



Recent Developments in the MODIS Albedo, Nadir BRDF- Adjusted Reflectance (NBAR) and Reflectance Anisotropy Products (MCD43)

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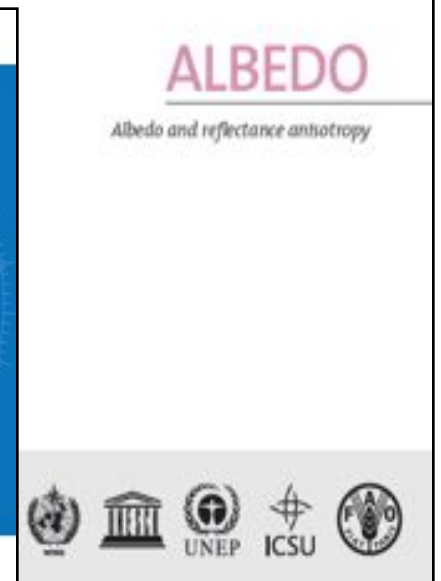
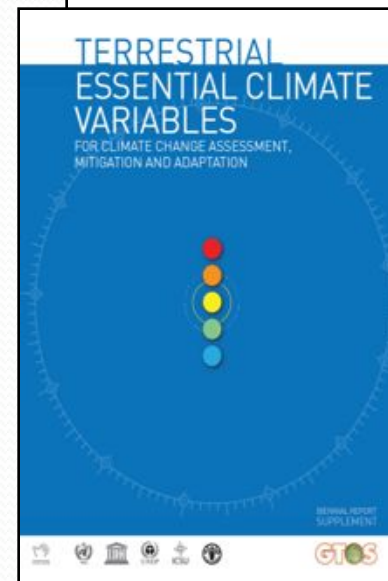
Albedo and Reflectance Anisotropy

- GTOS ECV
 - Essential Climate Variable

- Schaaf, C.B., J. Cihlar, A. Belward, E. Dutton, and M. Verstraete, Albedo and Reflectance Anisotropy: Assessment of the status of the development of standards for the Terrestrial Essential Climate Variables, GTOS-63/GTOS-ECV-T08, Ed. R. Sessa, Global Terrestrial Observing System (GTOS)Secretariat, FAO, Rome, May 2009.

- Schaaf, C., Albedo and Reflectance Anisotropy, Terrestrial Essential Climate Variables for Climate Change Assessment, Mitigation and Adaptation., GTOS-52, Eds. R. Sessa and H. Dolman, FAO, Rome, 28-29, January 2008.

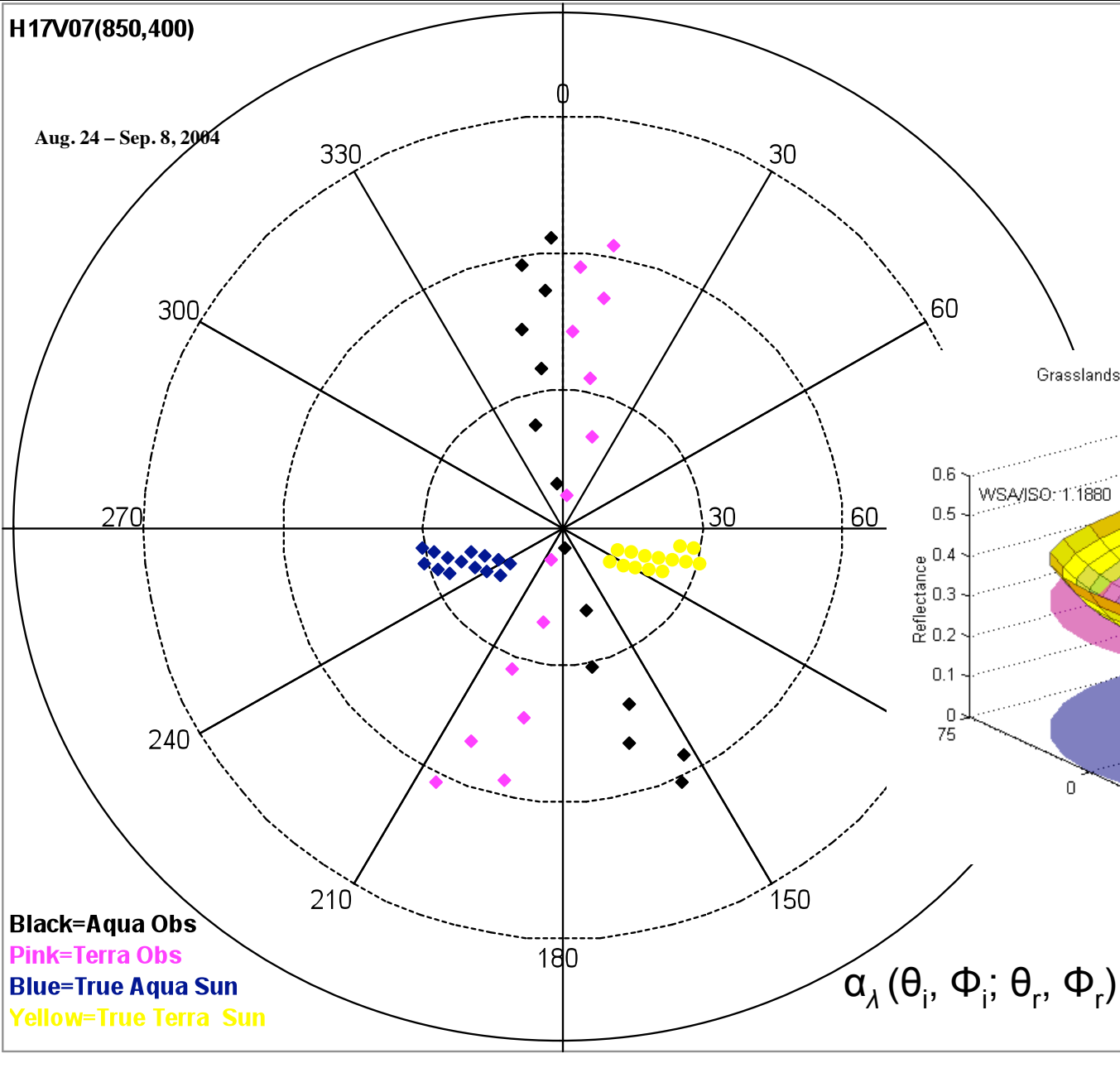
- Documents stress importance of supporting and expanding high caliber networks such as BSRN, Fluxnet, AERONET



