

NOAA-20 VIIRS Land Surface Albedo

Provisional Maturity Review

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Contributed by Jingjing Peng, Yuan Zhou and Dongdong Wang

Feb. 21, 2019

- Overview
 - Algorithm Cal/Val Team Members
 - Product Requirements
 - NOAA-20 VIIRS Albedo Status
- 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
- Documentation (Science Maturity Check List)
- Provisional Maturity Summary
- Path Forward to Validated Maturity

LSA Cal/Val Team Members

	Name	Organization	Major Task
JPSS-STAR	Ivan Csiszar	NOAA/NESDIS/STAR	Land Lead
	Yunyue Yu	NOAA/NESDIS/STAR	EDR Lead, algorithm development/improvement, calibration/validation, team management
	Shunlin Liang	NOAA Affiliate UMD/CICS	product monitoring and validation ; algorithm development/improvement
	Jingjing Peng	NOAA Affiliate, UMD/CICS	product monitoring and validation ; algorithm development/improvement
	Dongdong Wang	NOAA Affiliate, UMD/CICS	product monitoring and validation ; algorithm development/improvement
	Yuan Zhou	UMD/CICS	algorithm improvement, product calibration/validation
	Walter Walf	NOAA/NESDIS/STAR	STAR ASSIST Lead
	Arthur Russakoff	NOAA Affiliate, SciTech/IMSG	STAR ASSIST, Algorithm System integration
	Eric Buzan	NOAA Affiliate, SciTech/IMSG	STAR ASSIST, Algorithm System integration
	Jerry Zhan	NOAA/NESDIS/STAR	user readiness
NOAA/EMC			
	Yihua Wu	NOAA Affiliate	user readiness
	Weizhong Zheng	NOAA Affiliate	user readiness

LSA Product requirements

	JPSS VIIRS LSA	
Attribute	Threshold	Objective
Geographic coverage	global, including land, ocean and ice surface conditions	
Horizontal Cell Size	0.80 km	0.50Km
Mapping Uncertainty	1 km at Nadir	1 km
Measurement Range	0 to 1.0 (albedo units)	0 to 1.0
Measurement Accuracy	0.08 (albedo units)	0.02
Measurement Precision	0.05 (albedo units)	0.0125

*http://www.jpss.noaa.gov/assets/pdfs/technical_documents/level_1_requirements_supplement.pdf

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

2. Provisional

- o 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.
- o Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- o Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- o Product is recommended for potential operational use (user decision) and in scientific publications after consulting

Algorithm Update

- ☐ Enterprise VIIRS Albedo algorithm has been developed and integrated into the framework. The final DAP to NDE was delivered to NDE at the end of March, 2018.
- ☐ The enterprise LSA algorithm has been applied over NOAA 20 data. The near real time test data of NOAA 20 LSA has been generated in the ASSIST framework
- ☐ Issues observed since beta review have been fixed. Updated science code has been delivered in Jan 2019 DAP and in the queue to be operational.
- ☐ LUTs for NOAA-20 LSA production has been generated and tested, and will be delivered in March 2019.
- ☐ Beta Corrections

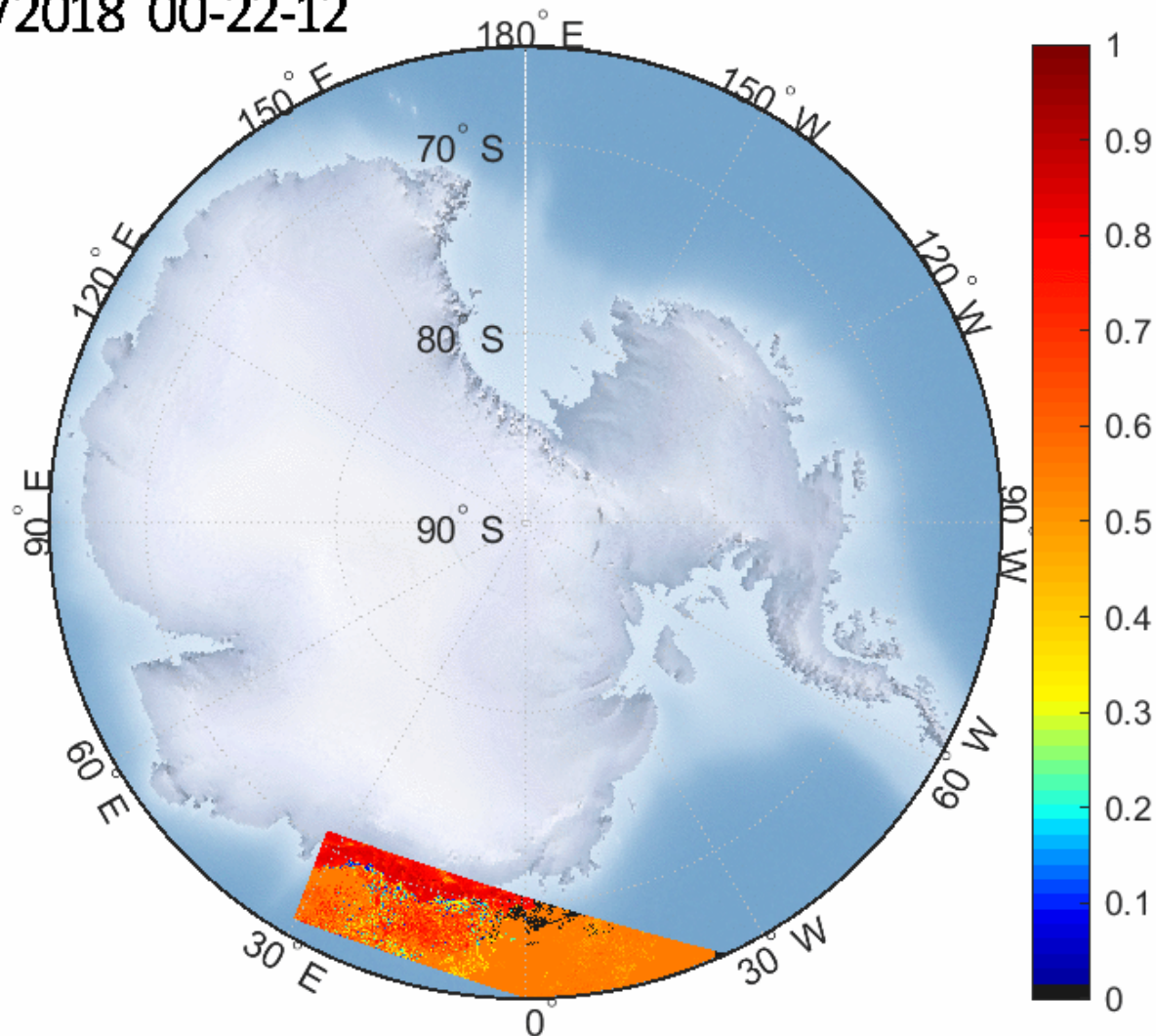
Issues found in Beta, and Corrections

- o Occasional incorrect metadata (standard deviation/Percentage) in NDE (3 in 2231 granules) -- not being found in current dataset
- o Missing granules in NDE -- framework disk issue, still happens
- o Overall data precision is slightly beyond the requirement -- the precision meets requirement with current dataset
- o Degradation of albedo quality is found at large angles and the heterogeneity ground station data – it's found to be the inherent uncertainty in albedo validation
- o Notable difference between NOAA-20 VIIRS albedo and MODIS albedo over Antarctica is observed in beta evaluation -- still exists but found mainly from snow cover recognition results (snow cover classification improvement needed)

- Visual inspection of the granule and global composite NOAA-20 LSA image
- Algorithm performance validation
 - Direct-comparison with ground measurements
 - Cross-comparison with MODIS Albedo
- Metadata analysis/validation
 - Check possible error in metadata calculation

Visual inspection of NOAA-20 LSA: granule

12/13/2018 00-22-12



NOAA-20 VIIRS L2 Granule LSA Dynamic Animation

Data source:

