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Recommendation for Instrument Performance Monitoring Website

In response to CGMS Action 36.14 (GSICS to finalise recommendations for its instrument performance monitoring website).

Instrument performance monitoring is critical for ensuring level 1b product quality for both numerical weather prediction and climate change detection. Since these products are increasingly dependent on data from the international constellation of earth observing satellites, it is important to establish a central interface from which instrument monitoring information from all over the world can be distributed. In this paper, a comprehensive web-interface for real-time instrument performance monitoring, maintained, is introduced. In addition, satellite calibration anomalies are discussed.

Recommendation for Instrument Performance Monitoring Website

1 INTRODUCTION

With more and more environmental satellite data are assimilated in numerical weather prediction (NWP) and climate models, the quality of these satellite data becomes a critical issue in the development of model themselves and analysis of model outputs. However, due to the feature of such ongoing working units, instruments always present some degree of variations, which possibly show fairly different patterns over different space locations or during different period of time. Therefore, a real time monitoring system for instrument status is able to explicitly provide users the information regarding the satellite data quality for product generation and the additional calibration efforts for better quality of satellite data. Meanwhile, long-term instrument monitoring system can also help to identify systematic error that is unknown before launch and to improve future instrument development techniques for better remote sensing. The instrument performance monitoring (IPM) can facilitate the communication of instrument anomalies amongst instrument and calibration scientists. In particular, a web-based IPM system will

- facilitates dissemination of IPM information to satellite program administrators, product providers and data users;
- allow a distributed archive of IPM data and information that is accessible through a single portal; and
- provide an opportunity to "advertise" the importance of calibration programs to numerical weather prediction and climate change detection.

Given these benefits of creating and maintaining a web-based interface for real-time IPM, the coordination center of the Global Space-based Inter-Calibration System (GSICS) – operating under the auspices of the World Meteorological Organization (WMO) – has developed such an interface.

2 Current Operational Instrument Monitoring Systems

At NOAA/NESDIS, instrument performance monitoring has been developed for individual instruments in the past years, either on Polar-orbiting Operational Environmental Satellite (POES) or on Geostationary Operational Environmental Satellite (GOES). Recently, these subsystems are being integrated into the Integrated Calibration/Validation System (ICVS) with a unified design concept. In this report, we will primarily focus on the description of POES IPM.

2.1 *POES MHS (Microwave Humidity Sounder)*

The instrument performance monitoring system for MHS has been designed, implemented, and documented on NOAA-18, Metop-A and NOAA-19. The parameters that the system monitors include pre-existing calibration-related parameters, e.g., calibration coefficients, blackbody and space view counts, and blackbody temperatures. It also includes newly implemented NEΔT, gain, and some instrument housekeeping temperatures, such as local oscillator (LO) temperature and intermediate frequency (IF) baseplate temperature. The latest seven-day orbital scan statistics, such as the numbers of invalid scans, quality control failed scans, and calibration failed scans, are also post on line, which provides users a straightforward quick report on orbit data quality. This instrument performance monitoring system also sent out warning messages to designated recipients when the calculated NEΔTs is

out of their specifications, which indicates that such instrument may face potential degradation in missions.

An example, time series of NOAA-19 MHS H3 cold calibration, warm calibration counts and noise are shown in Fig. 1 and 2. It is clearly shown that both cold and warm calibration counts presented a decreasing trend associated with two abrupt shifts during this period. Meanwhile, the instrument noise, NEΔT, is out of specification at the end of July. The noise continues rising and the instrument gain is decreasing since then. An independent assessment from Naval Research Laboratory (NRL) shows its NWP system has a large increase of MHS Channel 3 root mean square (RMS) error which is the difference between observed and simulated from NWP analysis fields (see Fig. 3). As the MHS performance is getting worse, another action to adjust gains and DC offsets on August 24, 2009. Both cold and warm calibration counts were adjusted to higher values.