MODIS Anisotropy, Albedo, NBAR

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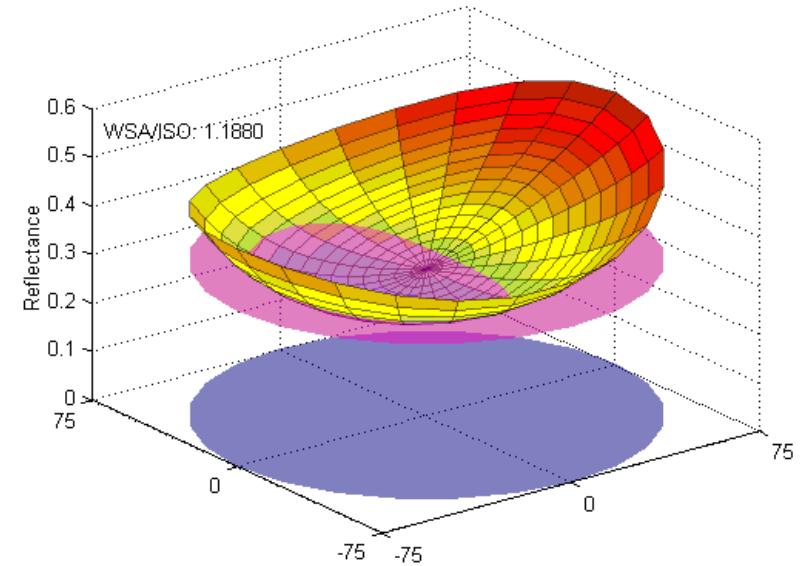
Aug. 24 – Sep. 8, 2004



Black=Aqua Obs
 Pink=Terra Obs
 Blue=True Aqua Sun
 Yellow=True Terra Sun

MODIS Aqua
 MODIS Terra
 Potentially MISR

Grasslands(7/11/2004) NIR, solar zenith angle 45 degree



$$\alpha_{\lambda}(\theta_i, \Phi_i; \theta_r, \Phi_r) = f_{\text{iso}} + f_{\text{vol}} k_{\text{vol}} + f_{\text{geo}} k_{\text{geo}}$$

Roujean et al., 1992

MODIS Albedo and Reflectance Anisotropy

- Collection 5 (V005)
 - MCD43A products
 - BRDF parameters
 - NBAR
 - Albedo (WSA, BSA@lsn)
 - Standard spatial grid resolution 500m
 - Global land, 10deg. tiles, sinusoidal projection
 - Produced every 8 days (on a 16 day period)
 - Snow albedo only retrieved when majority condition over a 16 day period.
 - Extensive quality information

MODIS Albedo, NBAR, Reflectance Anisotropy

- Collection 5 (V005)
 - MCD43D products
 - Climate Modeling Grid (CMG)
 - global lat/lon
 - 30arc sec grid
 - Majority quality
 - MCD43C products
 - CMG,
 - global lat/lon
 - 0.05degree grid
 - Majority quality
 - Separate snow-free version

