STAR Algorithm and Data Products (ADP) Beta Release

Suomi NPP Surface Albedo EDR Product

Prepared by

Yunyue Yu, Dongdong Wang, Leslie Belsma

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STAR ADP LSA EDR Team Members

- Ivan Csiszar (NOAA/NESDIS/STAR) *STAR Land EDRs Chair, management*
- Jeff Privette (NOAA/NESDIS/NCDC) *product validation Lead*
- Yunyue Yu (NOAA/NESDIS/STAR) *STAR LSA EDR lead, product monitoring and validation; algorithm development, project management*
- Shunlin Liang(UMD/Geography) *UMD PI, algorithm development, product validation*
- Dongdong Wang(UMD/Geography) *algorithm development, product validation*
- Crystal Schaaf (UMB) UMB PI, *algorithm development, product validation*
- Zhuosen Wang (UMB) *algorithm development, product validation*
- Leslie Belsma (JPSS/DPA, Aerospace Corp*) Algorithm Manager (JAM) for Land*
- Youhua Tang (NOAA Affiliate, SciTech/IMSG) *ADL verification*
- Michael EK (NOAA/EMC/NCEP) *user readiness*
- Jesse Meng (NOAA Affiliate) *user readiness*

Background of SA Product

- Surface albedo is produced as Environmental Data Record (EDR) .
- Surface albedo EDR (VIIRS-SA-EDR) has the global coverage, including land surface albedo (LSA), ocean surface albedo (OSA) and sea-ice surface albedo (ISA). Beta maturity is based on validation of LSA.
- Two algorithms (Dark Pixel Sub-Algorithm (DPSA) and Bright Pixel Sub-Algorithm (BPSA)) implemented for LSA; DPSA uses the BRDF information from the 16-day gridded albedo IP to first calculate spectral albedo and then convert spectral albedo to broadband albedo using empirical models. BPSA directly estimate broadband albedo from VIIRS TOA radiance.
- A LUT approach is applied for OSA, using solar zenith angle, aerosol optical thickness, wind speed and chlorophyll concentration as inputs.
- The BPSA is currently used to generate LSA from VIIRS. Several improvements have been made since launch.
- VIIRS-SA-EDR product is expected to be used by weather forecasting models, Agriculture monitoring, drought prediction and monitoring, ecosystem monitoring; climate studies etc approach is applied for ISA

L1RD Requirements

Albedo EDR		
Attribute	Threshold	Objective
Albedo Applicable Conditions: day time, Clear only		
a. Horizontal Cell Size		
Nadir	4 km	0.5 km
b. Mapping Uncertainty, 3 Sigma	*4km*	*1 km*
c. Measurement Range	0 to 1.0	0 to 1.0
d. Measurement Precision (1 sigma)	0.05 (albedo unit)	0.02
e. Measurement Accuracy (bias)	0.08 (albedo unit)	0.0125
f. Refresh	At least 90% coverage of the globe every 24 hours (monthly average) .	4 hrs.

Major Users of LSA product (Point of Contact)

- **U. S. Users*:**
  - NOAA National Weather Service Environmental Modeling Center (Michael EK, Jesse Meng, Weizhong Zheng)
  - USDA Agricultural Research Services(Martha Anderson)
  - USDA Forest Service (Brad Quayle)
  - NOAA/NESDIS Center for Satellite Applications and Research (Jerry Zhan)
  - NOAA/NESDIS National Climate Data Center (Peter Thorne)
  - Academy -- University of Maryland (Konstantin Vinnikov, Shunlin Liang, Cezar Kongoli)
  - Army Research Lab (Kurt Preston)
- **Foreign Users**
  - EUMETSAT (Yves Govaerts)
  - Météo France (Jean-Louis Roujean)
  - Academy: Italy IASMA Research and Innovation Centre (Barbara Marcolla), Beijing Normal University (Qiang Liu)

*The US USERs are to be verified.

Overview of Albedo Products

- VIIRS-SA-EDR is a full resolution product for each granule, under clear-sky condition.
- VIIRS-SA-EDR is a combined from LSA, OSA, ISA
- LSA is currently generated from the BPSA algorithm.
- LSA has met the beta version product requirements:
  - *Early release product*
  - *Initial calibration applied*
  - *Minimally validated and may still contain significant errors (additional changes are expected)*
  - *Available to allow users to gain familiarity with data formats and parameters*
  - *Product is not appropriate as the basis for quantitative scientific publications, studies and applications*
- A couple of algorithm refinements have been made since launch.
  - *The BPSA regression LUT was updated.*
  - *A new BRDF version of LUT is ready and will be implemented.*
- Assumptions of albedo validation:
  - *VIIRS SDR is calibrated and cloud/snow mask is reliable.*
  - *OSA, ISA are equivalent or higher quality than LSA because they are more stable over space and time*

History of Algorithm changes/updates

Date Submitted	Update/DR#	Description	Status
4/30/12	DR 4709	Update pre-launch 2002 seeded data for BRDF Archival tiles because even after gridding is turned on, it will take many months for these tiles to be populated with VIIRS data.	**Closed.** CCR 474-CCR-12-0610 went into ops 10/12/12
4/30/12	DR 4704	The pre-launch LUT of BPSA regression coefficients used old spectral response functions. We generated a set of new regression coefficients after launch. This algorithm update is about replacing the old LUT with this new one and slightly adjusting some codes as needed	**Closed.** The results from the updated LUT was verified. CCR-12-0606,0889 into ops with Mx6.7
9/12/12	DR 4901	SA Jump in precision after Mx6.2. Cal/Val analysis of the Albedo EDR shows a substantial degradation of performance for data gathered after August 9th when Mx6.2 went operational. This might be caused by an incorrect LUT used for this algorithm.	**Closed** Did not occur after SA BPSA LUT DR4704 became operational in Mx6.7.
8/22/12	DR 4882	SA Fix BRDF Kernel Selection. BRDF derivation using a "best" fitting kernel model is selected from a multiple kernel combination approach. This is not necessary, and even may cause problems. Investigation shows that a fixed RossThick Li-Sparse Reciproral (RTLSR) kernel (which is the MODIS heritage) is the best approach for the VIIRS Gridded Albedo/BRDF derivation.	**Closed.**474-CCR-12-0607 passed AERB 16 Jan 13 Approved 16 Jan AERB for Mx7.1
3/28/13	DR 7114	17-Day LSA GIP experienced failures in Mx6.7 due to the code was blindly using fill values for the coeff in the ProGipViirsGridToGridLSA when calculating Nbar, BlackSky, and WhiteSky causing the ProCmnScaler not to recognize the new fillvaules and causing a scale out of bound message	**Closed.**CCR_474-CCR-13-1031 passed AERB on17 May schedule for Mx8.0

