8.6 CALIBRATING GEOSTATIONARY SATELLITE INFRARED SENSORS FOR CLIMATE APPLICATIONS

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1. INTRODUCTION

In spite of on-board calibration, it is important to perform independent tests of satellite calibration to ensure the data are of the highest quality for climate research. Therefore methods have been developed to compare observations between a well-calibrated instrument and other radiometers whose calibration is suspect. In this way, we calibrate infrared radiometers aboard the three primary geostationary series of satellites:

- the U.S. Geostationary Operational Environmental Satellite (GOES) series,
- the Japanese Geostationary Meteorological Satellite (GMS) series, and
- the European Meteosat. Series.

The record of data from these satellites at NCDC covers 1983 to present and most of the globe. The reference instrument with a stable calibration is the High-resolution Infrared Radiation Sounder (HIRS) which has flown on all NOAA polar orbiting satellites since 1983.

The following details the calibration of geostationary sensors using the HIRS instruments. The results from the IR window channel (11µm) are a summary of work detailed by Knapp (2007). Using the same method for the IR water vapor channel, we present preliminary calibration results.

2. IR WINDOW CHANNEL RESULTS

All meteorological geostationary satellites provide observations within the ~11µm IR window (IRWIN) channel. These observations are calibrated on-orbit by having the sensor view an internal blackbody target with a known temperature. However, intercalibration is often required to remove inter-satellite biases. The following is a summary of the IRWIN calibration that is detailed by Knapp (2007).

The HIRS channel 8 is spectrally similar to the geostationary IRWIN channels. Also, the HIRS channel 8 has changed little during the different HIRS flights such that it represents a stable target (that is, a consistent set of observations). This is demonstrated by the daily-averaged channel 8 observations (Figure 1) which show little drift in time as well as little inter-satellite difference.

Much care went into making sure the observations from both satellites were as similar as possible. First, calculations determined which of the smaller (~10km) geostationary IRWIN pixels were within a given HIRS footprint. Second, these spatially collocated observations were then collocated in time (within 30 min) and geometry (to ensure similar viewing geometry). Finally, only observations with spatially smooth (i.e., low spatial standard deviations) were selected for comparisons between the satellites.

The initial comparison between the geostationary observations calibrated with the ISCCP calibration information and the HIRS channel 8 data are provided in Figure 2. In summary, the difference ranges from -4 to 4 K. Most notably, there is a shift in observations near 2001 from differences near zero to differences near 4K. This shift is attributed to a change in the raw data format which resulted in a loss of calibration accuracy. The calibration has been corrected using these match-ups and resulting differences (Figure 3) are much closer to zero. The infrared water vapor channel can be calibrated in an identical manner.

3. WATER VAPOR CHANNEL RESULTS

Given the global coverage of geostationary imagers beginning in 1998, many have worked to calibrate and intercalibrate these water vapor channels (Bréon *et al.*, 1999, Picon *et al.*, 2003, Tjemkes *et al.*, 2001). The work herein is simply an analysis of the calibration tables provided by ISCCP for the water vapor channels in the ISCCP B1 data set.

The spatial and temporal coverage with the geostationary water vapor channel (IRWVP) is less than the IR window. Only the Meteosat series has continuously provided IRWVP

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observations since 1983. The GOES series began IRWVP observations in 1995 with GOES-8 while GMS-5 was the first Japanese satellite to have an IRWVP channel, also starting in 1995. The HIRS instrument has a channel with similar spectral properties to IRWVP: HIRS channel 12. The spectral response function for all geostationary IRWVP channels and the HIRS channel 12 are provided in Figure 4. Most are quite similar providing similar observations. However beginning with NOAA-15, the HIRS channel 12 is quite different. The spectral response was shifted to a colder temperature which is noticed in (Figure 5). Thus, since the NOAA-16 and 17 represent a change in the “HIRS family”, it should not be used in calibration of the geostationary water vapor sensors. Otherwise, the temporal HIRS observations for channel 12 show little drift or inter-satellite biases. Thus, this channel should be an excellent calibration source for geostationary IRWVP channels prior to NOAA-15.