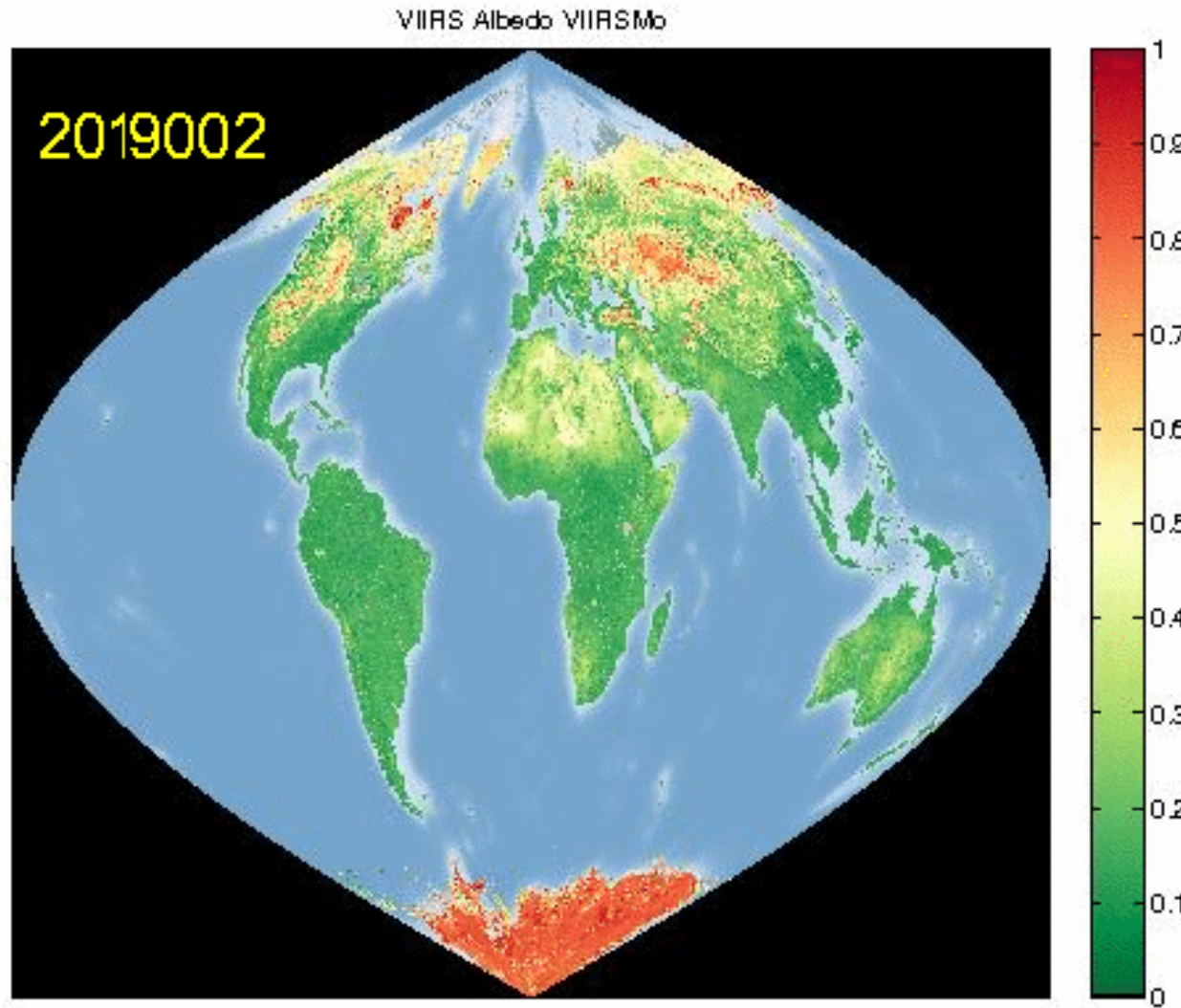
NOAA-20 LSA generated in
ASSISTT framework

Data Time:

All granules on the day
12/13/2018

*NOAA-20 VIIRS LSA product example, generated by
the ASSISST framework. Current result satisfies the
provisional maturity review requirements.*

Visual inspection of NOAA-20 LSA: Global



NOAA-20 **Global Composite** LSA Dynamic Animation

Data source:

NOAA-20 LSA generated in
local system

Data size:

Global map examples in
Jan, 2019

*NOAA-20 VIIRS LSA product example, generated by the
local production. The current result satisfies the provisional
maturity review requirements.*

Quality flag analysis/validation

Defined Quality Flags

Byte	Bit	Flag	Source	Description
0	0-1	Overall quality	LSA	00: high-quality retrieval, 01: retrieval, 10:no retrieval
	2-3	Cloud condition	Cloud mask	00=confidently clear, 01=probably clear,10=probably cloudy,11=confidently cloudy
	4	SDR quality	SDR	0 = normal , 1 = bad data
	5	Solar zenith angle flag	SDR	0: favorable SZA, 1: very large SZA (>60)
	6	View zenith angle flag	SDR	0: favorable VZA, 1: very large VZA (>60)
	7	Spare		
1	0-2	Retrieval Path	LSA	000: generic, 001: desert, 010: snow, 011: seaice, 100: no retrieval
	3-4	Temporal filter quality flag	LSA	00: high-quality retrieval, 01: degraded retrieval, 10:no retrieval
	5	Online filter flag	Online filter	0: no filter, 1: filtered
	6-7	Spare		

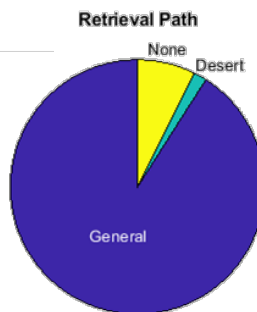
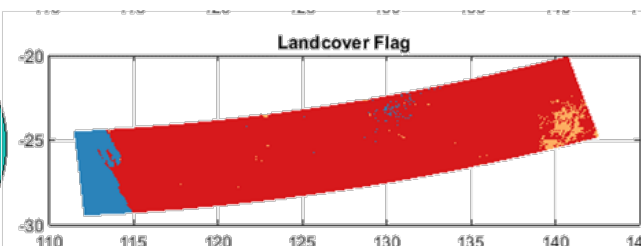
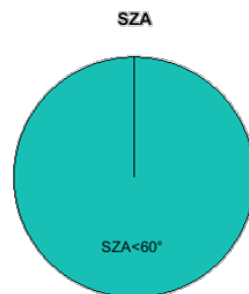
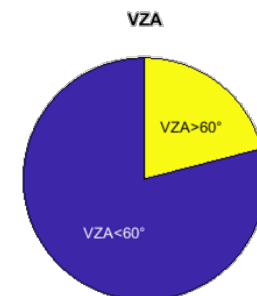
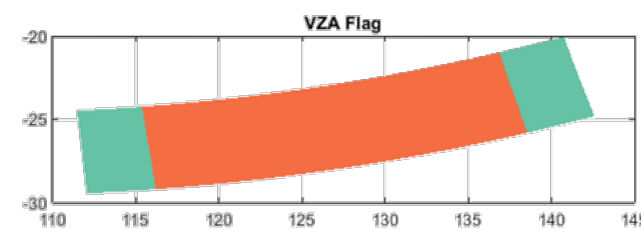
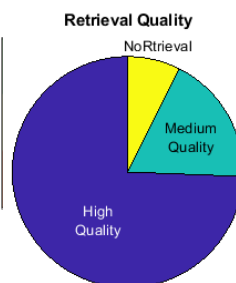
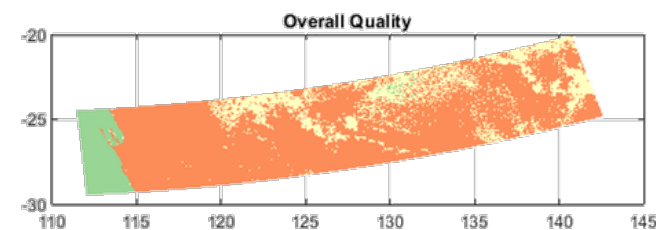
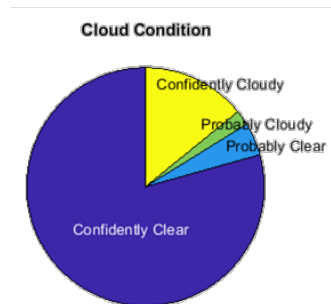
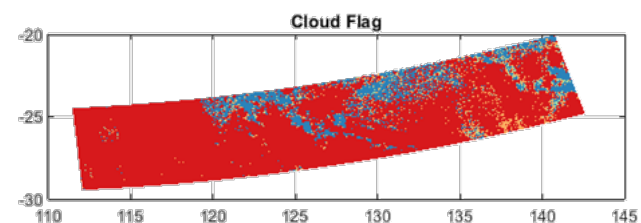
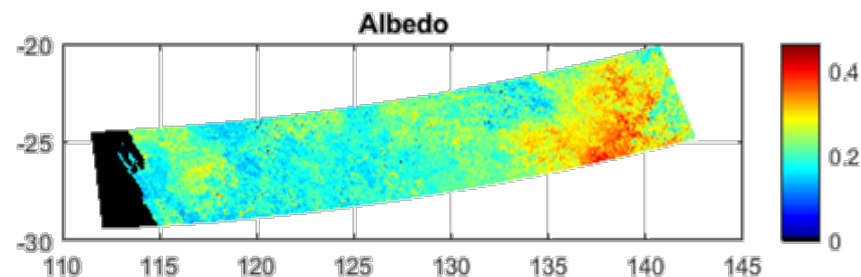
The PQI layer provides the Data Quality information of VIIRS albedo product.

- Each bit was locally recomputed, and compared with the value from the original input/out files. They all matched and no issues found.

