



# **Geostationary Operational Environmental Satellite (GOES) – R Series**

## **ABI L2+ Fractional Snow Cover (FSC) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)**

**ABI L2+ Fractional Snow Cover (FSC)  
Beta, Provisional and Full Validation  
Readiness, Implementation and Management Plan (RIMP)**

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## Table of Contents

Preface.....	1
1. Fractional Snow Cover Validation Overview.....	4
2. Schedule of Events.....	6
3. Roles and Responsibilities .....	8
4. Tools .....	9
5. Analysis Methods.....	10
6. Output Artifacts .....	11
7. Pre-launch .....	13
8. References.....	14
A. Appendix A: Validation Events.....	15
B. Appendix B: GOES-R and Validation Reference Data .....	19
C. Appendix C: Tools.....	21
D. Appendix D: Acronyms .....	23

## Table of Figures and Tables

Figure 1. GOES-R product maturity levels.....	2
Figure 2. Delineation of accountability between GOES-R and STAR.....	3
Table 1. FSC performance and verification cadences. ....	4
Figure 3. Schedule of events.....	7

## 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.

<b><u>GOES-R Product (L1b and L2+) Maturity Levels</u></b>
<p style="text-align: center;"><b><u>Beta Validation</u></b></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none"><li>○ Initial calibration applied (L1b).</li><li>○ Rapid changes in product input tables, and possibly product algorithms, can be expected.</li><li>○ Product quick looks and initial comparisons with ground truth data (if any) are not adequate to determine product quality.</li><li>○ Anomalies may be found in the product and the resolution strategy may not exist.</li></ul> <p><u>End state</u></p> <ul style="list-style-type: none"><li>○ Products are made available to users to gain familiarity with data formats and parameters.</li><li>○ Product has been minimally validated and may still contain significant errors.</li><li>○ Product is not optimized for operational use.</li></ul>
<p style="text-align: center;"><b><u>Provisional Validation</u></b></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none"><li>○ Validation and quality assurance (QA) activities are ongoing, and the general research community is now encouraged to participate.</li><li>○ Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing.</li><li>○ Incremental product improvements may still be occurring.</li><li>○ Users are engaged in the Customer Forums (L2+ products only), and user feedback is assessed.</li></ul> <p><u>End state</u></p> <ul style="list-style-type: none"><li>○ 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.</li><li>○ Product analysis are sufficient to communicate product performance to users relative to expectations.</li><li>○ 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.</li><li>○ Testing has been fully documented.</li><li>○ Product ready for operational use and for use in comprehensive calibration/validation activities and product optimization.</li></ul>
<p style="text-align: center;"><b><u>Full Validation</u></b></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none"><li>○ Validation, QA, and anomaly resolution activities are ongoing.</li><li>○ Incremental product improvements may still be occurring.</li><li>○ Users are engaged and user feedback is assessed.</li></ul> <p><u>End state</u></p> <ul style="list-style-type: none"><li>○ Product performance for all products is defined and documented over a wide range of representative conditions via ongoing ground-truth and validation efforts.</li><li>○ Products are operationally optimized, as necessary, considering mission parameters of cost, schedule, and technical competence as compared to user expectations.</li><li>○ All known product anomalies are documented and shared with the user community.</li><li>○ Product is operational.</li></ul>

Figure 1. GOES-R product maturity levels.

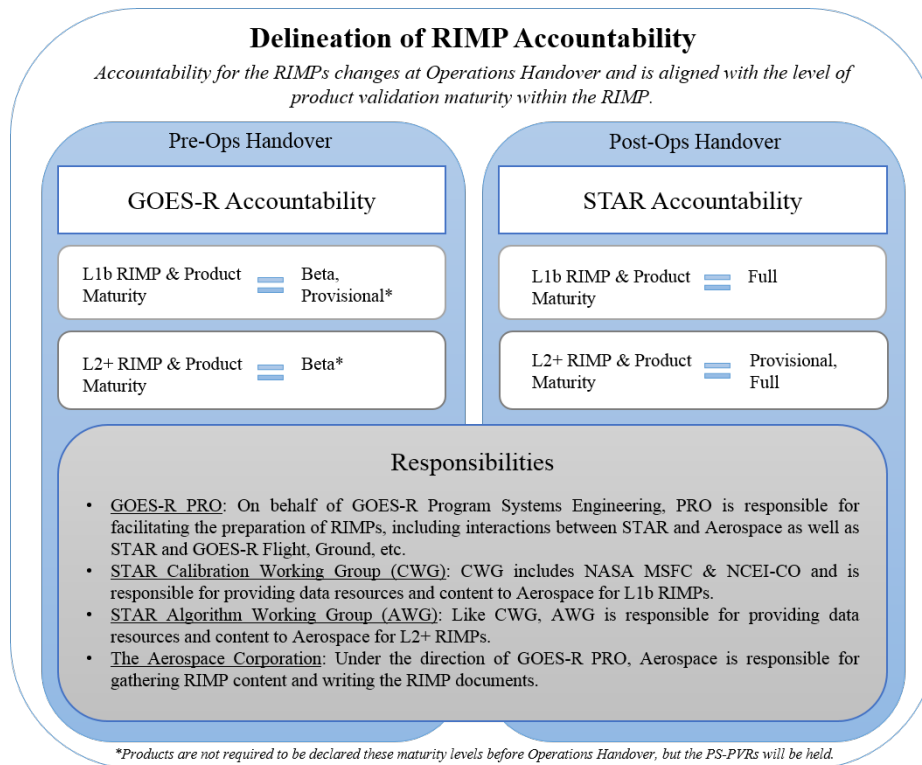


Figure 2. Delineation of accountability between GOES-R and STAR.