History of Algorithm changes/updates

Date Submitted	Update/DR#	Description	Status
7/7/11	DR 4303	IngMsdCoefficients_ViirsSurfAlbedoStruct has two problems. Not only does it need to be wrapped in a "pragma pack(4)", but it also contains several 'long' variables (which are 4 bytes on nppdev1, but 8 bytes on moddev64)...	Open - Not a science team issue
5/4/11	DR 4265	Surface Albedo Summary Quality flag does not count “fill” pixels. The summary quality flag is defined as "Exclusion Summary" and "Percent of pixels with one or more exclusion criteria flags" which does not meet the intent of the summary quality flag	Deferred
1/13/11	DR 4187	Surface Albedo Mission Quality Flag for Ice Concentration exclusion. The code outputs "fill" data for any ice fields that are less than 0.99 ice concentration, but no no quality flag to indicate why the data is "fill" from the ice concentration test. There is a spare bit available in the current output set that could be used to flag the test.	Deferred
1/13/11	DR 4186	Surface Albedo Quality indicator needs another level. Recommend a four level quality field:.. Good, Poor (degraded), Poor (excluded), and not calculated (excluded) - to replace the current three level field of Good, Poor, and not calculated.	Deferred
1/6/11	DR 4183	Surface Albedo Quality Flags are incorrect in the EDRPR. The code and EDRPR quality flag requirements differ. The problem comes about by the merging of the land, ice, and ocean albedo IP's that all tend to have different exclusions.	**Closed** 5/5/11 EDR PR updated.

Processing for Global VIIRS-SA-EDR

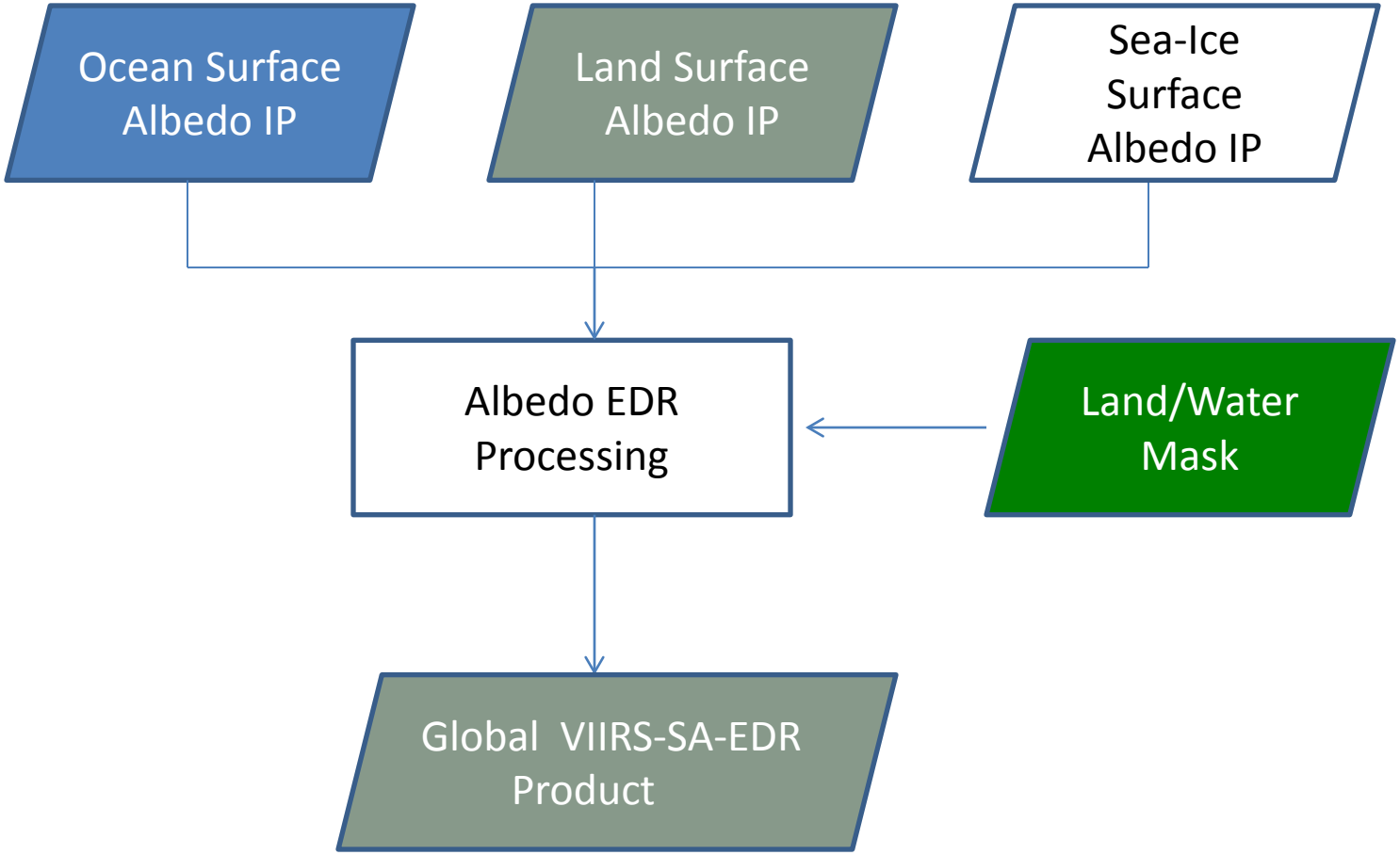


Table 10. Combined Albedo Outputs

Output	Data Type/Size	Description	Units/Valid Range
Global Albedo	Uint*16 x [MOD_TRACKS x MOD_SCANS]	Surface Albedo Values for ocean, land, or ice	Unitless/ 0.0 – 1.0 (EDR Scaled Units)