MODIS Albedo, NBAR, Reflectance Anisotropy

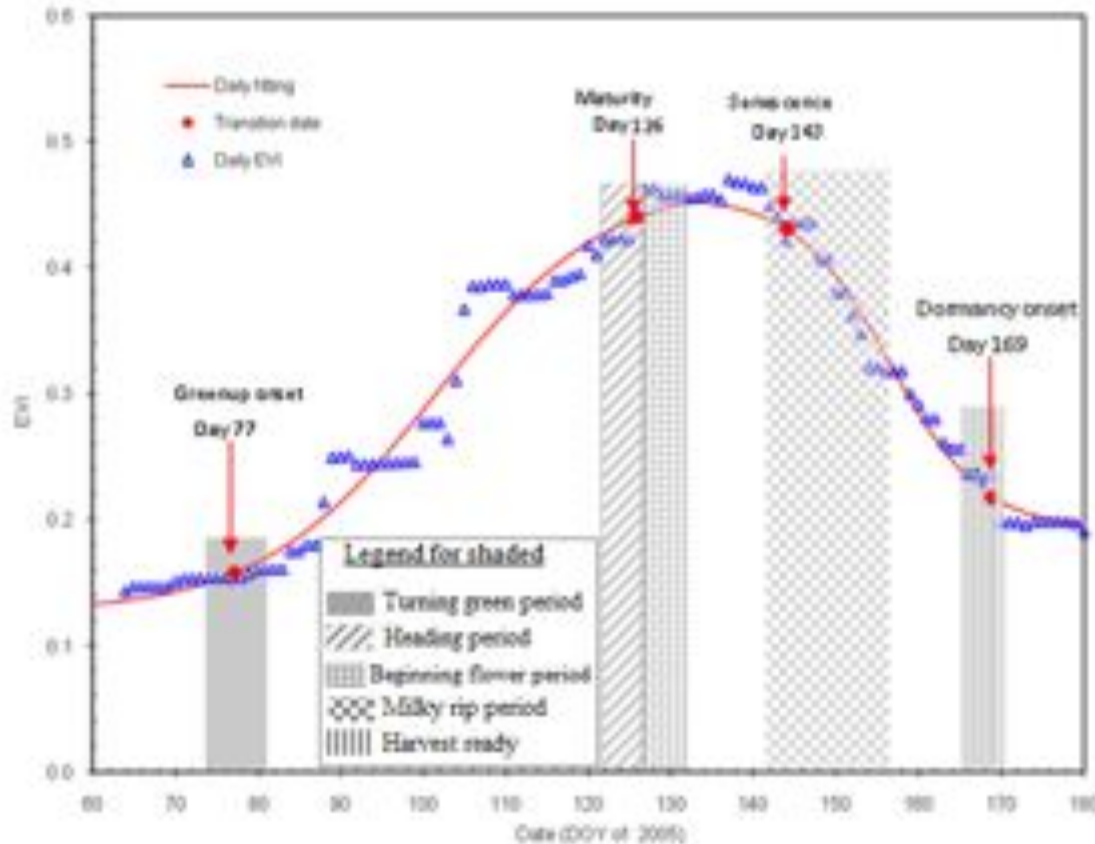
- Algorithm originally envisioned as a daily product
 - Long term archive constraints have limited production to periodic retrievals thus far
- Daily Direct Broadcast Algorithm has allowed implementation of daily rolling 500m (potentially 250m) retrievals in a regional context
- Australia, China, South Africa, USA (USFS, SDState)
 - view angle correction, rangeland and agricultural monitoring, assessment of disturbance/change
- UWisc – IMAPP package complete for transition to DRL (Strabala and Gumley)

MODIS Albedo, NBAR, Reflectance Anisotropy – Daily Direct Broadcast Algorithm

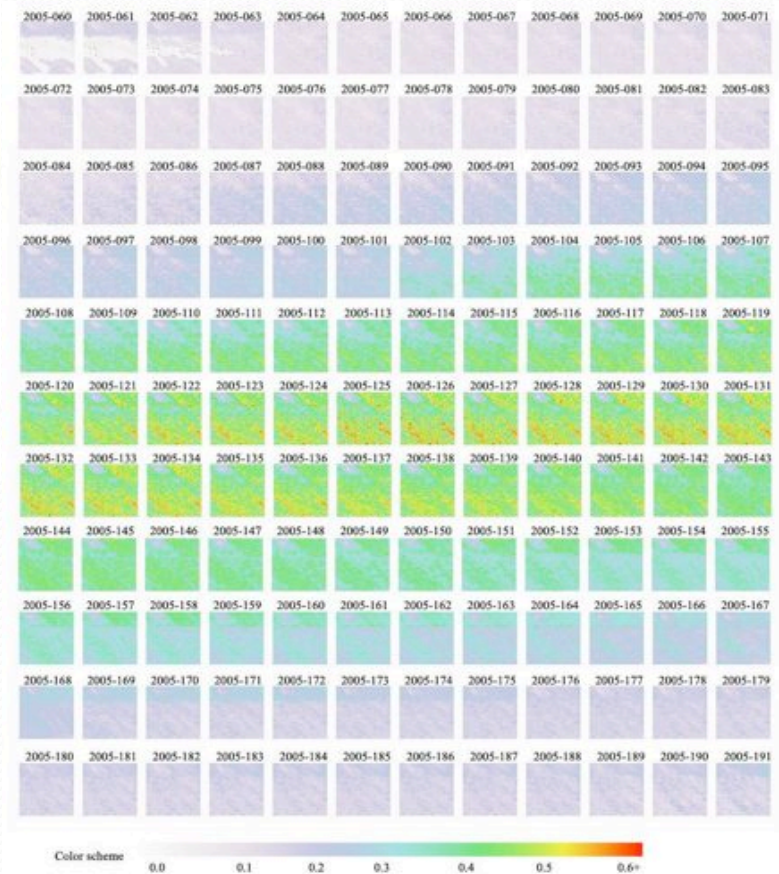
Daily temporal spectral BSA albedo (true color composites of MODIS band 1, 4, and 3) for the small area (30km by 30 km) centered on the Bartlett tower site for the 2005 growing season. Continuous cloud cover precluded a majority of the retrievals from Days 149-152. – Yanmin Shuai



