GOES-R AWG Land Team: ABI Land Surface Albedo and Land Surface Reflectace Algorithm

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  - » Wei Guo (Proxy data)

Executive Summary

- This ABI Albedo Algorithm generates the Option 2 products of Surface Albedo and Surface Reflectance.
- CDR has been passed and Code Version 1 has been delivered.
- Preparing for the Version 2 code and 80% ATBD delivery.
- An improved optimization algorithm was developed to estimate the surface properties and atmospheric conditions simultaneously.
- BRDF and AOD are used to retrieve surface albedo and surface reflectance.
- MODIS, SEVIRI and simulated data are used as proxy to verify the albedo algorithm.
- Preliminary validations show the albedo algorithm can satisfy the accuracy requirement.

Requirements and Product Qualifiers: Surface Albedo and Surface Reflectance

Name	User & Priority	Geographic Coverage (G, H, C, M)	Vertical Resolution	Horizontal Resolution	Mapping Accuracy	Measurements Range	Measurements Accuracy	Refresh Rate/Coverage Time Option (Mode 3)	Refresh Rate Option (Mode 4)	Data Latency	Product Measurement Precision	Temporal Coverage Qualifiers	Product Extent Qualifier	Cloud Cover Conditions Qualifier	Product Statistics Qualifier
Surface Albedo	GOES-R	FD	N/A	2 km	2 km	0 to 1 Albedo Units	0.08 Albedo Units	60 min	60 min	3236 sec	10 %	Sun at 67 degree daytime solar zenith angle	Quantitative out to at least 70 degrees LZA and qualitative beyond	Clear conditions associated with threshold accuracy	Over specified geographic area

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Surface Reflectance	GOES-R	FD	N/A	2 km	2 km	0 to 2	0.08	60 min	60 min	3236 sec	5 %	Sun at 67 degree daytime solar zenith angle	Quantitative out to at least 70 degrees LZA and qualitative beyond	Clear and cloudy conditions	Over specified geographic area

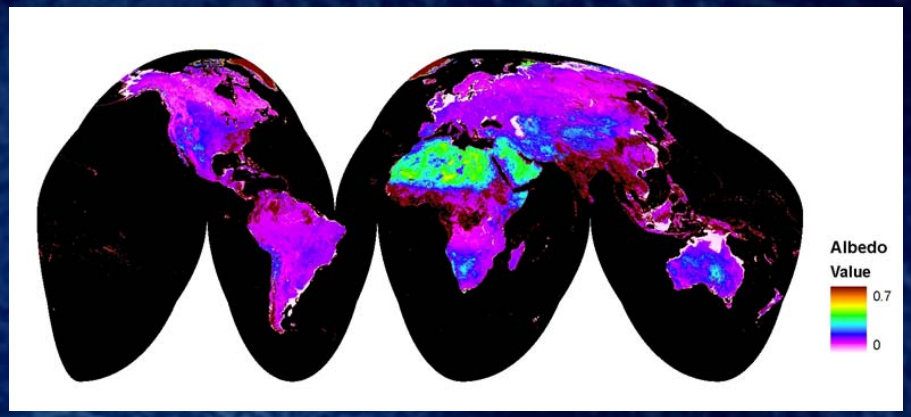
Algorithm Description

Algorithm Summary

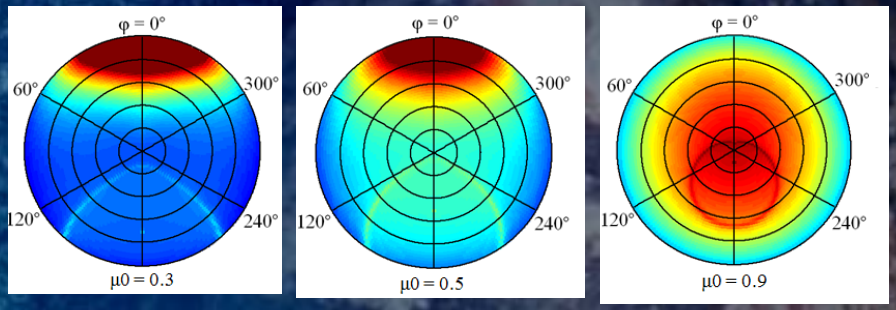
- This ABI Albedo Algorithm generates the Option 2 products of Surface Albedo and Surface Reflectance.
- The albedo algorithm combines atmospheric correction and surface BRDF modeling, producing both surface directional reflectance and shortwave albedo.
- The unique advantages of GOES-R (multi-channel and frequent refreshing rate) are fully utilized in the cooperative retrieval of surface BRDF and atmospheric parameters.
- We use existing BRDF and albedo products as prior knowledge and incorporate their climatologies effectively in the inversion algorithms.
- The algorithm needs no surface reflectance input.

What is Albedo?

- Surface albedo is the ratio between upward and downward radiation at the earth surface.
- Multi-angle information is needed to model the surface anisotropy and multi-band information is required to decouple surface properties from atmospheric variations.
- The frequent temporal refreshment, fine spectral resolution and large spatial coverage make ABI a unique data source for mapping surface albedo.



MODIS black-sky albedo July 28 – August 12, 2003
Lots of gaps due to insufficient observations or failure of retrieval.