Quality flag analysis

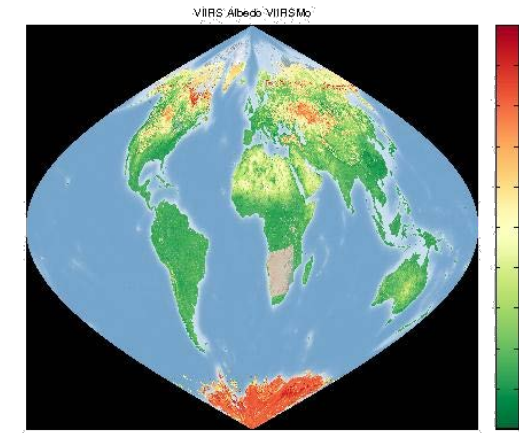
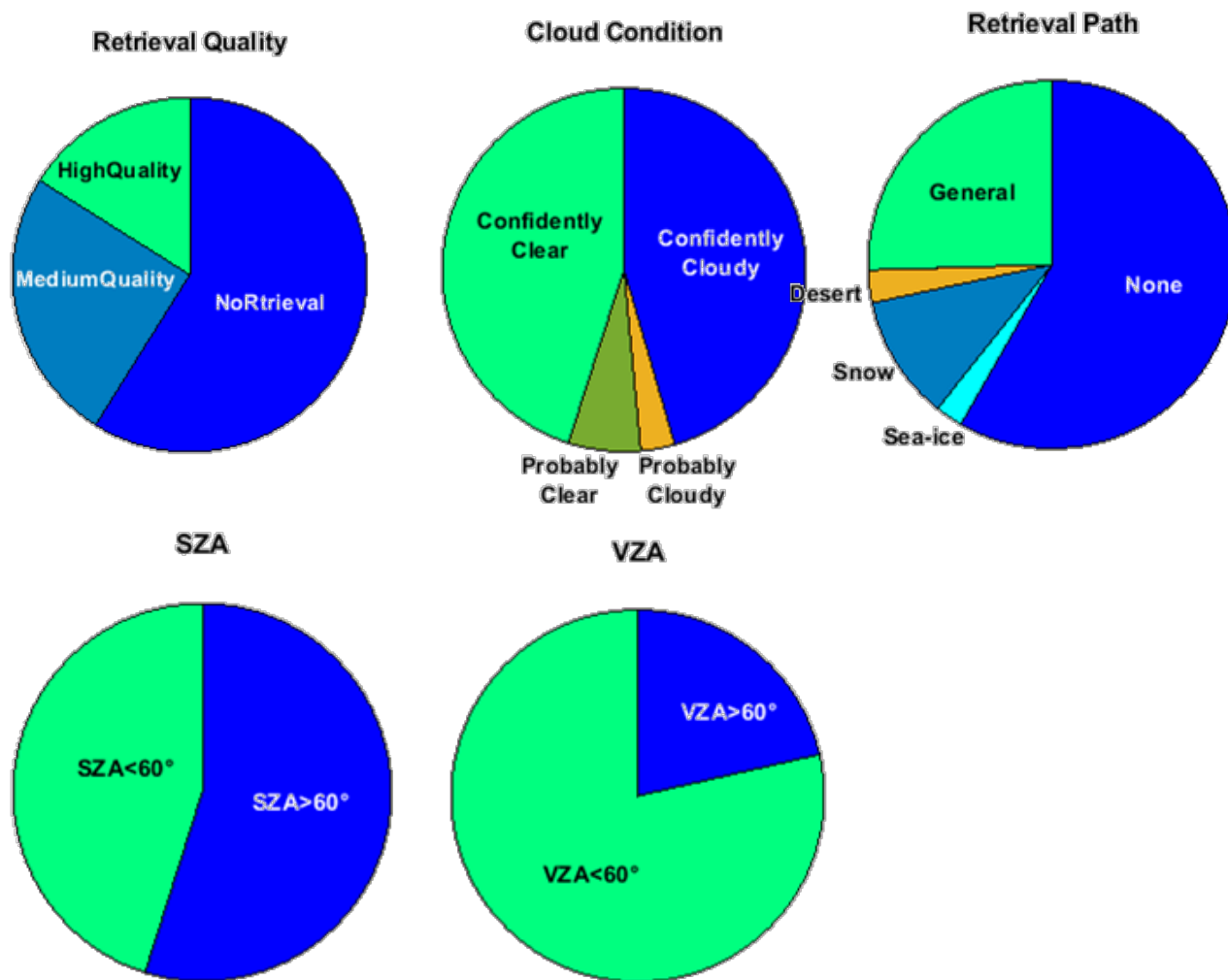
- Example granule:

JRR-LSA_v1r0_j01_s201812310513128_*.nc

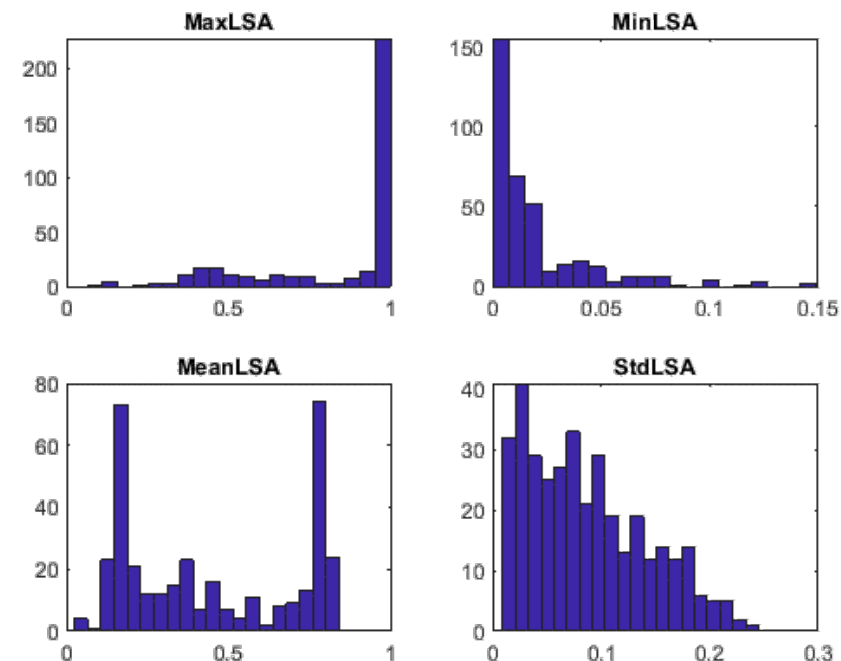


Quality flag analysis

- global mean of all granules on 20181231



- global distribution

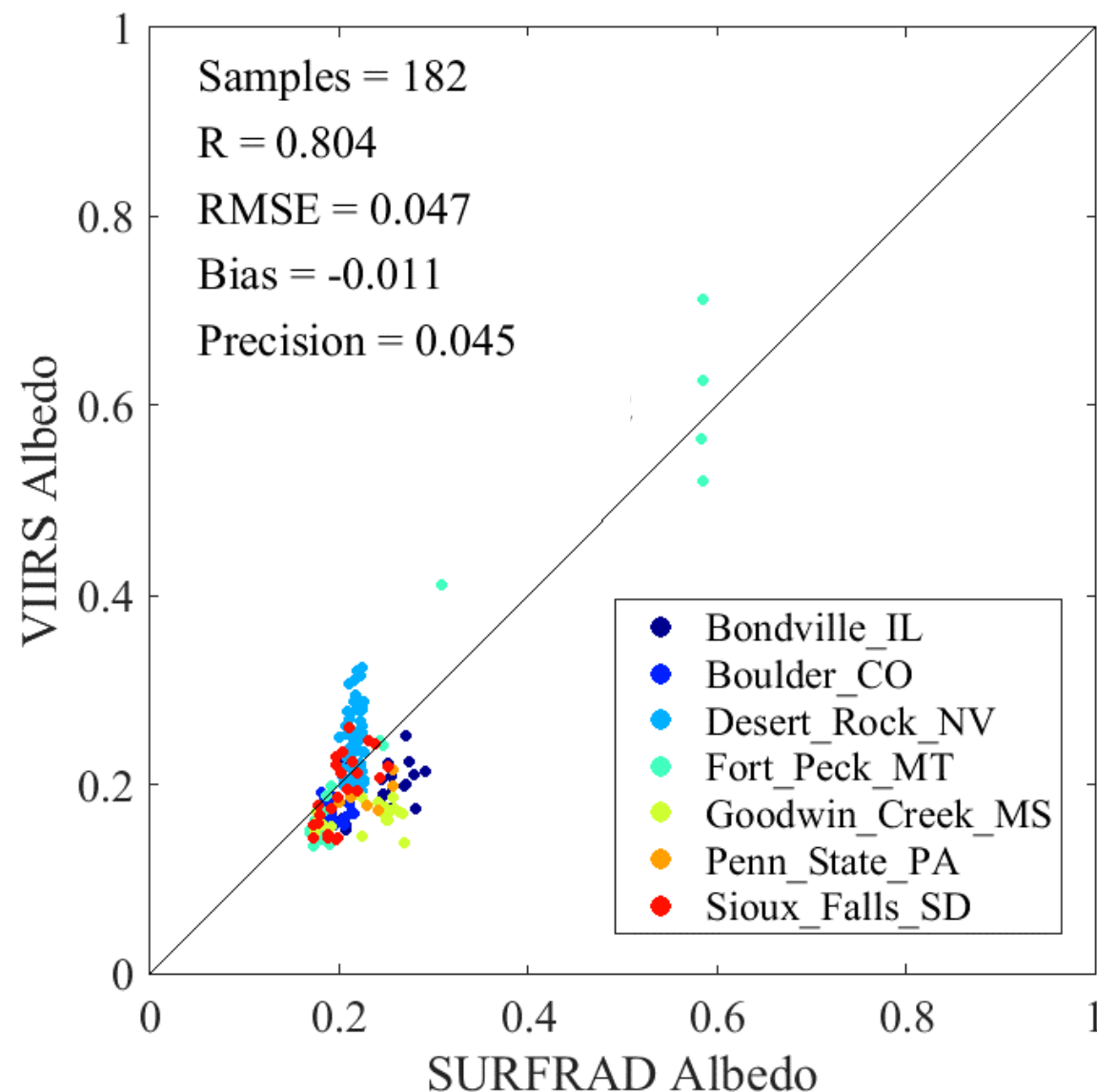


Global mean and distribution of the QF flag percentage reveal that the framework output have met the expectation.