# 1. Fractional Snow Cover Validation Overview

The GOES-R Advanced Baseline Imager (ABI) L2 Fractional Snow Cover product Post-Launch Product Test (PLPT) validation plan has fourteen (14) PLPT tests.<sup>1,2</sup> Eight (8) of the events are defined for attaining Beta maturity. Three (3) of the events are defined to attain Provisional maturity and three (3) are for Full maturity. The purpose of this document (FSC RIMP) is to address all fourteen validation events for the three validation stages. The Mission Requirements Document (MRD) specifications for this product are to meet an accuracy of 0.30 and precision of 0.15.<sup>3</sup> The Functional and Performance Specification (F&PS) specifications are 0.30 for accuracy and 0.05 for precision.<sup>4</sup> The latest specifications from the NOAA GOES-R Snow Cover team are: accuracy 0.15; precision 0.30 (with 0.20 objective).<sup>5</sup>

PLPT events that support the Beta maturity are listed below, with details in Appendix A.

- **ABI-FD\_FSC01:** verify that the product is generated every hour for every Full Disk (FD) where snow exists and falls within expected measurement range, for ABI Mode 3.
- **ABI-CONUS\_FSC02:** verify that the product is generated every hour for every CONUS where snow exists and falls within expected measurement range, for ABI Mode 3.
- **ABI-MESO\_FSC03:** verify that the product is generated every hour for every mesoscale (typo in [1] as CONUS) where snow exists and falls within expected measurement range, for ABI Mode 3.
- **ABI-FD\_FSC04:** same as ABI-FD\_FSC01, except for ABI Mode 4.
- **ABI-CONUS\_FSC05** (typo in [1] as FD): same as ABI-CONUS\_FSC02, except for ABI Mode 4.
- **ABI-FD\_FSC06:** assess accuracy and precision of FD product, to determine the product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.
- **ABI-CONUS\_FSC07:** assess accuracy and precision of CONUS product, to determine the product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.
- **ABI-MESO\_FSC08:** assess accuracy and precision of mesoscale product, to determine the product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.

The following Table identifies the frequency of each scan type for Modes 3 and 4. The table includes the required cadence for the FSC product defined by both the GOES-R Functional and Performance Specification (F&PS) and the Product User’s Guide (PUG). Note that the PUG is a forward looking document and, as such, may not match the F&PS. The frequencies shown in the FSC – F&PS row (4<sup>th</sup> row) will be used by the product for verification.

*\*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		
	FD	CONUS	Mesoscale	FD	CONUS	Mesoscale
Scan Freq	15 min	5 min	30 sec	5 min	5 min*	N/A
FSC – F&PS	60 min	60 min	60 min	60 min	60 min	N/A
FSC – PUG	15 min	5 min	15 min	5 min	5 min	N/A

Table 1. FSC performance and verification cadences.

PLPT events that support the Provisional maturity are listed below, with details in Appendix A.

- **ABI-FD\_FSC09:** assess accuracy and precision of FD product, to determine the product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.
- **ABI-CONUS\_FSC10:** assess accuracy and precision of CONUS product, to determine the product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.
- **ABI-MESO\_FSC11:** assess accuracy and precision of mesoscale product, to determine the product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.

PLPT events that support Full maturity are listed below, with details in Appendix A.

- **ABI-FD\_FSC12:** assess accuracy and precision of FD product, to determine the product meets MRD specifications for a large and wide range of representative conditions (i.e., seasonal) over a period of at least a year.
- **ABI-CONUS\_FSC13:** assess accuracy and precision of CONUS product, to determine the product meets MRD specifications for a large and wide range of representative conditions (i.e., seasonal) over a period of at least a year.
- **ABI-MESO\_FSC14:** assess accuracy and precision of mesoscale product, to determine the product meets MRD specifications for a large and wide range of representative conditions (i.e., seasonal) over a period of at least a year.

The Beta maturity, Provisional maturity, and Full maturity events shall use the same tool suite, which includes: routine data visualization in global and CONUS views with map projections, routine statistical analysis, and deep-dive data analysis. The validation tool suite is fully developed.

Test data sets include the Suomi National Polar-orbiting Partnership (SNPP) Visible Infrared Imaging Radiometer Suite (VIIRS), Landsat Snow Cover products, Moderate Resolution Imaging Spectroradiometer (MODIS), Snow Telemetry (SNOTEL) in-situ snow data, and National Operational Hydrologic Remote Sensing Center (NOHRSC) real-time snow model data (CONUS).