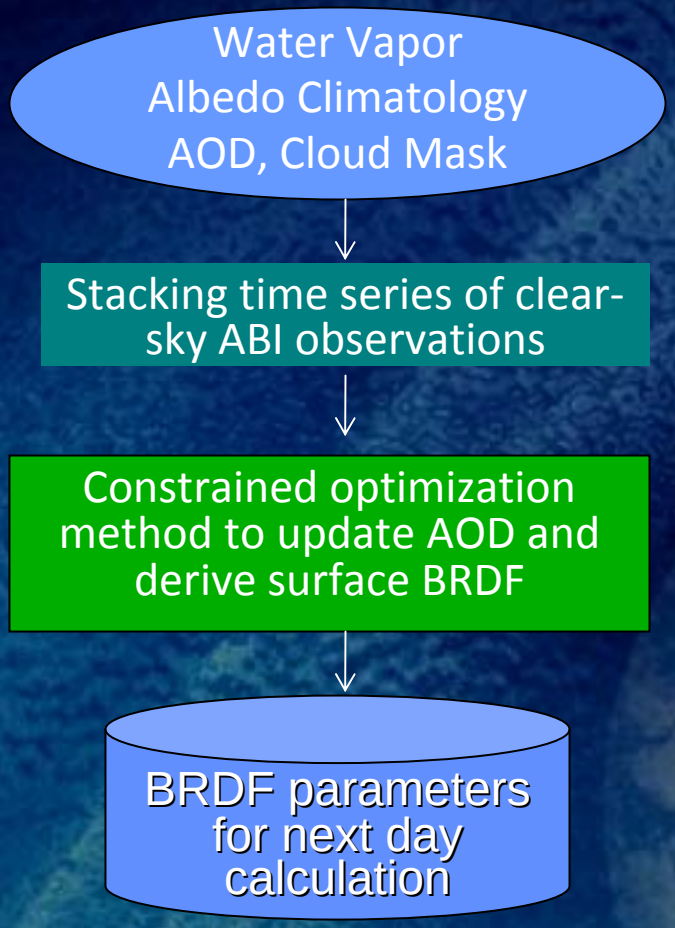


Surface usually reflects insolation anisotropically.
Theoretical calculation of BRDF distribution from Mishchenko's radiative transfer model

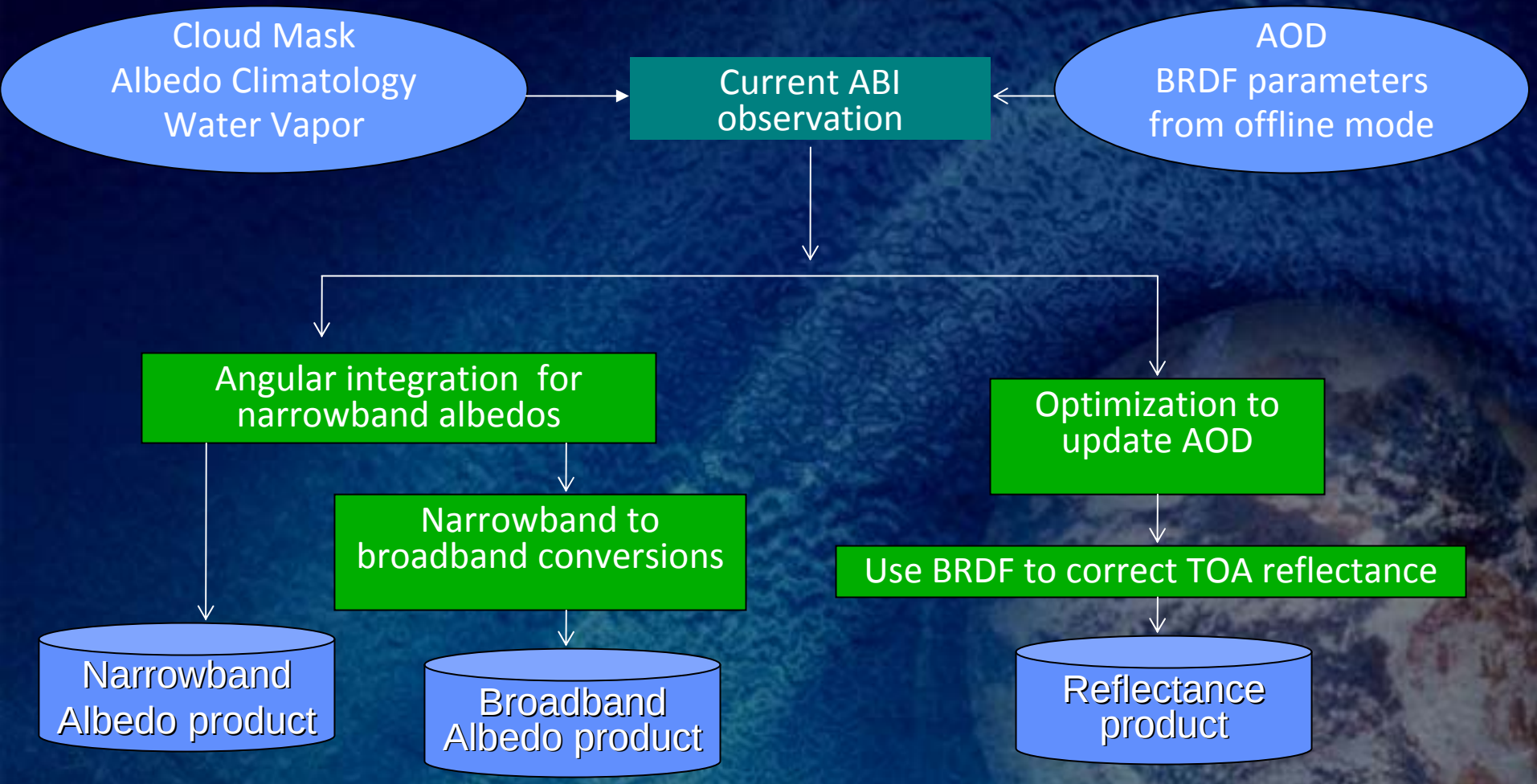
Introduction to the Offline Mode

- The calculation of albedo needs a long time series. To improve efficiency, an “offline” computation is carried out at the end of each day to derive BRDF parameters. These parameters will be stored to calculate albedo and surface reflectance for the next day.
- The online mode is run in real-time to generate instantaneous full-disk surface albedo and surface reflectance products.
- The offline and online modes share similar mathematical and physical theories and have slightly different input/output

