MODIS Albedo, Nadir BRDF-Adjusted Reflectance (NBAR) and Reflectance Anisotropy Products (MCD43): The First Decade

Crystal Schaaf, Alan Strahler, Xiaowen Li, Wolfgang Lucht, Feng Gao, Xiaoyang Zhang, Jicheng Liu, Zhuosen Wang and a huge cast of collaborators (including Phillip Lewis, Mike Barnsley, Jan-Peter Muller, Shunlin Liang, Jean-Louis Roujean, the MODLand Team, the MODIS Atmospheres Team, and all of our past and present graduate students)

Center for Remote Sensing, Boston University

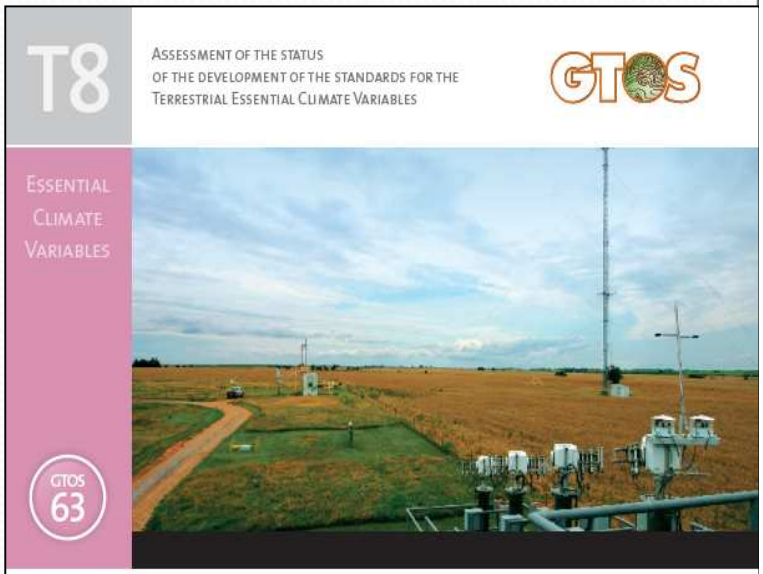
Albedo and Reflectance Anisotropy

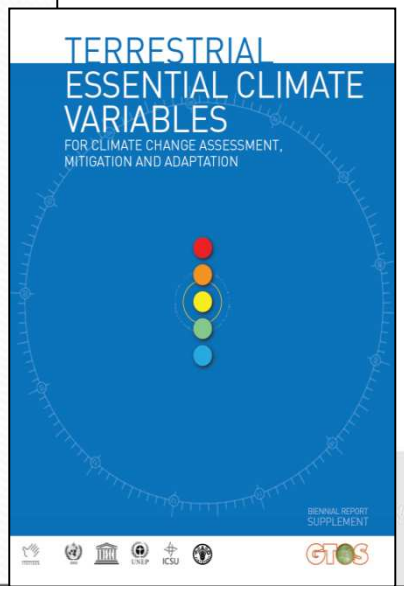
- GTOS ECV
  - Essential Climate Variable

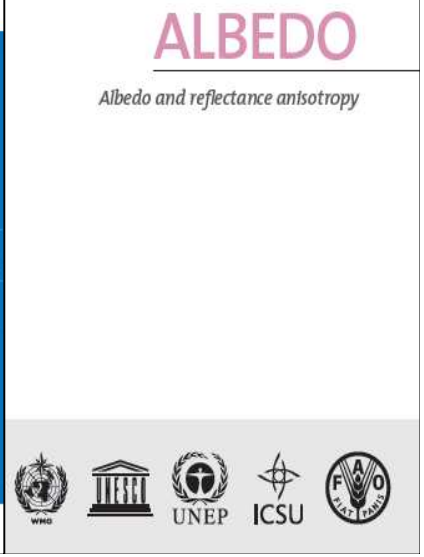
- Schaaf, C.B., J. Cihlar, A. Belward, E. Dutton, and M. Verstraete, Albedo and Reflectance Anisotropy: Assessment of the status of the development of standards for the Terrestrial Essential Climate Variables, GTOS-63/GTOS-ECV-T08, Ed. R. Sessa, Global Terrestrial Observing System (GTOS)Secretariat,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