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

## 2. Schedule of Events

The Fractional Snow Cover product Beta maturity effort can be divided into two stages. The first stage, which includes five PLPTs, is to verify that when the sensor is in Mode 3 and Mode 4, the FD, CONUS, and mesoscale Snow Cover product is generated every hour, and that the product falls within the expected measurement ranges. The first stage will take one week. The objectives of the second stage (three PLPTs) are to quantitatively assess performance of the product with a limited set of data, identify issues with the product, and document performance and issues in the beta report presentation. The second stage will take roughly 5 weeks. The total Beta maturity testing time is planned for 6 weeks. The latest date to start Beta testing is L+155 days, but can begin as soon as the ABI L1b and Cloud and Moisture Imagery (CMI) reach Beta (L+87 days).

The Fractional Snow Cover product Provisional maturity effort is to quantitatively assess performance of the product against product accuracy and precision requirements through analysis of a large, but still limited, number of independent measurements or field campaign data for FD, CONUS, and mesoscale. The total Provisional maturity time is planned for 6 months, starting from the end of the Beta maturity.

The Fractional Snow Cover product Full maturity validation effort is to quantitatively assess performance of the product against product accuracy and precision requirements through analysis of a large (global and seasonal representative) number of independent measurements or field campaign data for FD, CONUS, and mesoscale. The total Full maturity testing time is planned for 9 months, starting from the end of the Provisional maturity.

Figure 3 shows the GOES-R validation schedule. System Performance Operation Test (SPOT) begins 44 days after launch when ABI L1b and the L2 CMI Key Performance Beta evaluation begins and 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 nine months period for L2 products to reach Full maturity, 15 months after handover.

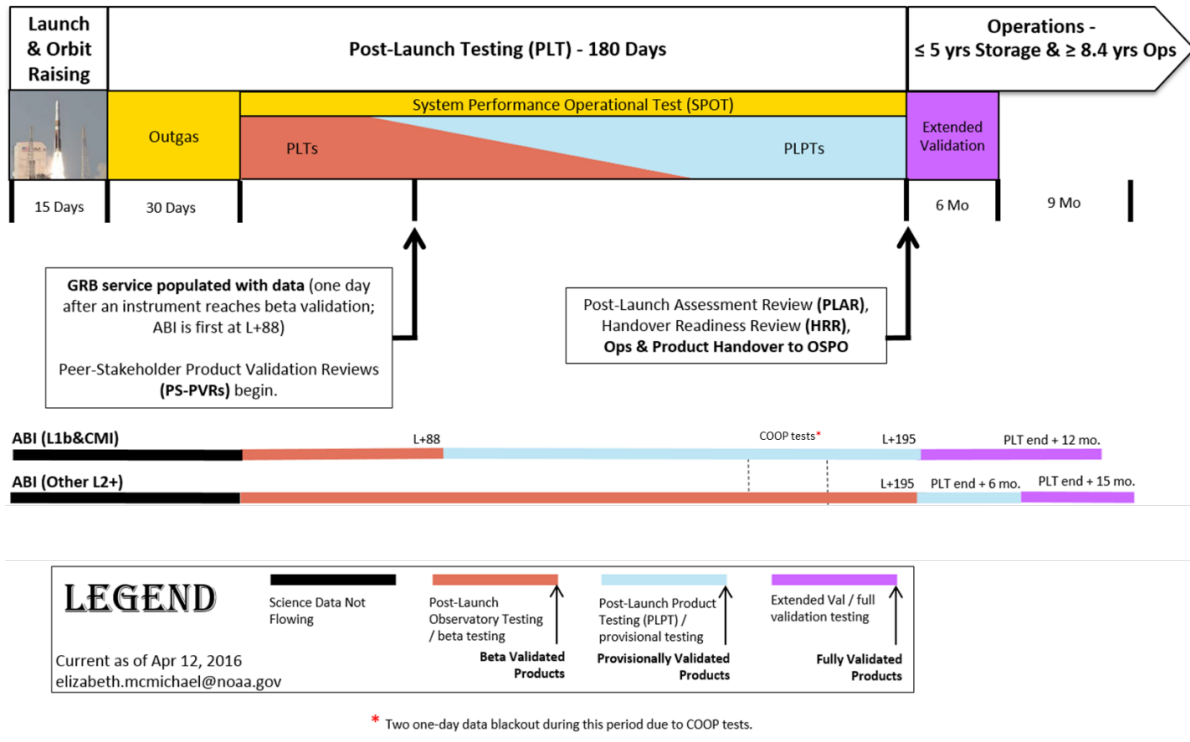


Figure 3. Schedule of events.

### **3. Roles and Responsibilities**

#### **3.1 Primary Point of Contact**

The primary Point of Contact (POC) for leading the FSC validation effort is Jeff Key (NESDIS/STAR).

#### **3.2 GOES-R Point of Contact**

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

#### **3.3 Test Analyst/Engineer**

Yinghui Liu (Cooperative Institute for Meteorological Satellite Studies (CIMSS, University of Wisconsin-Madison) is the primary test analyst/engineer.

#### **3.4 GOES-R Feedback**

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

#### **3.5 Level of Effort**

The validation effort for fractional snow cover is expected to require a total of 1.0 FTE, which includes 0.1 FTE for J. Key (federal) and 0.9 FTE for Y. Liu (university grantee). The effort will include monitoring and evaluating the performance of the real-time validation tools, as well conducting deep-dive analysis of cases where the real-time validation indicates significant, systematic differences between the satellite-derived snow fraction and the validation datasets. The deep-dive effort will also include identifying, developing, and testing algorithm modifications to address any systematic issue that are discovered. This level of effort is expected to continue throughout the Provisional and Full maturity assessments.