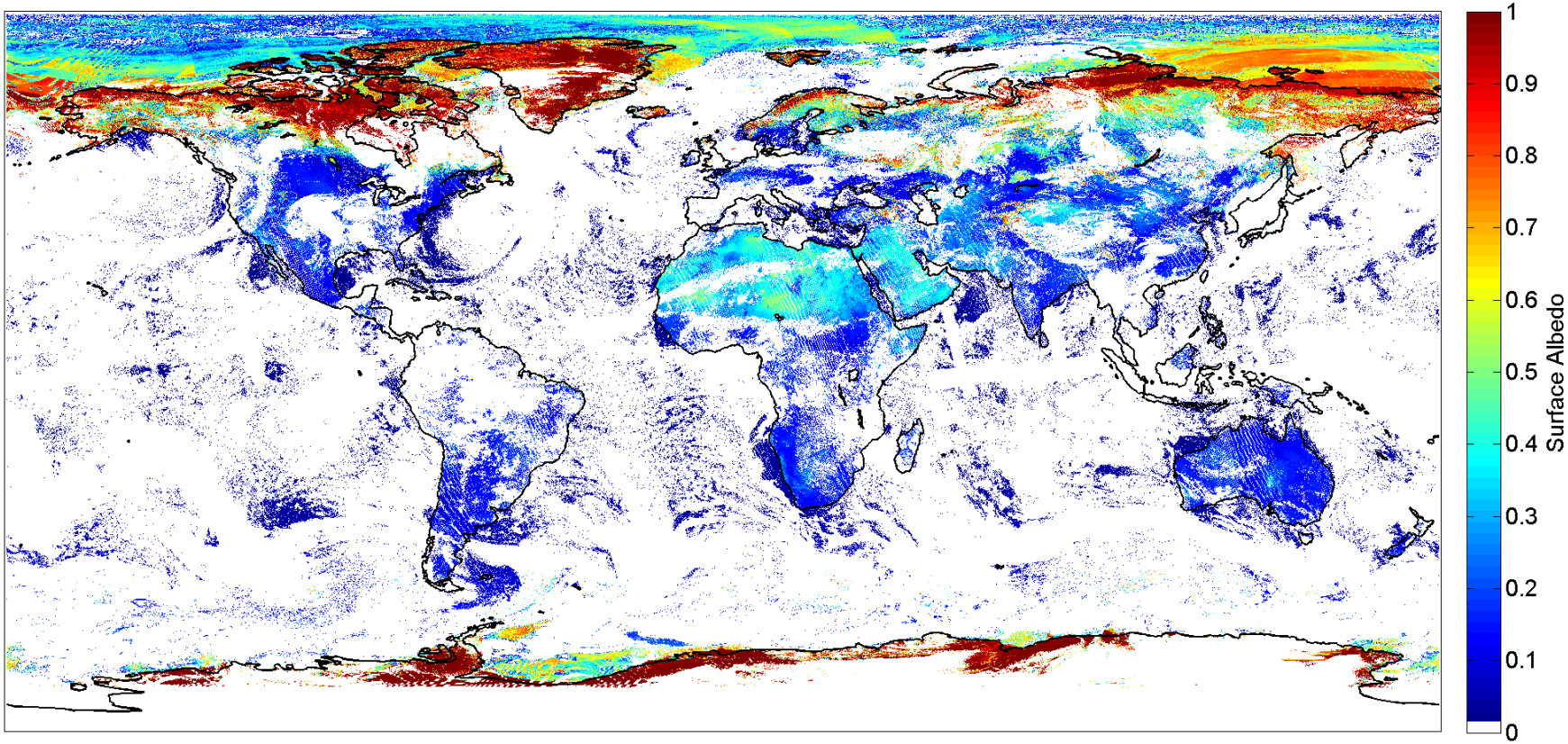
Refinement to the BPSA algorithm

- The BPSA LUT of regression coefficients was updated (DR4704).
- Another version of LUT is generated and ready for implementation.
  - Features:
    - Using latest spectral response function
    - Considering surface BRDF
  - Improvements:
    - Better accuracy when comparing with in situ data
    - The problem of angular dependency is addressed