Algorithm performance evaluation -- Overall

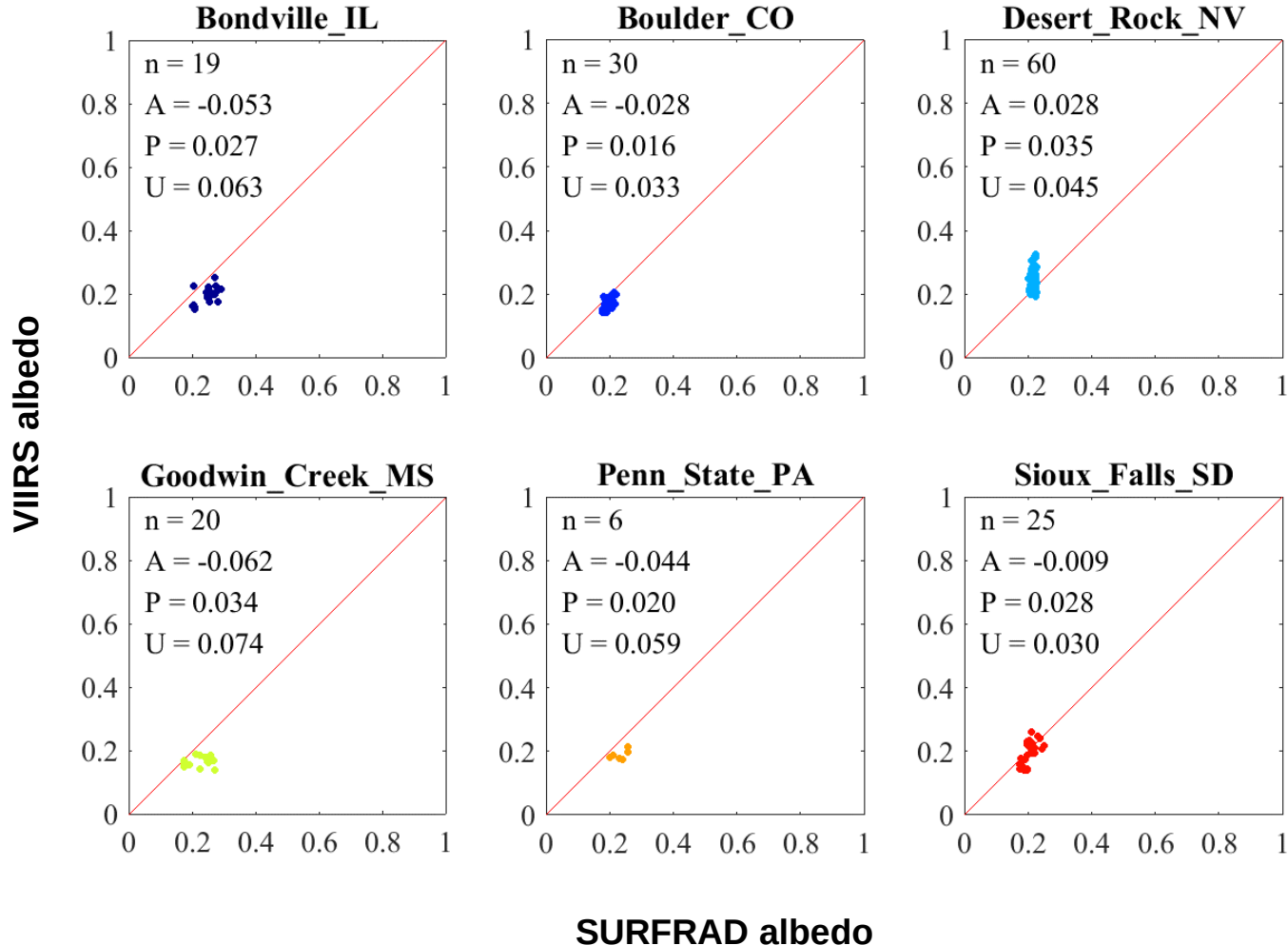
NOAA-20 vs. SURFRAD

- Validation data sets:
 - SURFRAD network measurements
 - 20180918-20181231
- Validation methods:
 - Direct-comparison
 - Over clear-sky retrievals



Algorithm performance evaluation

NOAA-20 vs. SURFRAD



Error Budget

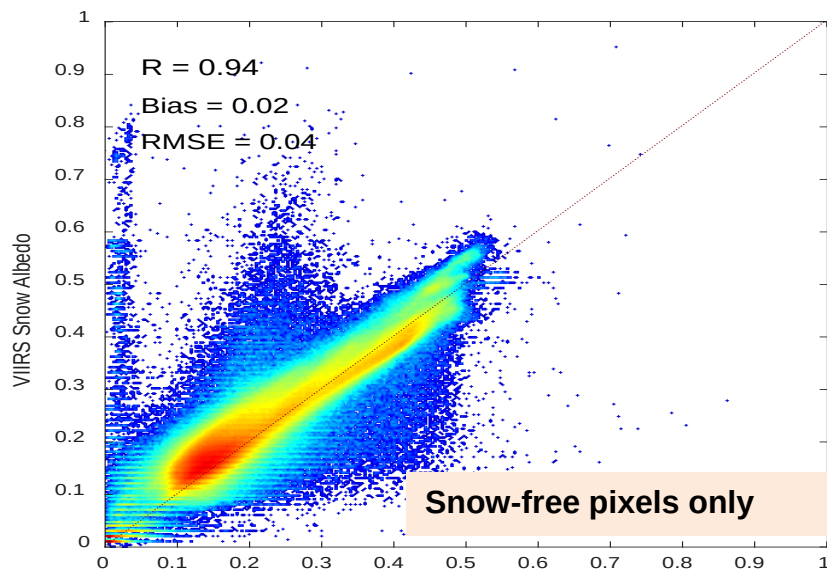
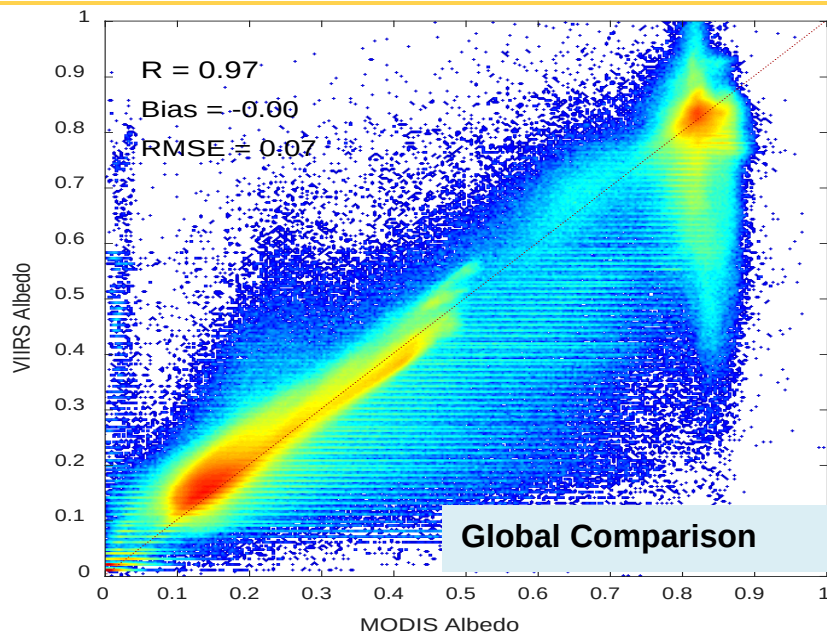
SITE	Sample count	Accuracy (Bias)	Precision (Std of Error)
Bondville_IL	19	-0.053	0.027
Boulder_CO	30	-0.028	0.016
Desert_Rock_NV	60	0.028	0.035
Fort_Peck_MT	22	-0.008	0.046
Goodwin_Creek_MS	20	-0.062	0.034
Penn_State_PA	6	-0.044	0.02
Sioux_Falls_SD	25	-0.009	0.028
Overall		-0.011	0.045

Note: the L1RD albedo requirement for Accuracy and Precision are 0.08 and 0.05 albedo unit, respectively.