Comparisons were made between geostationary IRWVP and HIRS channel 12 in an identical manner to that summarized above for the IRWIN. The resulting monthly averaged differences are shown by satellite in Figure 6. The comparisons are few in number before 1995 since only the Meteosat had the IRWVP channel. The differences before 1995 show some variation with some differences as large as 5K. However, differences after 2000 are much larger. The trend in NOAA-14 shows the problem. The time series of NOAA-14 observations (Figure 5) shows no significant shifts, but the difference between HIRS and the geostationary satellites (Figure 6) shows a ~10K shift in 2001. Also, the differences between NOAA-16 and the geostationary IRWVP show no difference, but as seen from Figure 5, it should show some difference. So the problem lies in the ISCCP use of NOAA-16 as a reference satellite. In doing so, they began using a sensor whose spectral response was very different from previous HIRS sensors and IRWVP instruments.

4. FUTURE WORK

Much work remains in the calibration of geostationary data for climatological studies. Given the water vapor channel change in the new HIRS instrument, it should not be used for calibration of geostationary IRWVP. This allows one to fix the calibration differences described above for the 2001 to 2006 time period. However, a calibration source is then needed once NOAA-14 ceases operations.

5. REFERENCES

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Picon, L., R. Roca, S. Serrar, J. L. Monge, and M. Desbois, 2003: A new METOSAT "water vapor" archive for climate studies. *Journal of Geophysical Research*, **108**.

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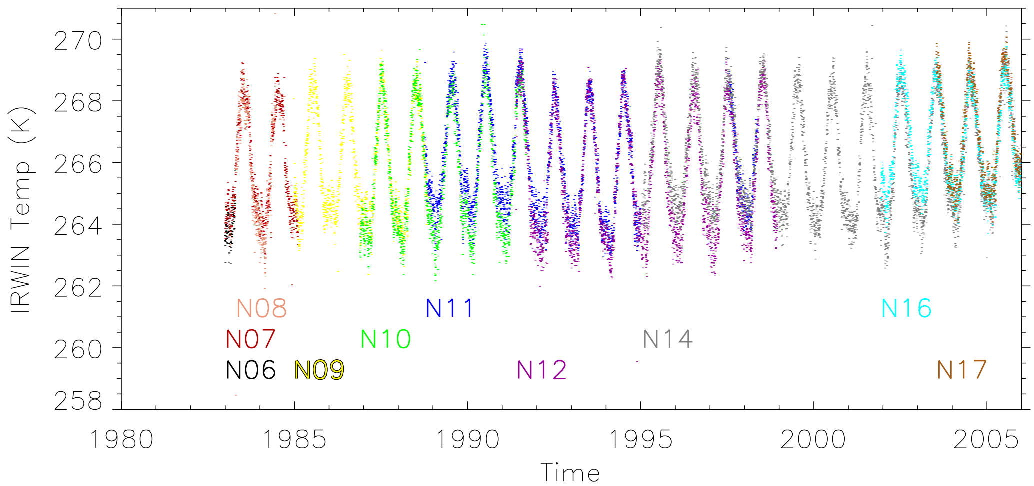

Figure 1. Time series of daily-averaged HIRS channel 8 brightness temperatures from NOAA satellites 6 (N06) through 17 (N17).