Flowchart of offline Mode



Flowchart of online mode



Albedo Algorithm Input

- Offline mode: time series of sensor data and ancillary data
- Online mode: sensor/ancillary data at the current time only and output of offline mode
- Sensor data
  - » ABI calibrated radiance in Channels 1,2,3,5,6
  - » Observational geometry (sensor view zenith, solar zenith, relative azimuth)
  - » Geolocation (latitude, longitude)
  - » ABI sensor quality flags
- Ancillary data
  - » ABI Data: Cloud mask, AOD
  - » Non-ABI Static Data: Land/water mask, Land surface albedo climatology, LUT
  - » Non-ABI Dynamic Data: Water Vapor, BRDF parameters (Online mode only)

Albedo Algorithm Output

- Offline mode:
  - » Intermediate data
    - – BRDF parameters
- Online mode
  - » Scientific data
    - – Five narrowband albedos
    - – One broadband albedo.
    - – Reflectance at five bands
    - – QC for retrieval quality
  - » Metadata
    - – Processing time stamp
    - – Observation time
    - – Others

Albedo Physical Description

- Retrieval of surface albedo requires multiple observations of surface reflectance under varied illuminating and viewing geometries. The retrieving process usually includes:
  - » Atmospheric correction
  - » BRDF modeling
  - » Angular integration
  - » Narrowband to broadband conversion

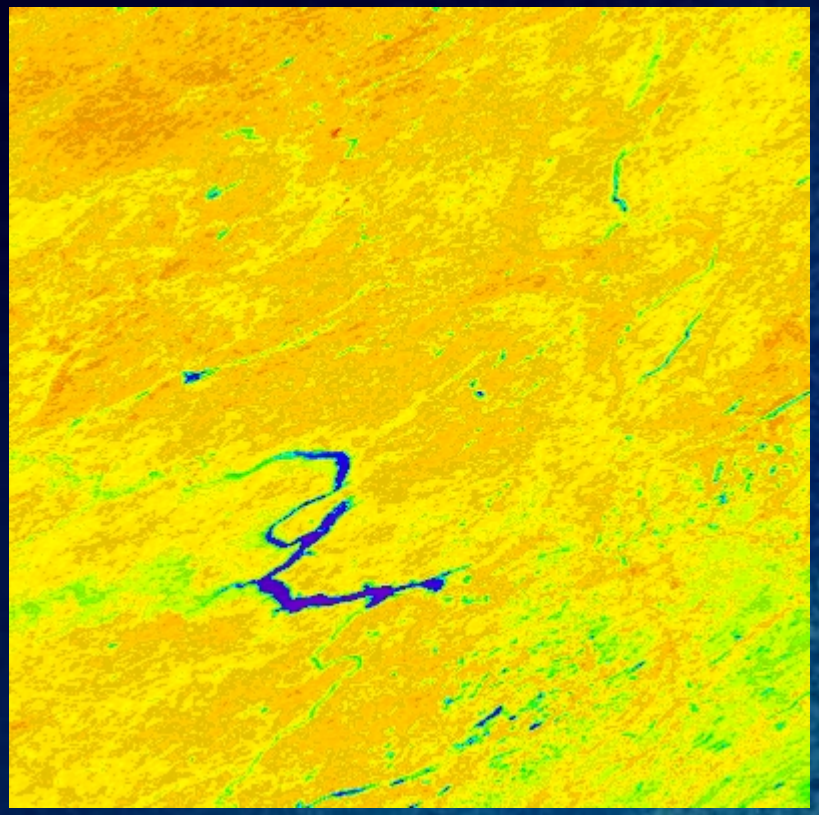
- Our ABI Albedo algorithm combines the atmospheric correction and BRDF modeling in one optimization step and also adds the prior background information from albedo climatology.

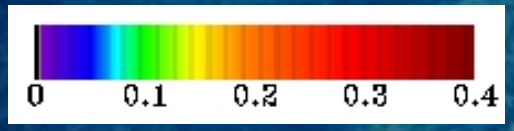
- After obtaining the BRDF parameters, we use these parameters to carry out another atmospheric correction and correct surface reflectance without the assumption of Lambertian surface.

Algorithm Description: Critical Steps

1. Derive BRDF parameters from a time series of ABI TOA observations
   - » Combine atmospheric correction and BRDF modeling in one optimization step
2. Angular integration to obtain narrowband albedos
3. Narrowband to broadband conversion
4. Run optimization code again for the current observations given the BRDF parameters to calculate the surface reflectance

Example of Surface Albedo Algorithm Output





- Retrieved broadband black-sky albedo map using MODIS as the proxy data
- May 1st, 2005
- Around 48˚N, 102˚W

