Provisional Release of the Land Surface Albedo component of the Suomi NPP Surface Albedo EDR Product

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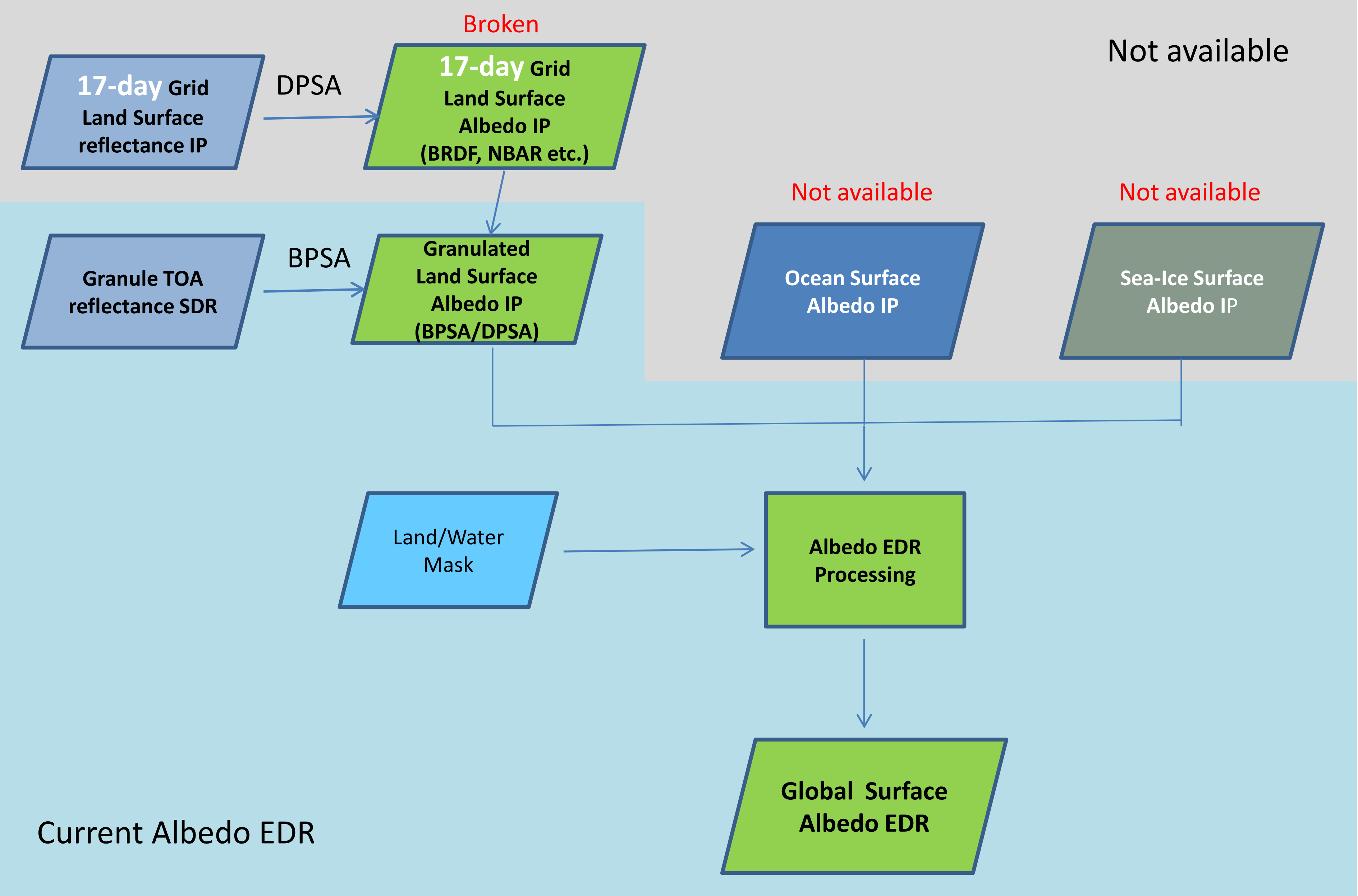
Overview of Surface Albedo EDR

- Surface albedo is the ratio between outgoing and incoming shortwave radiation at the Earth surface. It is an essential component of the Earth's surface radiation budget.
- Surface albedo is produced from VIIRS as Environmental Data Record (EDR).
- Surface albedo EDR has the global coverage, including land surface albedo (LSA), ocean surface albedo (OSA) and sea ice surface albedo (SSA).
- LSA is estimated for every clear-sky land pixel.
- Surface albedo EDR is a full resolution granulated product.
- Surface albedo product is expected to be used by weather forecasting models, agriculture monitoring, drought prediction and monitoring, ecosystem monitoring; climate studies etc.

