MODIS downward shortwave radiation (DSR) and photosynthetically active radiation (PAR) products (MCD18)

Dongdong Wang, Shunlin Liang
Xueyuan Gao, Meredith Brown
University of Maryland, College Park

Outline

- Background
- Status of MCD18 C6 and C61 products
- Product assessment
- Alternate retrieval algorithms
- Summary

Background

- DSR or PAR are key parameters required by almost all land process models and many applications.
- Land community needs high resolution (~1km) DSR and PAR data.
  - Ecosystem modeling (NPP)
  - Hydrological modeling (ET);
  - Other applications (e.g., agriculture management, drought monitoring, clean renewable solar energy).

Product name	Variables	Spatial resolution	Temporal coverage
ISCCP Stage H	DSR	110km	1982-2015
GEWEX-SRB	DSR	1°	1983-2007
CM SAF	DSR	0.05°	1982-2015
CERES	DSR, PAR	1°	1997-present
GLASS	DSR, PAR	5km	2000-present
MCD18	DSR, PAR	1km/5km	2000-present

Status of MODIS DSR and PAR (MCD18)

MODIS DSR and PAR Products added in 2017

Collection 6:

- MCD18A1: MODIS/Terra+Aqua Daily L3 5km DSR SIN Grid
- MCD18A2: MODIS/Terra+Aqua Daily L3 5km PAR SIN Grid

Collection 61:

- Under processing
- MCD18A1, MCD18A2: 1km
- MCD18C1, MCD18C2: CMG, 0.05°

Known Issues:

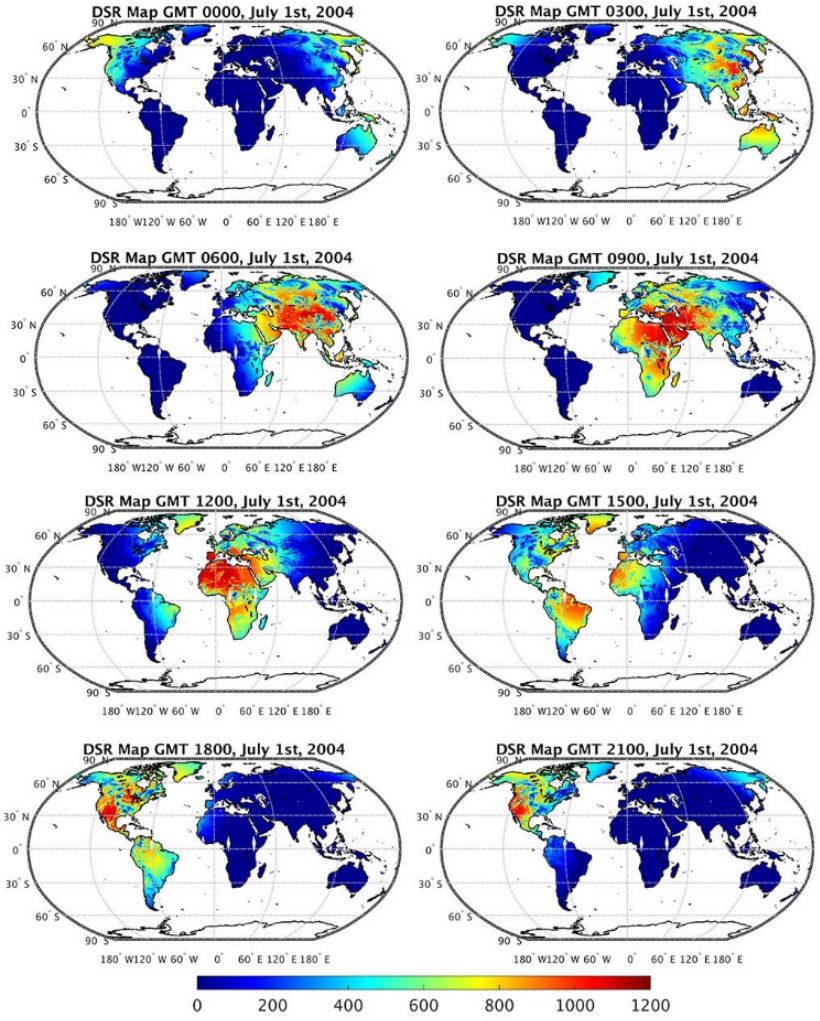
- Programming errors in C6 overestimating DSR and PAR

Status and Updates:

- C61 codes fixed the programming errors
- Spatial resolution was improved from 5km to 1km
- Added new 0.05 degree CMG products of DSR and PAR
- Improved LUT with better representation of clouds
- Adding VIIRS as additional data to better capture diurnal changes