Validation Approach and Results

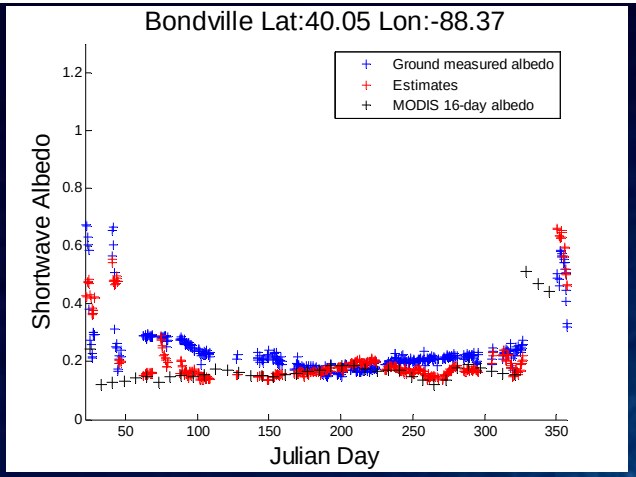
Validation Approach

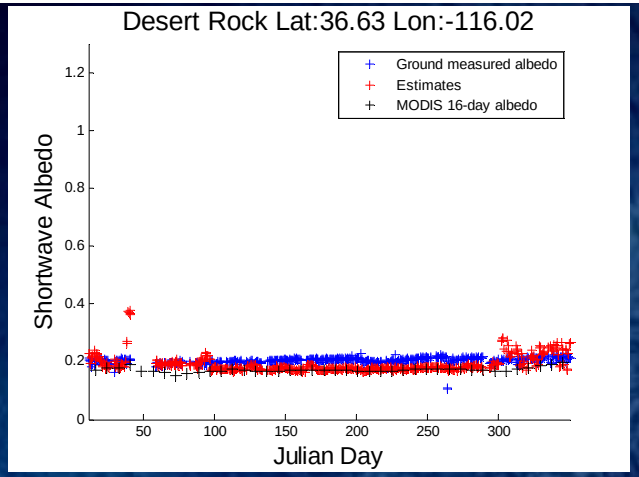
- Surface Albedo Validation
  - » Direct comparison of retrieved albedo with field measurements.
    - – Field measurements usually represent shorter temporal period. Temporal downscaling is used to match with satellite retrievals.
  - » Intercomparison with existing albedo products
    - – MODIS albedo product: 16-day composite
- Surface Reflectance Validation
  - » Direct validation
    - – No routine field measurements of surface reflectance
    - – Calculate “true” surface reflectance from TOA reflectance using in situ measurements of atmospheric parameters
  - » Intercomparison with other products

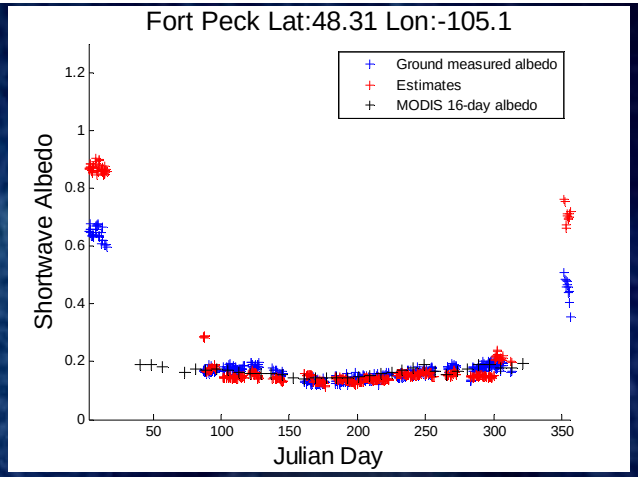
Validation Approach: datasets

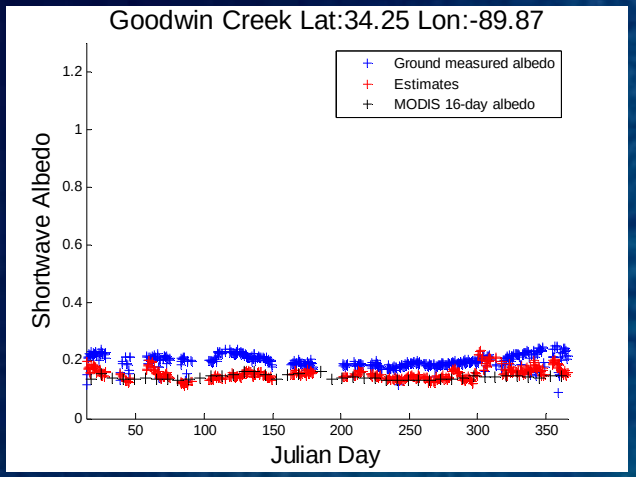
- We propose to use three types of proxy data to test and verify the ABI Albedo Algorithm
  - » MODIS: multi-channels, but polar orbiting
  - » SEVIRI: geostationary, but limited channels (three)
  - » Simulated ABI data
- The validation using MODIS as proxy data has been completed
  - » Points validation over SURFRAD and AmeriFlux sites
- We also have preliminary results using simulated ABI data.

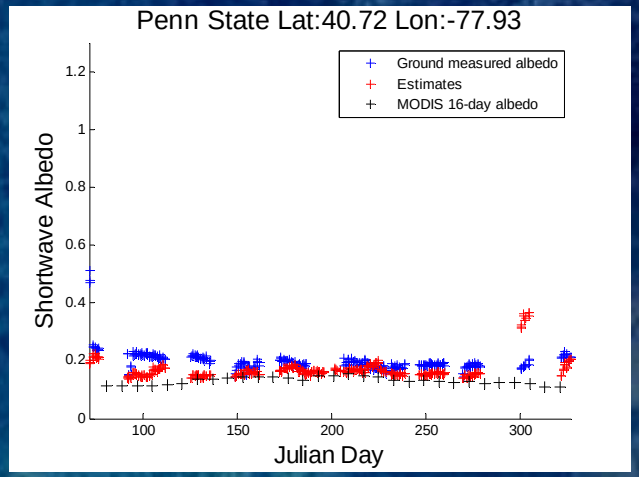
Validation Results: Time Series over SURFRAD