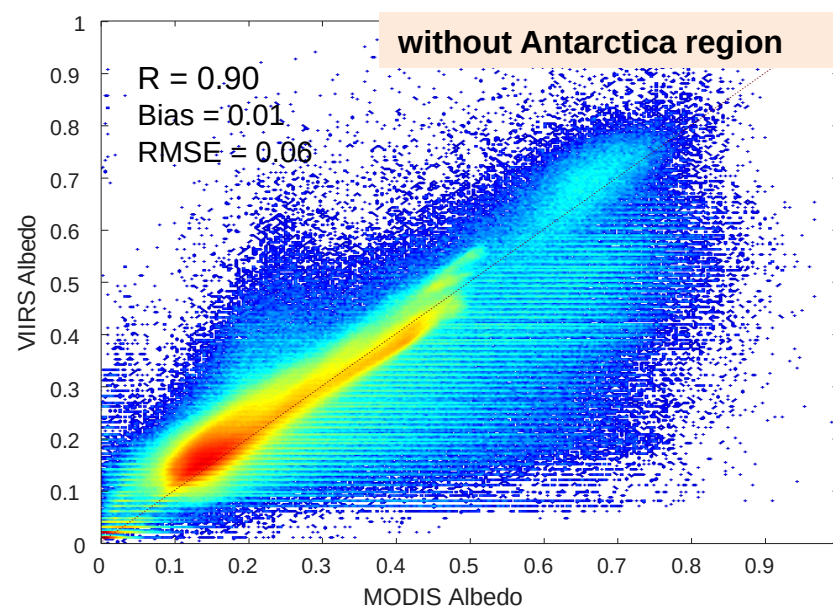
All sites meets the accuracy and precision requirement.

Algorithm performance evaluation

NOAA-20 vs. MODIS 20181207



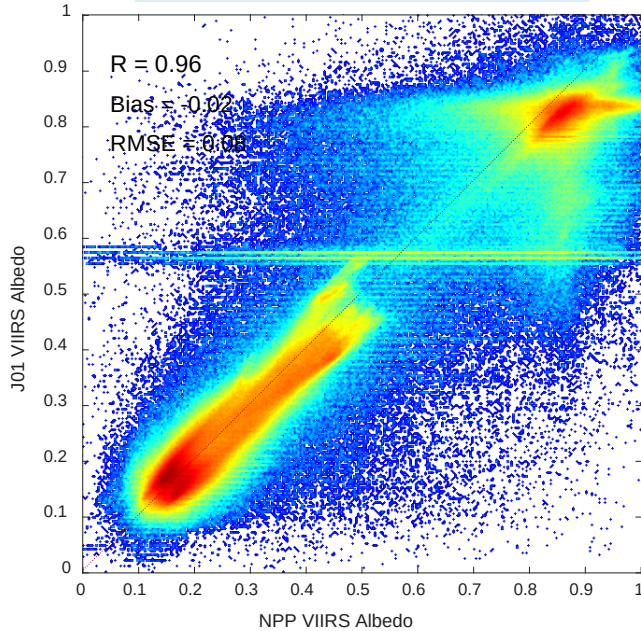
- Significant differences are mostly over snow/ice surface.
- Validation data sets:
MODIS daily mean albedo on 20181207



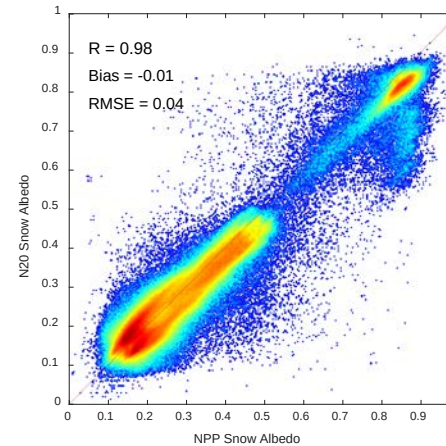
Algorithm performance evaluation

NOAA-20 vs. SNPP 20181207

Global Comparison



Comparing the NOAA-20 and SNPP VIIRS LSA, the result is generally consistent in high-quality retrievals, but has some difference in medium and low quality retrievals, which are filled values.

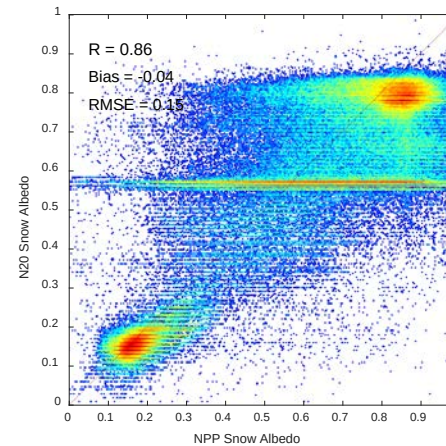
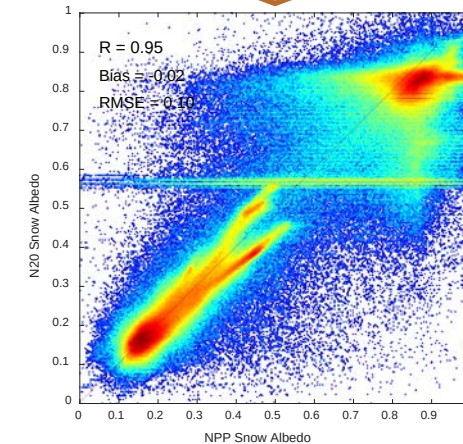


