Beta Maturity Science Review
For
NOAA-20 VIIRS Surface Albedo EDR

Prepared by

Yunyue Yu, NESDIS/STAR

Jingjing Peng, Yuan Zhou, Dongdong Wang, ESSIC/CICS

July 19, 2018

Outline

- LSA Cal/Val Team Members
- Product Requirements
- NOAA 20 VIIRS LSA Status
- Preliminary Evaluation of the LSA
- Documentation (Science Maturity Check List)
- Beta Maturity Conclusions
- Path Forward/Future Plan

LSA EDR Cal/Val Team Members

	Name	Organization	Major Task
STAR/EMB	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
STAR/OPDB	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

Product Requirements

Product Requirements from JPSS L1RD*

	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	0.05 (albedo units)	0.02
Measurement Precision	0.08 (albedo units)	0.0125

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

JPSS Data Products Maturity Definition

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.

NOAA-20 VIIRS Albedo Status

- The enterprise VIIRS Albedo algorithm has been developed and integrated into the framework. The final DAP (originally for SNPP) was delivered to NDE at the end of March, 2018.
- The enterprise LSA process is a consist of two components. The granule albedo is computed online from a combination of the direct estimated albedo and a historical temporally filtered gap-free albedo; the historical albedo is computed offline using previous days granule albedo.
- The enterprise LSA algorithm is applied in NDE for NOAA 20 data, with the LUTs developed for S-NPP VIIRS sensor.
- The LUT for NOAA-20 LSA production has been developing, and will be applied for the LST provisional release.
- Evaluation of the NDE NOAA-20 LSA data by the science team (following slides) is limited. .

Evaluation method

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

NOAA 20 Albedo Product Format

NetCDF format

Name	Long Name	Type
SURFALB_v1r0_j01_s2018070...	SURFALB_v1r0_j01_s201807020013040_e201807020014285_c20180703...	Local File
AlbOff	VIIRS LSA Albedo Offset	—
AlbScl	VIIRS LSA Albedo Scale Factor	—
CldConfCld	VIIRS LSA Cloud Condition: Confidently Cloudy	—
CldConfClr	VIIRS LSA Cloud Condition: Confidently Clear	—
CldProbCld	VIIRS LSA Cloud Condition: Probably Cloudy	—
CldProbClr	VIIRS LSA Cloud Condition: Probably Clear	—
DataQualityFlag	VIIRS LSA 2-bit High-Quality Flag	Geo2D
Latitude	Latitude	2D
Longitude	Longitude	2D
MaxLSA	Maximum of valid retrieval LSA	—
MeanLSA	Average of valid retrieval LSA	—
MinLSA	Minimum of valid retrieval LSA	—
OnFltFltd	VIIRS LSA Online Filter: Online Filtered	—
OnFltNoFlt	VIIRS LSA Online Filter: No Online Filter	—
OvQltyHghQltyRtr	VIIRS LSA Overall Quality: High Quality Retrieval	—
OvQltyNoRtr	VIIRS LSA Overall Quality: No Retrieval	—
OvQltyRtr	VIIRS LSA Overall Quality: Retrieval	—
PercentClearPixels	Percentage of clear pixels	—
PercentFilteredPixel	Percentage of filtered pixels over all valid retrievals	—
PercentHighQuality	Percentage of high-quality retrievals over all valid retrievals	—
PercentLandPixels	Percentage of land pixels	—
PercentLargeSZAPixels	Percentage of large solar zenith angle pixels (sza > 60)	—
PercentLargeVZAPixels	Percentage of large view zenith angle pixels (vza > 60)	—
PercentSeaicePixels	Percentage of seaice pixels	—
ProductQualityInformation	VIIRS LSA 2-byte Quality Flag	Geo2D
RtrPthDst	VIIRS LSA Retrieval Path: Desert	—
RtrPthGen	VIIRS LSA Retrieval Path: Generic	—
RtrPthNoRtr	VIIRS LSA Retrieval Path: No Retrieval	—
RtrPthSI	VIIRS LSA Retrieval Path: Sea Ice	—
RtrPthSnw	VIIRS LSA Retrieval Path: Snow	—
StartColumn	Start column index	—
StartRow	Start row index	—
StdLSA	Standard deviation of valid retrieval LSA	—
SZAFav	VIIRS LSA Solar Zenith Angle: Favorable SZA	—
SZALge	VIIRS LSA Solar Zenith Angle: Very Large SZA	—
TFDegRtr	VIIRS LSA Temporal Filter Flag: Degraded Retrieval	—
TFHghRtr	VIIRS LSA Temporal Filter Flag: High-Quality Retrieval	—
TFNoRtr	VIIRS LSA Temporal Filter Flag No Retrieval	—
VIIRS_Albedo_EDR	Improved VIIRS Land Surface Albedo	Geo2D
VIIRS_Albedo_IP	Primary VIIRS Land Surface Albedo Clear	Geo2D
VZAFav	VIIRS LSA View Zenith Angle: Favorable VZA	—
VZALge	VIIRS LSA View Zenith Angle: Very Large VZA	—

Show: All variables

File "SURFALB_v1r0_j01_s201807020013040_e201807020014285_c201807030851540.nc"

File type: Hierarchical Data Format, version 5

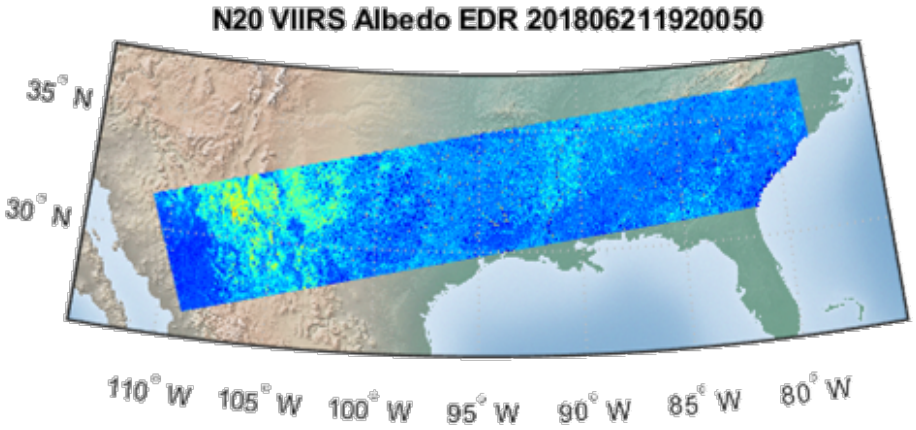
```
netcdf file:/G:/ScienceData/20171120-J1/J1_framework/new_version/20180702/SURFALB_v1r0_j01_
  dimensions:
    Columns = 3200;
    Rows = 768;
  variables:
    int StartRow;
      :long_name = "Start row index";

    int StartColumn;
      :long_name = "Start column index";

    short VIIRS_Albedo_IP(Rows=768, Columns=3200);
      :coordinates = "Longitude Latitude";
      :units = "1";
      :_FillValue = 32767S; // short
      :valid_range = 0S, 10000S; // short
      :long_name = "Primary VIIRS Land Surface Albedo Clear";
      :_ChunkSizes = 256U, 200U; // uint

    short VIIRS_Albedo_EDR(Rows=768, Columns=3200);
      :coordinates = "Longitude Latitude";
      :units = "1";
      :_FillValue = 32767S; // short
      :valid_range = 0S, 10000S; // short
      :long_name = "Improved VIIRS Land Surface Albedo";
      :_ChunkSizes = 256U, 200U; // uint

    byte DataQualityFlag(Rows=768, Columns=3200);
      :_FillValue = 2B; // byte
      :valid_range = 0B, 2B; // byte
      :units = "1";
      :long_name = "VIIRS LSA 2-bit High-Quality Flag";
      :coordinates = "Longitude Latitude";
      :_ChunkSizes = 256U, 200U; // uint

    ...rmation(Rows=768, Columns=3200);
    ...A 2-byte Quality Flag";
    ...ude Latitude";
      :_FillValue = -1S; // short
      :valid_range = 0S, 32767S; // short
      :_ChunkSizes = 256U, 200U; // uint
```