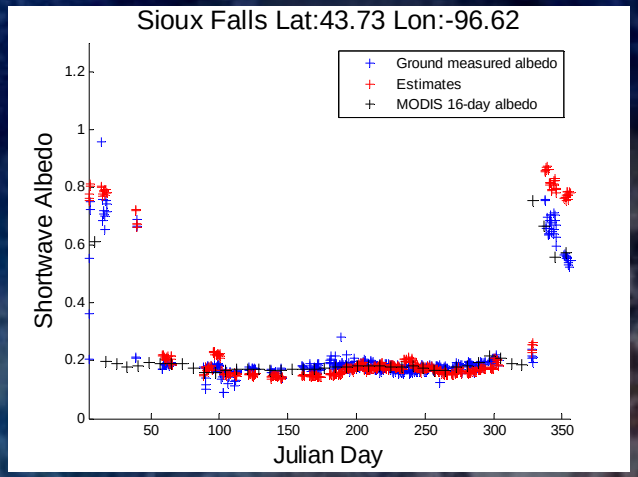






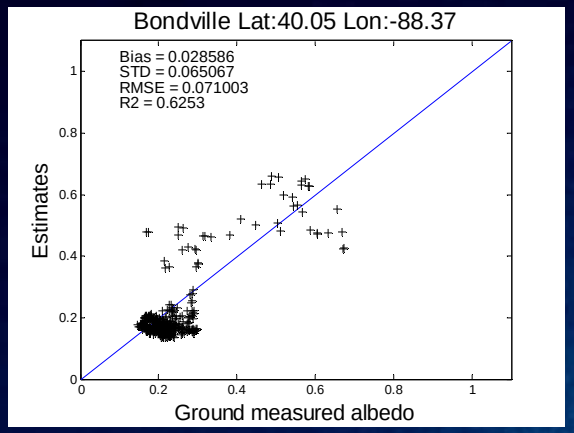


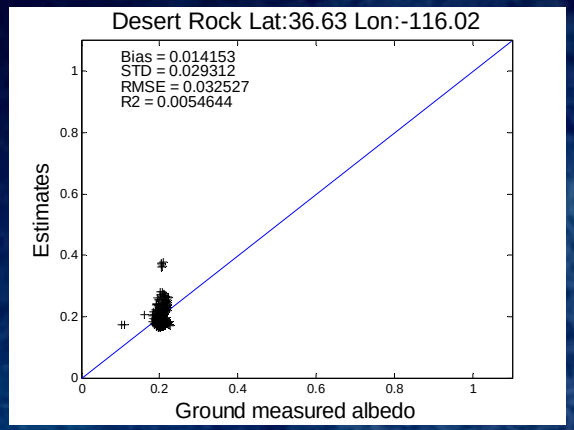


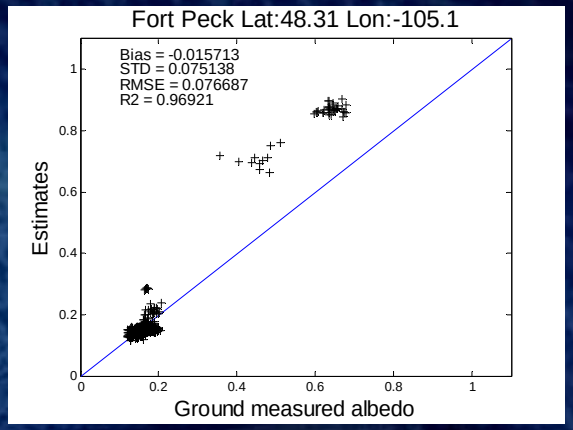


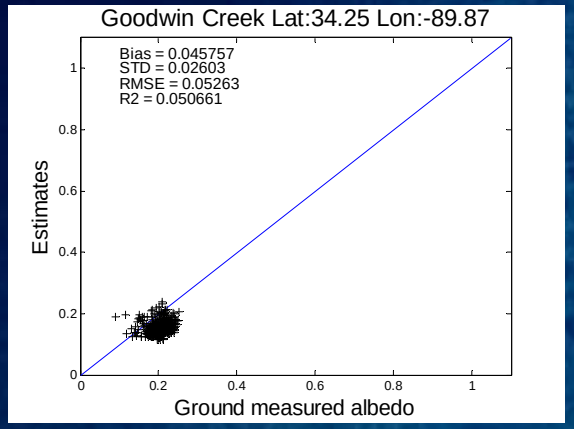
MODIS/Terra and MODIS/Aqua data in 2005 are used as proxy
MODIS albedos are also shown

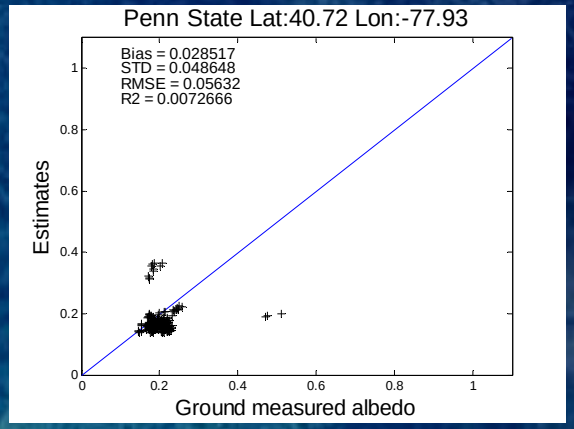
Validation Results: Scattering Plots over SURFRAD

