CGMS

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NOAA REPORT ON SATELLITE CALIBRATION ANOMALIES

Summary of the Working Paper

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.

NOAA REPORT ON SATELLITE CALIBRATION ANOMALIES

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 suite (IPMS) can facilitate the communication of instrument anomalies amongst instrument and calibration scientists. In particular, a web-based IPMS system will

facilitates dissemination of IPMS information to satellite program administrators, product providers and data users;

allow a distributed archive of IPMS data and information that is accessible through a single portal;

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 Integrated Calibration and Validation System (ICVS)

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. Based on previous frame, different display time terms, such as yearly and all time trending, are added to provide more completed instrumental performance information. In this report, we will primarily focus on the description of POES IPM.

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

NOAA-19/NOAA-18/MetOP-A AMSU-A instruments are monitored routinely from NESDIS/STAR Integrated Cal/Val System. Since AMSU have three subunits denoted as A1-1, A1-2, and A2, their calibration parameters are monitored separately. Figure 1 displays NEΔT trending of NOAA-19 AMSU-A Channel 7 (54.94 GHz) during the last year and whole lifetime. From January 2011, NEΔT started showing an out-of-spec trending over 0.25 K. The all time plot also presents an increasing trending at this channel. The warm calibration counts (Fig. 2a) and cold calibration counts (Fig. 2b) both show increasing trend but channel gain (Fig. 2c) does not give significant variations. Other AMSU-A1-1 channels (Channel 6 and 9 to 15) do not show significant anomaly during the last year.

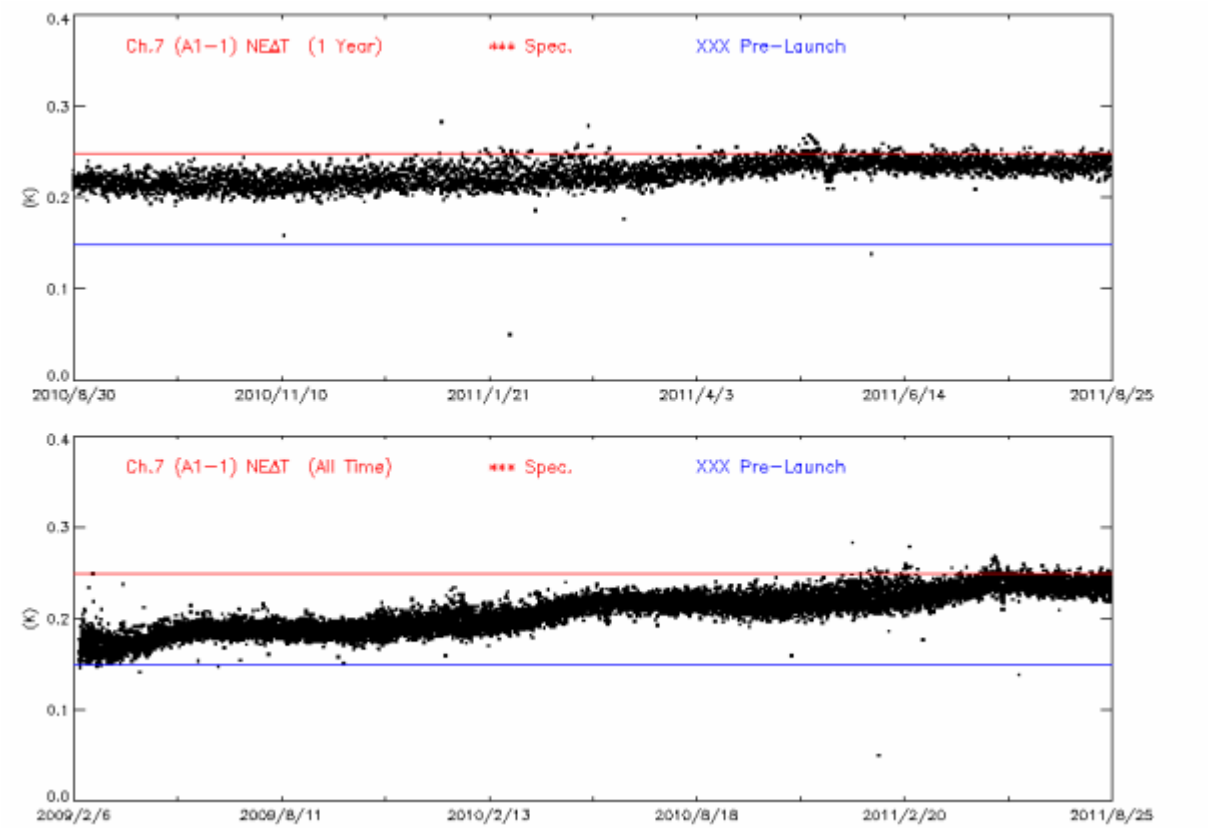
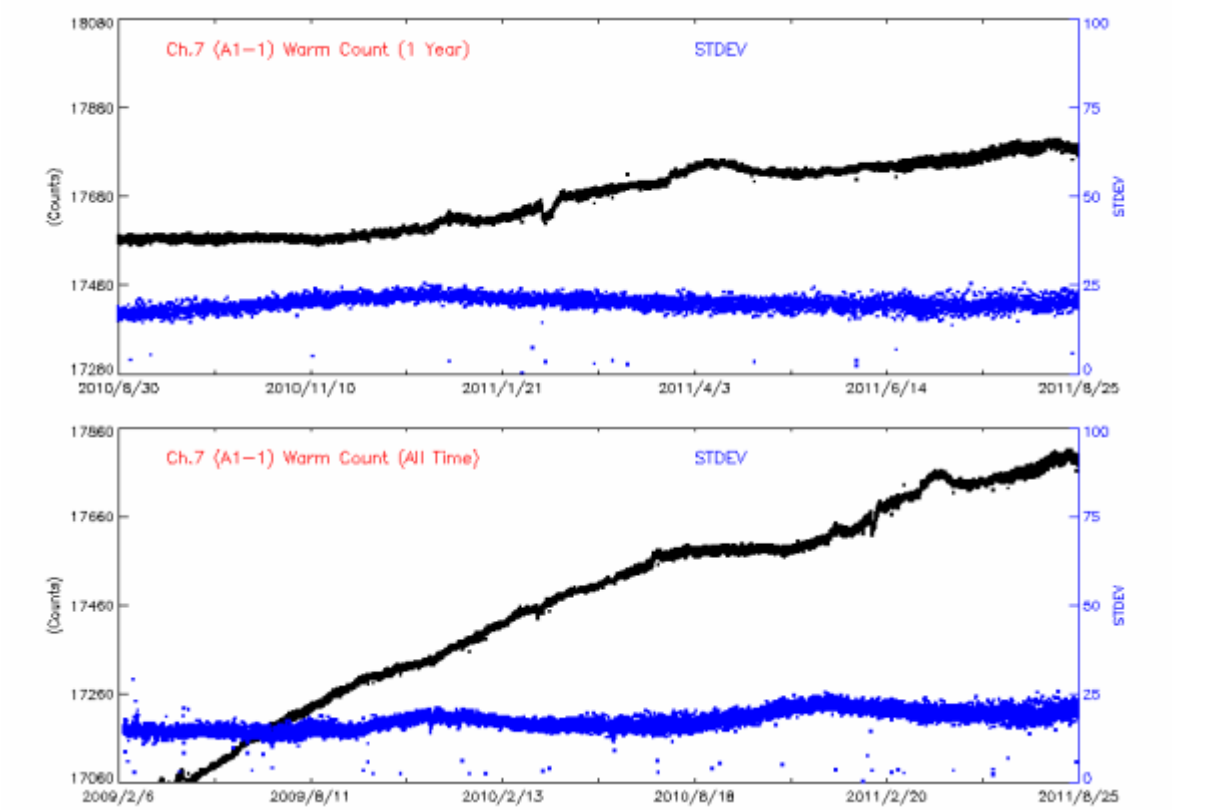