Overview of Surface Albedo EDR

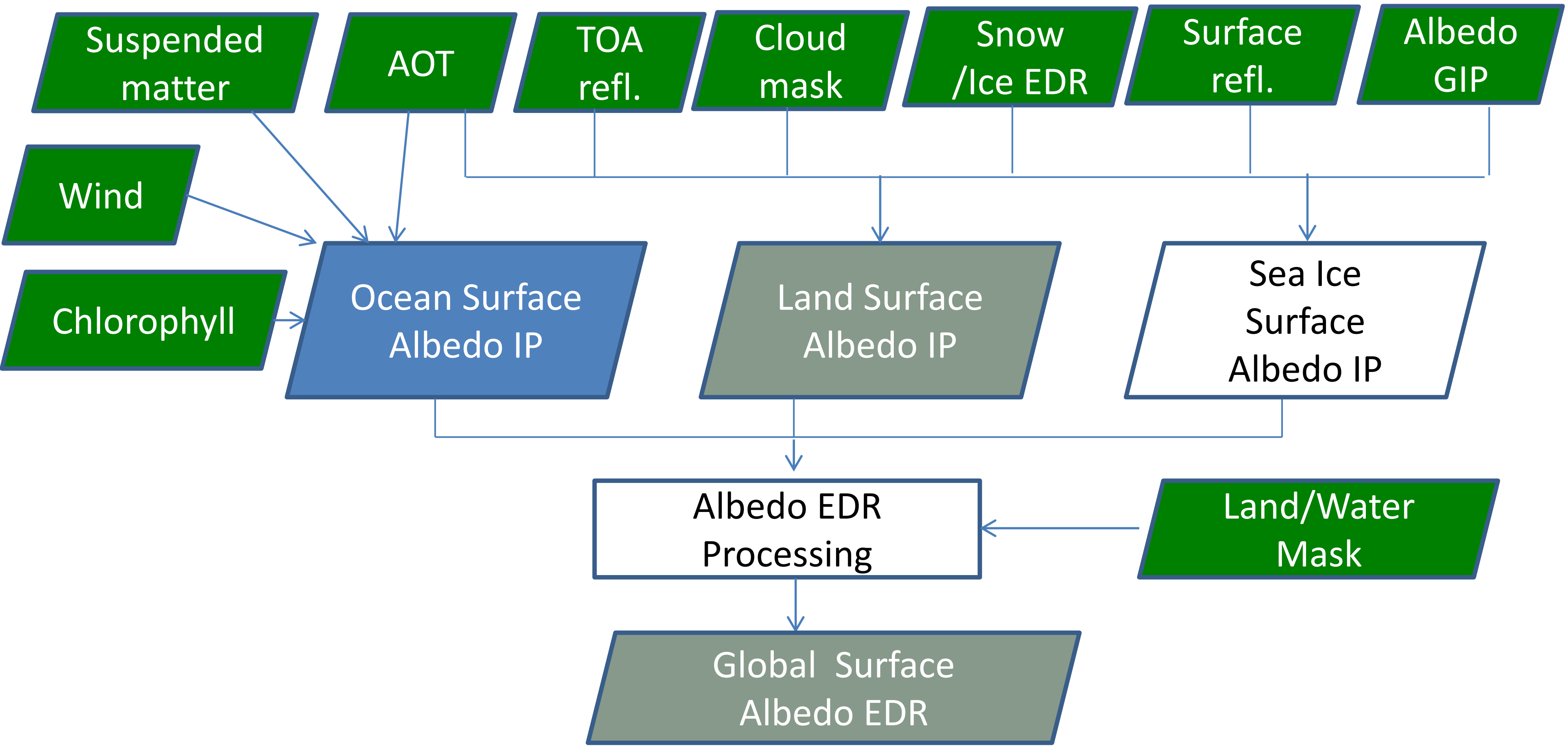
- Surface albedo EDR is combination of land surface albedo (LSA), ocean surface albedo (OSA) and sea-ice surface albedo (SSA); Only the LSA component is validated at provisional maturity.
- Two algorithms (Dark Pixel Sub-Algorithm (DPSA) and Bright Pixel Sub-Algorithm (BPSA)) implemented for LSA; DPSA derives the BRDF information from the 17-day gridded surface reflectance IP, and then calculates spectral albedoes which then are converted to broadband albedo using empirical models. BPSA directly estimate broadband albedo from VIIRS TOA radiances.
- The BPSA is currently used to generate LSA. Several improvements have been made since the S-NPP launch.
- BPSA is also applied to sea ice pixel to estimate SSA with a separate LUT specifically developed for sea-ice surfaces.
- OSA is retrieved from a pre-calculated LUT, with solar zenith angle, aerosol optical thickness, wind speed and chlorophyll concentration etc. as indices.

Processing for Global Surface Albedo EDR



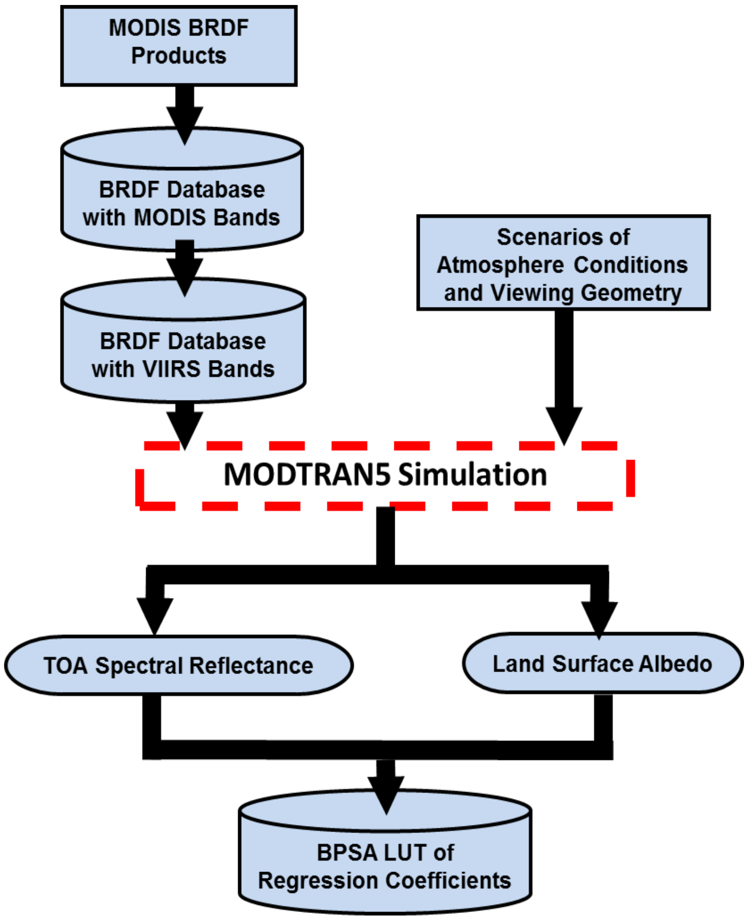
Brief Flowchart of Surface Albedo EDR

Major inputs data to surface albedo EDR algorithm



Refinement to the BPSA algorithm

- A new LUT of LSA BPSA regression coefficients was developed:
  - Using updated spectral response function;
  - Considering multiple aerosol types;
  - Including surface BRDF in radiative transfer simulation;
  - Developing surface-specific LUTs;
  - No correction of ozone and water vapor.
- The new BRDF LUT has not been implemented in the NOAA operational system yet.
- Analysis of results from the new BRDF LUT is based on the data generated at the UMd local facility.