## 4. Tools

The same suite of tools, including statistical analysis tools, data analysis tools, and visualization tools in global and CONUS views with map projections, shall be used for all the validation events. Tools are also categorized as routine validation tools and deep dive validation tools.<sup>6,8</sup> In general, tools are developed in-house with reasonable in-code documentation and user manuals.<sup>5</sup> A list of detailed functions/subroutines is given in the L2 Product Validation spreadsheet<sup>10</sup> (spreadsheet tab titled “Cryosphere Team, Snow cover”). Tools and processes have been tested with reference data sets. Tools and processes specific to GOES-R are scheduled to be tested with Data Operations Exercise (DOE)-3 and DOE-4 data.

An example of the deep dive tool is cluster mask.<sup>10</sup> This program finds clusters of high Root-Mean-Square Error (RMSE) values on pixels with a positive Fractional Snow Cover that are found on a two dimensional grid. It identifies: 1) clusters based on input thresholds; 2) center pixel of highest average RMSE within cluster; and 3) pixel with the highest RMSE in cluster.

The details of the tools used in the validation process are found in Appendix C.

## 5. Analysis Methods

Fractional Snow Cover is a quantitative, fractional area representation of Snow Cover in each pixel rather than a simple snow/no-snow binary detection of snow. This is somewhat different than heritage sensor products, such as VIIRS.

### 5.1 Comparisons with Snow Cover Products Derived From Other Sensors

GOES-R Fractional Snow Cover product shall be compared primarily with Landsat and MODIS Snow Cover products. Data from a new VIIRS snow fraction algorithm will also be used for case studies. High-spatial resolution Landsat 8 data (29 m) and VIIRS (375 m) can be used to assess spatial heterogeneity. The accuracy and precision of the FSC retrievals are calculated under the GOES-R definitions of accuracy and precision. MODIS, Landsat, and VIIRS data likelihood of availability is high. The consequence if not available is high.<sup>9</sup> Pre-launch exercises have been performed.<sup>4,6</sup> Further pre-launch activities have been planned.<sup>1</sup> See Section 7 for more details.

### 5.2 Comparisons with In-situ Snow Products

GOES-R fractional Snow Cover product shall be compared with SNOTEL in-situ snow products. California Cooperative Snow Surveys, NWS Cooperative Observer Program, and the Canadian Provincial automated snow monitoring networks are also considered. The likelihood of SNOTEL data availability is high. The consequence if not available is medium.<sup>7</sup>

### 5.3 Comparison with Model Data

GOES-R fractional Snow Cover product shall be compared with NOHRSC Snow Data Assimilation System (SNODAS) modeling products. The model is forced by numerical weather model state variables and periodically adjusted by assimilation with all available ground observations and satellite derived data. NOHRSC data likelihood of availability is high. The consequence if not available is low.<sup>9</sup>

### 5.4 Deep Dive Validation

Deep dive validation will track high RMSE clusters by snow regions and calculate row-column position of the centroid. Timely GOES-R L2 diagnostic data is critical for this task.

## 6. Output Artifacts

FSC MRD specifications are: Horizontal Resolution: 2 km, Mapping Accuracy: 1 km, Measurement Range: 0.0 - 1.0 Fractional Cover, Measurement Accuracy: 0.15, Product Measurement Precision: 0.30 (0.20 objective).<sup>5</sup>

Dependencies: The performance of this product will depend on upstream data quality, such as L1b products, clear-sky masks, and surface reflectance. Uncertainties from upstream products will be filtered and populated in the quality flags of this product.

### 6.1 Beta Maturity Output Artifacts

The purpose of Beta maturity is to quantitatively assess performance of the product with limited set of data, identify issues with the product and document performance and issues in the Beta report. The Beta maturity success criteria are not dependent upon the product meeting any performance requirements, and the pass/fail will not be dependent upon user satisfaction.

GOES-R Snow Cover will be assessed in terms of their fractional accuracy, fractional precision, and stability over space and time.

The first five PLPTs are to inspect that the product is generated for FD, CONUS, mesoscale, and for ABI Mode 3 and 4 fall within expected measurement range. OSPO will take the lead to ensure that the product is generated at the required time intervals. The Snow Cover cal/val team will take the lead on verifying that the product falls within the expected measurement range (0.0 - 1.0 fractional cover). A few days of continuous data are required by this process. The process is scheduled to finish in one week.

The other three PLPTs are to assess the product performance with a limited data set (not seasonally representative) to convey an initial characterization of product accuracy to the user community. Beta success criteria will follow the common language defined above (the first paragraph of Section 6).

At the completion of Beta, results shall be presented at Peer Stakeholder - Product Validation Reviews (PS-PVRs). The presentation shall detail the data sets and processes used and the results in terms of product accuracy and precision.

