

# *Provisional Maturity Science Review For NOAA-20 Snowfall Rate*



*Presented by Huan Meng  
Date: 2019/5/16*

- 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
- User 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
Jun Dong	CICS-MD	Algorithm development, validation
Cezar Kongoli	CICS-MD	Algorithm development, validation
Ralph Ferraro	STAR	Hydrology lead
Limin Zhao	OSPO	OSPO Precipitation PAL, transition to operations
Mark Liu	STAR	MIRS lead
Chris Grassotti	CICS-MD	MIRS technical lead
Shuyan Liu	CIRA	MIRS SFR integration
Wei Yu	NDE	NDE integration

- Product: Water equivalent snowfall rate (SFR) estimate over global land
- SFR is generated from passive microwave sensors aboard polar-orbiting satellites
  - Operational SFR products from S-NPP, NOAA-19, Metop-A, and Metop-B
  - Sensors: ATMS, AMSU-A/MHS
- SFR combines a Snowfall Detection and a Snowfall Rate components
  - Snowfall detection: statistical algorithm
  - Snowfall rate: 1DVAR-based physical algorithm
  - Algorithms use a combination of ‘window’ and temperature/water vapor sounding channels as well as NWP (GFS) model data

- Product performance requirements from JPSS L1RD supplement (threshold) versus observed/validated/JERD Vol. II

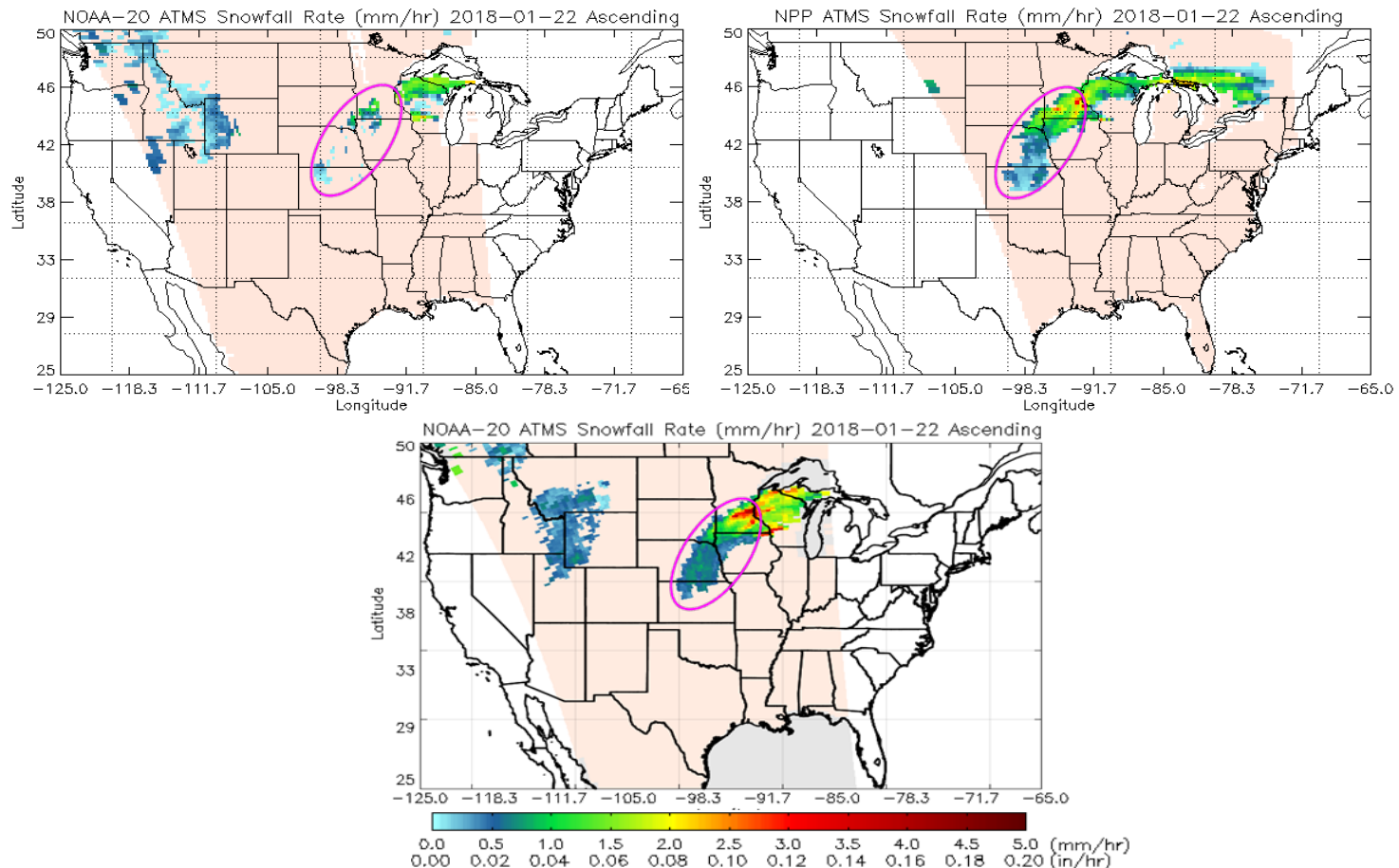
Attribute	Threshold	Observed/validated
Geographic coverage	Global land	Global
Vertical Coverage	Single layer in lower atmosphere	Single layer in lower atmosphere
Horizontal Cell Size	15 km at nadir	15 km at nadir
Mapping Uncertainty	N/A (reflects SDR characteristics)	N/A (reflects SDR characteristics)
Measurement Accuracy	0.3 mm/hr	0.15 mm/hr
Measurement Precision	1 mm/hr	0.7 mm/hr
Probability of Detection	40% over land and 30% over water	50% over land and 40% over water
False Alarm Rate	15% over land and water	10% over land and water