Figure 1: NOAA-19 AMSU-A NEΔT of Channel 7 in the last year (top) and all lifetime (bottom).

(a)



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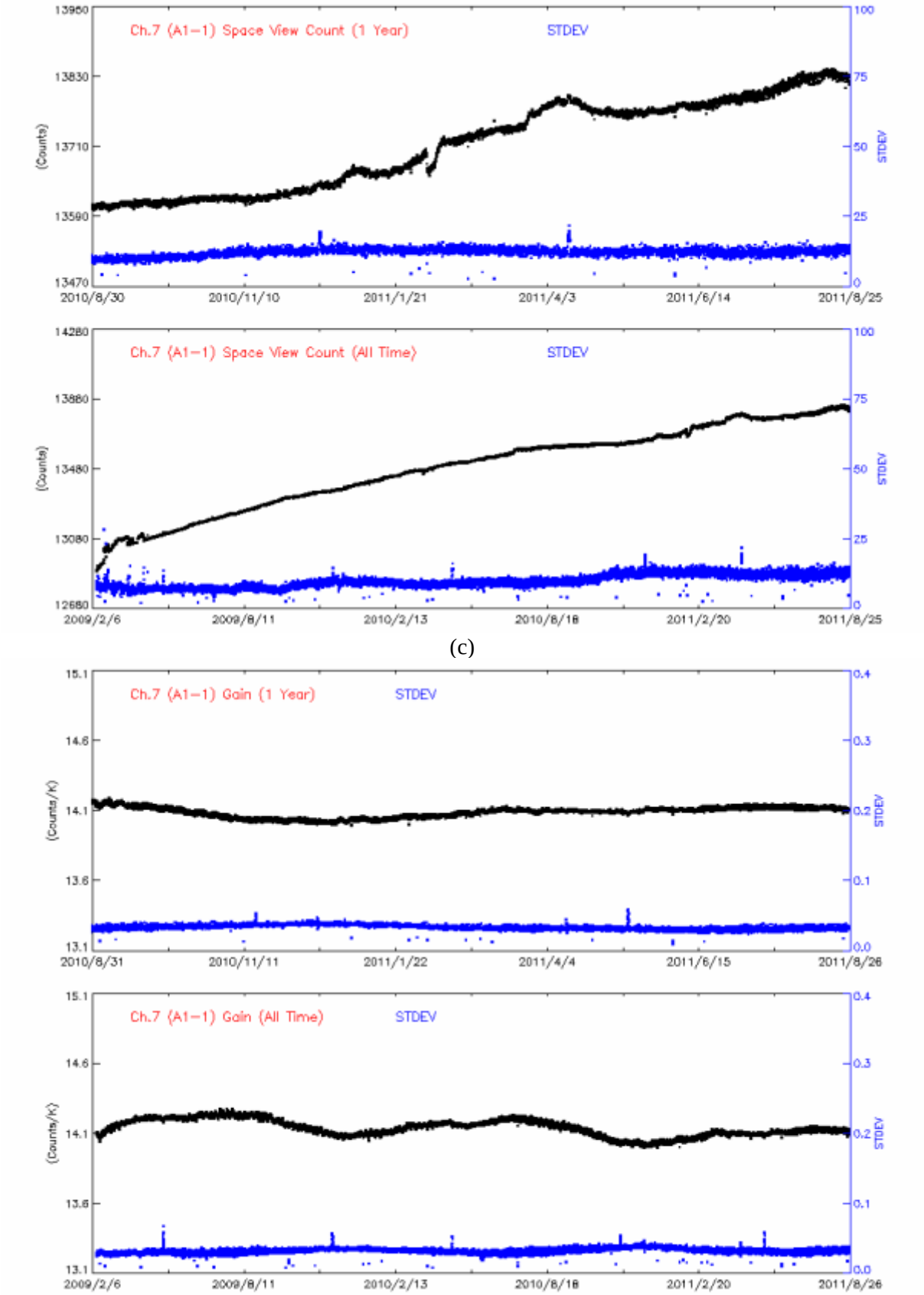

