Agenda Item: II/2
Discussed in WG-II

NOAA EXPERIENCE USING R&D SENORS

Summary and Purpose of Document

Response to Action 31.26 and an update to the intercalibration work reported previously.

Action Requested: None

INTERCALIBRATION OF OPERATIONAL GEOSTATIONARY IMAGERS AND POLAR-ORBITING AIRS

Mathew M. Gunshor [1], Timothy J. Schmit [2], and W. Paul Menzel [3]

1 Cooperative Institute for Meteorological Satellite Studies
2 NOAA/NESDIS/ORA/ASPT
3 NOAA/NESDIS/ORA
Madison, Wisconsin, 53706 USA

1. INTRODUCTION

The ability to compare the measured radiances from different instruments has become increasingly important, as satellites traditionally used for weather monitoring have proven to be useful for a variety of weather and climate applications. The Cooperative Institute for Meteorological Satellite Studies (CIMSS) has been intercalibrating the infrared window (IRW) and water vapor (WV) channels on geostationary satellites (GOES Imagers, METEOSAT, GMS-5) with a polar-orbiting satellite (NOAA HIRS and AVHRR) on a routine, automated basis using temporally and spatially co-located measurements. Those results have been reported at past CGMS meetings and updated results are posted at http://cimss.ssec.wisc.edu/goes/intercal. This paper introduces early results on intercomparison of the geostationary instruments with high spectral resolution AIRS (Atmospheric Infrared Sounder) data.

2. APPROACH

The intercalibration approach has been described in prior CGMS proceedings (see for example CGMS XXXI USA-WP-29); it has been adapted for AIRS data. As before, requirements for intercal include collocation in space and time (within thirty minutes) within 10 degrees from nadir for each instrument in order to minimize viewing angle differences. Data from each satellite are averaged to an effective 100 km resolution to mitigate the effects of differing field of view (fov) sizes and sampling densities; AIRS has a nadir 13 km fov, GOES-9, -10, and -12 imagers over-sample 4 km in the east west by a factor of 1.7, and METEOSAT-5 and –7 have a nadir 5 km fov. Mean radiances are computed within the collocation area. Mean radiances are converted, via the inverse Planck function, into brightness temperatures and the temperature difference between the GEO and AIRS is calculated.

The AIRS high spectral resolution data are convolved with the geostationary instrument's spectral response function (SRF). This mitigates the need for the very difficult correction for spectral response differences between two broadband instruments and is the considerable advantage of intercalibrating a broadband with a high spectral resolution instrument. After data are collocated and collected, AIRS is convolved with the geo SRF and the resulting data that are averaged to an effective 100 km resolution. The mean radiance computed for the convolved AIRS data is converted into brightness temperature using the same inverse Planck function used for the GEO radiances.

A representative AIRS spectrum is plotted with select spectral response functions from the five geostationary instruments in Figures 1 through 5. The AIRS instrument does not cover the entire range of wavelengths covered by the geostationary instruments. The spectral range of the GEO infrared windows is covered completely, but there are large spectral gaps in the water vapor channel coverage (see Figure 2) that degrade the intercomparisons.

3. RESULTS

Intercalibration results for the five geostationary satellites (between 21 January 2004 and 25 March 2004) with convolved AIRS data are shown in the tables below. In Table 2 there are much fewer comparisons for Meteosat-7 in the water vapor channel; this is due to a scheduling conflict and fewer images satisfy the temporal data collection requirement. The ΔTbb is the average of all cases for the indicated satellite and a negative sign indicates the convolved measurements from AIRS are warmer than those from the geostationary instrument. The standard deviation is the deviation about the mean. Differences for the infrared window bands are smaller, as was found in the broadband intercomparisons also (see for example CGMS XXXI USA-WP-29). The results for the water vapor channel in Table 2 are larger as expected since the gaps in AIRS spectral coverage (Figure 2) account for most of the temperature differences. The effect is exacerbated for the wider channels on GOES-12 and Meteosat because a higher percentage of the SRF falls in the spectral gap. The results for the 3.9 μm bands are separated into “Day versus Night” because that band is particularly sensitive to reflected solar energy during the day and the nighttime results are more reliable. The GOES-12 13.3 μm band (not shown) was found to have a mean difference ΔTbb of –0.75K and a standard deviation of 0.38K for 15 cases.