Perform VIIRS Land Surface Albedo (LSA) Internal Evaluation

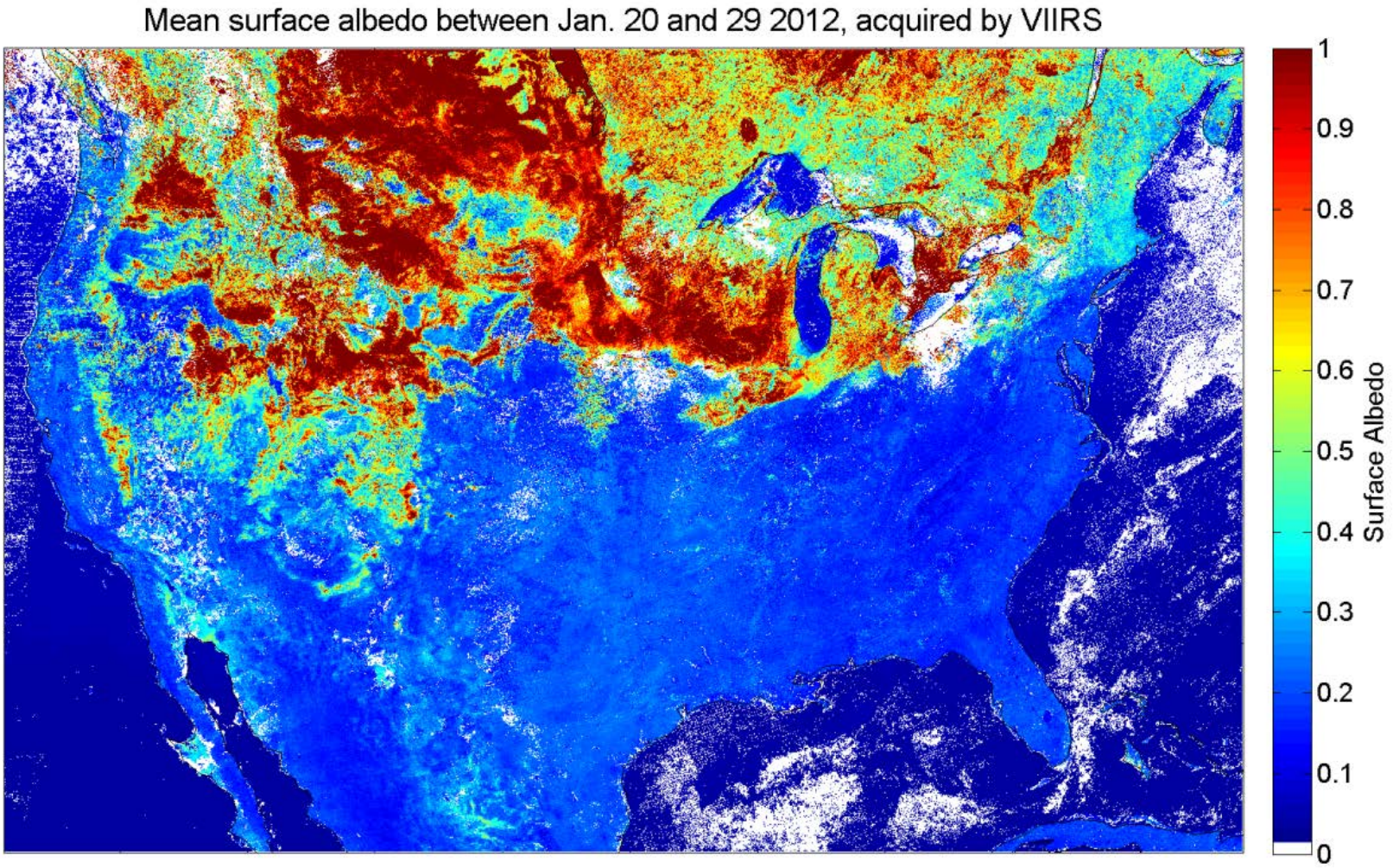
- VIIRS LSA data evaluation
- VIIRS LSA quality flag and metadata check
- Upstream (SDRs, EDRs and IPs inputs) data check
- Evaluation is performed at levels of
  - *Single granule map*
  - *Granule aggregation map (temporal composite)*
  - *Regional LSA map*
  - *Global LSA composite map*

Example of Suomi NPP VIIRS LSA



VIIRS-SA-EDR data obtained on April 3 2012

Example of Suomi NPP VIIRS LSA



Temporal aggregated map of surface albedo over continental USA

Internal Evaluation summary

- VIIRS-SA-EDR LSA data are checked and visually examined. Both the datasets of LSA and its quality flag are checked. The metadata associated with the data is also checked.
- The data files are correctly generated. The internal evaluation reveals no issues with the data structure and file format.
- There are 3 bytes pixel-level quality flag in total. Some fields of QF cannot correctly mark the retrieval quality. For example, some of filling values are marked as “good”.
- Its upstream SDRs, EDRs and IPs (i.e., TOA reflectance, cloud mask) are also checked. It reveals no issues with upstream SDRs, EDRs and IPs.

Perform VIIRS LSA Validation

External evaluation :

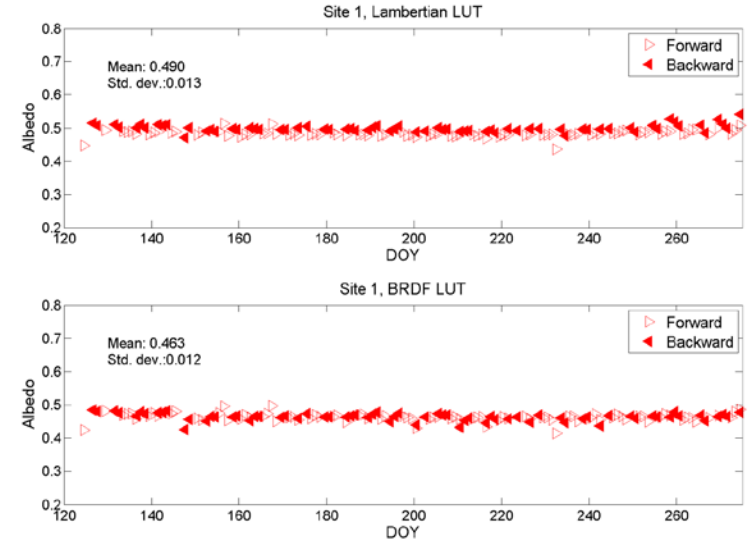
- Evaluate temporal variability
  - Over stable surfaces (e.g., desert)
  - Comparing with variability from other methods (e.g. BRDF fitting)
- Inter-comparison with MODIS albedo products