(c)

Figure 2: NOAA-19 AMSU-A Channel 7 (a) Warm Count, (b) Cold Count, and (c) Gain.

Fig.3 displays NEΔT of NOAA-19 AMSU-A Channel 8 which experienced sudden jumps from the end of June to the beginning of July 2009 and kept stable but out of its specification

at around 0.8 K since April 2010. In addition, ICVS also provides orbital failed scan percentage plot for orbital quality statistic analysis, as shown in Fig. 4. In this plot, a consistence between the increase of failed calibration scans and Channel 8 NEΔT in the beginning of 2010 is observed. It was found that the quality flag of failed scan was improperly set in channel level. The error was quickly corrected after both IPMS plots were sent to operational team.

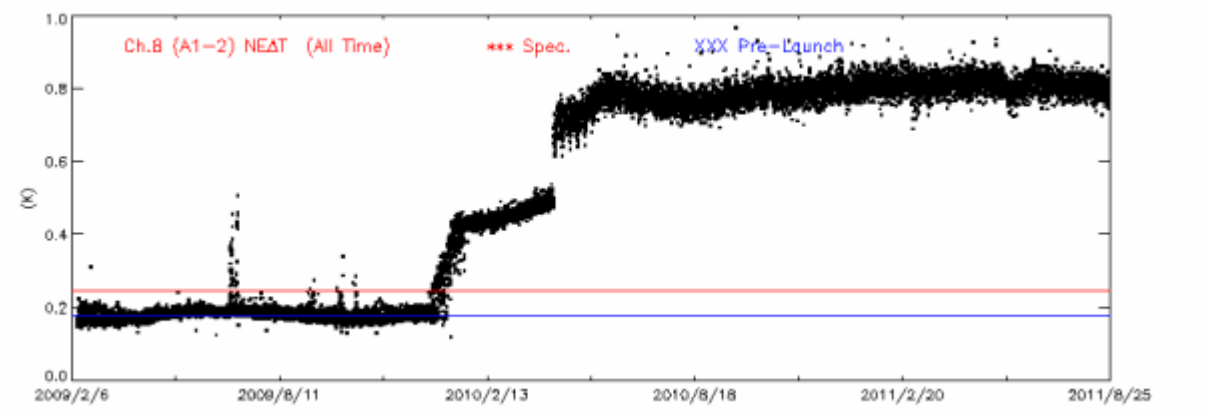

Figure 3: NOAA-19 AMSU-A NEΔT of Channel 8.