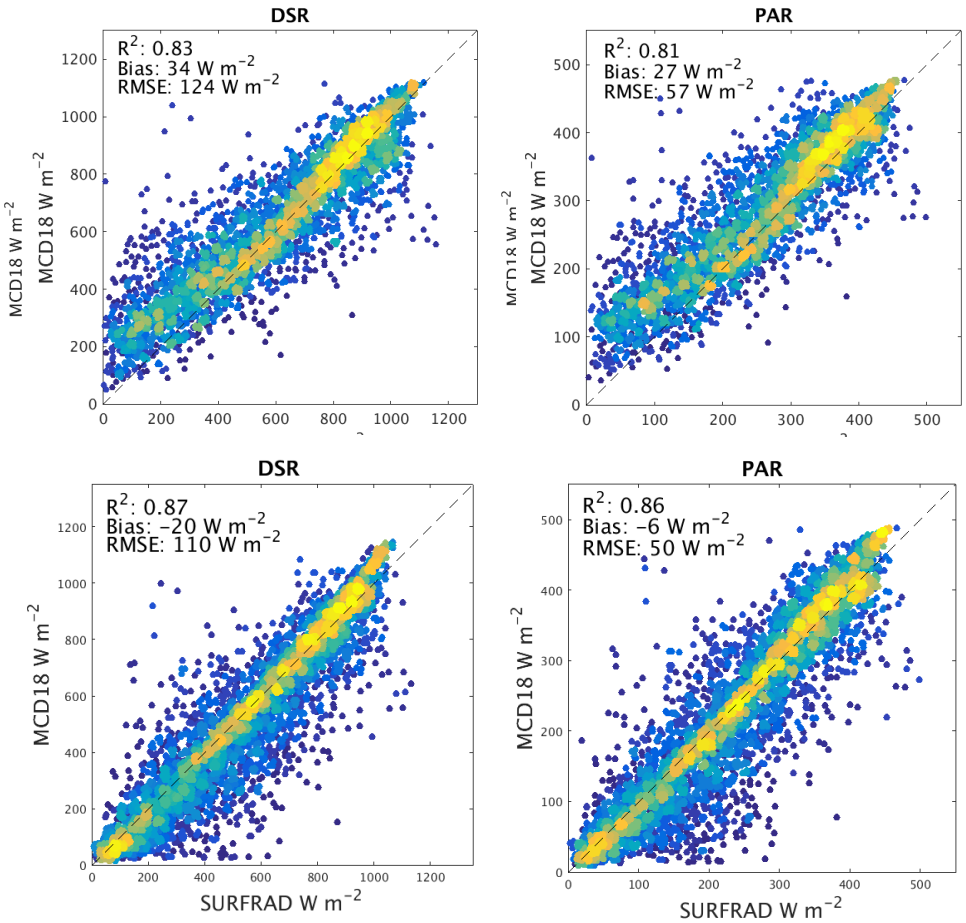
Recent Publications:

- Wang, D., Liang, S., Zhang, Y., Gao, X., Brown, M., & Jia, A. (2019). A new set of MODIS land products (MCD18): downward shortwave radiation and photosynthetically active radiation. *Science of Remote Sensing*, submitted
- Huang, G., Li, Z., Li, X., Liang, S., Yang, K., Wang, D., & Zhang, Y. (2019). Estimating surface solar irradiance from satellites: Past, present, and future perspectives. *Remote Sensing of Environment*, 233, 111371
- Zhang, Y., He, T., Liang, S., Wang, D., & Yu, Y. (2018). Estimation of all-sky instantaneous surface incident shortwave radiation from Moderate Resolution Imaging Spectroradiometer data using optimization method. *Remote Sensing of Environment*, 209, 468-479



Overestimation of early MCD18 C6 data

- MCD18 C6 is labelled as beta maturity level
  - Overestimation due to programming errors
- Issues fixed for C6 data after 2018 and all C61 data



Validation results of the MCD18A1 and MCD18A2 C6 products with SURFRAD measurements.

Comparison results of the DSR and PAR data generated from the C61 software. The issue of overestimation was fixed.