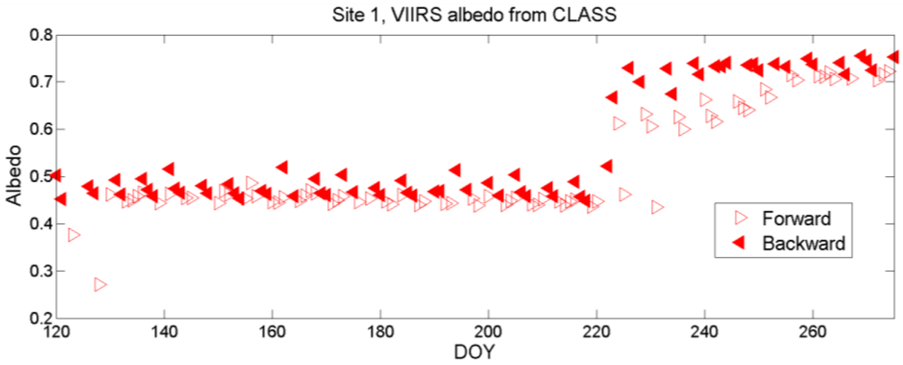


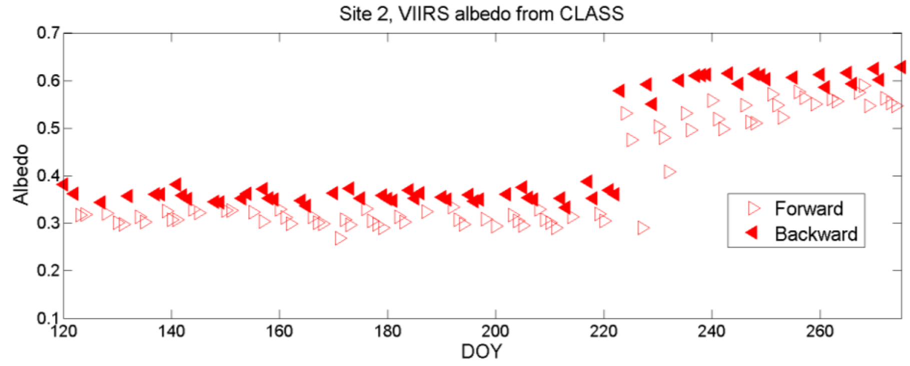
Perform VIIRS LSA Validation

- Evaluate temporal variability
  - Over stable surfaces (e.g., desert)
  - Comparing with variability from other methods (e.g. BRDF fitting)
- Validation against ground truth data
  - SURFRAD 2012-2013, GCNet
    - Direct validation of daily albedo
    - Comparison of 16-day mean albedo
- Inter-comparison with MODIS albedo products

Evaluation of temporal variability of LSA

The LSA retrievals in the summer of 2012 over two Libya desert sites (Site 1: 24.42˚N 13.35˚E and Site 2: 26.45˚N, 14.08˚E) are used to illustrate the issue of temporal variability of LSA.

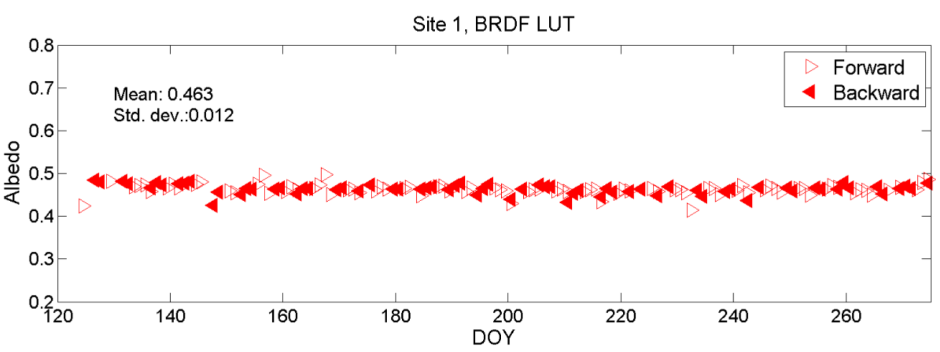


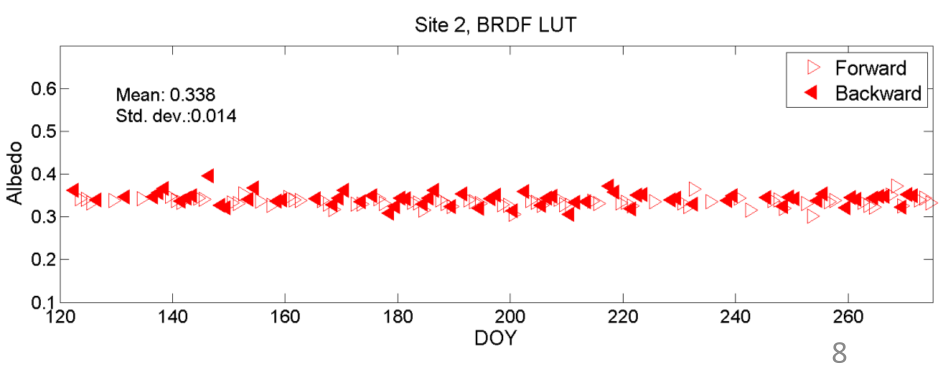


“Forward” means pixels with relative azimuth angle >90° and “backword” means those with relative azimuth angle <90°. Jumps around 8/9 were caused by the bugs in a early version of the operational codes.