# Processing Environment and Algorithms

- SFR is operationally produced using an independent sub-system inside MIRS but shares the input and output with MIRS
- A unified ATMS (NOAA-20 and S-NPP) SFR processing system was developed and integrated in MIRS in FY19
  - Previous processing systems were satellite specific
  - The unified system design allows processing of multiple satellites with the same code but satellite-specific, external algorithm coefficients; simplifying and accelerating the implementation of algorithm updates in operation
- MIRS runs on NDE
  - Current operational MIRS: Version 11.3
  - MIRS final DAP with NOAA-20 SFR: Version 11.4
  - MIRS v11.4 delivered to NDE in March 2019; the DAP has been integrated and tested successfully in the NDE I&T environment
  - Expected operational date: July/August 2019 pending successful reviews (Provisional Maturity Review, Operation Readiness Review)

- Findings/Issues from Beta Review
  - Snowfall detection (SD) algorithm may miss snowfall that was captured by S-NPP
  - Lack of NOAA-20 radiometric bias correction
  - No validation
- Improvements since Beta Review
  - Performed radiometric bias correction
  - Trained a snowfall detection (SD) model
  - SD validation
  - SFR calibration
  - SFR validation

- Snowstorm in the Midwestern US on January 22, 2018
  - Case from Beta Review showing the original NOAA-20 SFR missed snowfall identified by S-NPP SFR
  - Newly-developed SFR algorithm captures more snowfall





- Validation data
  - NCDC Quality Controlled Local Climatological Data (QCLCD), in-situ snowfall observations
  - Observations from 2018 and 2019
  - CONUS and Alaska stations
- Validation strategies / methods
  - NOAA-20 SD and in-situ data collocation (~ 6000 data pairs)
  - Validation Metrics:
    - Probability of Detection (POD)
    - False Alarm Rate (FAR)
    - Heidke Skill Score (HSS)
  - Over CONUS
  - Over Alaska

- Validation results – over CONUS
  - SD meets all Threshold Requirements

Year	2018	2019	Combined	Threshold (over land)	Objective (over land)
POD (%)	62	65	<b>64</b>	40	50
FAR (%)	7	8	<b>8</b>	15	10
HSS	0.52	0.53	<b>0.53</b>	N/A	N/A

- Comparison with S-NPP
  - NOAA-20 SD outperforms or is comparable to S-NPP SD

Year	2015	2016	2017	Combined
POD (%)	50	53	50	<b>51</b>
FAR (%)	7	8	8	<b>8</b>
HSS	0.42	0.42	0.40	<b>0.40</b>

- Validation results – over Alaska
  - SD performance for Alaska is inferior to for CONUS but still meets all Threshold Requirements