Extensive validation of MCD18 C6

Field data collection

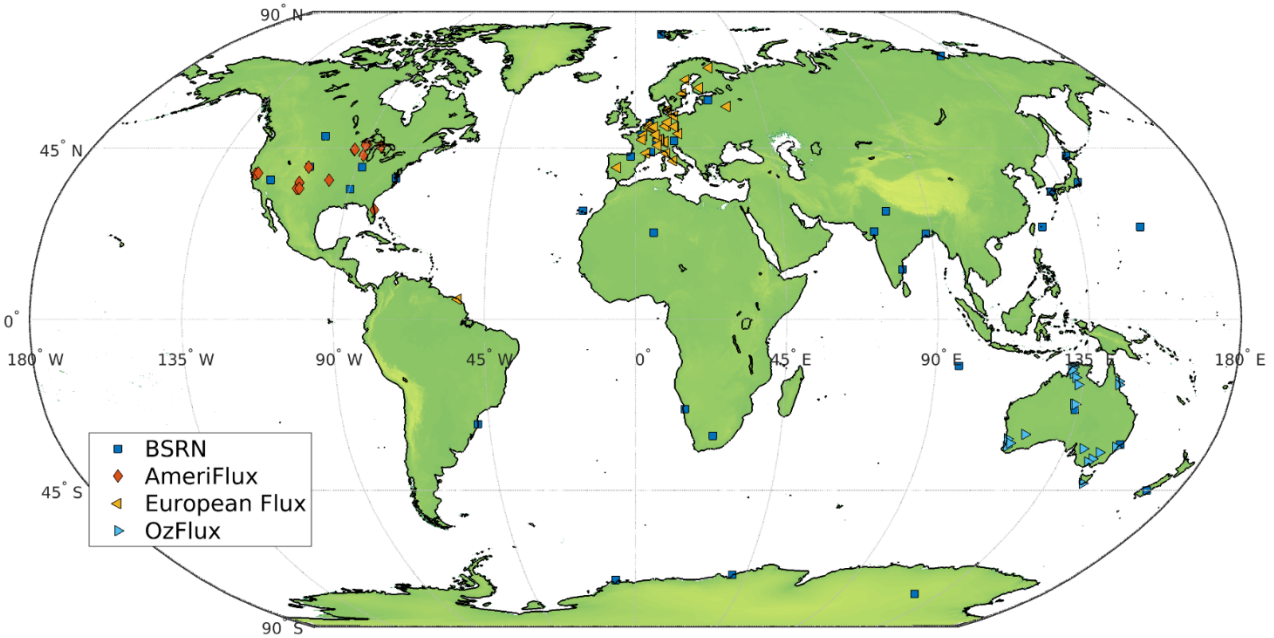
- Starting with data of 2018
- BSRN, AmeriFlux, European Flux, OzFlux 119 stations

Data for inter-comparison

- Clouds and the Earth's Radiant Energy System (CERES)
- Global LAnd Surface Satellite (GLASS)

Validation approaches

- Temporal and spatial aggregation
- Effects of input surface reflectance data
- Effects of daily overpass counts

