Calibration/validation Status for GOES-16 L1b Data Products

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ABSTRACT

The first satellite of the Geostationary Operational Environmental Satellite-R series (GOES-R), the next generation of NOAA geostationary environmental satellites, was launched November 19, 2016. This satellite, GOES-16, carries six instruments dedicated to the study of the Earth's weather (ABI), lightning mapping (GLM), solar observations (EXIS and SUVI), and space weather monitoring (SEISS and MAG). Each of these six instruments are in the process of going through a series of specialized calibration plans to achieve their product quality requirements. In this review paper we will describe the overall status of the on-orbit calibration program, the path forward to Full product validation status, and any changes that may occur for the cal/val plans for GOES-S, which is planned for launch in early 2018.

Keywords: GOES-R, Cal/Val Strategy, Advanced Baseline Imager, Geostationary Lightning Mapper, EXIS, SEISS, SUVI, GOES-R MAG

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1. INTRODUCTION

The GOES-R (Geostationary Operational Environmental Satellite) Series of satellites are the next generation of operational weather satellites for the United Sates, covering much of the Western Hemisphere. The four planned satellites of the series (GOES-R through GOES-U) are being developed, launched, and tested on-orbit through a collaborative development between NOAA and NASA with overall program management by NOAA. The launch of GOES-R, now named GOES-16, occurred on November 19, 2016 from Cape Canaveral Air Force Station, Florida.

The six instruments carried by GOES-R satellite series are advancements over the instruments carried by the GOES satellites presently on-orbit (GOES-13 through GOES-15). The suite includes two Earth-observing instruments: the Advanced Baseline Imager[1] (ABI) and the Geostationary Lighting Mapper[2] (GLM). The GOES-R satellite series satellites also carry four instruments dedicated to the study of space weather: The Extreme Ultraviolet X-Ray Irradiance Sensor[3, 4, 5] (EXIS) and the Solar Ultraviolet Imager[6, 7] (SUVI) study the activity of the Sun, while the Magnetometer[8] (MAG) and the Space Environmental In-Situ Suite[9] (SEISS) measure the in-situ space environment of the satellite.

The GOES-R Program transferred operations of the GOES-16 satellite to NOAA OSPO (Office of Satellite and Product Operations) on June 23, 2017. This Handover is a major milestone in the satellite timeline, as a new set of engineers take over the operational procedures, although the calibration and validation (cal/val) teams stay the same. Also, once the satellite reaches operational status the ability to interrupt nominal data flows for cal/val activities is greatly curtailed. At the data product level, the Handover and move to operational status translates into providing OSPO with a clear description of the state of the product quality, including any anomalies in the products and the mitigation steps in-work to resolve them.

As part of the product quality process, all of the GOES-R instruments have underwent extensive pre-launch testing to verify their performance met mission requirements. The major objective of on-orbit testing is to re-validate the product performance, that is, to ensure that the products delivered once the satellite arrived on-station are, within uncertainty, in line with what was measured pre-launch. In many cases, the post-launch testing cannot test every quantity tested pre-launch or at the same level of precision and accuracy as can be done in a controlled laboratory environment. Additionally, the time available before Handover or drift to the final assigned station (in the case of GOES-16, this will be GOES-East) may not be long enough to study all types of environmental phenomena (including those affecting the satellite). Therefore, the expectation is that by Handover the tests should do the best job possible to confirm the products fulfill the intended purpose in the intended environment. The product testing and review process will continue after Handover to cover the full range of expected environmental conditions and to allow more time for detailed analysis and additional data collection.

This paper describes the overall progress process of the responsible instrument and data product teams to re-certify the performance of the GOES-R L1b data products. This paper is a follow-on to our previous paper[1], which describes the GOES-R definitions of product quality, the algorithm maturity process, the data release plan, and the interactions between the teams involved. We also included the plans for the post-launch test process from launch, through Handover, and out through mission life as envisioned before launch. The purpose of this new paper is to give GOES-R users an update on the testing progress, how and when the expected data products have already and are expected to reach the various mission-specified quality levels, and to familiarize the technical community with the results of some of the important post-launch tests conducted so far in the L1b product cal/val process.