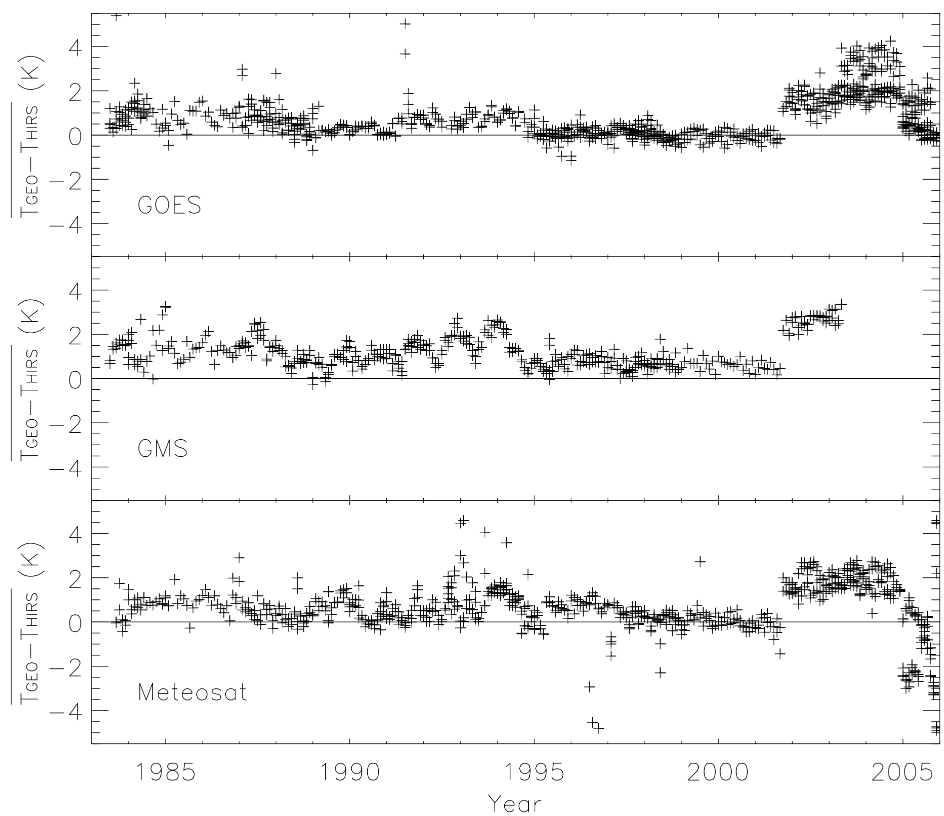

Figure 2. Monthly bias difference grouped by satelite series between T_{GEO} and T_{HIRS} for each satellite-month using the initial matchup filter.

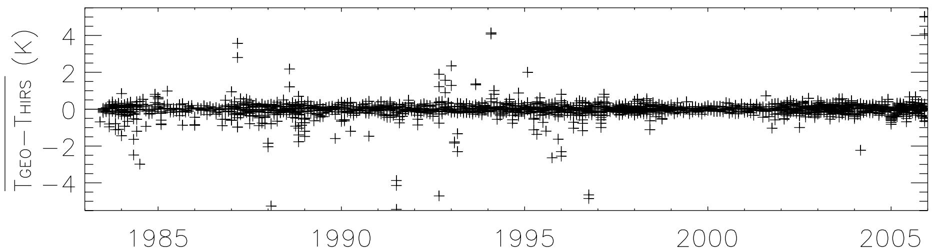

Figure 3. Monthly bias differences for all geostationary satellites and all months available after calibration correction based on the proportionate filter (cf. Figure 2).