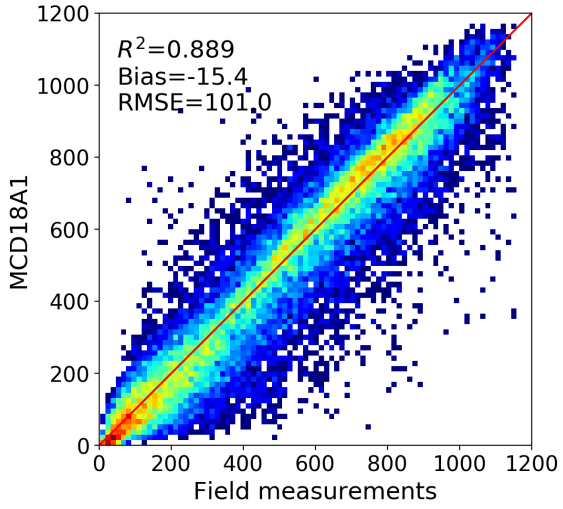


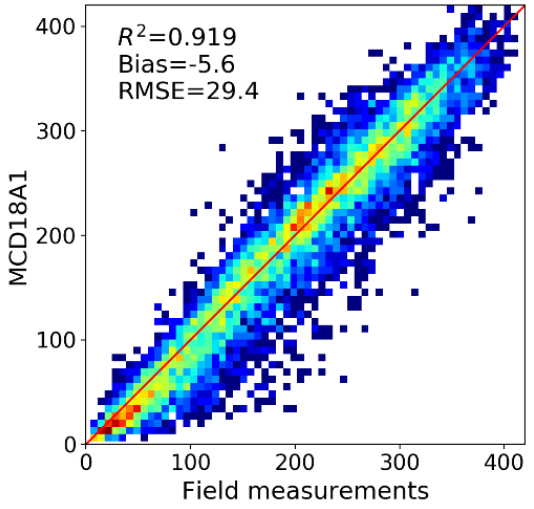
Overall results of MCD18 C6 validation

Instantaneous

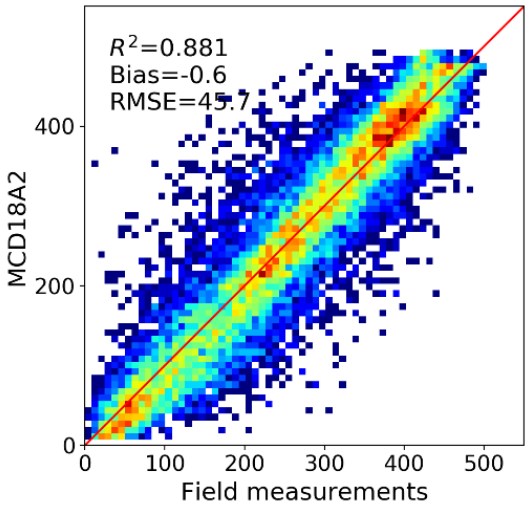
Daily

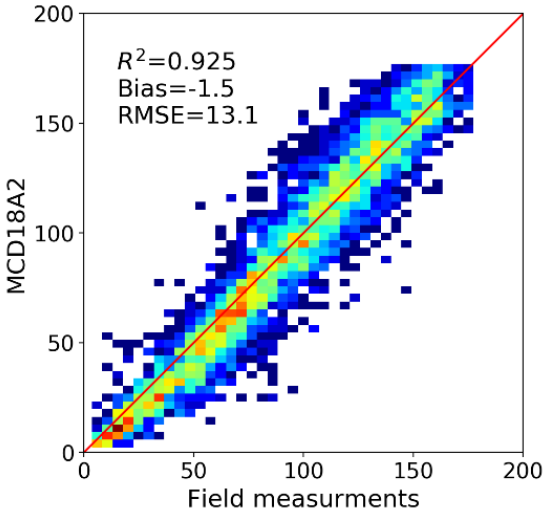
DSR





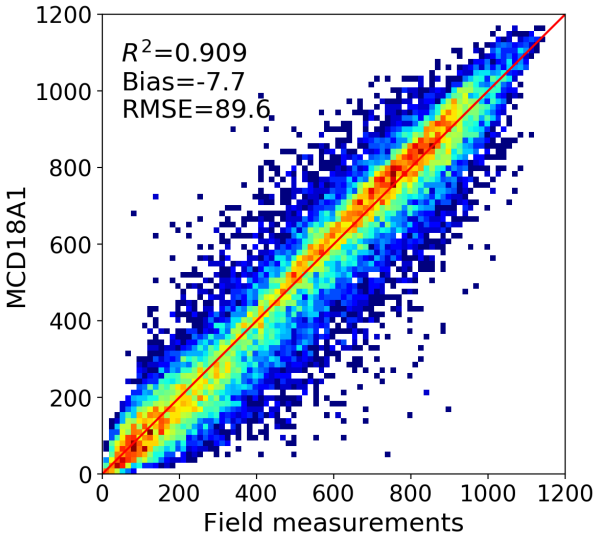
PAR



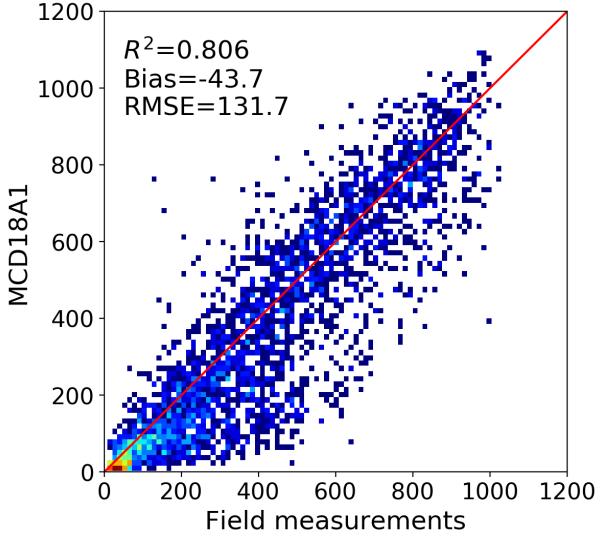


Surface reflectance and overpass number

Input of surface reflectance data

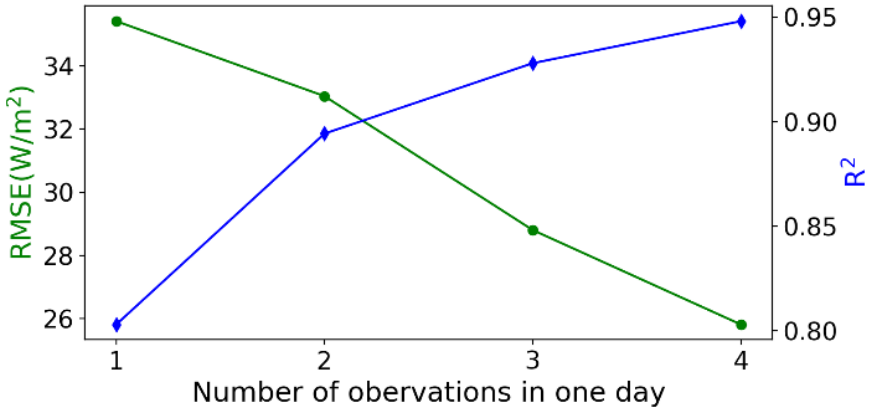


Actual MODIS product