MODIS Albedo, NBAR, Reflectance Anisotropy



Daily Temporal NBAR-EVI of small area (30km by 30 km) centered the YCES for year 2005



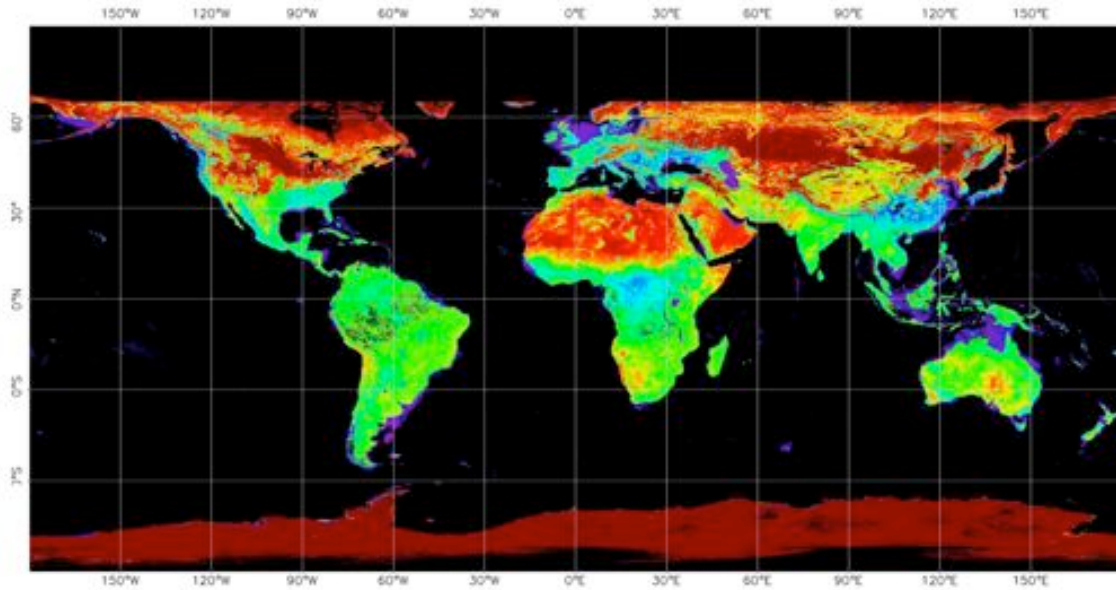
Zhang, X., M. A. Friedl, C. B. Schaaf, Global vegetation phenology from Moderate Resolution Imaging Spectroradiometer (MODIS): Evaluation of global patterns and comparison with in situ measurements, J. Geophys. Res., 111, G04017, doi:10.1029/2006JG000217, 2006

