



Geostationary Operational Environmental Satellite (GOES) – R Series

ABI L2+ Derived Stability Indices (DSI) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

**ABI L2+ Derived Stability Indices (DSI) 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.

<u>GOES-R Product (L1b and L2+) Maturity Levels</u>
<p style="text-align: center;"><u>Beta Validation</u></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none">○ 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. <p><u>End state</u></p> <ul style="list-style-type: none">○ 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.
<p style="text-align: center;"><u>Provisional Validation</u></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none">○ 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. <p><u>End state</u></p> <ul style="list-style-type: none">○ 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.
<p style="text-align: center;"><u>Full Validation</u></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none">○ Validation, QA, and anomaly resolution activities are ongoing.○ Incremental product improvements may still be occurring.○ Users are engaged and user feedback is assessed. <p><u>End state</u></p> <ul style="list-style-type: none">○ 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.

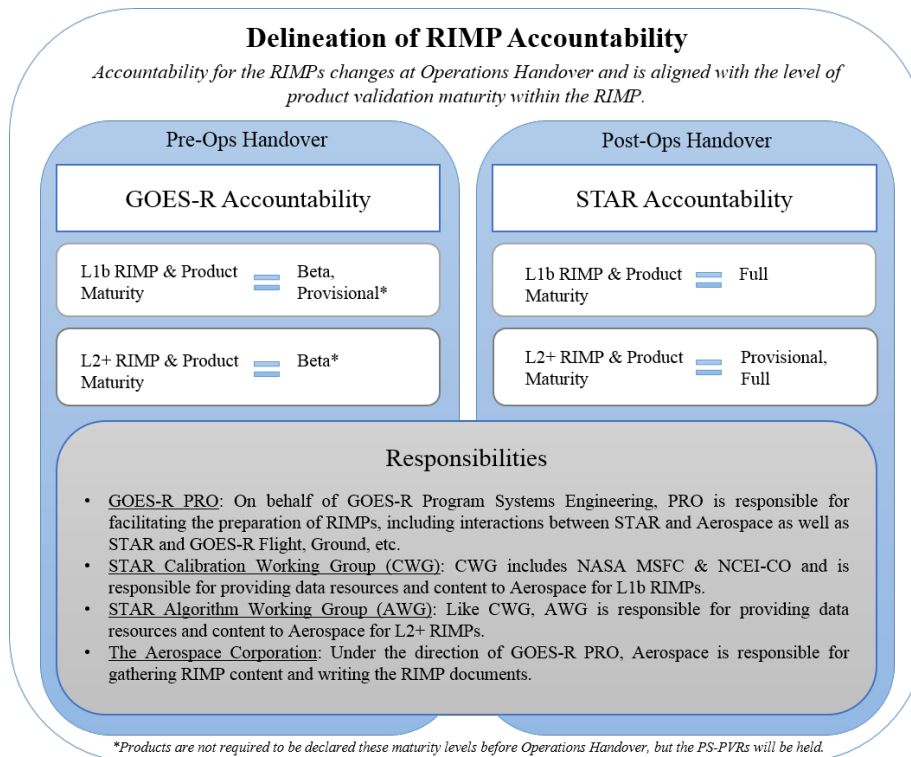


Figure 2. Delineation of accountability between GOES-R and STAR.

1. Derived Stability Indices Validation Overview

This Readiness, Implementation, and Management Plan (RIMP) covers all validation stages of the GOES-R Advanced Baseline Imager (ABI) Derived Stability Indices (DSI) Level 2 product. There are three stages in the validation process, Beta, Provisional, and Full. Each stage is defined by Post-Launch Product Tests (PLPTs), which guide the overall validation process. The RIMP includes a summary of the methods and tools employed to prove DSI has met a given validation stage. Feedback from the NWS will be provided through the PS-PVR process. Other forums are being considered, but are TBD at this time. Appendices are included that present more detail on each PLPT and detail on the different data sets employed in the validation of the DSI product. The DSI validation effort has no identified need for data from a North/South (N/S) scan or for a specific mesoscale scene. Data from field campaigns is not required for DSI validation, but high spectral IR measurements, such as from the Scanning High-resolution Interferometer Sounder, and radiosondes from field campaigns would be used if available.

The DSI are five indices that estimate the potential for atmospheric convection. All five use the derived temperature and moisture vertical profiles as inputs. The indices are: Lifted Index (LI, kelvin), Convective Available Potential Energy (CAPE, Joules/kg), Total Totals Index (TT, kelvin), Showalter Index (SI, kelvin), and K index (KI, kelvin).

The DSI product has eight PLPTs with identified Success Criteria for Beta maturity. Five of these PLPTs are verifications that various products are generated at the required frequency (see Table 1). The other three PLPTs are an initial assessment of the accuracy and precision of the FD, CONUS, and mesoscale data products when the sensor is in Mode 3.¹ The validation of product generation PLPTs are scheduled for 1 week, while the assessment of product accuracy and precision PLPTs are scheduled for 5 weeks. All Beta maturity PLPTs for DSI are scheduled to start simultaneously.