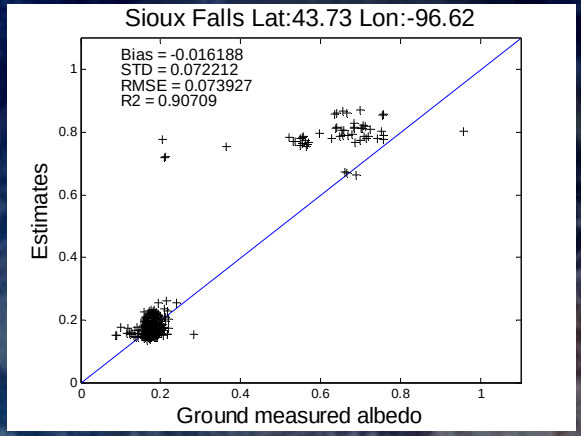






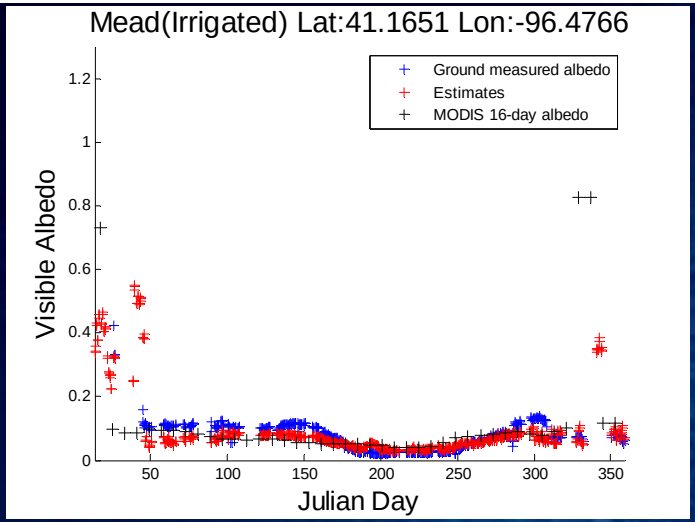


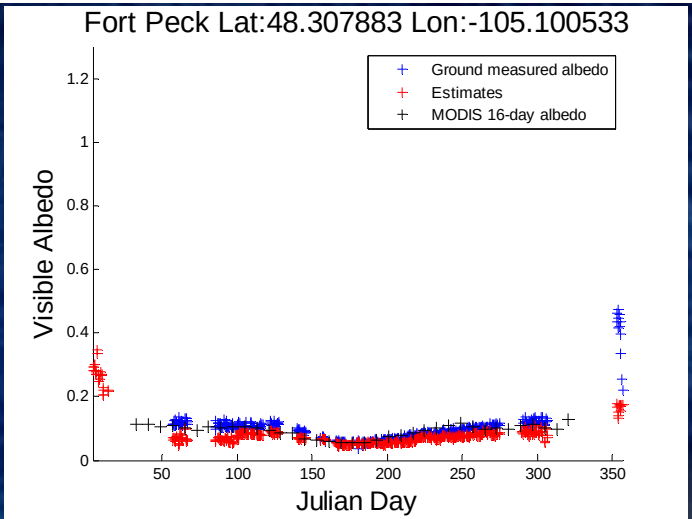


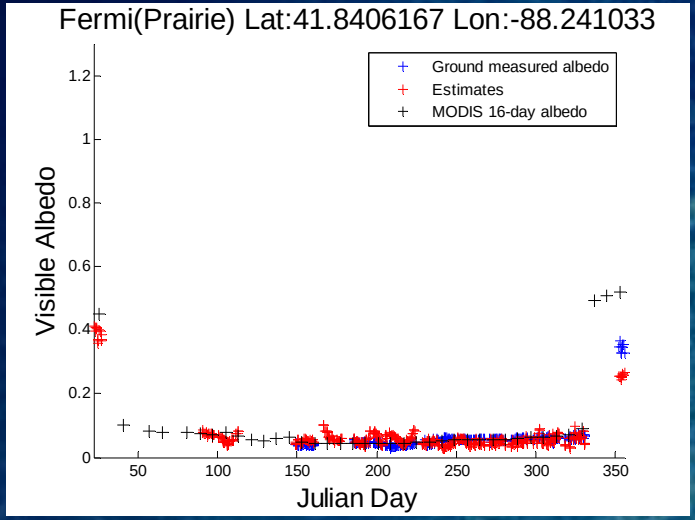


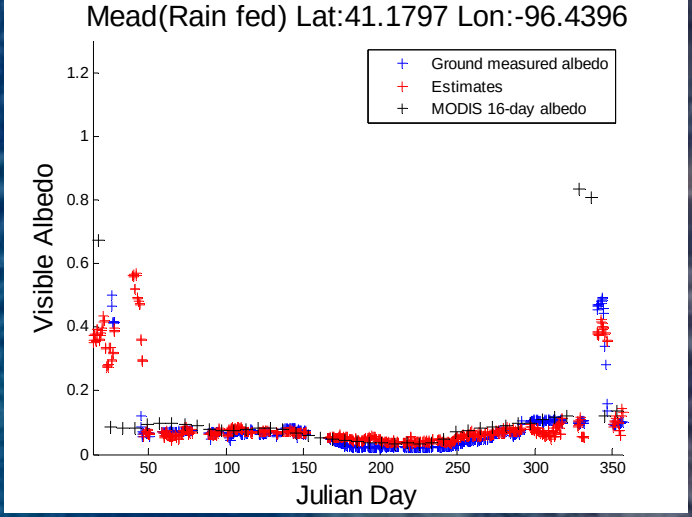
MODIS/Terra and MODIS/Aqua data in 2005 are used as proxy