New albedo estimated with the BRDF LUT has improved in temporal stability

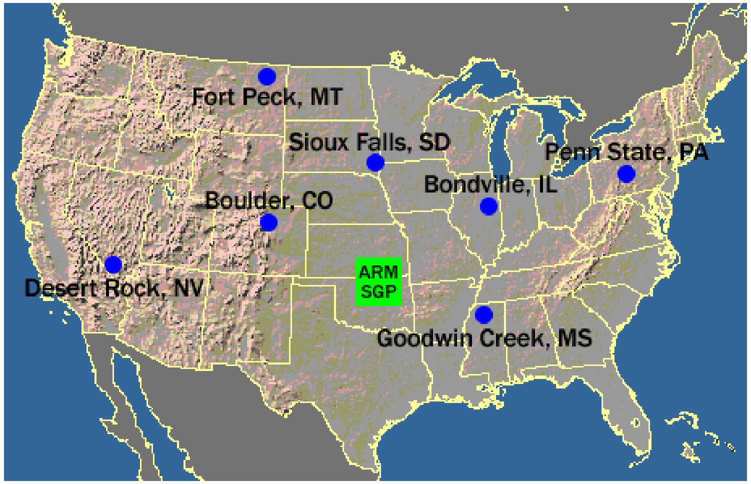
LSA retrieved from new BRDF LUT. The spurious retrievals caused by undetected cloud and cloud shadow are excluded with the threshold of mean ± 0.05.





Validation sites: SURFRAD

- Seven NOAA SURFRAD sites
- http://www.esrl.noaa.gov/gmd/grad/surfrad
- Surface Radiation Budget Network, established in 1993
- Bondville is not used due to great spatial heterogeneity
- Instantaneous measurements of downward and upward shortwave radiation at the surface every minute



Short name	Location	Latitude	Longitude	Land cover
DRA	Desert Rock, NV	36.63	-116.02	Desert
BON	Bondville, IL	40.05	-88.37	Cropland
FPK	Fort Peck, MT	48.31	-105.10	Grassland
GWN	Goodwin Creek, MS	34.25	-89.87	Forest/Pasture
PSU	Penn State, PA	40.72	-77.93	Cropland
SXF	Sioux Falls, SD	43.73	-96.62	Grassland
TBL	Boulder, CO	40.13	-105.24	Grassland

→ Bright surface (DRA)

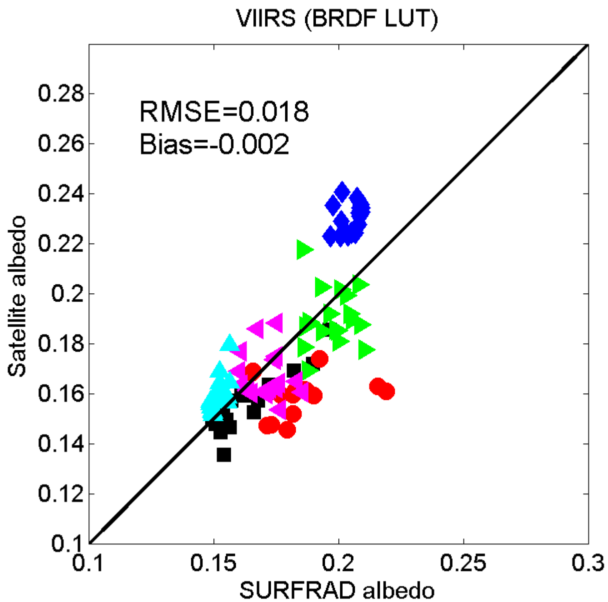
} Dark surface (BON, FPK, GWN, PSU, SXF, TBL)