Beta PLPTs of DSI will involve quantitative comparisons between the DSI data product and various truth data sources, to validate the reasonableness of the data products. A primary source of reference data for Beta validation will be Numerical Weather Prediction (NWP) short-term forecasts used to initialize the DSI algorithm. While not an independent source of reference data, NWP will be available for comparison with every DSI output and will be sufficient to assess the reasonableness of the data products. Comparisons may also be made to additional independent sources of reference data, including conventional radiosondes within GOES-R coverage. PLPT events that support Beta maturity are listed below; details are in Appendix A:

- **ABI-FD_DSI01:** verify that DSI products generated at the required cadence for FD for cloud-free areas while in ABI Mode 3 fall within the expected measurement ranges.
- **ABI-CONUS_DSI02:** verify that DSI products generated at the required cadence for CONUS for cloud-free areas while in ABI Mode 3 fall within the expected measurement ranges.
- **ABI-MESO_DSI03:** verify that DSI products generated at the required cadence for mesoscale for cloud-free areas while in ABI Mode 3 fall within the expected measurement ranges.
- **ABI-FD_DSI04:** verify that DSI products generated at the required cadence for FD for cloud-free areas while in ABI Mode 4 fall within the expected measurement ranges.
- **ABI-CONUS_DSI05:** verify that DSI products generated at the required cadence for CONUS for cloud-free areas while in ABI Mode 4 fall within the expected measurement ranges.
- **ABI-FD_DSI06:** assess the accuracy of DSI products generated for FD in ABI Modes 3 and 4 for a very limited (i.e., not seasonally representative) number of independent measurements to convey an initial characterization of product accuracy to the user community.

- **ABI-CONUS_DSI07:** assess the accuracy of DSI products generated for CONUS in ABI Mode 3 for a very limited (i.e., not seasonally representative) number of independent measurements to convey an initial characterization of product accuracy to the user community.
- **ABI-MESO_DSI08:** assess the accuracy of DSI products generated for mesoscale in ABI Mode 3 for a very limited (i.e., not seasonally representative) number of independent measurements to convey an initial characterization of product accuracy to the user community.

The following table identifies the frequency of each scan type for Modes 3 and 4. It includes the required cadence of the DSI product as defined by both the GOES-R Functional and Performance Specification (F&PS)⁷ and the Product User’s Guide (PUG)¹⁰. The PUG is a forward-looking document and may not match the F&PS. The DSI team will validate to whatever cadence the products are derived.

** 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
Freq	15 min	5 min	30 sec	5 min	5 min*	N/A
DSI - FPS	60 min	30 min	5 min	60 min	30 min	N/A
DSI - PUG	15 min	5 min	5 min	5 min	5 min	N/A

Table 1. Derived Stability Indices documented product and verification cadence

Three PLPTs have been defined to attain Provisional maturity. The success criteria for the Provisional PLPTs are that the DSI product, generated over a large and wide range of representative (except seasonally representative) conditions for all required modes have been:

- 1) Assessed sufficiently to characterize its accuracy and precision as well as the product limitations and to identify the potential fixes and improvements needed to satisfy the Functional and Performance Specification.
- 2) Established needed fixes to the ABI sensor performance for the DSI product to be ready for operational use.
- 3) Established needed fixes to the DSI algorithm for the product to be ready for operational use. Provisional validation events are planned to begin at the end of the PLPT, immediately after Beta maturity has been obtained and last 24 weeks.

Provisional PLPTs of DSI will involve quantitative comparisons between the DSI data product and various truth data sources, to provide an initial statistical assessment of data accuracy and precision. NWP short-term forecasts used to initialize the DSI algorithm will continue to be used, although these are not truly independent data sets. For Provisional maturity, a greater emphasis will be placed on comparisons to conventional NWS radiosondes within GOES-R coverage as an independent source of ground truth. PLPT events that support Provisional maturity are listed below; details are in Appendix A:

- **ABI-FD_DSI09:** assess the accuracy and precision of DSI products generated for FD in ABI Mode 3 and 4 for an extended period that includes some but not all seasonal variability, to facilitate user decision on operational readiness.
- **ABI-CONUS_DSI10:** assess the accuracy and precision of DSI products generated for CONUS in ABI Mode 3 for an extended period that includes some but not all seasonal variability, to facilitate user decision on operational readiness.
- **ABI-MESO_DSI11:** assess the accuracy and precision of DSI products generated for mesoscale in ABI Mode 3 for an extended period that includes some but not all seasonal variability, to facilitate user decision on operational readiness.

Validation of Full maturity of DSI will involve quantitative comparisons between the DSI data product and various truth data sources over an extended period of time, to provide a statistical assessment of data accuracy and precision. NWP short-term forecasts used to initialize the DSI algorithm and conventional NWS radiosondes within GOES-R coverage will continue to be used. Additional sources of ground truth, such as radiosondes from ARM sites and European Centre for Medium-Range Weather Forecasts (ECMWF) analyses will also be used.

Three PLPTs have been defined to attain Full maturity. The success criteria for Full maturity are that the DSI product meets accuracy and precision specifications for a large and wide range of representative conditions (i.e., seasonal) over a period of at least a year for all required modes. Full maturity tests are planned to begin after PLPT, immediately after the completion of Provisional PLPTs and last 36 weeks. PLPT events that support Full maturity are listed below; details are in Appendix A:

- **ABI-FD_DSI12:** assess the accuracy and precision of DSI products generated for FD ABI Mode 3 and 4 for an extended period of at least one year that includes seasonal variability, to facilitate user decision on operational readiness.
- **ABI-CONUS_DSI13:** assess the accuracy and precision of DSI products generated for CONUS in ABI Mode 3 for an extended period of at least one year that includes seasonal variability, to facilitate user decision on operational readiness.
- **ABI-MESO_DSI14:** assess the accuracy and precision of DSI products generated for mesoscale in ABI Mode 3 for an extended period of at least one year that includes seasonal variability, to facilitate user decision on operational readiness.

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 are contained in Appendix A and of each reference data set are in Appendix B.

