CGMS

CGMS-36, NOAA-WP-14
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Discussed in WG II

A Web-based Interface for Near Real-time Instrument Performance Monitoring

In response to CGMS Action 35.18 (GSICS GCC to propose a web-based interface to other satellite agencies for near real time instrument monitoring)

Summary of the Working Paper

NOAA WP-14 notes that 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 near real-time instrument performance monitoring – curated, maintained, and located at the WMO Global Space-based Inter-Calibration System (GSICS) Coordination Center - is introduced.

1 INTRODUCTION

In November 2007, a paper entitled "Real time Assessments of Instrument Performance from GSICS and NOAA Websites" was presented at the CGMS 35 meeting in Cocoa Beach, Florida. In that presentation, the scope of current instrument performance monitoring (IPM) efforts at NOAA was clearly outlined, and the importance of this activity to numerical weather prediction and climate change detection was expressed. In addition, all CGMS members were encouraged to "… develop standardized instrument performance monitoring systems and share the results with the members through GSICS." In the present paper, a web-based interface for near-real-time IPM is introduced.

2 Why a Web-Interface for Monitoring Instrument Performance?

At 12Z 15 August 2005, the NOAA Office of Satellite Operations reported in their satellite summary page for NOAA-18 HIRS that "HIRS payload and channel-1 component downgraded to YELLOW status because of degraded imagery (ref: TOAR 448) first detected on 6 June 05." In response to this perplexing problem, data providers and instrument and calibration scientists from government and industry were charged to determine the root cause of the noise anomaly, and then mitigate it if possible. On the other hand, the fact that this relatively large group of investigators worked at facilities spread across the United States presented a real obstacle in resolving the problem quickly. This led investigators at NOAA to establish a web-based IPM system for NOAA-18 HIRS. Although it was discovered later that the NOAA-18 HIRS instrument had an irreparable loose lens, the utility of a web-based IPM tool became apparent.

Besides facilitating communication of instrument anomalies amongst instrument and calibration scientists, there are several reasons for having a near-real-time, web-based IPM system:

- Web availability facilitates dissemination of IPM information to satellite program administrators, product providers and data users;
- Web networks can allow a distributed archive of IPM data and information that is accessible through a single portal; and
- Web sites 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 near-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) – is proposing to develop such an interface.

3 Developing a Web-Interface for IPM at the GSICS Coordination Center (GCC)

The need for available near-real-time instrument information and data, and a method to serve them, are the drivers of the IPM web interface to be hosted by the GCC. This leads to the development of an IPM system design concept of how the information and data from this system is to be served to the meteorological satellite community.

3.1 *System design concept*

The instrument monitoring system is designed as an automated, near-real-time, and web-based system. To this end, the following guiding principles have been identified for system design: 1) efficient, easy-to-use web-based interface for users; 2) timely availability of instrument information; 3) paperless electronic data log on instruments for future diagnosis; 4) automated data processing; and 5) system flexibility that meets demands of future instruments as well as other requirements.

Figure 1 shows the system process flow chart for the instrument monitoring system. When satellites send data back to the data archive centers, the system automatically "grabs" the near-real-time data from the servers. The instrument information including calibration target counts, calibration coefficients, and instrument parameters is decoded from the satellite data. The time series of the corresponding monitoring parameters are plotted and posted to the web server. At the same time, the instrument noise is calculated. When the noise level is beyond a prescribed threshold value or the instruments meet anomaly criteria, a warning message is triggered and sent out to instrument scientists. The data of instrument information is also archived in the server for future use. During the whole process, the system is automatically running without the human involvement.