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

- ABI-FD\_FSC01
- ABI-CONUS\_FSC02
- ABI-MESO\_FSC03
- ABI-FD\_FSC04
- ABI-CONUS\_FSC05
- ABI-FD\_FSC06
- ABI-CONUS\_FSC07
- ABI-MESO\_FSC08

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

### 6.2 Provisional Maturity Output

The Fractional Snow Cover product Provisional maturity effort is to quantitatively assess performance of the product against product accuracy and precision requirements through analysis of a large, but still limited (i.e., not seasonally representative), number of independent measurements or field campaign data. The Provisional maturity pass/fail criteria are:

- Product performance has been demonstrated and compared against accuracy and precision requirements through analysis of a large, but still limited (i.e., not seasonally representative), number of independent measurements or field campaign data.



- Documentation of product performance, identified product performance anomalies, including recommended remediation strategies. Accuracy and precision do not have to meet requirements to attain Provisional status, however, if they do not do so, the reasons need be documented.
- Documentation of impacts from challenges with upstream dependencies.
- Product is ready for potential operational use (user decision) and for use in scientific publications.
- Documentation of feedback from the primary user (NWS), if any.

At the completion of the Provisional, results will be presented at PS-PVRs. The presentation shall detail the above list.

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

- ABI-FD\_FSC09
- ABI-CONUS\_FSC10
- ABI-MESO\_FSC11

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

### **6.3 Full Maturity Output Artifacts**

The Fractional Snow Cover product Full maturity validation effort is to quantitatively assess performance of the product against product accuracy and precision requirements through analysis of a large (global and seasonal representative) number of independent measurements or field campaign data. The Full maturity pass/fail criteria are:

- Product performance has been demonstrated and compared against accuracy and precision requirements through over a large and wide range of representative conditions, (i.e., global, seasonal representative).
- Documentation of product performance, identified product performance anomalies, including recommended remediation strategies. If the product accuracy and precision requirements cannot be met due to non-algorithm error at certain regions or under certain conditions, the reasons need to be documented.
- Documentation of impacts from challenges with upstream dependencies.
- Product is ready for operational use and for use in scientific publications.

At the completion of Full maturity validation, results will be presented at PS-PVRs. The presentation shall detail the above list.

**6.3.1** These tests of priority 1 all must pass in order to achieve Full maturity: [insert test names here].

- ABI-FD\_FSC12
- ABI-CONUS\_FSC13
- ABI-MESO\_FSC14

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

### **6.4 Key Artifacts**

Key artifacts for the FSC validation are power point presentations to report validation results.

### **6.5 More Output Artifacts**

There are no additional artifacts for the FSC product.

### **6.6 Delivery Schedule**

The delivery schedule of artifacts for the FSC validation is tied to the schedule for completing Beta, Provisional, and Full validation as given in section 2. Power point presentations will be ready in time for the PS-PVR.

## 7. Pre-launch

Pre-launch exercises have been performed and/or planned to ensure all the team members were prepared for PLPT validation events. Fractional Snow Cover cal/val tools and processes have been developed and results and progress have been reported.<sup>6,8</sup> Tools and processes specific for GOES-R were scheduled to exercise with DOE-3 and DOE-4 data, which are supposed to include diagnostics. Therefore, all the tools and processes have been exercised pre-launch. The rehearsal names, resources, proxy data needed are listed in [1]. While DOE data is exact in format, data values might be unrealistic, so there is a need for additional testing on orbit with real data. One example of a data issue from DOE-4 is that surface reflectance is not available so instead the input is reflectance at the top of the atmosphere (TOA). This isn't correct and can introduce non-trivial errors, up to 10% in fractional snow cover.

All tools and processes were developed by the team with reasonable code documentation and readme instructions. Therefore, all the team members, including back up, are able to access and operate the tool set.<sup>5</sup>

## 8. References

- [1] PLPT\_VE\_List\_L2\_v1\_0\_20141022.xlsx.
- [2] CalValPlan\_Vol2\_L2\_v1-1-draft-redlines\_inc-ERB\_comments\_v2a - Clean - BobEdits.docx.
- [3] MRD\_V3\_17.pdf.
- [4] GOES-R\_GS\_FPS.pdf.
- [5] Snow Cover RIMP Telecom Discussion 2015 06 16, Frank Sun, Jeff Key, Wayne Mackenzie, Kelley Eicher, et al.
- [6] GOES-R AWG Product Validation Tool Development: Snow Cover Team.
- [7] GOES-R Series Ground Segment Project Algorithm Change Management Plan.
- [8] 05\_Eicher\_FSCValidation2013.pptx.
- [9] Product Name\_Validation\_Table\_snowcover\_v2\_ricov2.docx.
- [10] L2 Product Validation Tools\_05-12-2015.xlsx.

## A. Appendix A: Validation Events

### A.1 PLPT Events that Support Beta Maturity

#### A.1.1 Name: ABI-FD\_FSC01

**Objective:** Verify that product is generated every hour of the day for every FD where snow exists.

**Description:** Inspection of Snow Cover.

**Justification:** Provides an early assessment of product performance.

**Start Time:** TBD.

**Duration:** TBD.

**Projected End Date:** TBD.

**ABI Mode:** Mode 3.

**GOES-R Data Type(s):** FD every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Beta Success Criteria:** to inspect that the product is generated and fall within expected measurement range

**PLPT Lead:** Jeff Key (NESDIS/STAR).

**PLPT Analysts:** Yinghui Liu (CIMSS) and Tom Painter (JPL).

**Procedure References:** GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation.<sup>2</sup>

#### A.1.3 Name: ABI-CONUS\_FSC02

Same as ABI-FD\_FSC01 except for:

**Objective:** Verify that product is generated every hour of the day for every CONUS where snow exists.

**Start Time:** TBD.

**Duration:** TBD.

**Projected End Date:** TBD.

**GOES-R Data Type(s):** CONUS every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Beta Success Criteria:** Product generated in cloud-free areas and falls within expected measurement range.