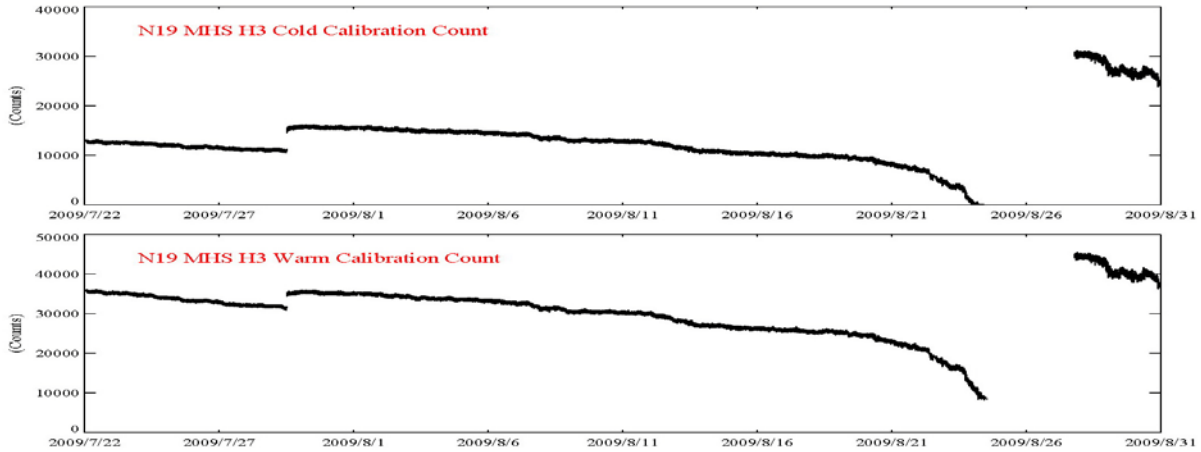

Figure 1: Time series of NOAA-19 MHS H3 cold calibration count (top) and warm calibration count (bottom) for 22 July to 30 August 2009.

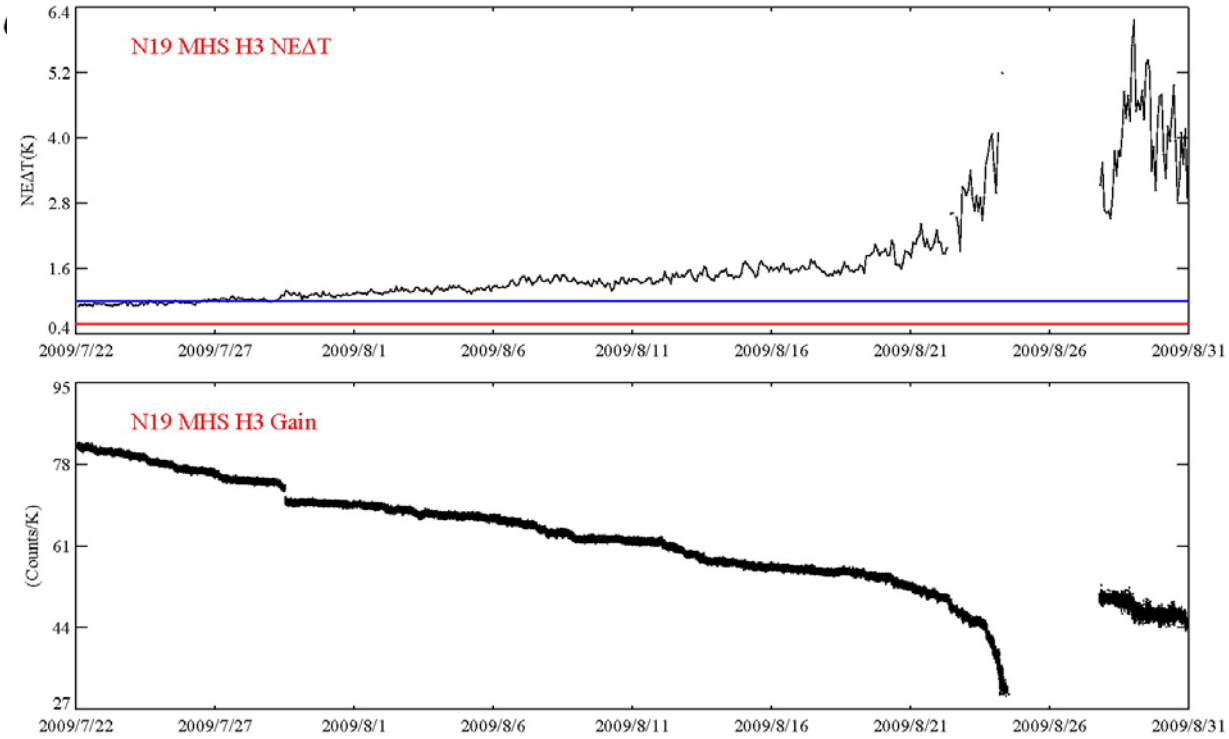

Figure 2: Same as Figure 1, but for NEΔT (top) and channel gain (bottom)