2. Schedule of Events

Figure 3 shows the GOES-R validation schedule. System Performance Operation Test (SPOT) begins 44 days after launch when ABI L1b and the L2 Cloud and Moisture Imagery (CMI) Key Performance Beta evaluation begins and should be declared Beta maturity by L+87. One day later, the GOES Rebroadcast (GRB) will be populated with that data. The L2 product must reach Beta maturity by Handover at L+197, the same time that ABI L1b and CMI must reach Provisional. Given that L2 Beta tests require at least 6 weeks, L2 Beta testing must get underway by L+155, but can begin as soon as the ABI L1b and CMI reach Beta (L+87).

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 month period for the L2 product to reach Full maturity, 15 months after Handover. DSI validation is expected to require the entire allocated period.

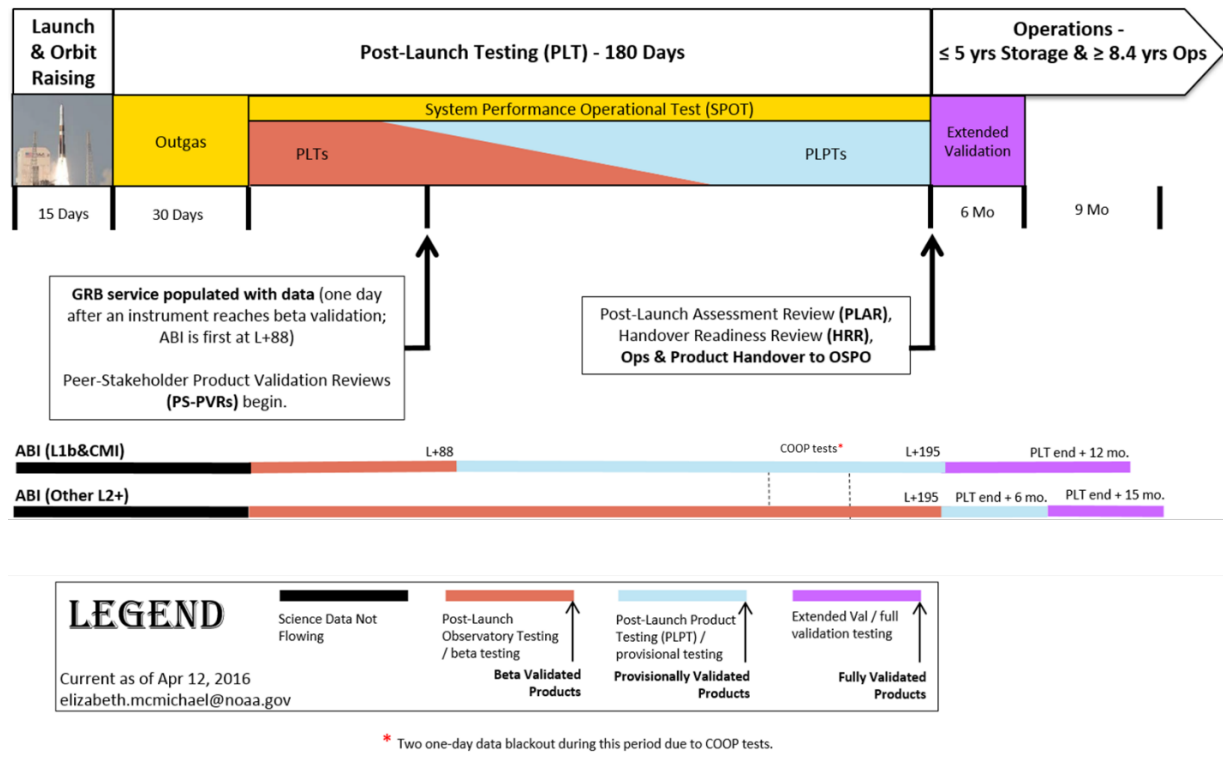


Figure 3. Schedule of events.

All Beta DSI tests will commence at the start of PLPT and progress in parallel. Inspection of DSI products to ensure data are produced at the specified cadence in each mode and will be the responsibility of OSPO personnel and any failures will be reported to the product analyst. In parallel, the product analyst will perform checks that the data outputs are within the expected range and begin initial quantitative assessments of DSI quality. These quality assessments continue over the first five weeks of PLPT. Comparisons will be made on an ongoing basis with summaries made approximately weekly, so as to identify unreasonable data products as early in PLPT as possible. Provisional DSI validation events are planned to begin at the end of

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the PLPT period, immediately after the Beta PLPTs are complete, and they are planned to last 24 weeks. Finally, Full DSI PLPTs will be carried out immediately after the Provisional stage for another 36 weeks.

3. Roles and Responsibilities

3.1 Primary Point of Contact

The primary point-of-contact (POC) for managing the DSI validation effort and coordinating algorithm updates is Tim Schmit, with Jun Li (CIMSS) as secondary POC.

3.2 GOES-R Point of Contact

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

3.3 Test Analyst/Engineer

The PLPT analyst for all PLPT stages of DSI is Yong-Keun Lee. If Yong-Keun Lee is unavailable during PLPT, the primary backup analyst is Zhenglong Li.

3.4 GOES-R Feedback

Formal feedback to the GOES-R program regarding DSI products will be provided by the DSI product lead Tim Schmit.

3.5 Level of Effort

The first five product generation DSI PLPTs (checking that values are within range) are each budgeted 0.08 FTE (0.08 person-weeks), for a total of 0.4 FTE (0.4 person-weeks).

