Validated Maturity Science Review For NOAA-20 VIIRS Albedo Product

JPSS STAR Land Science Team
Presenter: Yunyue Yu
Date: 11/21/2019

Albedo Cal/Val Team Members

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

JPSS Data Products Maturity Definition

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.

Outline

- 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
  - Error Budget
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

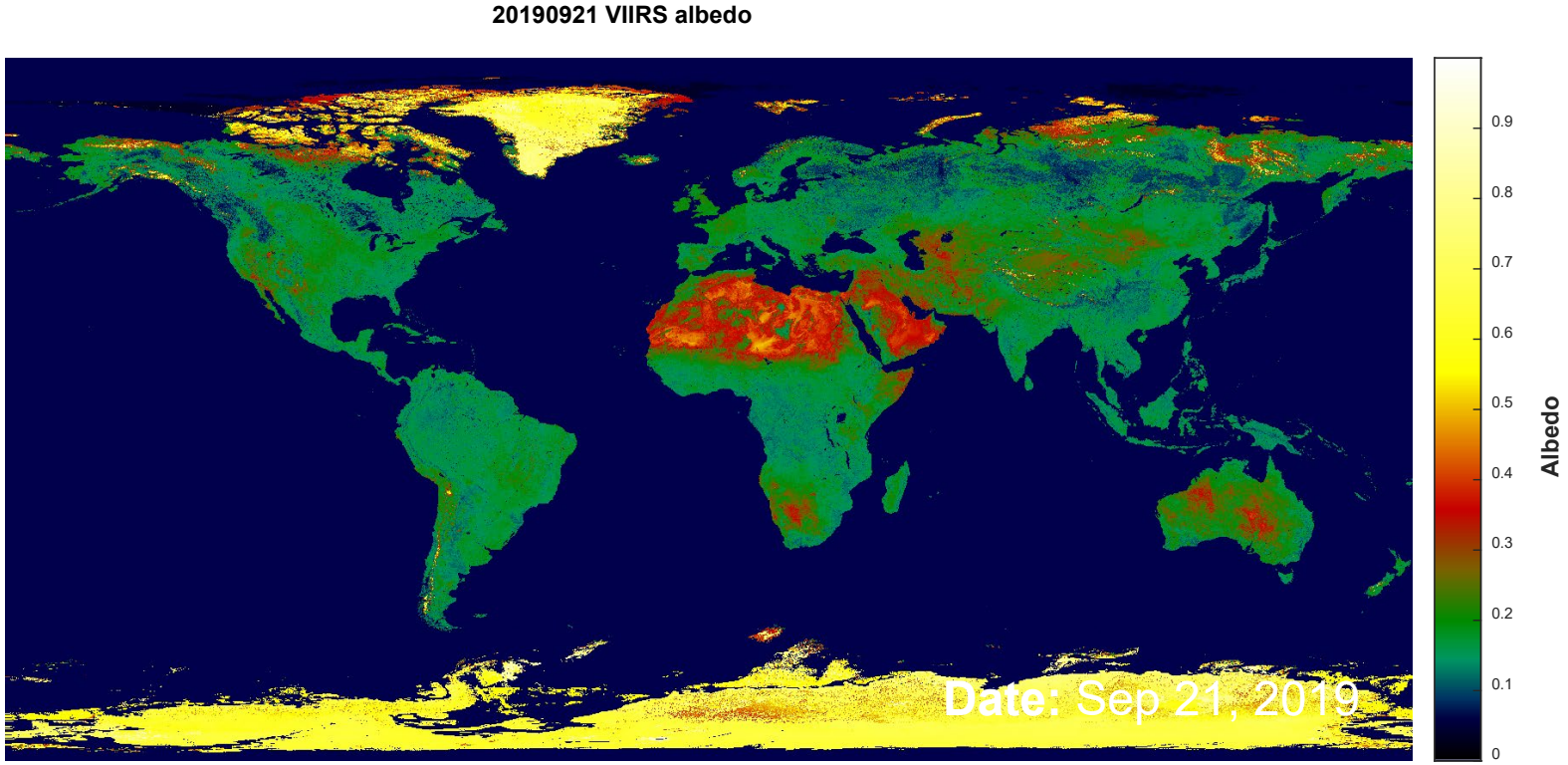
VIIRS Albedo Product overview

NOAA 20 Albedo Algorithm

- Enterprise algorithm for SNPP as well
- Applied over NOAA 20 data through the provisional review.
- Updates of science code and auxiliary data were delivered to ASSISTT in 2018 and in 2019.
- LUTs for NOAA-20 Albedo production has been generated and tested, and delivered in March 2019.
- Provisional maturity review passed on Feb 21, 2019

Operational Status

- NOAA 20 VIIRS Albedo has been available in CLASS since 09/19/2019.
- Also available at SCDR under data type “VIIRS-SURFALB” for STAR internal users and interested groups.
- Update of Climatology dataset is ongoing



Albedo Product requirements

	JPSS VIIRS Albedo	
Attribute	Threshold	Objective
Geographic coverage	global, including land and sea 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

Evaluation of algorithm performance to specification requirements

- Findings/Issues from Provisional Review
  - Improvements since Provisional Review
    - Algorithm Improvements
    - LUT / PCT updates
- Algorithm performance evaluation
  - Validation data sets (type, periods, coverage)
  - Validation strategies / methods
  - Validation results
  - Long term monitoring readiness

Provisional Corrections

Issues found in Provisional

- Degradation of albedo quality is found at large angles and the heterogeneity ground station data – it's found to be the inherent uncertainty in current satellite albedo algorithms, improvement through future research
- The cross-comparison using MODIS data shows some significant difference over snow-covered pixels in Antarctic, mainly caused by the snow cover difference – would be improved through recognizing permanent snow using VIIRS surface type data (input depending on framework feed)

Issues found after Provisional

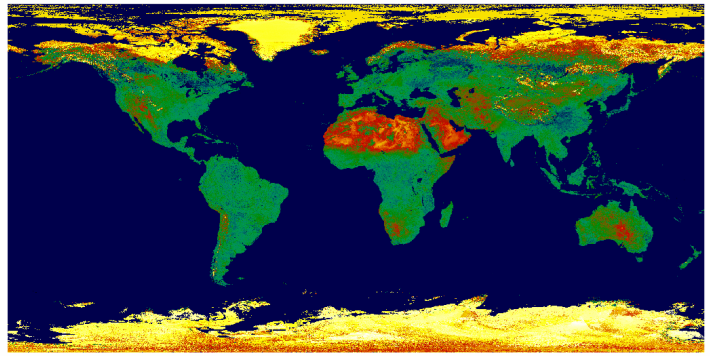
- Updated climatology in framework has not been applied in operational system – new climatology would be delivered to NDE soon
- Data discontinuity within Greenland in October due to climatology discontinuity – would be improved in July 2020 DAP

Validation strategies / methods

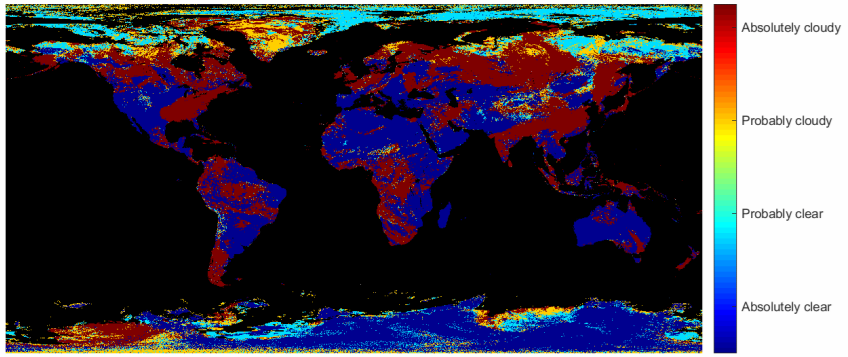
- Visual inspection of the global composite NOAA-20 Albedo image
- Algorithm performance validation
  - Direct-comparison with ground measurements
  - Cross-comparison with MODIS Albedo
- Metadata analysis/validation
  - Check possible error in metadata calculation

Visual inspection of NOAA-20 Albedo: Global

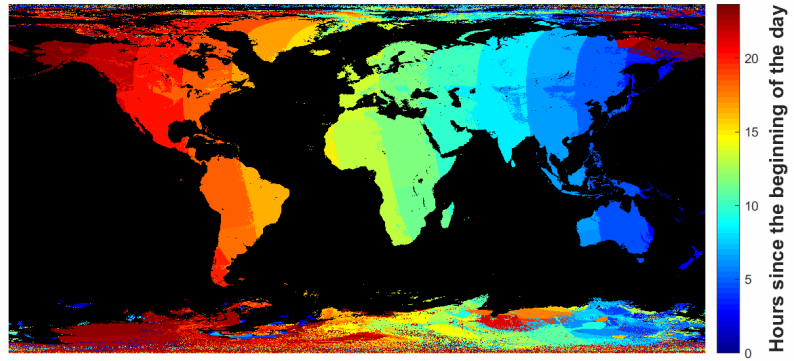
20191025 VIIRS albedo



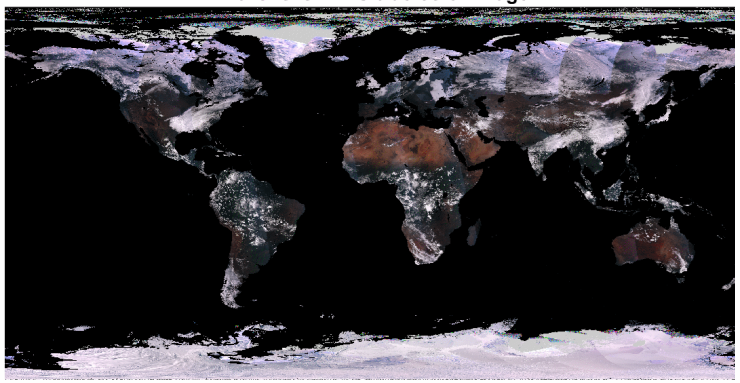
20191025 cloud condition



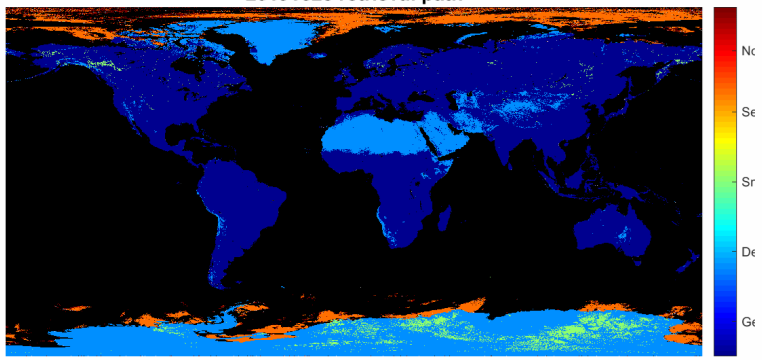
20191025 view time



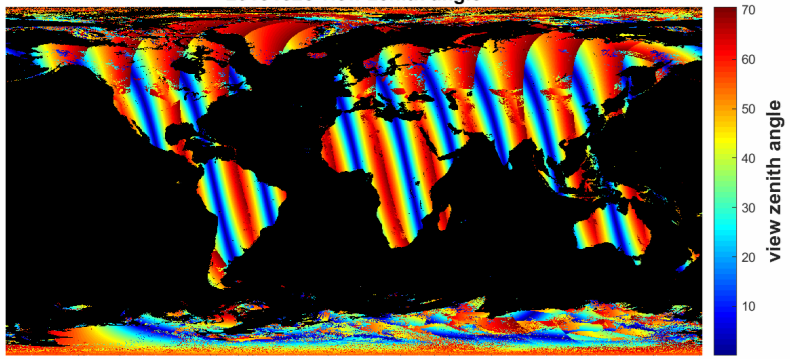
20191025 VIIRS true color image



20191025 retrieval path



20191025 view zenith angle



Data size:

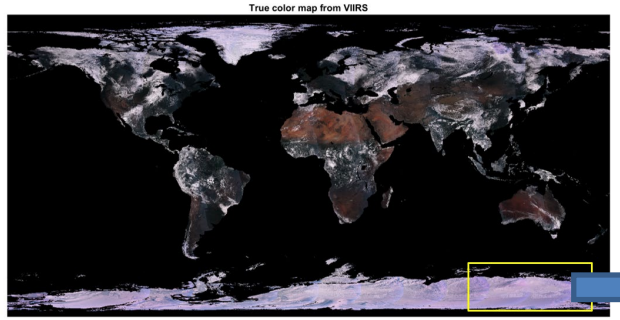
Global map examples in Oct 25, 2019 ~ Nov 10, 2019

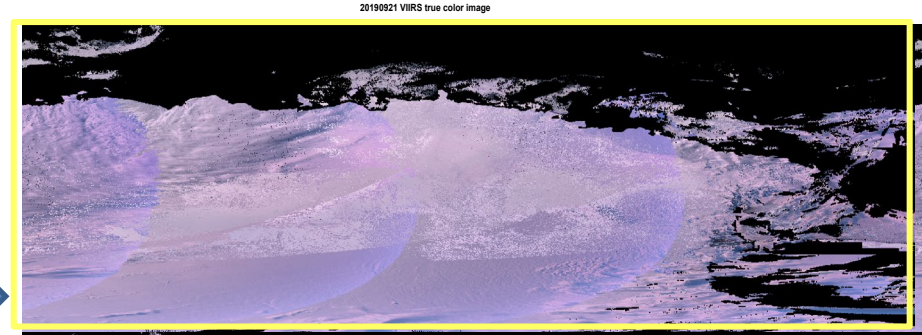
NOAA-20 Global Composite SURFALB

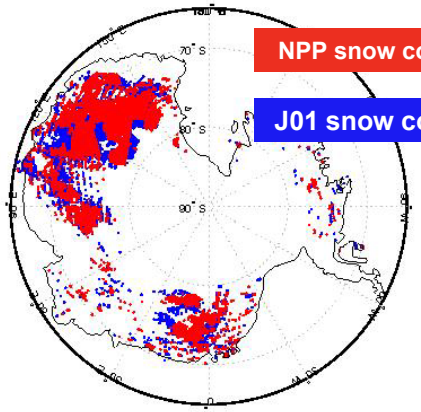
NOAA-20 VIIRS SURFALB product example, generated by the local production. The current result satisfies the validated maturity review requirements.