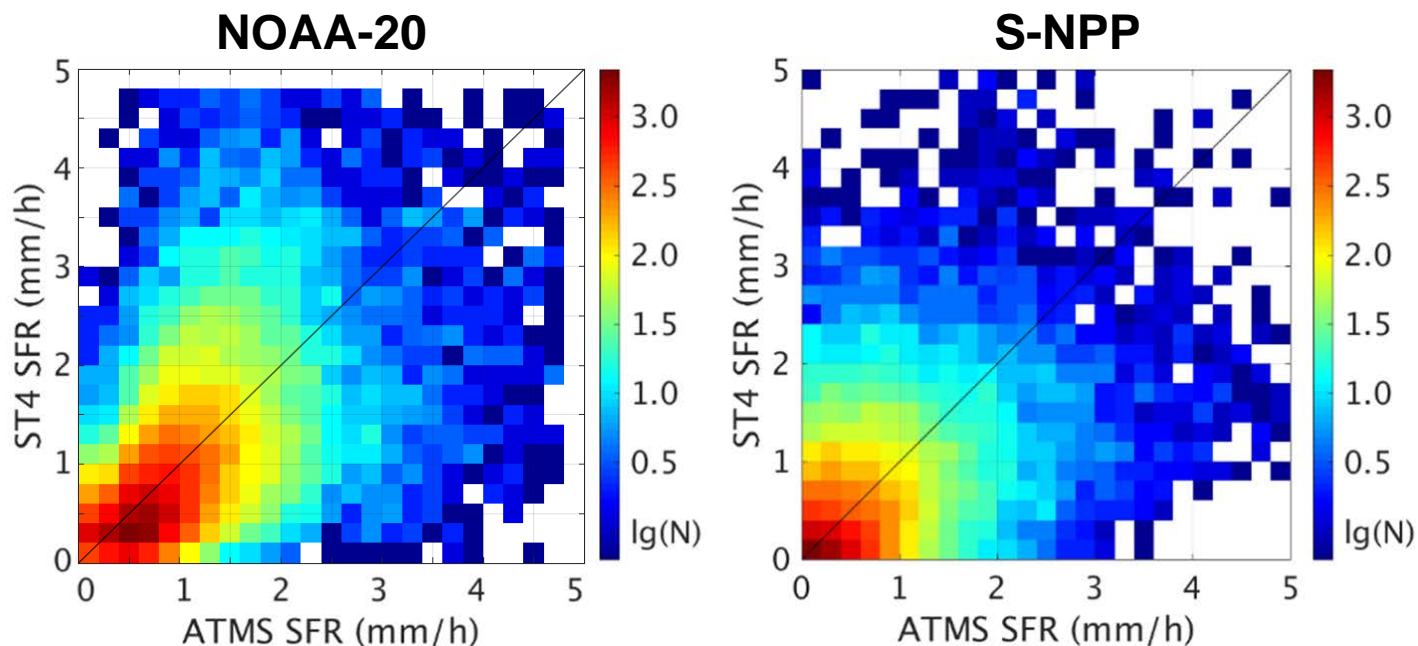
Year	2018	2019	Combined	Threshold (over land)	Objective (over land)
POD (%)	49	48	<b>48</b>	40	50
FAR (%)	11	10	<b>11</b>	15	10
HSS	0.44	0.43	<b>0.43</b>	N/A	N/A

- Comparison with S-NPP
  - NOAA-20 SD outperforms or is comparable to S-NPP SD

Year	2015	2016	2017	Combined
POD (%)	45	47	47	<b>46</b>
FAR (%)	9	10	11	<b>10</b>
HSS	0.39	0.38	0.35	<b>0.37</b>

- Validation data
  - NCEP Stage IV radar and gauge combined precipitation analysis
    - Uses NSSL Multi-Radar Multi-Sensor (MRMS) precipitation data as input, incorporates gauge/model/satellite data, and applies human quality control
  - Two-month data (February - March 2019)
  - CONUS coverage only
- Validation strategies / methods
  - NOAA-20 SFR and Stage IV collocation through convolution (~ 58,817 data pairs)
  - Comparison of instantaneous/hourly snowfall rates and seasonal averages
  - Validation Metrics:
    - Correlation coefficient
    - Accuracy
    - Precision
  - Over CONUS
- Long term monitoring readiness
  - NDE and ESPC routine monitoring of MIRS processing
  - STAR MIRS: <https://www.star.nesdis.noaa.gov/mirs/highresolutionv.php>
  - CICS-MD: <http://cics.umd.edu/sfr/>