The remaining three product assessment PLPTs, to be worked in parallel over the first five weeks, are each budgeted 0.13 FTE (0.65 person-weeks), for a total of 0.39 FTE (1.95 person-weeks). Note that the same analyst is responsible for nearly identical tasks for the Total Precipitable Water products, with identical allotments of time. Thus the total LAP commitment for this analyst during PLPT is nearly 0.8 FTE per week for six weeks.

The DSI Provisional PLPTs should be budgeted for 0.4 FTE (0.4 person-weeks) per week, for a total of 9.6 FTE (9.6 person-weeks). In addition to the DSI Provisional PLPT, this analyst will be the analyst for the TPW Provisional PLPTs, budgeted for the same effort. Therefore the total commitment for this analyst during the Provisional stage is 0.8 FTE (0.8 person-weeks) per week, for a total of 19.2 FTE (19.2 person-weeks).

The DSI Full tests should be budgeted for 0.4 FTE (0.4 person-weeks) per week, for a total of 14.4 FTE (14.4 person-weeks). In addition to the DSI Full test, this analyst will be the analyst for the TPW Full tests, budgeted for the same effort. Therefore, the total commitment for this analyst during the Full stage is 0.8 FTE (0.8 person-weeks) per week, for a total of 28.8 FTE (28.8 person-weeks).

4. Tools

The DSI validation effort utilizes a set of two tools: colocation and statistical analysis. The colocation tool compares Latitude, Longitude and time between DSI data and “truth” data sets to establish matched pairs of data for comparison. The statistical analysis tool will calculate bias, standard deviation, and RMS error between truth data sets and collocated ABI DSI products as well as visualization tools for such comparisons. Each of these tools is detailed in Appendix C.

5. Analysis Methods

There are 3 analysis methods used for the PLPTs which are listed below. Only the first two of the listed Visualization and Software Tools are likely to be used during Beta validation of the DSI data products. The other Tools will be required for later stages of product validation. Similarly, the only data sets used during Beta validation will be NWP forecast used in the LAP retrieval, radiosondes (conventional), and ABI IR brightness temperatures.

5.1 Routine Analysis⁴

Capabilities: Monitoring the quality of derived Stability Index products in near real time.

Data Sets Used: NWP forecast used in the LAP retrieval; radiosondes (conventional); ABI IR brightness temperatures.

Visualization and Software Tools:

- Animation of RTVL images (LI, CAPE, TT, KI, SI).
- Animation of FCST images (LI, CAPE, TT, KI, SI).
- Animation of difference (RTVL - FCST) images (LI, CAPE, TT, KI, SI).
- Time series of LI, CAPE, TT, KI, SI from GOES-R RTVLs, and FCSTs for each radiosonde location where radiosonde observation, GOES-R RTVLs and FCSTs are available.
- Statistics of retrievals against conventional radiosondes.
- Monitor Product quality.

5.2 Deep-Dive Validation Tools⁴ (Not used for Beta validation PLPTs)

Capabilities: Monitor any anomalies of any GOES-R LAP product and identify the cause. Quantify the error/uncertainty of GOES-R LAP products for better applications.

Data Sets Used: Radiosondes (conventional); ABI IR brightness temperatures;

Visualization and Software Tools:

- Full and/or zoomed difference (LI, CAPE, KI, TT, SI) between RTVLs and FCSTs images.
- Full and/or zoomed (LI, CAPE, KI, TT, SI) RTVL images.
- Full and/or zoomed (LI, CAPE, KI, TT, SI) FCST images.
- Vertical (temperature and water vapor) profiles can be shown where both ground truth and retrieval are available.

5.3 Long-term performance Analysis (Not used for Beta validation PLPTs)

Capabilities: Monitoring the quality of derived Stability Index products.

Data Sets Used: the LAP retrieval; Radiosondes (ARM site); ECMWF analysis.

Visualization and Software Tools:

- Statistics of retrievals against ARM site radiosondes.
- Statistics of retrievals against ECMWF analysis.

6. Output Artifacts

At the end of the first week of PLPT, the results from the range testing will be summarized in a report that will be made available for review by the Program. During the weeks 2-6 of PLPT the validation results from the Analysis Methods in Section 5 will be made available in the web-based display.

6.1 Beta Maturity Artifacts

The success criterion for Beta is the successful characterization of product accuracy and precision regardless of scene type or season. At the completion of the Beta phase, a report will be prepared and presented detailing the methods used and the results in terms of mean (accuracy), standard deviation (precision), and root mean square, minimum and maximum values and probability distribution will be reported.

At the end of the first week of PLPT, the results from the range testing will be summarized in a report that will be made available for review by the Program. During the weeks 2-6 of PLPT the validation results from the analysis methods in Section 5 will be made available in the web-based display.

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

- ABI-FD_DSI01
- ABI-CONUS_DSI02
- ABI-MESO_DSI03
- ABI-FD_DSI04
- ABI-CONUS_DSI05
- ABI-FD_DSI06
- ABI-CONUS_DSI07
- ABI-MESO_DSI08

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

6.2 Provisional Maturity Artifacts

The success criteria for the Provisional PLPTs are: 1. the product, generated over a large and wide range of representative (except seasonally representative) conditions for all required frequencies (see Table 1) has been assessed sufficiently to characterize its accuracy and precision as well as the product limitations. Accuracy and precision have been compared to requirements for each product as described in Appendix A; 2. Potential fixes and improvements needed to satisfy the Functional and Performance Specification (F&PS) have been identified; 3. Necessary fixes to the ABI sensor performance for the DSI products to be ready for operational use have been established; and 4. Necessary fixes to the DSI algorithms for the products to be ready for operational use have been established.