The data for each product was inserted into the GOES-R Rebroadcast (GRB) stream and other select product delivery mechanisms to select users as soon as they reached Beta product maturity. This has the advantage of allowing more users to see the data and test the ability of their systems to ingest and process the data. A web search utilizing the term "#goes16" will produce many items of pre-operational data products (especially for ABI, GLM, and SUVI) made public by non-program sources. The excitement users have shown for the GOES-16 data has been a source of motivation for the cal/val program.

In Section 2, we give an overview of the overall cal/val process and schedule, while the specific details and test results relevant to the individual instruments and L1b products are given in Section 3. A look forward to the post-launch testing for GOES-S, planned to be launched in March 2018, is in Section 4.

The cal/val work described in this paper is the result of the tireless efforts of members of the GOES-R Flight Project, the instrument vendors, the GOES-R Ground Segment Project, the Program office, the Mission Operations Support Team (MOST), the Data Operations Support Team (DOST), the GOES-R Product Readiness and Operations (PRO) team, members of the Calibration Working Group (CWG), and several other individuals and teams. Many of these results will never be published beyond internal memos (although some early results are being given at this meeting), but these hard-working contributors deserve gratitude for the great strides the project has made.

2. MISSION TIMELINE AND PRESENT STATUS

2.1 Launch, Orbit-raising, Outgassing, and Instrument Turn-on

GOES-R was launched on an Atlas V rocket at 23:42 UTC on November 19, 2016 from Cape Canaveral Air Force Station, Florida. Through early December, the orbit of the satellite was raised to geostationary and stabilized until it reached its check-out location at 89.5 W longitude. At this point GOES-R was renamed GOES-16. Once on station, instrument out-gassing began, with most of the instruments being turned on even if science data was not being collected. The dates of various activities for the six science instruments are given on Table 1. Instrument out-gassing took about 30 days. The MAG boom was deployed at instrument activation, and the MAG did not require outgassing before delivering science data.

Table 1. Key dates in GOES-16 instrument and L1b data product maturity.

Instrument	Activation	First Science Data	L1b Beta Product Maturity	L1b Provisional Product Maturity
ABI	12/09/2016	01/07/2017	02/28/2017	06/01/2017
GLM	12/09/2016	01/04/2017	07/05/2017[a]	11/2017[b]
EXIS	12/09/2016	01/20/2017	03/23/2017[a]	11/2017[b]
MAG	12/07/2016	12/07/2017	05/25/2017	11/2017[b]
SEISS	12/21/2016	01/08/2017	02/10/2017	11/2017[b]
SUVI	12/09/2016	01/26/2017	04/19/2017	11/2017[b]

[a]Dates of PS-PVR given in the text do not match these dates. Minor product revisions were deemed necessary by the chair, and these dates signify when the revisions were complete and data release was approved.
[b]Dates for the Provisional Peer/Stakeholder-Product Validation Reviews (PS-PVRs) for these instruments are the estimated dates at the time of writing.

2.2 Post-Launch Test Phase

The approximately six-month long period from instrument activation to Handover of GOES-R from the Program to NOAA/OSPO was called the "Post-Launch Test" (PLT) phase. The initial phase of post-launch testing was performed by the GOES-R Flight Project and the instrument vendors working together (shortened to "Flight-led PLT"), and consists of a number of individual Post-Launch Tests ("PLTs"). These tests included health and safety tests, functional tests of all modes and settings, housekeeping functions, and the initial calibration activities (see the first paper for details). One of the major cal/val goals of this testing campaign was to show that the instruments have been delivered to orbit in the same functional state as tested pre-launch. In addition, initial calibration activities were performed. While the bulk of this phase was led by the Flight and vendor teams, these cal/val-related tests were also by the CWG teams.

2.3 Post-Launch Product Tests

As described in the our pre-launch paper, the cal/val plans by the CWG science teams were described in Readiness Implementation and Management Plans (RIMPs). These RIMP documents list the Post-Launch Product Tests ("PLPTs") to be conducted during all parts of mission life (including the sub-sample of tests that are required throughout mission life to preserve the calibration), the schedule for the testing, tool and data requirements (including external data sources), and staffing assignments. For most of the instruments, the PLPTs evaluation began with the first nominal science data collects.