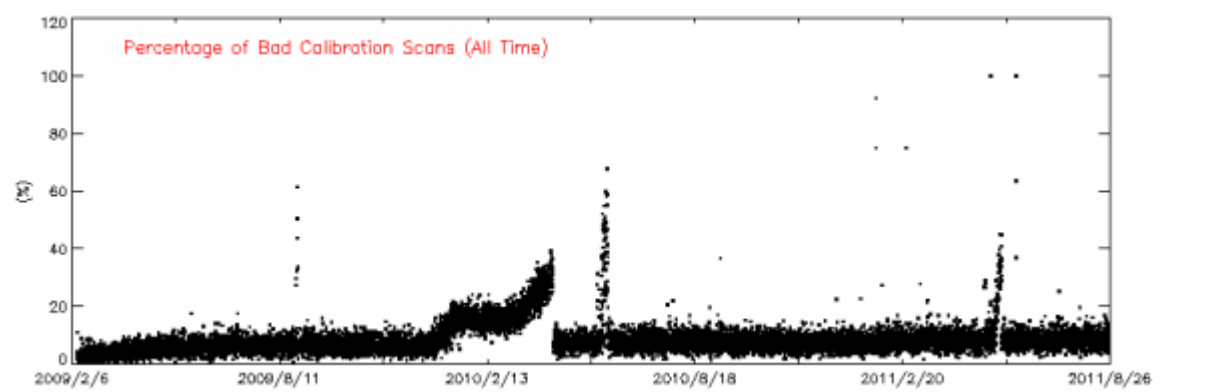

Figure 4: NOAA-19 AMSU-A orbital percentage of calibration failed scans

MetOP-A datasets were split into half-orbit size in June 2011. Since then the NEΔT of AMSU-A Channel 1 and 2 have presented a separated distribution pattern, as shown in Fig. 5. The warm counts and cold counts as well as gains of both channels, however, do not show abnormal variations in IPMS trending plots. The checkup of other AMSU A2 unit monitored temperatures, such as PRT temperature, local oscillator temperature, and other parameters, provide regular variation patterns. Further investigation of such phenomena is still on the way.

Again, NEΔT of MetOP-A Channel 7 has out of its specification since October 2009 and quickly jumped far higher within couple of days. Now, this channel is considered to be failed due to its extremely high NEΔT, as shown in Fig. 6.

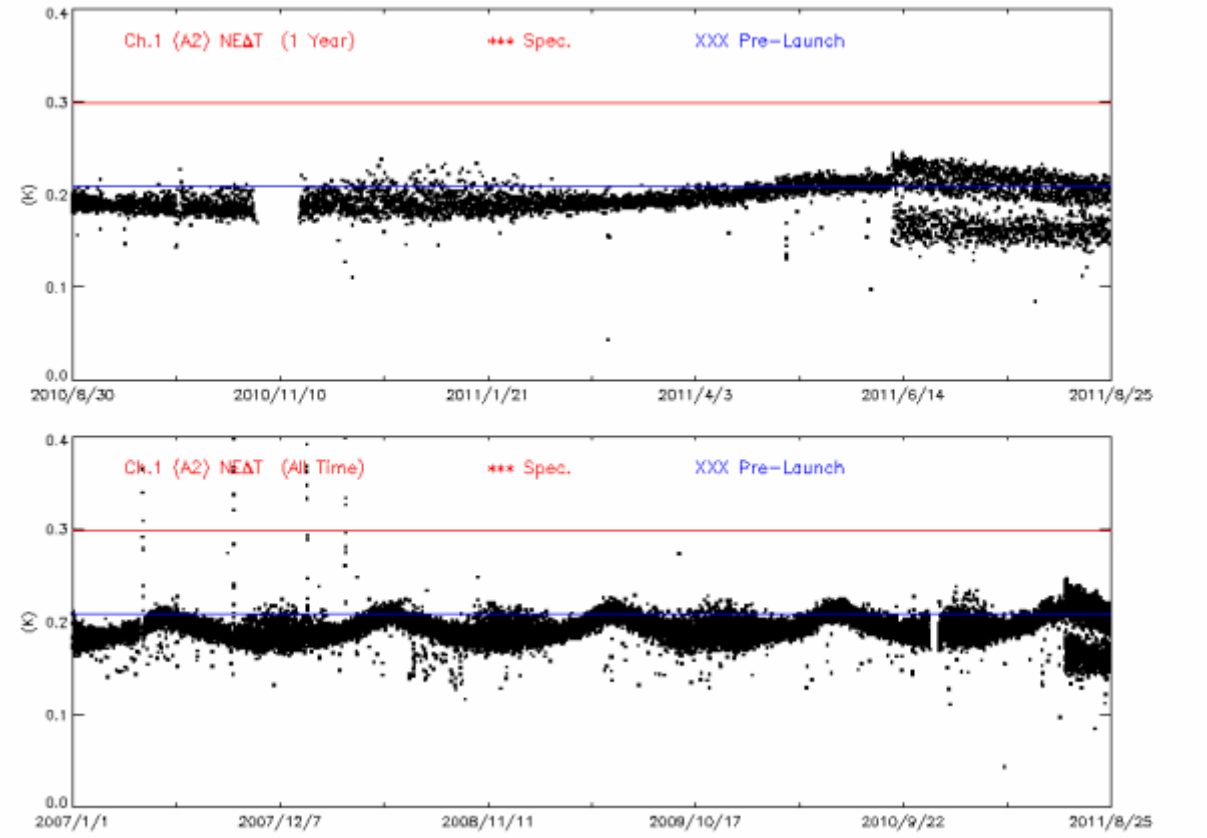

Figure 5: MetOP-A AMSU-A Channel 1 NEΔT.

