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Geostationary Operational Environmental Satellite (GOES) – R Series

ABI L2+ Clear Sky Mask Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

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ABI L2+ Clear Sky Mask Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

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Preface

The evolving calibration and validation (cal/val) maturity of Geostationary Operational Environmental Satellite R-Series (GOES-R) products throughout the beginning of the mission is described by three levels: Beta, Provisional, and Full validation. The Flight Project is responsible for producing the Level 1b (L1b) products according to the Level III requirement documents. Once Beta Maturity of the L1b products is achieved, the Level 2+ (L2+) will begin analysis towards Beta maturity. Further levels of maturity (Provisional and Full validation) require additional and often long-term activities. A detailed description of the three product maturity levels is given in Figure 1, but brief descriptions of the three maturity levels are:

Beta: the product is minimally validated and may still contain significant errors; based on product quick looks using the initial calibration parameters.
Provisional: product performance has been demonstrated through a large, but still (seasonally or otherwise) limited, number of independent measurements. The analysis is sufficient for limited qualitative determinations of product fitness-for-purpose, and the product is potentially ready for testing operational use.
Full: product performance has been demonstrated over a large and wide range of representative conditions, with comprehensive documentation of product performance, including known anomalies and their remediation strategies. Products are ready for operational use.

Assessment and declaration of maturity levels is performed during Peer Stakeholder–Product Validation Reviews (PS-PVRs). At each PS-PVR, the status of products will be presented by members of the cal/val science teams. For L2+ products, Beta maturity PS-PVRs are held in close proximity with and prior to Operations Handover. The review panel at the PS-PVRs will include the GOES-R Operational Readiness Working Group (GORWG), GOES-R Program System Engineering (PSE), NOAA Office of Satellite and Product Operations (OSPO), and GOES-R Product Readiness and Operations (PRO). The Readiness, Implementation, and Management Plans (RIMPs) have been created to document the analysis techniques, methodology, duration, tools, data, resources, staffing, and schedule of the Post-Launch Product Tests (PLPTs) to be used by the cal/val science teams to demonstrate the different levels of product maturity. The primary purpose of the RIMPs is to act as a planning resource for the cal/val teams as they prepare for Launch. Additionally, the RIMPs can be used by other members of the GOES-R Program to prepare for cal/val activities, to assess the suitability of the cal/val test plans, and to understand the data and resource requirements the science teams have. Cal/val testing is likely to reveal necessary algorithm changes to evolve the product quality through the maturity levels. The Algorithm Change Management Plan (ACMP) will be used to track and implement these algorithm changes.

The introspection necessary to create these RIMPs has led to extensive consultations between the cal/val teams and other groups within the GOES-R Program, including the Flight Project, the Ground Segment, and a team of experts from The Aerospace Corporation under contract from GOES-R PSE to help improve the cal/val mission. Figure 2 below describes the responsibilities and accountability of each of the main parties involved in the creation of the RIMPs. This delineation is required because GOES-R operations are to be handed over from the GOES-R Program to NOAA OSPO at the end of the PLT period, yet the process of validating product maturity will continue. This changing nature of accountability during the process must be acknowledged. Accountability of the RIMPs changes at Operations Handover from NASA to NOAA and is aligned with the level of each RIMPs' validation maturity objective. Accountability determines which organization owns documentation, process, and procedures. Responsibility determines which organization creates, executes, and maintains specific activities.

GOES-R Product (L1b and L2+) Maturity Levels

Beta Validation

Preparation Activities
- Initial calibration applied (L1b).
- Rapid changes in product input tables, and possibly product algorithms, can be expected.
- Product quick looks and initial comparisons with ground truth data (if any) are not adequate to determine product quality.
- Anomalies may be found in the product and the resolution strategy may not exist.

End state
- Products are made available to users to gain familiarity with data formats and parameters.
- Product has been minimally validated and may still contain significant errors.
- Product is not optimized for operational use.

Provisional Validation

Preparation Activities
- Validation and quality assurance (QA) activities are ongoing, and the general research community is now encouraged to participate.
- Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing.
- Incremental product improvements may still be occurring.
- Users are engaged in the Customer Forums (L2+ products only), and user feedback is assessed.

End state
- Product performance (L1b or L2+) has been demonstrated through analysis of a small number of independent measurements obtained from selected locations, periods, and associated ground-truth/field program efforts.
- Product analysis are sufficient to communicate product performance to users relative to expectations.
- Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.
- Testing has been fully documented.
- Product ready for operational use and for use in comprehensive calibration/validation activities and product optimization.

Full Validation

Preparation Activities
- Validation, QA, and anomaly resolution activities are ongoing.
- Incremental product improvements may still be occurring.
- Users are engaged and user feedback is assessed.

End state
- Product performance for all products is defined and documented over a wide range of representative conditions via ongoing ground-truth and validation efforts.
- Products are operationally optimized, as necessary, considering mission parameters of cost, schedule, and technical competence as compared to user expectations.
- All known product anomalies are documented and shared with the user community.
- Product is operational.

Figure 1. GOES-R product maturity levels.

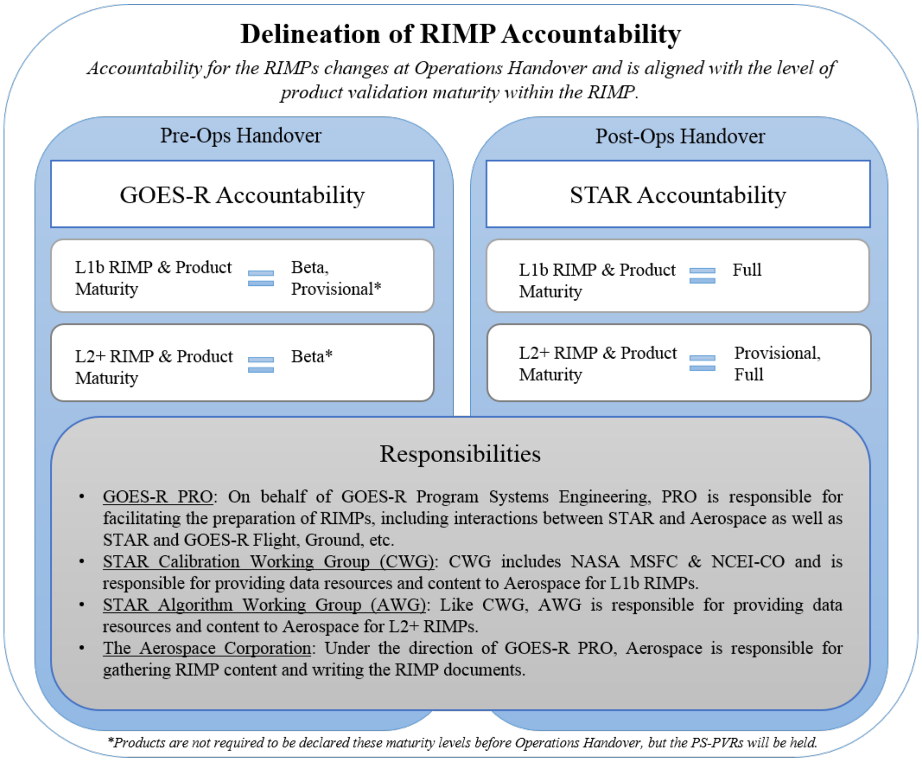

Figure 2. Delineation of accountability between GOES-R and STAR.