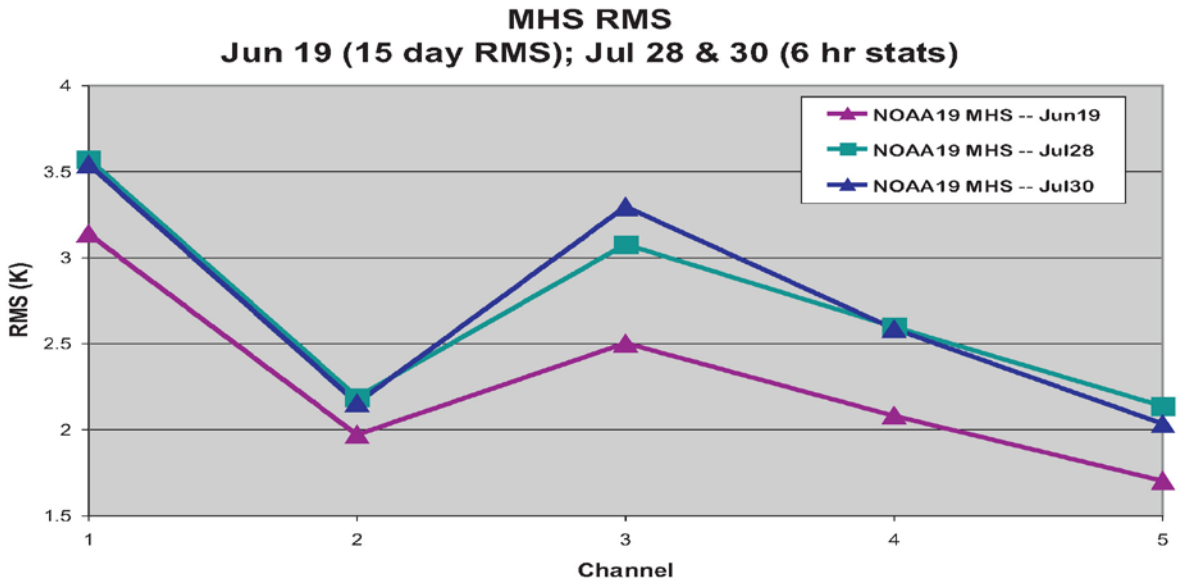

Figure 3: NOAA-19 MHS observed minus simulated from the NWP analysis field (Ben Ruston, NRL)

2.2 *POES AMSU-A (Advanced Microwave Sounding Unit-A)*

AMSU-A instrument is also monitored routinely from NESDIS/STAR integrated calval system. Since AMSU have three subunits denoted as A1-1, A1-2, and A2, their calibration parameters are monitored separately. Figure 4 displays NEΔT of NOAA-19 AMSU-A Channel 8 which experienced sudden jumps from the end of June to the beginning of July 2009. Before and after that, NEΔT of both channels returns to normal. Since Channel 8 is one of A1-2 unit, the A1-2 warm load platinum resistance thermometer (PRT) temperature is also illustrated in Figure 4 for analysis purposes.

