

***Beta Maturity Science Review
For NOAA-21 Snowfall Rate***



*Presented by Huan Meng
Date:04/26/2023*

JPSS/GOES-R Data Product Validation Maturity Stages - COMMON DEFINITIONS (Nominal Mission)

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- Beta Maturity Performance Validation
 - On-orbit instrument performance assessment
 - Identify all of the instrument and product characteristics you have verified/validated as individual bullets
 - Identify pre-launch concerns/waivers, mitigation and evaluation attempts with on-orbit data
- Users/Downstream-Products feedback
- Risks, Actions, Mitigations
 - Potential issues, concerns
- Path forward (to the next maturity stage)
- Summary

Maturity Review - Exit Criteria

- Beta Maturity Performance is well characterized and meets/exceeds the requirements:
 - On-orbit instrument performance assessment
 - Provide summary for each identified instrument and product characteristic you have validated/verified as part of the entry criteria
 - Provide summary of pre-launch concerns/waivers mitigations/evaluation and address whether any of them are still a concern that raises any risk.
- Updated Maturity Review Slide Package addressing review committee's comments for:
 - Cal/Val Plan and Schedules
 - Product Requirements
 - Beta Maturity Performance
 - Risks, Actions, Mitigations
 - Path forward (to the next maturity stage)



NOAA-21 SNOWFALL RATE (SFR) BETA MATURITY REVIEW MATERIAL

- Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
 - Algorithm version, processing environment
 - Evaluation of the effect of required algorithm inputs
 - Quality flag analysis/validation
 - Error Budget
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

Algorithm Cal/Val Team Members

Name	Organization	Major Task
Huan Meng	STAR	Snowfall Rate product lead
Yongzhen Fan	CISESS-MD	Algorithm development and validation
Jun Dong	CISESS-MD	System development, algorithm development and validation
Yulan Hong	CISESS-MD	Algorithm development and validation
Liqun Ma	OSPO	OSPO Precipitation PAL
Priyanka Roy	OSGS ASSISTT	Transition to operations
Tracey Dorian	OSGS ASSISTT	Transition to operations

- Product: Water equivalent snowfall rate (SFR) estimate
- SFR is generated from passive microwave sensors aboard polar-orbiting satellites
 - Operational SFR products from NOAA-20, S-NPP, NOAA-19, Metop-B, and Metop-C
 - Sensors: ATMS, AMSU-A/MHS
- SFR is retrieved from a Snowfall Detection and a Snowfall Rate algorithms
 - Snowfall detection: machine learning (ML) model
 - Snowfall rate: 1DVAR-based physical algorithm with ML initialization and bias correction
 - Algorithms use a combination of ‘window’ and temperature/water vapor sounding channels as well as NWP (GFS) model data