Albedo and Reflectance Anisotropy

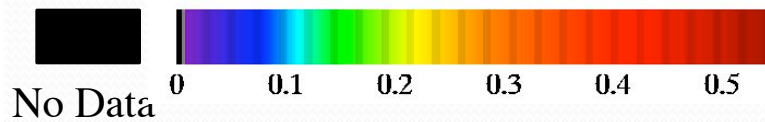
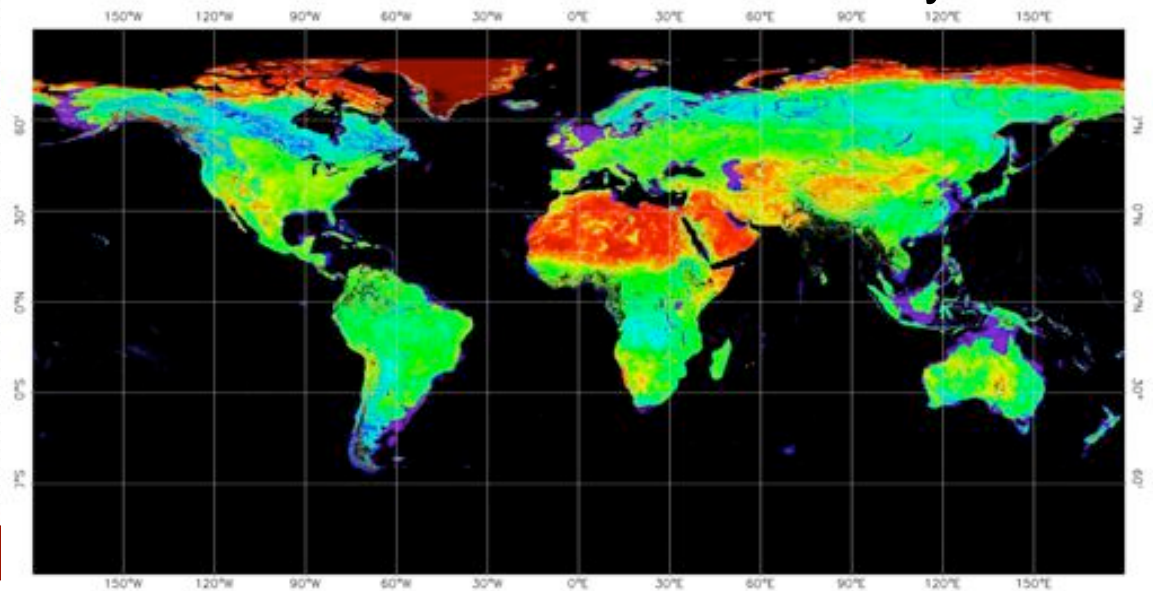
- Gap-filled snow-free products
 - V004 global 1 min albedos were a very successful collaborative effort with MODIS atmospheres
 - Moody, E. G., M. D. King, S. Platnick, C. B. Schaaf, and F. Gao, [Spatially complete global spectral surface albedos: Value-added datasets derived from Terra MODIS land products](#), *IEEE Transactions on Geoscience and Remote Sensing*, Vol.43,144-158,2005.
 - Moody, E. G., M. D. King, C. B. Schaaf, D. K. Hall [Northern Hemisphere five-year average \(2000-2004\) spectral albedos of surfaces in the presence of snow: Statistics computed from Terra MODIS land products](#) *Remote Sensing of Environment* 111 (2007) 337-345.
 - Moody, E. G., M. D. King, C. B. Schaaf, and S. Platnick, [MODIS-Derived Spatially Complete Surface Albedo Products: Spatial and Temporal Pixel Distribution and Zonal Averages](#), *Journal of Applied Meteorology and Climatology*, 47,2879-2894,2008
 - V005 gap-filled 30arc sec effort currently underway
 - Global lat/lon (from MCD43D)
 - Every 8days (16 day period)

Standard MCD43 Broadband White-Sky Albedo (0.3-5.0mm)

June 2001

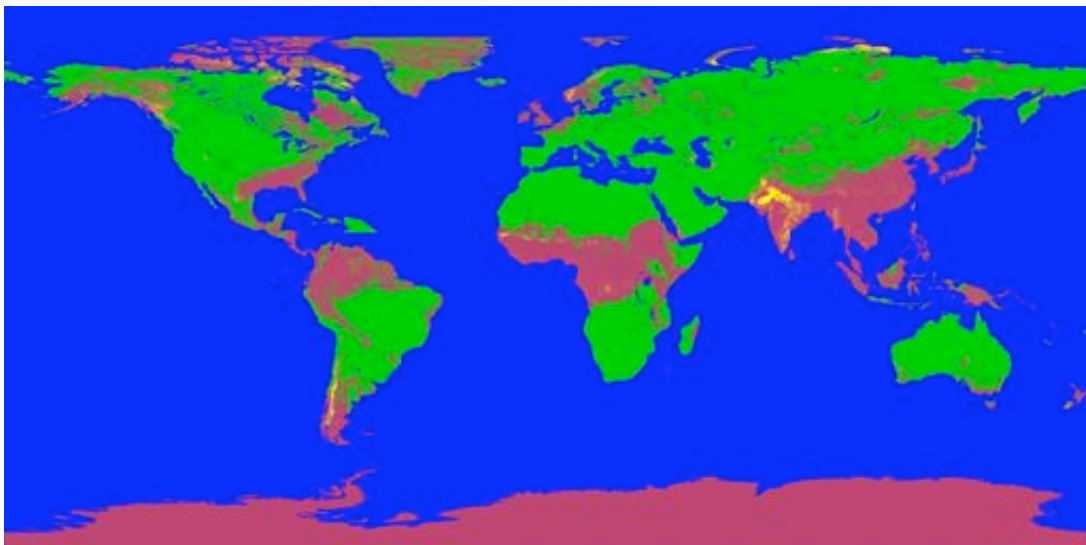


July 2001



Albedo, NBAR, Reflectance Anisotropy

- Gap-filled snow-free products
 - GlobalV005
 - 30arc sec
 - global lat/lon
 - (MCD43D)



Gap-filled MODIS BRDF product
Day 185 2007

Green: high quality,
Magenta: temporal fill
Yellow :spatial fill

Albedo, NBAR, Reflectance Anisotropy

- Gap-filled snow-free products
 - NACP V005 500m tiles



MODIS NBAR product (DOY 145) 2007, original version with white fill values where no retrievals were possible.