At the completion of the Provisional analysis, a report will be prepared and presented detailing the methods used and the results in terms of mean (accuracy), standard deviation (precision), and root mean square, minimum and maximum values, and probability distribution will be reported for the DSI (LI, CAPE, KI, TT, SI). Results will be presented showing dependencies on diurnal cycle and region (east or west CONUS).

6.2.1 The following test of priority 1 must pass in order to achieve Provisional maturity:

- ABI-FD_DSI09
- ABI-CONUS_DSI10
- ABI-MESO_DSI11

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

6.3 Full Maturity Artifacts

The success criteria for the Full PLPTs are that the DSI products meet accuracy and precision specifications for a large and wide range of representative conditions (i.e., seasonal) over a period of at least a year for all required frequencies (see Table 1). Accuracy and precision specifications for each product are described in Appendix A.

At the completion of the Full analysis, a report will be prepared and presented detailing the methods used and the results in terms of mean (accuracy), standard deviation (precision), and root mean square, minimum and maximum values, and probability distribution will be reported for the DSI (LI, CAPE, KI, TT, SI). Results will be presented showing dependencies on diurnal cycle, region (east or west CONUS, ocean), and season.

6.3.1 The following test of priority must pass in order to achieve Full maturity:

- ABI-FD_DSI12
- ABI-CONUS_DSI13
- ABI-MESO_DSI14

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

6.4 Key Artifacts

Key artifacts for the DSI validation effort are reports generated at the end of each validation stage..

6.5 More Output Artifacts

None.

6.6 Delivery Schedule

The delivery schedule of artifacts for the DSI validation effort is tied to the schedule for completing beta, provisional, and full validation as given in section 2. The generation of reports will the responsibility of the Test Lead, working in conjunction with the Test Analyst.

7. Pre-launch

Software tools that will be utilized throughout the DSI validation effort are 90% complete. All validation tools have been developed and web tools are now available at <http://soundingval.ssec.wisc.edu/>. Testing of colocation and analysis tools with GOES-R proxy data, Southern Great Plains radiosonde data, CONUS standard radiosonde sites, and archived AMSR-E data from 2011 have been successfully completed.⁵ SEVIRI onboard MSG, MODIS, and GOES Sounders data are all available proxies for ABI LAP validation available pre-launch.⁶

Data Operations Exercises (DOEs) 1, 2, and 3 data have been provided and the DSI team has responded with comments. Additional data from DOE 4 are anticipated by the end of September 2016. Remaining tests of the tools require routine files to be produced and run through the system, staged and accessed by the PDS in real time. Future test data must contain forecast DSI products which are needed in the GOES-R ABI LAP validation tool. Software tools are expected to be fully tested by October 2016.

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_VE_List_L2_v1_0_20141022.xlsx.
- [2] CalValPlan_Vol2_L2_v1-1-draft-redlines_inc-ERB_comments_v2a - Clean - BobEdits.docx.
- [3] Derived_LAP_TPW_Stability_Validation_Table_v2_rico.docx.
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- [5] GOES-R_ABI_Validation_Tools_LAP_v1.3.docx.
- [6] GOESR-CVCT-PLPT_BriefingToNOAA-IAC_2015-02-03_FINAL.pptx – Shortcut.
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- [8] GOES-R_Field_Campaign_Plan_IAC_bds.pptx.
- [9] MRD_v3_17.pdf.
- [10] SE-16_CGS_7035538_PUG_V5_L2_RevD.pdf.
- [11] Lee, Y.-K., Z. Li, J. Li, and T. Schmit 2016: “Application of GOES-R LAP algorithm to AHI on Himawari-8”, AMS 96th annual meeting, 10-14, New Orleans, LA.

A. Appendix A: Validation Events

A.1 PLPT Events that Support Beta Maturity

A.1.1 Event Name: ABI-FD_DSI01

Objective: Verify that products generated at the required cadence for FD are within measurement range.

Start Time: Start of PLPT.

Duration: 1 week.

ABI Mode: Mode 3.

GOES-R Data Type(s): Bands 8-16, FD.

Beta Success Criteria: Range assessment results reported. Analyst will inspect products to assess whether DSI products are generated at the required cadence (see Table 1) for FD and fall within expected ranges ($-10 < LI < 40$; $0 < CAPE < 5000$; $-90 < KI < 60$; $-43 < TT < 80$; $-10 < SI < 50$)¹¹. Note that the expected ranges for some DSI products have been modified from what was included in the F&PS/PUG based on the application of the GOES-R ABI LAP algorithm to AHI measurements. The monitoring of the product generation cadence will primarily be the responsibility of OSPO (not the PLPT analyst) and the results conveyed to the PLPT analyst. If there are issues with data products not being produced on time or falling outside expected values, a root cause and path forward should be identified prior to Beta validation being achieved.

Dependencies: Any issues with data access to DSI products will directly impact the schedule of DSI validation activities. Analyst requires access to near-real-time data through PDA.

PLPT Lead: Tim Schmit.

PLPT Analyst: Yong-Keun Lee; 0.08 FTE; 0.08 Person weeks.

Comparison / Reference Data: None.

Monitoring and Analysis Method: Product inspection.

A.1.2 Event Name: ABI-CONUS_DSI02

Same as for ABI-FD_DSI01, except for:

Objective: Verify that product is generated at the required cadence for CONUS.

GOES-R Data Type(s): Bands 8-16, CONUS every 30 min.