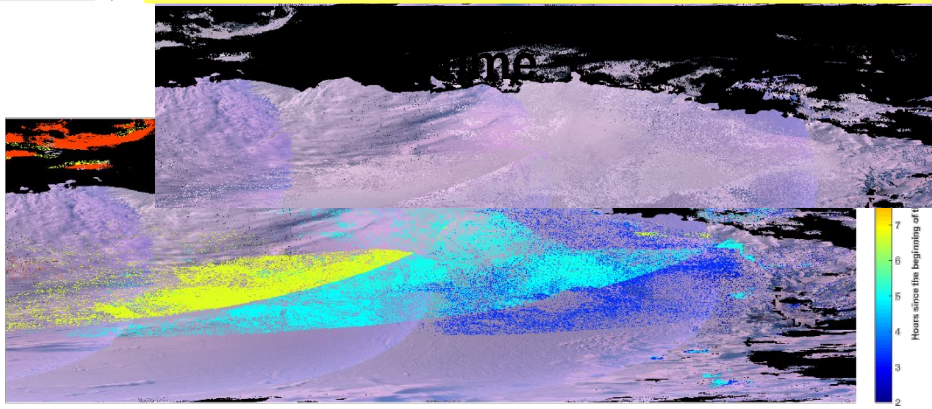
An extreme case to show the influence from input data

True color imagery / 20190921

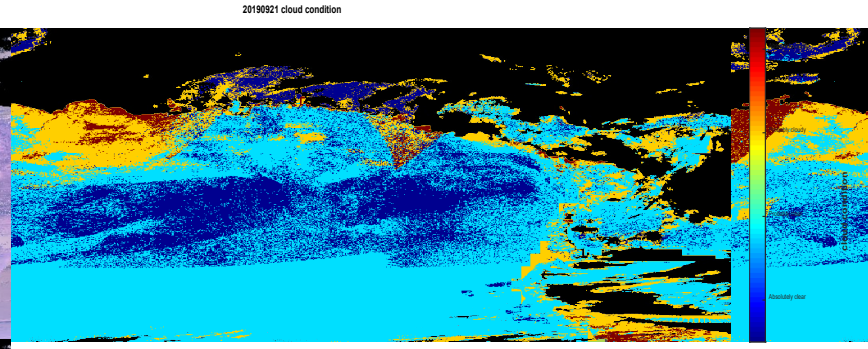




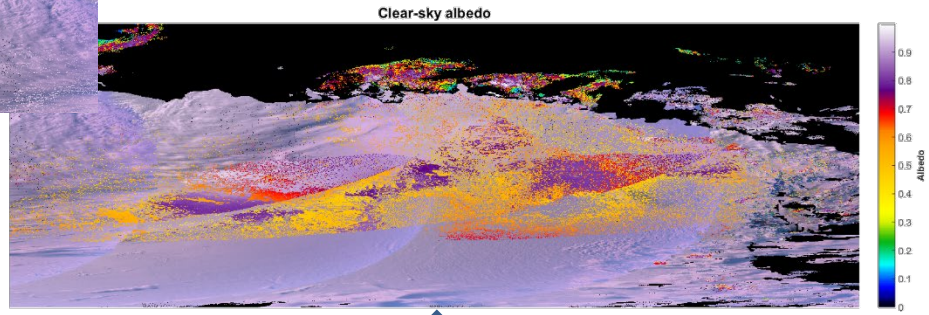




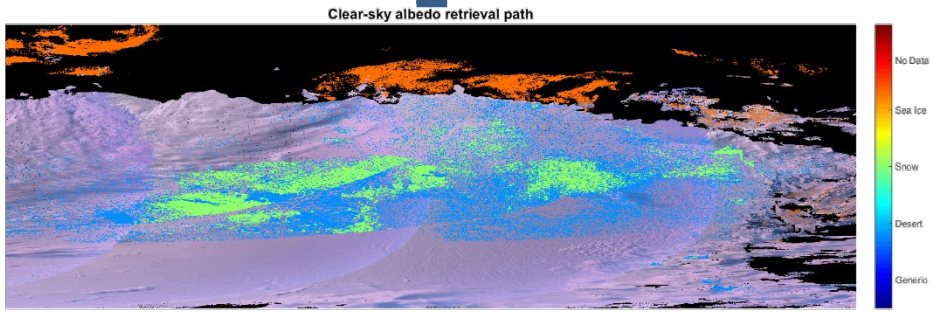
Cloud Mask



Clear-sky albedo

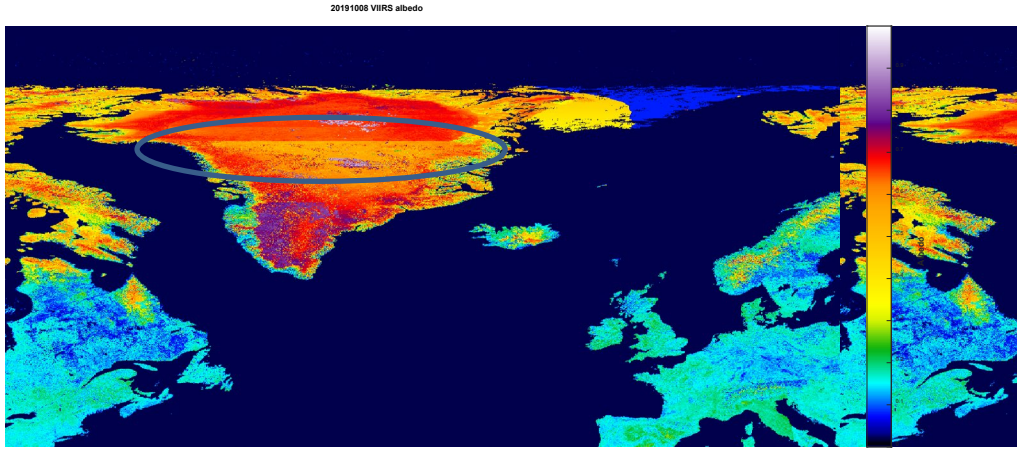


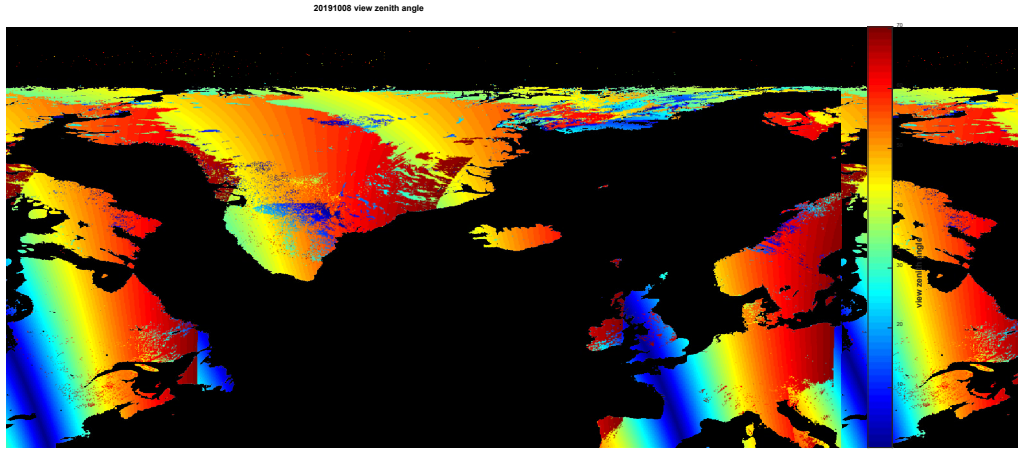
Retrieval path



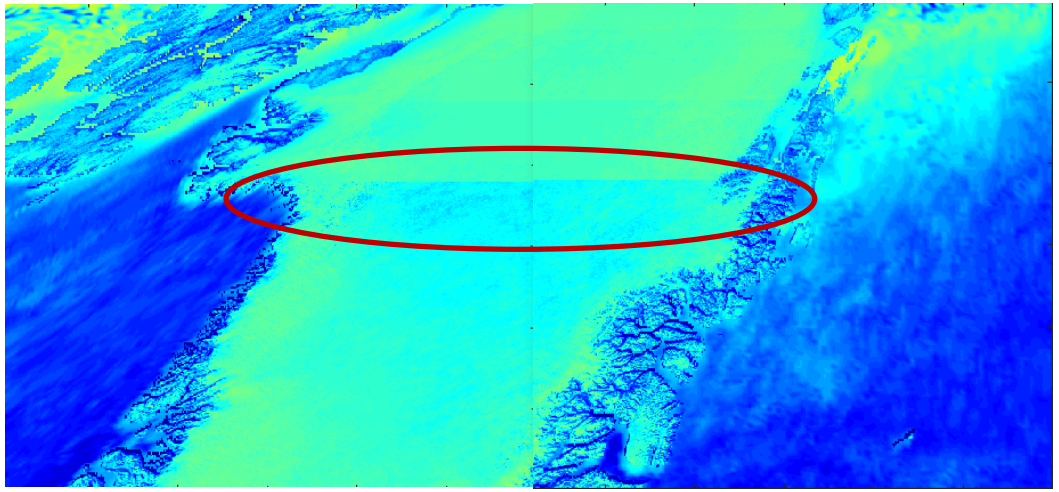
- The absolutely clear pixels distribute like salt and pepper
- The directly retrieved albedo is used as output over absolutely-clear sky pixels; however, it exhibits some discontinuity over Antarctic
- First due to the orbit difference (view time difference);
- Second reason is the snow cover discontinuity so that some pixels has been retrieved using desert LUT.

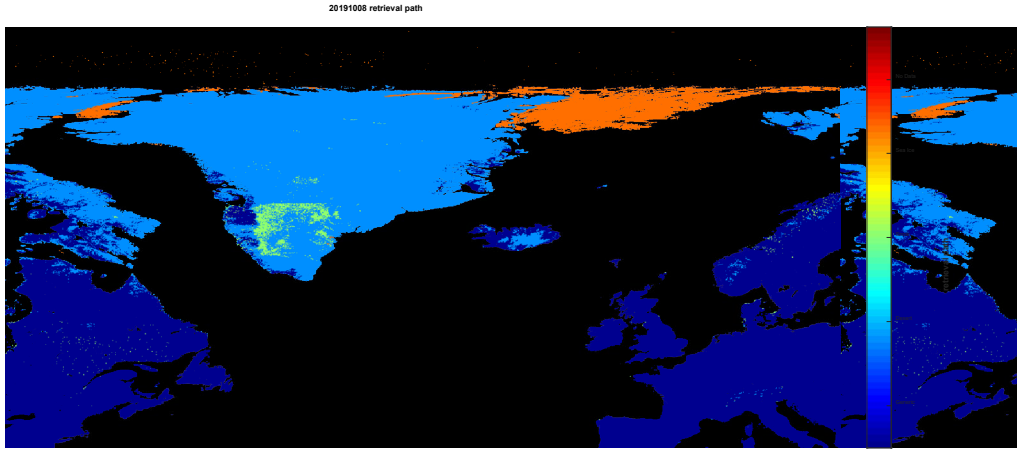
Another case to show the influence from the climatology data





DOY 273, Climatology



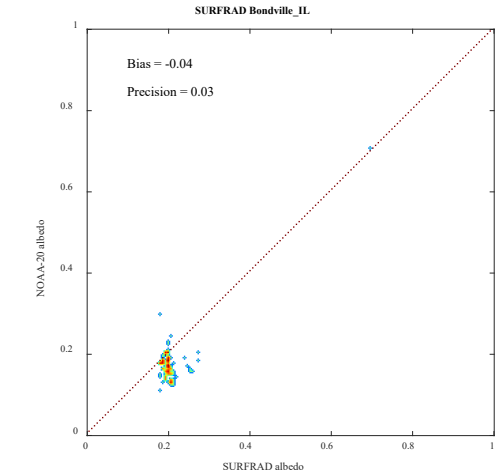


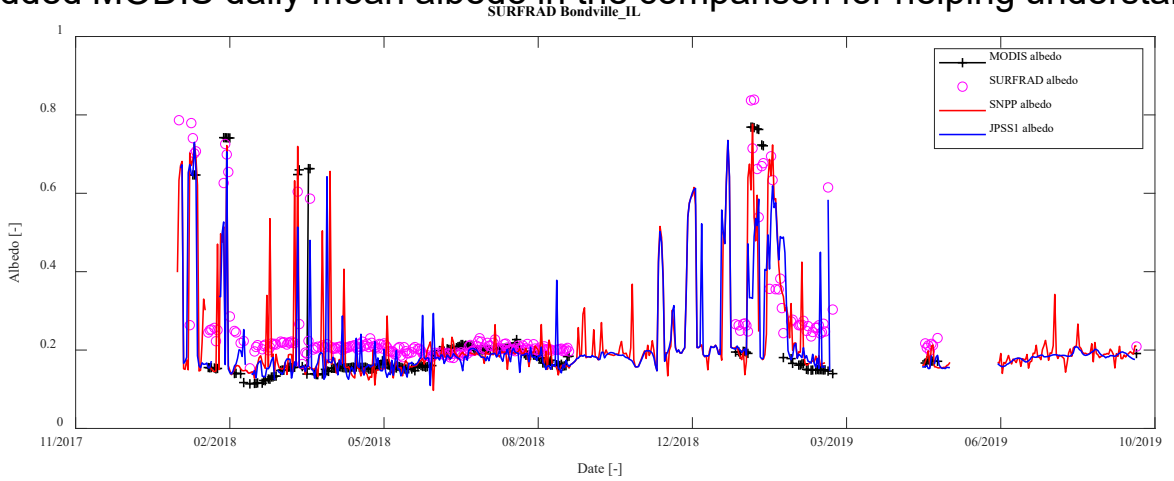
- The albedo over Greenland in October and November show a horizontal discontinuity due to a discontinuity pattern in the Climatology data, which serves as the fill value source over cloudy pixels
- This will be solved in July 2020 DAP