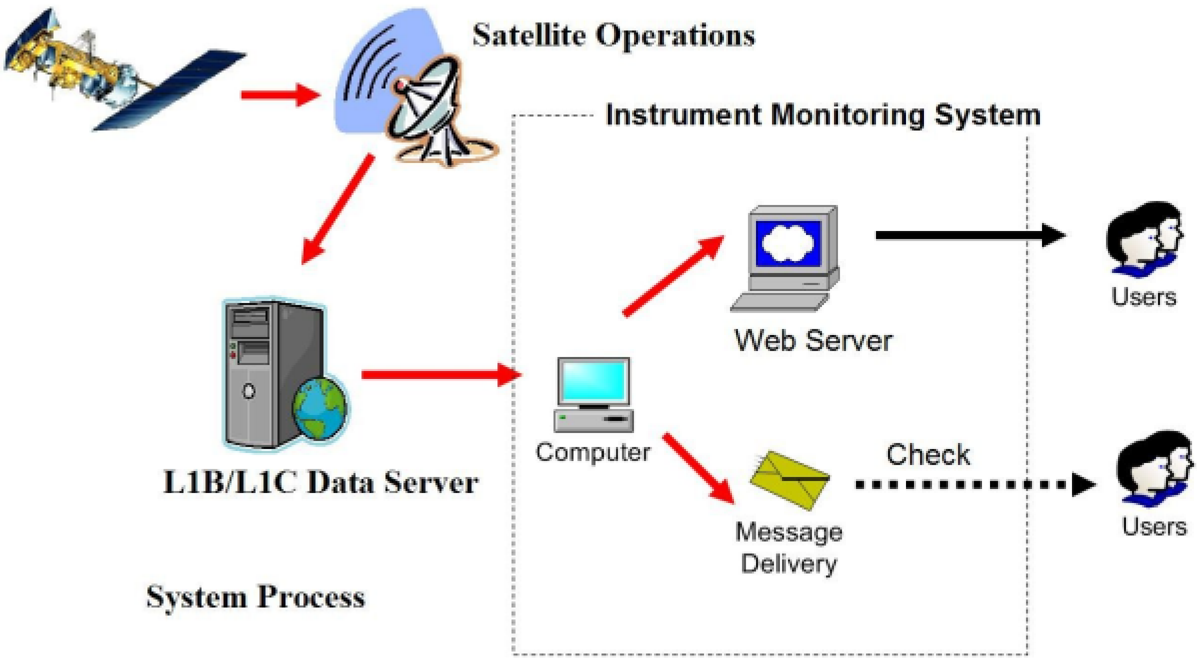

Figure 1: The system process flow chart for the instrument monitoring system.

3.2 *Serving IPM information and data*

The web site hosted by the GSICS Coordination Center (GCC) has recently undergone a very significant transformation using the NOAA/NESDIS Center for Satellite Applications and Research (StAR) web site kit. This web site kit offers:

Web page templates that do not require design work, and are edited with a simple text editor;

Web pages without frames;

Accessibility to persons with disabilities as dictated by Section 508 of the U.S. Rehabilitation Act; and

Instant approval by StAR for use on StAR web servers.

The URL for the current GSICS central web site is http://www.star.nesdis.noaa.gov/smcd/spb/calibration/icvs/GSICS/index.php. The proposed location of the IPM results within the GSICS web site is under the "Products" menu item. Meanwhile, the proposed IPM information and data that can be shared through this web site is discussed below.

The current philosophy regarding presenting IPM information and results is to classify them as being derived from geostationary (GEO) or low-earth-orbiting (LEO) satellites. This classification scheme makes it convenient to create tables of IPM links for each satellite instrument based on the satellite name and the instrument type. An example of such a table for GEO and LEO satellites is given in Figure 2.

LEO Instrument Distribution, By Satellite

Satellites	Instrument Types					
	VIS/IR Imager	IR Sounder	IR Hyperspectral	MW Imager	MW Sounder	UV
EOS Aqua	MODIS	N/A	AIRS	AMSR-E	AMSU-A HSB	N/A
N16	AVHRR	HIRS	N/A	N/A	AMSU-A AMSU-B	SBUV
N17	AVHRR	HIRS	N/A	N/A	AMSU-A AMSU-B	SBUV
N18	AVHRR	HIRS	N/A	N/A	AMSU-A MHS	SBUV
MetOp-A	AVHRR	HIRS	IASI	N/A	AMSU-A MHS	GOME-2
FY-1	VHRSR	N/A	N/A	N/A	N/A	N/A
FY-3	VIRR MRVIR	IAS	N/A	MRI	MWTS	TOM-OP

N/A - instrument type is not present on the satellite.