1. Clear Sky Mask Validation Overview

This RIMP covers all validation stages for the GOES-R Advanced Baseline Imager (ABI) Clear Sky Mask (CSM) product. There are three stages in the validation process: Beta, Provisional, and Full. Each stage is characterized by PLPTs, which guide the overall validation process. The RIMP includes a summary of the methods and tools employed to prove the CSM has met a given validation stage. Appendices are included that present more detail on each applicable PLPT and detail on the different data sets and tools employed in the CSM validation process.

Eight PLPT have been defined to attain Beta maturity for the CSM product. Three of these establish that the CSM product is created at ABI Mode 3 for Full Disk (FD), CONUS, and mesoscale scenes and they are generated at the frequencies required. Two additional PLPTs apply to FD and CONUS in ABI Mode 4. These five are all verified by OSPO in the first week of the PLPT period. The remaining three PLPTs determine how closely the CSM product attains the level of accuracy and performance required in the requirements document, but only for a limited time frame. The Beta PLPTs related to the accuracy and precision commence at the end of the PLPT period and occurring in parallel, lasting approximately 5 weeks. No specific type of mesoscale scene is necessary, other than some should have clouds (a reasonable expectation). The CSM validation effort does not require any field campaign data. No North/South (N/S) scan data is needed or used for the validation of CSM. National Weather Service (NWS) feedback will be via the Peer Stakeholder-Product Validation Review (PS-PVR) process, with additional insight from the National Center for Environmental Prediction (NCEP) and the Earth System Research Laboratory (ESRL).

These three PLPTs are the responsibility of the cal/val team.[1,2] PLPT events that support Beta maturity are listed below; details are in Appendix A.

- **ABI-FD_CSM01:** verify the FD product is generated every 15 min in Mode 3.
- **ABI-CONUS_CSM01:** verify the CONUS product is generated every 15 min in Mode 3.
- **ABI-MESO_CSM01:** verify the mesoscale product is generated every 5 min in Mode 3.
- **ABI-FD_CSM02:** verify the FD product is generated every 15 min in Mode 4.
- **ABI-CONUS_CSM02:** verify the CONUS product is generated every 15 min in Mode 4.
- **ABI-FD_CSM03:** determine the extent to which the CSM FD product meets the Mission Requirements Document[3] (MRD) product specification over a very limited number of independent measurements.
- **ABI-CONUS_CSM03:** determine the extent to which the CSM CONUS product meets the MRD product specification over a very limited number of independent measurements.
- **ABI-MESO_CSM02:** determine the extent to which the CSM mesoscale product meets the MRD product specification over a very limited number of independent measurements.

The following Table identifies the frequency of each scan type for Modes 3 and 4. It includes the required cadence of the CSM product as defined by both the GOES-R Functional and Performance Specification (F&PS) and the Product User's Guide (PUG). The bottom line reflects, for each appropriate scan type, the frequency of that product used for verification purposes. Any validation that occurs will use the frequency of the operational output, as indicated in the Table. Note the F&PS and the PUG do not agree, as the PUG is a forward looking document that reflects the frequency at which the ground system will actually produce the product. That is the product frequency to be used for validation.

** There is no CONUS scan type for Mode 4, but there are required products over the CONUS that are derived from the FD output*

Mode	Mode 3			Mode 4		
Scan Type	FD	CONUS	Mesoscale	FD	CONUS	Mesoscale

Scan Freq	15 min	5 min	30 sec	5 min	5 min[1]	N/A
F&PS	15 min	15 min	5 min	15 min	15 min	N/A
PUG	15 min	5 min	5 min	5 min	5 min	N/A
Verif Freq	15 min	5 min	5 min	5 min	5 min	N/A

Table 1. CSM documented product cadence and verification approach

Three events in the PLPT list have been defined to attain Provisional maturity. The Provisional stage focuses more on the ability of the CSM to satisfy its downstream users' needs as well as accomplish statistical analysis sufficient to prove the CSM meets its requirements over global conditions. The Provisional PLPTs last 24 weeks (TBR), occur in parallel, and commence immediately after Beta maturity has been attained.[1,2] PLPT events that support Provisional maturity are listed below; details are in Appendix A.

- **ABI-FD_CSM04:** assess the accuracy and precision of the CSM FD product over a large and wide range of representative conditions.
- **ABI-CONUS_CSM04:** assess the accuracy and precision of the CSM CONUS product over a large and wide range of representative conditions.
- **ABI-MESO_CSM03:** assess the accuracy and precision of the CSM mesoscale product over a large and wide range of representative conditions.

Moving to the Full stage of maturity, the only additional consideration compared to the Provisional stage is the use of a more complete and thorough set of CSM data. Because the CSM must meet all of its requirements at the Provisional stage, what remains is establishing the CSM meets those requirements for all seasons. The Provisional stage accounts for all conditions but is unlikely to account for all seasonal effects since it is scheduled to be completed approximately 6 months after launch. Therefore, the CSM cannot achieve Full maturity until at least one year's worth of data is available and analyzed. The methods and tools necessary to prove Full maturity are the same as those for proving Provisional maturity. PLPT events that support Full maturity are listed below; details are in Appendix A.

- **ABI-FD_CSM05:** assess the accuracy and precision of the CSM FD product over all representative conditions, to include all seasons, over at least one year's worth of CSM results.
- **ABI-CONUS_CSM05:** assess the accuracy and precision of the CSM CONUS product over all representative conditions, to include all seasons, over at least one years' worth of CSM results.
- **ABI-MESO_CSM04:** assess the accuracy and precision of the CSM mesoscale product over all representative conditions, to include all seasons, over at least one years' worth of CSM results.

The validation processes and procedures, monitoring and analysis methods, tools, and expected output artifacts are described in the following sections. The details of each PLPT test are contained in Appendix A and of each reference data set in Appendix B. The details of any tools used in the validation process are in Appendix C.