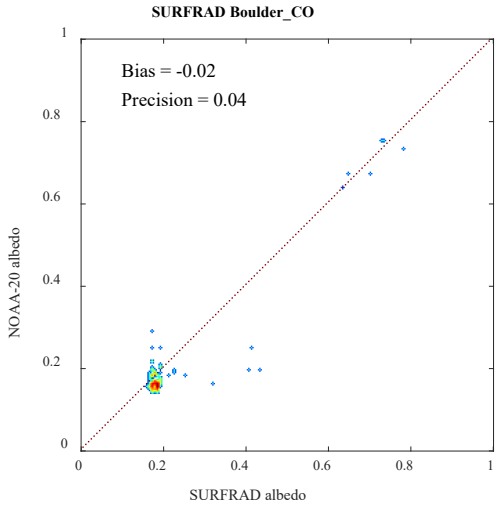
Algorithm performance evaluation

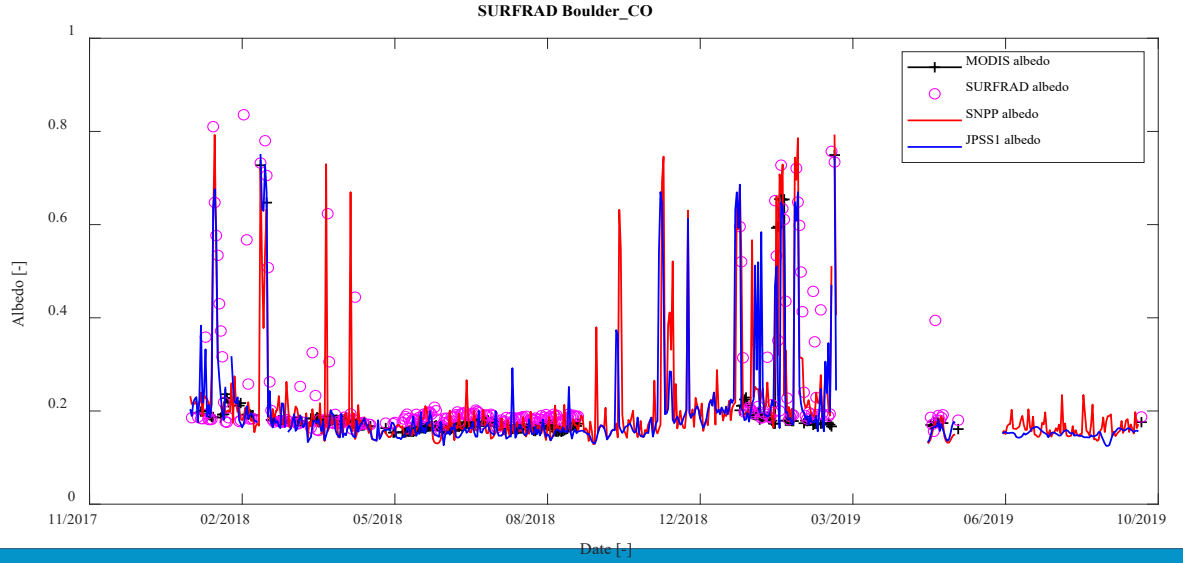
NOAA-20 VIIRS SURFALB has become operational since Sep 19, 2019. For long-term algorithm validation purpose, here we used locally reprocessed albedo at SURFRAD sites since Jan 07, 2018. However, the input data comes from IDPS version, which decreased the quality of the VIIRS albedo retrieval and caused larger noise. Even with this limitation, the high-quality NOAA-20 VIIRS albedo still meets the accuracy requirement. We also added MODIS daily mean albedo in the comparison for helping understanding the VIIRS albedo performance.

NOAA-20 vs. SURFRAD





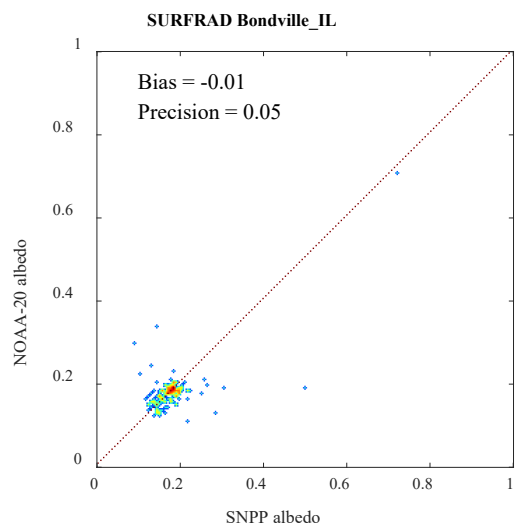


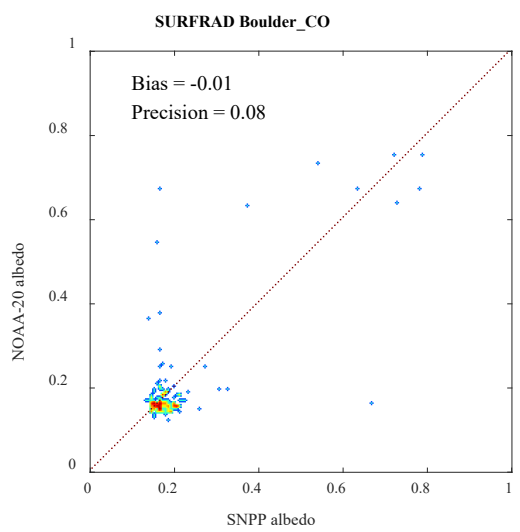


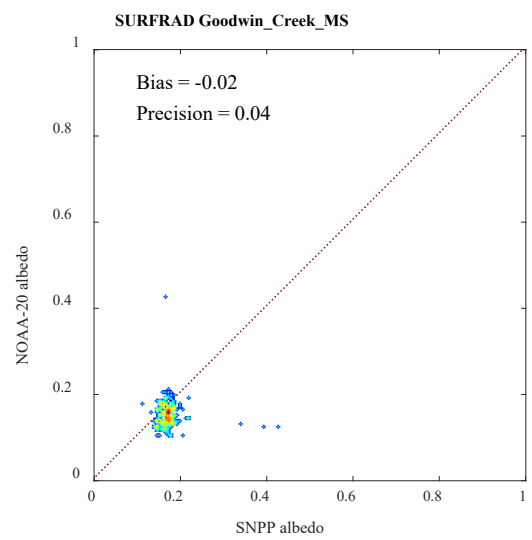
VIIRS daily mean albedo	MODIS daily mean albedo
Advances 1) Near real time; 2) Spatial and temporal continuous coverage; 3) Prompt response to temporal snow	Advances 1)Higher quality over stable surface such as desert 2)Provide BRDF coefficients 3)Lower sensitivity to undetected cloud contamination
Dis-advances 1) Slight fluctuations in time series; 2) Sensitive to undetected cloud contamination; 3) Cloudy pixels quality related to climatology	Dis-advances 1) 8-day latency; 2) With data gaps and data missing; 3) Missed some snow events

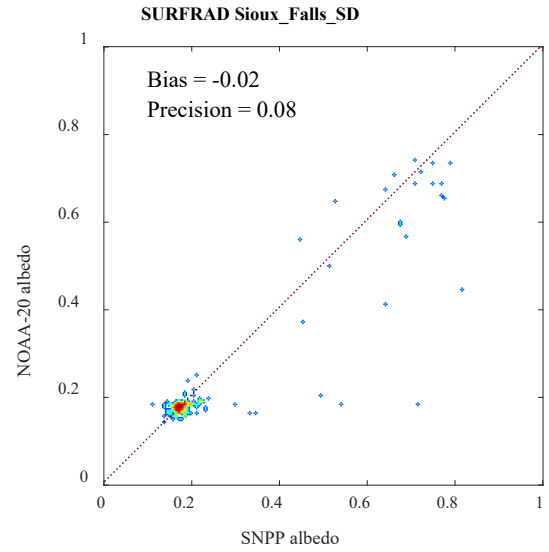
Algorithm performance evaluation

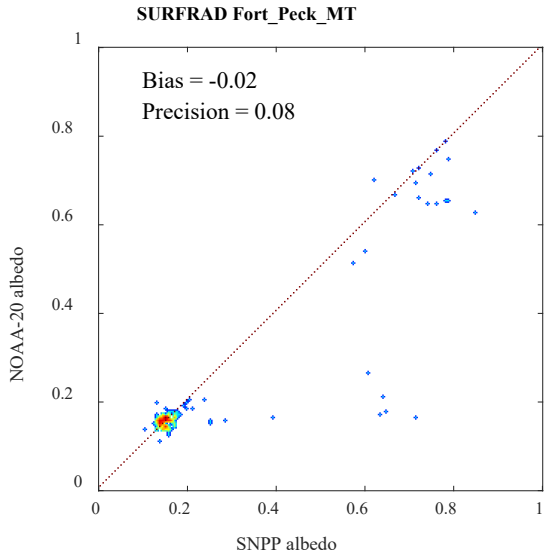
SNPP vs. NOAA-20

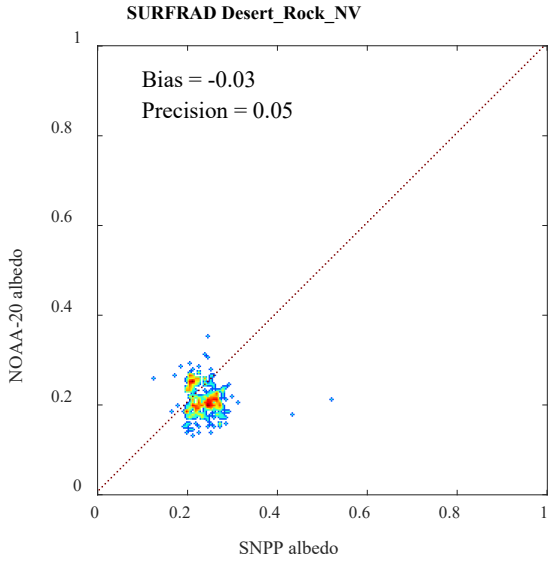


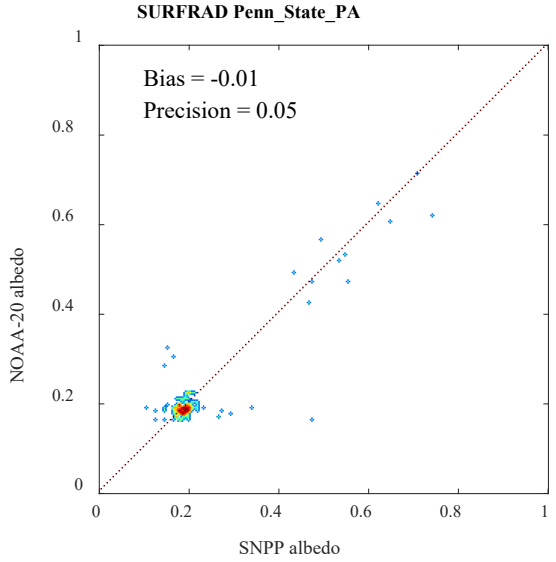










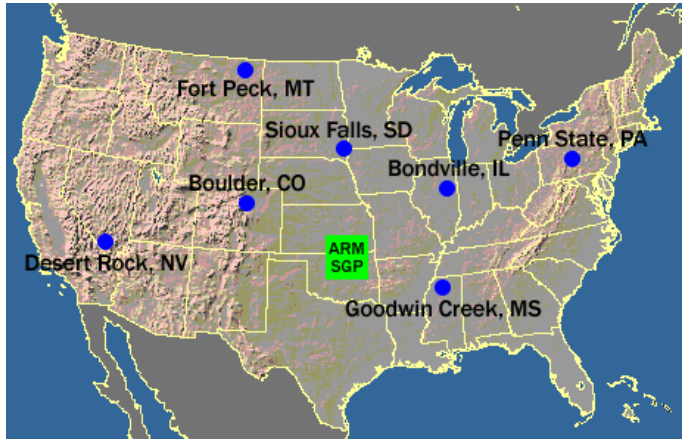


- Data source: the locally reprocessed albedo at SURFRAD sites from IDPS input.
- The SNPP albedo and NOAA-20 albedo are basically consistent; however, they both suffer from outliers due to the input EDR data quality.
- This comparison cannot define the product accuracy, but with the advantage of long time series and can serve as a reference.

Algorithm performance evaluation

SNPP vs. SURFRAD

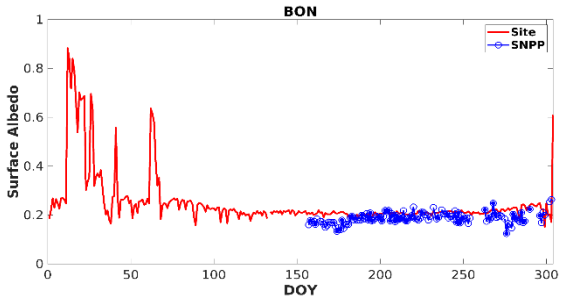
- SURFRAD

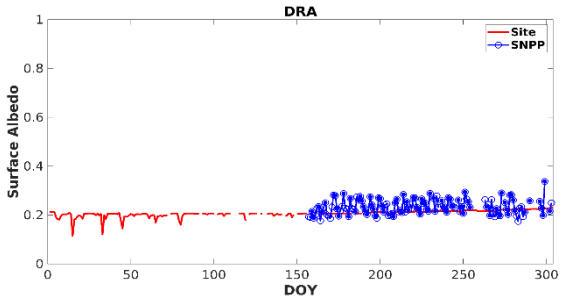


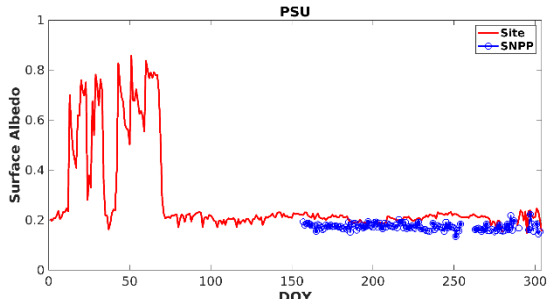
2019.06.07 – 2019.10.29

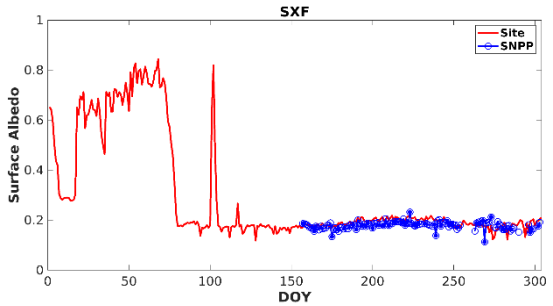
SITE	VIIRS-A (Bias)	NOAA-20 VIIRS-P (Std of Error)
Bondville_IL (BON)	-0.02	0.03
Boulder_CO (TBL)	-0.04	0.07
Desert_Rock_NV (DRA)	0.02	0.03
Fort_Peck_MT (FPK)	0.02	0.05
Goodwin_Creek_MS (GWN)	-0.01	0.02
Penn_State_PA (PSU)	-0.03	0.02
Sioux_Falls_SD (SXF)	-0.01	0.02

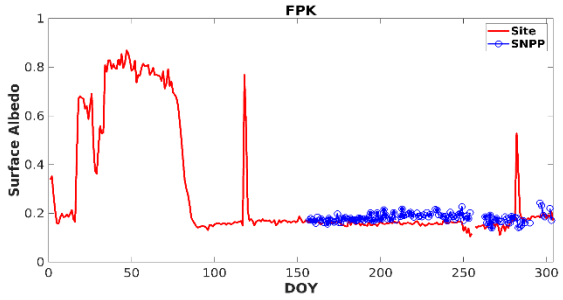
Note: the L1RD albedo requirement for Accuracy and Precision are 0.08 and 0.05 albedo unit, respectively.