Product Requirements

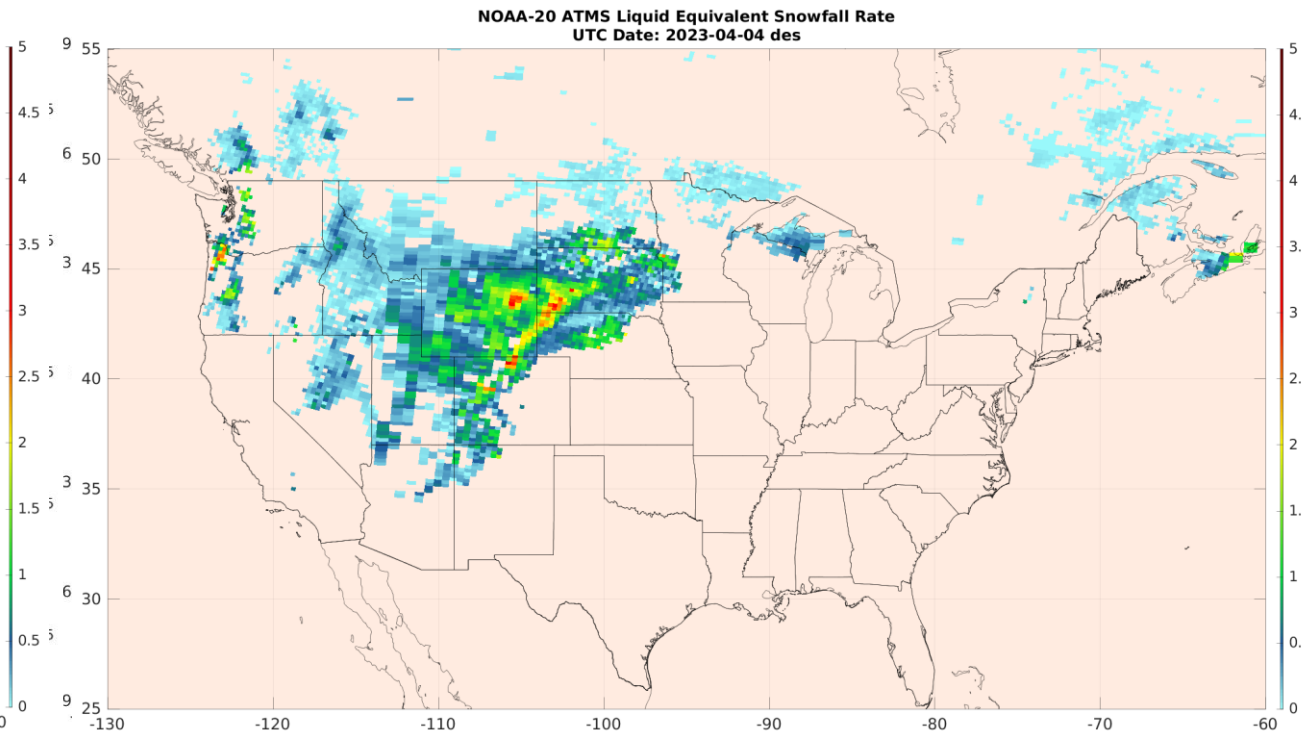
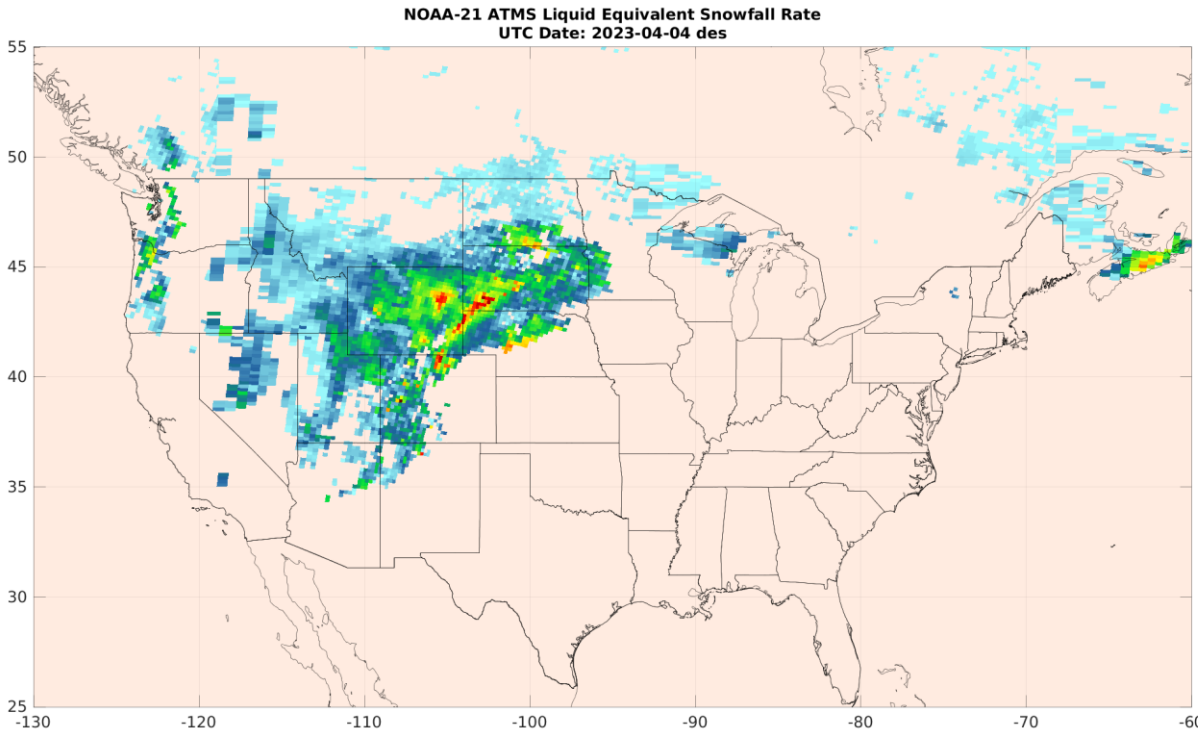
Attribute	DPS	Requirement/Threshold	Performance
Accuracy	DPS-1756	0.3 mm/hr	
Precision	DPS-1757	1 mm/hr	