2. Schedule of Events

The details of the GOES-R validation schedule are shown in Figure 3. System Performance Operation Test (SPOT) begins 44 days after launch when ABI Level 1b (L1b) and the L2 Cloud and Moisture Imagery (CMI) key performance Beta evaluation begins. The L1b and L2 CMI data should be declared Beta maturity by L+87 days. One day later, the GOES Rebroadcast (GRB) will be populated with that data. The L2 products must reach Beta maturity by handover at L+197 days, the same time that ABI L1b and CMI reach Provisional. Given that L2 Beta tests require at least 6 weeks, L2 Beta testing must get underway by L+155 days, but can begin as soon as the ABI L1b and CMI reach Beta (L+87 days). The GOES-R operations phase begins after handover marking the start of a 12 month Extended Validation period for ABI L1b and CMI, which is coincident with the start of the 6 month L2 Provisional evaluation, followed by another 9 month period for L2 products to reach Full maturity, 15 months after operational handover to OSPO. Because there are many products which depend upon the CSM, the CSM schedule contains completion dates earlier than the actual "no later than" dates in the formal L2 schedule. The CSM at handover is to be, at a minimum, at the Beta stage of verification.[1,2,16] Further, the CSM intends to reach Provisional at L+197 days, even though that is the "no later than" date to reach Beta, to assist dependent products and allow them more time to validate their products with a well-defined CSM.

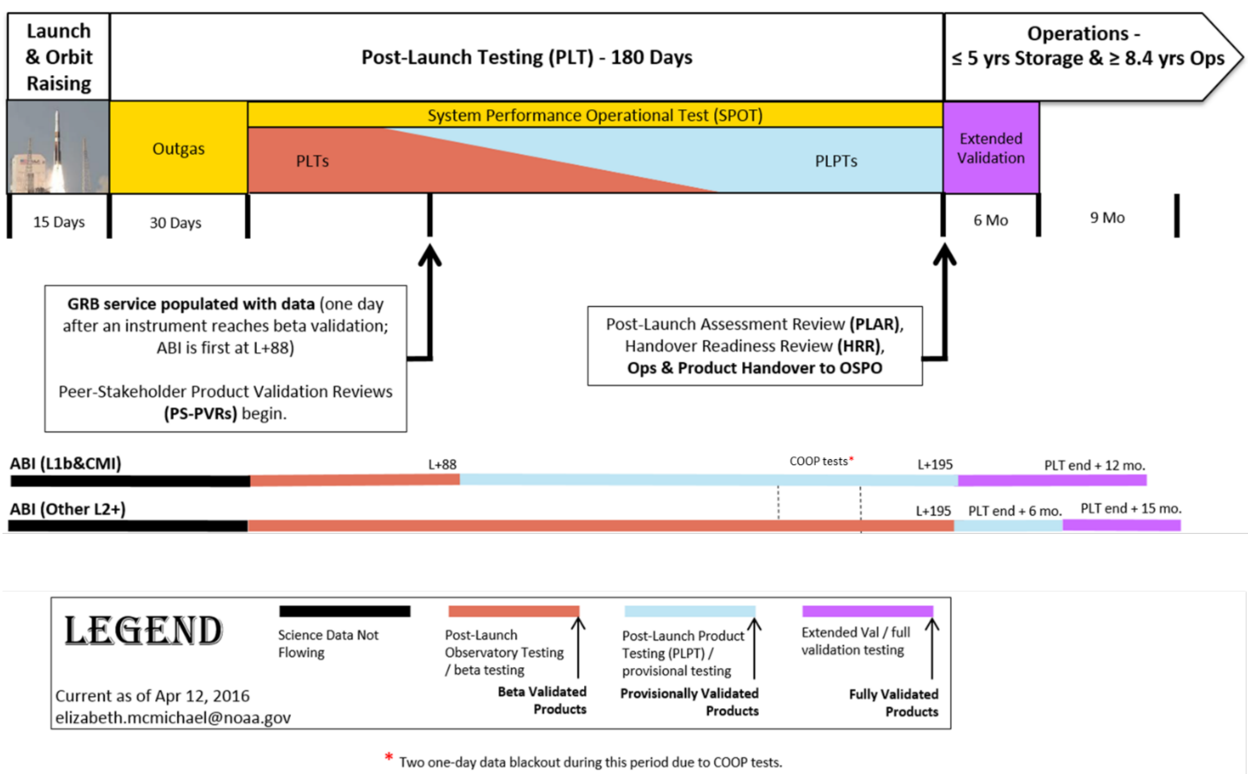

Figure 3. Schedule of events.

A schedule of specific CSM activities includes:

- Current – December 2015: finish testing all CSM validation tools.
- Current – July/August 2016: evaluate results using data from Data Operations Exercises (DOEs) 3 and 4.

- July 2016 complete final version of all CSM validation tools.
- Current – October 2016: test and evaluate algorithm with Himawari-8 data.
- L+70 days: begin CSM Beta cal/val activities.
- L+77 days: complete verification of cadence requirements (OSPO).
- L+100 days: complete Beta phase of validation (no later than date L+197 days).
- L+197 days: complete Provisional phase of validation (no later than date L+337 days).
- L+433 days: complete Full phase of validation (no later than date L+647 days).

Other aspects and dependencies related to schedule include:

- The CSM will be quantitatively compared to truth data sets described in Appendix B starting in the Beta cal/val period.[1,2,6,7]
- Additional cloud masks will be brought in and/or produced at the Cooperative Institute for Meteorological Satellite Studies (CIMSS) to compare with the CSM, starting with the Provisional stage of validation.[1,6,7]
- Six months of data is optimal to determine if Provisional has been met, as this allows for each season to be accounted for, but given the dependencies on the CSM, 90 days has been allocated from the end of the Beta stage to the end of the Provisional stage.
- Any issues with data access to any CSM products will directly impact the schedule of CSM validation activities.
- The CSM takes precedence over other cloud products since all other cloud products depend on the CSM output.[1,4]

3. Roles and Responsibilities

3.1 Primary Point of Contact

The primary point-of-contact (POC) for managing the CSM and coordinating algorithm updates is Andy Heidinger.[1,6,7]

3.2 GOES-R Point of Contact

The primary POC at GOES-R for the CSM validation effort is Wayne MacKenzie.

3.3 Test Analyst/Engineer

The test analyst is Denis Botambekov for both the Beta and Provisional phases.

3.4 GOES-R Feedback

Formal feedback to the GOES-R Program regarding the CSM validation will be provided by Jaime Daniels.