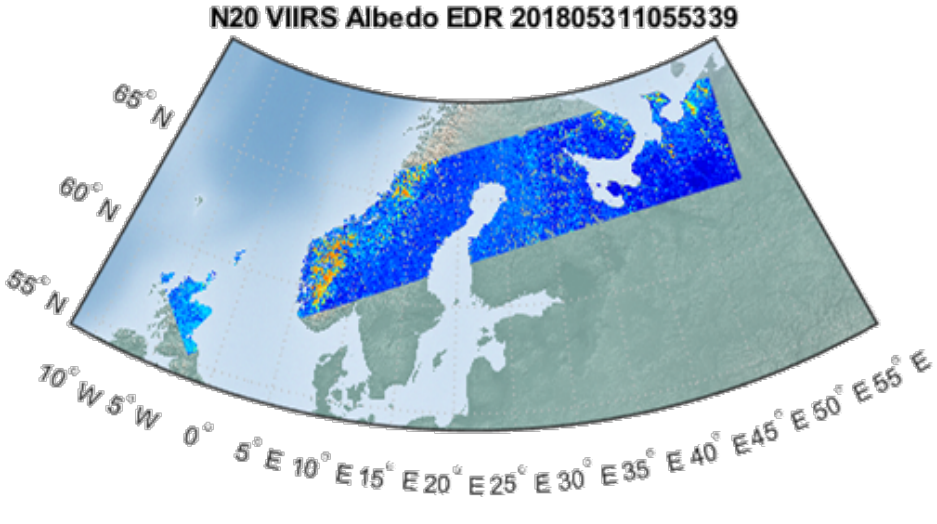
Metadata

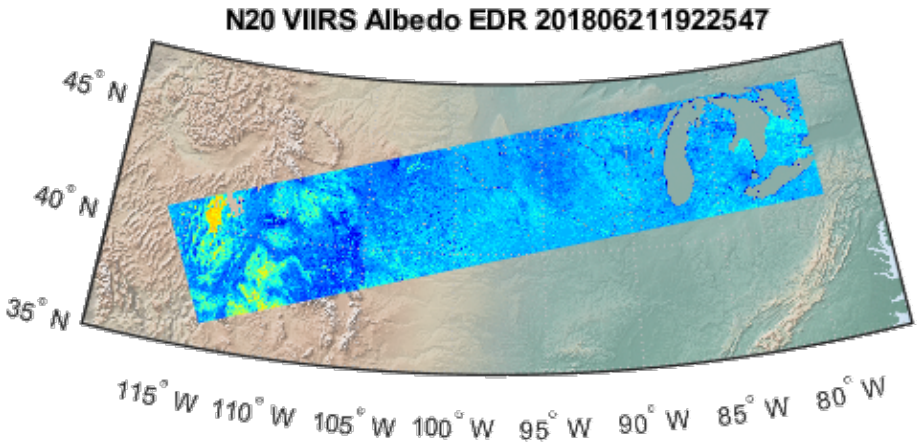
LSA Quality Flag

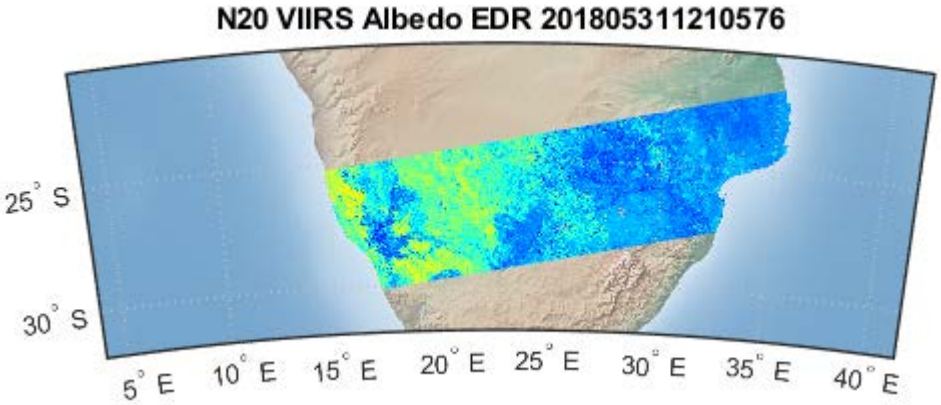
LSA Value

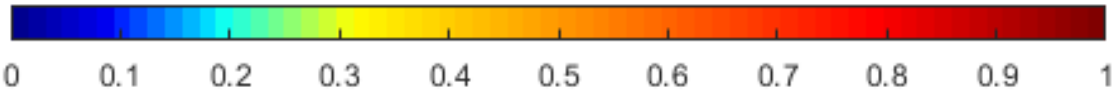
N20 VIIRS NDE Albedo EDR Example-Granules