## SFR Validation – Instantaneous/hourly Snowfall Rate

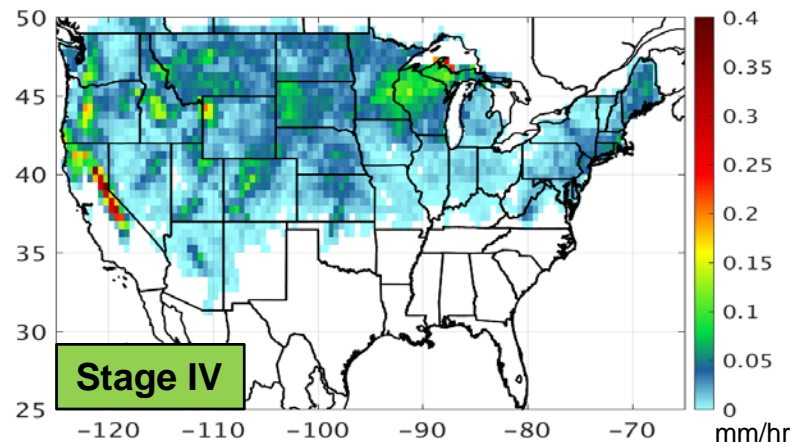
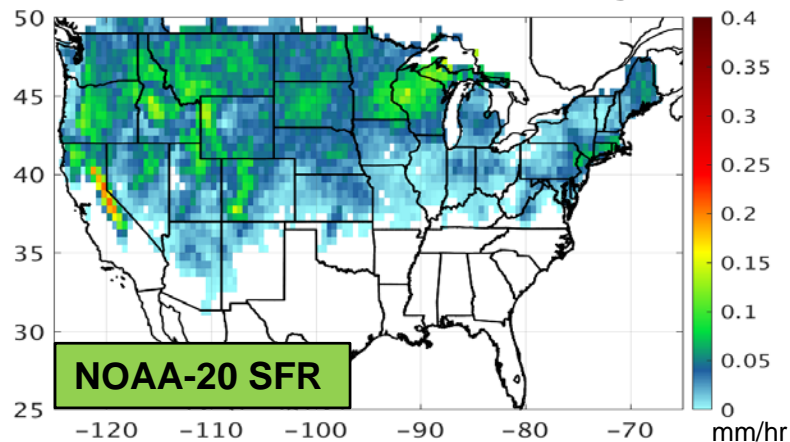


Metrics	N20 SFR	S-NPP SFR	Threshold	Objective
Corr. Coeff.	0.56	0.50	N/A	N/A
Accuracy (mm/hr)	0.03	0.06	0.30	0.15
Precision (mm/hr)	0.73	0.74	1.00	0.70

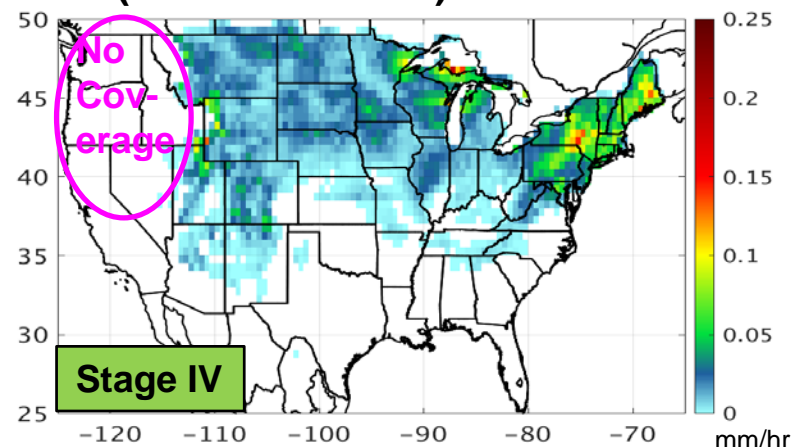
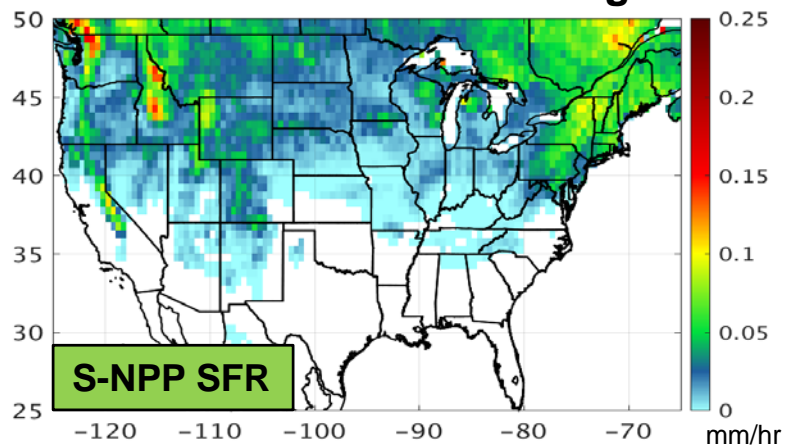
- NOAA-20 SFR meets all Threshold Requirements
- NOAA-20 SFR outperforms S-NPP