2.4 Extended Validation and Transition to Operations

The period for the time between operational Handover and the drift to GOES-East is dedicated to additional cal/val efforts, desire is to keep the instruments and satellite in nominal operational modes. A few exceptional special modes are allowed and the normal mission-life cal/val activities can go on more frequently than during operations, if requested.

For ABI, the scheduled frequency for conducting the solar calibration timelines (referred to as "SCT events") for the VNIR radiometric trending is lower than it was during PLT and PLPT and is increasing to the final 90 day cadence between events. Lunar calibrations, including a continuation of chasing the Moon across the full field of regard to characterize and trend the response vs scan angle (RVS), can be done as requested. For GLM, the laser beacon campaign continues, including some of the first activities with the laser located at Monument Peak, CA.

On May 25, 2017, NOAA announced that GOES-16 would be assigned to the GOES-East location, which covers the Atlantic Ocean to the west coast of North America. At the time of writing this paper, the exact dates of the transition plan have not been finalized (see www.goes-r.gov for updates), but it is likely to happen in November 2017. From a data product and cal/val perspective, the drift plan includes placing all the instruments except MAG and SEISS into storage mode (the high data-rate X-band radio link is not permitted to be operated during drift). MAG and SEISS can provide data via the telemetry link during drift.

At the end of the drift, the GOES-16 instruments will be re-activated and a full set of routine health, safety, and calibration tests will be performed to ensure the instruments have returned to a similar calibration status as before drift and to re-establish the data quality trending. GOES-13, which is the present satellite at the GOES-East station, will continue simultaneous operations for a given period. This will be a boon for SIESS and, especially, MAG, because the proximity between the two satellites will allow for exceptional inter-calibration. If possible (based on operational need and the state of the geomagnetic field), GOES-16 will conduct axis-swapping maneuvers both before and after the drift to help improve the MAG calibration. After all of the instrument calibrations, including reestablishing the image navigation and registration (INR) solutions for both the ABI L1b and GLM L2 products, GOES-16 will be declared the operational GOES-East satellite and the nominal operational cal/val schedule will be performed.

3. L1B PRODUCT STATUS

In this section, we present the status of the L1b products (L2 for GLM) for the GOES-16 instruments. These descriptions are based on the reports given by the CWG teams at the "Peer/Stakeholder-Product Validation Reviews" (or PS-PVRs) based on the PLTs and PLPTs performed to assess the products. The PS-PVR process and the product maturity guidelines are further described in our first paper[1]. The Beta PS-PVRs have been held for all six instruments, and the Provisional PS-PVR for the ABI L1b/CMI (Cloud Moisture Imagery) products was held on June 1, 2017. The L1b Provisional PS-PVRs for the remaining five instruments should be held in the near future, but there are pending algorithm corrections necessary to reach Provisional product maturity for these products. Provisional maturity does not require all the major algorithm issues to be fixed, only described for the users. However, the Provisional product maturity level is also linked to some operational data flows, so any algorithm changes required to transition the products to operational status have been given priority.

The Beta PS-PVRs consisted of a review of the PLT results and any test outcomes requiring additional attention and an assessment of the path to Provisional maturity, which included a preview of the PLPTs needed to assess Provisional maturity (often including initial results) and a listing of risks to achieving Provisional maturity. Many of these risks are related to ground processing algorithm updates. This is due to both the fact that the instruments mostly performed very well during PLT, as described below, and also because by the time the PS-PVRs were held many of the solutions available to the instrument teams were already applied, leaving the remaining corrective actions to ground algorithms. The Provisional PS-PVR held for ABI L1b, and the mission "Key Performance Parameter" (KPP) Cloud Moisture

Imagery (CMI) followed a similar format: a review of PLPT progress to date, including comparisons to the Performance Baseline (described in the first paper) and a description of the path to Full product maturity, again with a listing of the risks to obtaining that status. The review materials for the PS-PVR are to be made public at the NOAA STAR web site and other outward-facing web sites, including the NOAA CLASS data archive.