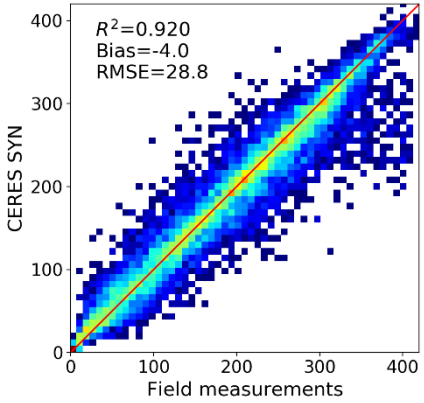


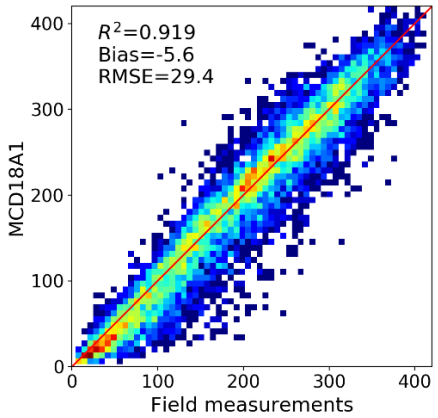
Climatology data

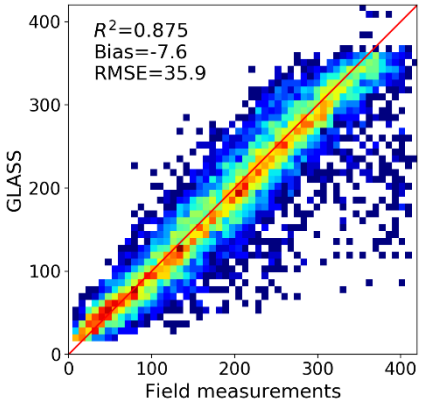
Impacts of daily MODIS overpass counts



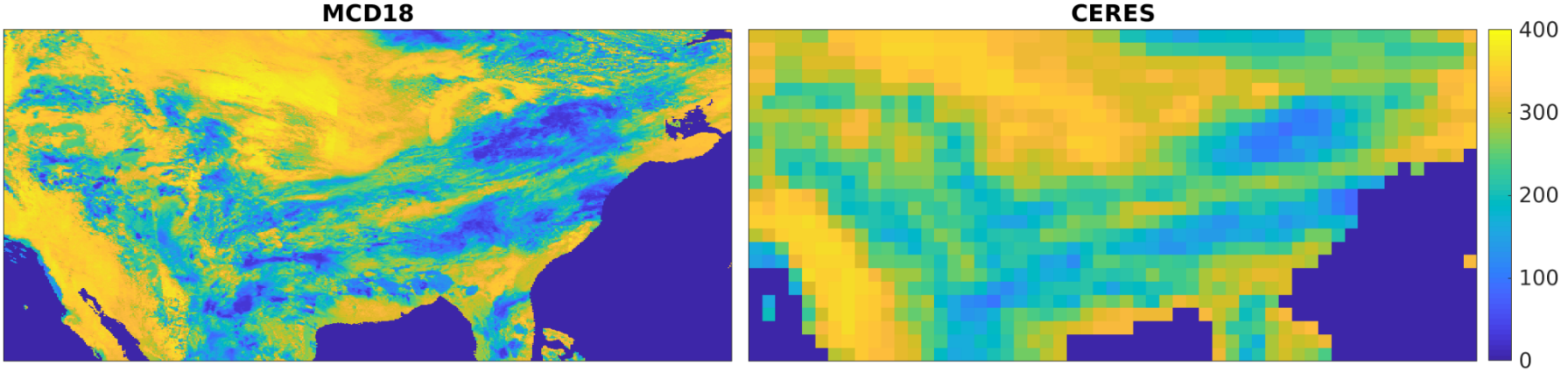
Comparison with other products







- MCD18 has higher accuracy than GLASS
- MCD18 is comparable to CERES
  - MCD18 has higher spatial resolution.
  - MCD18 uses only MODIS observations.
  - CERES incorporates geostationary data with better capturing diurnal variability.