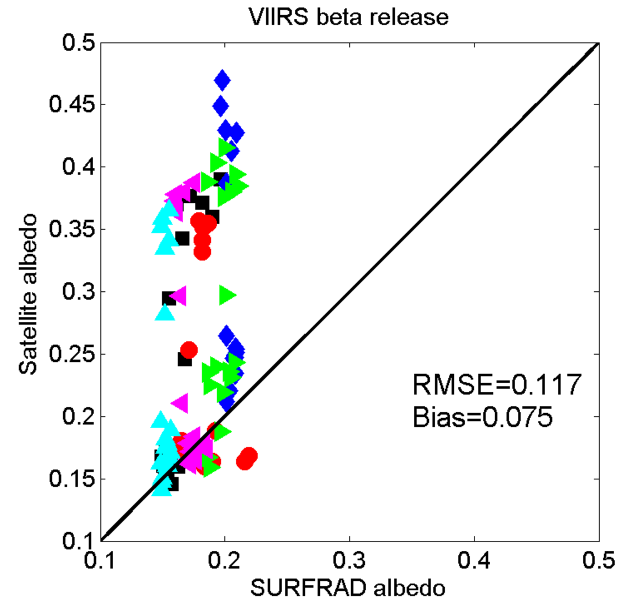
Summary of validation: 2012

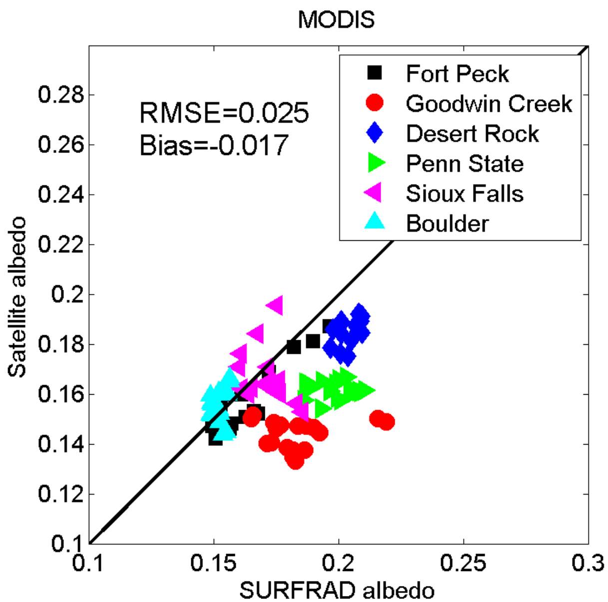
Summary of validation results at seven SURFRAD sites. Three satellite albedo data (VIIRS LSA from the Lambertian LUT, VIIRS LSA from the BRDF LUT and MODIS albedo) are validated against field measurements.

Site	VIIRS (BRDF LUT)			VIIRS (beta release)			MODIS		
	R^2	RMSE	Bias	R^2	RMSE	Bias	R^2	RMSE	Bias
Boulder	0.96	0.029	0.011	0.91	0.034	0.012	0.79	0.047	0.002
Fort Peck	0.89	0.070	0.001	0.72	0.138	0.076	0.98	0.043	-0.020
Goodwin Creek	0.01	0.040	-0.033	0.19	0.122	0.066	0.11	0.051	-0.048
Desert Rock	0.10	0.032	0.026	0.11	0.157	0.116	0.02	0.025	-0.023
Penn State	0.60	0.040	-0.020	0.27	0.127	0.073	0.02	0.079	-0.054
Sioux Falls	0.89	0.064	0.004	0.59	0.149	0.088	0.87	0.059	-0.001
Overall	**0.84**	**0.046**	**0.001**	**0.48**	**0.143**	**0.090**	**0.80**	**0.050**	**-0.023**

Validation of 16-day mean LSA: 2012







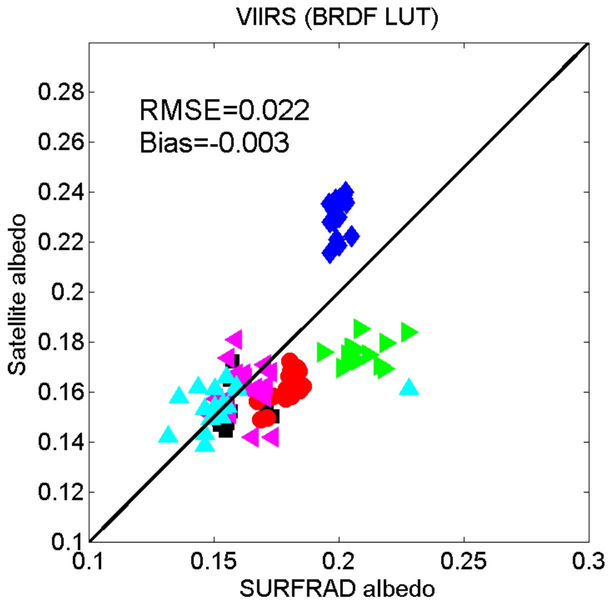
Validation results of 16-day mean albedo from VIIRS BRDF LUT (top left), CLASS VIIRS data (top right) and MODIS (bottom), using data from 2012 non-snow seasons (May-September) at seven SURFRAD sites.

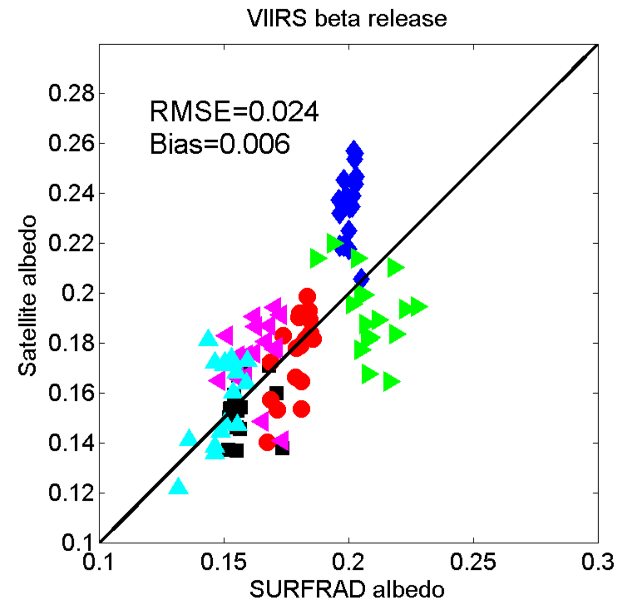
Summary of validation: 2013

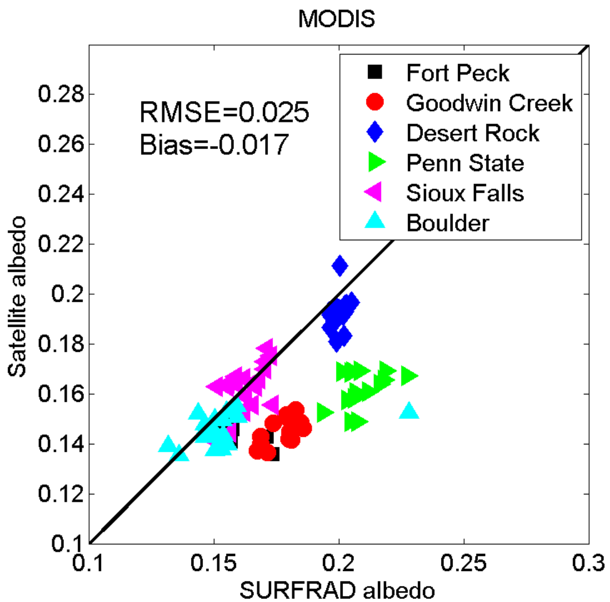
Summary of validation results at seven SURFRAD sites. Three satellite albedo data (VIIRS LSA from the Lambertian LUT, VIIRS LSA from the BRDF LUT and MODIS albedo) are validated against field measurements.