The following descriptions of the product status point out many of the issues facing the products, but the reader should keep in mind that these are often the exceptions. The instruments and satellite, at the time of writing, are in good health, delivering high-quality L0 (raw) data and have passed through thorough testing on-orbit. Some of the ground system processing has needed updates to match what the instruments can deliver, and those updates are in progress. The ground processing system also has requirements to have continuous uptime with hot-backup capability, deal with high data rates (handling data and mission management for up to three satellites at a time), with low latency. The ground processing system itself is a remarkable piece of engineering, and the success of the teams that built and maintain it should be noted.

We cannot describe all of the remarkable instrument product tests conducted by the Flight Project and vendor teams or by the CWG. While we would like the reader understand what is being done in the cal/val process, space does not allow for all of the PLT and PLPT results to be given here. However, some of these results are being presented more fully by CWG team members at this meeting or at future science meetings.

3.1 Ground System Updates

At the time of launch, the ground system (GS) data operations (DO) processing baseline was DO.04.01.00 (the first number is the build, second is the patch number onto the build, and the third is the emergency release number). Each DO build may have a few hundred changes to the data processing algorithms, tool updates, product monitor upgrades, and other updates. A patch may have a few dozen changes, while an emergency release may have only a few immediately-necessary fixes. Most LUT (look-up table) updates can be implemented without a patch or build.[11] During each update process, data products created on the development environment are distributed to the cal/val teams via a manual data egress mechanism to allow for early product assessment.

Post-launch, there have been a continuous series of GS updates, including a full build, plus several patches and other releases. Content relevant to the cal/val process and product maturity are described in the subsections below. Another major build is planned for promotion in late 2017 and will be the last major build before GOES-S launch. These builds, patches, and other releases and updates are strictly intended to mature the product performance to meet the mission requirements.

3.2 ABI

PLT and Beta Maturity: The Advanced Baseline Imager creates the KPP for ABI: Cloud Moisture Imagery. CMI is grouped with the ABI L1b product, radiances, for the purposes of product maturity assessment. Due to its importance to the mission, the progress of the algorithm development and revision has been given priority compared to the other instruments.

ABI was activated on December 9, 2016. The ABI door was opened and the first VNIR (visual/near IR); $\lambda < 3$ μm) band Earth-imaging data was obtained on January 7, 2017, and the first 16-band Earth images were obtained January 11, 2017. The PLT activity for ABI consisted of radiometric testing, noise and linearity characterization, image navigation and registration (INR) testing, and filter performance characterization. The Beta PS-PVR for ABI radiances[12] and CMI[13] was held on February 28, 2017. At that time, the performance of the data products were exceeding the Beta definition and the main risks to reaching Provisional were related to intermediate data products that assist CWG with their data assessment.

Provisional Maturity: The Provisional PS-PVR for ABI radiances[14] and CMI[15] was held on June 1, 2017. The evaluation focused on three main issues facing the products: the IR radiometric calibration, the VNIR radiometric calibration, and the INR quality, especially stability and channel-to-channel biases. The IR calibration performance was generally very good, with comparisons to SNPP CrIS being well within 0.5 K. There were issues with striping (resolved with a parameter update) and some periodic calibration issues related to the application of space look data.

The VNIR channel radiometric performance was generally acceptable (shown by comparisons to SNPP-VIIRS, for example), but PLPTs showed that there were jumps in the calibration and some striping issues. The radiometric jumps were traced to the ground system not synching the values of the calibration coefficients correctly between the two operational data processing ground sites. The striping has been significantly alleviated by parameter updates.

The INR issues were discovered by comparisons to fixed ground sites. The ABI INR algorithm uses routine star looks to assess the fine pointing of the mirrors. If a star is not observed and processed about every 10 minutes, the INR solution is reset to default values, and it takes about 30 hours for the solution to stabilize. One of the main issues with the INR during PLT was that the consistent use of non-nominal observing modes for which star looks were either not included or not processed. A ground system update will allow for the processing of star looks when taken by non-nominal observing modes, so this problem should be greatly reduced during GOES-S PLT. The default INR solution were leading to large channel-to-channel biases which were not present pre-launch. While the origin of this shift from pre-launch has not been determined, the default values have been changed to greatly reduce the bias. Therefore, when the INR solution resets, the default solution is much closer to the requirements limit than before.