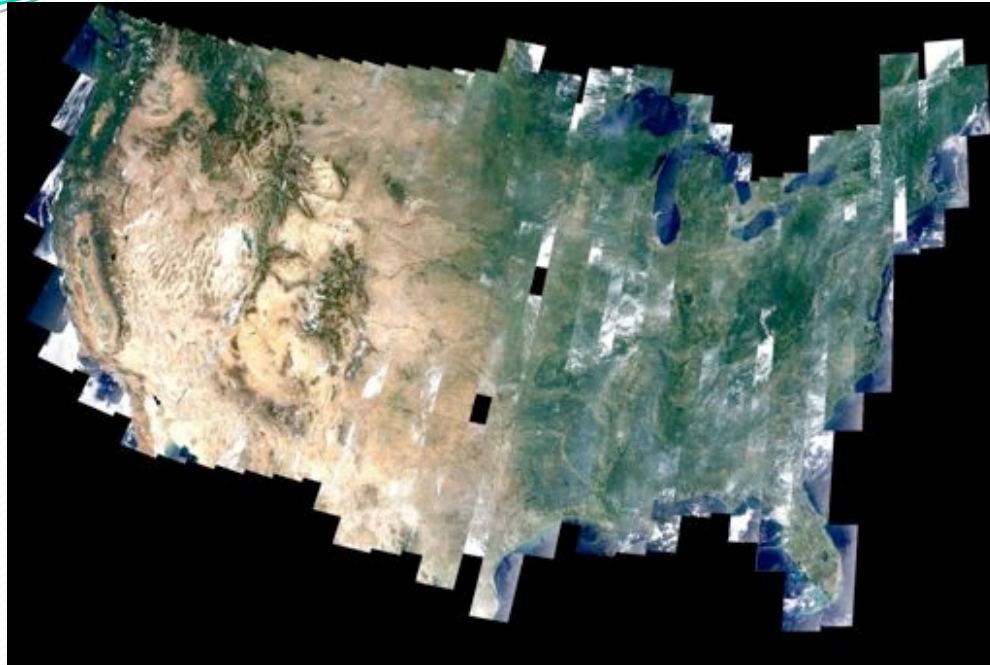


Gap-filled version

Albedo, NBAR, Reflectance Anisotropy

- Modelers have embraced the MODIS global products and current collaborators await the new global gap filled products
 - CLM-CCSM (Lawrence and Chase, 2007)
 - ECMWF (Morcrette et al., 2008)
 - HadGEM-JULES (Houldcroft et al., 2009)
 - GISS (Kiang, pers.com.)
- Support for derivative products
 - MODIS land cover, phenology, cloud optical properties (Platnick), radiation/PAR (Liang)
 - AATSR aerosol retrievals
 - MERIS GLOBABLEDO albedo precursor (Muller)
 - Surface structural quantities (Hill, Chopping)
 - Landsat corrected reflectance, albedo (Gao/Masek/Shuai, Roy)

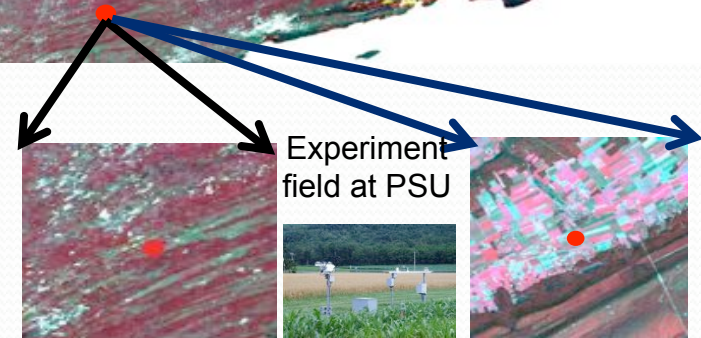
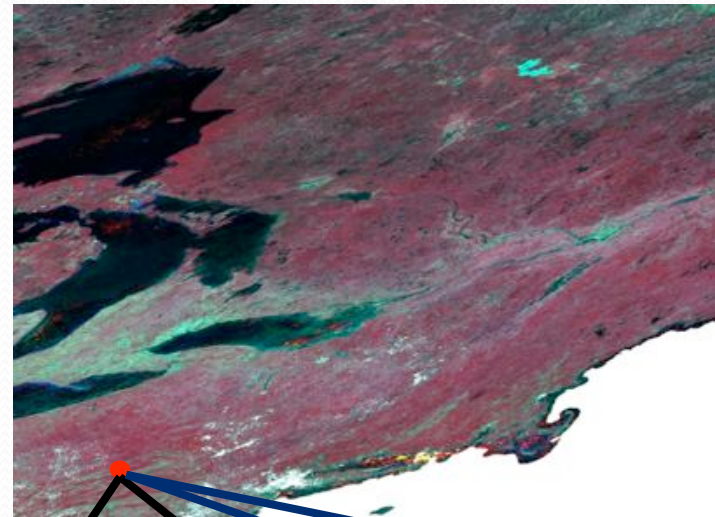
Albedo, NBAR, Reflectance Anisotropy



WELD radiometrically normalized July 2008 30m Landsat composite. Band 3, 2, 1 (red, green, blue) TOA reflectance

Roy, D.P., Ju, J., Lewis, P., Schaaf, C., Gao, F., Hansen, M., Lindquist, E., 2008, Multi-temporal MODIS-Landsat data fusion for relative radiometric normalization, gap filling, and prediction of Landsat data, *Remote Sensing of Environment*, 112:3112-3130.