## SFR Validation – Seasonal Average

### 2-month Average Snowfall Rate (Feb ~ Mar 2019)



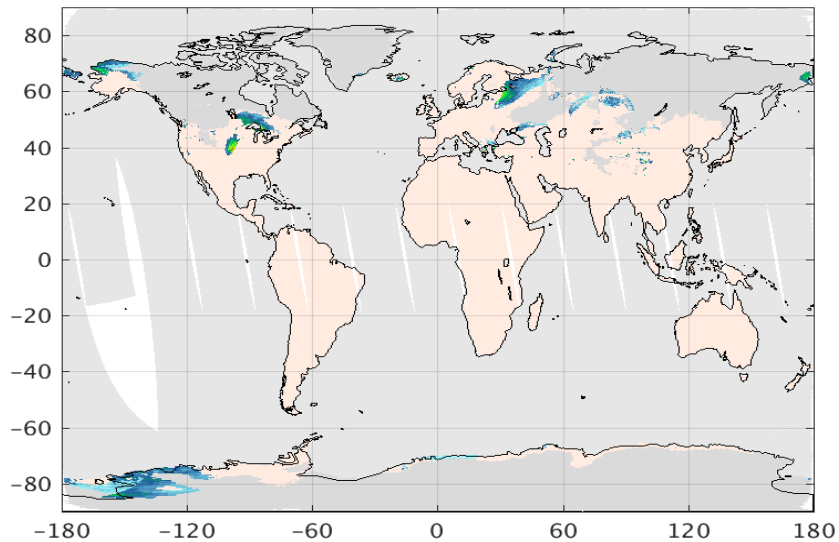
### 3-month Average Snowfall Rate (Jan ~ Mar 2017)



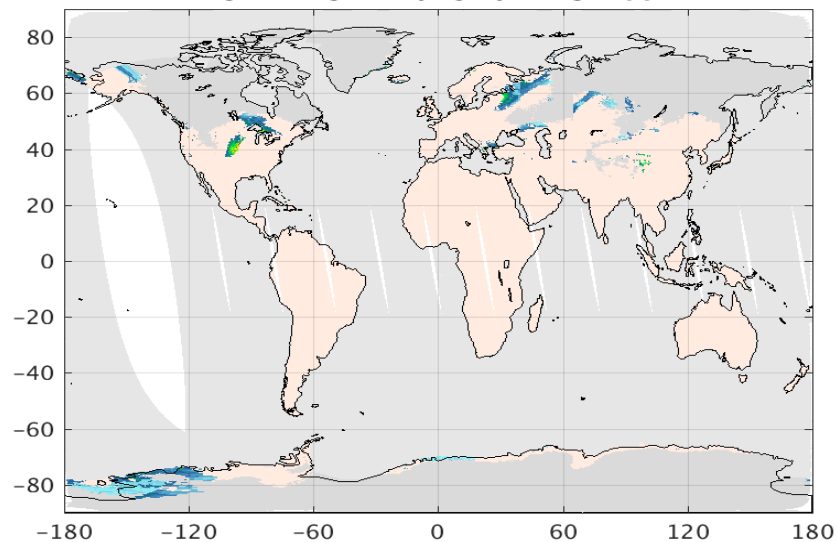
Metrics	Corr Coeff	Accuracy (mm/hr)	Precision (mm/hr)
NOAA-20	0.80	0.01	0.03
S-NPP	0.65	0.00	0.02