Field Campaign: As described in the first paper, GOES-16 PLPT will be assisted by the execution of a field campaign utilizing a NASA ER-2 aircraft[16]. The instrument set for this campaign includes radiometric instruments for both the VNIR and IR channels. This campaign was conducted starting March 12, 2017 and ending May 17, 2017. Of the sixteen flights, three were dedicated to ABI L1b products: two for VNIR, one for the thermal IR. The VNIR flights utilized the Sonoran desert and the IR flight flew over the Gulf of Mexico. The field campaign included flights over ground calibration sites and underflights of the LEO satellites SNPP and Metop-B. The field campaign data are to be made public to assist with research projects

3.3 GLM

The Geostationary Lightning Mapper (GLM) is the first operational lightning mapper in geostationary orbit. As a revolutionary instrument, the natural development cycle meant the development of ground processing algorithm required several iterations, with the final operational implementation occurring in April 2017. Therefore much of the PLT work was done with off-line processing by the vendor.

GLM was first activated on December 9, 2016. The aperture door was opened, and first Earth images were obtained on January 4, 2017 (prior to ABI, although these images are not released as part of the official GLM product). Example PLT activities for GLM include detection threshold adjustments and INR assessments. A major component of the PLPT activities involve comparing the GLM L2 products to results from ground-based detection arrays.

The Beta maturity PS-PVR[17] for the GLM L2 products (lightning events, groups, and flashes; these are grouped with the L1b products for the other GOES-16 instruments due to how the data processing occurs) was held on June 9, 2017. This was the last of the L1b PS-PVRs due to the later implementation of the algorithms. At this review, the issues with the data products included INR offsets, a large false event detection rate (thought to be due to radiation), and several metadata/product file errors. Updates of LUT files have helped fix some of these problems, and other issues may be resolved through post- processing.

The NASA ER-2 field campaign has provided valuable data to help with Full validation. A lightning detection instrument called FEGS (“Fly’s Eye GLM Simulator”) is designed to look down on the tops of thunderstorms just like GLM and utilize as similar a detection methodology as GLM[18]. Eleven ER-2 flights utilized FEGS and other airborne lightning detection data to collect data for GLM validation, including flying over the massive severe storm that produced damaging hail in the Denver, CO region on May 8, 2017.

Support for the INR assessment is underway via the use of ground-based laser beacons[19]. The two lasers are tuned to 777 nm and pulsed to simulate real lightning. They are located in Greenbelt, MD, just outside the main Goddard Space Flight Center campus, and on Monument Peak, CA, about 50 miles east of San Diego,. The beacons are at known, fixed locations and create a strong lightning detection signal in the L2 data products, both day and night. The GLM INR algorithm uses a coastline-finding method and cannot operate at night. Therefore, the beacons provide an excellent test of the INR solution. The laser beacon tests are scheduled to continue through the end of Extended Validation and will support Full Validation maturity.

3.4 EXIS

The Extreme UV and X-ray Irradiance Sensors (EXIS) is one of the two instruments on the Sun Pointing Platform (SPP). Like SUVI (described below), EXIS detects solar activity to help predict when such activity may lead to harm to other satellites, astronauts, or ground systems like power grids or communications. Both the X-ray and EUV sensors detect wave bands sensitive to the solar activity level. EXIS was first activated on December 9, 2016, with closed-door tests extending until when the aperture door was opened January 10, 2017. The SPP was first pointed towards the Sun on January 20, 2017. Testing consisted of dark determinations, filter checks, gain and signal-to-noise determinations, and field-of-view mapping.

The Beta PS-PVR[20] for the EXIS L1b products (solar EUV flux and solar X-ray irradiance) was held on March 8, 2017. The PLTs results found the data products included a poor dark value for one X-ray band, poor fitting of the Mg II region, and, most serious, electron contamination creating a spurious X-ray signal at low flux levels. The first two issues were mitigated by retesting and parameter fixes, but the electron contamination may have to be solved at the L2 product level, possibly by using SEISS particle detection data to quantify the incident electron flux levels. In addition to the science fixes, there are several data format and metadata issues in the L1b product that need attention before downstream users can effectively use the data. These fixes have been accomplished, or are in the process of being corrected in the ground system. As an instrument meant to detect solar activity, the product maturity assessment is enhanced by periods of strong solar activity. We are in a quiet period for the Sun, but PLPT progress will continue whether the Sun cooperates or not.