GEO Instrument Distribution, By Satellite

Satellites	Instrument Types	
	VIS/IR Imager	Infrared Sounder
COMS	Meteorological Imager	N/A
GOES-10	Imager	Sounder
GOES-11	Imager	Sounder
GOES-12	Imager	Sounder
GOES-13	Imager	Sounder
METEOSAT	MVIRI SEVIRI	N/A
FY-2	MISSR	N/A
MTSAT	Imager	N/A

N/A - instrument type is not present on the satellite.

Figure 2: Table of LEO (**top**) and GEO (**bottom**) instruments as a function of instrument type and satellite. Instrument type refers to the frequency bands that the instrument operates in, while satellite refers to the satellite bus carrying the instruments.

In Figure 2, each instrument name is linked to a web page that contains IPM information and data, when they are available. Currently, the idea is to link to web pages maintained by each individual GSICS Processing and Research Center (GPRC), which are the GSICS member agencies that provide operational meteorological satellite data. This "dispatch" type of web server processes the user's request for data to different web sites, as shown in Figure 3A. Therefore, NOAA, EUMETSAT, JMA, CMA, and KMA would create their own IPM pages that would be linked to the central GSICS web site. Another way to handle the dissemination of IPM information and results is by first sharing data, plots, and information amongst the GPRC servers, and then distributing them through the central GSICS web server. This is called the collaborative web server model.