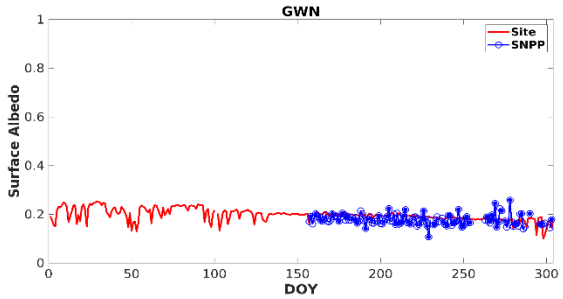


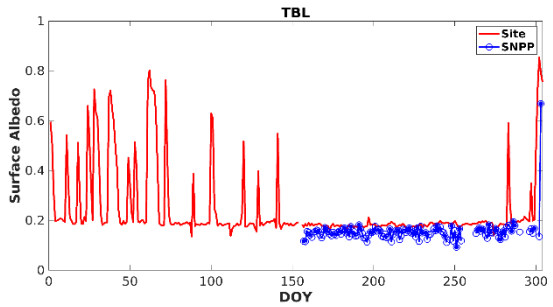










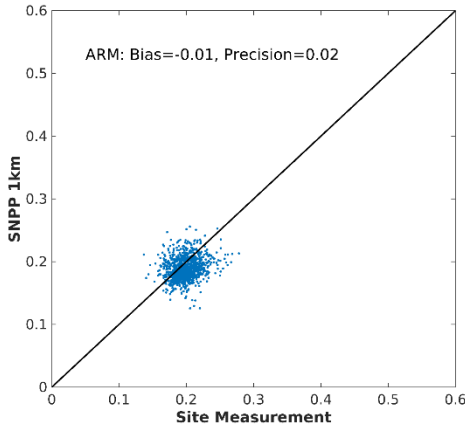


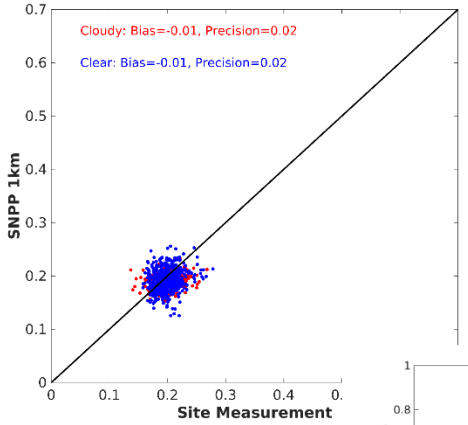
- Data source: the operational SNPP VIIRS SURFALB
- The operational SNPP SURFALB data demonstrates much less fluctuations than retrievals from IDPS input.

Algorithm performance evaluation

SNPP vs. ARM-SGP

- ARM-SGP data

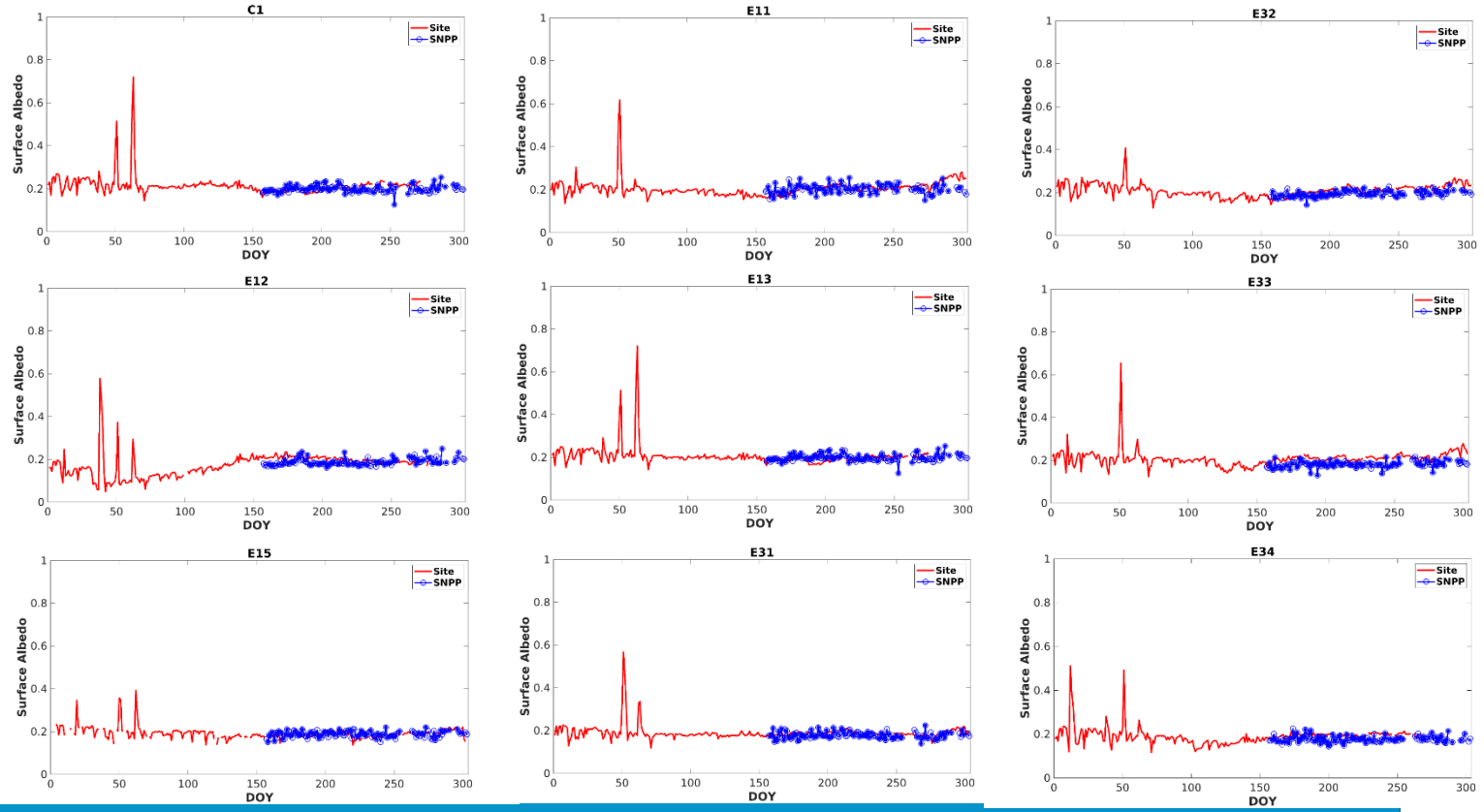




Code	Latitude	Longitude	Bias	Precision
C1	36.605	-97.48500	0.00	0.02
E11	36.881	-98.285	-0.01	0.03
E12	36.841	-96.427	-0.01	0.02
E13	36.605	-97.485	0.00	0.02
E15	36.431	-98.284	0.00	0.02
E31	37.1509	-98.362	-0.01	0.02
E32	36.189	-97.8199	-0.02	0.02
E33	36.9255	-97.0817	-0.03	0.02
E34	37.0694	-96.7606	-0.02	0.02