3.5 SUVI

The solar imager SUVI uses six channels to image solar activity. SUVI was activated on December 9, 2016, and the first images taken on January 26, 2017. The Beta PS-PVR[21] for the L1b product (solar EUV imagery) was held on April 19, 2017. The PLT process was successful, although some of the flat fielding processes had to be modified and repeated to improve the results. Other successful PLT tests include the calibration of the guide telescope, characterizing the opto-mechanical functions, and measuring the CCD performance parameters.

The SUVI L1b product issues have been identified during the testing regimen. Some issues, like incorrect or missing metadata, may look minor at first glance, but has implications for the downstream processing for operational users. More strikingly, the background subtraction needs modification to meet requirements and will be fixed in the near-term. Additionally, radiation events can dominate the image statistics, but it has been decided that the removal of these artifacts can be done in the downstream processing. Off-line processing has shown that SUVI provides excellent solar images, so Provisional and Full product maturity should follow with the needed algorithm updates and testing. Like EXIS, the lack of solar activity has prevented some of the PLPTs from full completion.

3.6 SEISS

The SEISS instrument is composed of several particle detectors: The MPS-LO and MPS-HI sensor detect low- and high-energy magnetosperic electrons and protons. The SGPS detects solar and galactic protons, while EHIS is sensitive to energetic heavy ions. The SEISS data processing unit was activated on December 21, 2016, and the sensor suite was activated on January 8, 2017. On that same date the initial in-flight calibrations (IFCs) were conducted to determine the correct gain ranges and voltage settings for the sensors. These IFC were mostly successful, with a few requiring adjustments before being repeated. The high-voltage settings for the microchannel plates of MPS-LO needed adjustment and the SGPS sensor showed temperature sensitivities for some channels.

The SIESS L1b products (energetic heavy ions, magnetospheric electrons and protons of low and high energy, and solar and galactic protons) were the first to achieve Beta maturity on February 10, 2017. During the PS-PVR[22] four issues with the product were discussed: 1) non-physical flux differences between the east- and west-facing SGPS sensors, 2) unexpected sensitivity to electrons by EHIS, 3) high backgrounds for MPS-HI, and 4) overcorrection for electron contamination for some channels for MPS-HI. These issues have been resolved. While some ground processing issues remain, the prospects for reaching Provisional and Full product maturity may only be limited by the need for space weather events with enough high-energy particles to test the full range of the sensors.

3.7 MAG

The GOES-16 Magnetometer (MAG) was activated on December 7, 2016. The activation included the deployment of the magnetometer boom. The two fluxgate magnetometers are mounted 6.3-m and 8.5-m from the spacecraft bus. The magnetometers were active during the 43 second deployment with the purpose of characterizing the magnetic field of the spacecraft as it decreases with distance.

Soon after deployment, though, it was suspected that the magnetic field interference from the spacecraft was larger than intended in the GOES-R satellite series design. The MAG was designed with to have a measurement range of ±512 nT, an accuracy requirement of 1.7 nT per axis and a noise requirement of 0.3 nT per axis. The interference signal was manifest as a field difference between the inbound and outbound magnetometer of up to 70 nT. The difference changes rapidly, and it was decided that it is likely the result of current loops created by the thermoelectric effect and changing solar illumination through the orbit. Additional interference sources and/or design issues are suspected, such as from the firing of the arcjet thrusters for station-keeping maneuvers, but these cause smaller or shorter-term signals. Actions have been taken to mitigate the possibility of these issues for the follow-on GOES-S/-T/-U magnetometers.