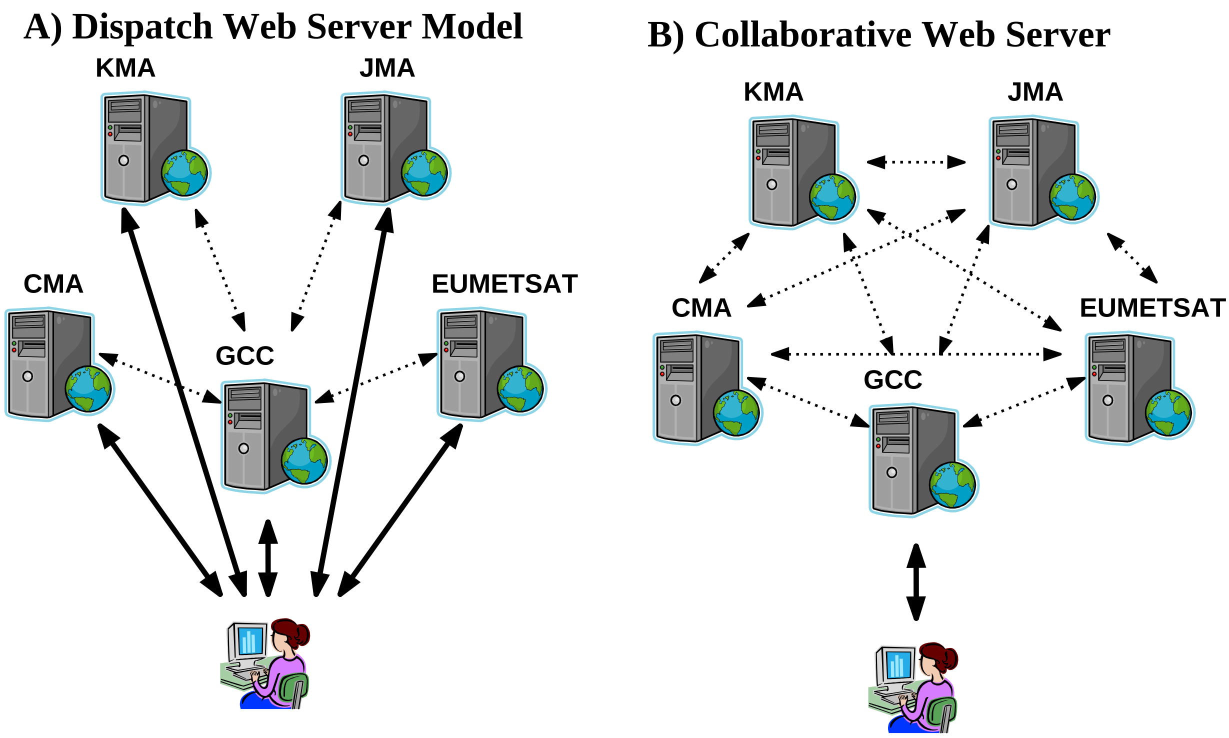

Figure 3: Dispatch (**A**) and collaborative (**B**) web server models for controlling the flow of information to users looking for IPM information and data.

The main advantage of the dispatch web server model is that the GCC does not have to maintain all web pages associated with IPM information and results. At present, this is the default model of choice given the current level of staffing at the GCC. On the other hand, in the dispatch model it is difficult to control the consistency and presentation of IPM data and information. GSICS data users that are forced to visit web sites that do not have similar presentation styles can make erroneous assumptions about the nature of the products they are downloading. If the dispatch model is to be adopted over the long-term by GSICS, then this issue needs to be address by the GSICS Data Working Group (GDWG).

An intrinsic advantage of the collaborative web server model is that IPM information and data produced by each GPRC is shared directly by all GPRC's. This creates an extensive backup system for IPM products. Also, a single portal access through the central web site at GCC homogenizes the IPM product user interface. The main drawback of this approach is that maintaining the central web site becomes more difficult. The GSICS web content curator and web master would have to make sure the correct data is linked properly to the individual IPM web pages. This means communication between the GPRC entities and the web administrators at GCC would have to be very clear. Any changes in the data production procedures of a given GPRC could enter the web site without the notice of web site administrators or users.

The design of the actual web pages that ultimately serve IPM products to users is guided by the need of users ability to navigate, comprehend, and access the information and data. As mentioned earlier, IPM web pages born from the dispatch model are likely not to employ the same data server techniques. On the other hand, at GCC new techniques are being developed to serve IPM information and data for NOAA satellite instruments. These techniques feature menu-driven table and plot selection driven by javascript/php scripts that can parse filename strings. The strings then can be used to create information about the tables and plots that will help users to understand what they are seeing. These scripts also are capable of creating comment blocks that can help persons with disabilities navigate the site. In addition, the tables and plots are served in “inline Frames” or “iFrames.” According to Wikipedia, an iFrame is an HTML element which makes it possible to embed a HTML document inside another HTML document. This method is a very efficient way to serve IPM information and data. With the technical aspects of serving IPM information and results, the remainder of the paper focuses on the actual products.

4 Current Operational Instrument Monitoring Systems at NOAA/NESDIS

At NOAA/NESDIS, the instrument monitoring system has been designed for different operational instruments on Polar-orbiting Operational Environmental Satellite (POES) and Geostationary-orbiting Operational Environmental Satellite (GOES) satellites. Although the same design concept is used, the different systems may have their own characteristics. The detailed description for each system is given in the following subsections. We should point out that the efforts are being made to consolidate all the systems into one to better serve the users’ needs.

4.1 *GOES Imager*

The GOES Imager IPM system is designed to track the stability and noise of the sensor parameters that affect the instrument calibration. 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. The diurnal and seasonal variations and long-term change of each sensor parameter are also plotted and monitored with this system. Currently the systems are operationally running for the GOES-11 and GOES-12 Imagers, and are ready for the GOES-13 Imager once it is in operation in the future. Figure 4 demonstrates the first-order gain for one detector of GOES-12 Imager Channel 2 (3.9µm). The upper two curves are the calibration parameter of the last two days and over the past 10 days, clearly showing the diurnal variation and short-term stability of this parameter. The third and fourth curves from the top are plotted with one year of data, which shows the seasonal variation and the stability of diurnal variation over the past one year. Long-term change of this calibration parameter is plotted in the last curve. It shows that a similar annual variation pattern persists since GOES-12 became operational. The sensitivity of this sensor gradually reduced before the de-contamination event in the summer of 2007, although there is about one year of data not available in the plot. Rapid change in the calibration parameter due to the decontamination event is also shown in this curve. Note that the responsivity dropped greatly over the past year. If it continues to drop at this rate, the GVAR data will saturate again and decontamination may be scheduled.