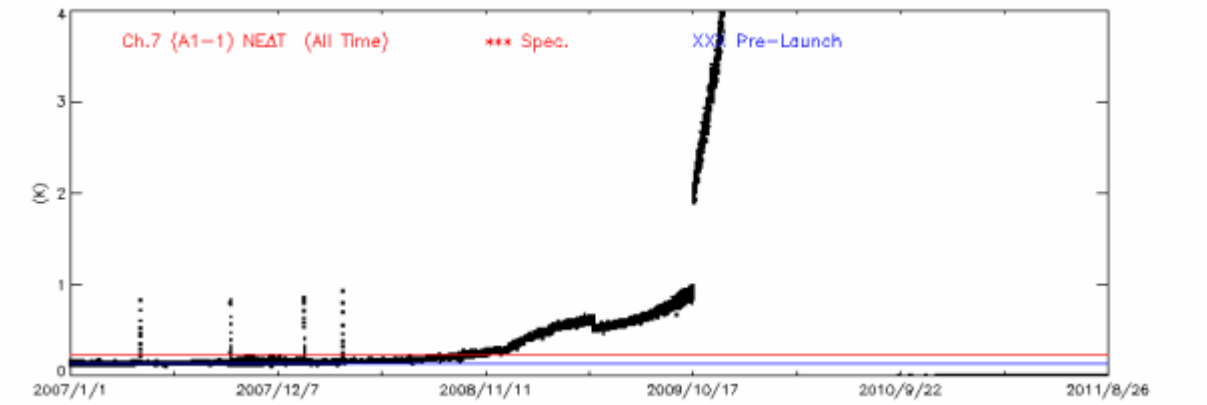

Figure 6: MetOP-A AMSU-A Channel 7 NEΔT.

2.2 *POES MHS (Microwave Humidity Sounder)*

The instrument performance monitoring system for MHS has also 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 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.

Some abnormal variations of NOAA-19 MHS H3/H4 cold calibration, warm calibration counts, channel gains and noise were reported in the last CGMS report. So far, the NEΔTs of NOAA-19 MHS H3 and H4 have been stable since the adjustment of gains and DC offsets on August 24, 2009. As shown in Fig.7, the noise level of H4 came back under its specification. However, H3 keeps stable at around 3K, which is still out of its specification at 1K.

Other than NOAA-19, MHSs aboard both MetOP-A and NOAA-18 presented normal condition from IPMS.

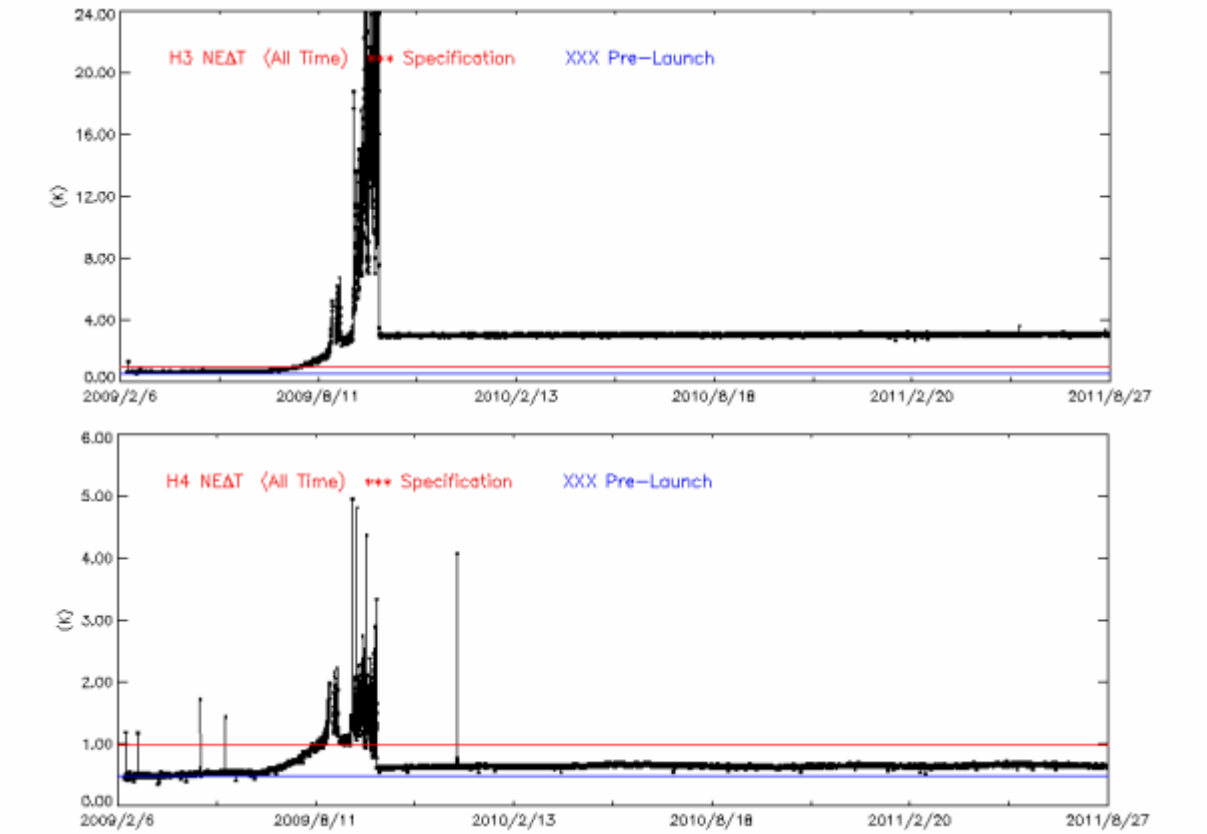

Figure 7: Time series of NOAA-19 MHS NEΔT H3 (top) and H4 (bottom) since the launch.