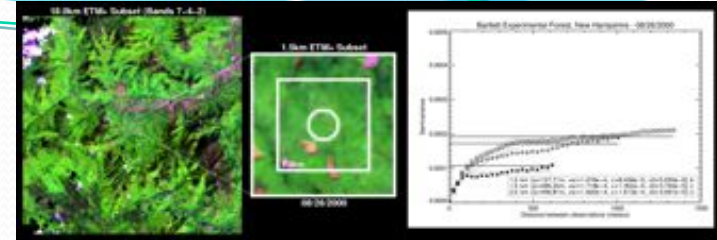
Landsat-MODIS Albedo Preliminary validation site: PSU



MODIS scale

LandSat scale

Albedo, NBAR, Reflectance Anisotropy



- Validation Strategy

- Tower albedometers

- BSRN sites (including SURFRAD and ARM (Dutton))

- Fluxnet/Ameriflux sites (calibration/ventilation/heated)

- Román, M. O., C. B. Schaaf, P. Lewis, F. Gao, G. P. Anderson, J. L. Privette, A. H. Strahler, C. E. Woodcock, M. Barnsley, [Assessing the coupling between surface albedo derived from MODIS and the fraction of diffuse skylight over spatially-characterized landscapes](#), Remote Sensing of Environment, doi:10.1016/j.rse.2009.11.014,2009.

- Román, M. O., C. B. Schaaf, C. E. Woodcock, A. H. Strahler, X. Yang, R.H. Braswell, P. Curtis, K.J. Davis, D. Dragoni, M. L. Goulden, L. Gu, D. Y. Hollinger, T. E. Kolb, T.P. Meyer, J. W. Munger, J.L. Privette, A.D. Richardson, T.B. Wilson, S. C. Wofsy, [The MODIS \(Collection V005\) BRDF/albedo product: Assessment of spatial representativeness over forested landscapes](#), Remote Sensing of Environment, 113, 2476-2498,2009.

- Liu, J., C. Schaaf, A. Strahler, Z. Jiao, Y. Shuai, Q. Zhang, M. Roman, J. A. Augustine, and E. G. Dutton, [Validation of Moderate Resolution Imaging Spectroradiometer \(MODIS\) albedo retrieval algorithm: Dependence of albedo on solar zenith angle](#), J. Geophys. Res., 114, D01106, doi:10.1029/2008JD009969,2009.

- Cloud Absorption Radiometer (CAR) BRDF validation

- CLASIC field campaign 2007 ARM SGP (Román)