Daily DSR maps over US CONUS area

Alternate retrieval algorithms

- Main algorithm: the LUT based approach
  - Pros: working with TOA data, fewer missing data
  - Cons: limited spectral information
- Developing alternate retrieval approaches

Parameterization

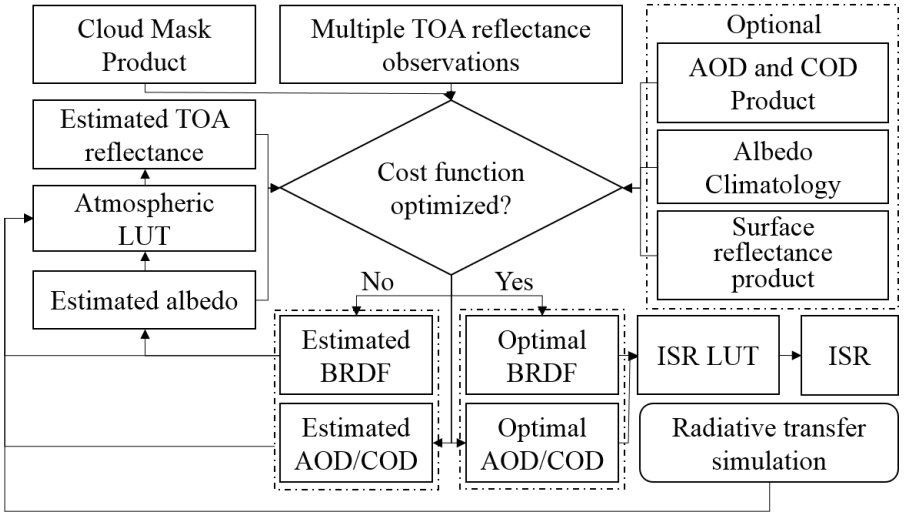
Calculate DSR from products of atmospheric and surface parameters

By parameterizing transmittances and spherical albedo

$$s = s_0\tau_b + s_0\tau_d + s_0(\tau_b + \tau_d)\frac{\rho_s\rho_a}{1-\rho_s\rho_a}$$