#### A.1.4 Name: ABI-MESO\_FSC03

**Start Time:** TBD.

**Duration:** TBD.

**Projected End Date:** TBD.

**GOES-R Data Type(s):** Mesoscale every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Beta Success Criteria:** Product generated in cloud-free areas and falls within expected measurement range.

#### A.1.5 Name: ABI-FD\_FSC04

Same as ABI-FD\_FSC01, except for:

**ABI Mode:** Mode 4.

**Beta Success Criteria:** Product generated in cloud-free areas and falls within expected measurement range.

#### A.1.6 Name: ABI-CONUS\_FSC05

This test is the same as ABI-CONUS\_FSC02, except for:

**ABI Mode:** Mode 4.

**Beta Success Criteria:** Product generated in cloud-free areas and falls within expected measurement range.

**A.1.7 Name: ABI-FD\_FSC06**

**Objective:** Assess accuracy and precision of product.

**Description:** Compare to reference/ground truth data. See reference [2], Section 3.14.

**Start Time:** TBD.

**Duration:** TBD.

**ABI Mode:** Mode 3.

**GOES-R Data Type(s):** FD every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Beta Success Criteria:** Product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.

**PLPT Lead:** Jeff Key.

**PLPT Analyst:** Yinghui Liu and Tom Painter.

**Procedure References:** GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation.<sup>2</sup>

**Validation Data:** Selected data set from VIIRS, Landsat Snow Cover products, MODIS, SNOTEL in-situ snow, NOHRSC real-time snow model data (CONUS). The primary validation data sets will be retrievals of Snow Cover from VIIRS (370 m) and Landsat-8 (29 m).<sup>2</sup>

**A.1.8 Name: ABI-CONUS\_FSC07**

Same as ABI-FD\_FSC06, except for:

**GOES-R Data Type(s):** CONUS every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Beta Success Criteria:** Product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.

**A.1.9 Name: ABI-MESO\_FSC08**

Same as ABI-FD\_FSC06, except for:

**GOES-R Data Type(s):** Mesoscale every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Beta Success Criteria:** Product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements.

**A.2 PLPT Events that Support Provisional Maturity**

**A.2.1 Name: ABI-FD\_FSC09**

**Objective:** Assess accuracy and precision of product.

**Description:** Compare to reference/ground truth data. See reference [2], Section 3.14.

**Justification:** Provides an early assessment of product performance. Focuses on assessing and characterizing product accuracy and precision that needs to be conveyed to the user community.

**Projected End Date:** 24 weeks.

**Start Time:** Right after Beta maturity.

**Duration:** 24 weeks.

**ABI Mode:** Mode 3.

**GOES-R Data Type(s):** FD every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Provisional Success Criteria:** Product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements. Product is ready for operational use (user decision).

**PLPT Lead:** Jeff Key (NESDIS/STAR).

**PLPT Analysts:** Yinghui Liu (CIMSS) and Tom Painter (JPL).

**Validation Data:** selected data set from VIIRS, Landsat Snow Cover products, MODIS, SNOTEL in-situ snow, NOHRSC real-time snow model data (CONUS). The primary validation data sets will be retrievals of Snow Cover from VIIRS (370 m) and Landsat-8 (29 m).<sup>2</sup>

**Procedure References:** GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation.<sup>2</sup>

**A.2.2 ID Name: ABI-CONUS\_FSC10**

Same as ABI-FD\_FSC09, except for:

**GOES-R Data Type(s):** CONUS every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Provisional Success Criteria:** Product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements. Product is ready for operational use (user decision).

**A.2.3 Name: ABI-MESO\_FSC11**

This test is the same as ABI-CONUS\_FSC10, except for:

**GOES-R Data Type(s):** Mesoscale every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Provisional Success Criteria:** Product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements. Product is ready for operational use (user decision).

**A.3 PLPT Events that Support Full Maturity**

**A.3.1 Name: ABI-FD\_FSC12**

**Objective:** Assess accuracy and precision of product.

**Description:** Compare to reference/ground truth data. See reference [2], Section 3.14.

**Justification:** Provides an early assessment of product performance. Focuses on assessing and characterizing product accuracy and precision that needs to be conveyed to the user community.