3.5 Level of Effort

Denis Botambekov will work the validation of the GOES-R CSM during the Beta and Provisional phases at an effort of 0.5 Full-Time Equivalent (FTE) for both phases.[16]

4. Tools

The CSM validation methodology includes a set of nine tools, which are described in Appendix C. Colocation tools operate to collocate clouds identified by independent platforms, such as CALIPSO, with GOES-R pixels and the associated CSM output. The analysis tools either enable visualization of the results and/or provide for the necessary statistical comparisons that indicate if CSM has achieved a given validation stage. The same tools are used throughout the CSM validation process.

5. Analysis Methods

The following methods will be utilized to evaluate and validate the CSM.

- **Method 1:** quantitative comparisons with "truth" data.[1,6,7] CSM results will be compared to Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), Surface Radiation Budget (SURFRAD) network, and Atmospheric Radiation Measurement (ARM) results.[1,6,7] This heritage method has been used with prior sensors such as the Visible Infrared Imaging Radiometer Suite (VIIRS).[2,11] Results are fundamental to proving Beta has been achieved.[1] Further, this is the only method available that can prove the 87% measurement accuracy requirement directly and can quantify the CSM performance over any specific atmospheric and ground conditions.[3,6,7] The tool cloud_mask_metrics.pro will be the tool that actually creates these quantitative results.[16] Details related to this tool are described in Appendix C. Finally, the quantitative analysis will be applied to the binary (yes/no) CSM only.[6,7]
- **Method 2:** qualitative comparisons with cloud masks derived from other sensors.[1,6,7] Cloud masks derived from Advanced Very High Resolution Radiometer (AVHRR), Moderate Resolution Imaging Spectroradiometer (MODIS), and VIIRS will be used to compare to the GOES-R CSM.[1,6,7] This heritage method has been used with prior sensors as a way to check consistency among the different results.[6,7] Significant differences indicate issues on a larger scale not possible with available truth data described in Appendix B.[6,7,11] Any anomalies identified through this method will be properly documented as part of fulfilling the Beta criteria as described in Section 6.[16] Differences will be compared side-by-side to identify large scale discrepancies in the CSM product, primarily using GLANCE.[6,16]
- **Method 3:** impact of CSM on GOES-R Sea Surface Temperature (SST) product.[1] Cloud masks have been evaluated historically based on their impacts to dependent downstream products.[1,12] Assessments are planned with the GOES-R SST product, as cold biases in the SST output often indicate cloud leakage.[1,16] This method is applicable only for the Provisional and Full stages.[16]

6. Output Artifacts

6.1 Beta Maturity Artifacts

The criteria by which the GOES-R CSM will be evaluated to determine if Beta maturity has been met are as follows.

- The CSM product performance has been quantitatively assessed with a limited set of data.
- Any issues associated with the CSM product have been identified. This includes initial feedback from any downstream users.

Further, artifacts associated with the Beta maturity validation effort are as follows.

- The critical CSM requirement is to attain a measurement accuracy of 87% for its binary (yes/no) mask, and this must be proven by the end of the Provisional period.[3,16] Therefore, one artifact to be provided at the Beta maturity stage is the statistical accuracy of the CSM as derived from comparisons to CALIPSO, SURFRAD, and ARM sites.[2,7]
- Statistics will also be derived which compare the results of the GOES-R CSM with cloud masks derived from other satellites using method #2 in Section 5.[6,7]
- Further, the comparative large scale CSM results over the initial 30-day period will be shown as part of Beta verification.[1,7]
- Performance and product issues will be documented in a Beta test report.

6.1.1 These tests of priority 1 all must pass in order to achieve Beta maturity:

- ABI-FD_CSM01
- ABI-CONUS_CSM01
- ABI-MESO_CSM01
- ABI-FD_CSM02
- ABI-CONUS_CSM02
- ABI-MESO_CSM02
- ABI-FD_CSM03
- ABI-CONUS_CSM03

6.1.2 The CSM Beta maturity validation effort does not include any tests of priority 2.

6.2 Provisional Maturity Artifacts

The criteria by which the GOES-R CSM will be evaluated to determine if Provisional maturity has been met are as follows.

- Accuracy and precision of the CSM product has been assessed over a large and wide range of representative conditions.
- On a global basis the CSM shall meet all of its documented requirements, including the requirement of 87% correct detection (global requirement), for all modes; note the 87% requirement is only applicable under conditions where the solar zenith angle is equal or less than 70 degrees.
- Remediation strategies are in place for known issues, including those identified by downstream users.
- Product is ready for potential operational use (user recommendation) and for use in scientific publications.

Further, artifacts associated with the Provisional maturity validation effort are as follows.

- Present statistical evidence of performance over the following backgrounds and conditions: day/ocean, day/land, day/snow, night/ocean, and night/land. The time allocated to proving the provisional phase is sufficient to verify the different types of clouds the CSM algorithm should detect (e.g. fog/stratus, cirrus, etc.) though seasonal events may be missed during PLPT depending on the exact 30 day period (will it be spring/fall or summer/winter).[16]

- The critical CSM requirement is to attain a measurement accuracy of 87% for its binary (yes/no) mask, and this must be proven by the end of the provisional period.[3,16] Therefore, as in the Beta maturity state, one artifact to be presented is the statistical accuracy of the CSM as derived from comparisons to CALIPSO, SURFRAD, and ARM sites.[2,7]
- As in the Beta maturity stage, statistics will also be derived which compare the results of the GOES-R CSM with cloud masks derived from other satellites using method #2 in Section 5.[6,7]
- Documentation of feedback from downstream users on strengths and weaknesses of the CSM, to include reporting of incidents/issues as an Algorithm Discrepancy Report (ADR) for discussion at the Algorithm Action Review Team (AART).

6.2.1 These tests of priority 1 all must pass in order to achieve Provisional maturity:

- ABI-FD_CSM04
- ABI-CONUS_CSM04
- ABI-MESO_CSM03

6.2.2 The CSM Provisional maturity validation effort does not include any tests of priority 2.

6.3 Full Maturity Artifacts

It is critical that the CSM evaluations occur on schedule, as many downstream products, especially other cloud products, are dependent on the CSM. That dependency drives the following additional criteria to pass the Full stage, on top of the Provisional criteria listed above.

- Any documented concern from downstream dependent products have a corresponding documented approach on how it will be addressed. Note that these concerns do not all have to be fixed for the CSM to pass Full, but they each must have a path forward.

6.3.1 These tests of priority 1 all must pass in order to achieve Full maturity:

- ABI-FD_CSM05
- ABI-CONUS_CSM05
- ABI-MESO_CSM04

6.3.2 The CSM Full maturity validation effort does not include any tests of priority 2.

6.4 Key Artifacts

Key artifacts for the CSM validation effort are the power point presentation tied to the PS-PVR. The most critical artifacts are graphical displays of the CSM accuracy covering all of the backgrounds and categories noted above.