2019.06.07 – 2019.10.29

ARM-SGP

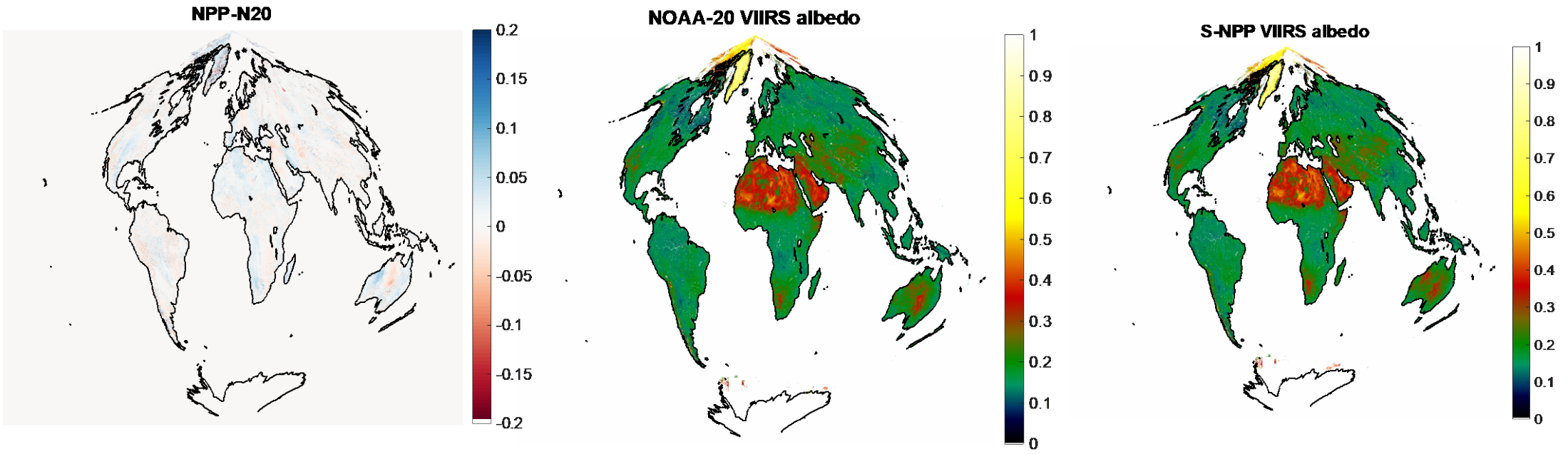


Algorithm performance evaluation

NOAA-20 vs. S-NPP

Single-day comparison

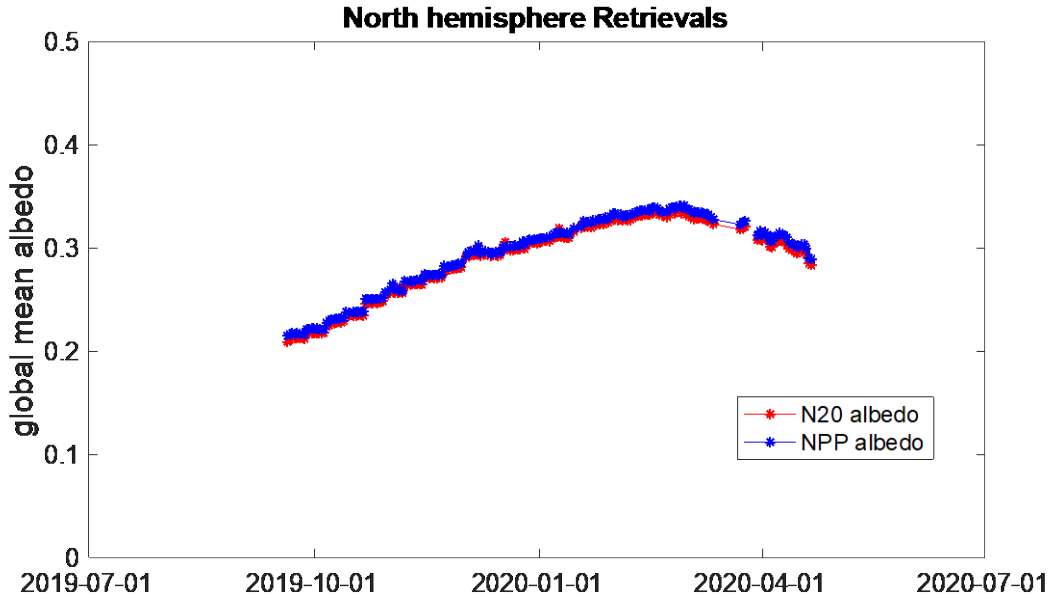
06/30/2019

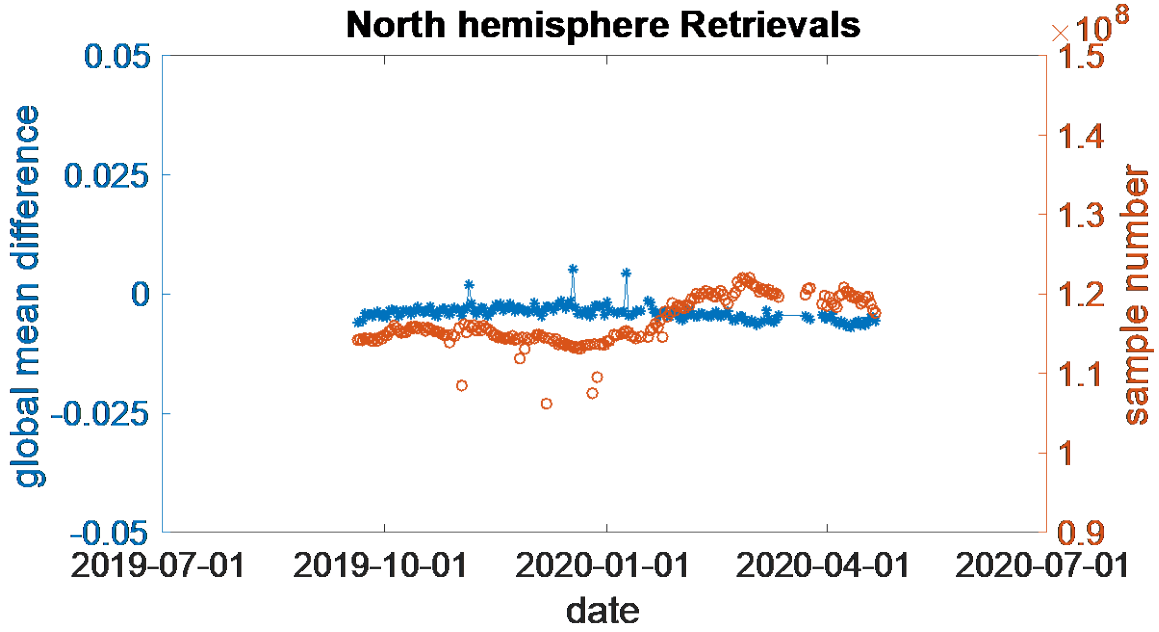


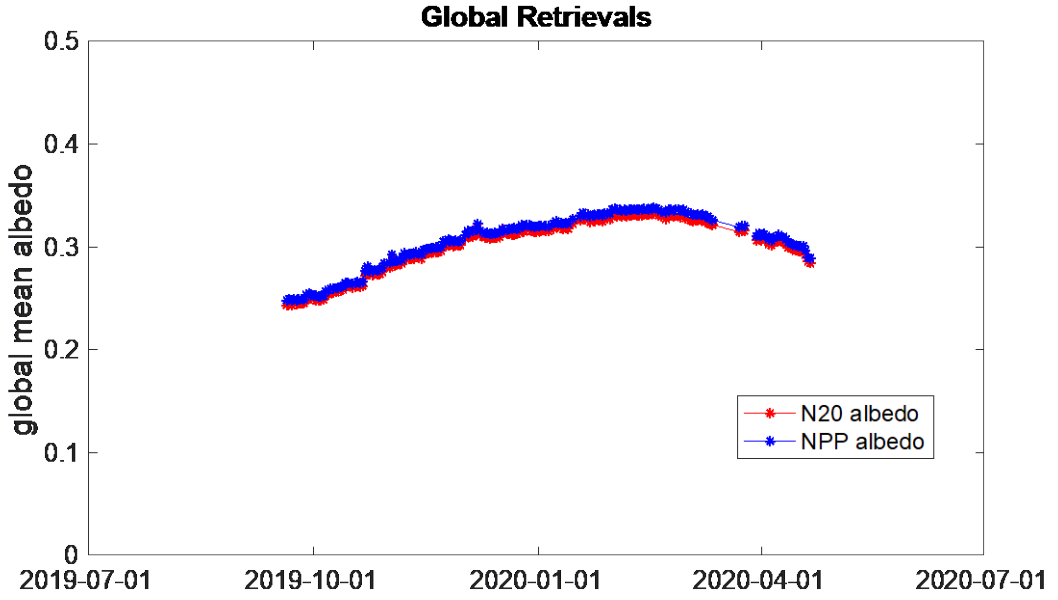
The daily comparison shows that the N20 and NPP albedos has minor difference which shows orbit features as the light blue and red strips in the left figure.

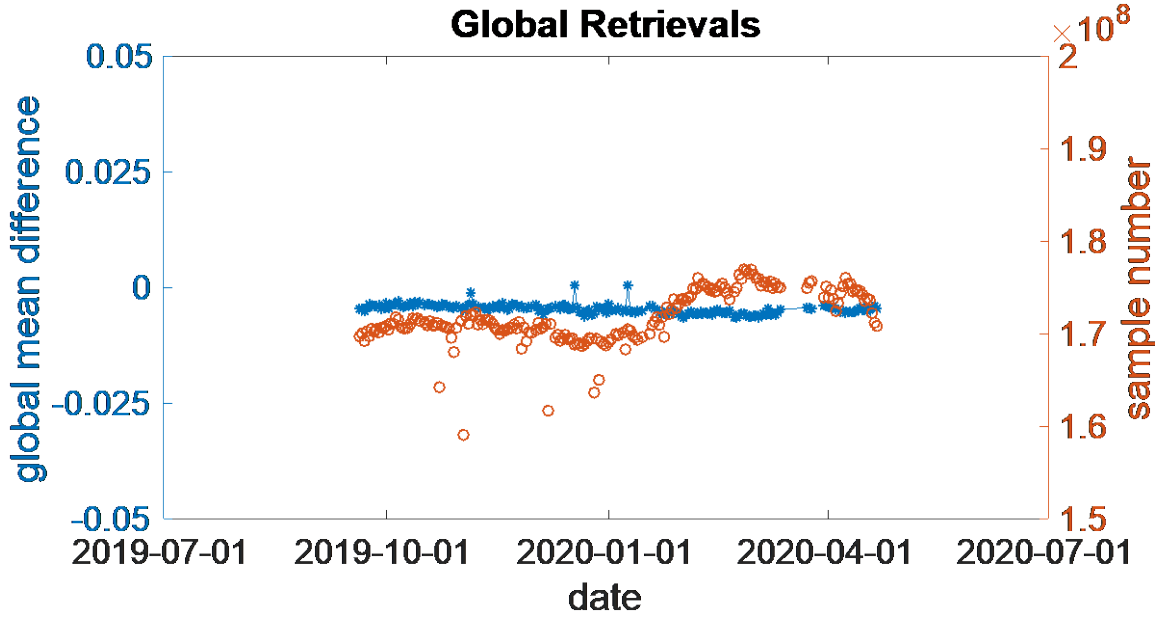
We have time-series comparison over their global mean albedo, which suggests their overall magnitude and calibration status is generally consistent in the following slides.

Time-series comparison between SNPP and NOAA-20







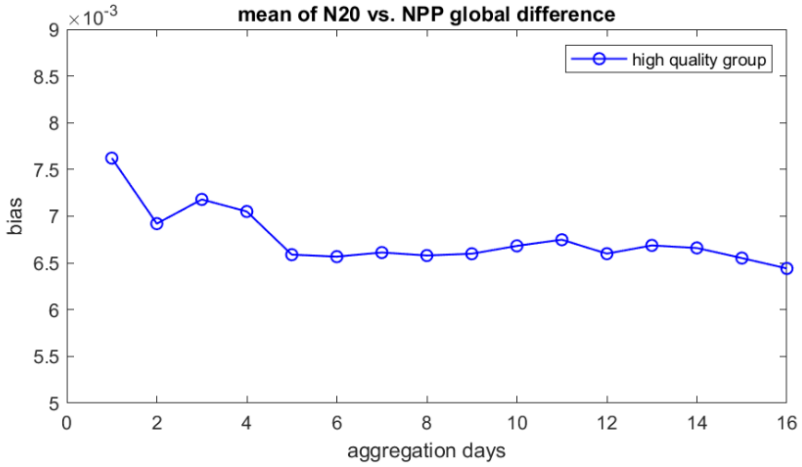


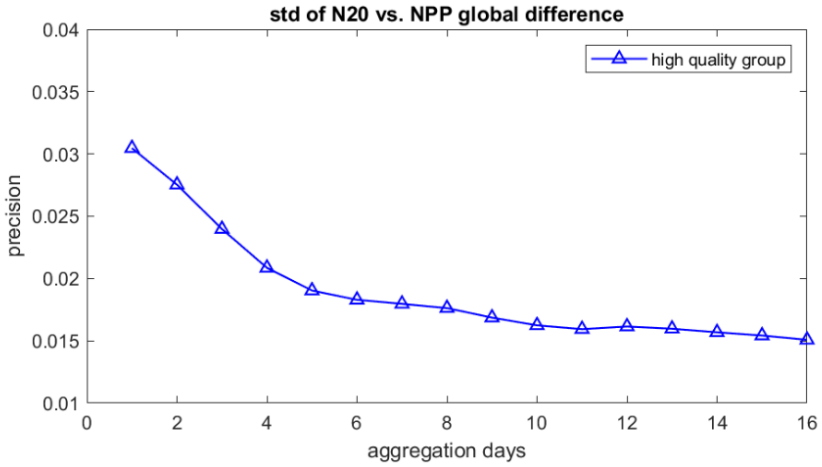
Algorithm performance evaluation

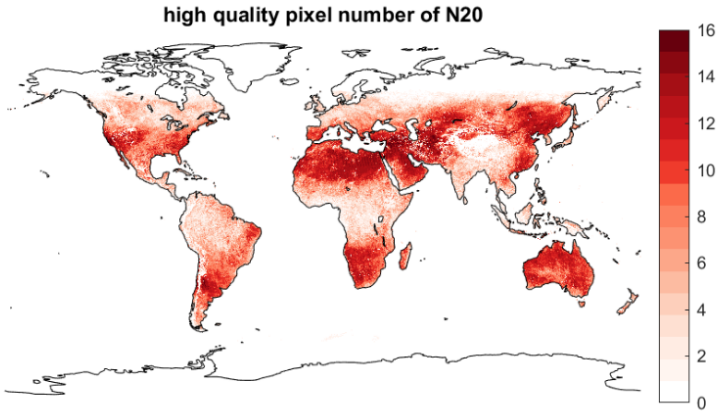
NOAA-20 vs. S-NPP

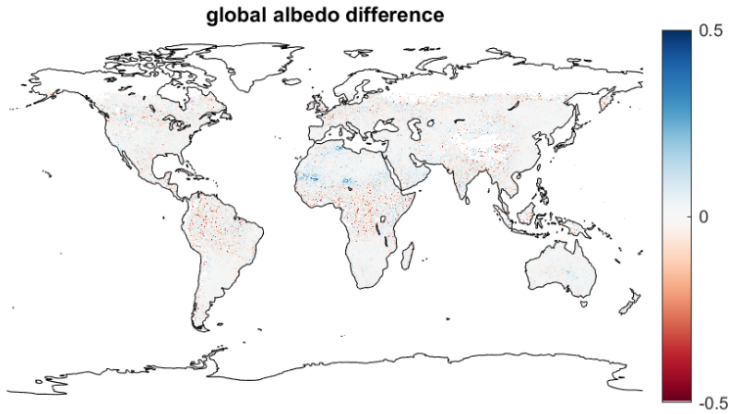
Temporal average comparison

- Test case: 09/20/2019~10/05/2019







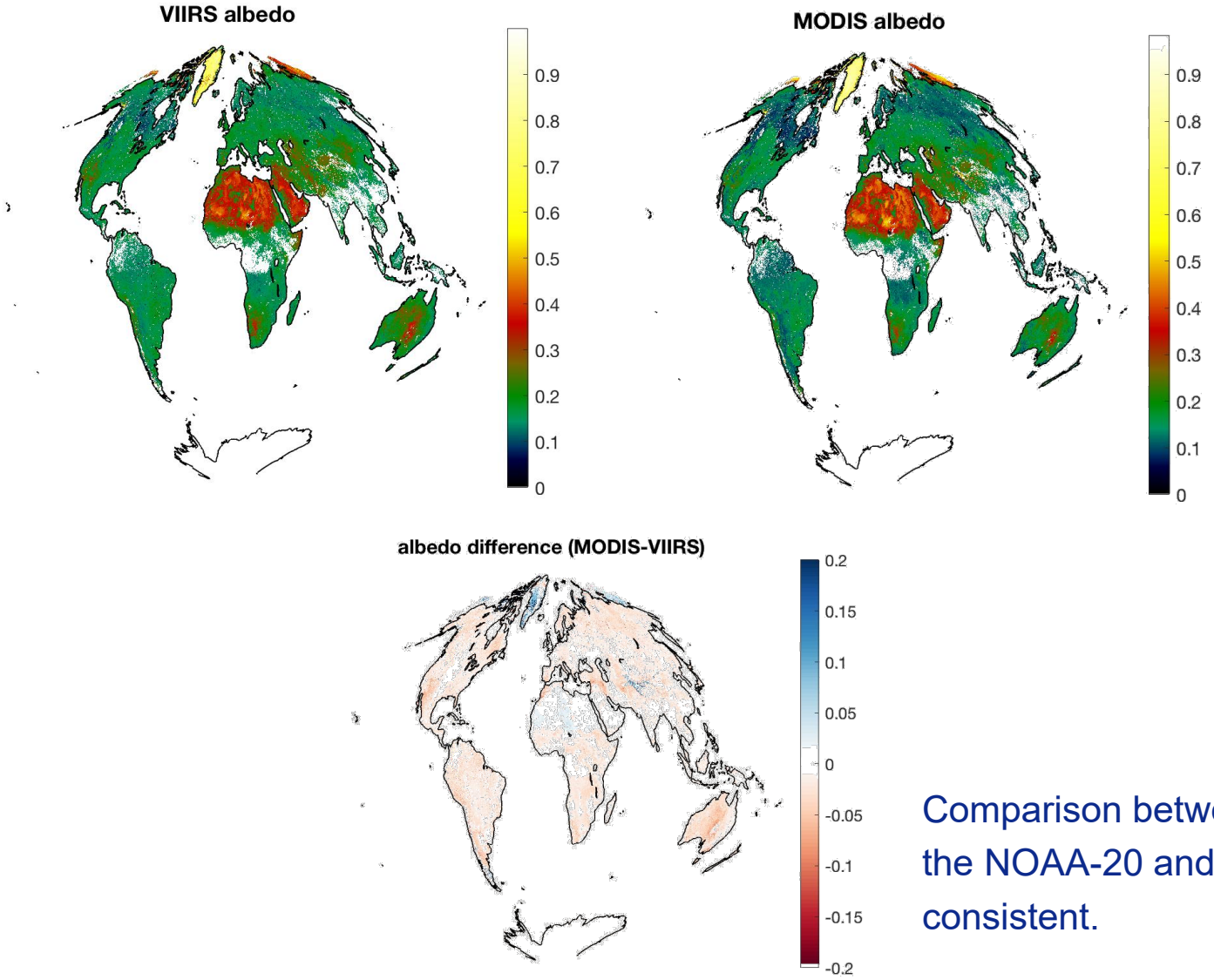


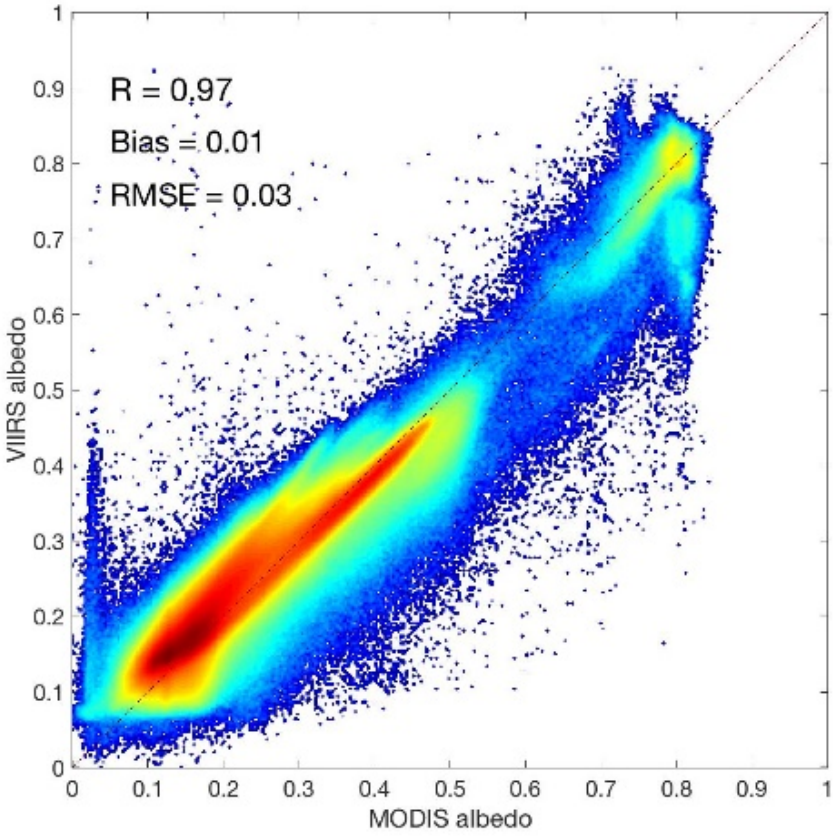
- Comparison between temporally aggregated albedo to decrease orbit influence
  1. Daily difference is partly due to the orbit coverage difference;
  2. Temporal aggregation over direct retrievals would decrease the difference.