After period of intense scrutiny and testing, there is some measured optimism for the MAG L1b product based on the repeatability of the interference from day-to-day (this is once case where the recent "quiet" space weather has helped). These tests included a series of spacecraft maneuvers (rotations around the axes) and comparisons to the GOES-13 magnetometer at 75.0 W longitude. Additional tests, including another maneuver, are planned during the satellite drift to the GOES-East location. Having GOES-16 and GOES-13 in proximity to each other for even a short period would eliminate environmental differences in the comparisons for that time. The MAG L1b product (geomagnetic field) reached Beta product maturity[23] on May 25, 2017. The MAG product is expected to reach Provisional and Full product maturity, and the CWG and MIT/LL teams want to characterize the interference signal over a full year with some additional processing corrections implemented into the ground system as part of the maturity process.

4. CAL/VAL PLANS FOR GOES-S

At present, the launch of the second satellite of the GOES-R satellite series, called GOES-S, is planned for March 2018. Once this satellite reaches geostationary orbit, it will be renamed GOES-17. The immediate post-launch orbit for GOES-17 (and the two remaining GOES-R series satellites will place it in the same check-out location as GOES-16. Like GOES-16, GOES-17 will go through an approximate six-month period of intensive satellite and instrument check-out (PLT), but there will be several differences in the cal/val maturity of GOES-17.

First, there will be no Extended Validation period for GOES-17. The Extended Validation period for GOES-16 was to test the product algorithms over a full year of seasonal changes. Once that is done, it is believed that the seasonal effects for the overall algorithm suite will be sufficiently characterized. While there will be instrumental characteristics unique to each flight model, it is expected that these differences will not be large enough to affect the transition to operations after PLT.

Second, the ABI cal/val efforts will not benefit from another field campaign with the ER-2. There is, however, a proposal to continue the GLM laser beacon campaign for GOES-17. The likely final destination for GOES-17 is the GOES-West orbital station (over the eastern Pacific Ocean), where the GLM field of view will not cover many coastline regions aside from western North America. The INR algorithm for GLM depends on these coastlines, and there is concern that the INR quality of GLM for GOES-West may not be optimized. The laser beacon on Monument Peak, CA would be very useful to ascertain the INR quality, especially if it is joined by another laser on a Pacific island (for example, at the satellite laser ranging site on Haleakala, Maui).

Finally, the cal/val check-out of GOES-17 will benefit from the experiences and existence of GOES-16. The algorithms and ground system will be much more mature, the engineering and scientific staff will have a greater understanding of the systems, and which post-launch tests were the most useful in preparing the instrument and products.

Importantly, having two copies of each instrument in orbit will allow for invaluable product inter-comparisons. The check-out location is only about 15 degrees west of the GOES-East station, so there will be a large overlap in parts of the Earth both GLM and ABI instruments will see (although at slightly different view angles). EXIS and SUVI will see essentially the same Sun. The MAG and SEISS instruments on the two satellites will not detect the exact same space environment (which is the case at present between GOES-13 and GOES-16), but, again, having identical instruments on-orbit will improve the inter-calibration.

The ability of the ground processing system to handle two-satellite operations has been tested using the GOES-16 input data stream, processing it on two separate processing strings as if two satellites were in operations. The NOAA operations team have already assumed responsibility for GOES-16 operations, so the NASA Flight/vendor teams can concentrate on GOES-17 PLT.

5. SUMMARY

During its first eight months in orbit, the cal/val check-out of the GOES-16 L1b products has produced many successes. The satellite and communication system has been fully functional and stable. The ABI L1b products reached Provisional product maturity on schedule. The data quality caveats given for the ABI L1b products at the time of the

Provisional PS-PVR are tractable, and the fixes for most are in the system or in the works at present. While not a focus of this paper, most of the ABI L2+ products have reached Beta maturity, with the exception of a few that need minor algorithm revisions and the hurricane intensity product, which requires tropical activity to test the product.

The operational algorithm for GLM was installed five months after launch, but the GLM L2 data products reached Beta product maturity approximately six weeks later due to the hard work of the instrument vendors and the CWG team. Several of the algorithm modifications needed to reach Provisional maturity have been installed or in-work.

The L1b products for the space weather instruments (MAG, SEISS, EXIS, and SUVI) reached Beta maturity during PLT. The algorithm corrections necessary to reach Provisional maturity are in-work. The contamination and other issues affecting the MAG L1b product is of concern, but progress has been made since the Beta PS-PVR in characterizing the product behavior towards achieving Provisional.

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