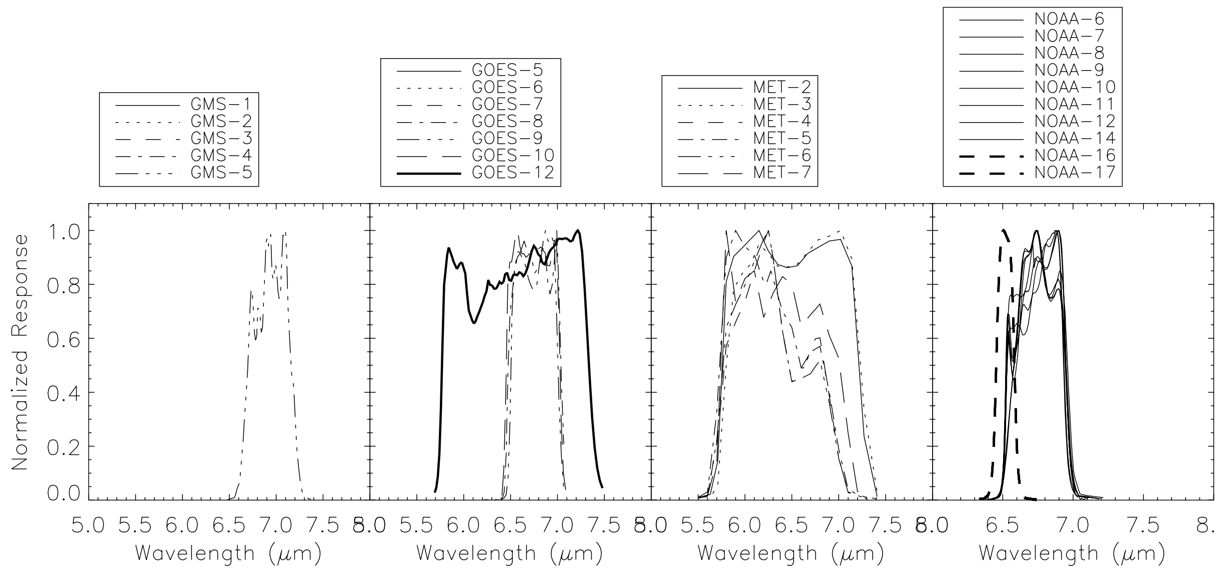

Figure 4. Spectral response functions on the geostationary satellites which provide IRWVP observations and the HIRS channel 12 spectral responses on various NOAA platforms.

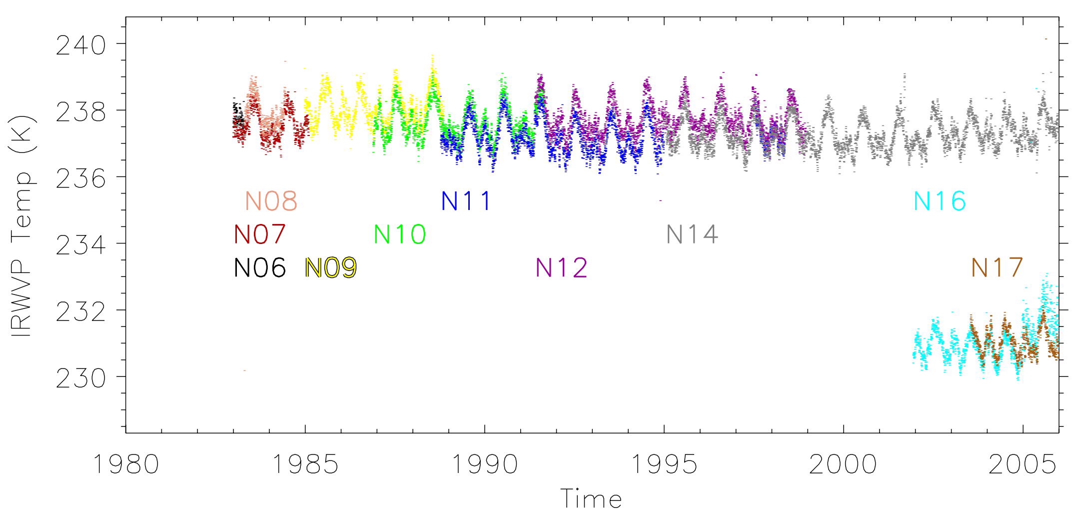

Figure 5. Time series of daily-averaged HIRS channel 12 (IRWVP) brightness temperatures from NOAA satellites 6 (N06) through 17 (N17).