Site	VIIRS (BRDF LUT)			VIIRS (beta release)			MODIS		
	R^2	RMSE	Bias	R^2	RMSE	Bias	R^2	RMSE	Bias
Fort Peck	0.97	0.042	-0.006	0.94	0.063	0.001	0.99	0.064	-0.038
Goodwin Creek	0.02	0.037	-0.031	0.03	0.086	-0.010	0.02	0.048	-0.046
Desert Rock	0.06	0.038	0.029	0.07	0.101	0.048	0.29	0.013	-0.010
Penn State	0.98	0.081	-0.066	0.92	0.097	-0.069	0.28	0.066	-0.062
Sioux Falls	0.86	0.114	0.048	0.82	0.142	0.057	0.91	0.062	-0.007
Boulder	0.97	0.050	0.020	0.89	0.087	0.029	0.27	0.134	-0.037
Overall	**0.88**	**0.061**	**0.010**	**0.77**	**0.099**	**0.024**	**0.82**	**0.068**	**-0.026**

Validation of 16-day mean LSA: 2013



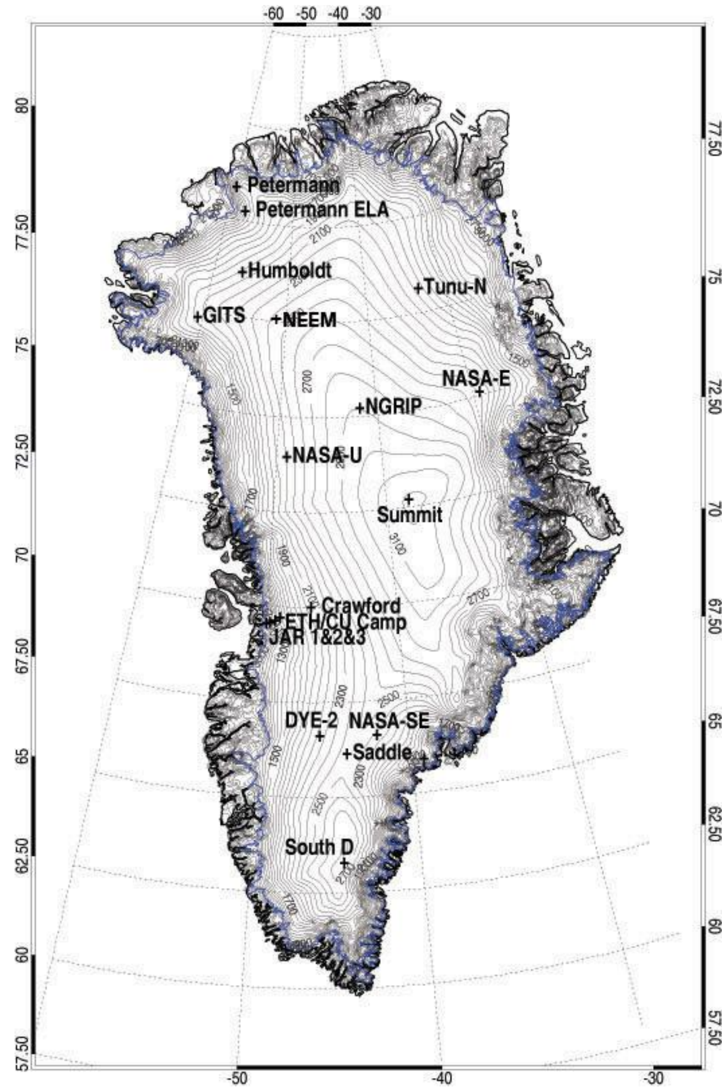




Validation results of 16-day mean albedo from VIIRS BRDF LUT (top left), CLASS VIIRS data (top right) and MODIS (bottom), using data from 2013 non-snow seasons (May-September) at six SURFRAD sites.

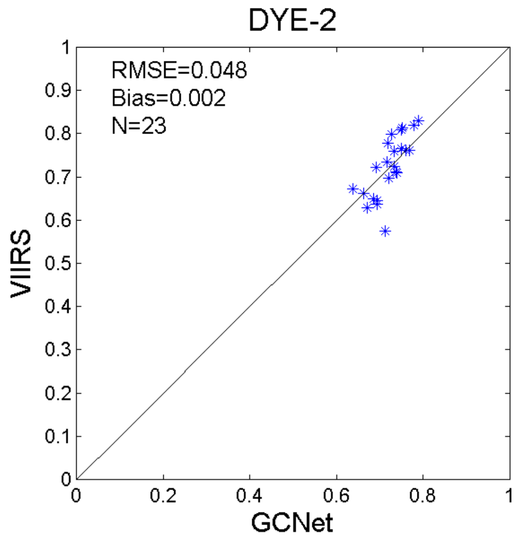
Validating snow albedo

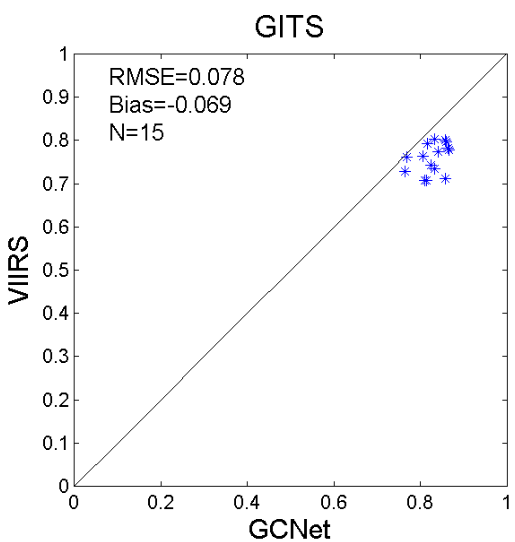
- Greenland Climate Network (GC-Net)
- http://cires.colorado.edu/science/groups/steffen/gcnet/
- 18 automatic weather stations (AWS), transmitting measurements of shortwave radiation every hour.
- Data of May-October 2012 are used in this comparison.