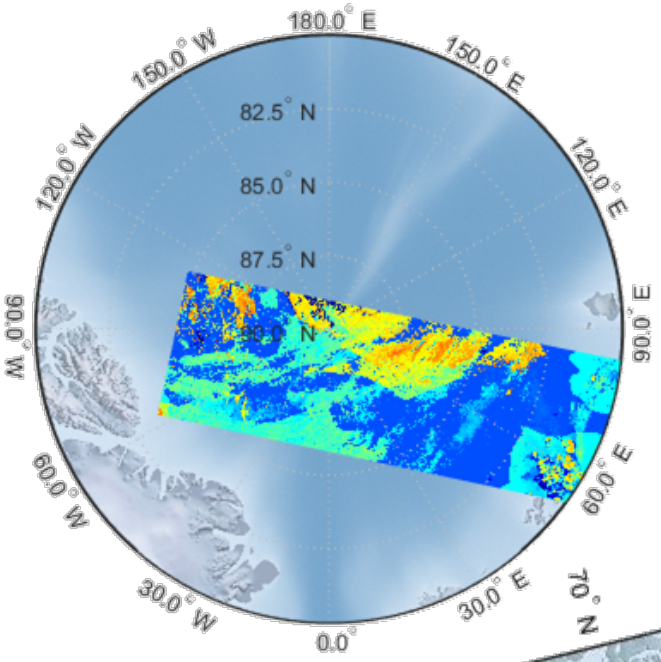




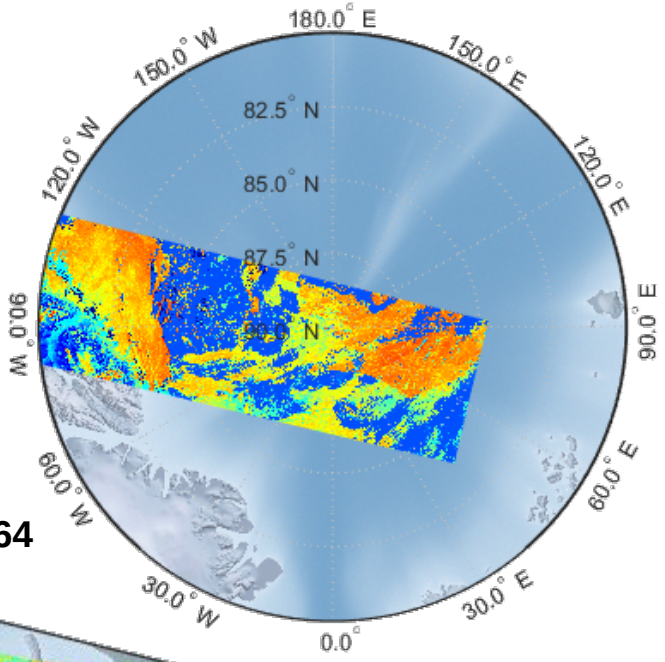


N20 VIIRS NDE Albedo EDR Example-Granules

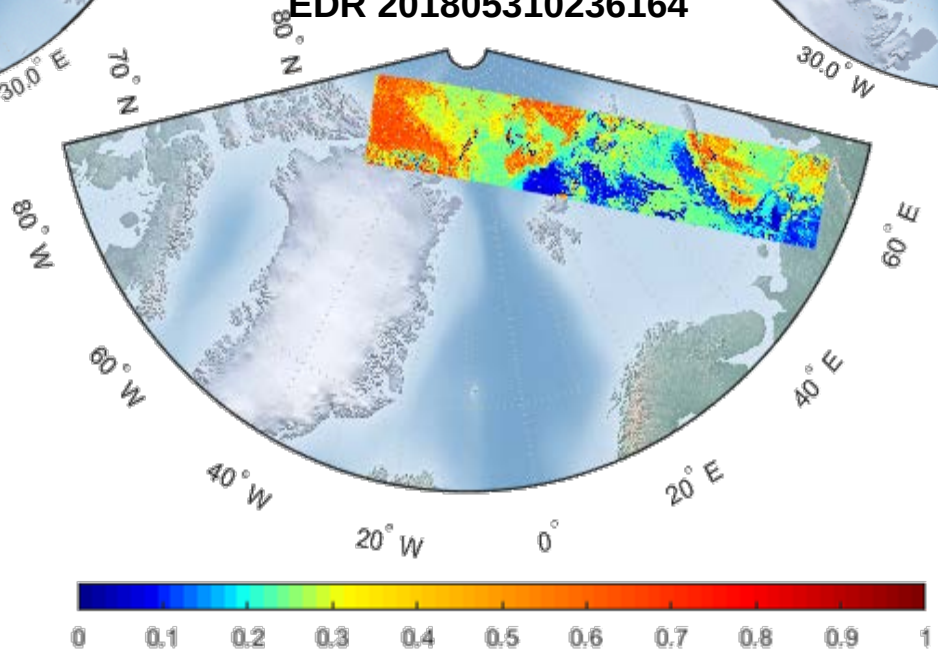
EDR 201806280210007



EDR 201806271418462



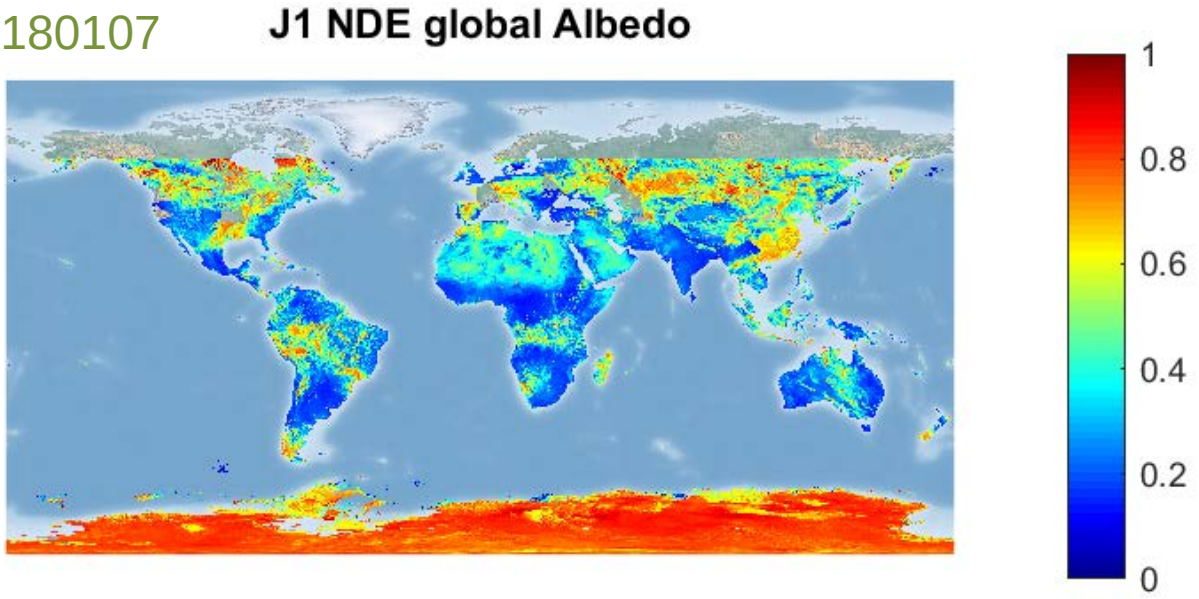
EDR 201805310236164



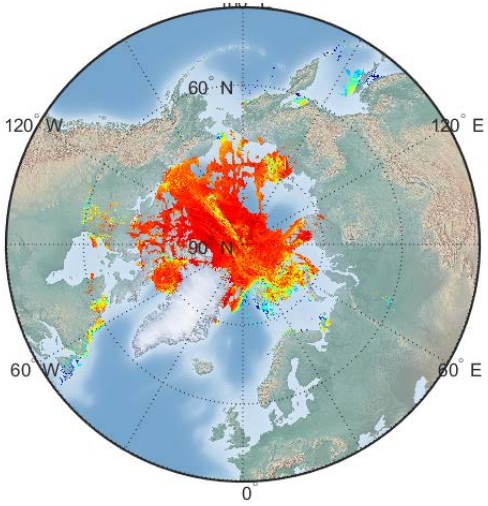
N20 VIIRS NDE Albedo EDR Example

Composited global map from N20 (J1) granule albedo product

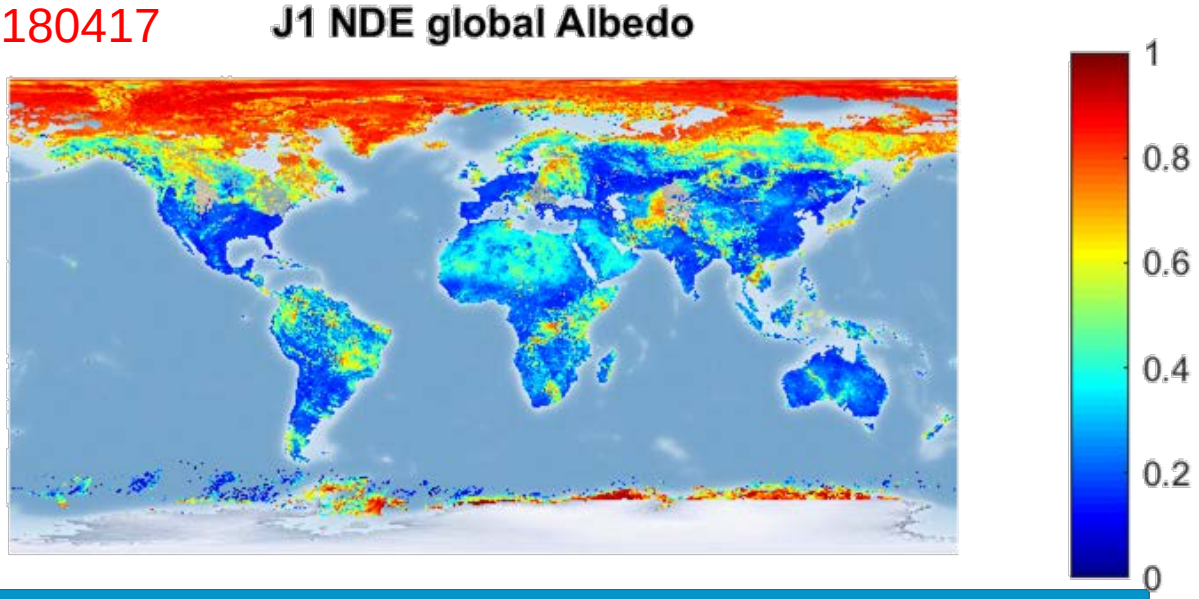
20180107



J1 NDE sea ice Albedo



20180417



Quality flag analysis/validation (2-5 slides)

Defined Quality Flags

PQI

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		

DQF

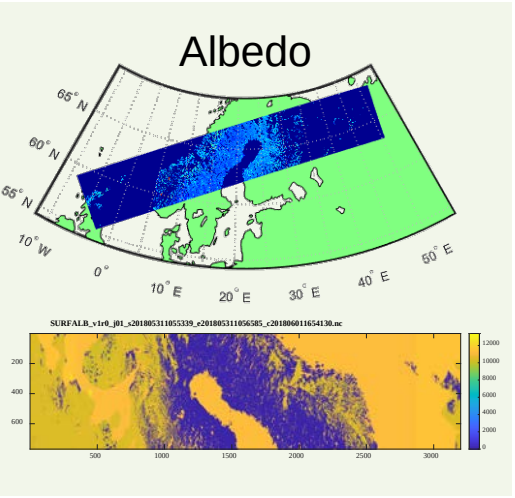
Byte	Bit	Flag	Source	Description
0	0-1	Overall quality	LSA	00: high-quality retrieval, 01: retrieval, 10:no retrieval

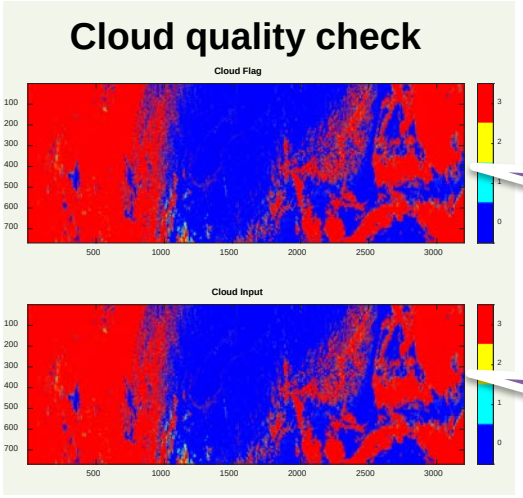
PQI and DQF provides the Data Quality information of VIIRS albedo product.