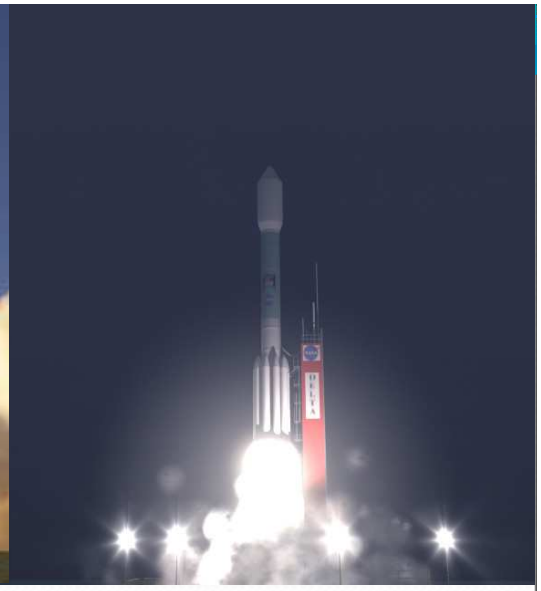
- Documents stress importance of supporting and expanding high caliber field networks such as BSRN, Fluxnet, AERONET







MODIS



Orbit: Sun-synchronous, near-polar 705.3 km, 98.21° inclin.

EOS-Terra Platform

- 10:30 AM local solar equatorial crossing time (descending node)
- Launched December 18, 1999, first light 2/24/2000