high-quality retrievals

Direct retrieval

medium-quality retrievals

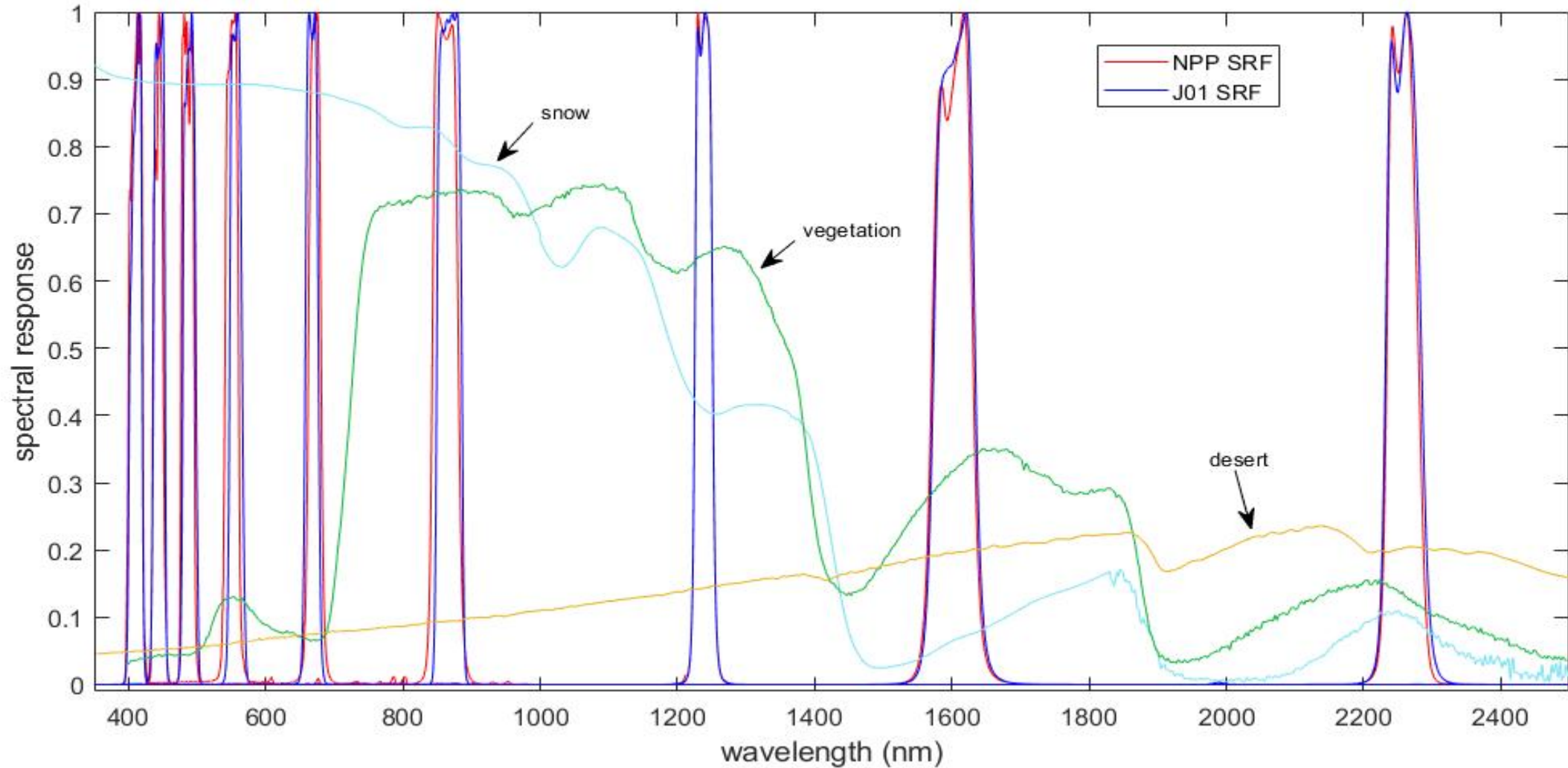
Large angle retrieval



low-quality retrievals

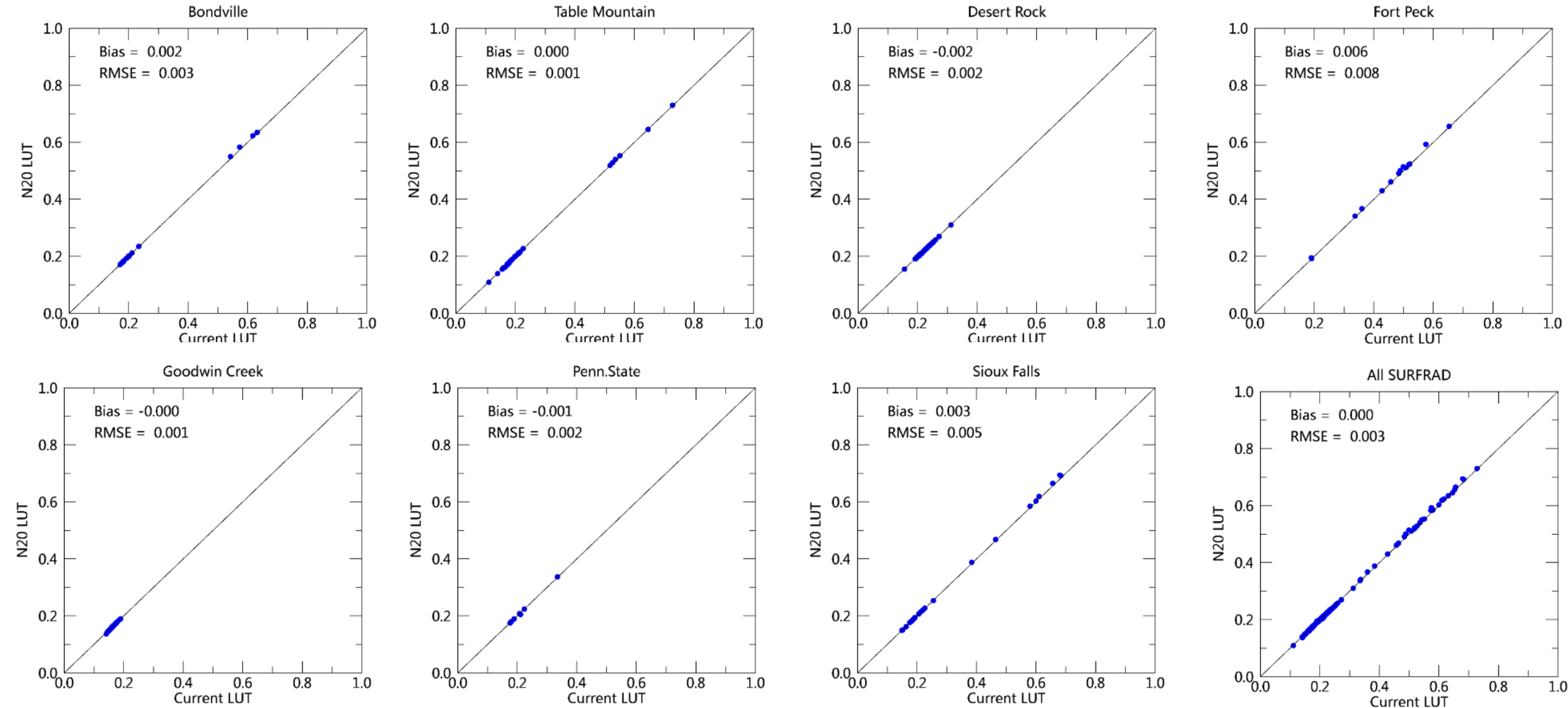
Filled Value

LUTs Difference



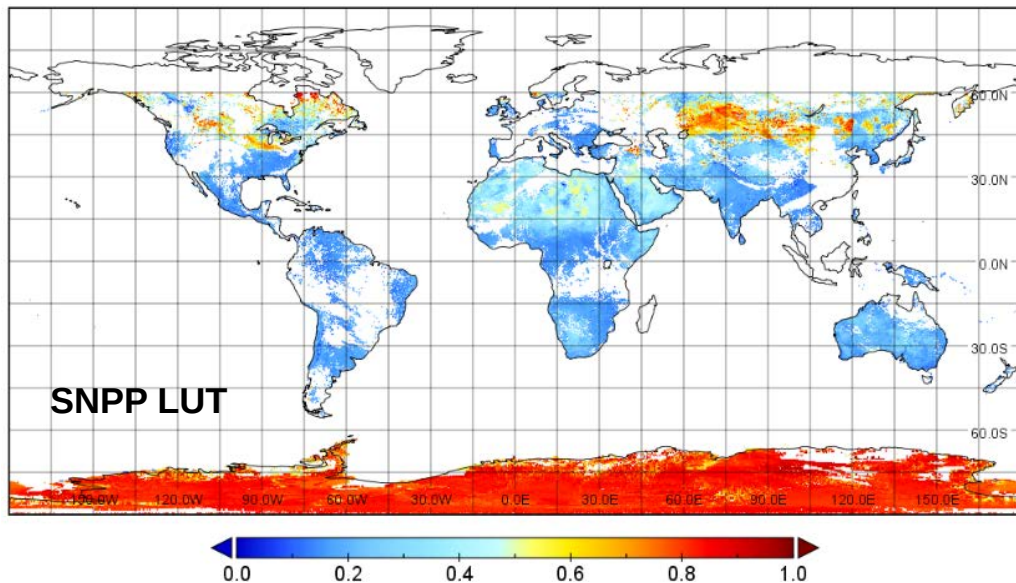
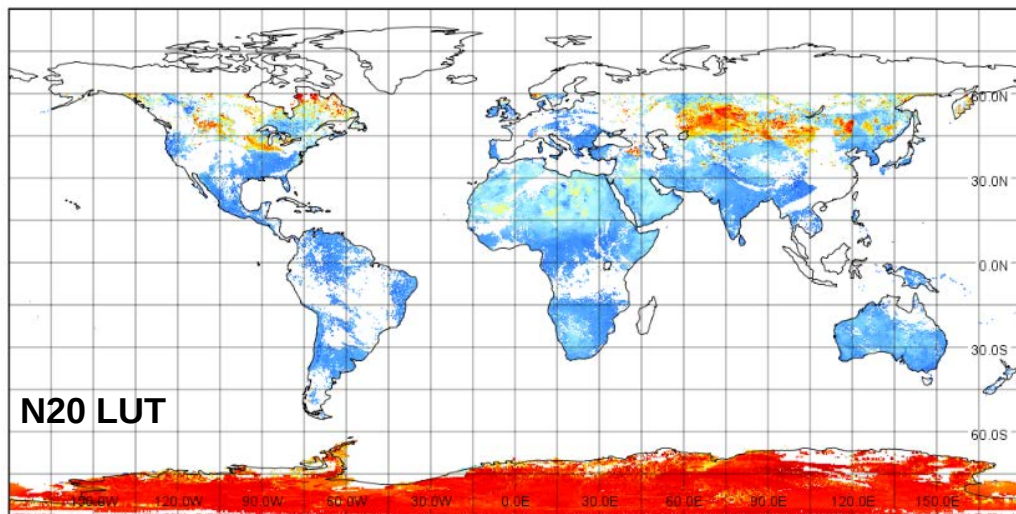
The spectral response functions of SNPP VIIRS and J01 VIIRS are close with slight difference. Therefore, it is expected the performance of their LUTs is similar.