- Each bit was locally recomputed, and compared with the value from the original input/out files. They all matched and no issues found.
- The redundant DQF contains the same content with the first 2 bits in PQI. Is it still needed?

Quality flag analysis/validation (2-5 slides)

- ProductQualityInformation (PQI) j01_d20180531_t1055339_e1056585_b02754





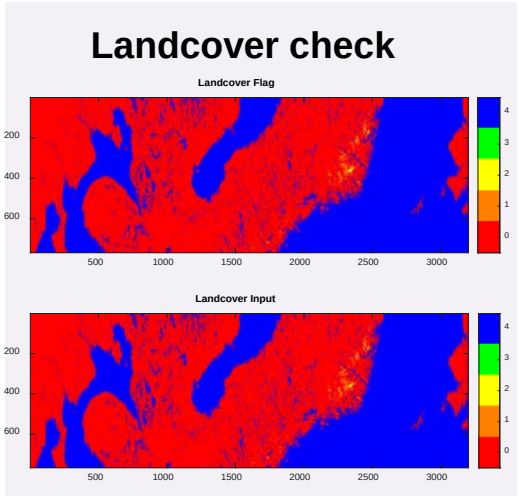
Framework Output

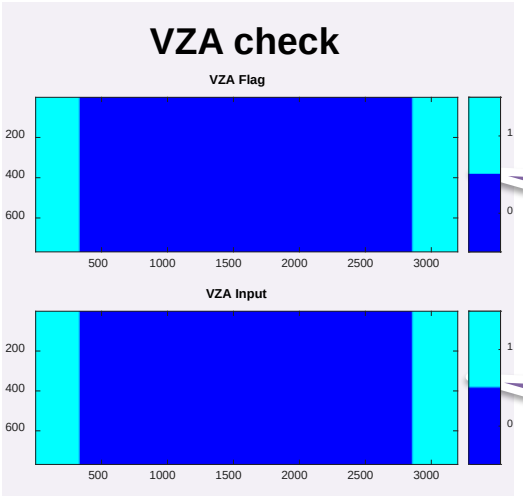
Local Verification

Example Preview

✓ Matched

✓ Matched





Framework Output

Local Verification

✓ Matched

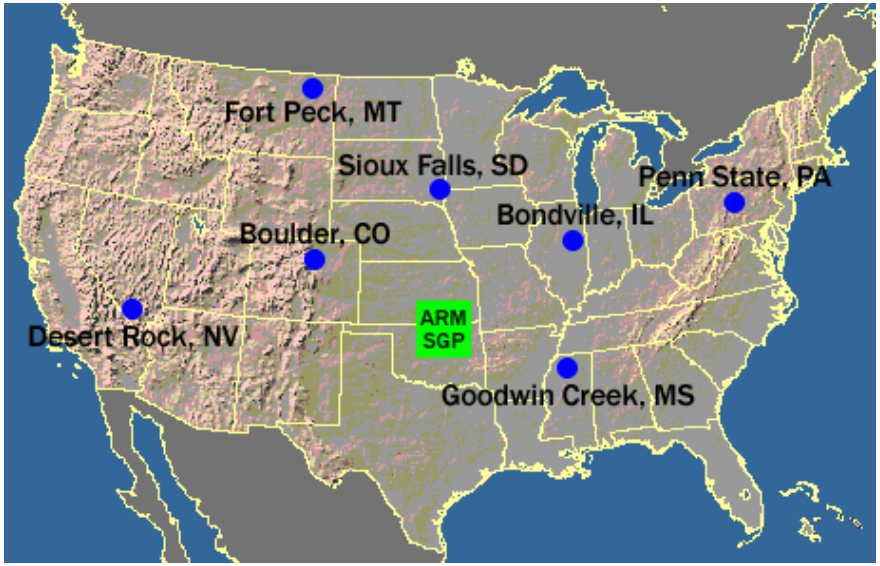
✓ Matched

✓ Matched

Evaluation of algorithm performance to specification requirements

Albedo value evaluation

- Direct comparison with Ground measurement (SURFRAD)
  - Jan 7~June 9, 2018
  - over 7 sites
- Cross-comparison with MODIS daily mean albedo

