Direct Estimation of Land Surface Albedo from VIIRS Data

Algorithm Improvement and Preliminary Validation

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Overview

- 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 EDR is combination of land surface albedo (LSA), ocean surface albedo (OSA) and sea-ice surface albedo (SSA).
- 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.
- BPSA is also applied to sea ice pixel to estimate SSA with a separate LUT specifically developed for sea-ice surfaces.
- The BPSA is currently used to generate LSA. Several improvements have been made since the S-NPP launch.

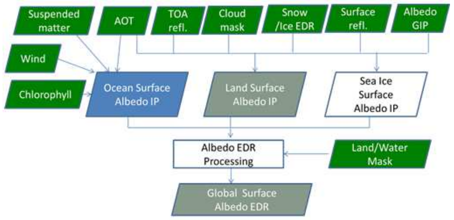

Fig. 1. A flowchart showing the major inputs data to surface albedo EDR algorithm

Example of VIIRS LSA maps

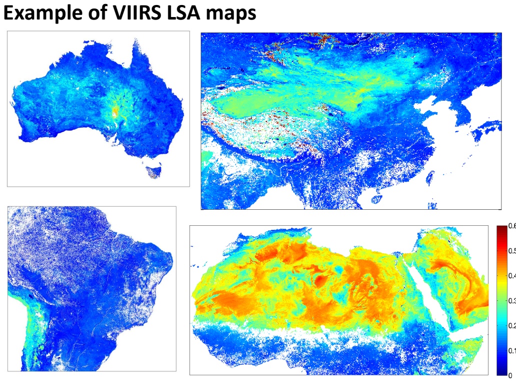

Fig. 2. Temporal averaged maps of surface albedo, May 8-23, 2012

Publication

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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.
- 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.

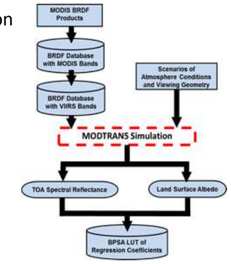

Fig. 3. A brief flowchart showing how the BPSA LUT of regression coefficients is generated

Temporal stability of LSA retrievals

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.

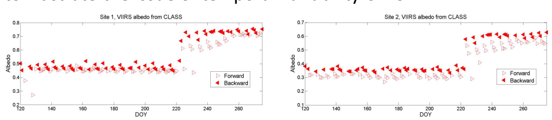

Fig. 4. Time series of beta release data. Jumps around 8/9 were caused by the bugs in a early version of the operational codes. "Forward" means pixels with relative azimuth angle >90° and "backword" means those with relative azimuth angle <90°.

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

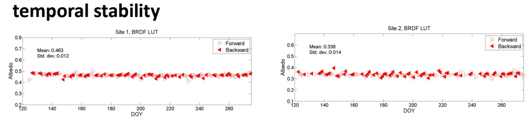

Fig. 5. LSA retrieved from new BRDF LUT. The spurious retrievals caused by undetected cloud and cloud shadow are excluded with the threshold of mean ± 0.05.

Compare residual variations with those from alternative methods

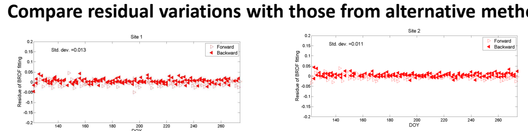

Fig. 6. Residue of BRDF fitting, calculated as the difference between MODIS surface reflectance and BRF predicted from MODIS BRDF. The narrow-to-broadband conversion coefficients are used to covert spectral residues to the broadband residue.

Validation at 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

Table 1. List of seven SURFRAD sites.

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

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**

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**

Table 2. Summary of validation results at seven SURFRAD sites (Top: 2012, bottom: 2013). Three satellite albedo data (VIIRS LSA from the Lambertian LUT, VIIRS LSA from the BRDF LUT and MODIS albedo) are validated against field measurements.

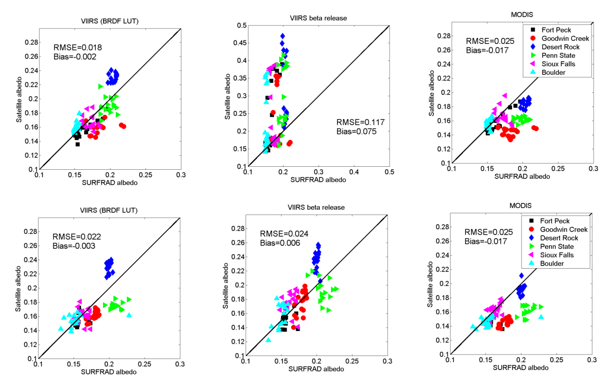

Fig. 7. Validation results of 16-day mean albedo from VIIRS BRDF LUT, CLASS VIIRS data and MODIS, using data from 2012(top) and 2013 (bottom) non-snow seasons (May-September) at six SURFRAD sites.

Summary

- 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.
- 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.