Processing Environment and Algorithms (1 slide)

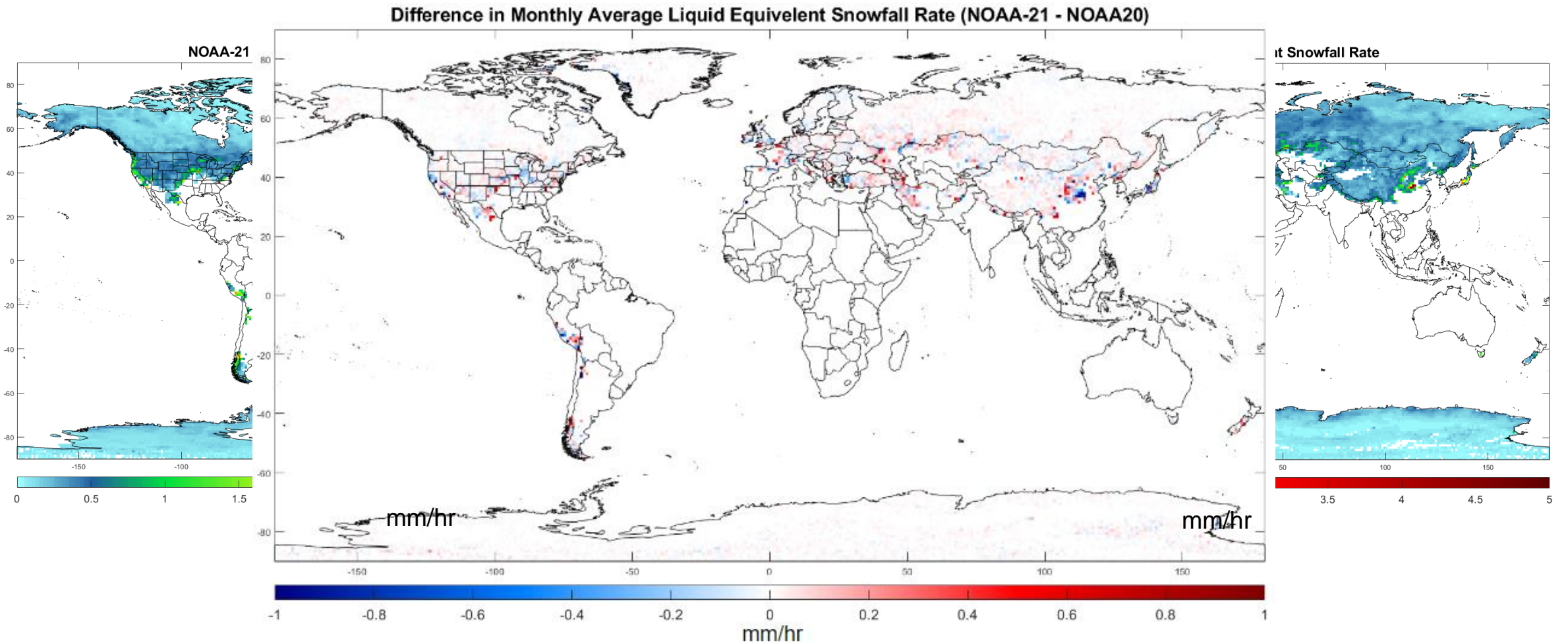
- Currently, SFR is operationally produced from an independent sub-system inside MIRS but shares the input and output with MIRS
- A standalone Enterprise SFR CCAP was delivered to ASSISTT in Oct 2022
- An updated SFR CCAP will be delivered to ASSISTT in May after NOAA-21 SFR reaches Beta Maturity (this review). The Enterprise SFR will be transitioned to NCCF and become operational in late 2023 or early 2024.
 - Algorithm version 1.0
 - LUTs version 1.0
 - Effective date depends on when the standalone SFR becomes operational
- MIRS will discontinue SFR production in summer 2024

- NOAA-21 SFR is evaluated against NOAA-20 SFR
 - One month (3/7/2023 – 4/6/2023) data
 - Qualitative comparisons: SFR images
 - Quantitative comparisons:
 - Monthly average and difference
 - Scatter plot and statistics
 - Probability density