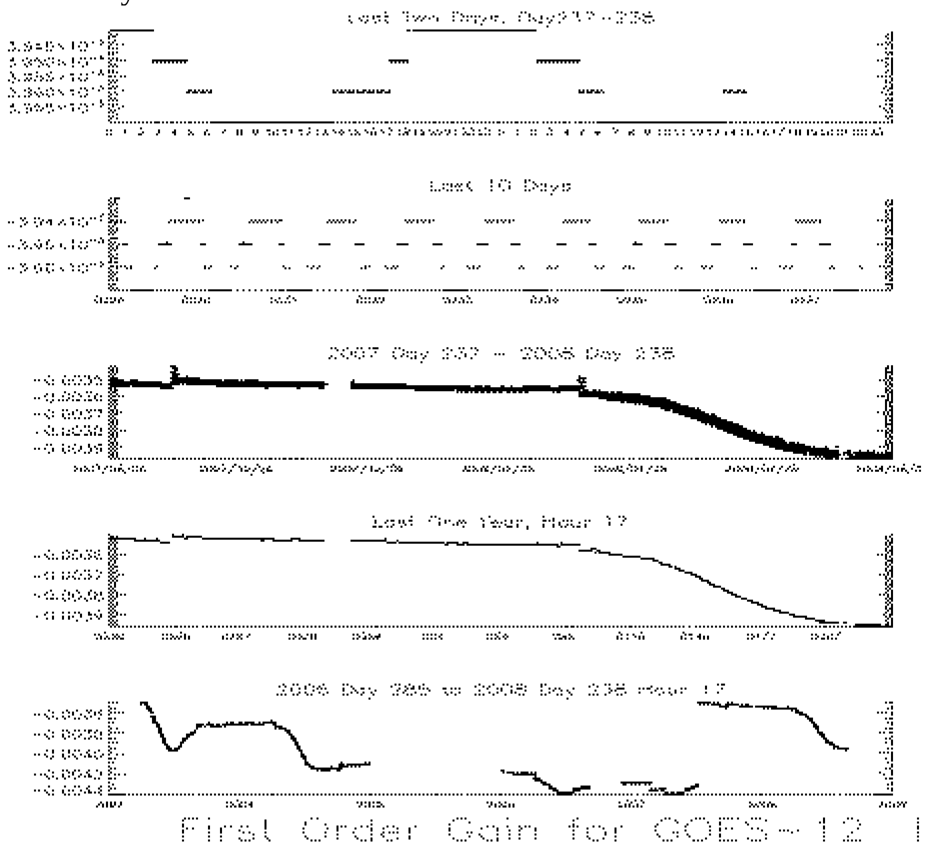

Figure 4: GOES-12 Imager channel 2 first order gain monitoring. From top to bottom is last two days, last 10 days, all data in the past one year, data at UTC17:00 over the past one year, and all UTC 17:00 data during operational status.

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

The AVHRR instrument performance monitoring system is used to detect any anomaly in the space view, blackbody counts, and telemetry readings for AVHRR. The system currently operationally tracks the instrument status for the three AVHRRs onboard NOAA-17, NOAA-18, and Metop-A. This system also monitors and validates the pre-launch and post-launch calibration coefficients for the solar reflective channels on the operational NOAA AVHRR. The time series plots of all these parameters are available online. Figure 5 is an example of Metop-A PRT temperature trending, showing its diurnal variation during orbit, and the short- and long-term stability of the telemetry. Large noise can be detected, and when this occurs a warning email is generated and sent out.