## SFR Validation – Instantaneous Snowfall Rate

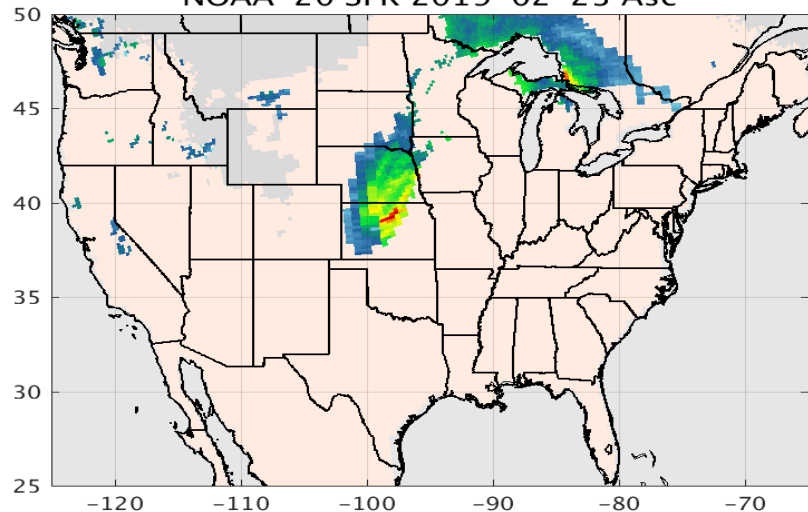
NOAA-20 SFR 2019-02-23 Asc



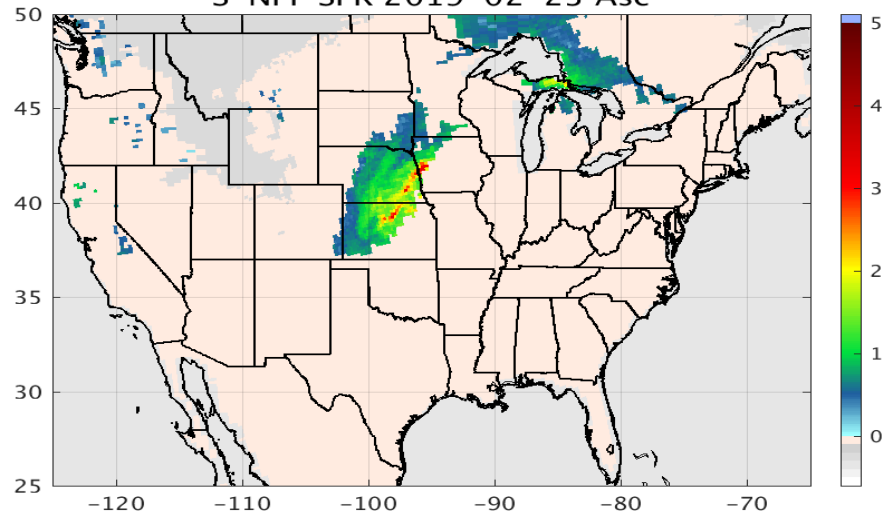
S-NPP SFR 2019-02-23 Asc



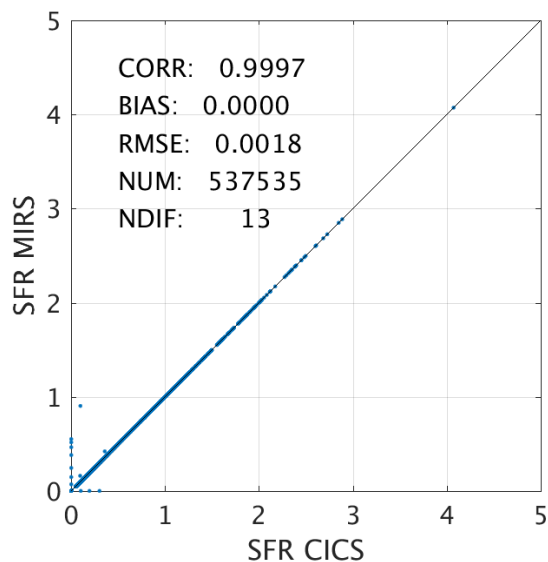
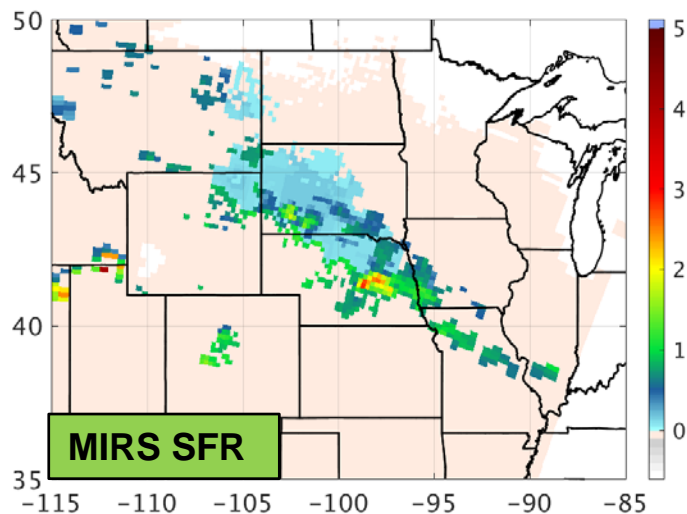
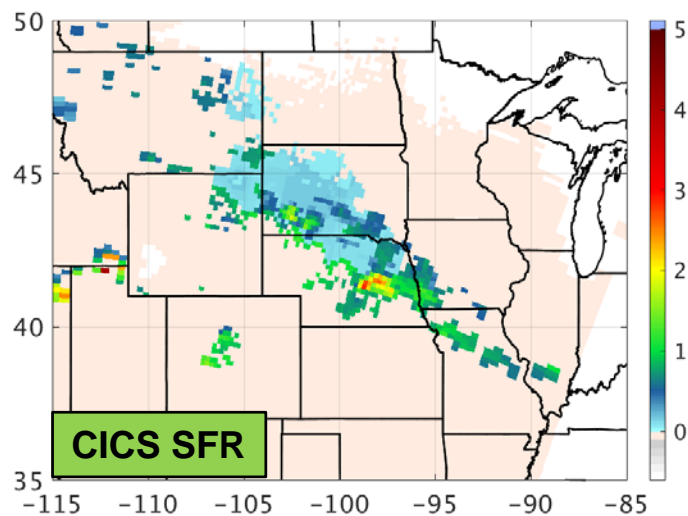
NOAA-20 SFR 2019-02-23 Asc