Beta Success Criteria: Range assessment results reported. Analyst will inspect products to assess whether products are generated at the required cadence (see Table 1) for CONUS and fall within expected range ($-10 < LI < 40$; $0 < CAPE < 5000$; $-90 < KI < 60$; $-43 < TT < 80$; $-10 < SI < 50$)¹¹. Note that the expected ranges for some DSI products have been modified from what was included in the F&PS/PUG based on the application of the GOES-R ABI LAP algorithm to AHI measurements. The monitoring of the product generation cadence will primarily be the responsibility of OSPO (not the PLPT analyst) and the results conveyed to the PLPT analyst. If there are issues with data products not being produced on time or falling outside expected values, a root cause and path forward should be identified prior to Beta validation being achieved.

A.1.3 Event Name: ABI-MESO_DSI03

Same as for ABI-FD_DSI01, except for:

Objective: Verify that product is generated at the required cadence for mesoscale.

GOES-R Data Type(s): Bands 8-16, mesoscale every 5 min.

Beta Success Criteria: Range assessment results reported. Analyst will inspect products to assess whether products are generated at the required cadence (see Table 1) for mesoscale and fall within expected range ($-10 < LI < 40$; $0 < CAPE < 5000$; $-90 < KI < 60$; $-43 < TT < 80$; $-10 < SI < 50$)¹¹. Note that the expected ranges for some DSI products have been modified from what was included in the F&PS/PUG based on the application of the GOES-R ABI LAP algorithm to AHI measurements.

The monitoring of the product generation cadence will primarily be the responsibility of OSPO (not the PLPT analyst) and the results conveyed to the PLPT analyst. If there are issues with data products not being produced on time or falling outside expected values, a root cause and path forward should be identified prior to Beta validation being achieved.

A.1.4 Event Name: ABI-FD_DSI04

Same as for ABI-FD_DSI01, except for:
ABI Mode: Mode 4.

A.1.5 Event Name: ABI-CONUS_DSI05

Same as for ABI-CONUS_DSI02, except for:
ABI Mode: Mode 4.

A.1.6 Event Name: ABI-FD_DSI06

Objective: Assess accuracy and precision of FD product.

Start Time: Start of PLPT.

Duration: 5 weeks.

ABI Mode: Modes 3 and 4.

GOES-R Data Type(s): Bands 8-16, FD.

Beta Success Criteria: Quantitatively assess performance with limited set of data. Identify issues with DSI product. Document performance and issue in the beta report.

Dependencies: Any issues with data access to DSI products will directly impact the schedule of DSI validation activities. Analyst requires access to near-real time data through PDA. Any issues with access to Global Forecast System profiles of moisture and temperature will also impact DSI accuracy and precision validation activities.

PLPT Lead: Tim Schmit.

PLPT Analyst: Yong-Keun Lee (primary), 0.13 FTE, 0.65 person-weeks; Zhenglong Li (backup).

Comparison / Reference Data: Numerical Weather Prediction (NWP) inputs to algorithm; NWS radiosondes; GOES Sounder Vertical Temperature Profiles over CONUS.¹

Monitoring and Analysis Method: Colocation tools and statistical analysis tools. Colocation tools will extract DSI data matched in time and space with reference “truth” data. Statistical analysis tools will calculate accuracy and precision metrics relative to reference data.

A.1.7 Event Name: ABI-CONUS_DSI07

Same as for ABI-FD_DSI06, except for:

Objective: Assess accuracy and precision of CONUS product.

GOES-R Data Type(s): Bands 8-16, CONUS.

ABI Mode: Mode 3.

A.1.8 Event Name: ABI-MESO_DSI08

Same as for ABI-FD_DSI06, except for:

Objective: Assess accuracy and precision of mesoscale product.

GOES-R Data Type(s): Bands 8-16, mesoscale.

ABI Mode: Mode 3.

A.2 PLPT Events that Support Provisional Maturity

A.2.1 Event Name: ABI-FD_DSI09

Objective: Assess accuracy and precision of FD products for an adequate number of independent measurements to characterize accuracy and precision adequately for the user to determine if the product is ready for operational use.

Start Time: At completion of Beta Analysis and start of Operational phase

Duration: 24 weeks.

ABI Mode: Modes 3 and 4.

GOES-R Data Type(s): Bands 8-16, FD.

Provisional Success Criteria:

- Accuracy and precision determined over a large and wide range of representative conditions for all required modes. Accuracy and precision requirements do not have to be met to attain provisional status, however, if they do not do so, the reasons behind not meeting these requirements must be documented.
 - Accuracy^{7,9,10}: Lifted Index: 2.0 K; CAPE: 1000 J/kg; Showalter index: 2 K; Total totals Index: 1 K; K-index: 2 K.
 - Precision^{7,9,10}: Lifted Index: 6.5 K; CAPE: 2500 J/kg; Showalter index: 6.5 K; Total totals Index: 4 K; K-index: 6.5 K.
 - Horizontal Resolution^{7,9}: 10 km.
 - Mapping Accuracy^{7,9}: 2 km.
- Remediation strategies are in place for known issues;
- Impacts from challenges with upstream dependencies are documented;
- Feedback from the primary user (NWS) is documented;
- Product is ready for potential operational use (user decision) and for use in scientific publications.

Dependencies: Any issues with data access to DSI products will directly impact the schedule of DSI validation activities. Analyst requires access to near-real time data through PDA. Any issues with access to Global Forecast System profiles of moisture and temperature will also impact DSI accuracy and precision validation activities.

PLPT Lead: Tim Schmit.