**Projected End Date:** End of Full Validation stage define by schedule chart.

**Start Time:** Right after Provisional maturity.

**Duration:** End of Full Validation stage define by schedule chart.

**ABI Mode:** Mode 3.

**GOES-R Data Type(s):** FD every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Full Success Criteria:** Product meets F&PS specifications for a large and wide range of representative conditions over a period of at least a year. Product is ready for operational use and for use in scientific publications

**PLPT Lead:** Jeff Key (NESDIS/STAR).

**PLPT Analysts:** Yinghui Liu (CIMSS) and Tom Painter (JPL).

**Validation Data:** selected data set from VIIRS, Landsat Snow Cover products, MODIS, SNOTEL in-situ snow, NOHRSC real-time snow model data (CONUS). The primary validation data sets will be retrievals of Snow Cover from VIIRS (370 m) and Landsat-8 (29 m).<sup>2</sup>

**Procedure References:** GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation.<sup>2</sup>

**A.3.2 Name: ABI-CONUS\_FSC13**

This test is the same as ABI-FD\_FSC12, except for:

**GOES-R Data Type(s):** CONUS every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

**Full Success Criteria:** Product meets F&PS specifications for a large and wide range of representative conditions over a period of at least a year. Product is ready for operational use and for use in scientific publications

**A.3.3 Name: ABI-MESO\_SNC14**

This test is the same as ABI-CONUS\_SNC13, except for:

**GOES-R Data Type(s):** Mesoscale every hour. ABI Bands 1, 2, 3, 5, 6, 7, and 13.

Effective Date: Date of Last Signature  
Responsible Organization: GOES-R Ground Segment/Code 416

416-R-RIMP-0329  
Version 1.0

**Full Success Criteria:** Product meets F&PS specifications for a large and wide range of representative conditions over a period of at least a year. Product is ready for operational use and for use in scientific publications

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

### **B.1 Data Set #1: VIIRS Snow Cover**

**Description:** Suomi National Polar-orbiting Partnership (SNPP) VIIRS.  
**Consequence If Not Available:** High.  
**Storage Location:** CLASS  
(<http://www.class.ngdc.noaa.gov>)  
**Access Process:** Download.  
**POC:** CLASS help desk.  
**Spatial Coverage:** Global  
**Temporal Coverage:** Daily.  
**Contingency:** If data is not available, dataset #2 or #3 can be used instead.

### **B.2 Data Set #2: Landsat-8 Snow Cover**

**Description:** Landsat 8.  
**Likelihood of Availability:** High.  
**Consequence If Not Available:** High.  
**Storage Location:** United States Geological Survey (USGS)  
([http://www.usgs.gov/climate\\_landuse/lcs/projects/snow.asp](http://www.usgs.gov/climate_landuse/lcs/projects/snow.asp)).  
**Access Process:** Download.  
**POC:** USGS  
**Spatial Coverage:** Global  
**Temporal Coverage:** Daily.  
**Contingency:** If data is not available, dataset #1 or #3 can be used instead.

### **B.3 Data Set #3: MODIS Snow Cover**

**Description:** Terra and Aqua MODIS data (if still available).  
**Likelihood of Availability:** High.  
**Consequence If Not Available:** High.  
**Storage Location:** National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) (<https://earthdata.nasa.gov/data/near-real-time-data/data/instrument/modis>).  
**Access Process:** Download.  
**POC:** NASA GSFC.  
**Spatial Coverage:** Global  
**Temporal Coverage:** Daily.  
**Contingency:** If data is not available, dataset #1 or #2 can be used instead.

### **B.4 Data Set #4: Natural Resources Conservation Service (NRCS) Snow Telemetry (SNOTEL) in-situ snow**

**Description:** The Natural Resources Conservation Service (NRCS) Snow Telemetry (SNOTEL) network.  
**Likelihood of Availability:** High.  
**Consequence If Not Available:** Medium.  
**Storage Location:** SNOTEL Snow Water Equivalent (SWE) and snow depth on a daily basis that is accessible in real time, SNOTEL network, SNOTEL network  
(<http://www.wcc.nrcs.usda.gov/snow/snowup-graph.html>).  
**POC:** Help Center  
**Access Process:** Download.  
**Spatial Coverage:** The western CONUS except for the southern Sierra Nevada and also covers Alaska.



**Temporal Coverage:** As needed.

**Contingency:** California Cooperative Snow Surveys, and the Canadian Provincial automated snow monitoring are also considered.

**B.5 Data Set #5: NOHRSC real-time snow model data (CONUS)**

**Description:** NOHRSC Snow Data Assimilation System (SNODAS) modeling products. The model is forced by numerical weather model state variables and periodically adjusted by assimilation with all available ground observations and satellite derived data. The input data of NOHRSC includes areal extent of snow cover over the coterminous U.S. inferred from full spectral and spatial resolution GOES East and West image data four times each hour.

**Likelihood of Availability:** High.

**Consequence If Not Available:** Low.

**Storage location:** NWS/NOHRSC (<http://www.nohrsc.noaa.gov/>).

**Access Process:** Download.

**POC:** NWS/NOHRSC.

**Spatial Coverage:** CONUS.

**Temporal Coverage:** Daily and seasonally.

**Contingency If Not Available:** None

## C. Appendix C: Tools

### C.1 Tool #1: Cluster Mask

**Location:** In house.

**Description:** This program finds clusters of high root-mean-square error (RMSE) values on pixels with a positive fractional snow cover (FSC) that are found on a two dimensional grid. It identifies 1) Clusters based on input thresholds; 2) Center pixel of highest average RMSE within cluster; and 3) Pixel with the highest RMSE in cluster.

**Developer:** Kelley Eicher (NOHRSC)

**Development Schedule:** Fully functional September 2015 (ready for launch). Tools are developed with reasonable in code documentation and user manuals.