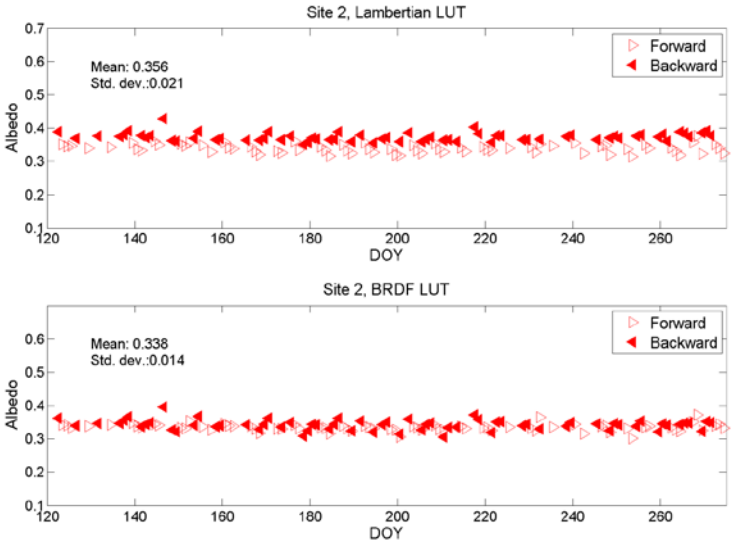
- Validation against ground truth data
  - Direct validation of daily albedo
  - Comparison of 16-day mean albedo

Evaluation of temporal variability of LSA

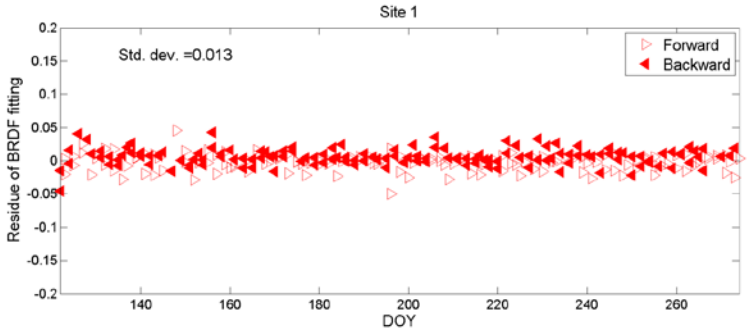
The LSA retrievals over two Libya desert sites (Site 1: 24.42˚N 13.35˚E and Site 2: 26.45˚N, 14.08˚E) are used to illustrate the issue of temporal variability of LSA.

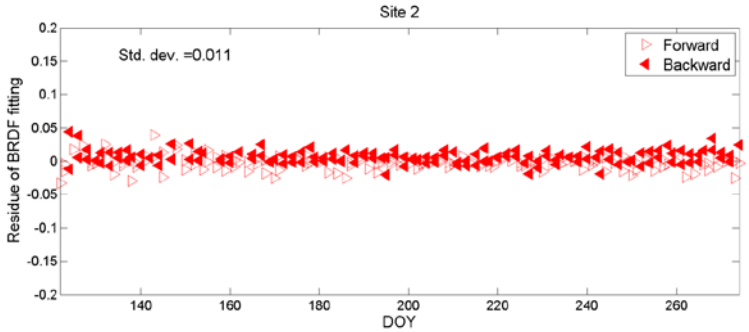
LSA retrieved from two LUT (Lambertian and BRDF LUT) at two desert sites. The spurious retrievals caused by undetected cloud and cloud shadow are excluded with the threshold of mean ± 0.05