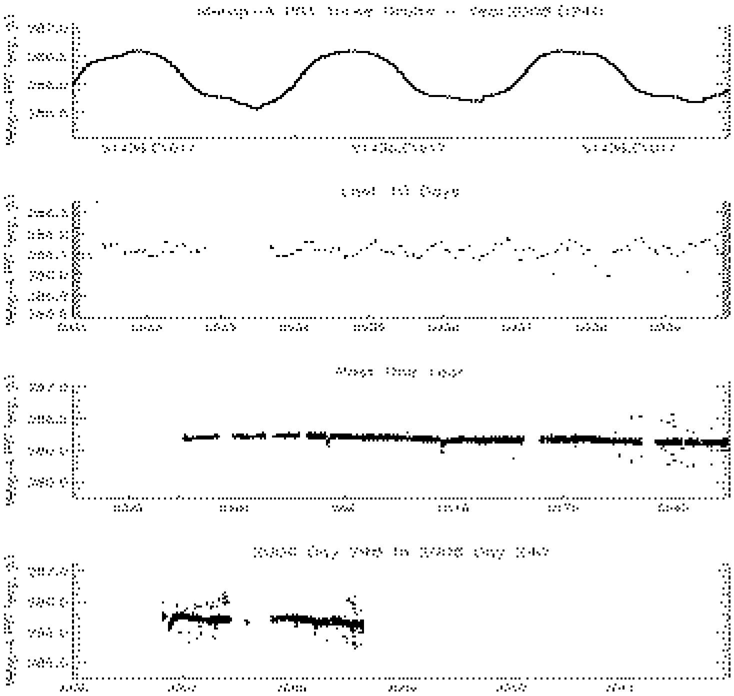

Figure 5: Metop-A AVHRR PRT trending. PRT temperature of most recent three orbits (top), last 10 days (upper middle), past one year (lower middle), and since after launch (bottom).

4.3 *POES MHS (Microwave Humidity Sounder)*

An instrument performance monitoring system has been designed, implemented, and documented this year for MHS on NOAA-18 and Metop-A. The parameters that the system monitors include calibration-related parameters, e.g., calibration coefficients, blackbody and space view counts, and blackbody temperature. It also includes instrument housekeeping data and status flags. The output of the system includes plots, tables, and anomaly warning e-mail messages.

An example set of routinely generated plots is given in Figure 6. In this figure, time series of Metop-A MHS Channel 1 noise equivalent delta temperature (NEDT) from 25 January 2008 to 25 April 2008 are given. Furthermore, the software includes an automated instrument anomaly warning system that generates e-mail messages about NEDT that exceeds specifications, the percentage of set bad flags within an orbit, and significant jumps of instrument parameters.