S-NPP SFR 2019-02-23 Asc



## Consistency Check with MIRS



- One-day data
- 537,535 matched data pairs between CICS SFR and MIRS SFR
- Only 13 pairs are different due to different rounding of computer systems

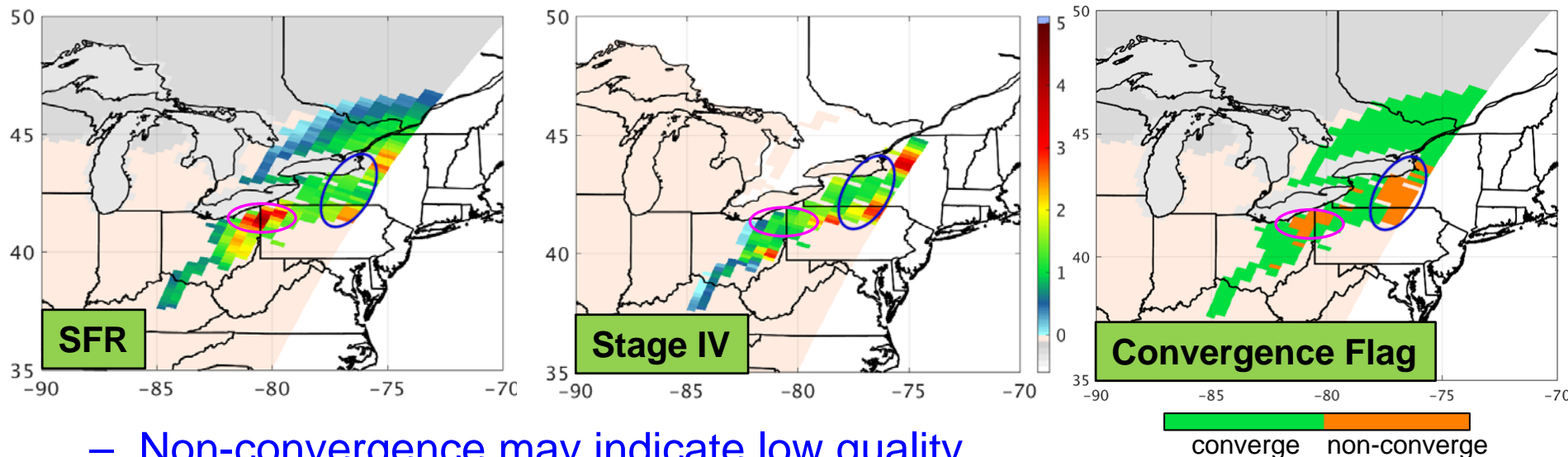


- Required Algorithm Inputs
  - Primary Sensor Data
    - ATMS “window”, temperature and water vapor sounding channels, 23.8 ~ 183.31±1 GHz
  - Ancillary Data
    - GFS surface and atmospheric variables
  - LUTs / PCTs
    - Ice particle optical properties LUT
    - Calibration coefficients
    - Land-sea mask
    - etc.