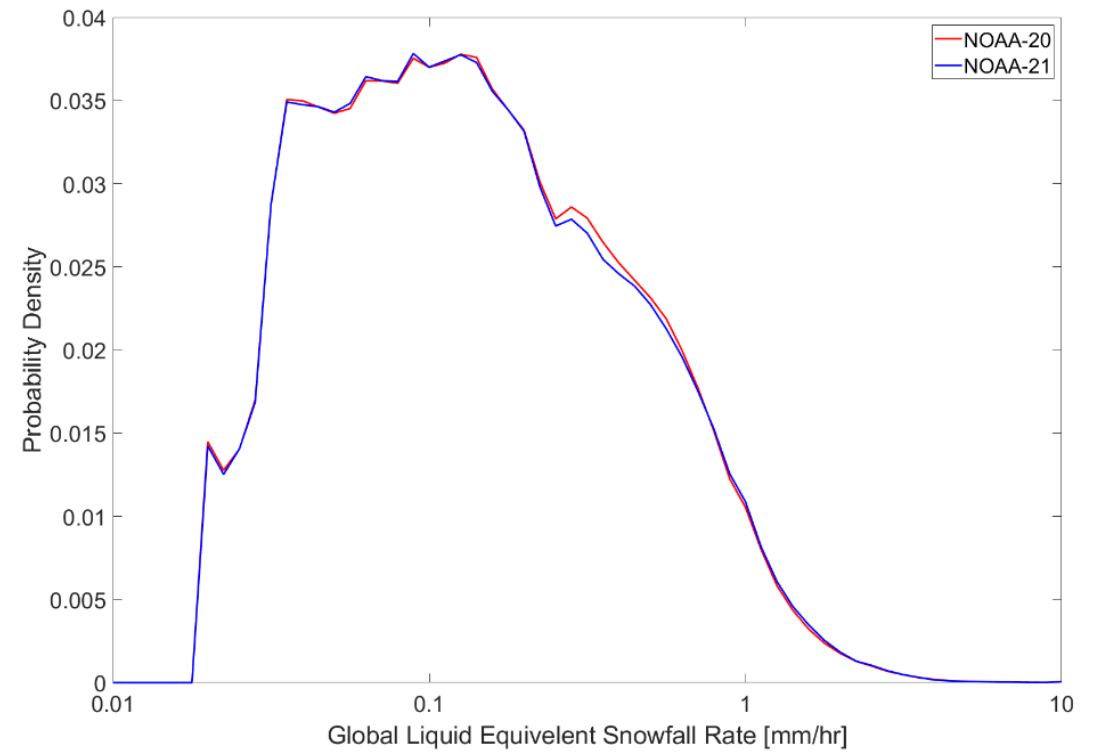
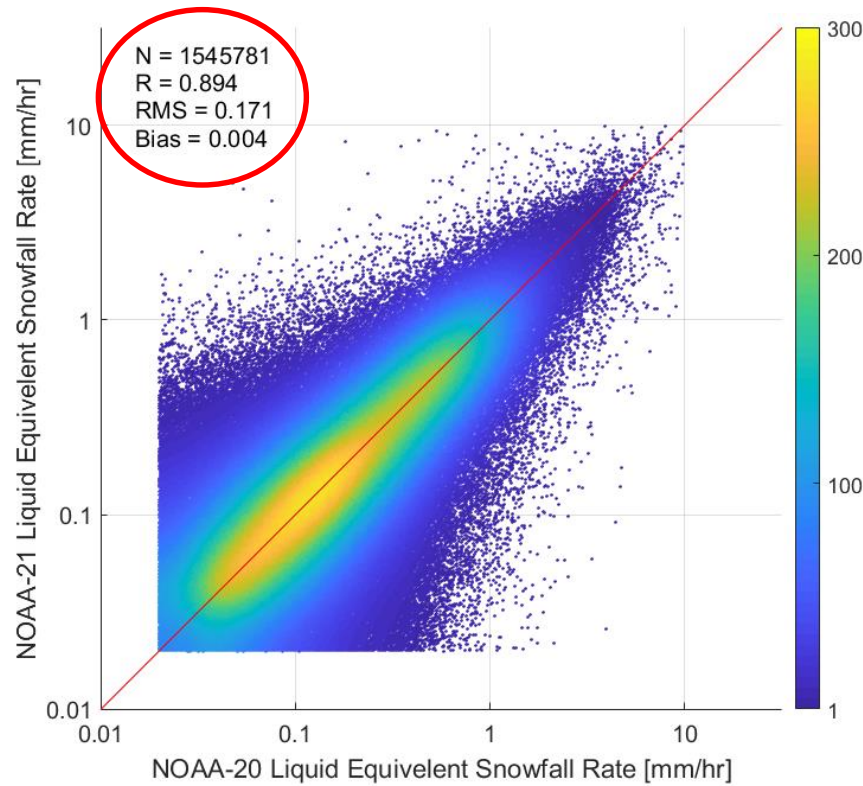
- NOAA-21 SFR (left) and NOAA-20 SFR (right) on April 4, 2023
- Similar snowfall distribution and intensity