Algorithm performance evaluation

NOAA-20 vs. MODIS global

Global 20190630



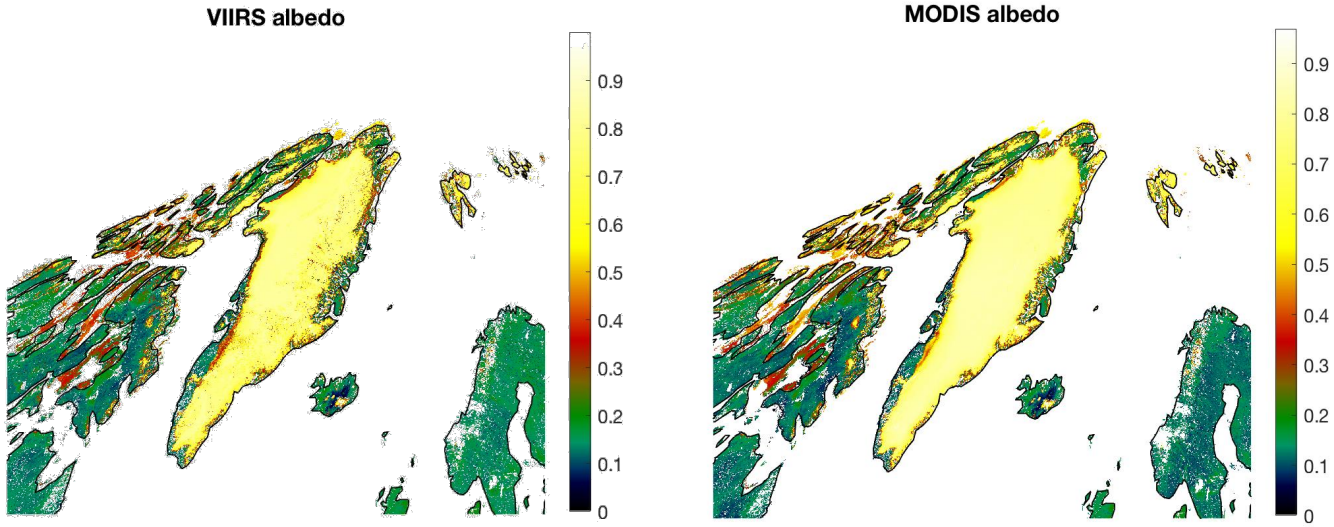


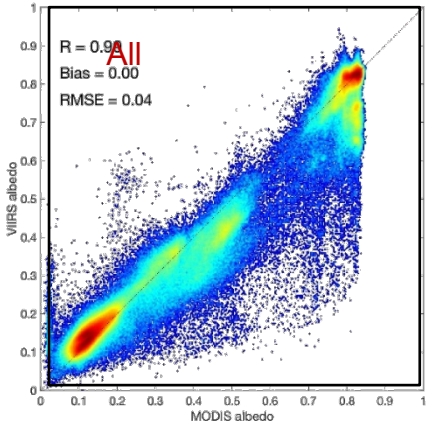
Comparison between high-quality retrievals over globe shows that the NOAA-20 and S-NPP VIIRS SURFALB are generally consistent.

Algorithm performance evaluation

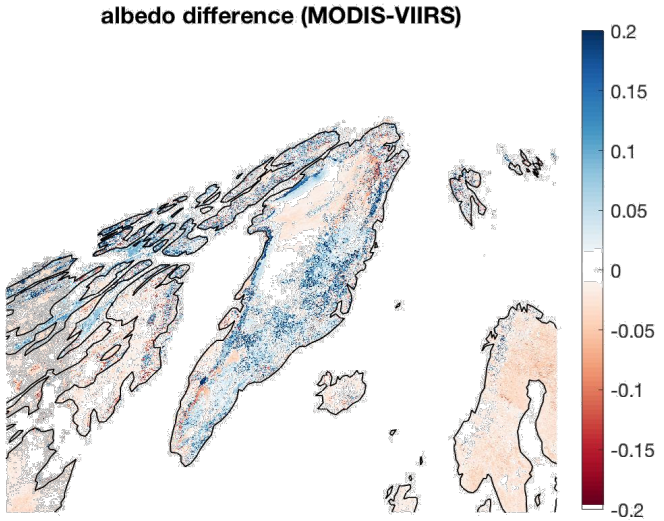
NOAA-20 vs. MODIS Greenland

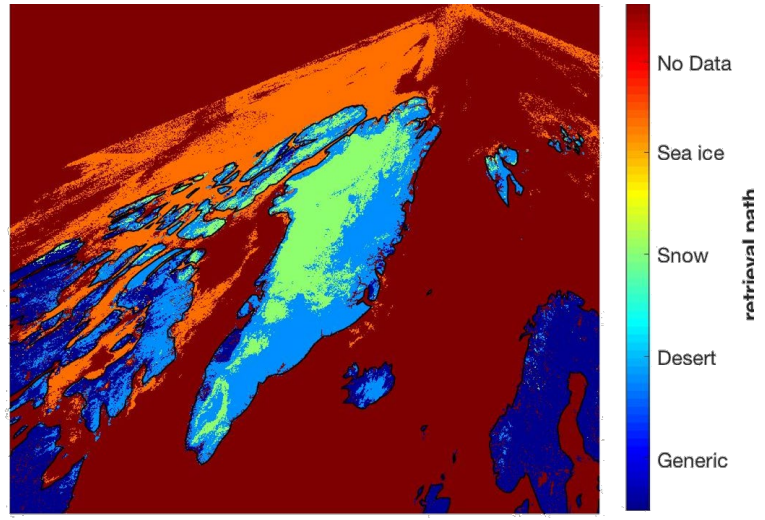
Greenland 20190630

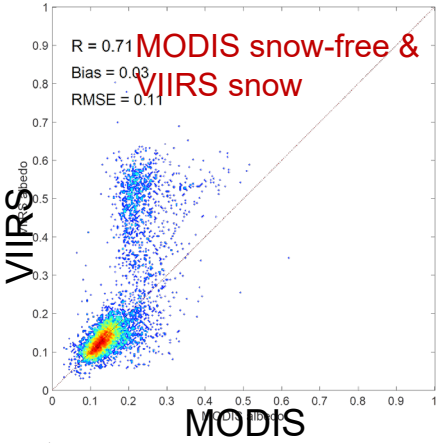


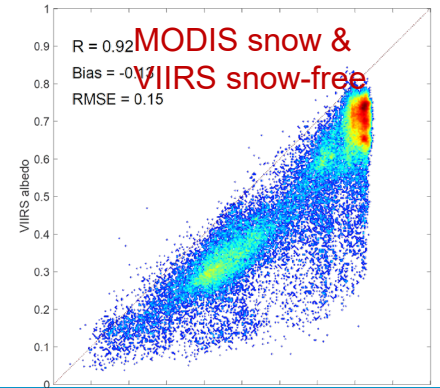


Bias exists over some snow pixel when the snow mask are inconsistent.





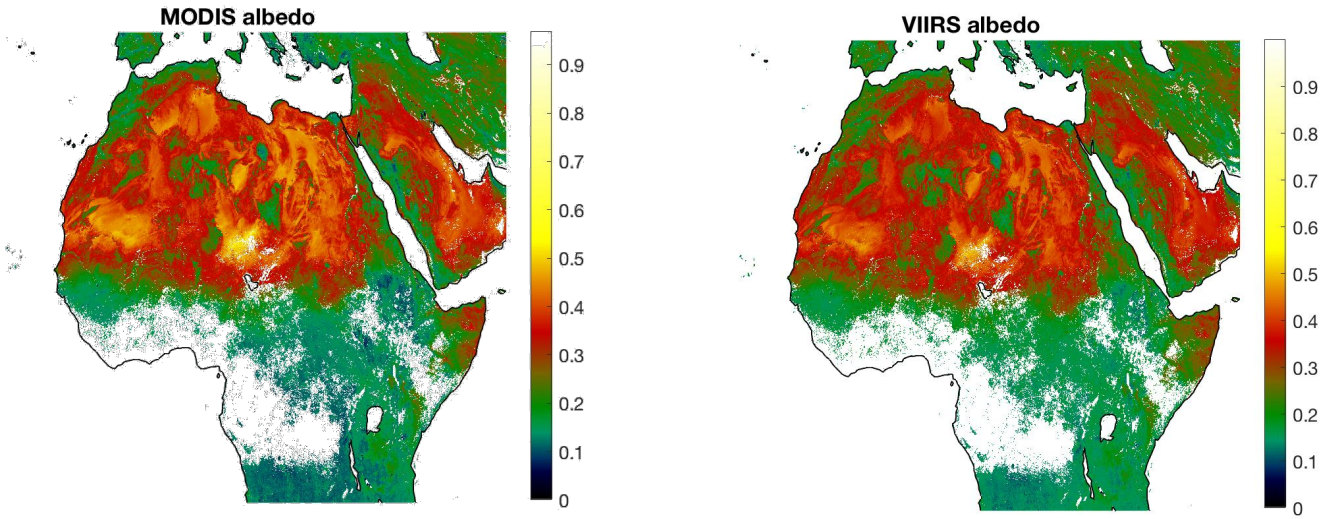


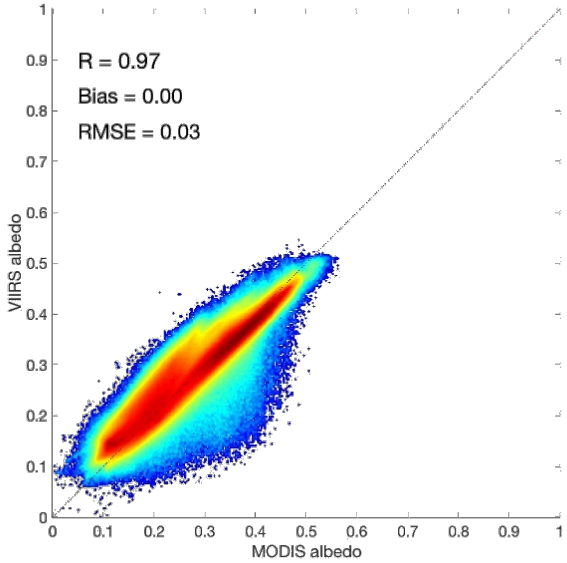


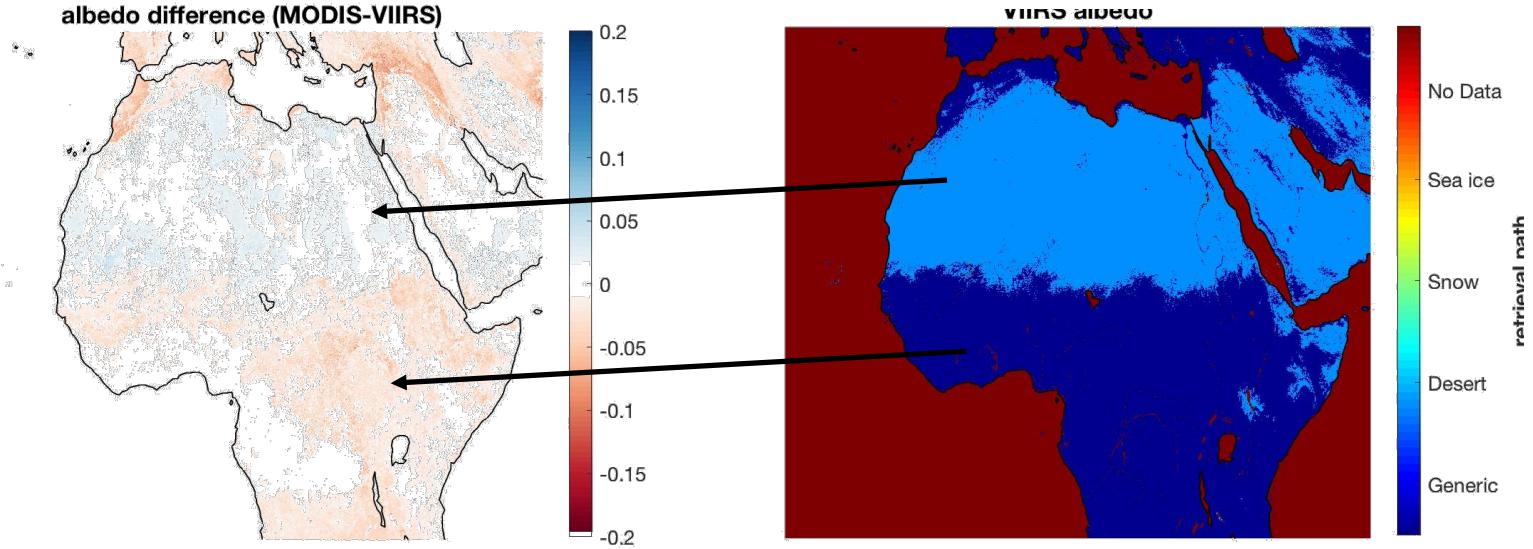
Algorithm performance evaluation

NOAA-20 vs. MODIS Sahara

Sahara 20190630





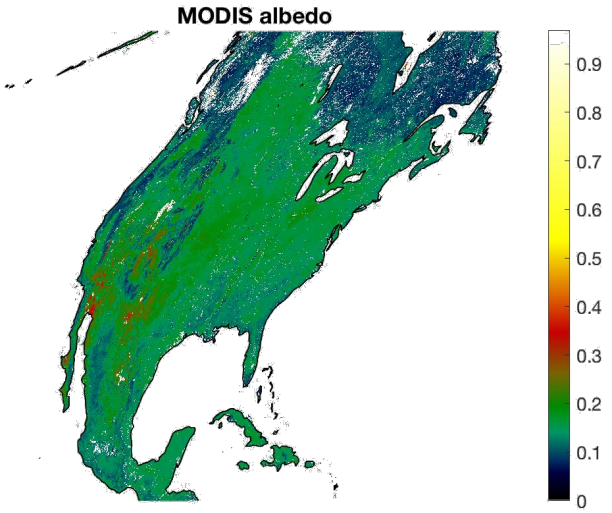


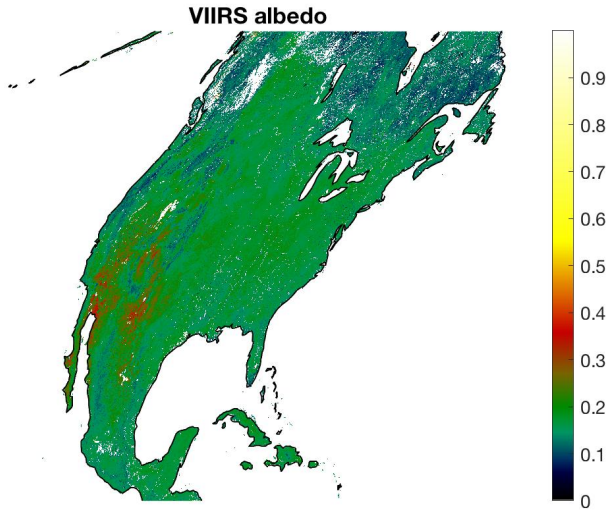
VIIRS retrieval from desert LUT is slightly lower than MODIS while the result from generic LUT is slightly higher. The difference is acceptable.