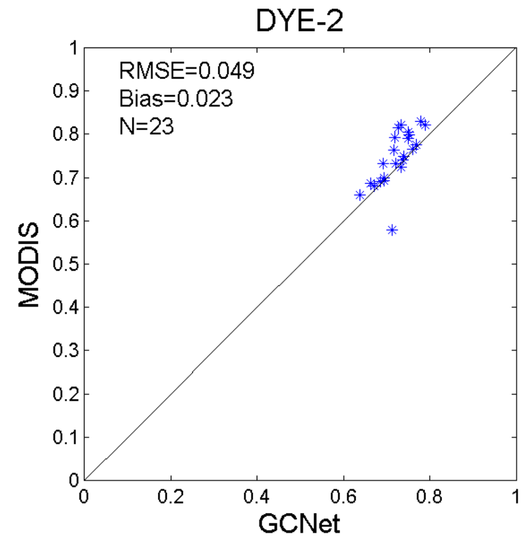
Validation results: GCNet

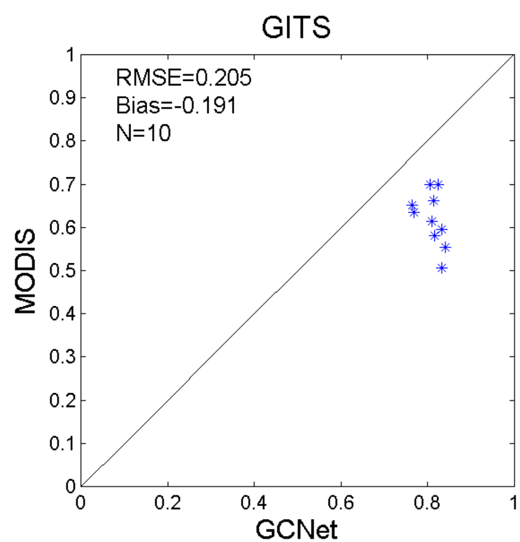
VIIRS BRDF LUT



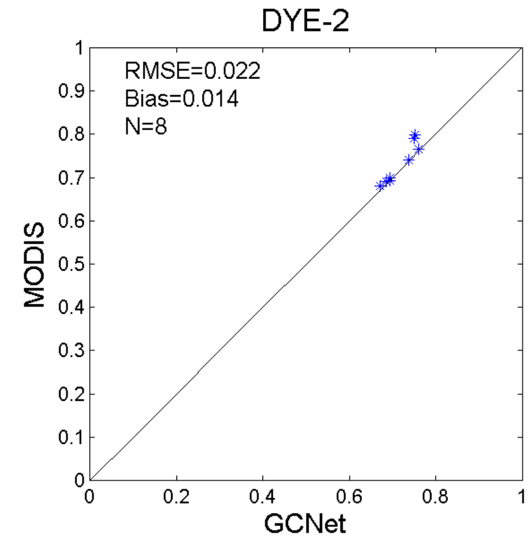


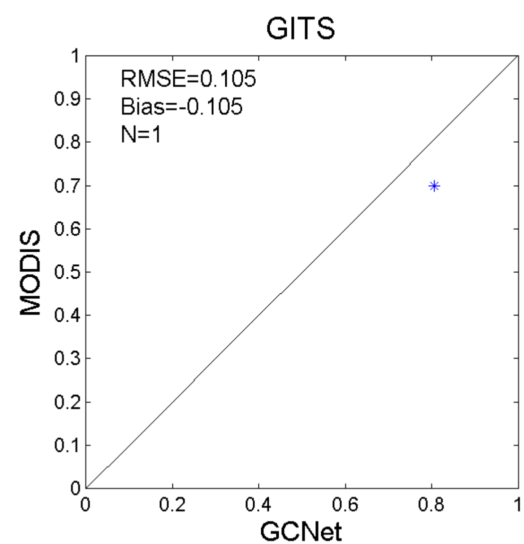
MODIS all data





MODIS high quality data





Summary of 16-day mean albedo

Site	VIIRS BRDF			MODIS					
				Highest quality			All data		
	N	RMSE	Bias	N	RMSE	Bias	N	RMSE	Bias
GITS	15	0.078	-0.069	1	0.105	-0.105	10	0.205	-0.191
Humboldt	14	0.080	-0.079	3	0.085	-0.084	17	0.138	-0.125
Summit	20	0.045	-0.033	1	0.028	-0.028	21	0.102	-0.082
Tunu-N	19	0.093	-0.085	7	0.091	-0.089	20	0.130	-0.119
DYE-2	23	0.048	0.002	8	0.022	0.014	23	0.049	0.023
Saddle	23	0.048	-0.028	6	0.020	0.008	23	0.073	-0.026
SouthDome	23	0.039	0.013	2	0.065	0.064	21	0.065	0.032
NASA-E	20	0.079	-0.071	3	0.098	-0.098	16	0.131	-0.114
NASA-SE	23	0.072	-0.049	7	0.030	-0.008	21	0.054	-0.030
NEEM	18	0.071	-0.066	9	0.095	-0.090	20	0.138	-0.124