Geo:	GOES-9	GOES-10	GOES-12	MET-7	MET-5
N	14	16	15	14	16
ΔTbb (K)	-0.63	-0.10	-0.13	-0.87	-1.93
STD (K)	1.04	0.35	0.55	0.38	.55

Table 1. 11μm band results. ΔTbb (GEO minus AIRS) is the mean of N cases.

Geo:	GOES-9	GOES-10	GOES-12	MET-7	MET-5
N	14	16	15	6	16
ΔTbb (K)	-1.31	-1.35	-9.94	-7.24	-9.26
STD (K)	0.39	0.18	0.49	0.54	2.42

Table 2. 6 μm band results. ΔTbb (GEO minus AIRS) is the mean of N cases.

Geo:	GOES-9	GOES-10
N	14	16
ΔTbb (K)	-0.50	0.32
STD(K)	1.03	0.32

Table 3. 12 μm band results. ΔTbb (GEO minus AIRS) is the mean of N cases.

Geo:	GOES-9	GOES-10	GOES-12
N	8	16	14
N (Day)	7	11	8
N (Night)	1	5	6
ΔTbb (K)	-0.97	-0.06	-0.62
ΔTbb (K) (Day)	-1.16	-0.25	-1.13
ΔTbb (K) (Night)	0.35	0.37	0.07
STD (K)	0.95	0.42	0.74
STD (K) (Day)	0.85	0.35	0.51
STD (K) (Night)	NA	0.17	0.29

Table 4. 3.9 μm band results. ΔTbb (GEO minus AIRS) is the mean of N cases.
Day and night are determined by local sunrise and sunset times.

4. DISCUSSION

Intercomparison of GEO and AIRS finds that the GEO instruments generally compare most favorably in the infrared window channel. The best (differences closest to 0 K) comparisons in that channel are for the GOES instruments, particularly GOES-10 and –12.

The 3.9μm band, sensitive to reflected solar radiation, shows correlation between ΔTbb and time of comparison. The correlation is strongest for GOES-12. The correlation for GOES-10 is not as strong, possibly due to the fact that the data was collected very close to sunrise and sunset times.

The results are highly dependent upon the accuracy of GEO SRF measurements.

5. CONCLUSIONS/FUTURE WORK

Intercalibration with AIRS is a very powerful calibration tool as AIRS calibration is generally considered to be very accurate. A method is being devised to fill AIRS spectral gaps and should be reported on at the AMS Satellite Meteorology and Oceanography conference later this year. Meteosat-8 data is just now becoming readily available at CIMSS and plans are to repeat this process with the bands on that instrument. Automation of the AIRS intercalibration is under study; when implemented it will facilitate greater numbers of intercomparisons.

CIMSS intercalibrate geostationary instruments daily with NOAA-15 and –16 HIRS and AVHRR; time series plots and other information reside at http://cimss.ssec.wisc.edu/goes/intercal.