- Monthly average SFR from NOAA-21 (left) and NOAA-20 (right)
- Good agreement in snowfall pattern and intensity



- Collocated NOAA-21 and NOAA-20 SFR (with 25-min temporal shift, i.e. not coincident) show high correlation
- NOAA-21 SFR probability density agrees well with that of NOAA-20



- Required Algorithm Inputs
 - Primary Sensor Data
 - ATMS TDR window, and temperature and water vapor sounding channels (23.8 GHz - 183±1 GHz)
 - Ancillary Data
 - GFS surface and atmospheric variables
 - Upstream algorithms
 - None
 - LUTs / PCTs
 - Ice particle optical properties LUT
 - Algorithm coefficient files
 - Land-sea mask
 - Other ancillary files

Quality flag analysis/validation (2-5 slides)

- Defined Quality Flags
 - There is one quality flag (32 bit) in the SFR file that specifies two quality variables:

Quality flag bit	Meaning	Value
0	1DVAR Convergence	1: Non-convergent 0: Convergent
1	SFR threshold	1: SFR is below threshold, set to 0 0: SFR is above threshold, value unchanged

Error Budget (1 slide)

Compare analysis/validation results against requirements, present as a table. Error budget limitations should be explained. Describe prospects for overcoming error budget limitations with future improvements of the algorithm, test data, and error analysis methodology.

Attribute Analyzed	DPS	Requirement/Threshold	Pre-Launch Performance	On-orbit Performance			Meet Requirement?	Additional Comments
				NOAA-21	NOAA-20	S-NPP		
Accuracy	DPS-1756	0.3 mm/hr		TBD	0.02	0.02	Yes	N20 and NPP validation against 3-year of radar data
Precision	DPS-1757	1 mm/hr		TBD	0.57	0.57	Yes	N20 and NPP validation against 3-year of radar data

User Feedback

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Pingping Xie	NCEP/CPC	Level-3 global blended precipitation analysis	The NCEP/CPC CMORPH team will be ready to ingest the NOAA-21 SFR data and bring the data to CPC operations once the SFR data becomes operational in late 2023 or early 2024

Downstream Product Feedback

Algorithm	Product	Downstream Product Feedback - Reports from downstream product teams on the dependencies and impacts
Second-generation CPC MORPHing technique	CMORPH2	The NCEP/CPC CMORPH2 global blended precipitation product requires the NESDIS SFR product as a critical input. The NOAA-21 SFR will further improve the accuracy of the CMORPH2 winter precipitation.

Risks, Actions, and Mitigations

- Provide updates for the status of the risks/actions identified during the previous maturity review(s); add new ones as needed

Identified Risk	Description	Impact	Action/Mitigation and Schedule
None			

Documentations (Check List, 1 slide)

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes
Algorithm Theoretical Basis Document (ATBD)	Yes
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	Yes (MIRS)
System Maintenance Manual (for ESPC products)	Yes (MIRS)
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	Yes

Check List - Beta Maturity

Beta Maturity End State	Assessment
Product is minimally validated, and may still contain significant identified and unidentified errors	Yes
Information/data from validation efforts can only be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose	Yes
Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists	Yes

Conclusion (1 slide)

- Cal/Val results summary:
 - The SFR team recommends the NOAA-21 SFR algorithm Beta Maturity starting on 12/3/2022 at 23:49:55 UTC (Provisional maturity status declaration for NOAA-21 ATMS TDR & SDR Effective Date 12/3/2022 at 23:49:55 UTC)
 - The NOAA-21 and NOAA-20 SFR are highly consistent visually and statistically both on daily and monthly scales
 - Need to acquire more snowfall data for developing machine learning (ML) models such as snowfall detection and bias correction models
 - No caveats for NOAA-21 SFR

- **Lessons learned for NOAA-21 Cal/Val**
 - NOAA-21 is highly consistent with NOAA-20
- **Planned improvements**
 - Orographic snowfall estimation
- **Future Cal/Val activities / milestones**
 - Update the radiometric bias corrections
 - Train a machine learning (ML) snowfall detection model
 - Train an ice water path ML initialization model
 - Train a ML SFR bias correction model
 - Conduct cal/val and reach provisional maturity
 - Once NOAA-21 SFR reaches provisional maturity, deliver the product to ASSISTT for transition to operation
 - Update documentation with new development