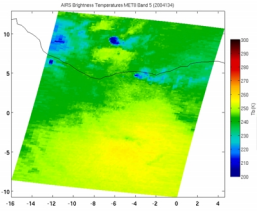
10.8 µm Window Channel



Convolve AIRS with GEO SRF



Gap Filling Example With MET-8 Water Vapor



AIRS data with spectral gaps convolved with MET-8 SRF

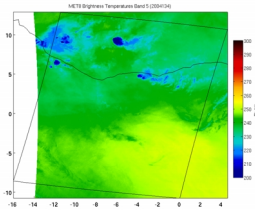
Correcting for AIRS Spectral Gaps

• Gaps can be filled with theoretical spectral information such as an adjusted US Standard atmosphere spectrum (shown here)

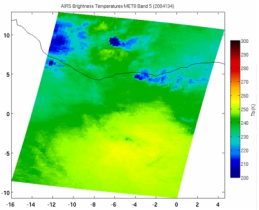
• Gaps can be filled with with calculated spectral information from forward model calculations performed on AIRS retrievals.

• A correction can be applied if the effect of the gaps is known or estimated

Any of these methods improve the comparisons in bands with large spectral gaps, such as the water vapor.



Meteosat-8Observed 6.2 µm Water Vapor Channel



AIRS data with spectral gaps filled by theoretical spectra (adjusted US Std Atmosphere).

THE GLOBAL OBSERVING SYSTEM

Brightness Temperature Differences

• Spectral gaps ignored for initial analysis

• Brightness Temperature Differences are GEO-AIRS

Notes:

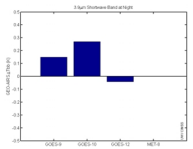
• Central wavelengths listed on plots are approximate.

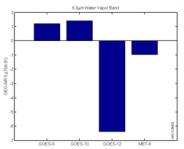
• MET-8 water vapor band is the 7.4 micron band.

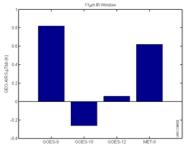
• There is no MET-8 3.9 micron band comparison because the band is wider than AIRS coverage and a reasonable comparison cannot be made.

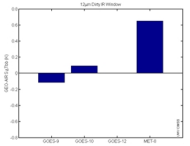
• GOES-12 does not have a 12 micron band.

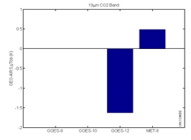
• GOES-9 and –10 do not have 13 micron bands







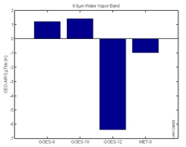




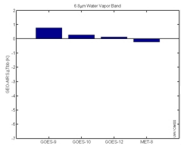
Results Correcting for AIRS Spectral Gaps

• Gaps were filled with theoretical spectral information from an adjusted US Standard atmosphere spectrum

• The adjustment is made by forcing the calculated spectrum to fit the measured spectrum at the gap edges. Then the calculated spectrum is adjusted (up and down) by the weighted average between the gap edges.



Water Vapor Results *Before* Filling the gaps



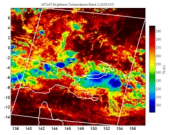
Water Vapor Results *After* Filling the gaps

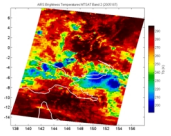
New To The Scene: MTSAT-1R and FY-2C

• Preliminary comparisons of the latest geostationary imagers to AIRS have begun.

• Preliminary results with MTSAT-1R show good agreement with AIRS but more work needs to be done.

• Preliminary results with FY-2C indicate there may be problems with FY-2C calibration for various bands (for instance too cold in cold scenes for the IR window and imagery is unusable near midnight). Much work needs to be done to better characterize FY-2C calibration.





MTSAT-1R compared to AIRS IR Window preliminary comparison.

Discussion

• Intercalibration using AIRS is powerful due to AIRS calibration accuracy and higher spectral resolution.

• Filling AIRS spectral gaps generally improves the results (smaller satellite-to-satellite differences); there are still large differences in some bands where the gaps are too large to be reliably filled.

• Results show that the operational geostationary imagers are generally well-calibrated for most bands.

• Comparisons between AIRS and the GOES series of Imagers show similar results.

For more information, including results with more satellite instruments such as GOES, AVHRR, and HIRS visit the CIMSS Intercalibration web page:

http://cimss.ssec.wisc.edu/goes/intercal/

Acknowledgements

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