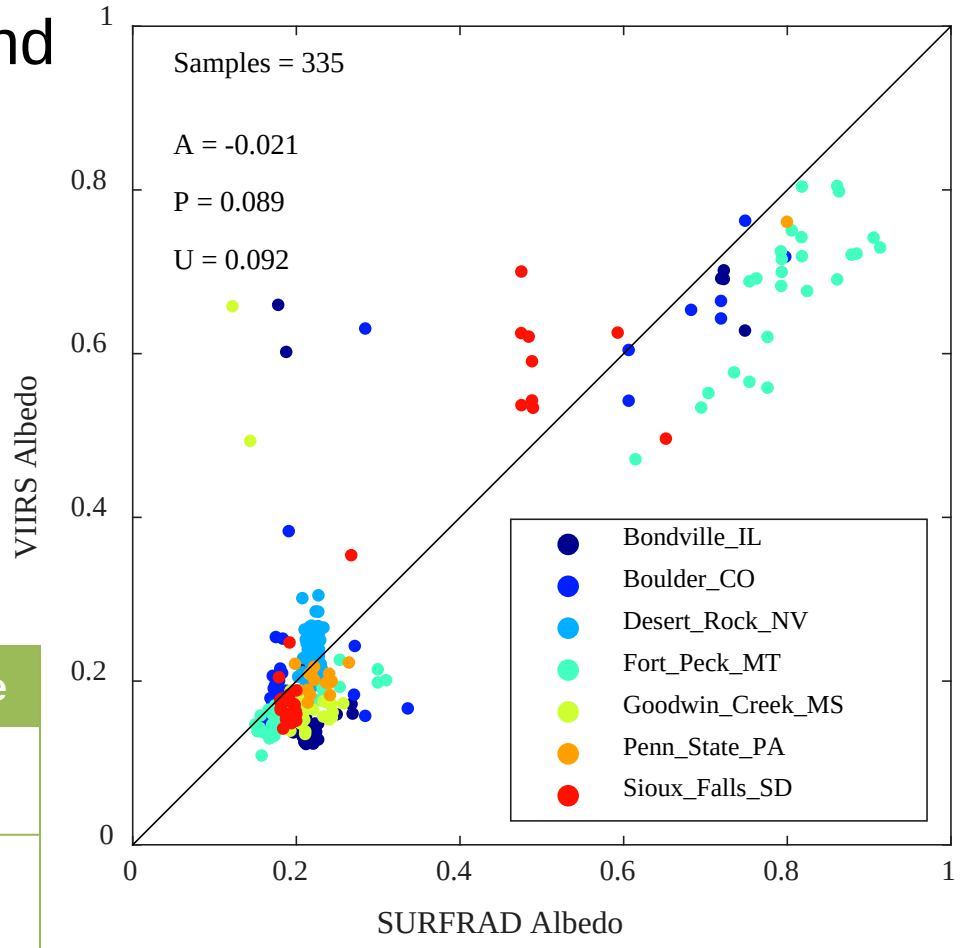


SURFRAD site distribution (https://www.esrl.noaa.gov/gmd/grad/surfrad/sitepage.html)

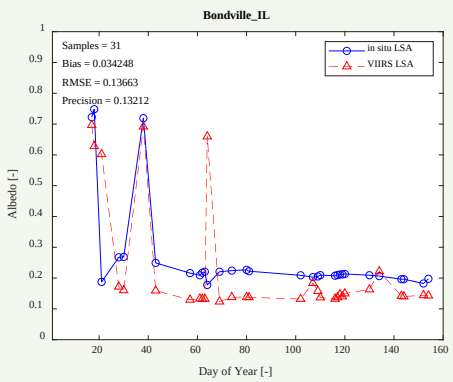
NOAA-20 VIIRS LSA against ground data

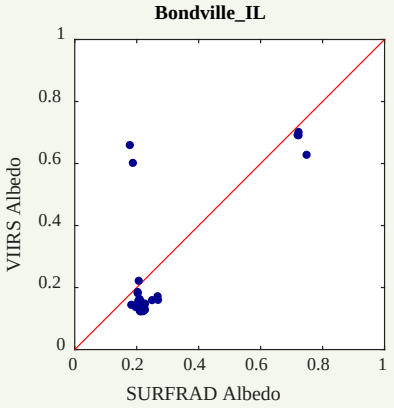
- Direct-comparison with ground measurements
  - Validation of N20 albedo against SURFRAD
  - Time Analysis series
  - Jan 7~June 9, 2018
  - over 7 sites

	Requirement	Performance
Accuracy (Bias)	0.05	-0.021
Precision (Standard deviation of error)	0.08	0.089

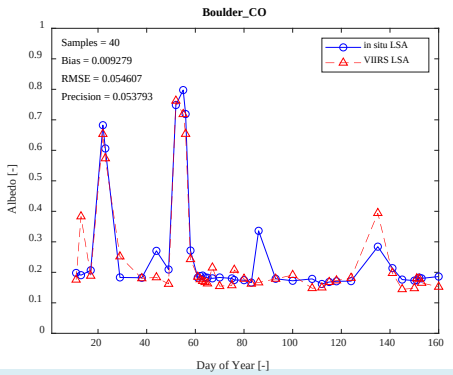


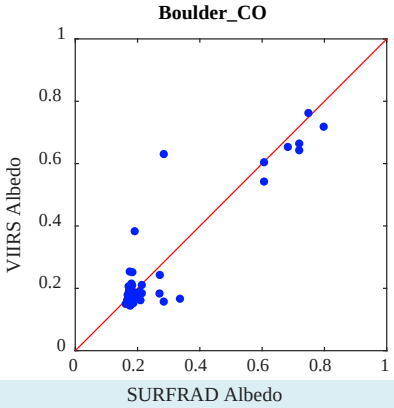
J1 NDE albedo (beta version) vs. SURFRAD albedo

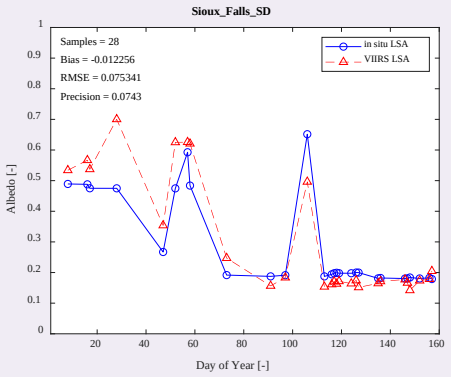


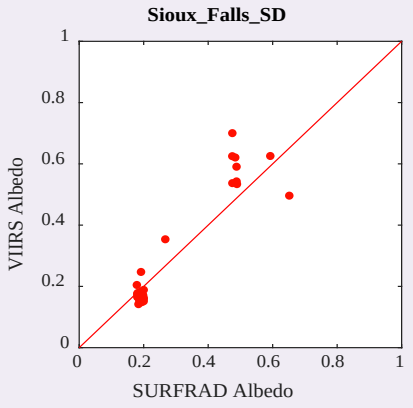


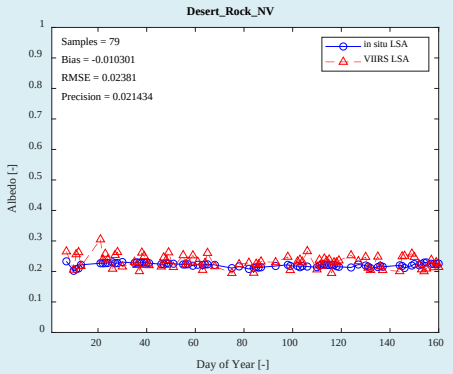
J1 NDE albedo generally can catch the surface albedo variation trend. The outliers mainly happens at very large SZA (>60) and VZA (>60).