- Arctic Research of the Composition of the

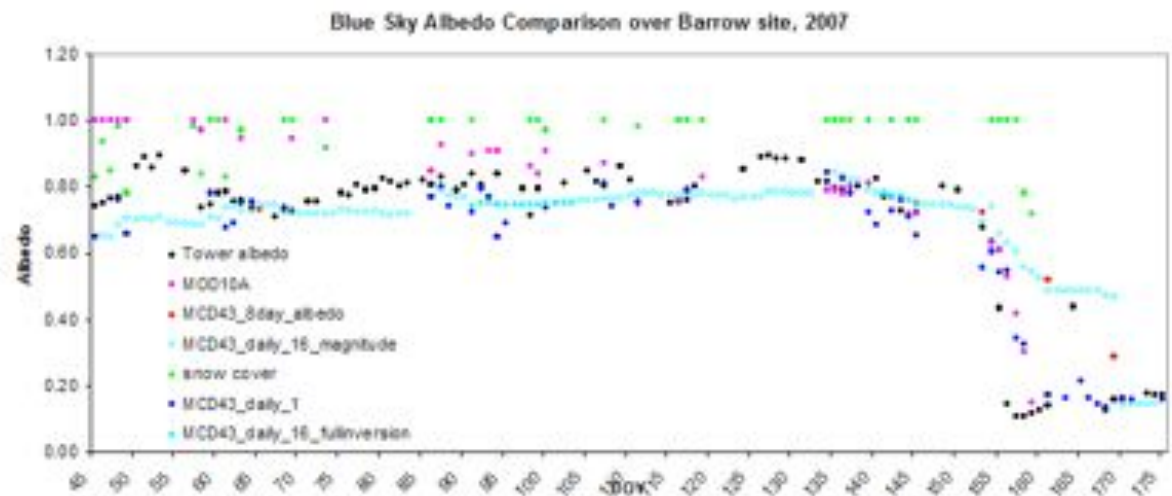
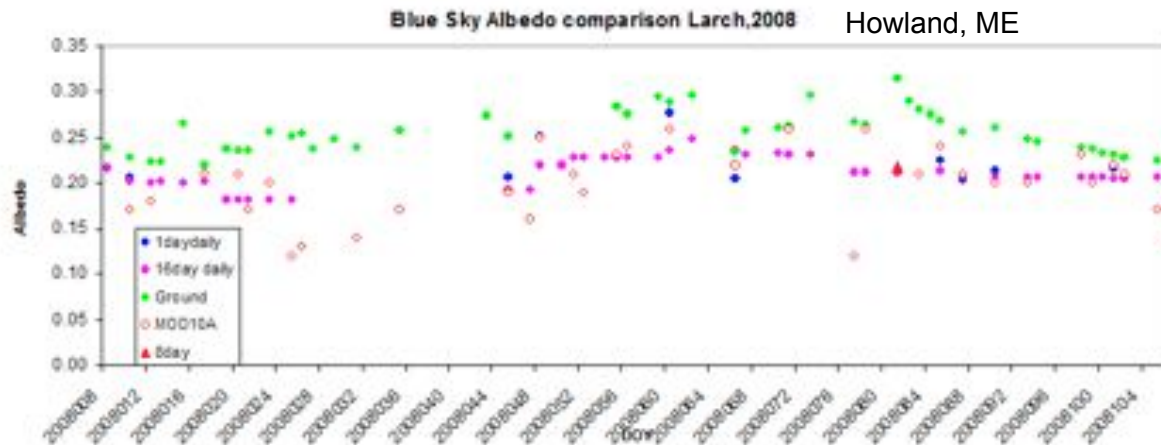
- Troposphere from Aircraft and Satellites (ARCTAS)

- 2008 winter field campaign (Lyapustin/Kahn)

- CAR and SSF

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- Collaboration underway with MODIS Snow Team (Hall/Riggs)
 - Make use of daily MCD43 BRDFs for vegetated scenes

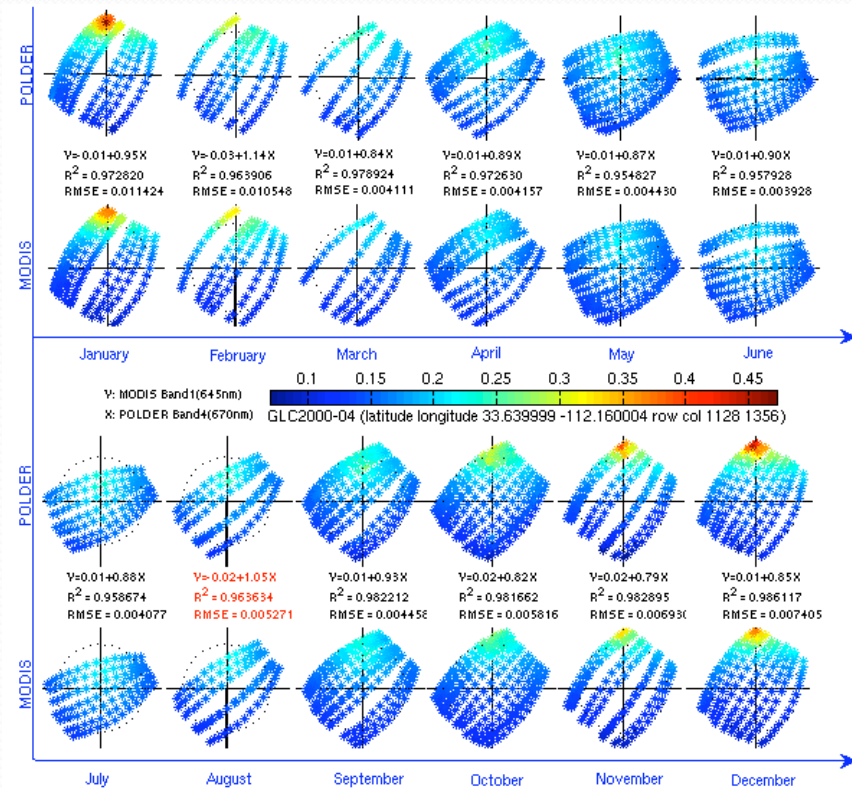


Albedo, NBAR, Reflectance Anisotropy

- Satellite Product Intercomparisons

MODIS with:

- MISR
- POLDER/Parasol
- Meteosat
- SEVIRI (MSG)
- SPOT VGT
- MERIS/GLOBALBEDO
- CERES



- CEOS/WGCV/LPV subgroup on Albedo

- <http://lpvs.gsfc.nasa.gov/> (Nightingale)
- Current Albedo Chairs: Gabriela Schaepman, Crystal Schaaf
- Workshops: Boston 2002, Vienna EGU 2005, Beijing 2009