Validation Results: Time Series over AmeriFlux



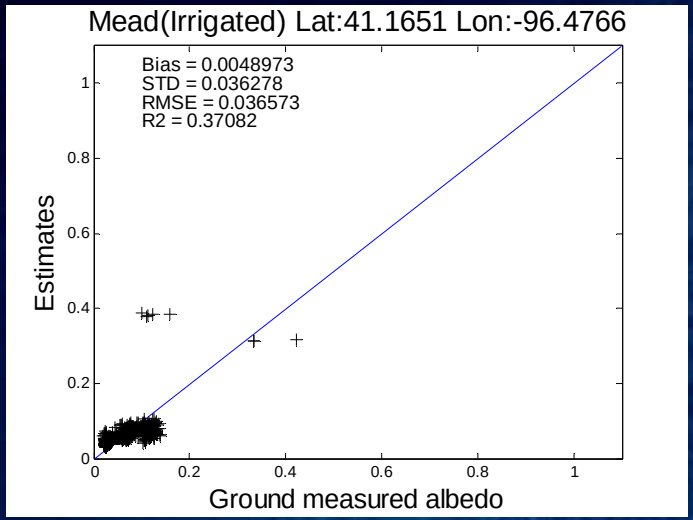


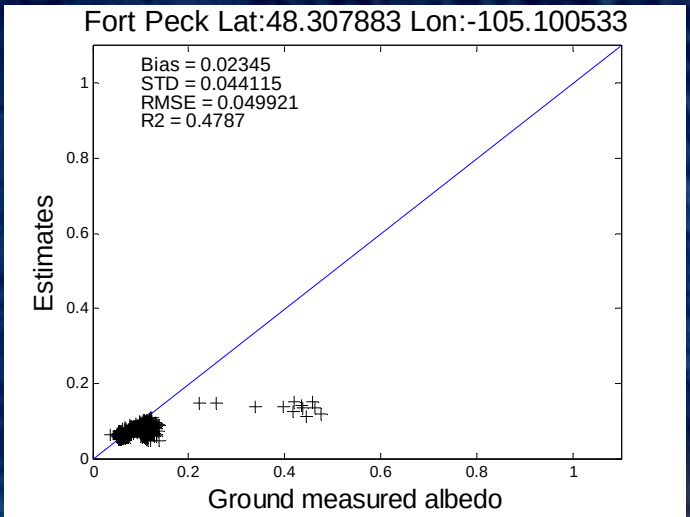


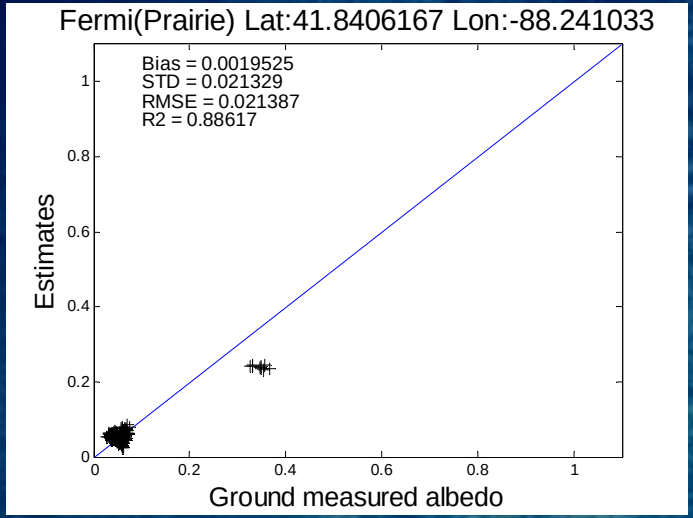


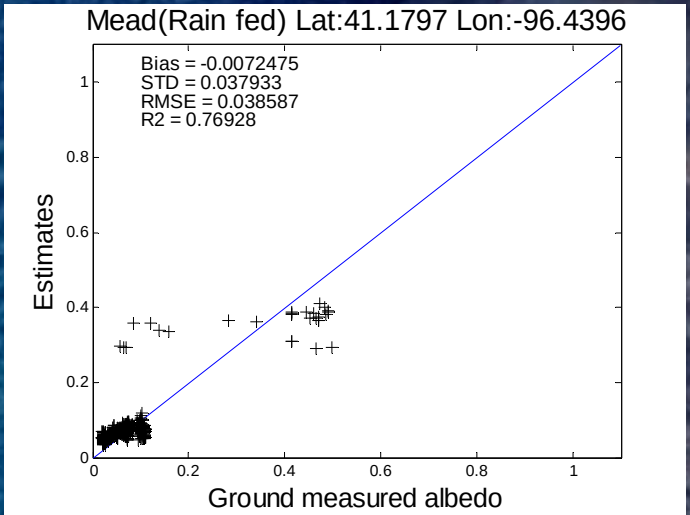
Similar to SURFRAD, but only visible albedos are measured at these AmeriFlux sites