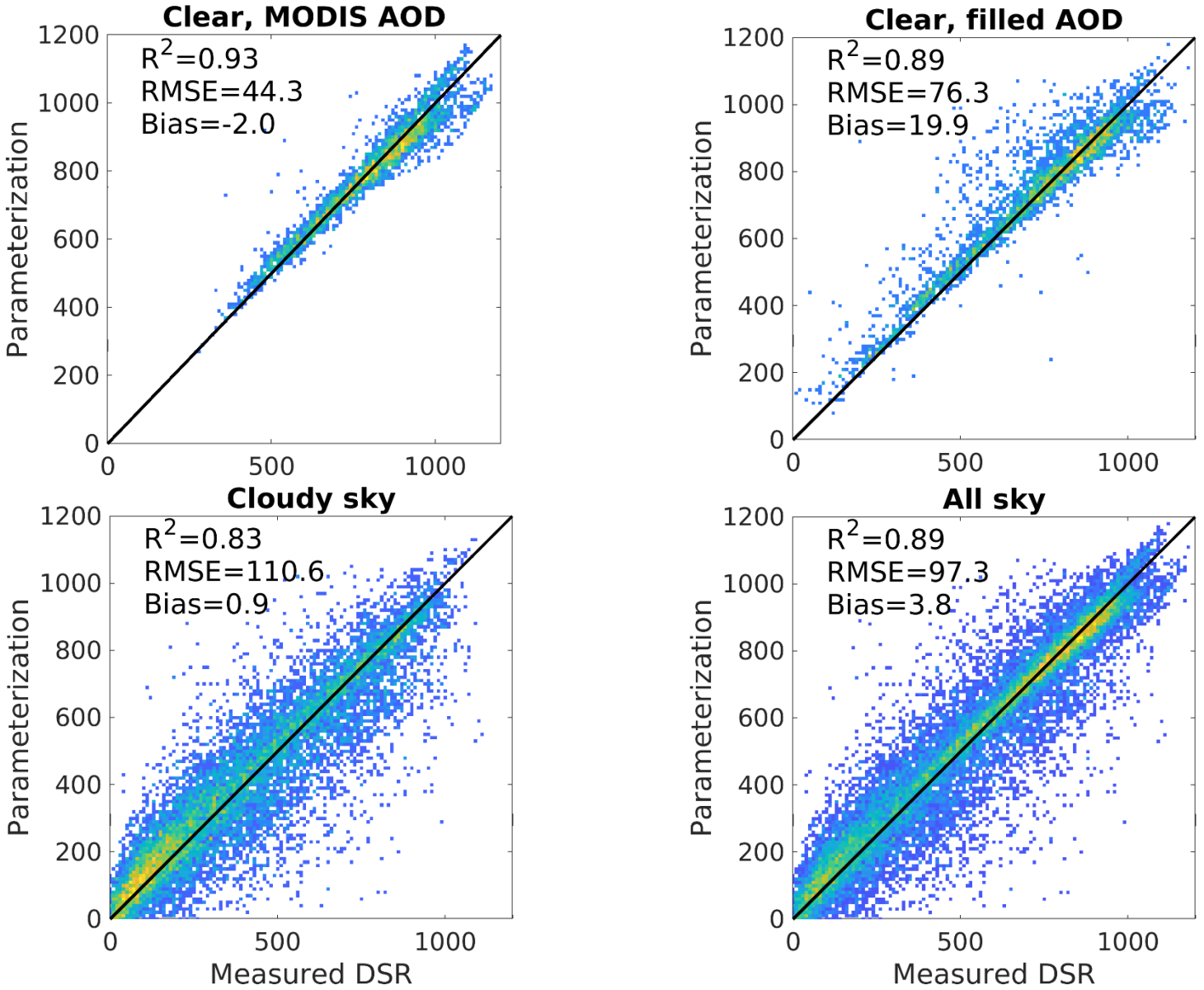
Optimization

Simultaneously retrieve atmospheric and surface parameters



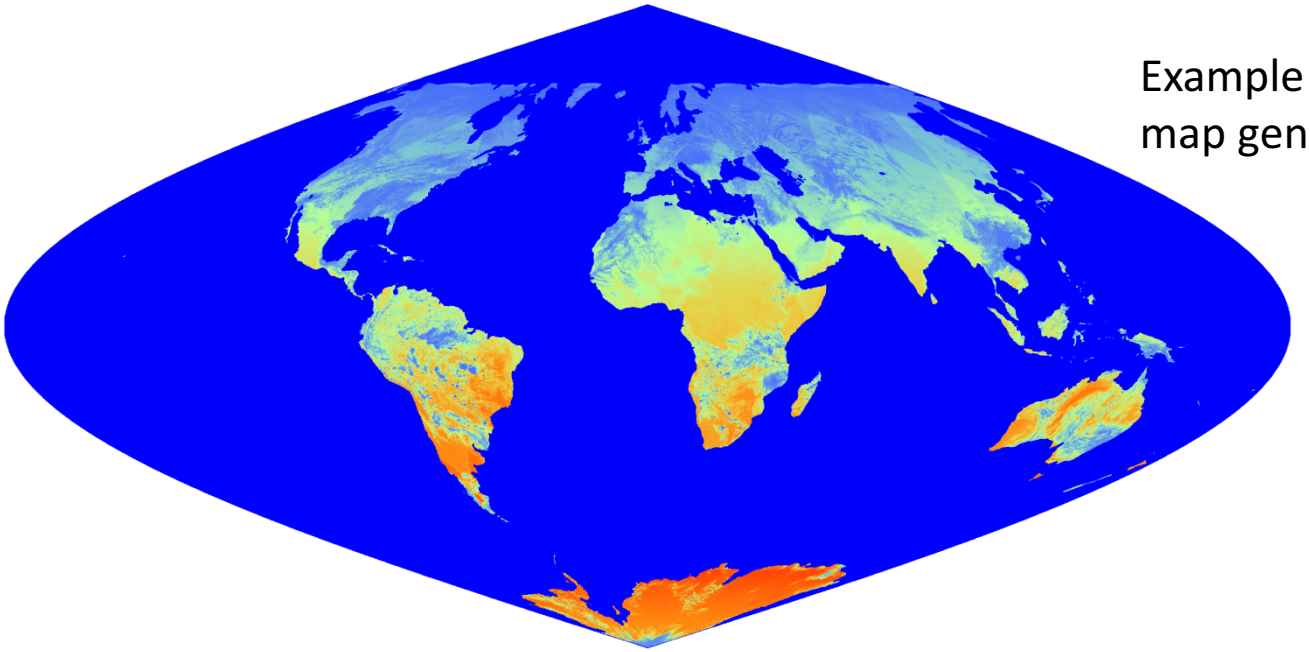
Adding parameterization as a secondary algorithm

- Handling missing inputs
- Coarse spatial resolution



Incorporating VIIRS data

- VIIRS is proposed here as ancillary data of MODIS production.
- Serving as additional data sources
  - To improve accuracy of 3-hourly interpolation
  - To fill swath coverage gaps
- Software framework is flexible at taking in additional observational data sources.