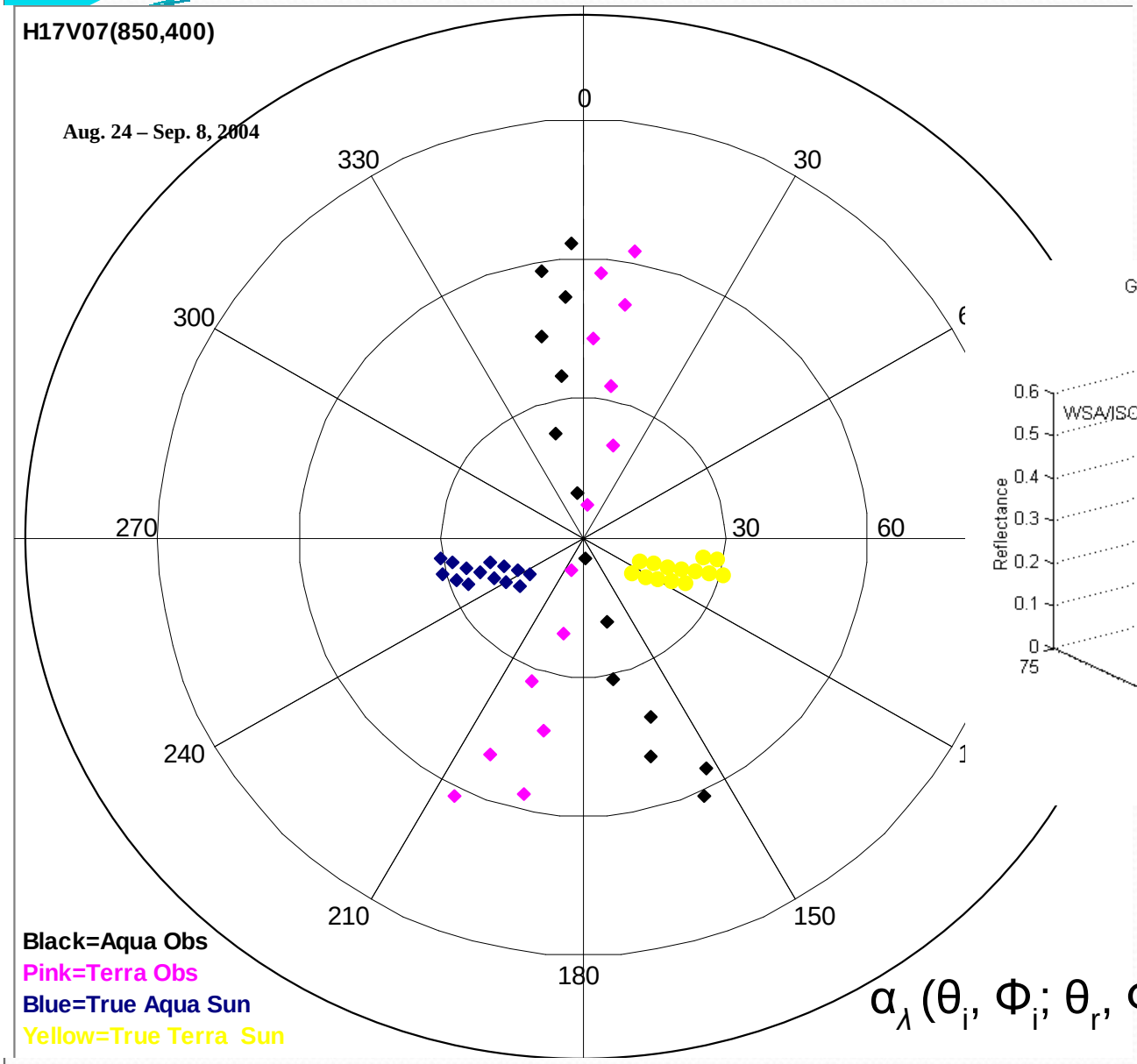
EOS-Aqua Platform

- 1:30 PM local solar equatorial crossing time (ascending node)
- Launched May 4, 2002, first light 6/24/2002

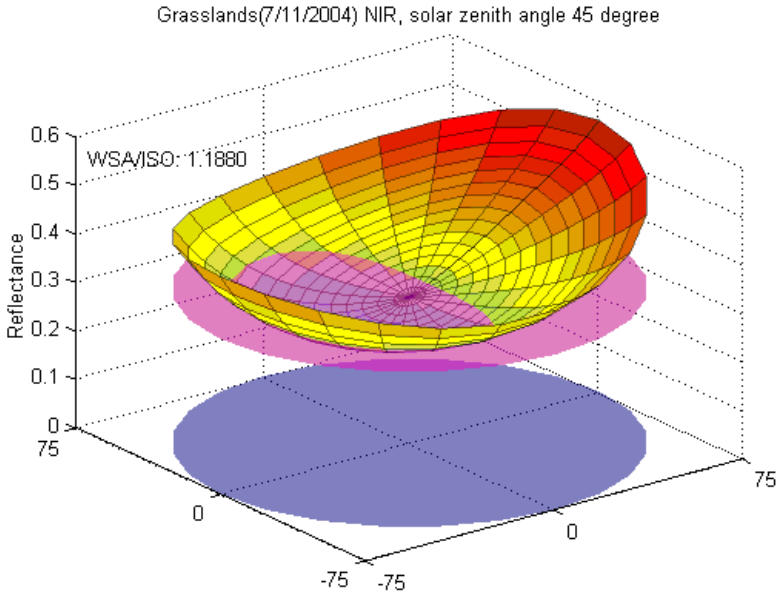
Instrument Characteristics

- Whiskbroom design—double-sided rotating mirror 10 lines per scan
- Four focal planes: Visible, NIR, SWIR, Thermal IR
- Scan angle: ±55°, 2330–km swath
- Repeat: 2-day global repeat, 1-day or less poleward of 30° lat.
- 36 spectral bands (0.4–14 μm)
- Spatial resolutions at 250-, 500-, and 1000-m (nadir) depending on λ
- 645, 858, 469, 555, 1240, 1640, 2130nm