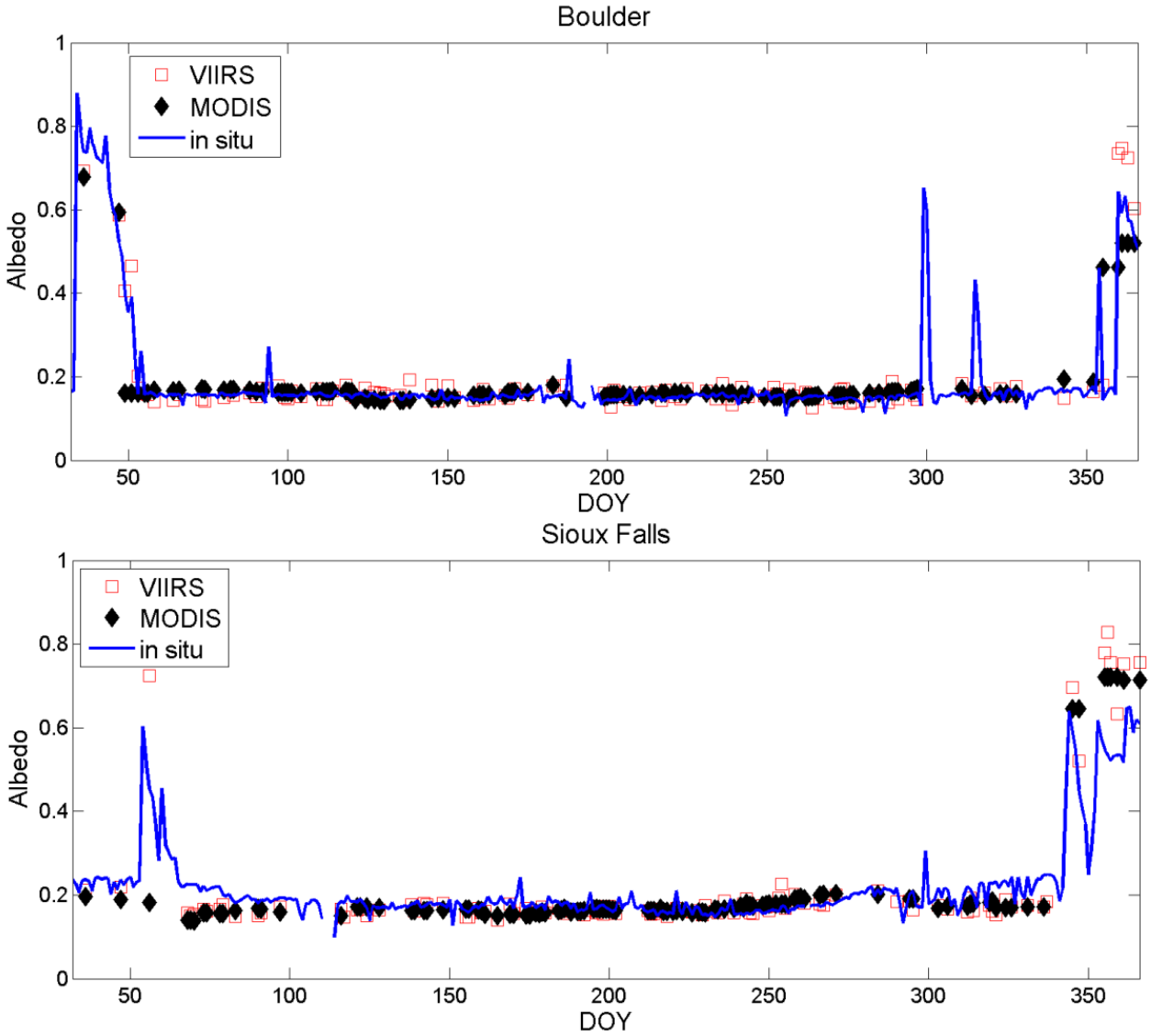


Residue of BRDF fitting, calculated as the difference between MODIS surface reflectance and BRF predicted from MODIS BRDF. The narrow-to-broadband conversion coefficients are used to covert spectral residues to the broadband residue





Comparing VIIRS LSA with in situ and MODIS



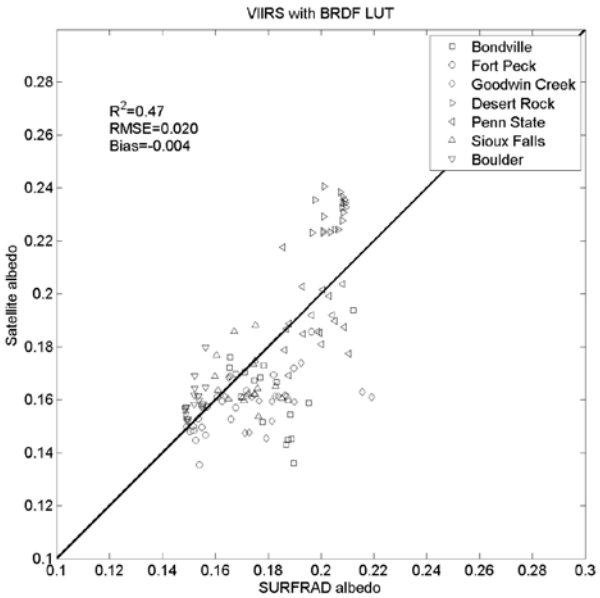
Examples of comparison between LSA retrieved from VIIRS and MODIS and LSA measured at two SURFRAD sites

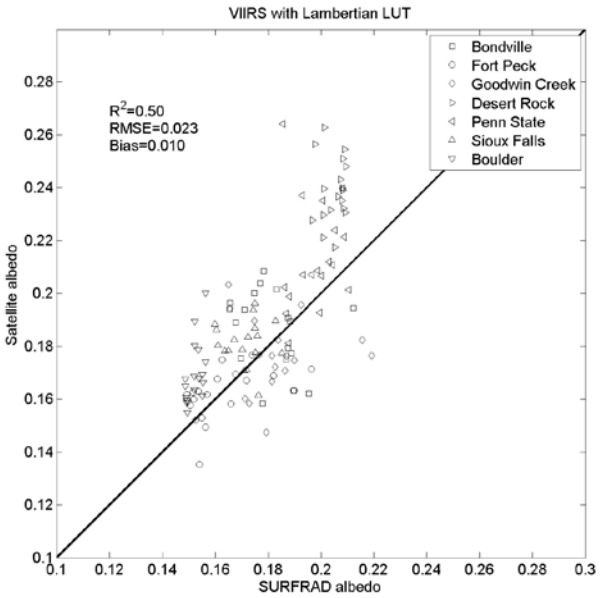
Summary of validation

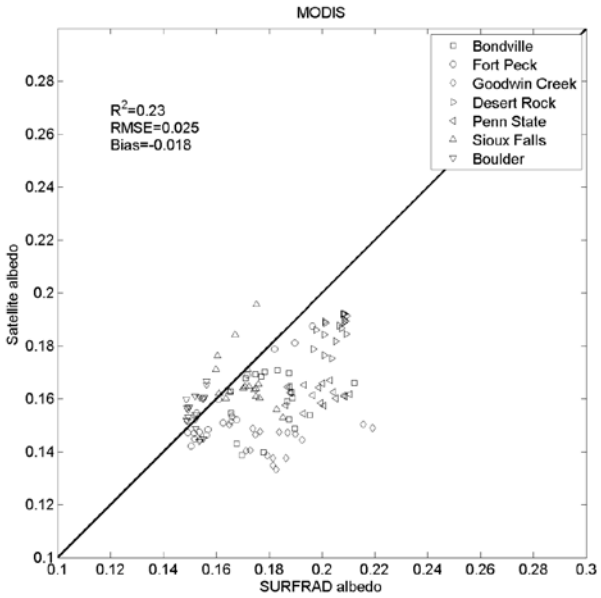
Summary of validation results at seven SURFRAD sites. Three satellite albedo data (VIIRS LSA from the Lambertian LUT, VIIRS LSA from the BRDF LUT and MODIS albedo) are validated against field measurements.