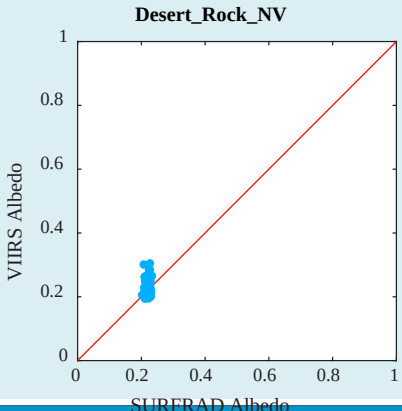


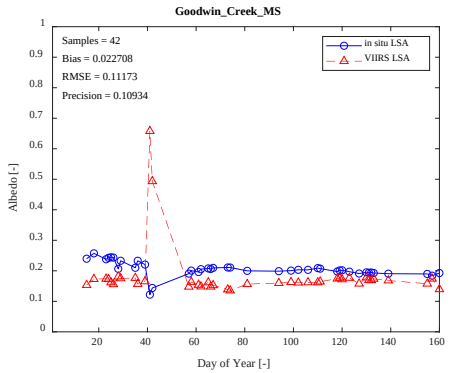


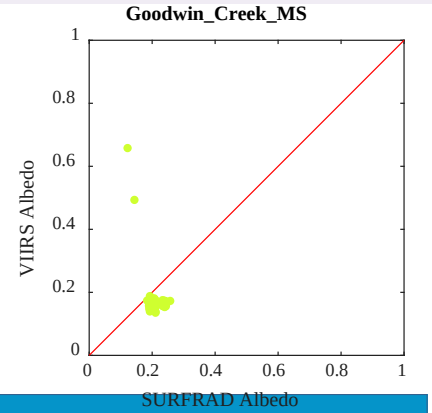




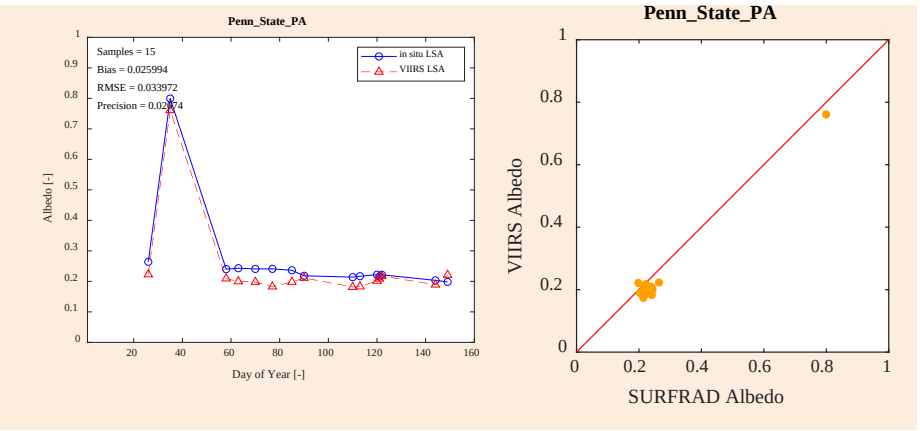


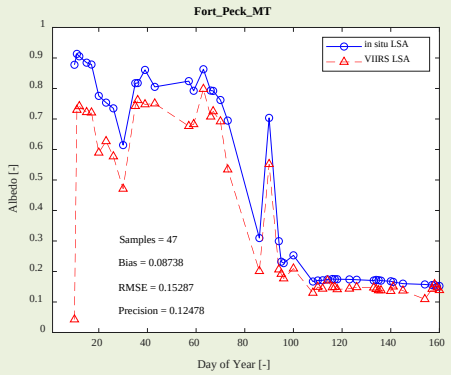


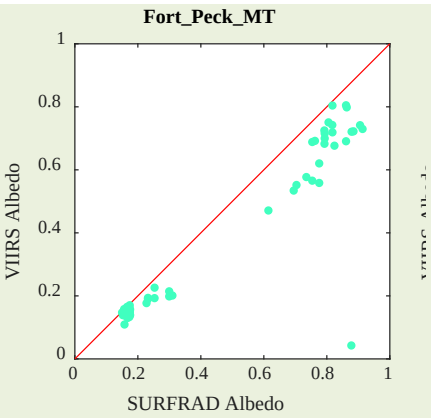




J1 NDE albedo (beta version) vs. SURFRAD albedo

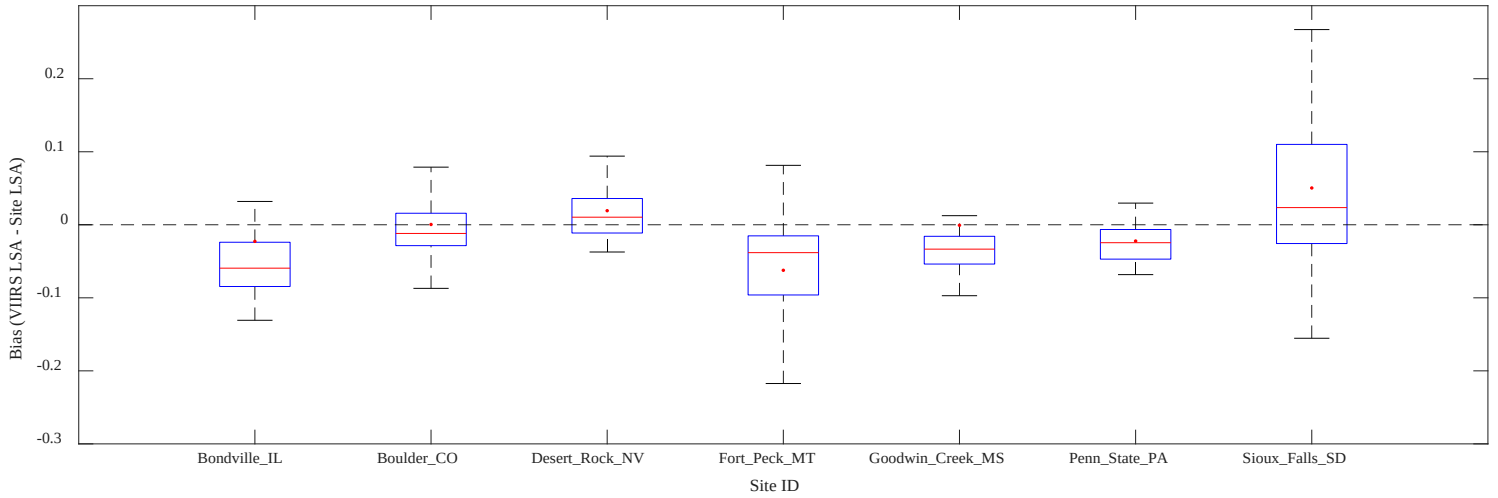






J1 NDE albedo generally shows reasonable output, but still needs further improvement to meet the requirement.