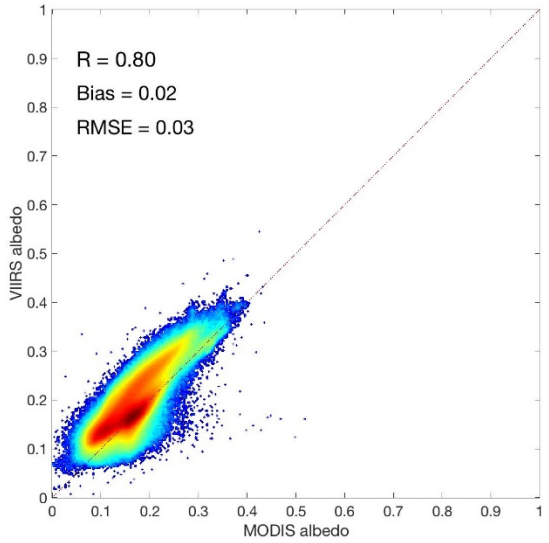
Algorithm performance evaluation

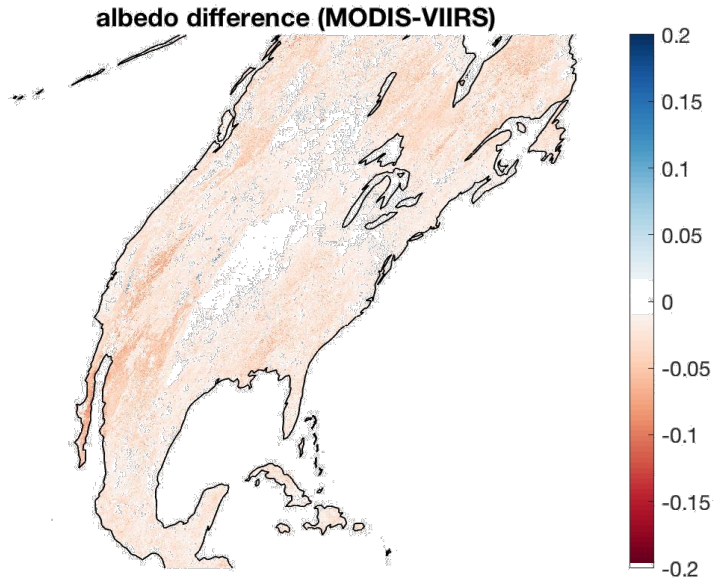
NOAA-20 vs. MODIS CONUS

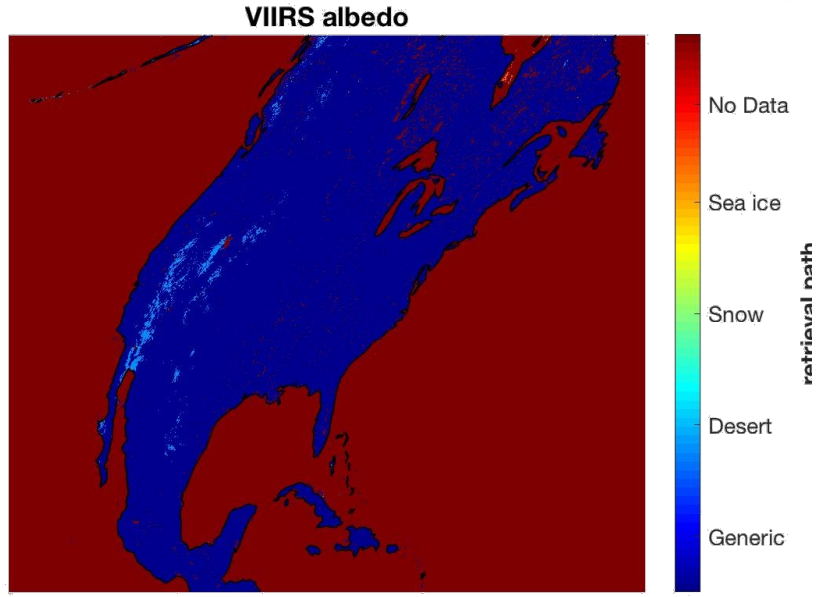
CONUS 20190630









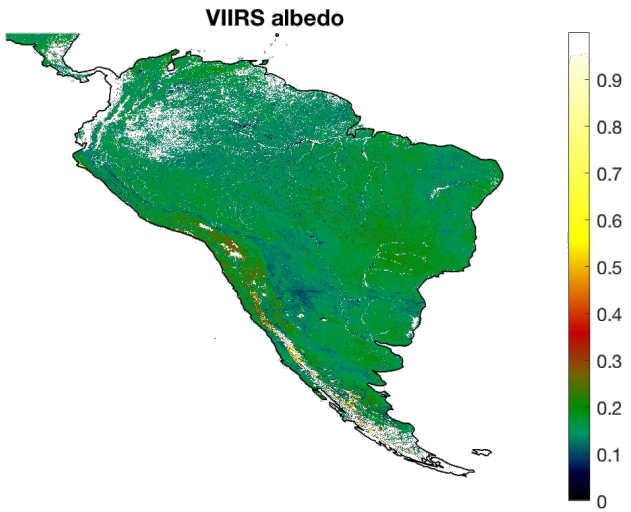


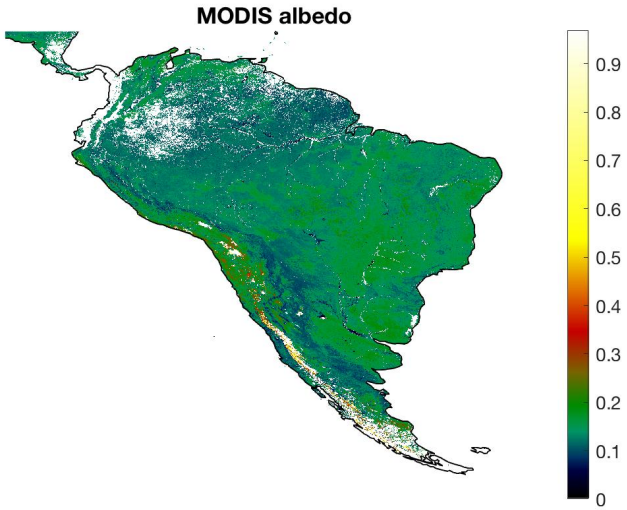
VIIRS and MODIS daily mean albedo show some difference over western US due to the terrain influence which would alter the actual irradiance to the local surface.

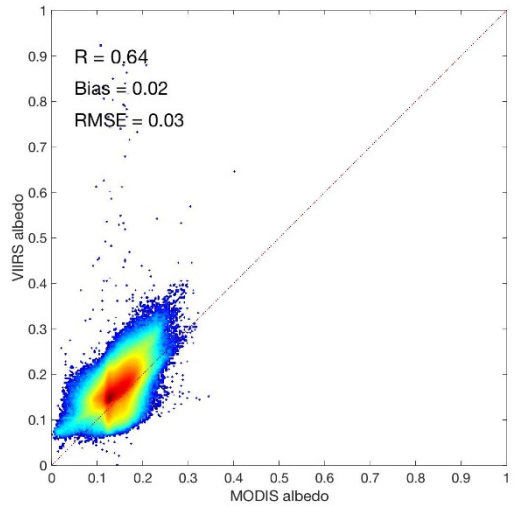
Algorithm performance evaluation

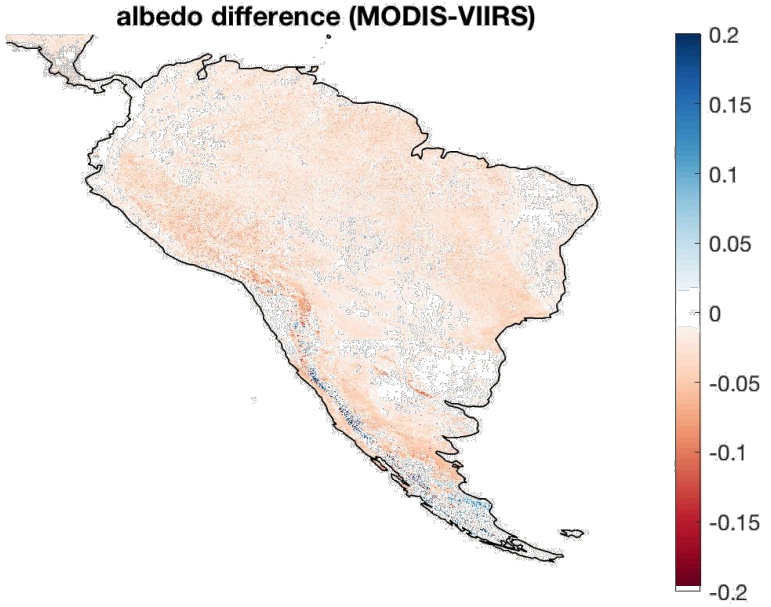
NOAA-20 vs. MODIS South America

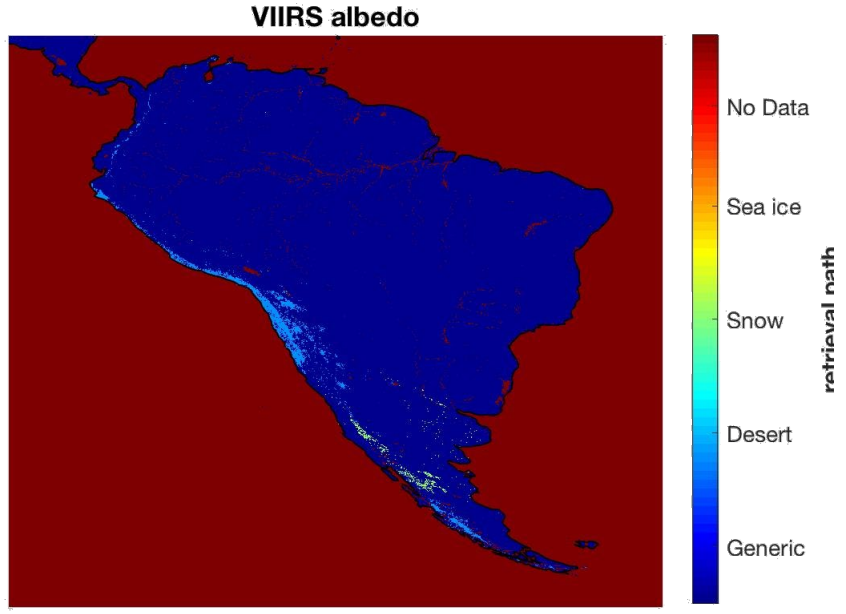
South America 20190630









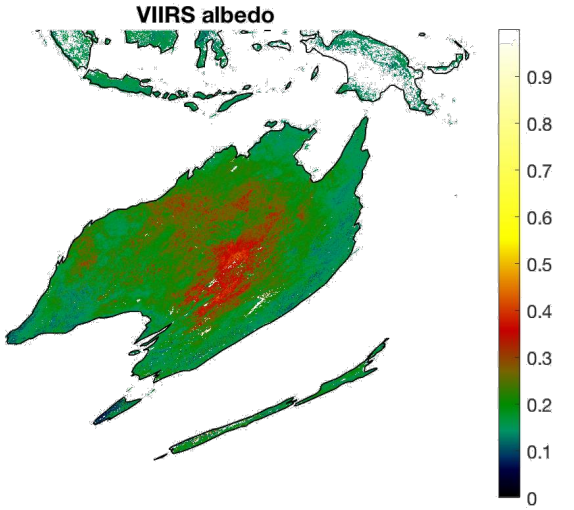


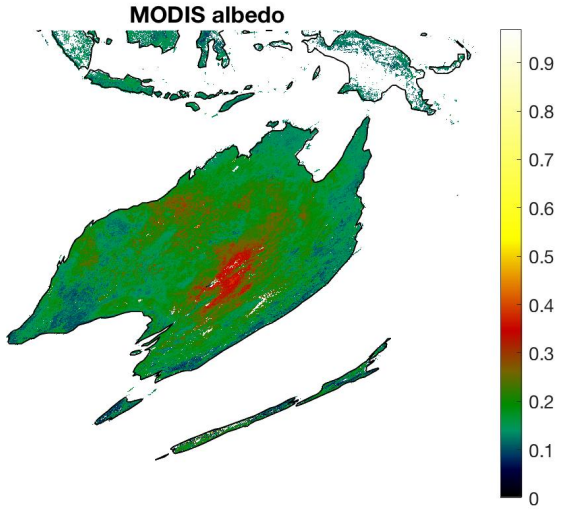
VIIRS and MODIS daily mean albedo match well over Amazon region, but shows some difference over Chile and Argentina due to terrain influence and surface heterogeneity.