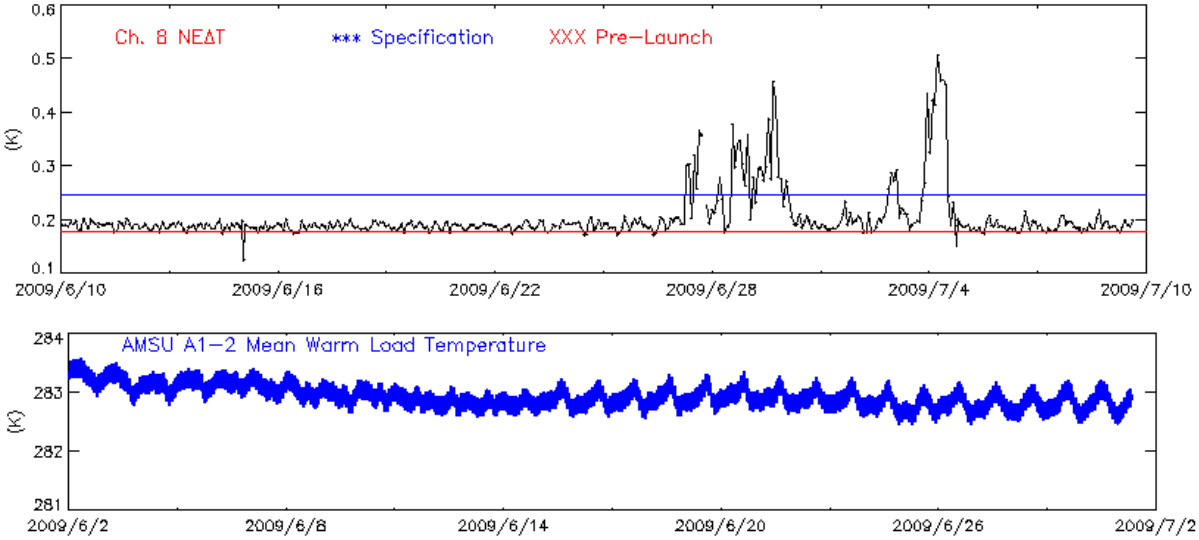

Figure 4: NOAA-19 AMSU-A NEΔT of Channel 8 (top) and A1-2 mean warm load PRT temperature (bottom).

2.3 *POES AVHRR (*Advanced Very High Resolution Radiometer*)*

The AVHRR instrument on NOAA-18/19 and METOP-A is monitored and trended to detect anomalies in its space view, blackbody counts, telemetry readings, NEΔT, and gain. This subsystem also monitors the pre-launch and post-launch calibration coefficients of the solar reflective channels. Figure 5 is an example of NOAA-19 PRT temperature trending, showing its orbital PRT mean, and the dispersion of four individual PRTs. Figure 6 is the AVHRR channel 3B of NOAA-19 space view count and blackbody view count trending. Because AVHRR channel 3A was turned off to reduce the contamination on 3B, Channel 3B presents relatively stable conditions than that onboard MetOP-A (not shown). Larger than channel designated NEΔT specifications noise can also be detected, and when this occurs a warning email is generated and sent out.

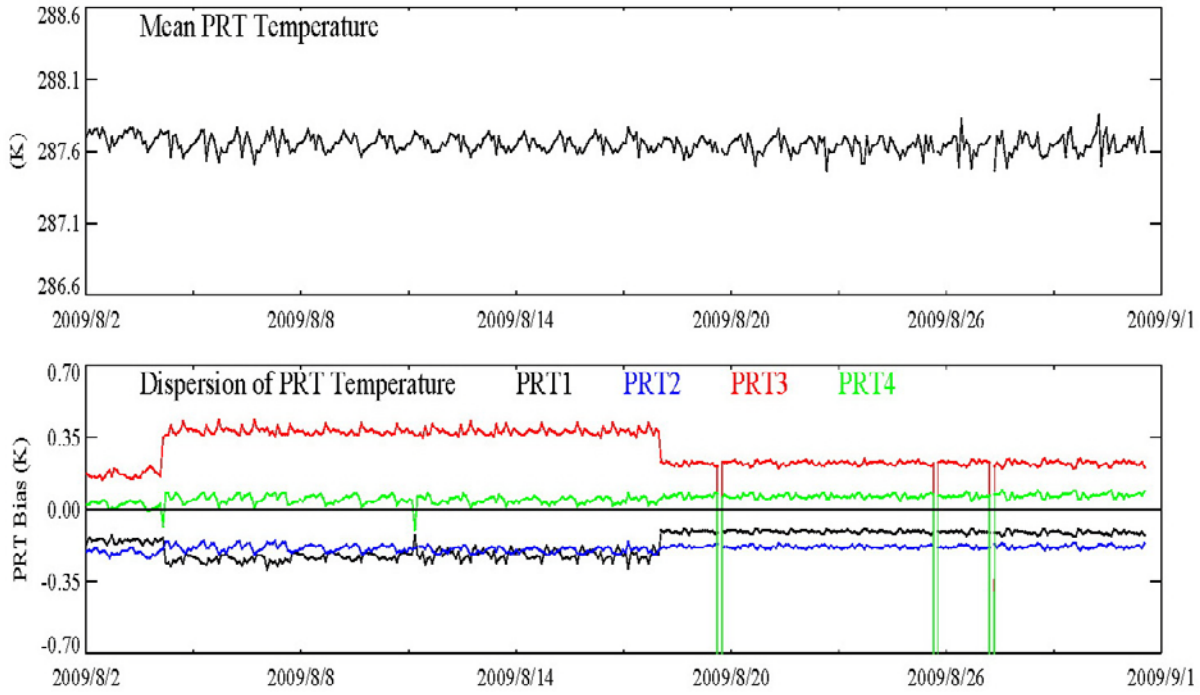

Figure 5: NOAA-19 AVHRR PRT trending. Mean PRT temperature of past 30 days (top), dispersion of four PRTs during the same period of time showing the difference among four PRTs (bottom).