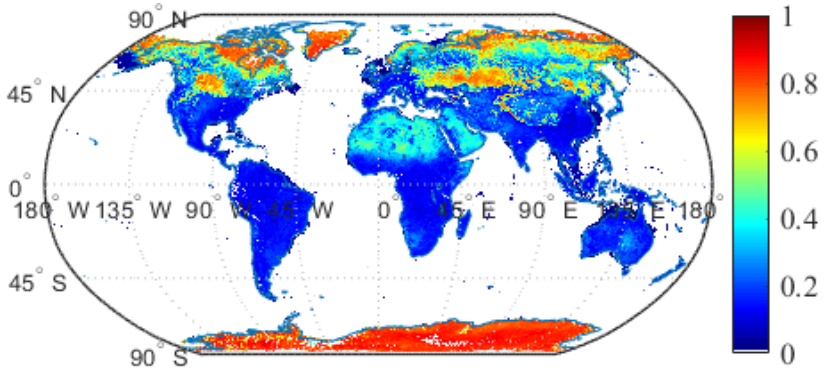
- LUTs need to be updated according to N20 VIIRS spectral response
- Gridded Albedo Product should be developed to reduce noise



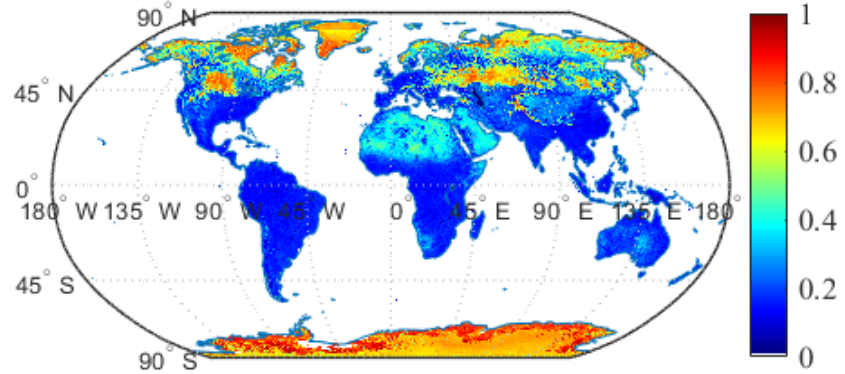
NOAA-20 NDE albedo vs. MODIS albedo

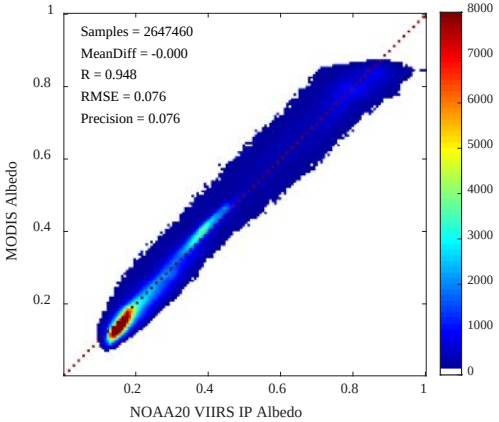
Spring Case: 20180309

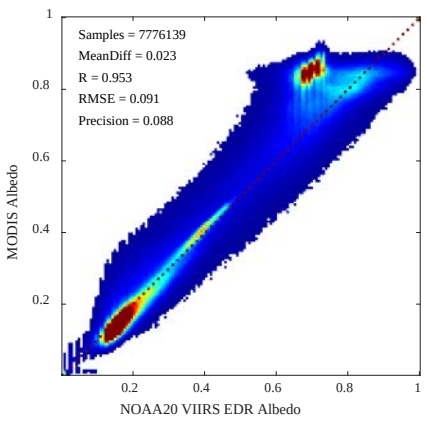
MODIS Daily Mean Albedo



N20 VIIRS EDR Albedo

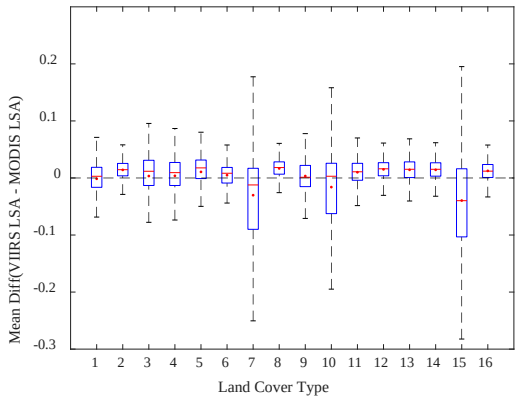






NOAA 20 and MODIS albedo agrees under most land cover types, except snow-covered regions.
The filled albedo from climatology (included in VIIRS EDR layer) shows more significant difference over snow, demonstrating that the NOAA 20 albedo climatology in Antarctic region should be improved.

1	Evergreen Needleleaf Forest	9	Savannas
2	Evergreen Broadleaf Forest	10	Grasslands
3	Deciduous Needleleaf Forest	11	Permanent Wetlands
4	Deciduous Broadleaf Forest	12	Croplands
5	Mixed Forest	13	Urban and Built-Up
6	Closed Shrubland	14	Cropland/Natural Vegetation Mosaic
7	Open Shrubland	15	Snow
8	Woody Savannas	16	Barren or Sparsely Vegetated

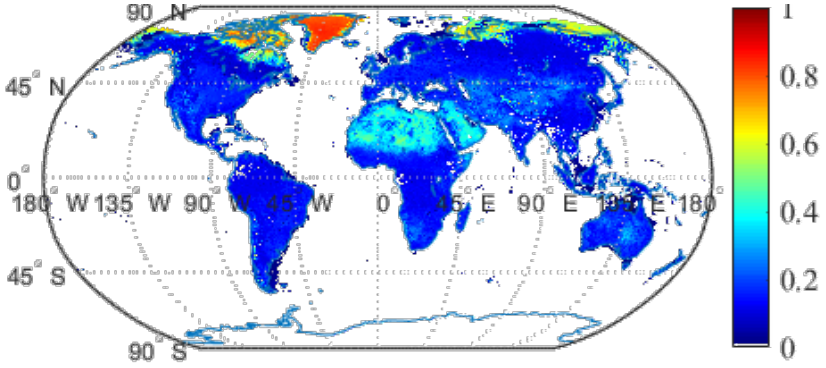


The Open Shrubland and Grasslands pixels with larger discrepancy are also influenced by snow in this season.