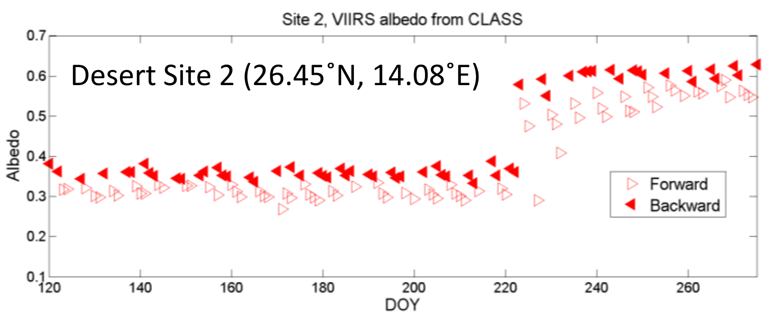
- Two groups of MODIS data are used
  - All valid MODIS retrievals
  - Those data with highest QC

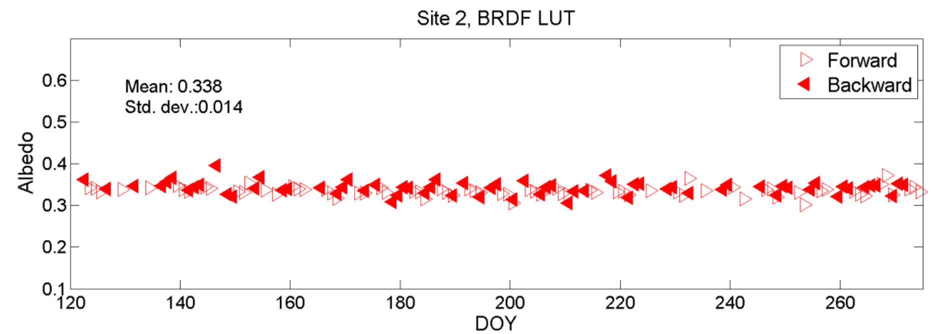
Summary of validation results

- A new BRDF LUT is developed to address the issue of angular dependency of albedo retrieved from the Lambertian LUT.
- The variation of instantaneous albedo retrieved from the new BRDF LUT is comparable with the reflectance residue of BRDF fitting (i.e., MODIS algorithm).
- Validation with two years SURFRAD data demonstrates that the BRDF LUT can retrieve LSA reliably from VIIRS data. RMSE of snow-free VIIRS albedo is 0.02, smaller than the requirement.
- VIIRS LSA retrievals generally agree well with the MODIS albedo products.

From beta release to provisional release

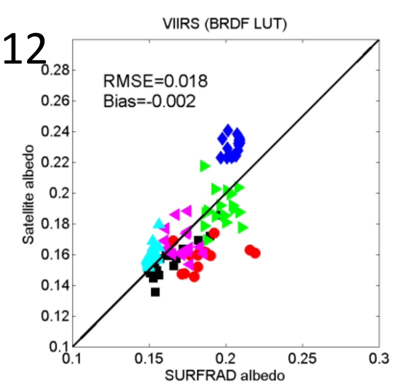
- The improved LUT will be implemented.
- Incorporation of BRDF information results in more stable and consistent retrievals of LSA.

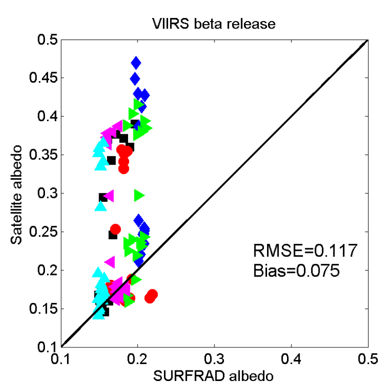




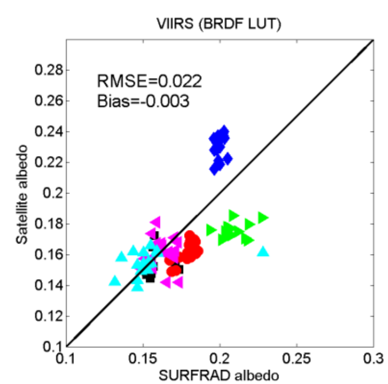
- The accuracy of LSA has been significantly improved as well:
  - RMSE 0.117-> 0.018 (2012); 0.024->0.022 (2013)
  - Bias 0.075-> -0.002 (2012); 0.006-> -0.003 (2013)

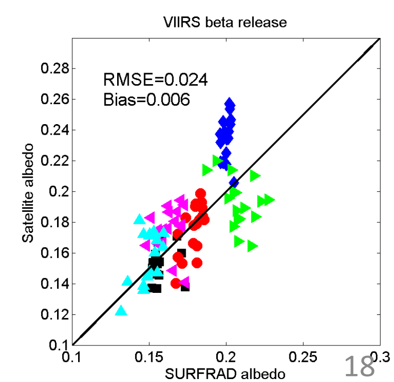
2012





2013





Summary

- Provisional release of the LSA component of the Suomi NPP VIIRS LSA is ready.
  - *LSA provisional "effectivity date" will coincide with operational implementation of the new LUT (DR 7653/474-CCR-14-1722).*
- Validations are performed with comparisons to MODIS LSA, in-situ LSA, LSA map monitoring, evaluation of LSA temporal stability.
- Validation results demonstrate the VIIRS BPSA algorithm can reliably retrieve LSA over both dark and bright surfaces.
- A temporal filter is proposed to reduce the impacts of undetected cloud and cloud shadow on BPSA retrievals.
- Continuous efforts have been put to improve the BPSA LSA algorithm. The refined algorithm will be able to provide more stable and consistent LSA with higher accuracy for the J1 mission.
- Comprehensive validation will be carried out to better understand uncertainties of LSA products and provide comprehensive validation reports.