Site	VIIRS (BRDF LUT)			VIIRS (Lambertian LUT)			MODIS		
	R^2	RMSE	Bias	R^2	RMSE	Bias	R^2	RMSE	Bias
Bondville	0.50	0.070	-0.048	0.15	0.081	-0.038	0.57	0.071	-0.052
Fort Peck	0.89	0.070	0.001	0.87	0.073	-0.005	0.98	0.043	-0.020
Goodwin Creek	0.01	0.040	-0.033	0.15	0.051	-0.031	0.11	0.051	-0.048
Desert Rock	0.10	0.032	0.026	0.02	0.045	0.020	0.02	0.025	-0.023
Penn State	0.60	0.040	-0.020	0.27	0.054	-0.011	0.02	0.079	-0.054
Sioux Falls	0.89	0.064	0.004	0.82	0.066	0.007	0.87	0.059	-0.001
Boulder	0.96	0.029	0.011	0.91	0.034	0.012	0.79	0.047	0.002
Overall	**0.80**	**0.049**	**-0.004**	**0.71**	**0.057**	**-0.003**	**0.78**	**0.052**	**-0.026**

Validation of 16-day mean LSA

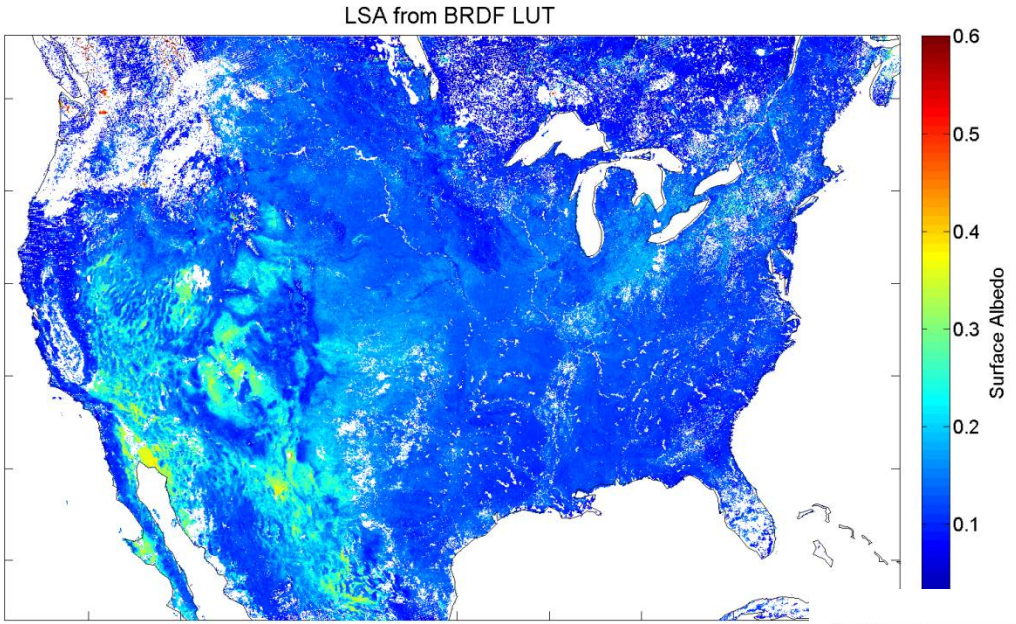


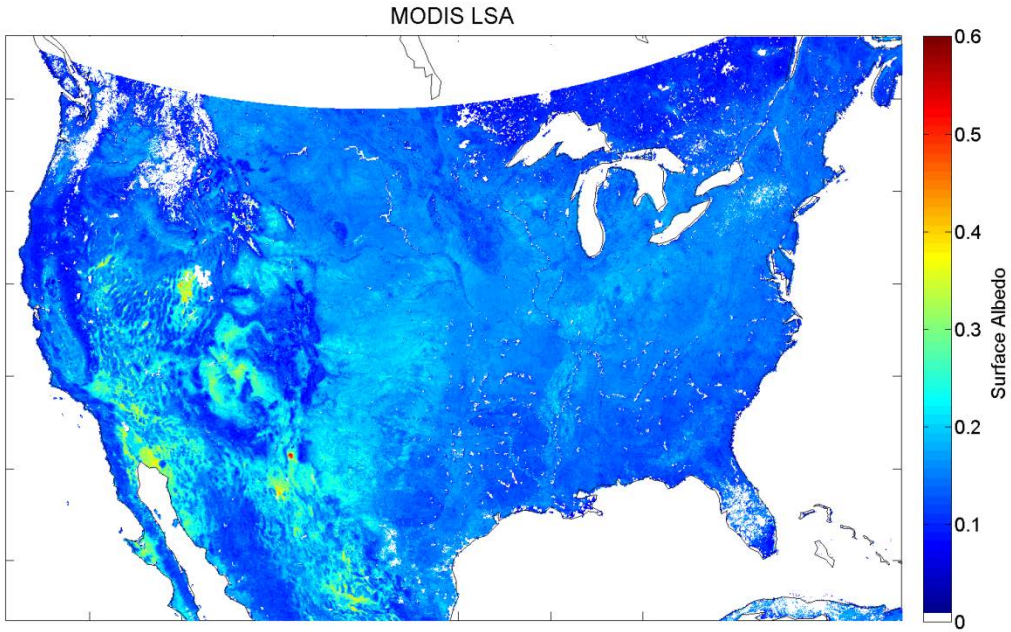




Validation results of 16-day mean albedo from VIIRS BRDF LUT (top left), VIIRS Lambertian LUT (top right) and MODIS (bottom), using data from 2012 non-snow seasons (May-September) at seven SURFRAD sites.