2.4 *POES HIRS (High Resolution Infrared Radiation Sounder)*

The HIRS instrument monitoring system was originally designed for NOAA-18 HIRS diagnosis in 2005. After that, the system was improved for operational purpose. In 2007, with the launch of Metop-A, the system was further modified to meet the needs of HIRS on Metop-A. Because of the launch of NOAA-19 and the development of ICVS, the HIRS performance monitoring system is redesigned and updated to include more monitoring parameters. The system keeps the ability to automatically monitoring the instrument performance related parameters, including space view and blackbody counts, calibration coefficients and noise equivalent radiance (NEΔN), and filter wheel, warm target, and instrument temperatures (such as the baseplate, electronics, cooler housing, and detector temperatures). It also includes the latest 7-day orbital status statistics for quantitatively analysis. The time series of these instrument parameters are updated in real-time, and are made available on the NOAA ICVS web site. When the noise level is out of the designed specification value (e.g., NEΔN), the warning message is automatically triggered and sent out to instrument scientists. Figure 7 demonstrates an example of the time series of NEΔN for channel 5 of NOAA-19 HIRS. Most of the NEΔN in this channel is out of its specification and also shows a larger variation since July. The source of such higher noise is still not clear.

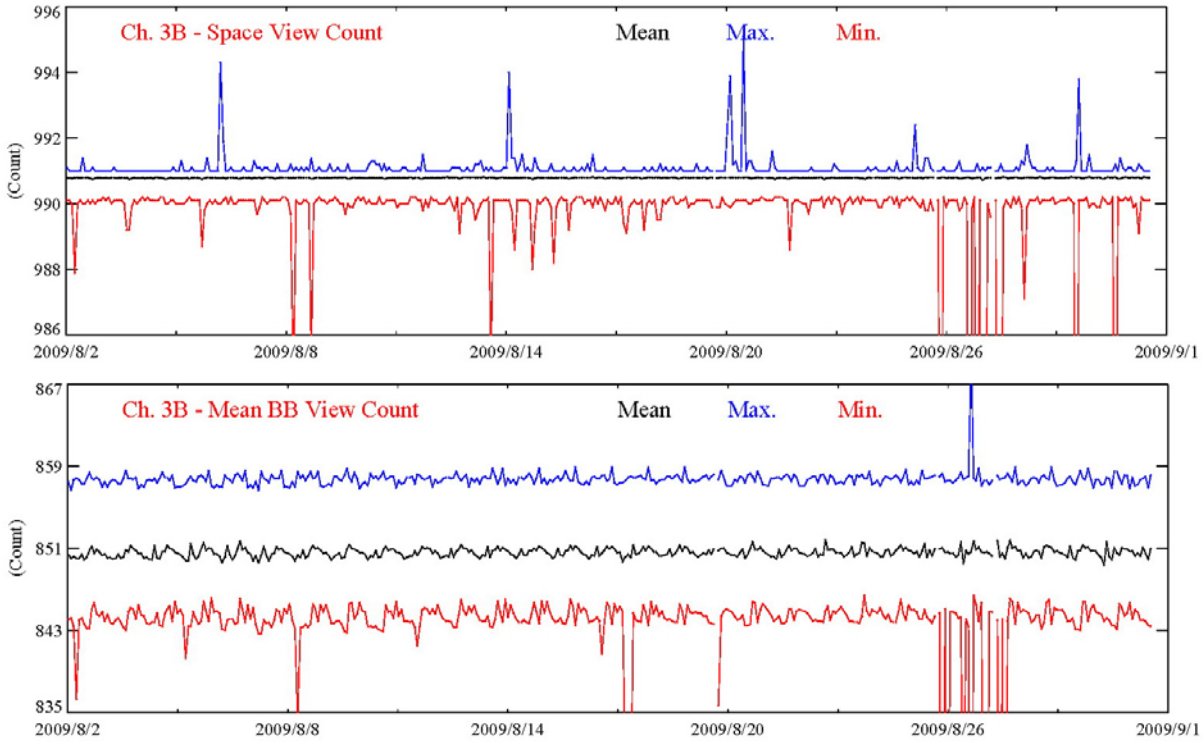

Figure 6: NOAA-19 AVHRR Channel 3B space view count (top) and blackbody view count (bottom) of past 30 days.