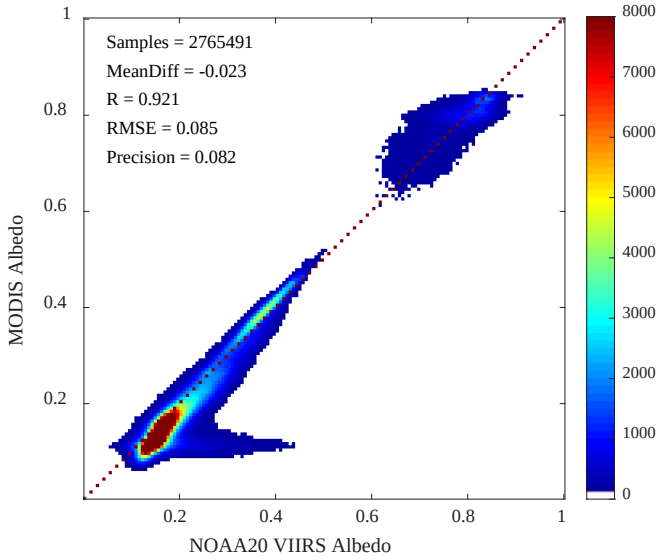
NOAA 20 NDE albedo vs. MODIS albedo

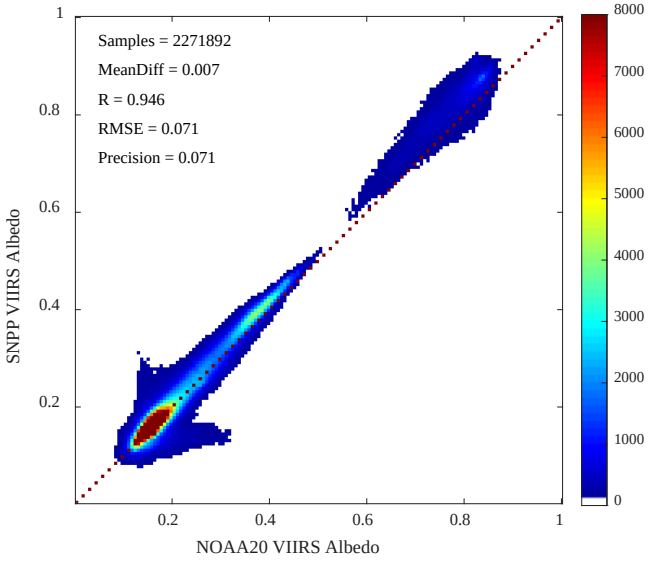
Summer Case: 20180609

VIIRS EDR Albedo



NOAA 20 and MODIS albedo agrees under most land cover types, except snow-covered and needleleaf forest pixels.





NOAA 20 VIIRS albedo and SNPP VIIRS albedo shows better agreement than NOAA 20 and MODIS albedo.

NOAA-20 VIIRS LST against ground data

Site wide statistics

SITE	Sample count	Accuracy (Bias)	Precision (Std of Error)
Bondville_IL	31	0.0343	0.1321
Boulder_CO	40	0.0093	0.0538
Desert_Rock_NV	79	-0.0103	0.0214
Fort_Peck_MT	47	0.0874	0.1248
Goodwin_Creek_MS	42	0.0227	0.1093
Penn_State_PA	15	0.0260	0.0207
Sioux_Falls_SD	28	-0.0123	0.0743
Overall		**-0.021**	**0.089**

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

The results above is based on SNPP LUT allied for NOAA-20
Improvement is expected after LUT update for NOAA-20

Metadata analysis/validation

Metadata Items	Description	Check Result
OvQltyHghQltyRtr	Number of High Quality Retrieval	√
OvQltyRtr	Number of medium Quality Retrieval	√
OvQltyNoRtr	Number of Invalid Retrieval	√
CldConfClr	Number of Confidently Clear Pixels	√
CldProbClr	Number of Probably Clear Pixels	√
CldProbCld	Number of Probably Cloudly Pixels	√
CldConfCld	Number of Confidently Cloudy Pixels	√
RtrPthGen	Number of generic pixels	√
RtrPthDst	Number of desert pixels	√
RtrPthSnw	Number of snow pixels	√
RtrPthSI	Number of sea ice pixels	√
RtrPthNoRtr	Number of other pixels	√
SZAFav	Number of pixels with Favorable SZA	√
SZALge	Number of pixels with Very Large SZA	√
VZAFav	Number of pixels with Favorable VZA	√
VZALge	Number of pixels with Very Large VZA	√
TFHghRtr	Temporal filtered high quality retrieval	√
TFDegRtr	Temporal filtered low quality retrieval	√
TFNoRtr	Temporal filtered no retrieval	√
OnFltNoFlt	Number of pixels without online simple filtering	√
OnFltFltd	Number of pixels after online simple filtering	√
MaxLSA	Maximum Valid Albedo Value	√
MinLSA	Minimum Valid Albedo Value	√
MeanLSA	Mean value of Valid Albedo Value	3 error cases found from 2231 test granules
StdLSA	Standard deviation of Valid Albedo Value	3 error cases found from 2231 test granules
PercentHighQuality	OvQltyHghQltyRtr/(TFDegRtr+TFHghRtr)	3 error cases found from 2231 test granules
PercentFilteredPixel	TFDegRtr/ (TFDegRtr+TFHghRtr)	3 error cases found from 2231 test granules
PercentLandPixels	(RtrPthGen+RtrPthSnw+RtrPthDst)/ AllPixelNumber	3 error cases found from 2231 test granules
PercentSeaicePixels	RtrPthSI/ AllPixelNumber	3 error cases found from 2231 test granules
PercentClearPixels	CldConfClr / AllPixelNumber	3 error cases found from 2231 test granules
PercentLargeSZAPixels	VZALge/ AllPixelNumber	3 error cases found from 2231 test granules
PercentLargeVZAPixels	SZALge/ AllPixelNumber	3 error cases found from 2231 test granules

Metadata analysis/validation

Known errors/issues/limitations

– Metadata of averages/standard deviation/Percentages have occasional invalid output in Framework (3 in 2231 granules):

GranuleID	Framework Output				Correct values	
	MaxLSA	MinLSA	MeanLSA	StdLSA	MeanLSA	StdLSA
201806291151231	0.2691	0.0563	-999		0.1655	0.0251
20180629115248	0.2532	0.0539			0.1642	0.0256
201806291155386	0.3048	0.0605			0.1808	0.0731

GranuleID	Framework Output	Correct values						
		PercentClearPixels	PercentFilteredPixel	PercentHighQuality	PercentLandPixels	PercentLargeSZAPixels	PercentLargeVZAPixels	PercentSeaicePixels
xxx1231	-999	19.36%	0%	100%	13.24%	0%	6.670%	0%
xxx5248		2.756%	0%	100%	5.550%	0%	3.338%	0%
xxx5386		5.619%	0%	100%	0.3794%	0%	10.03%	0%

Beta Maturity Conclusions

- NOAA-20 LSA Product has been verified and preliminarily validated. The product is suggested being released as beta maturity version.
- Some issues and problems are found that will be solved or improved for the provisional release:
  - Metadata has occasional errors.
  - The DQF is redundant to PQI, that should be removed.
  - NOAA-20 Albedo data is slightly worse than the requirement; further calibration of the LUTs and Climatology data are needed
  - Upstream data missing is a concern for albedo data continuity
  - Reference data collection for covering surface seasonal variation is critical for provision release.
  - Snow/sea-ice surface validation needs more efforts

Check List - Beta Maturity

Beta Maturity End State	Assessment
Product is minimally validated, and may still contain significant identified and unidentified errors	Yes. Product has been validated using the most reliable method, but still seasonally limited number of independent global in situ matchups
Information/data from validation efforts can only be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose	Yes. Validation efforts initially proved the availability of the N20 Albedo product, but further calibration and improvement is still needed to meet the product requirement
Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists	Yes

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 (and update version is in preparation)
(External/Internal) Users Manual	Yes
System Maintenance Manual (for ESPC products)	Yes
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	In preparation
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	Yes

Path Forward/Future Plan

- Comprehensive validation
  - Over multiple land cover types, especially snow/sea-ice
  - Over more seasons including Autumn and Winter
  - Develop the monitoring tool
  - Validation plan update
  - Extended cross-comparisons
- Future Cal/Val activities
  - LUTs update
  - Climatology update
  - Provisional Maturity Review
  - Validated maturity Review
- Application in NOAA climate models
- Improved albedo products
  - NOAA-20 Gridded Surface Albedo Product
  - Blended Albedo product with S-NPP VIIRS Albedo

Thanks for Your Review !