6.5 More Output Artifacts

Additional output artifacts for the CSM validation effort are as follows.

- The required horizontal resolution matches that of the GOES-R IR pixels, therefore determining and showing the CSM is created at the IR pixel resolution is sufficient to prove that requirement.[6,7]
- Results from the SST validation will also be shown to indicate impacts of the CSM to downstream dependent products as part of the Provisional and Full cal/val efforts.[1]

6.6 Delivery Schedule

The delivery schedule of artifacts for the CSM validation effort is tied to the schedule for completing beta, provisional, and full validation as given in section 2. All statistical analysis necessary to prove a given validation stage will be included in a power point presentation in time for the appropriate PS-PVR.

7. Pre-launch

The only pre-launch verification of the CSM is to insure the format and data content are correct.[2,4] Output from the DOEs will be used to verify the tools can properly read and use applicable diagnostics; this is the only remaining pre-launch activity for the CSM.[16] The CSM cal/val team plans to use output from DOEs 3 and 4 to verify use of their tools with the proper diagnostics.[16] Data flow for DOE output will be through STAR.[16]

8. References

The references listed below were used to generate this document, augmented with written and/or verbal feedback with the STAR product team. Superscripts are invoked within the text of this document to indicate a reference that can provide additional detail for the reader.

[1] PLPT spreadsheet (PLPT_Validation_Event_List_L2_v0_1_20140903_with_Post-PLT_Entries).
[2] GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation.
[3] GOES-R Series Mission Requirements Document.
[4] GOES-R Series System – Level Calibration and Product Measurement Validation Concept of Operations (CONOPS) and Operational Concepts (OPSCON).
[5] GOES-R Post-Launch Product Testing Overview February 3, 2015.
[6] GOES-R Algorithm Working Group (AWG) Algorithm Product Validation Tool Development, Cloud Products; 1st GOES-R Validation Workshop, May 10, 2011.
[7] GOES-R AWG Product Validation Tool Development, Cloud Team Report, 2nd GOES-R Validation Workshop, January 9, 2014.
[8] Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) sensor at http://www-calipso.larc.nasa.gov/about/payload.php.
[9] ARM descriptions and data source at http://www.arm.gov/about.
[10] Heidinger, A. K., cited 2007: Clouds from AVHRR Extended (CLAVR-X) research at Cooperative Institute for Meteorological Satellite Studies (CIMSS) [Available online at http://cimss.ssec.wisc.edu/clavr/index.html].
[11] Ackerman, S.A., and coauthors: Cloud Detection with MODIS. Part II. Validation; J. Atm. Ocean. Tech., **25,** 2008, pp. 1073-1086.
[12] Kopp, T.J., and coauthors: The VIIRS Cloud Mask: Progress in the First Year of S-NPP Towards a Common Cloud Detection Scheme; J. Geoph. Res., Special Issue of the Suomi National Polar-Orbiting Partnership, Satellite Calibration, Validation and Applications, 2014, SNPP403 – SNPP418.
[13] GOES-R Field Campaign, NOAA Satellite Science Week, February, 2015.
[14] NOAA SURFRAD Capabilities and Status Update, GOES-R Field Campaign Workshop, April 8, 2015.
[15] Geostationary Cloud Algorithm Testbed (GeoCAT) - http://www.star.nesdis.noaa.gov/star/documents/corp/SATB/SATBgeocat.pdf.
[16] Interview with the Cloud Cal/Val Team, June 2, 2015.
[17] GOES-R Field Campaign Preparation, October 26, 2015.

A. Appendix A: Validation Events

A.1 PLPT Events that Support the Beta Maturity

A.1.1 Event Name: ABI-FD_CSM01[1]

Objective: verify that product is generated every 15 min for every FD.[3]
Start Time: start of PLPT period.[1]
Duration: 1 week.[1]
ABI Mode: Mode 3.[1]
GOES-R Data Type(s): 15 min FD.[1]
Beta Success Criteria: product generated and falls within expected measurement range; all that is required for this PLPT is that the product is created and received at the validation sites with a 15 minute cadence.[1,3]
Dependencies: the CSM product is created by the ground system and delivery of such product to the validation team is sufficient to keep up with the cadence of the FD.[1,4]
PLPT Lead: PRO[5,16]
PLPT Analyst: PRO
Validation Data: none (quality assessed in a different PLPT).[1]
Procedural References: none (quality assessed in a different PLPT).[1]
Comparison/Reference Data: see Appendix B.1.
Monitoring and Analysis Method: product inspection. Either the CSM is produced at the correct cadence or it is not.[1,3]

A.1.2 Event Name: ABI-CONUS_CSM01

Same as ABI-FD_CSM01 except for:
GOES-R Data Type(s): 5 minute CONUS.[1,3]

A.1.3 Event Name: ABI-MESO_CSM01

Same as ABI-FD_CSM01 except for:
GOES-R Data Type(s): 5 minute mesoscale.[1,3]
Beta Success Criteria: product generated and falls within expected measurement range. All that is required for this PLPT is that the product is created and received at the validation site with a 5 minute cadence.[1]

A.1.4 Event Name ABI-FD_CSM02

Same as ABI-FD_CSM01 except for:
ABI Mode: Mode 4.[1]
GOES-R Data Type(s): 5 min FD.[1]

A.1.5 Event Name ABI-CONUS_CSM02

Same as ABI-CONUS_CSM01 except for:
ABI Mode: Mode 4.[1]

A.1.6 Event Name ABI-FD_CSM03

Objective: assess the initial accuracy and precision of the CSM product.[1] Determine the extent to which the CSM product meets the MRD product specification over a very limited number of independent measurements and identify any appropriate issues negatively impacting the CSM.[1,16]
Start Time: start of PLPT.[1]
Duration: 30 days.[1]
ABI Mode: Mode 3.[1]

GOES-R Data Type(s): 15 minute FD CSM.[1,3]
Beta Success Criteria: the FD CSM output is quantitatively assessed for a limited set of independent measurements, and any issues are properly identified. The key requirement is a measurement accuracy of 87%, though this does not have to be met to attain Beta. This must occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 15 minute cadence.[1,2,6,7]
Dependencies: the CSM product is created by the ground system and delivery of such product to the validation team is sufficient to keep up with the cadence of FD CSM output.[1,3]
PLPT Lead: Andy Heidinger.[6,7]
PLPT Analyst: Denis Botambekov.[16]
Validation Data: overlapping data from CALIPSO, SURFRAD, and ARM; derived cloud masks from L1b or Sensor Data Record (SDR) data from GOES, AVHRR, MODIS, and VIIRS via CLAVR-X.[1,16]
Procedural References: Section 5, methods #1 and #2.[1,4,16]
Comparison/Reference Data: all available in Appendix B.
Monitoring and Analysis Method: derive statistics using the match-up data as truth, and produce comparative statistics with cloud masks generated over the same area as GOES-R but derived from GOES, MODIS, VIIRS, and AVHRR.[1,6,7]