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

Current ICVS IPM system does not reveal any new anomaly on AVHRR instrument on NOAA-18/19 and METOP-A.

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

NOAA-18 HIRS noise has been out of specification since the beginning. HIRS instruments on NOAA-19 and METOP-A have been performing well since last year.

2.5 *DMSP SSMIS (Special Sensor Microwave Imager/Sounder)*

ICVS is now also monitoring the performance of Defence Meteorological Satellite Program (DMSP) F16/F17/F18 Special Sensor Microwave Imager/Sounder (SSMIS) parameters. We produce both scan and orbital level calibration targets and instrument status monitoring. The SSMIS instrument status aboard F16/F17/F18 can be well described from its PRT temperature long term trending plots, shown in Fig. 8 – 10. It is clearly shown that the warm calibration target PRT temperatures of F16/F17 SSMIS demonstrated much larger abnormal variations than that of F18, which indicates that data quality of DMSP F18 SSMIS should be better than other two satellites even extensive recalibration works have been done on F17/F18 SSMIS.

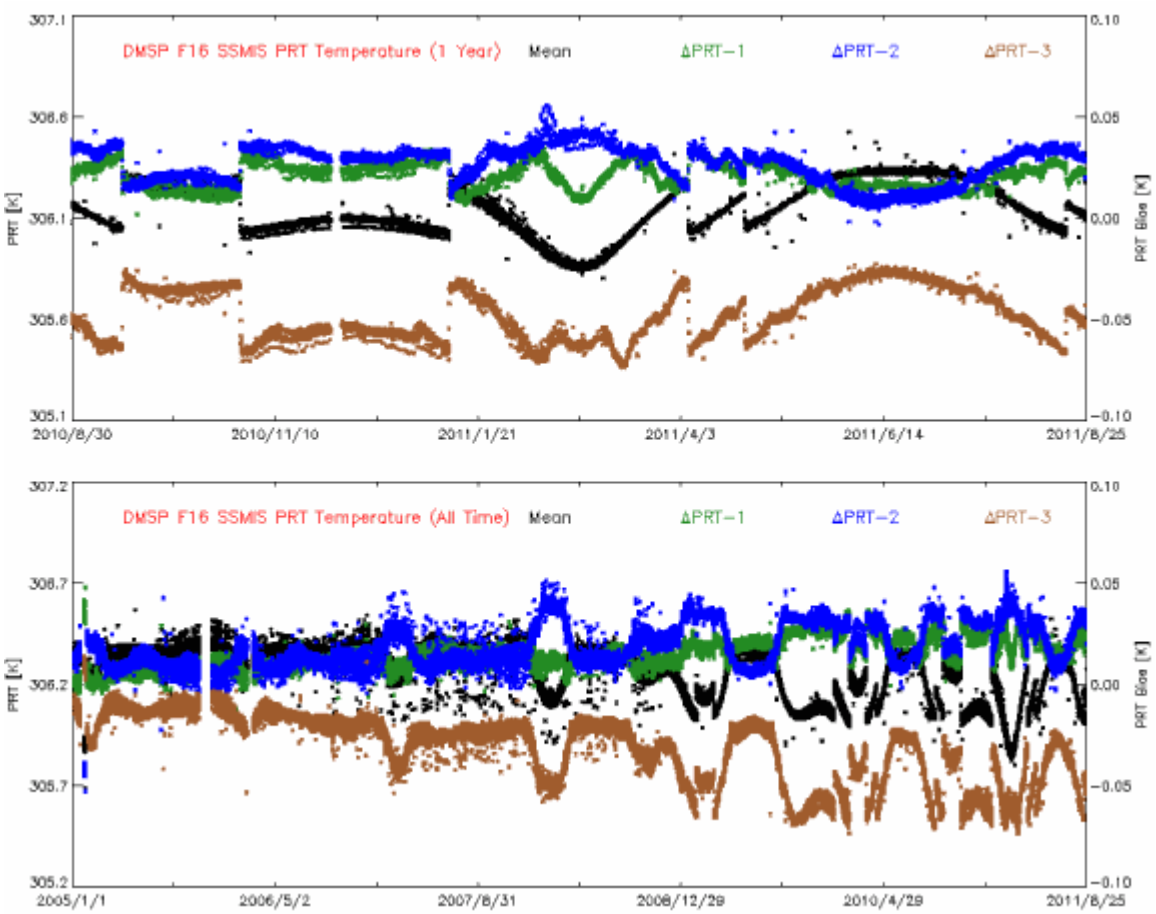

Figure 8: Time series of F16 SSMIS PRT Temperature in the last year (top) and all time (bottom)