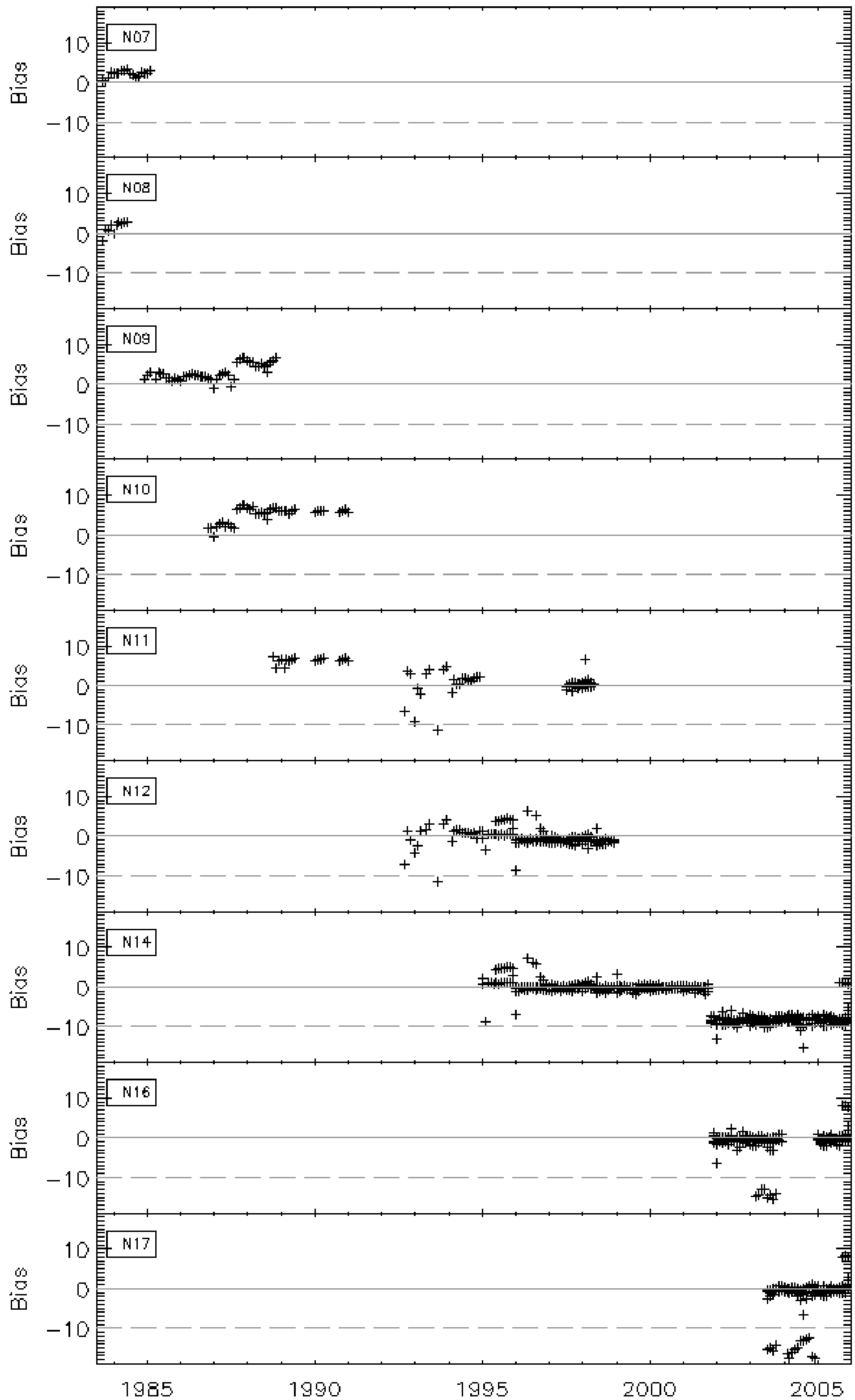

Figure 6. Monthly bias differences between geostationary IRWVP and that from HIRS plotted by the NOAA series.