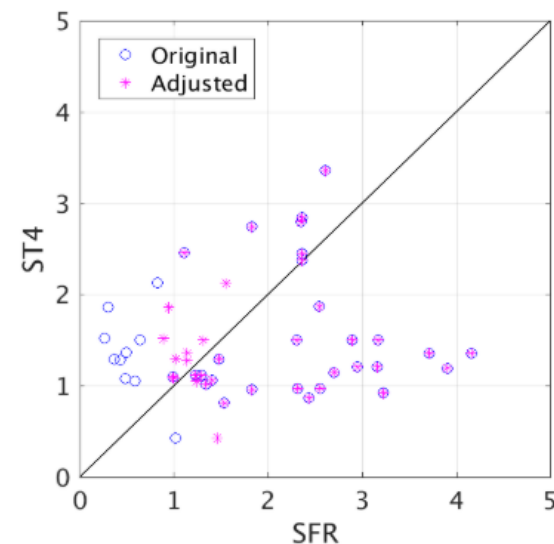
- Defined Quality Flag
  - Convergence flag
  - Flag indicates if 1DVAR model converges ( $\Delta T_b \leq$  preset thresholds) after five iterations
  - 0: converge; 1: non-converge
- Other flags integrated in SFR
  - Over water (-10): no retrieval over ocean or large water bodies
  - Too cold (-13): no retrieval if limb-corrected 53.6 GHz < 240 K
  - Below low limit (-17): retrieval is below threshold (0.05 mm/hr)
  - Missing or bad data (-99)

# Quality flag analysis/validation

## • Quality flag analysis/validation



- Non-convergence may indicate low quality retrieval
- Calibration improves non-convergent retrievals
- Analysis / validation plan
  - Improve forward modeling including first guess control vector
  - Further improve calibration



Name	Organization	Application	<b>User Feedback</b> - User readiness dates for ingest of data and bringing data to operations
Pingping Xie	NOAA/NWS/NCEP/CPC	Infusion into CMORPH2 to represent cold season precipitation	Infusion of the JPSS Level 2 retrievals of snowfall rate (SFR) greatly improved the detection and quantification of cold season precipitation with the 2 <sup>nd</sup> generation CMORPH integrated precipitation estimates which are expected to be widely used by end users at field meteorological and hydrological offices as well as in many research and development activities. NCEP/CPC is ready to ingest the NOAA-20 SFR product from NESDIS. We strongly request that the JPSS SFR products be reprocessed for historical periods to enable climate applications of the SFR products and other products (like CMORPH) that rely on it.

Name	Organization	Application	<b>User Feedback</b> - User readiness dates for ingest of data and bringing data to operations
Kristopher White	NASA SPoRT/ NWS	NASA SPoRT has disseminated the SFR product to NWS offices to assess the applicability of the data for determining snowfall rates. Operational meteorologists have supported this application, particularly in regions with relatively little radar or ground observations, and for tracking snowfall maxima.	Forecasters are ready for NOAA-20 SFR data, especially if it's similar to the legacy SFR product

# 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	Action/Mitigation and Schedule
Potential complication caused by adding GFS ingestion to MIRS processing in NDE	NDE has successfully implemented MIRS v11.3 with S-NPP SFR in operation including GFS ingestion ( <b>Closed</b> )
SFR quality check was not part of the MIRS quality flags	SFR 1DVAR convergence flag has been added to the MIRS quality flags ( <b>Closed</b> )
S-NPP SCR identified a few instances where code does not follow prudent coding practice	All instances related to ATMS SFR have been corrected. The remaining instances are for MHS SFR (POES and Metop satellites). The MHS SFR has been in operation since 2012. The OSPO Precipitation PAL has agreed to defer the correction to when Metop-C SFR is transitioned to operation. The current MHS SFR processing system will be replaced by a unified system for both MHS and ATMS ( <b>Open</b> )

# Documentations (Check List)

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)	

# Check List - Provisional Maturity

Provisional Maturity End State	Assessment
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 select locations, periods, and associated ground truth or field campaign efforts.	The NOAA-20 SFR product has been validated against radar precipitation analyses and in-situ observations over CONUS (and SD also over Alaska). Results indicate that the product meets JPSS Threshold Requirements and most Objective Requirements.
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	The NOAA-20 SFR product meets this requirement.
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.	The ATMS ATBD v1.0 meets the requirements.
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	The NOAA-20 SFR product meets this requirement.



- Team recommends algorithm provisional maturity based on validation results
  - Validation shows that the NOAA-20 SFR product has met all JPSS threshold requirements
- No pre-launch concerns/waivers
  - The development and cal/val activities have addressed the concerns identified at the Beta Review
- Caveats
  - Additional cal/val is required to improve non-convergence and product quality in general
  - Need to expand validation coverage to outside the U.S.

- Planned improvements
  - Improve non-convergence
  - Adopt more advanced ice particle microphysics
  - Enhance calibration method
- Future Cal/Val activities / milestones
  - Operational production at NDE
  - Validated maturity
    - Algorithm improvement
    - Enhanced calibration
    - Validation with data outside the U.S.