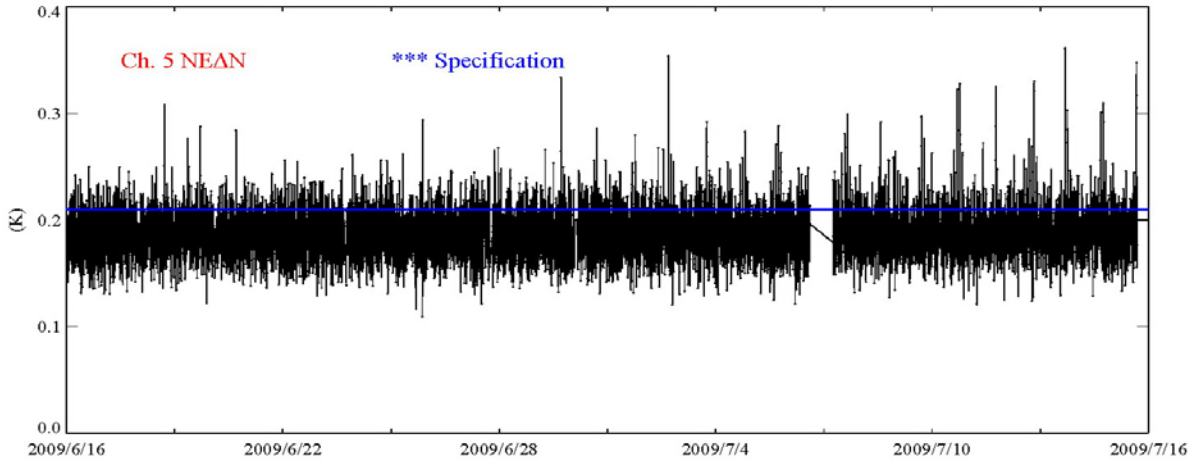

Figure 7: Time series of NEΔN for channel 5 of NOAA-19 HIRS. The red line is the designed specific NEDN value while the blue line is daily-mean NEDN value.

The HIRS users recently reported that the bit 28 of MetOp-A HIRS calibration flag have been trigged, resulting in a failure of ingesting HIRS data into operational data assimilation systems. The bit 28 is an indicator of HIRS calibration quality for each scan line. After investigation, the STAR scientists found out that the bit 28 is trigged by two scenarios: 1) PRT data marginal, some readings were rejected; and 2) failure of QC test for all IR channels that occurs when the HIRS calibration HCF file is missing. Both of the cases indicate that the HIRS level-1B data processing system may miss some HIRS calibration files.

2.5 *GOES Imager*

The GOES Imager IPM subsystem is designed to track the stability and noise of the sensor parameters that affect the instrument calibration. Currently, the IPM on GOES-11 and GOES-12 Imagers are routinely operated since the end of 2006. The monitoring of GOES-13 has been ready and is waiting for the start of its operation in the future. Time series of telemetry statistics, patch temperature, blackbody temperatures and first order calibration gain of the infrared (IR) channels of each GOES Imager, and space look count for all of the Imager visible and IR detectors are plotted and available online. Each parameter is monitored at four temporal scales ranging from hourly, daily, yearly to the whole instrument life.

Over the past a few years, the GOES Imager IPM system successfully detected instrument anomalies and help to diagnosis those anomalies both for both visible vicarious calibration and infrared on-board calibration. It also made major impacts in several critical moments, such as the GOES decontaminations. It is expected that this IPM system will play an important role in the GSICS project to investigate the root causes of calibration basis between the GOES and the high quality hyperspectral infrared data.

However, this IPM system is experimental, serving more like a visual report of GOES Imager level 1B data. A new GOES IPM system with more efficient monitoring of instrument performance and calibration status is currently under development. This upgrading system will not only implement the statistics of calibration parameters, sensor sensitivity index, and key instrument telemetries at varying temporal scales, but also expand from Imagers to Sounders. Instruments under monitoring will include the Imager and Sounder for GOES-11 and 12 (current operational satellites) and GOES-10 which is half-operational.

3 Summary

In summary, IPM is critical for ensuring level 1b product quality for both numerical weather prediction and climate change detection. Since these products are increasingly dependent on data from the international constellation of earth observing satellites, it is important to establish a central interface from which instrument monitoring information from all over the world can be distributed. In this paper, a comprehensive web-interface for real-time instrument performance monitoring within the integrated calibration/validation system (ICVS) is introduced. Several significant cases are also described. It is proved that this monitoring system can greatly help to find the error in satellite data and provide a convenient tool for data diagnose.