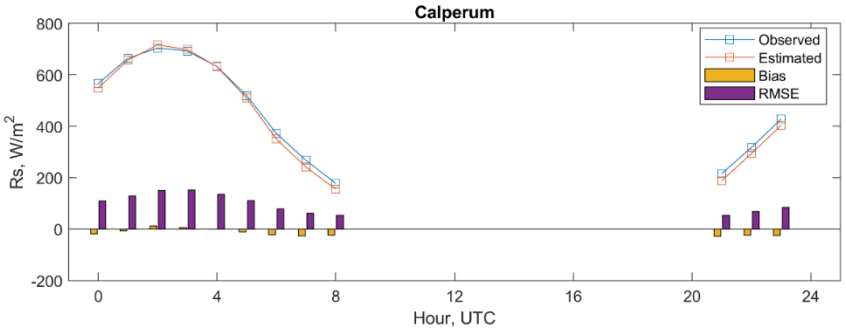


Example of a global daily DSR map generated from VIIRS.

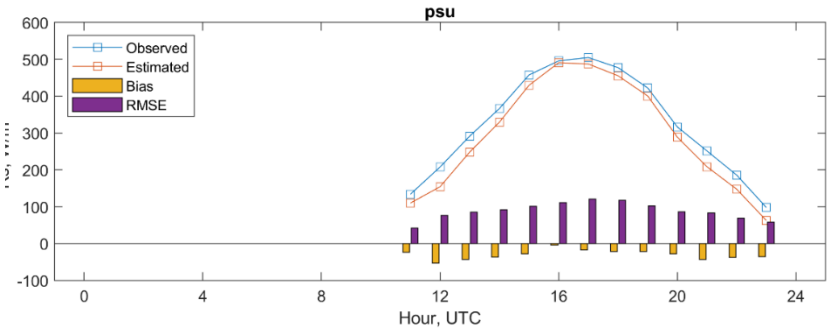
Potential use of geostationary data

- Adapt the algorithms to AHI and ABI data
- Better capture diurnal DSR changes

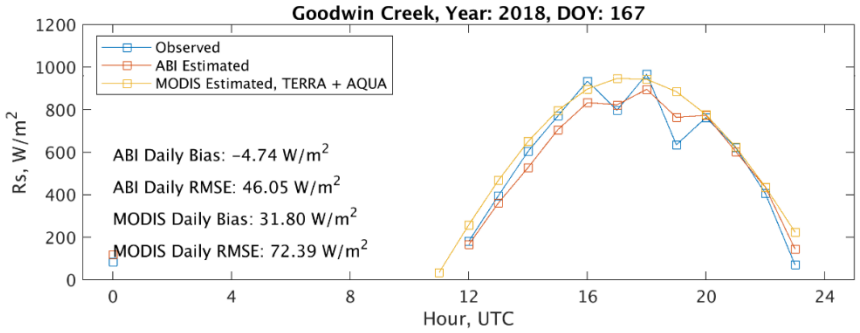
OzFlux site, AHI data

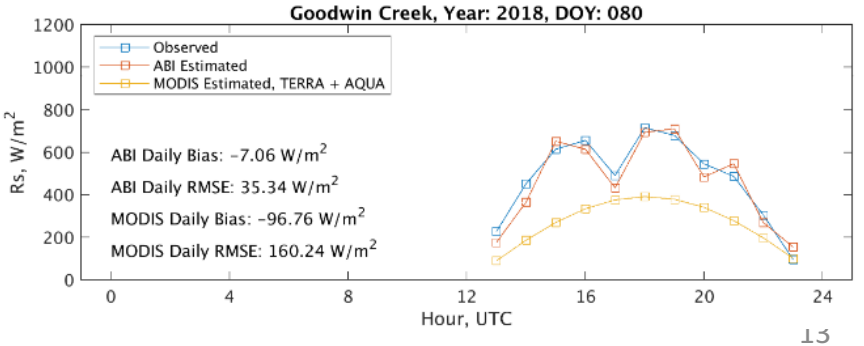


SURFRAD site, ABI data



MODIS vs. ABI





Summary

- MCD18 C6 data were labeled as beta maturity level due to overestimation for low SZA cases.
- MCD18 C6 data after 2018 are free of the issue.
- The improved MCD18 C61 products and are currently under processing.
- Validation suggests the MCD18 C6 data after 2018 are highly accurate.
- Active researches are underway to develop alternate retrieval algorithms.