PLPT Analyst: Yong-Keun Lee (primary), 0.13 FTE, 3.2 person-weeks; Zhenglong Li (backup).
Comparison / Reference Data: Numerical Weather Prediction (NWP) inputs to algorithm; NWS radiosondes; GOES Sounder Derived Stability Indices over CONUS.¹

Monitoring and Analysis Method: Colocation tools and statistical analysis tools. Colocation tools will extract DSI data matched in time and space with reference “truth” data. Statistical analysis tools will calculate accuracy and precision metrics relative to reference data.

A.2.2 Event Name: ABI-CONUS_DSI10

Same as for ABI-FD_DSI09, except for:

Objective: Assess accuracy and precision of CONUS products for an adequate number of independent measurements to characterize accuracy and precision adequately for the user to determine if the product is ready for operational use.

GOES-R Data Type(s): Bands 8-16, CONUS.

ABI Mode: Mode 3.

A.2.3 Event Name: ABI-MESO_DSI11

Same as for ABI-FD_DSI09, except for:

Objective: Assess accuracy and precision of mesoscale products for an adequate number of independent measurements to characterize accuracy and precision adequately for the user to determine if the product is ready for operational use.

GOES-R Data Type(s): Bands 8-16, mesoscale.

ABI Mode: Mode 3.

A.3 PLPT Events that Support Full Maturity

A.3.1 Event Name: ABI-FD_DSI12

Objective: Assess accuracy and precision of FD products for an adequate number of independent measurements to characterize accuracy and precision over a range of conditions, including seasonal variability.

Start Time: At completion of Provisional analysis.

Duration: 36 weeks.

ABI Mode: Modes 3 and 4.

GOES-R Data Type(s): Bands 8-16, FD.

Full Success Criteria:

- Accuracy and precision determined over a large and wide range of representative conditions for all required modes. Accuracy and precision requirements should be met to attain Full status. However, if they do not do so, the reasons behind not meeting these requirements must be documented and remediation strategies must be in place for known issues.
 - Accuracy^{7,9,10}: Lifted Index: 2.0 K; CAPE: 1000 J/kg; Showalter index: 2 K; Total totals Index: 1; K index: 2.
 - Precision^{7,9,10}: Lifted Index: 6.5 K; CAPE: 2500 J/kg; Showalter index: 6.5 K; Total totals Index: 4 K; K-index: 6.5 K.
 - Horizontal Resolution^{7,10}: 10 km.
 - Mapping Accuracy^{7,10}: 2 km.

Dependencies: Any issues with data access to DSI products will directly impact the schedule of DSI validation activities. Analyst requires access to near-real time data through PDA. Any issues with access to Global Forecast System profiles of moisture and temperature will also impact DSI accuracy and precision validation activities.

PLPT Lead: Tim Schmit.

PLPT Analyst: Yong-Keun Lee (primary), 0.13 FTE, 4.8 person-weeks; Zhenglong Li (backup).
Comparison / Reference Data: Numerical Weather Prediction (NWP) inputs to algorithm; NWS radiosondes; ARM radiosondes; European Centre for Medium-Range Weather Forecasts (ECMWF) analysis; GOES Sounder Derived Stability Indices over CONUS.¹

Monitoring and Analysis Method: Colocation tools and statistical analysis tools. Colocation tools will extract DSI data matched in time and space with reference “truth” data. Statistical analysis tools will calculate accuracy and precision metrics relative to reference data.

A.3.2 Event Name: ABI-CONUS_DSI13

Same as for ABI-FD_DSI12, except for:

Objective: Assess accuracy and precision of CONUS products for an adequate number of independent measurements to characterize accuracy and precision over a range of conditions, including seasonal variability.

GOES-R Data Type(s): Bands 8-16, CONUS.

ABI Mode: Mode 3.

A.3.3 Event Name: ABI-MESO_DSI14

Same as for ABI-FD_DSI12, except for:

Objective: Assess accuracy and precision of mesoscale products for an adequate number of independent measurements to characterize accuracy and precision over a range of conditions, including seasonal variability.

GOES-R Data Type(s): Bands 8-16, mesoscale.

ABI Mode: Mode 3.

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

416-R-RIMP-0339
Version 1.0

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

B.1 Data Set #1: GFS Forecast products³

Description: The GOES-R field campaign will consist of measurements of aerosol backscatter vertical profile and aerosol type from a Cloud Physics Lidar (CPL) on an aircraft. These data are expected to be similar to CALIPSO.

Access Process: <ftp.ncep.noaa.gov>.

POC: N/A.

Spatial Coverage: FD coverage.

Temporal Coverage: 00, 06, 12, and 18 UTC daily.

Contingency: N/A (cannot produce DSI products without GFS Forecast products).

B.2 Data Set #2: Conventional (NWS) radiosonde observations³

Description: The GOES-R field campaign will consist of measurements of aerosol backscatter vertical profile and aerosol type from a Cloud Physics Lidar (CPL) on an aircraft. These data are expected to be similar to CALIPSO.

Access Process: OSPO McIDAS ADDE server NCEP prep BUFR files (<ftp.ncep.noaa.gov>)

POC: N/A.

Spatial Coverage: Network distributed fairly evenly over CONUS. Colocation and analysis tools testing used 57 locations in eastern CONUS.⁵

Temporal Coverage: 00 UTC and 12 UTC daily.

Contingency: GFS Forecast.

B.3 Data Set #3: Southern Great Plain (SGP) ARM Site Radiosondes

Description: Vertical profiles of temperature, pressure, and water vapor collected from the ARM-CART site at SGP (CONUS) location every six hours. The quality of the rawinsonde observation data from SGP has been shown to be of higher quality than conventional rawinsonde observation⁵. Instability indices will be derived from the vertical profiles.