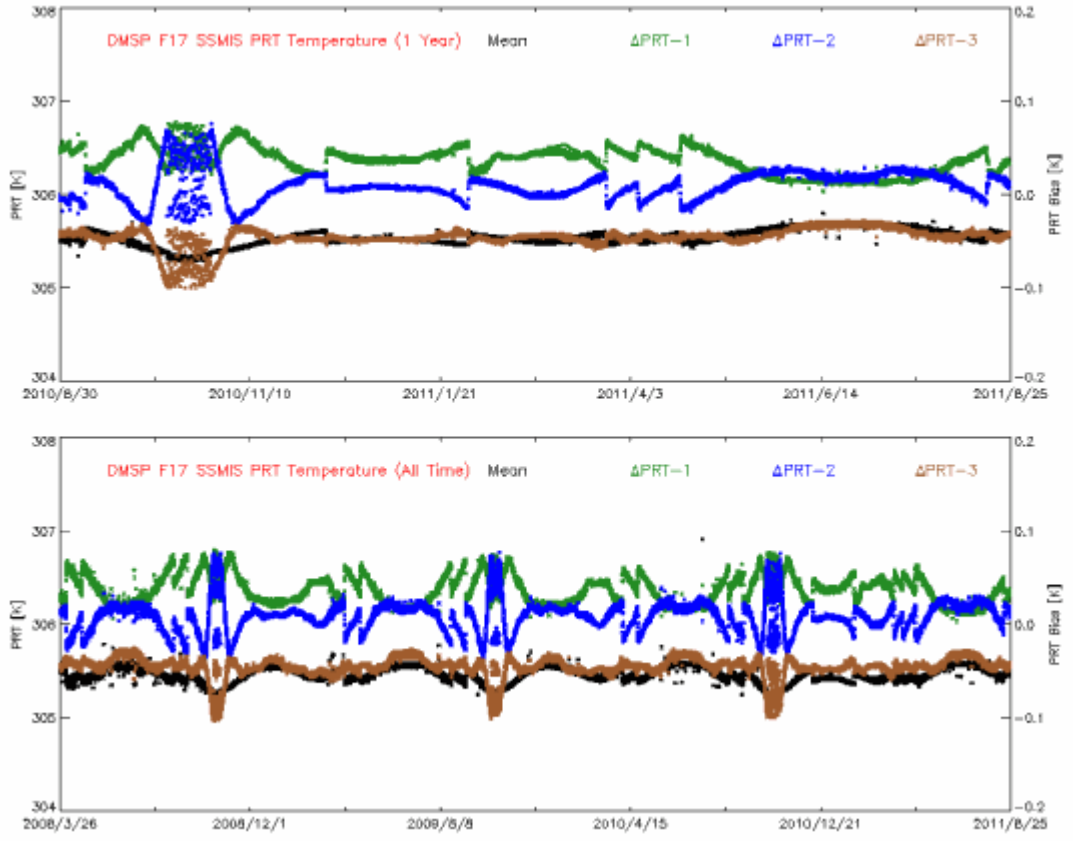

Figure 9: Same as Figure 8 but for F17 SSMIS

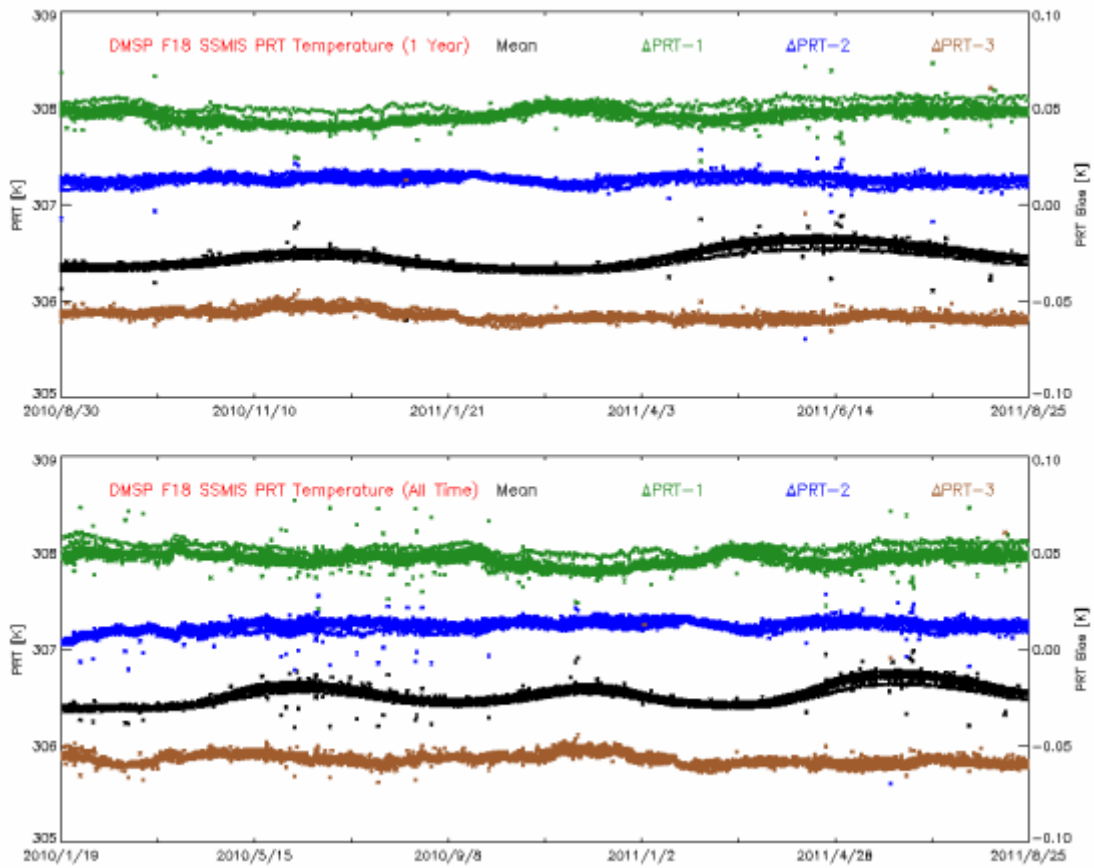

Figure 10: Same as Figure 8 but for F18 SSMIS

2.6 *GOES Sounder*

The GOES Sounder IPMS is designed to track the stability and noise of the sensor parameters that affect the instrument calibration. Currently, the IPMS on GOES-11/12/13/14/15 sounders are routinely operated since the end of 2006. The monitoring of GOES-R has been ready and is waiting for the start of its operation in the future. Time series of NEΔT/NEΔN, telemetry statistics, patch temperature, blackbody temperatures and first order calibration gain of the infrared (IR) channels of each GOES sounder, and space look count for all of the visible and IR detectors are plotted but only selected information available online due to some uncertainties. Each parameter is monitored at four temporal scales ranging from hourly, daily, yearly to the whole instrument life. Shown in Fig. 11 is NEΔN of GOES-15 sounding channel 1.

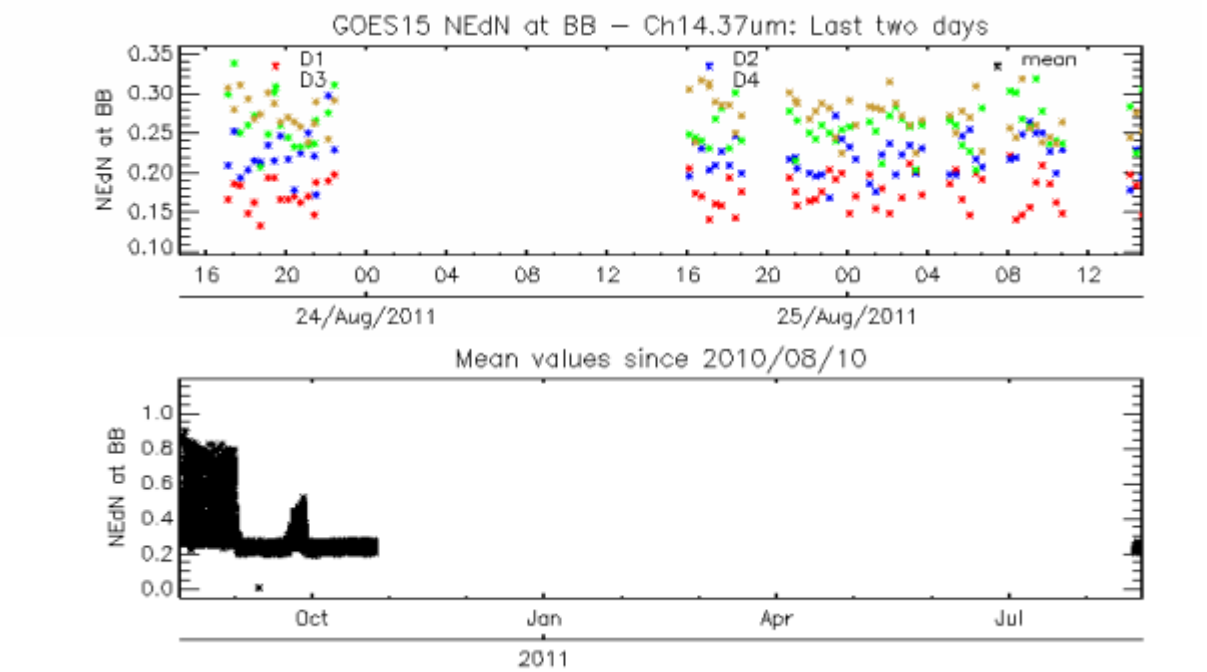

Figure 11: GOES-15 Channel 1 NEΔN of the last two days (top) and lift time (bottom)

Over the past a few years, the GOES Imager/Sounder IPMS 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 IPMS 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, current IPMS is experimental, serving more like a visual report of GOES Imager/Sounder Level 1B data. A new GOES IPMS 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

ICVS IPMS 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. This system can provide not only daily orbital monitoring for real time operational missions but also satellite long term variation trending information for inter-sensor calibration in satellite climate study. 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.

New instrument anomaly or update events in 2010-2011:

NOAA-19 AMSU-A Channel 7 NEΔT started increasing and approached its specification in year of 2011. It was even occasionally out of the specification during the past year. A close watch of this channel will be kept so as to report any abnormal situation to community.

NOAA-19 AMSU-A the number of failed scan quality flag was improperly set at channel level, which led to extreme high failed scan number due to the failure of NOAA-9 AMSU-A Channel 8. It was corrected sooner after the detection of the error.

MetOP-A AMSU-A Channel 1 and 2 presented split NEΔT phenomena beginning from the change of dataset size from orbit to half-orbit datasets. Further investigation is still on the way for the root cause of such situation.

Long term monitoring of DMSP SSMIS instrument trending aboard F16/F17/F18 indicates a better quality dataset from F18.

GOES 11/12/13/14/15 sounder instrumental performance monitoring parameters are also added to ICVS.