A.1.7 Event Name ABI-CONUS_CSM03

Same as ABI-FD_CSM03 except for:
GOES-R Data Type(s): 5 minute CONUS CSM.[1,3]
Beta Success Criteria: the CONUS CSM output is quantitatively assessed for a limited set of independent measurements, and any issues are properly identified. The key requirement is a measurement accuracy of 87%, though this does not have to be met to attain Beta. This must occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 15 minute cadence.[1,2,6,7]

A.1.8 Event Name ABI-MESO_CSM02

Same as ABI-FD_CSM03 except for:
GOES-R Data Type(s): 5 minute mesoscale CSM.[1,3]
Beta Success Criteria: the mesoscale CSM output is quantitatively assessed for a limited set of independent measurements, and any issues are properly identified. The key requirement is a measurement accuracy of 87%, though this does not have to be met to attain Beta. This must occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 5 minute cadence.[1,2,6,7]

A.2 PLPT Events that Support Provisional Maturity

A.2.1 Event Name ABI-FD _CSM04[1]

Objective: assess the accuracy and precision of the CSM product over a large and wide range of representative conditions.[1]
Start Time: immediately following PLPT period.[1]
Duration: 4 months.[1]
ABI Mode: Mode 3.[1]
GOES-R Data Type(s): 15 min FD.[1]
Provisional Success Criteria: the FD CSM meets the quantitative requirements for a seasonal set of independent measurements. The key requirement is a measurement accuracy of 87%. This must occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 15 minute cadence.[1,2,6,7]
Dependencies: the CSM has reached the Beta level of maturity.[1,2,4]
PLPT Lead: Andy Heidinger.[1,6,7]
PLPT Analyst: Denis Botambekov.[16]
Validation Data: overlapping data from CALIPSO, SURFRAD, and ARM. [6,7]

Procedural References: Section 5, methods #1, 2, and 3.
Comparison/Reference Data: all available in Appendix B.
Monitoring and Analysis Method: derive statistics using the match-up data as truth, and produce comparative statistics with cloud masks generated over the same area as GOES-R but derived from MODIS, VIIRS, and AVHRR.[1,6,7]

A.2.2 2.2.2 Event Name ABI-CONUS_CSM04

Same as ABI-FD_CSM04 except for:
GOES-R Data Type(s): 5 min CONUS CSM.[1]
Provisional Success Criteria: the CONUS CSM meets the quantitative requirements for a seasonal set of independent measurements. The key requirement is a measurement accuracy of 87%. This must occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 15 minute cadence.[1,2,6,7]

A.2.3 2.2.3 Event Name ABI-MESO_CSM03

Same as ABI-FD_CSM04 except for:
GOES-R Data Type(s): 5 minute mesoscale CSM.[1]
Provisional Success Criteria: the mesoscale CSM meets the quantitative requirements for a seasonal set of independent measurements. The key requirement is a measurement accuracy of 87%. This must occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 5 minute cadence.[1,2,6,7]

A.3 PLPT Events that Support Full Maturity

A.3.1 Event Name ABI-FD _CSM05[1]

Objective: assess the accuracy and precision of the CSM product over all representative conditions, to include all seasons, over at least one year's worth of CSM results.[1]
Start Time: immediately following achievement of Provisional maturity.[1]
Duration: 6 months.[1]
ABI Mode: Mode 3.[1]
GOES-R Data Type(s): 15 min FD.[1]
Full Success Criteria: the FD CSM meets the quantitative requirements for an annual set of independent measurements. The key requirement is a measurement accuracy of 87%. This must occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 15 minute cadence.[1,2,6,7]
Dependencies: the CSM has reached the Provisional level of maturity.[1,2,4]
PLPT Lead: Andy Heidinger.[1,6,7]
PLPT Analyst: Denis Botambekov.[16]
Validation Data: overlapping data from CALIPSO, SURFRAD, and ARM. [6,7]
Procedural References: Section 5, methods #1, 2, and 3.
Comparison/Reference Data: all available in Appendix B.
Monitoring and Analysis Method: derive statistics using the match-up data as truth, and produce comparative statistics with cloud masks generated over the same area as GOES-R but derived from MODIS, VIIRS, and AVHRR.[1,6,7]

A.3.2 2.2.2 Event Name ABI-CONUS_CSM05

Same as ABI-FD_CSM05 except for:
GOES-R Data Type(s): 5 min CONUS CSM.[1]
Full Success Criteria: the CONUS CSM meets the quantitative requirements for an annual set of independent measurements. The key requirement is a measurement accuracy of 87%. This must

occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 15 minute cadence.[1,2,6,7]

A.3.3 2.2.3 Event Name ABI-MESO_CSM04

Same as ABI-FD_CSM05 except for:
GOES-R Data Type(s): 5 minute mesoscale CSM.[1]
Full Success Criteria: the mesoscale CSM meets the quantitative requirements for an annual set of independent measurements. The key requirement is a measurement accuracy of 87%. This must occur with a horizontal resolution of 2 km and a mapping accuracy of 1 km, at a 5 minute cadence.[1,2,6,7]

B. Appendix B: GOES-R and Validation Reference Data

B.1 Data Set #1: ABI-L2-ACM[3]

Storage Location: CIMSS Data Center.[16]
Point of Contact: Jerald Robaidek.[16]
Access Process: Product Distribution and Access (PDA) or STAR.[4]
Spatial Coverage: All ABI Modes, FD, CONUS, and mesoscale.[1,3]
Temporal Coverage: All ABI Modes, 15 minutes for FD and CONUS, 5 minutes for mesoscale.[1,3]
Contingency: None, this is the product the team must validate, there is no validation without the core product.
Special Considerations: The cloud product team expects to obtain the data through PDA, but the status of that is unclear. The data may also be obtained through STAR, though with a delay of unknown extent.