Validation Results: Scattering Plots over AmeriFlux

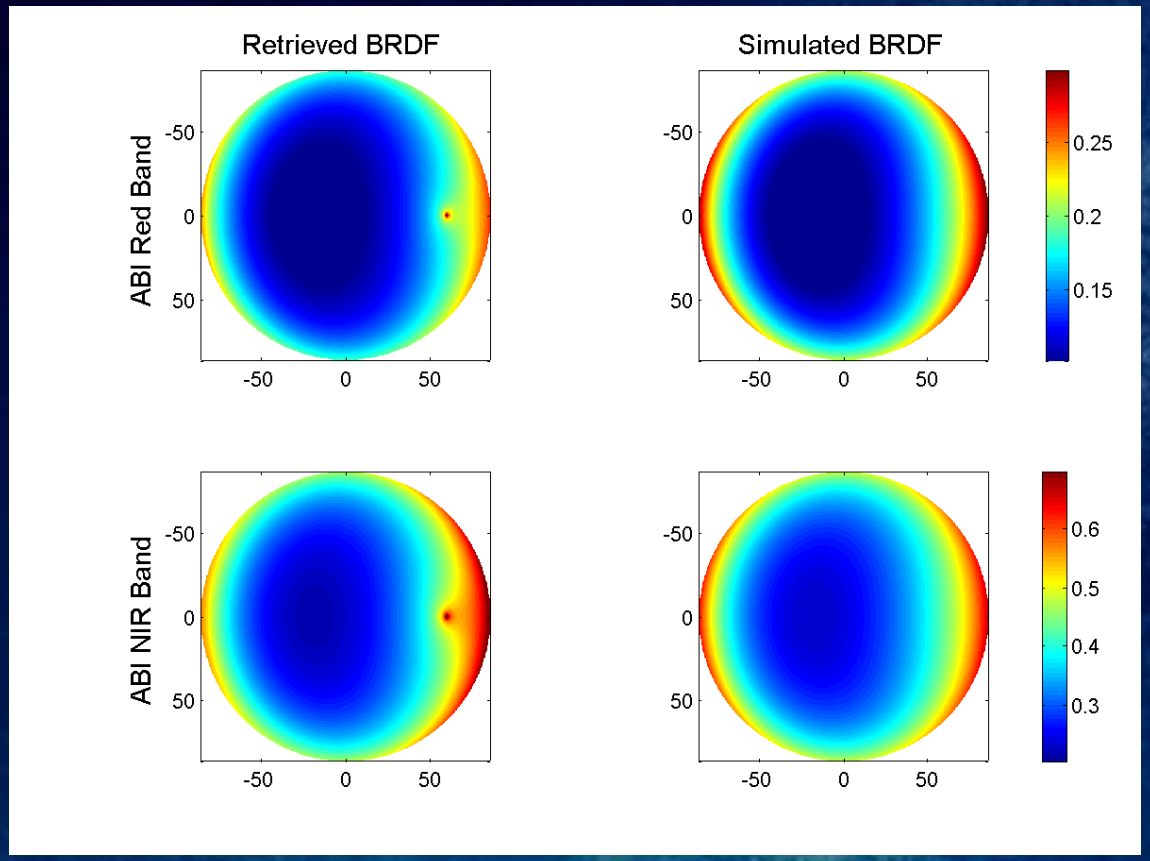








Validation Results: Simulated ABI Data

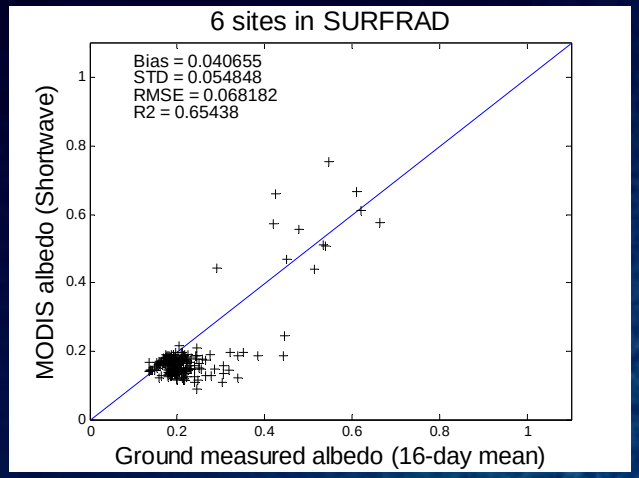


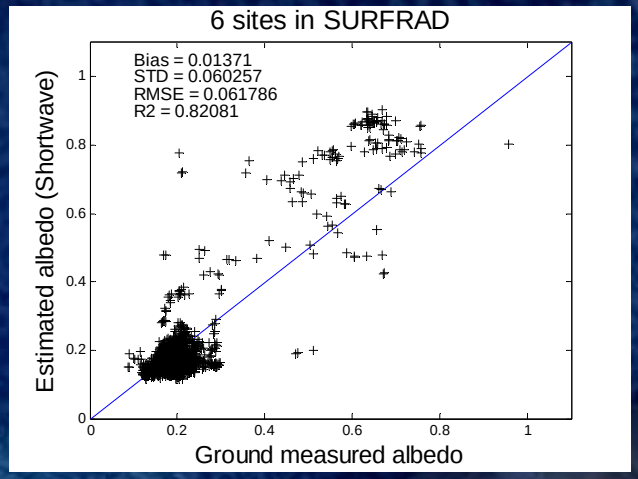
Given the surface properties and atmospheric conditions, the simulated ABI TOA signals were generated using 6S by fully considering the surface BRDF effects.

Then apply our albedo algorithm on the simulated datasets.

Results here show our retrieved BRDF and the actual BRDF used in the simulation at two ABI bands

Validation Results: Statistics over All SURFRAD Sites





Validation Results Summary

	Our Retrievals	MODIS Products	F&PS Requirements
Accuracy (Bias)	0.01	0.04	0.08
Precision (RMSE)	0.06	0.07	10%
R^2	0.82	0.65	N/A

Next Steps to Reach 100%

- Continue to improve the algorithm in terms of accuracy and computational efficiency
- Further validate the algorithm, e.g. using SEVIRI data and validating surface reflectance
- Test the code over the ABI proxy data in perspective of software engineering
- Revise the code by following the coding regulation
- Complete relevant documents, e.g. ATBD and user manual

Summary

- The ABI Albedo Algorithm takes full advantage of the ABI's unique capabilities of frequent multichannel observations.
- Algorithm works on both bright and dark surfaces.
- Version 2 code and the 80% ATBD delivery is coming.
- Preliminary validation shows the albedo algorithm can satisfy the F&PS requirement.
- Albedo products have been evaluated using MODIS and simulated ABI data as proxy.
- More validation of albedo and evaluation of surface reflectance products are on the way.