**Testing Accomplished or Planned:** Section 4, first paragraph.

**POC:** Kelley Eicher.

**Classification:** Routine.

**Description to Include Language and Data to Be Used:** Reference [10].

**Documentation:** User manuals.

### C.2 Tool #2: Histogram

**Location:** In house.

**Description:** A program for generating a histogram of snow cover differences over the same area derived from different satellites.

**Developer:** Kelley Eicher (NOHRSC)

**Development Schedule:** Fully functional September 2015 (ready for launch). Tools are developed with reasonable in code documentation and user manuals

**Testing Accomplished or Planned:** Section 4, first paragraph.

**POC:** Kelley Eicher.

**Classification:** Routine.

**Description to Include Language and Data to Be Used:** Reference [10].

**Documentation:** User manuals.

### C.3 Tool #3: Scatter plot

**Location:** In house.

**Description:** A program for generating a scatter plot of snow cover over the same area derived from different satellites.

**Developer:** Kelley Eicher (NOHRSC)

**Development Schedule:** Fully functional September 2015 (ready for launch). Tools are developed with reasonable in code documentation and user manuals.

**Testing Accomplished or Planned:** Section 4, first paragraph.

**Documentation:** User manuals.

**POC:** Kelley Eicher.

**Classification:** Deep dive.

**Description to Include Language and Data to Be Used:** Reference [10].

**Documentation:** User manuals.

### C.4 Tool #4: Data Visualization & Image Generator Tools

**Location:** In house.

**Description:** Displaying snow cover product over select areas.

**Developer:** Kelley Eicher (NOHRSC)

**Development Schedule:** Fully functional. Programs to show fraction snow and statistical analysis in global and CONUS views with map projections have been added (October 2015). Tools are developed with reasonable in code documentation and user manuals.

**Testing Accomplished or Planned:** Section 4, first paragraph.

**POC:** Kelley Eicher.

**Classification:** Routine.

**Description to Include Language and Data to Be Used:** Reference [10].

**Documentation:** User manuals.

## D. Appendix D: Acronyms

<b>Acronym</b>	<b>Definition</b>
<b>ABI</b>	Advanced Baseline Imager
<b>AWG</b>	Algorithm Working Group
<b>Cal/Val</b>	Calibration and Validation
<b>CCR</b>	Configuration Change Request
<b>CIMSS</b>	Cooperative Institute for Meteorological Satellite Studies
<b>CLASS</b>	Comprehensive Large Array-data Stewardship System
<b>CMI</b>	Cloud and Moisture Imagery
<b>CONUS</b>	Continental United States
<b>CWG</b>	Calibration Working Group
<b>DOE</b>	Data Operations Exercise
<b>F&amp;PS</b>	Functional and Performance Specification
<b>FD</b>	Full Disk
<b>FSC</b>	Fractional Snow Cover
<b>GOES</b>	Geostationary Operational Environmental Satellite
<b>GOES-R</b>	Geostationary Operational Environmental Satellite R-Series
<b>GORWG</b>	GOES-R Series Operational Requirements Working Group
<b>GRB</b>	Global Rebroadcast
<b>GSFC</b>	Goddard Space Flight Center
<b>HRR</b>	Handover Readiness Review
<b>JPL</b>	Jet Propulsion Laboratory
<b>L1</b>	Level 1
<b>L1b</b>	Level 1b
<b>L2</b>	Level 2
<b>MODIS</b>	Moderate Resolution Imaging Spectroradiometer
<b>MOST</b>	Mission Operations Support Team
<b>MRD</b>	Mission Requirements Document
<b>MSFC</b>	Marshall Space Flight Center
<b>NASA</b>	National Aeronautics and Space Administration
<b>NCEI-CO</b>	NCEI - Colorado
<b>NESDIS</b>	National Environmental Satellite, Data, and Information Service
<b>NOAA</b>	National Oceanic and Atmospheric Administration
<b>NOHRSC</b>	National Operational Hydrologic Remote Sensing Center
<b>NRCS</b>	Natural Resources Conservation Service
<b>NWS</b>	National Weather Service
<b>OSPO</b>	Office of Satellite and Product Operations
<b>PLAR</b>	Post-Launch Assessment Review
<b>PLPT</b>	Post-Launch Product Test
<b>PLT</b>	Post-Launch Test

<b>Acronym</b>	<b>Definition</b>
<b>POC</b>	Point of Contact
<b>PRO</b>	Product Readiness and Operations
<b>PSE</b>	Program System Engineering
<b>PS-PVR</b>	Peer Stakeholder-Product Validation Review
<b>PUG</b>	Product User's Guide
<b>QA</b>	Quality Assurance
<b>RIMP</b>	Readiness, Implementation and Management Plan
<b>RMSE</b>	Root Mean Square Error
<b>SNODAS</b>	Snow Data Assimilation System
<b>SNOTEL</b>	Snow Telemetry
<b>SNPP</b>	Suomi National Polar-orbiting Partnership
<b>SPOT</b>	System Performance Operational Test
<b>STAR</b>	Center for Satellite Applications and Research
<b>SWE</b>	Snow Water Equivalent
<b>TBD</b>	To Be Determined
<b>USGS</b>	United States Geological Survey
<b>VCRM</b>	Verification Cross Reference Matrix
<b>VIIRS</b>	Visible Infrared Imaging Radiometer Suite