Source: ARM-CART at SGP.

Access Process: Data available for download.

POC: N/A.

Spatial Coverage: Latitude 36.61° N and longitude 97.47° W.

Temporal Coverage: Once every 6 hours.

Contingency: Conventional (NWS) radiosonde observations, ECMWF forecasts.

B.4 Data Set #4: ECMWF analyses

Description: Forecasts of temperature, pressure, and water vapor calculated by the European Centre for Medium-Range Weather Forecasts (ECMWF). Instability indices will be derived from the vertical profiles.

Source: ECMWF.

Access Process: Ordered as needed.

POC: The CIMSS POC for obtaining ECMWF data is Kevin Baggett.

Spatial Coverage: Calculations performed globally at grid points.

Temporal Coverage: 00 UTC to 24 UTC daily at 6 hour intervals.

Contingency: GFS forecast, radiosonde observations.

C. Appendix C: Tools

C.1 Tool #1: Colocation Tools⁵

Data Sets: ABI Derived Stability Indices products. Latitude, Longitude, and time of reference (“truth”) data sets.

Location: CIMSS.

Description: MATLAB Tools to compile ABI LAP temperature profile data that meets matchup criteria with ground truth data sets. Designed to run on MATLAB software version 7.10.0.499 (R2010a) on 64 bit Linux machine. Should work on newer versions as well.

Developer: Yong-Keun Lee (Tim Schmit, Jun Li, Zhenglong Li co-authors on Reference [5]).

Development Schedule: 90% complete. All validation tools have been developed and web tools are now available at <http://soundingval.ssec.wisc.edu/>. Software tools are expected to be fully tested by October 2016.

Tools are internal to STAR and shared within the team. No handover plan is required.

Testing Accomplished and Planned: Testing of Statistical Analysis Tools performed with GOES data and ROAB data collected between April 7, 2010 and March 26, 2011. Data Operations Exercises (DOEs) 1, 2, and 3 data have been provided and the DSI team has responded with comments. Additional data from DOE 4 are anticipated by the end of September 2016. Remaining tests of the tools require routine files to be produced and run through the system, staged and accessed by the PDS in real time. Future test data must contain forecast DSI products which are needed in the GOES-R ABI LAP validation tool. Software tools are expected to be fully tested by October 2016.

POC: Yong-Keun Lee and Zhenglong Li.

C.2 Tool #2: Statistical Analysis Tool⁵

Data Sets: NWP inputs to the LAP retrievals. RAOB data from 57 NWS conventional RAOB sites (twice daily). ABI LAP retrieval products temporally and spatially matched for each of these sites by the Colocation Tools.

Location: CIMSS.

Description: MATLAB Tools to calculate bias, standard deviation, and RMS error between ground truth data sets and collocated ABI Derived Stability Indices products as well as visualization tools for such comparisons. Designed to run on MATLAB software version 7.10.0.499 (R2010a) on 64 bit Linux machine. Should work on newer versions as well.

Developer: Yong-Keun Lee (Tim Schmit, Jun Li, Zhenglong Li co-authors on Reference [5]).

Development Schedule: 90% complete. All validation tools have been developed and web tools are now available at <http://soundingval.ssec.wisc.edu/>. Software tools are expected to be fully tested by October 2016.

Tools are internal to STAR and shared within the team. No handover plan is required.

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POC: Yong-Keun Lee and Zhenglong Li.

D. Appendix D: Acronym List

Acronym	Definition
ABI	Advanced Baseline Imager
ACMP	Algorithm Change Management Plan
ARM	Atmospheric Radiation Measurement
AWG	Algorithm Working Group
BUFR	Binary Universal Form for the Representation of meteorological data
Cal/Val	Calibration and Validation
CAPE	Convective Available Potential Energy
CART	Cloud and Radiation Testbed
CCR	Configuration Change Request
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CMI	Cloud and Moisture Imagery
CONUS	Continental United States
COVE	CERES Ocean Validation Experiment
CWG	Calibration Working Group
DOE	Data Operations Exercise
DSI	Derived Stability Index
ECMWF	European Centre for Medium-Range Weather Forecasts
F&PS	GOES-R Functional and Performance Specification
FCST	Forecast
FD	Full Disk
FTE	Full-Time Equivalent
GFS	Global Forecast System
GOES	Geostationary Operational Environmental Satellite
GOES-R	GOES R-Series
GORWG	GOES-R Series Operational Requirements Working Group
GRB	GOES Rebroadcast
HRR	Handover Readiness Review
IR	Infrared
KI	K Index
L1b	Level 1b
L2	Level 2
LAP	Legacy Atmospheric Profile
LI	Lift Index
McIDAS	Man-computer Interactive Data Access System
McIDAS ADDE	McIDAS Abstract Data Distribution Environment
MOST	Mission Operations Support Team
MRD	Mission Requirements Document

Acronym	Definition
MSFC	Marshall Space Flight Center
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NCEI-CO	NCEI - Colorado
NCEP	National Centers for Environmental Prediction
NWP	Numerical Weather Prediction
NWS	National Weather Service
OSPO	Office of Satellite and Product Operations
PLAR	Post-Launch Assessment Review
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
RAOB	Radiosonde Observation
RIMP	Readiness, Implementation and Management Plan
RTVL	Retrieval
SGP	Southern Great Plains
SI	Showalter Index
STAR	Center for Satellite Applications and Research
TBD	To Be Determined