B.2 Data Set #2: CALIPSO[1,6,7]

Storage Location: Science Investigator-led Processing System (SIPS).[16]
Access Process: Public internet.[16]
Point of Contact: Liam Gumley.[8,16]
Spatial Coverage: 333 m across track, 1-5 m along track.[8]
Temporal Coverage: N/A
Contingency: If Cloud Aerosol Transport System (CATS) data is available it is capable of replacing CALIPSO. Should the CALIPSO become unavailable after the launch of GOES-R, then CATS data may be used instead.[16]
Special Considerations: The CALIOP sensor on CALIPSO measures clouds and aerosols via Lidar, and is often used to verify many aspects of clouds, including their presence, as needed and described elsewhere in this document.[8]

B.3 Data Set #3: ARM sites[1,6,7]

Storage Location: SIPS[16]
Access Process: NOAA public internet (http://www.arm.gov/).[16]
Point of Contact: N/A[16]
Spatial Coverage: Single point locations.[9]
Temporal Coverage: Hourly.[9]
Contingency: Use other truth sources such as SURFRAD (Data Set #4).
Special Considerations: ARM locations include hourly measurements of cloud cover, which may be used as single point sources of truth for cloud mask verifications.[9]

B.4 Data Set #4: SURFRAD Sites[1,6,7]

Storage Location: SIPS.[16]
Access Process: Public internet (http://www.esrl.noaa.gov/gmd/dv/ftpdata.html).[16]
Point of Contact: N/A.[16]
Spatial Coverage: Single point locations.
Temporal Coverage: Hourly.
Contingency: Use other truth sources such as ARM (Data Set #3).
Special Considerations: SURFRAD locations include hourly measurements of cloud cover, which may be used as single point sources of truth for cloud mask verifications.[14]

B.5 Data Set #5: AVHRR Derived Cloud Mask from AVHRR L1b Data[1]

Storage Location: SIPS.[16]
Access Process: CLAVR-X.[16]

Point of Contact: Liam Gumley.[16]
Spatial Coverage: GOES coverage area.[1,2]
Temporal Coverage: N/A.
Contingency: Use the other available cloud masks.[1,7]
Special Considerations: The AVHRR cloud mask uses the CLAVR-X algorithm designed and led by Andy Heidinger. It may be executed on site at Space Science Environmental Center (SSEC).[10]

B.6 Data Set #6: MODIS Derived Cloud Mask from MODIS L1b Data[1]

Storage Location: SIPS.[16]
Access Process: CLAVR-X.[16]
Point of Contact: Liam Gumley[11]
Spatial Coverage: GOES coverage area.[1,2]
Temporal Coverage: N/A.
Contingency: Use the other available cloud masks.[1,7]
Special Considerations: The MODIS cloud mask uses an algorithm designed and led by CIMSS. It may be executed on site at SSEC.[11]

B.7 Data Set #7: VIIRS Derived Cloud Mask from VIIRS SDRs[1]

Storage Location: Comprehensive Large Array-data Stewardship System (CLASS) and SIPS.[12]
Access Process: Either computed on CLAVR-X or public internet access to CLASS.[12,16]
Point of Contact: Liam Gumley.[6,7]
Spatial Coverage: GOES coverage area.[1,2]
Temporal Coverage: N/A.
Contingency: Use the other available cloud masks.[1,7]
Special Considerations: The VIIRS cloud mask is run operationally on the Interface Data Processing Segment (IDPS) owned by the Joint Polar Satellite System (JPSS) program and stored for archive in CLASS, but it may also be recreated locally at CIMSS through the CLAVR-X architecture.[12,16]

B.8 Data Set #8: GOES Derived Cloud Mask from GOES L1b[1]

Storage Location: SIPS.[12]
Access Process: CLAVR-X.[12,16]
Point of Contact: Liam Gumley.[6,7]
Spatial Coverage: GOES coverage area.[1,2]
Temporal Coverage: N/A.
Contingency: Use the other available cloud masks.[1,7]
Special Considerations: The GOES cloud mask uses an algorithm designed and led by CIMSS. It may be executed on site at SSEC.[16]

B.9 Data Set #9: Field Campaign Data

Source: If available, the Cloud Physics Lidar (CPL) and the Cloud Radar System (CRS) placed on the Earth Resources 2 (ER-2) aircraft.[13]
POC: Francis Padula
Access Process: TBD.
Frequency of Transmission: Not applicable, any field campaign is a finite event.[13]
Contingency: Validation of the CSM is not strongly dependent on a field campaign; other sources of truth (e.g. CALIPSO) are more critical. It is not employed for Beta or Provisional but if available could be used during the Full stage of cal/val if the current field campaign schedule holds.[1,6,7,17]

C. Appendix C: Tools

C.1 Tool #1: Man-computer Interactive Data Access System (McIDAS)[1,6,7]

Location: CIMSS.[6,7]
Description: In house, though tool itself is employed by many outside of CIMSS, McIDAS has the capability to display cloud/clear mask output from numerous sensors over the original imagery, to include those produced from data sets B.1, B.5, B.6, and B.7.[6,7]
Developer: SSEC McIDAS Programmers.[16]
Development Schedule: Tool is ready for cal/val use with GOES-R, though certain diagnostic data has yet to be tested.[16]
Data Dependencies: GOES-R, MODIS, and VIIRS cloud masks.[6,7]
Testing Accomplished or Planned: Testing has been accomplished with both surrogate and simulated GOES-R CSM output; the only remaining testing is with diagnostics that are expected with DOE testing.[16]
POC: McIDAS User's Group (MUG).[16]

C.2 Tool #2: patmosx_colocate_1km.pro[16]

Location: CIMSS.[16]
Description: In house tool that collocates cloud product files with CALIOP L2 1 km cloud layer data files. These cloud product files may be either those derived essentially from any of the data sets in Appendix B, including satellite L1b/SDRs or ground sites such as ARM or SURFRAD.[16]
Developer: CIMSS.[16]
Development Schedule: Development for this tool has been completed.[16]
Data Dependencies: GOES-R, MODIS, and VIIRS cloud mask output, ARM and SURFRAD surface observations, and CALIOP data.[6,7,16]
Testing Accomplished or Planned: Testing has been all but completed, a minor amount of testing remains with output that includes diagnostics, as planned in upcoming DOEs.[16]
POC: Cloud Product Team.[16]

C.3 Tool #3: plot_calipso_matchup.pro[16]

Location: CIMSS.[16]
Description: In house tool that plots cloud output, including cloud mask output, with CALIOP 1 km cloud layer data files.[16]
Developer: CIMSS.[16]
Development Schedule: Development for this tool has been completed.[16]
Data Dependencies: GOES-R, MODIS, and VIIRS cloud mask output, ARM and SURFRAD surface observations, and CALIOP data.[6,7,16]
Testing Accomplished or Planned: Testing has been all but completed, though a minor amount of testing remains with output that includes diagnostics, as planned in upcoming DOEs.[16]
POC: Cloud Product Team.[16]

C.4 Tool #4: make_training_data.pro[16]