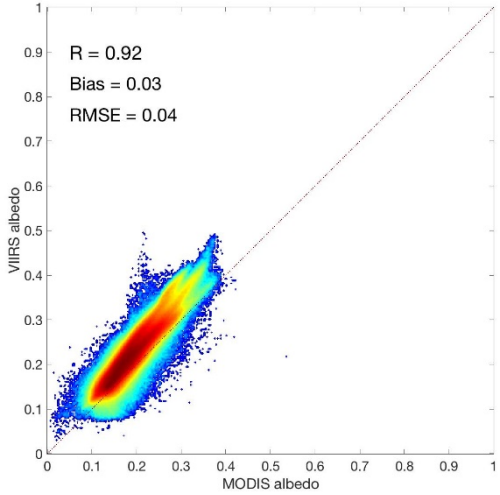
Algorithm performance evaluation

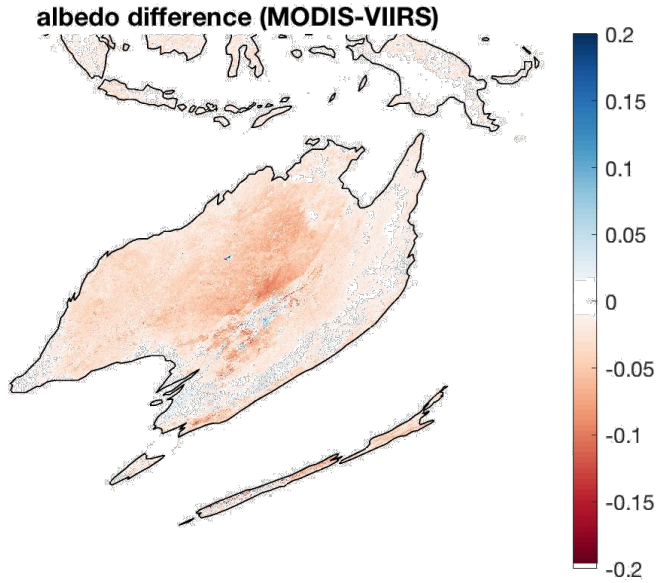
NOAA-20 vs. MODIS Australia

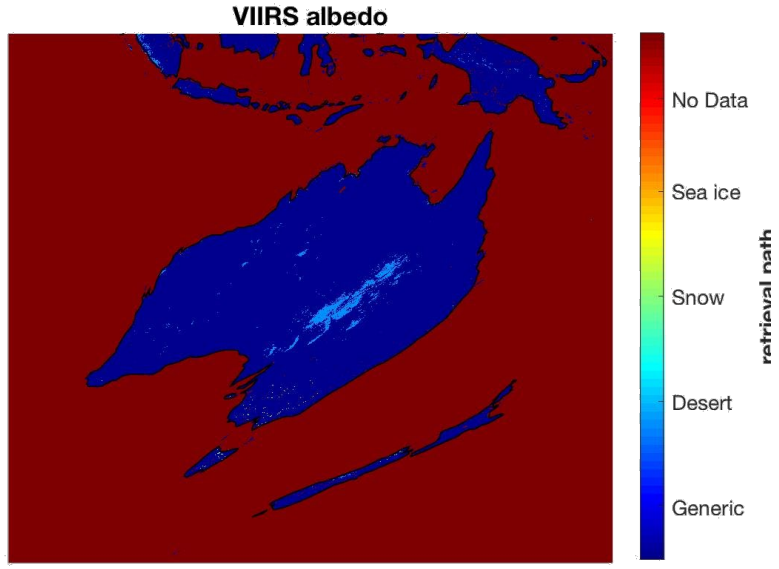
Australia 20190630









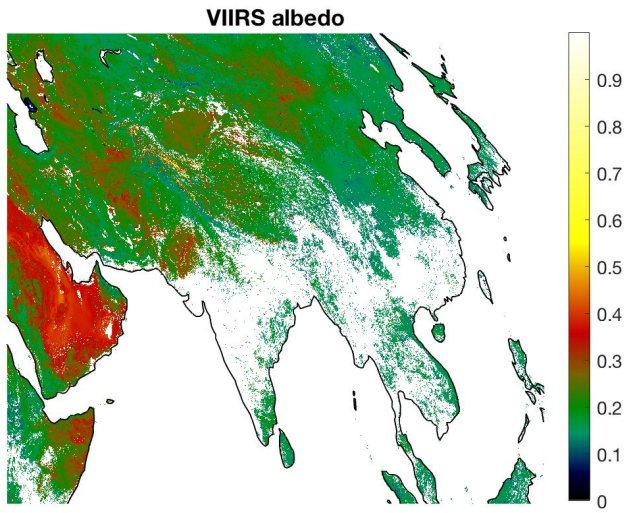


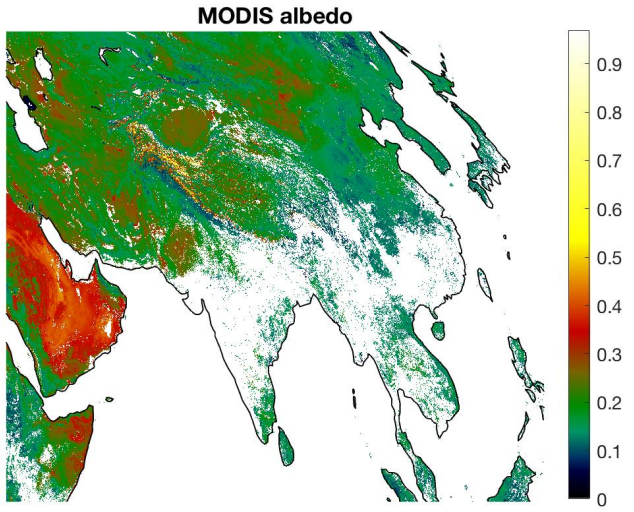
VIIRS and MODIS daily mean albedo match well over Australia except that the generic LUT of VIIRS will generate a slightly higher albedo than MODIS.

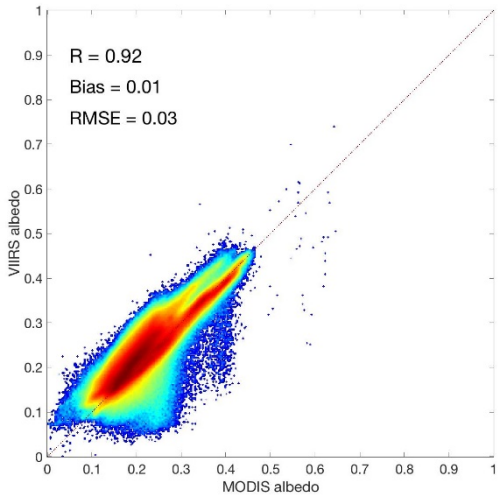
Algorithm performance evaluation

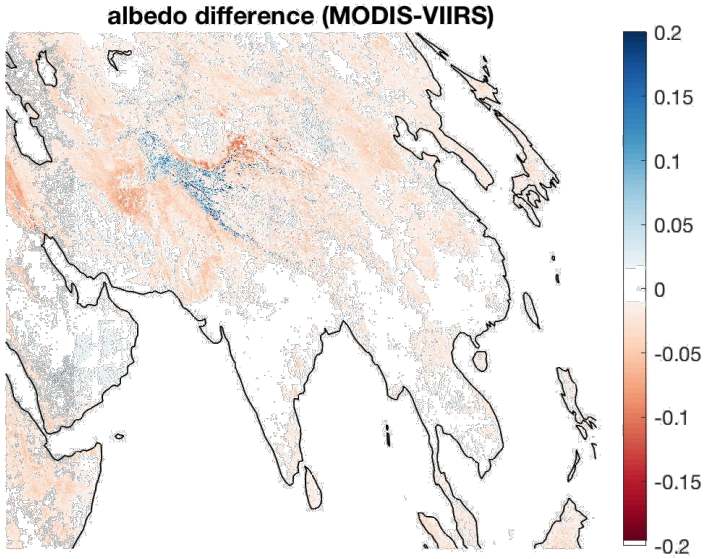
NOAA-20 vs. MODIS Asia

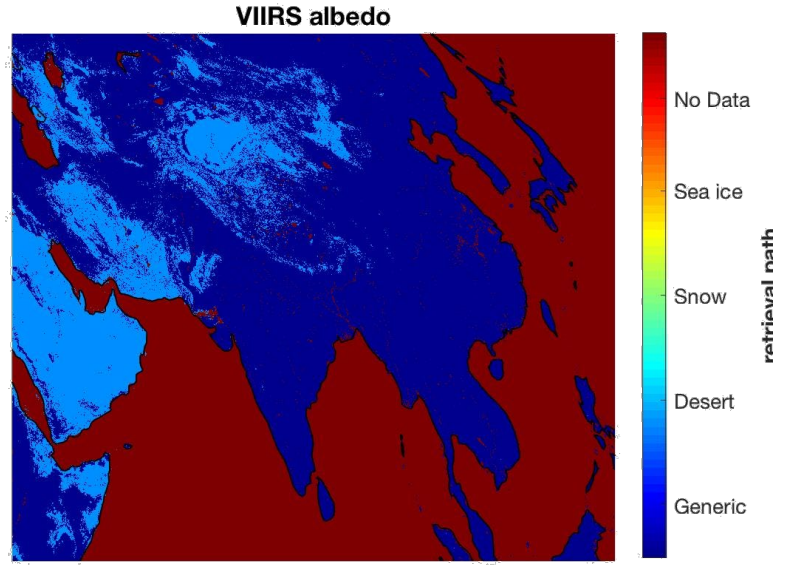
Asia 20190630











VIIRS and MODIS daily mean albedo match well over Asia except the central mountainous area due to the terrain effect.

User Feedback

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Xiwu Zhan	STAR	improve land surface model simulation of soil moisture	Real-time albedo data can substantially improve land surface model simulation of soil moisture compared to the multi-year averages of land surface albedo, which is used by the current operational Noah land surface model. The daily VIIRS albedo product will be the ideal input for this purpose. The VIIRS near real time albedo product will also be needed for our daily evapotranspiration data production.
Feng Gao	USDA	deriving evapotranspiration and drought monitoring	Land surface albedo, as a key component of surface radiation budget, is needed for deriving evapotranspiration and drought monitoring. The VIIRS land surface albedo product will provide us the continued data coverage as replacement of MODIS albedo product.
David Mocko	NASA	land data assimilation system	Land surface albedo is an important input parameter of land surface models. Many land data assimilation systems use albedo climatology because of gaps and uncertainties of existing albedo products. A high-quality gap-free gridded land surface albedo product such as VIIRS land surface albedo product is needed for improved hydrologic and land products from a land data assimilation system.

Downstream Product Feedback

No Downstream Product for Albedo so far

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
snow cover inconsistency	The snow cover EDR input cannot recognize all snow cover and shows some inconsistency between SNPP and JPSS-1, which decrease the snow albedo accuracy	High	**Open.** The issue would be partly improved through recognizing permanent snow using VIIRS surface type data (input depending on framework feed)
new albedo climatology has not been applied in NDE	Updated climatology in framework has not been applied in operational system, which decreased the sea-ice albedo accuracy	High	**Open**. The latest climatology would be delivered from framework to NDE soon
Artificial data discontinuity over Greenland in October	Data discontinuity within Greenland in October happened due to the climatology discontinuity, which has influenced the regional data discontinuity	Medium	**Open**. It is planned to be developed and delivered in July 2020 DAP
NOAA-20 land LUTs update	The new NOAA-20 LUTs have been developed according to the spectral response function of NOAA VIIRS sensor	High	**Closed**. The new LUTs have been used in operational system.
Sea-water pixels not set as fill value	Some sea water pixels have albedo values derived from climatology data	Medium	**Closed**. The sea-water pixels have been set as fill value
Pure sea-water granules with all fill value	The pure sea-water granules are included in the output but with no valid retrieval	Low	**Closed**. The pure sea-water granules have been excluded from the output
Pure sea-water tiles go through calculation	I/O of pure sea-water tiles has cost computation resource	Low	**Closed**. The pure sea-water tiles have been skipped from the calculation process.

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

Peer-reviewed publications:

1. Peng, J. J., Yu, Y. Y., Yu, P., & Liang, S. L. (2018). The VIIRS Sea-Ice Albedo Product Generation and Preliminary Validation. *Remote Sensing*, 10(11). [10.3390/rs10111826]
2. Wang, D. D., Liang, S. L., Zhou, Y., He, T., & Yu, Y. Y. (2017). A New Method for Retrieving Daily Land Surface Albedo from VIIRS Data. *IEEE Transactions on Geoscience and Remote Sensing*, 55(3), 1765-1775. [10.1109/tgrs.2016.2632624]
3. Zhou, Y., Wang, D., Liang, S., Yu, Y., & He, T. (2016). Assessment of the Suomi NPP VIIRS Land Surface Albedo Data Using Station Measurements and High-Resolution Albedo Maps. *Remote Sensing*, 8(2). [10.3390/rs8020137]
4. Wang, D. D., Liang, S. L., He, T., & Yu, Y. Y. (2013). Direct Estimation of Land Surface Albedo from VIIRS Data: Algorithm Improvement and Preliminary Validation. *Journal of Geophysical Research-Atmospheres*, 118(22), 12577-12586. [10.1002/2013jd020417]

Check List - Validated Maturity

Validated Maturity End State	Assessment
Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).	**Yes**, both direct-comparison with long-term SURFRAD station measurements and cross-comparison with MODIS albedo have been conducted.
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.	**Yes**, all potential issues have been included in the ATBD, review reports, readme files, and published papers.
Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.	**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.
Product is ready for operational use based on documented validation findings and user feedback.	**Yes**, the current product has met the requirements and ready for use. Continuous effort will be invested for further improvements.
Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument	**Yes**, the product will be monitored through the lifetime for periodically and regularly validation and calibration according to the sensor performance.

Requirement Check List – Albedo

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

Conclusion

The Albedo team recommends the NOAA20 VIIRS Albedo product validated maturity based on its performance in the ground validation, long term monitoring and global cross-satellite Albedo comparison.

Path Forward

- Algorithm improvements
  - Switch the surface type input from AVHRR to VIIRS
  - Climatology Update
    - Update sea-ice albedo climatology (delivered to ASSISTT in Sep 2018)
    - Update climatology over Greenland and Antarctic
- Future Cal/Val activities / milestones
  - Comprehensive Validation over more networks
  - Annual validation reports
- Improved albedo products
  - NOAA-20 Gridded Surface Albedo Product (Integrated)
  - Blended Albedo product with S-NPP VIIRS Albedo (in investigation)
- Promote the application of VIIRS SURFALB product in NOAA climate models

Thank You !