6. FIGURES

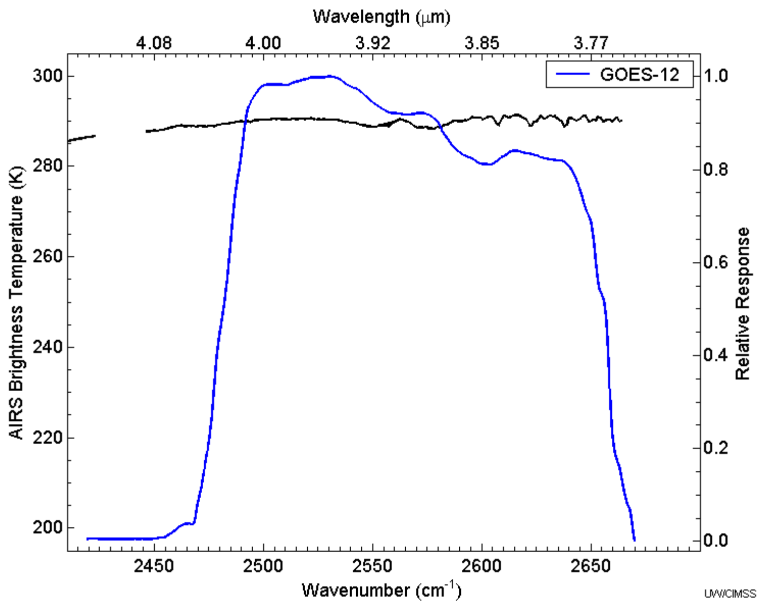

Figure 1. 3.9 μm band GOES-12 spectral response function plotted with representative AIRS brightness temperature spectrum. GOES-9 and GOES-10 have similar spectral coverage. Note that on the shortwave side, AIRS coverage ceases very close to the end of GOES spectral coverage.

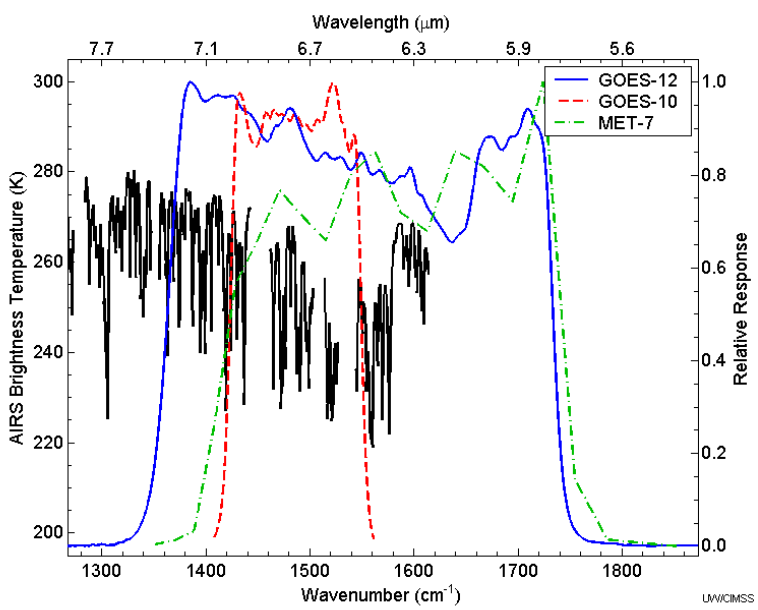

Figure 2. 6 μm band spectral response functions plotted with representative AIRS brightness temperature spectrum. GOES-9 has similar spectral coverage to GOES-10 and Meteosat-5 has similar spectral coverage to Meteosat-7. Note the large percentage of SRF not covered on the shortwave side by AIRS data for the wider responses of GOES-12 and Meteosat.