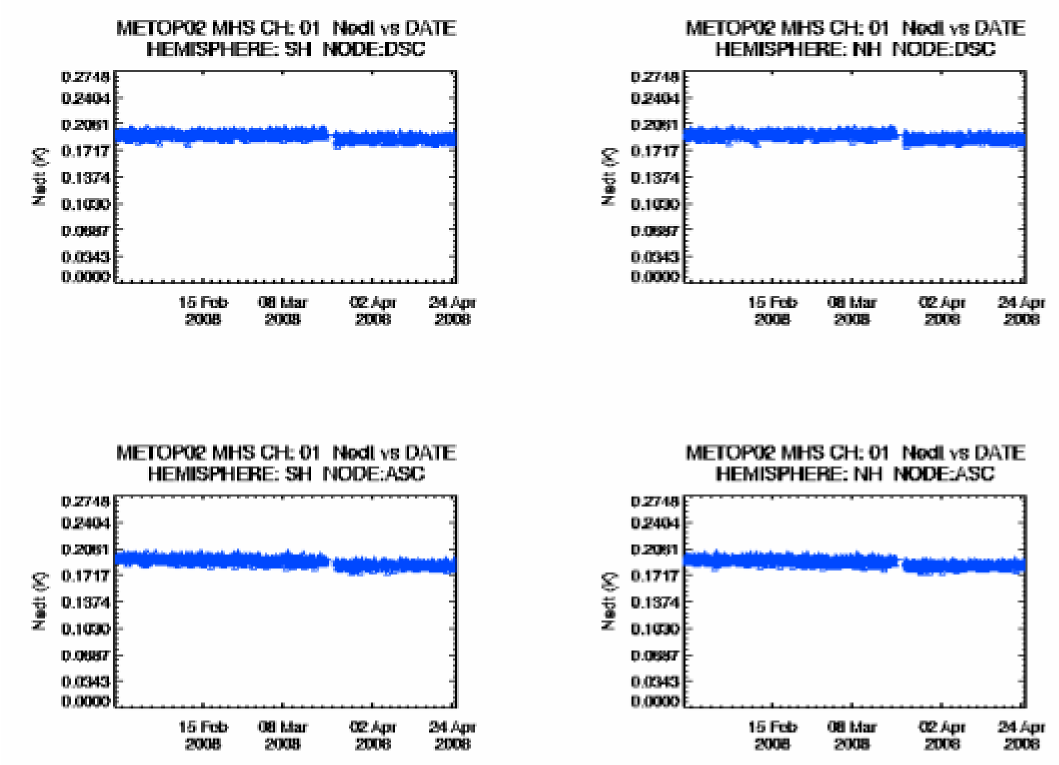

Figure 6: Time series of Metop-A MHS Channel 1 NEDT for 25 January to 25 April 2008. The four plots are divided into Northern (Southern) Hemisphere region on the right (left), and ascending (descending) node on the bottom (top).

The functionality of the software includes the ability to log the results of data granule analyses on an orbit-by-orbit basis. Thus, the software can go back to analyze missing granules without having to re-analyze granules that are not missing. This speeds up data processing immensely, and allows a very extensive archive of data to be easily accessible.

4.4 *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. The system automatically monitors the instrument performance related parameters, including space view and blackbody counts, calibration coefficients and NEDN (noise equivalent delta radiance), and filter wheel, warm target, and instrument temperatures (such as the baseplate, electronics, cooler housing, and detector temperatures). The time series of the these instrument parameters are updated in near-real-time, and are made available on the NOAA GSICS web site. When the noise level is out of the designed specification value (e.g., NEDN), the warning message is automatically triggered and sent out to instrument scientists.

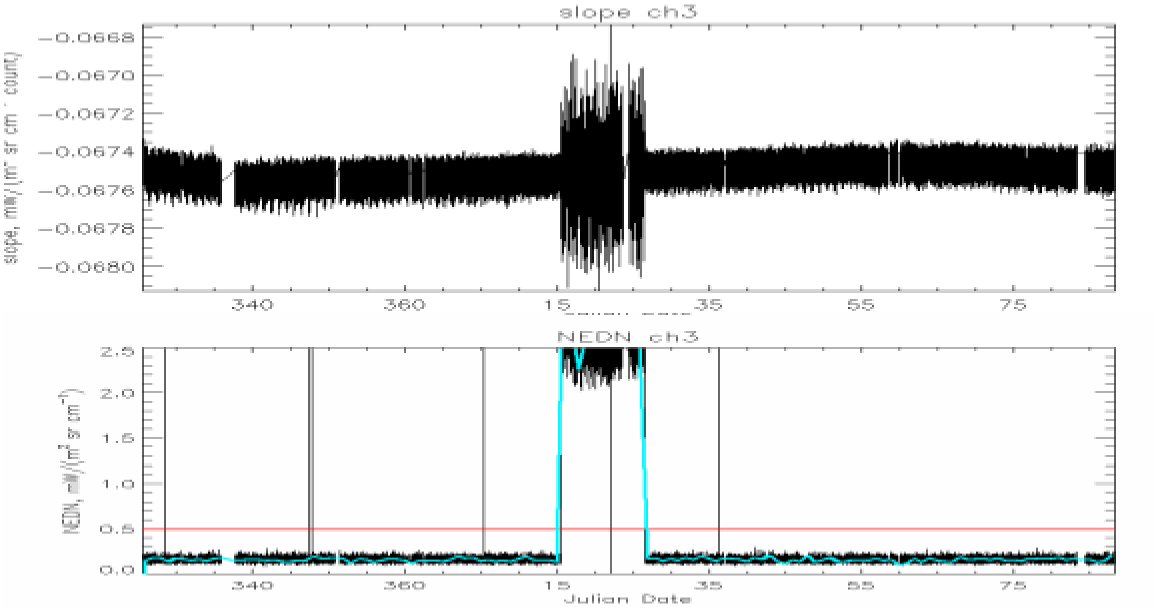

Figure 7: Time series of calibration coefficients and NEDN for channel 3 of Metop-A HIRS. The red line is the designed specific NEDN value while the blue line is daily-mean NEDN value.