MODIS Anisotropy, Albedo, NBAR



MODIS Aqua
MODIS Terra



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

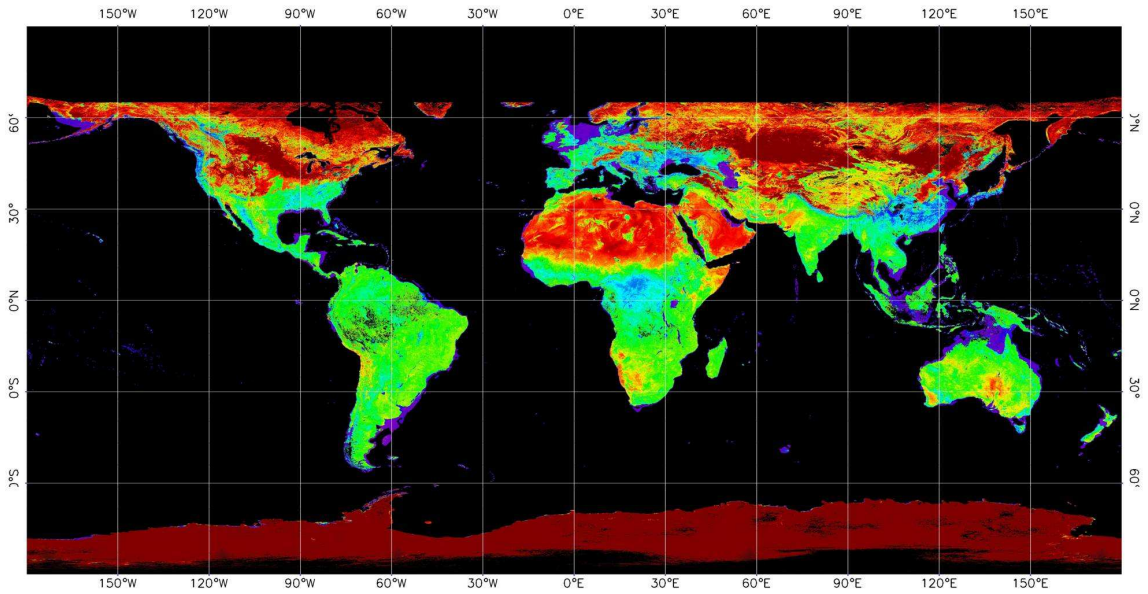
Roujean et al., 1992

MODIS Reflectance Anisotropy, Albedo, NBAR

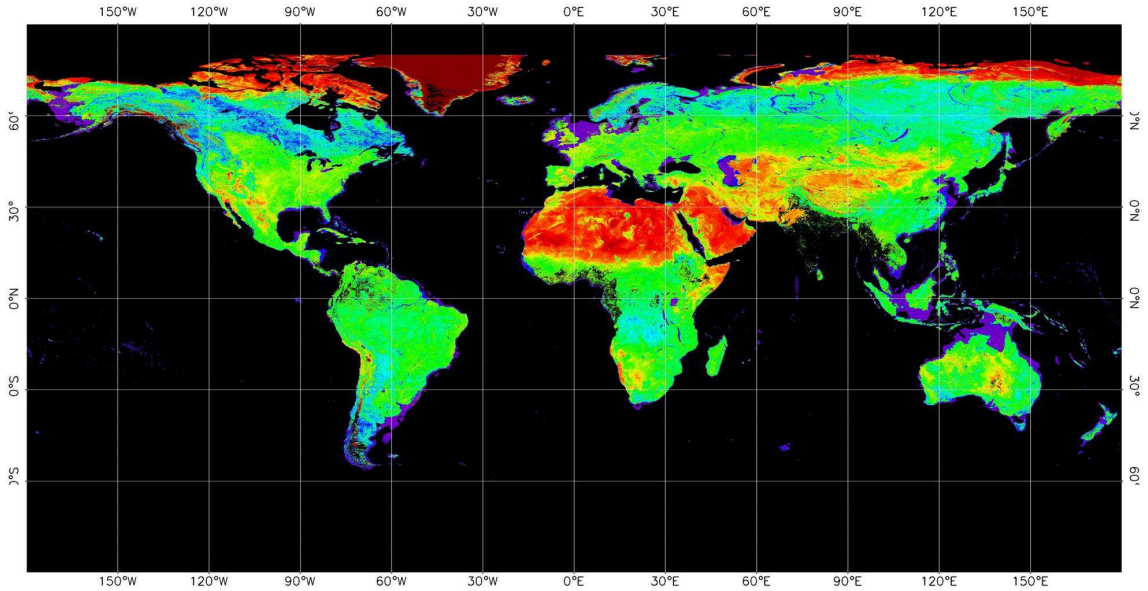
- Collection 5 (V005) MCD43A products
  - BRDF parameters (RossThickLiSparseReciprocal)
  - Albedo (WSA, BSA@lsn)
  - NBAR @lsn
    - 7 Spectral Bands plus three broadbands (Liang et al., 1999)
    - Standard spatial grid resolution 500m
    - Global land, 10deg. tiles, sinusoidal projection
    - Produced every 8 days (on a 16 day period)
    - Snow albedo only retrieved when majority condition over 16day period
  - **Extensive quality information**
- MCD43D, MCD43C products
    - Climate Modeling Grid (CMG)
    - Global lat/lon
    - 30arc sec grid, 0.05degree grid
    - Majority quality