Location: CIMSS.[16]
Description: In house tool which creates a save file from the data and results created by other tools employed in the CSM cal/val process.[16]
Developer: CIMSS.[16]
Development Schedule: Development for this tool has been completed.[16]
Data Dependencies: CLAVR-X and CALIOP 1 km cloud layer data, see tool #9.[16]
Testing Accomplished or Planned: Testing has been all but completed, though a minor amount of testing remains with output that includes diagnostics, as planned in upcoming DOEs.[16]

POC: Cloud Product Team.[16]

C.5 Tool #5: plot_acha_val.pro[16]

Location: CIMSS.[16]
Description: In house tool which computes statistics of cloud masks determined through CLAVR-X (tool #9) and compares them to CALIOP 1 km cloud layer data, then create plots from those outputs.[16]
Developer: CIMSS.[16]
Development Schedule: Development for this tool has been completed.[16]
Data Dependencies: Cloud masks derived from CLAVR-X along with CALIOP 1 km cloud layer data (see tool #9).[16]
Testing Accomplished or Planned: Testing has been all but completed, though a minor amount of testing remains with output that includes diagnostics, as planned in upcoming DOEs.[16]
POC: Cloud Product Team.[16]

C.6 Tool #6: cloud_mask_metrics.pro[16]

Location: CIMSS.[16]
Description: In house tool which computes statistics of cloud masks derived from many different weather satellites and compares them to CALIOP 1 km cloud layer data, then create plots from those outputs. This tool allows the results to be broken down by surface type (land/ocean/snow, etc.).[16]
Developer: CIMSS.[16]
Development Schedule: Development for this tool has been completed.[16]
Data Dependencies: CLAVR-X and CALIOP 1 km cloud layer data (see tool #9).[16]
Testing accomplished or planned: testing has been all but completed, though a minor amount of testing remains with output that includes diagnostics, as planned in upcoming DOEs.[16]
POC: Cloud Product Team.[16]

C.7 Tool #7: cloud_mask_threshold_generation.pro[16]

Location: CIMSS.[16]
Description: In house tool which allows the user to adjust thresholds tied to the CSM (tuning).[16]
Developer: CIMSS.[16]
Development Schedule: Development for this tool has been completed.[16]
Data Dependencies: GOES-R CSM.[16]
Testing Accomplished or Planned: Testing has been completed.[16]
POC: Cloud Product Team.[16]

C.8 Tool #8: GLANCE[1,6,7]

Location: CIMSS.[6,7]
Description: GLANCE allows users to perform inter-comparisons, in this case among cloud masks from different sources, or between cloud masks created from the same source but through different methods or with different inputs, to include the L1b/SDR data sets noted in Appendix B.[16]
Developer: CIMSS, in collaboration with the Algorithm Integration Team (AIT).[16]
Development Schedule: AIT has completed development.[16]
Data Dependencies: GOES-R, GOES, VIIRS, MODIS, AVHRR cloud masks or cloud masks derived from their L1b/SDRs.[16]
Testing Accomplished or Planned: AIT has completed its testing activities.[16]
POC: AIT.[16]

C.9 Tool #9: CLAVR-X[16]

Location: CIMSS.[16]
Description: In the context of GOES-R cal/val, CLAVR-X is actually an architecture under which much of the validation for the CSM will occur. The CLAVR-X architecture includes the capability to compute cloud masks from a variety of sources. These masks are tied to the validation of the CSM. As such, it is listed here as a "tool", though its purpose extends far beyond the validation of GOES-R products, and it is not a "tool" in the strict sense of the word.[16]
Developer: CIMSS.[16]
Development Schedule: Development for this tool has been completed.[16]
Data Dependencies: GOES-R, GOES, MODIS, VIIRS, and AVHRR L1b/SDRs.[16]
Testing accomplished or planned: testing has been completed.[16]
POC: Cloud Product Team.[16]

D. Appendix D: Acronym List

Acronym	Definition
AART	Algorithm Action Review Team
ABI	Advanced Baseline Imager
ACM	ABI Cloud Mask
ADR	Algorithm Discrepancy Report
AIT	Algorithm Integration Team
ARM	Atmospheric Radiation Measurement
AVHRR	Advanced Very High Resolution Radiometer
AWG	Algorithm Working Group
Cal/Val	Calibration and Validation
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarization
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CATS	Cloud Aerosol Transport System
CCR	Configuration Change Request
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CLASS	Comprehensive Large Array-data Stewardship System
CLAVR-X	Clouds from AVHRR - Extended
CMI	Cloud and Moisture Imagery
CONOPS	Concept of Operations
CONUS	Continental United States
CPL	Cloud Physics Lidar
CRS	Cloud Radar System
CSM	Clear-Sky Mask
CWG	Calibration Working Group
DOE	Data Operations Exercise
ESRL	Earth System Research Laboratory
F&PS	Functional and Performance Specification
FD	Full Disk
FTE	Full-Time Equivalent
GeoCAT	Geostationary Cloud Algorithm Testbed
GOES	Geostationary Operational Environmental Satellite
GOES-R	GOES R-Series
GORWG	GOES-R Series Operational Requirements Working Group
GRB	GOES Rebroadcast
IDPS	Interface Data Processing Segment
JPSS	Joint Polar Satellite System
L1b	Level 1b
L2	Level 2
McIDAS	Man-computer Interactive Data Access System

Acronym	Definition
MODIS	Moderate Resolution Imaging Spectroradiometer
MOST	Mission Operations Support Team
MRD	Mission Requirements Document
MSFC	Marshall Space Flight Center
MUG	McIDAS User's Group
N/A	Not Applicable
N/S	North/South Scan
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NCEP	National Center for Environmental Prediction
NCEI-CO	NCEI - Colorado
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OPSCON	Operational Concepts
OSPO	Office of Satellite and Product Operations
PDA	Product Distribution and Access
PLPT	Post-Launch Product Test
PLT	Post-Launch Test
POC	Point of Contact
PRO	Product Readiness and Operations
PSE	Program System Engineering
PS-PVR	Peer Stakeholder-Product Validation Review
PUG	Product User's Guide
QA	Quality Assurance
RIMP	Readiness, Implementation and Management Plan
SDR	Sensor Data Records
SIPS	Science Investigator-led Processing System
SNPP	Suomi National Polar-orbiting Partnership
SPOT	System Performance Operational Test
SSEC	Space Science and Engineering Center
SST	Sea Surface Temperature
STAR	Center for Satellite Applications and Research
SURFRAD	Surface Radiation Budget
TBD	To Be Determined
TBR	To Be Reviewed
VIIRS	Visible Infrared Imaging Radiometer Suite