Figure 7 demonstrates an example of the time series of calibration coefficients and NEDN for channel 3 of Metop-A HIRS. When the Low-Resolution Picture Transmission (LRPT) was turned on 15 January 2008, noise was suddenly triggered and affected the data quality of HIRS. Figure 3 clearly shows that the NEDN value was out of specification and the calibration coefficients became noisy. After the LRPT was turned off on 27 January 2008, the instrument assumed to the normal status.

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

The AMSU-A instrument monitoring system is also fully functioned at NOAA/NESDIS. The monitoring parameters include calibration-related parameters, e.g., calibration coefficients, blackbody and space view counts, and blackbody temperature. It also includes instrument housekeeping data. In addition to telemetry monitoring and trending, the data quality of earth observations are monitored regularly near real time. The image of each orbit is also posted on the web for users to check the data quality.

Figure 8 exemplifies the earth view data monitoring for NOAA-18 AMSU-A on 20 August 2008, where one orbit of data is displayed by channel for the 15 microwave channels. The system successfully detected a noise problem on 20 August 2008. There are many dropped lines due to the instrument noise problem.

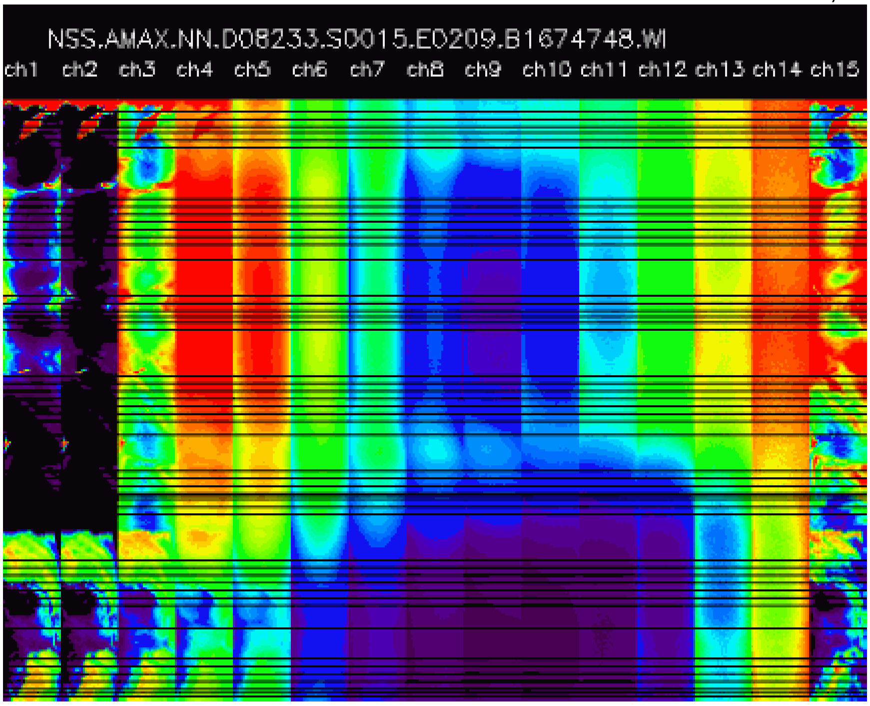

Figure 8: One orbit AMSU-A image for all 15 channels on 20 August 2008 from NOAA-18 AMSUA. There are many dropped lines due to the instrument noise problem.

5 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 near real-time instrument performance monitoring – curated, maintained, and located at the WMO Global Space-based Inter-Calibration System (GSICS) Coordination Center – has been carefully outlined.