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

Jan 2001



July 2001



No Data

0 0.1 0.2 0.3 0.4 0.5

MODIS Reflectance Anisotropy, Albedo, NBAR

- Algorithm was originally envisioned as a daily product
  - Long term archive constraints have limited standard global production to periodic retrievals thus far

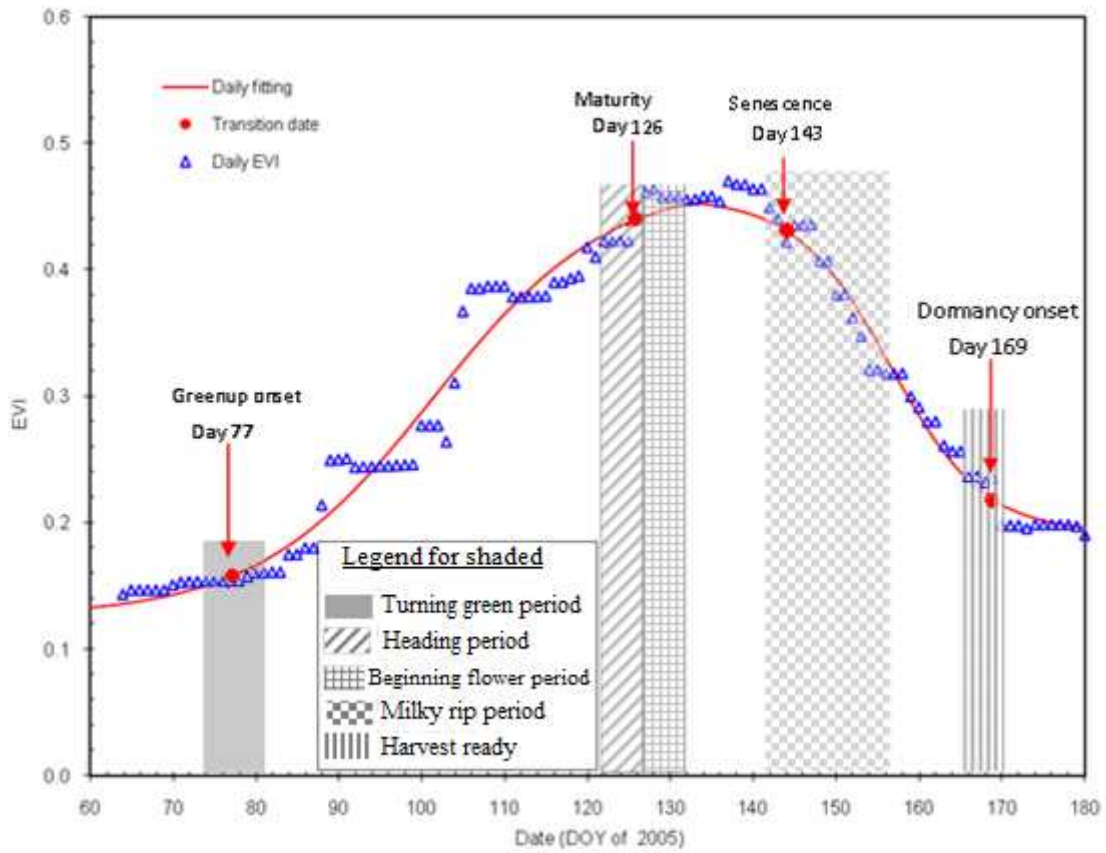
- Daily MODIS Direct Broadcast Algorithm developed
  - Terra Aqua Direct Broadcast X-band downlink
  - UWisc International MODIS/AIRS Processing Pkg (IMAPP)
  - Daily BRDF/Albedo/NBAR DB Algorithm
  - Grid, bin MOD09_SPA into 500m sinusoidal tiles
  - DRL package available
  - Terra, Aqua
  - Allows implementation of daily rolling 500m (potentially 250m) retrievals in a regional context