New N20 LUT v.s Current SNPP LUT over SURFRAD



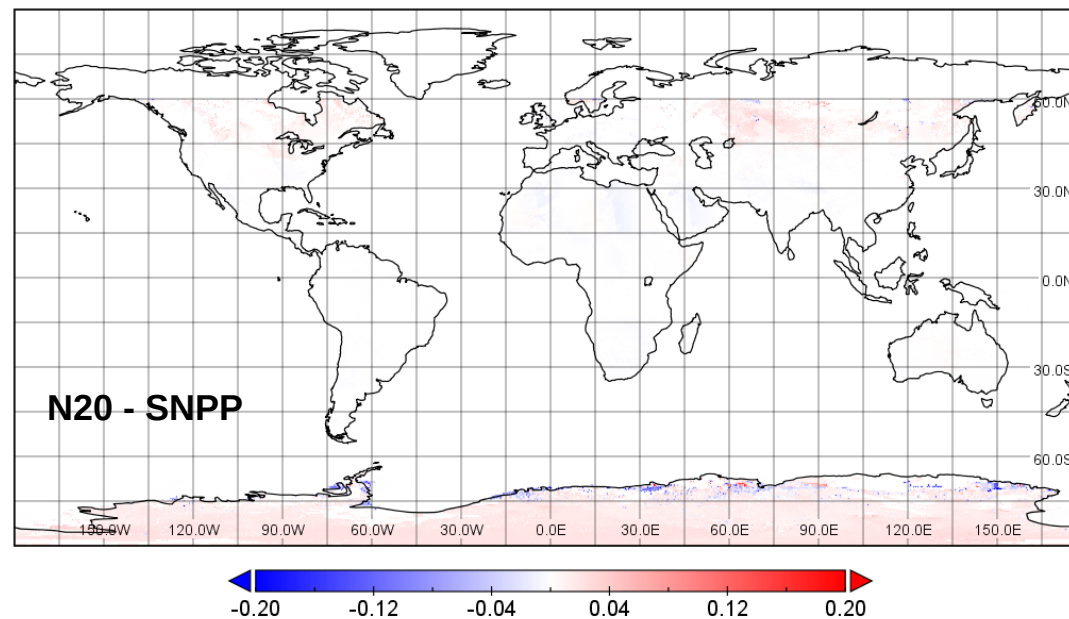
Current SNPP LUT generates nearly the same LSA results with new developed N20 LUT over the seven SURFRAD sites (Bias = 0, RMSE = 0.003).

Influence of LUTs

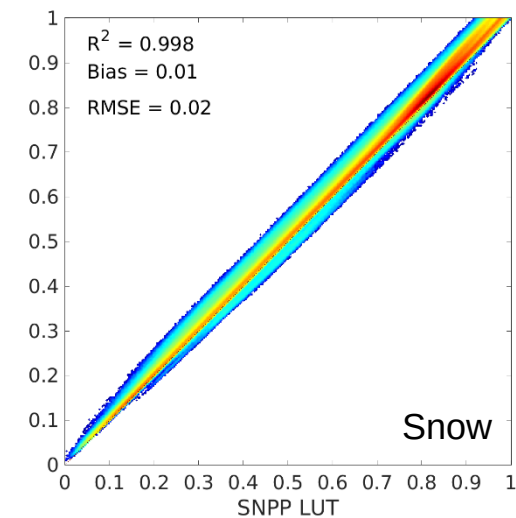
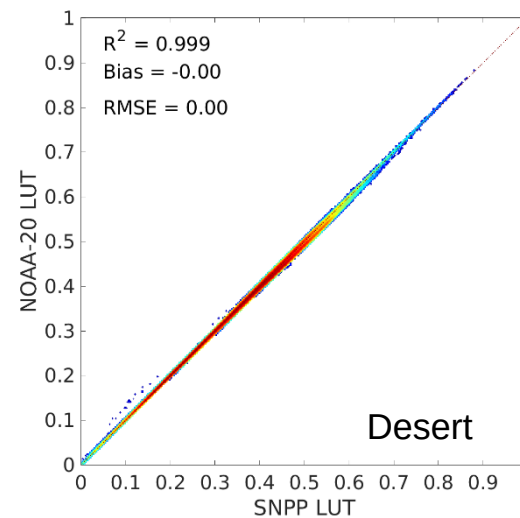
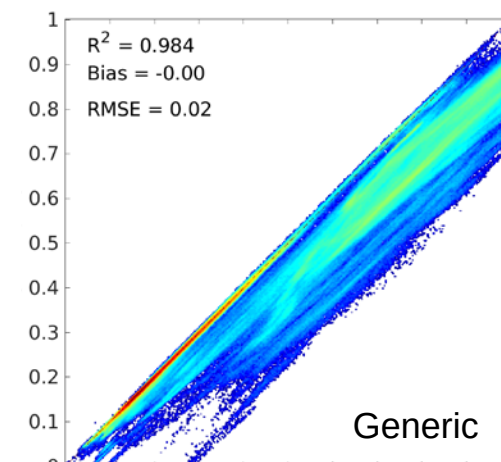
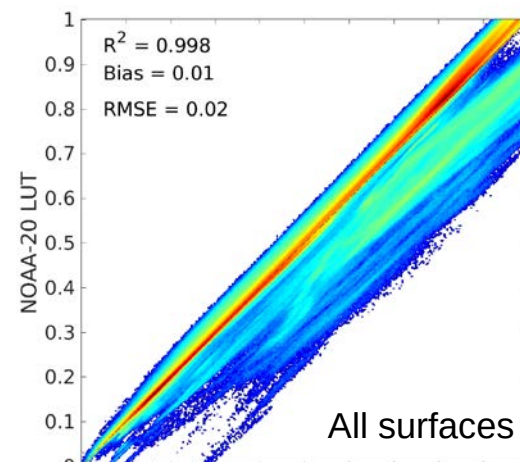
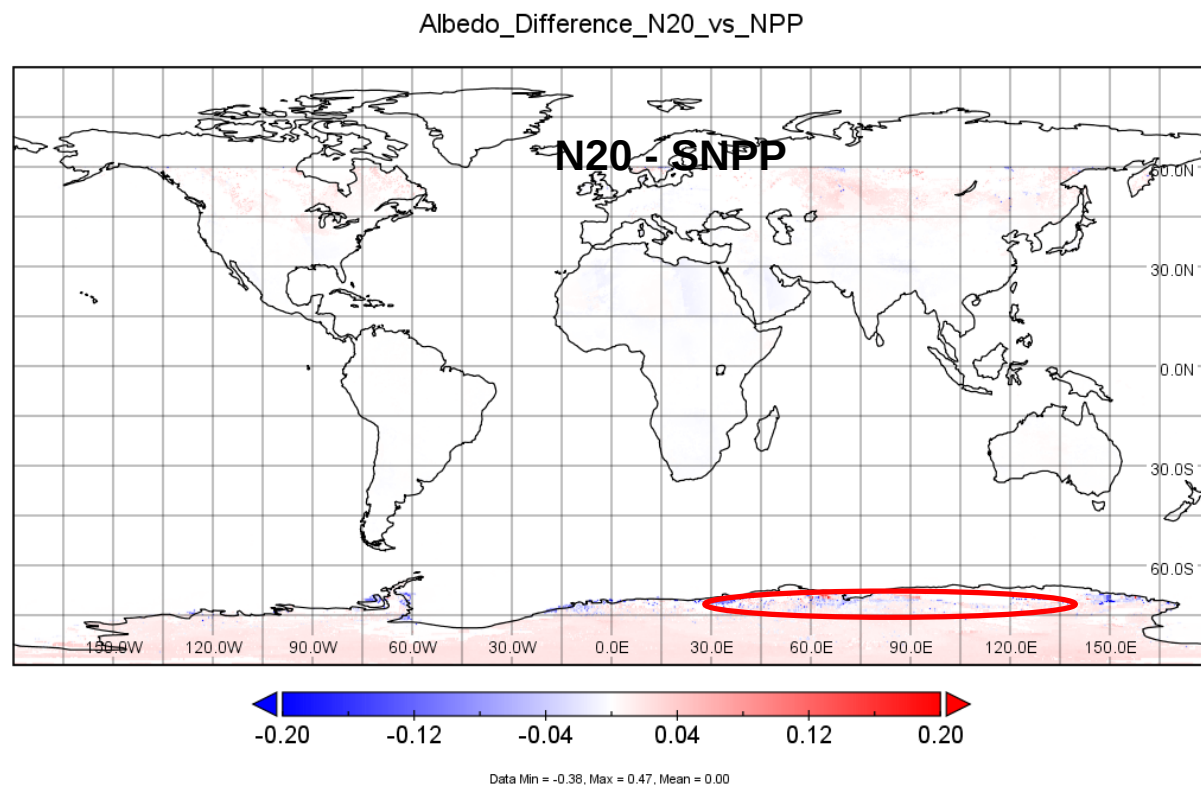