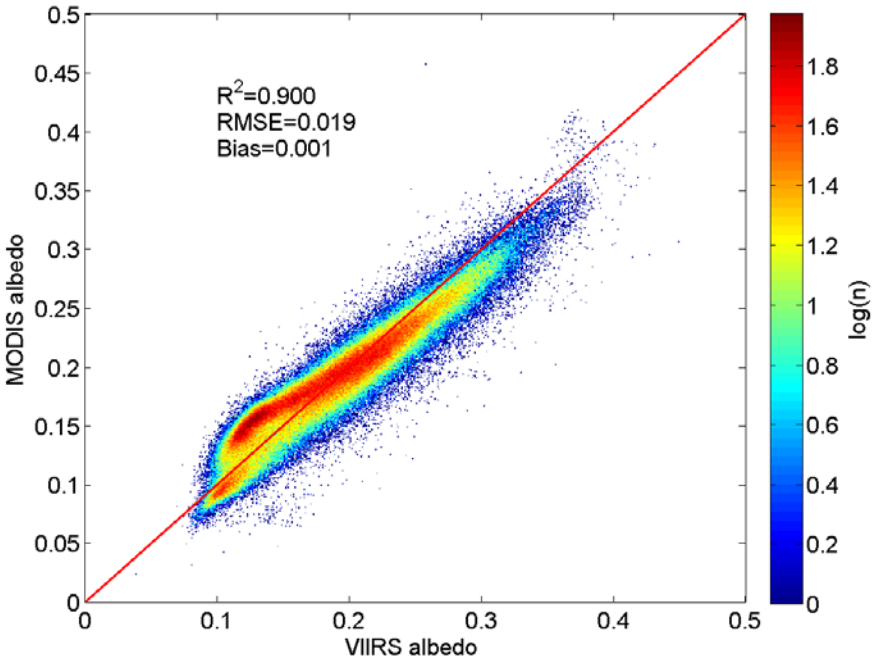
Maps of 16-day mean albedo

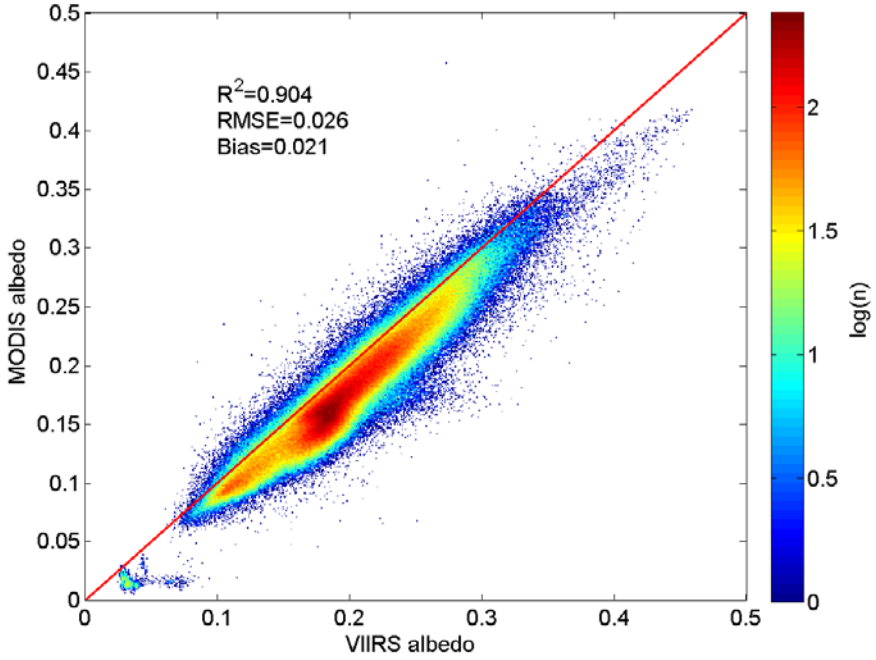




Contiguous US maps of 16-day mean LSA from VIIRS BRDF LUT (top) and MODIS (bottom), during DOY 145-160, 2012

Comparison between VIIRS and MODIS albedo





Comparing 16-day mean VIIRS albedo from BRDF LUT (top) and Lambertian LUT (bottom) with MODIS blue-sky albedo. Data are limited to those with at least 8 clear-day observations during the composite period of 16 days.

Evaluation/Validation Conclusion

- The individual LSA retrieval from the current BPSA algorithm shows the problem of angular dependency.
- A new BRDF LUT is developed. The variations of albedo retrievals from the BRDF LUT are reduced significantly. The variation is comparable with the reflectance residue of BRDF fitting.
- VIIRS LSA retrievals agree well with the MODIS albedo products. Comparison with field measurements at seven SURFRAD sites shows that VIIRS LSA retrieved from the BRDF LUT has a R^2 value of 0.80 and root mean squared error of 0.049, better than MODIS albedo products.
- The BRDF LUT generates a small negative bias of -0.004, whereas the MODIS albedo is underestimated with a larger bias of -0.026.

Known Issues

- The current BPSA LUT implemented in CLASS doesn't consider surface BRDF. This leads to temporal variability of LSA retrievals over stable surfaces.
- The quality of BPSA retrievals rely on the accurate detection of cloud and cloud shadow. Undetected cloud/shadow will generate spurious high/low values.
- QF cannot correctly mark the retrieval quality. For example, Some of fill values are marked as "good".
- Validation difficulties
  - *Limited high quality in-situ data*
  - *Surface heterogeneity in a pixel*
  - *Impact of cloud contamination*

Future Plans

- Near-term
  - *Collect OSA, ISA evaluation results from the* Net Heat Flux team and the Cryosphere team, respectively, *for a comprehensive Surface Albedo evaluation report.*
  - *Continue monitoring the LSA data and comparisons to MODIS LSAs*
  - *Perform the LSA validation with a global distribution of ground measurements of radiative fluxes.*
  - *Develop algorithms of temporal filtering to reduce the impacts of undented cloud and cloud shadow*
  - *Determine an approach of integrating BPSA and DPSA outputs*
  - *Initial end user evaluation and feedback*

- Mid- to long-term
  - *Full evaluation of updated science algorithm and code*
  - *Provisional status by Nov, 2013 (adjustment request: March 2014)*
  - *Validated Version 1 status by July, 2014 (adjustment request: Nov 2014)*

Summary

- Beta release of Suomi NPP VIIRS-SA-EDR is ready.
- Validations are performed with comparisons to MODIS LSA, in-situ LSA, LSA map monitoring, evaluation of LSA temporal stability.
- Continuous efforts have been put to improve the BPSA LSA retrievals. The latest LUT with BRDF as inputs is ready for implementation.
- A temporal filter will be developed to reduce the impacts of undetected cloud and cloud shadow on BPSA retrievals.
- Further evaluation will be conducted to better understand uncertainties of LSA products and provide comprehensive validation reports.