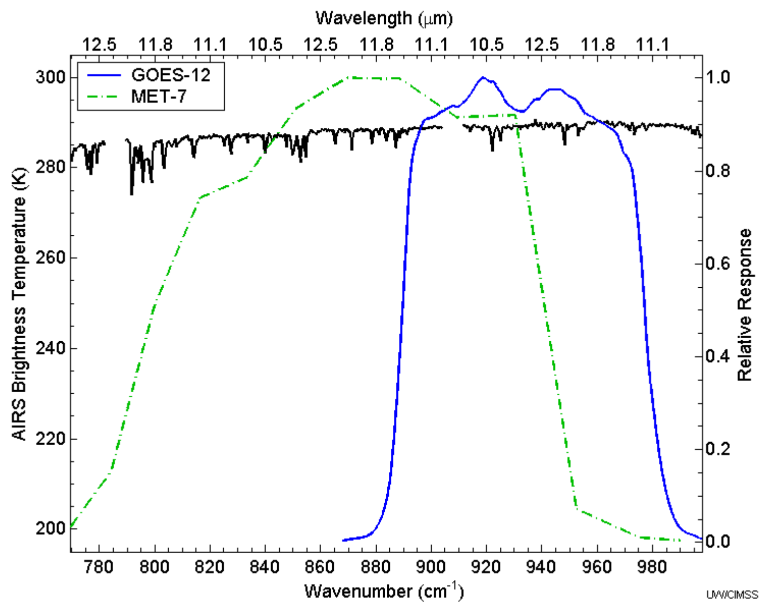

Figure 3. 11 µm band spectral response functions plotted with representative AIRS brightness temperature spectrum. GOES-9 and -10 have similar spectral coverage to GOES-12 and Meteosat-5 has similar spectral coverage to Meteosat-7.

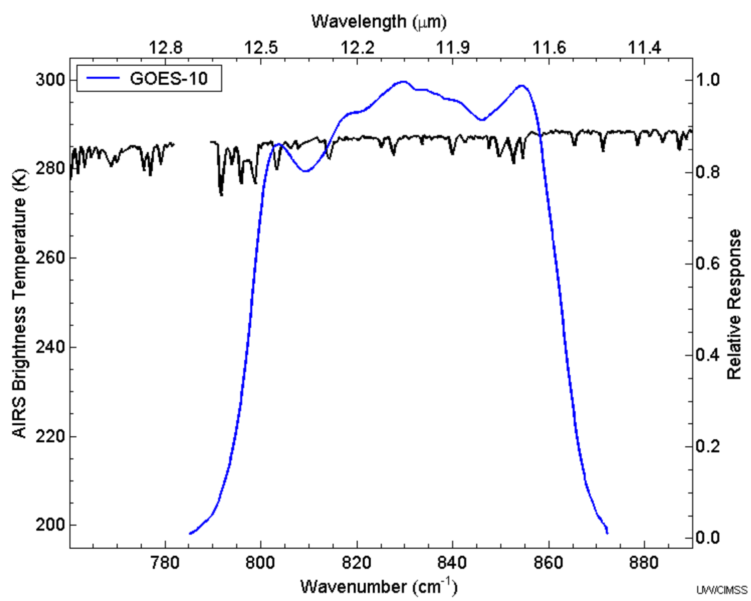

Figure 4. 12 µm band GOES-10 spectral response function plotted with representative AIRS brightness temperature spectrum. GOES-9 has similar spectral coverage to GOES-10.

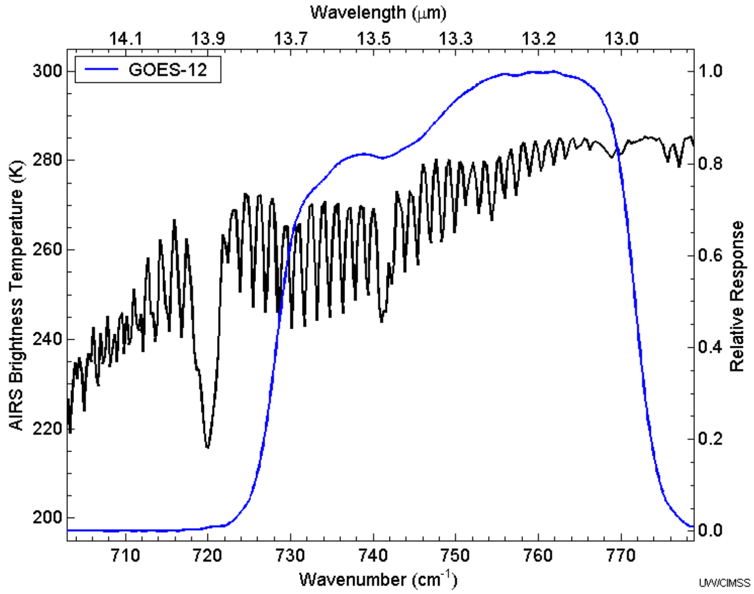

Figure 5. 13 μm band GOES-12 spectral response function plotted with representative AIRS brightness temperature spectrum.