**New N20 LUT v.s Current SNPP LUT over globe
(January 6th, 2018)**

Albedo_Difference_N20_vs_NPP

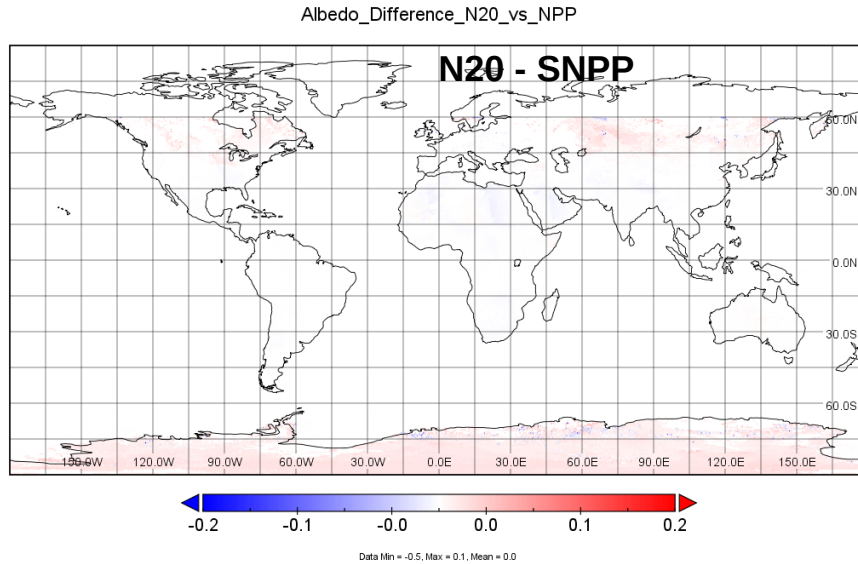


Influence of LUTs

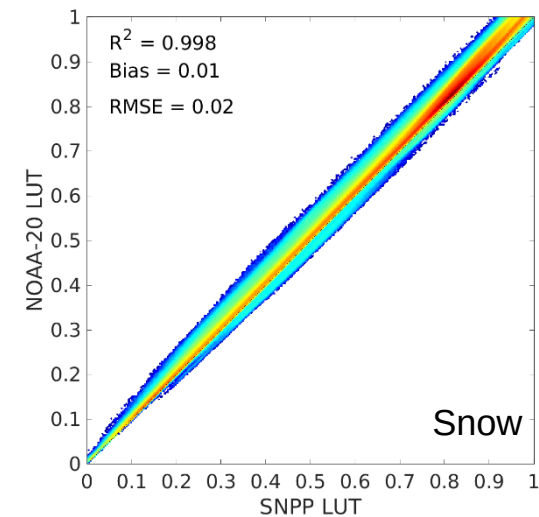
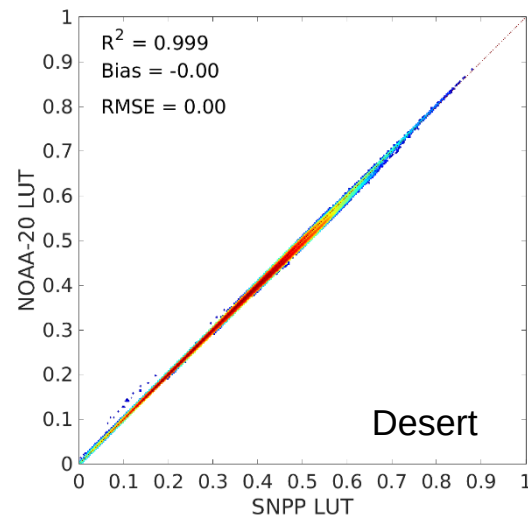
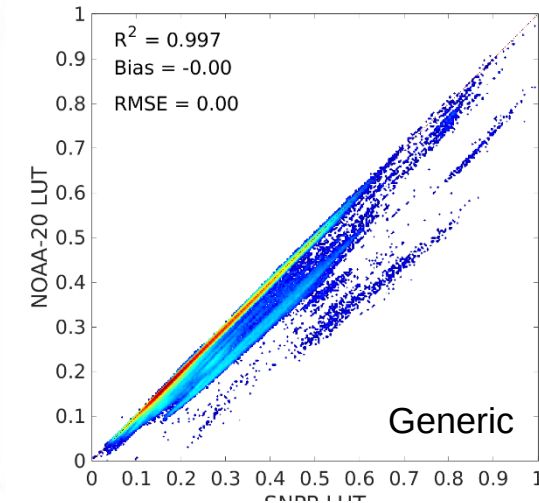
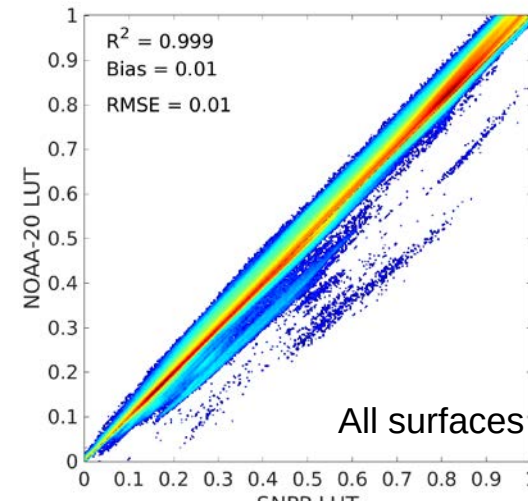


Scatter plot per surfaces

Influence of LUTs



Some suspicious pixels in Antarctic region which are treated as snow-free in VIIRS snow mask but marked as permanent snow in MODIS land cover data have been corrected as snow. Then the consistency between the two LUTs' performance is largely improved



- Snow correction_Scatter

Summary of LUTs impact

- Overall, LUTs for SNPP and for NOAA-20 generate very close LSA values over the seven SUFRAD sites (Bias = 0, RMSE = 0.003).
- Similarly, LUTs for SNPP and for NOAA-20 generate close LSA values over global regions in the test date (Jan 6th, 2018) (Bias = 0.01, RMSE = 0.02).
- At a close look, consistencies between the two LUTs vary with the land surfaces:
 - Desert/Barren land surface achieves the highest agreement (Bias = 0, RMSE = 0);
 - Snow surface show slight positive differences (N20>SNPP), with Bias of 0.01 and RMSE of 0.02. No pixels with significant differences (>0.1) exist.
 - Generic surface displays many cases of significant differences, likely due to incorrect snow mask information.

Documentations

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
System Maintenance Manual (for ESPC products)	Yes
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	Yes

NOAA-20 LSA Product has been verified and validated. The product is suggested being released as provisional maturity version.

- Validation against the SURFRAD measurements suggests the overall accuracy and precision of current NOAA-20 LSA product both meet the requirement.
- The cross-comparison using MODIS data shows that the snow-covered pixels in Antarctic show some difference, mainly caused by the snow cover difference.
- The cross-comparison using SNPP LSA shows overall consistency in high-quality retrievals, but has some difference in medium and low quality retrievals which are filled values from offline filtered results mostly degraded due to missing data issue.
- Global mean and distribution of the QF flag percentage reveal that the framework output have met the expectation.
- LUTs for N20 is tested and will be delivered shortly. It shows satisfactory performance according to validation.
- Some issues and problems are found that will be solved or improved for the provisional release.
 - Upstream data missing is a concern for albedo data continuity

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.	Yes, both direct-comparison with long-term SURFRAD station measurements and cross-comparison with MODIS albedo have been conducted. The limitation is the three months ground measurements cannot represent the seasonal variation and all surface cover types.
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	Yes, a series of analyses have been conducted, from checking of input to evaluation of all output layers. The content has contained all common points that the users want to know.
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.	Yes, all potential issues have been included in and tracked.
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	Yes, the current product meets the requirements and ready for use. Continuous effort will be invested for further improvements.

Requirement Check List – LSA

JERD	Requirement	Performance
	Applicable Conditions: 1. Daytime, clear sky only	
JERD-2440	The algorithm shall produce a surface albedo product with a horizontal cell size of 0.80 km	Yes
JERD-2523	The algorithm shall produce a surface albedo product with a mapping uncertainty (3 sigma) of 1 km at Nadir	Yes
JERD-2524	The algorithm shall produce a surface albedo product with a measurement range of 0 to 1.0 (albedo units)	Correct
JERD-2525	The algorithm shall produce a surface albedo product with a measurement precision of 0.05 (albedo units). (Note 1)	Satisfied
JERD-2526	The algorithm shall produce a surface albedo product with a measurement accuracy of 0.08 (albedo units). (Note 1)	Satisfied
JERD-2527	The algorithm shall produce a surface albedo product with geographic coverage of global, including land ocean and ice surface conditions	Land and sea-ice
JERD-2528	The algorithm shall produce a surface albedo product with spectra coverage of broad band values from 0.4 to 4.0 microns	Yes

Note 1. Accuracy and precision performance will be verified and validated for an aggregated 4 km horizontal cell to provide for adequate comparability of performance across the scan

- Algorithm improvements
 - Update to NOAA-20 land LUTs (planned)
 - Set the sea-water pixels as fill value (delivered)
 - Exclude pure sea-water granules in output to save storage (planned)
 - Exclude sea-water tiles in offline run to save time (delivered)
 - Update sea-ice albedo climatology (delivered)
- Future Cal/Val activities / milestones
 - Validation for 2019 DAPs
 - Validation for validated maturity review
- Improved albedo products (in investigation)
 - NOAA-20 Gridded Surface Albedo Product
 - Blended Albedo product with S-NPP VIIRS Albedo
- Promote the application of VIIRS LSA product in NOAA climate models

Thank You !