Reference from http://dbmeeting.sci.gsfc.nasa.gov/posters_presentations2008.cfm

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

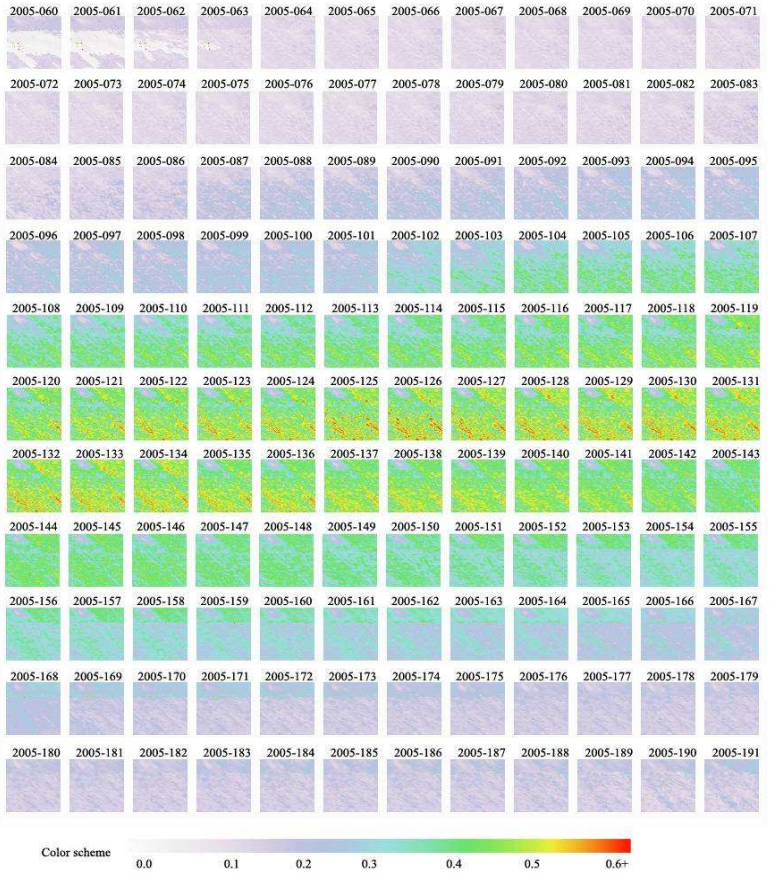
Daily temporal spectral BSA albedo (true color composites of MODIS band 1, 4, and 3) for the small area (30km by 30 km) centered on the Bartlett tower site for the 2005 growing season. Continuous cloud cover precluded a majority of the retrievals from Days 149-152.

MODIS Albedo, NBAR, Reflectance Anisotropy



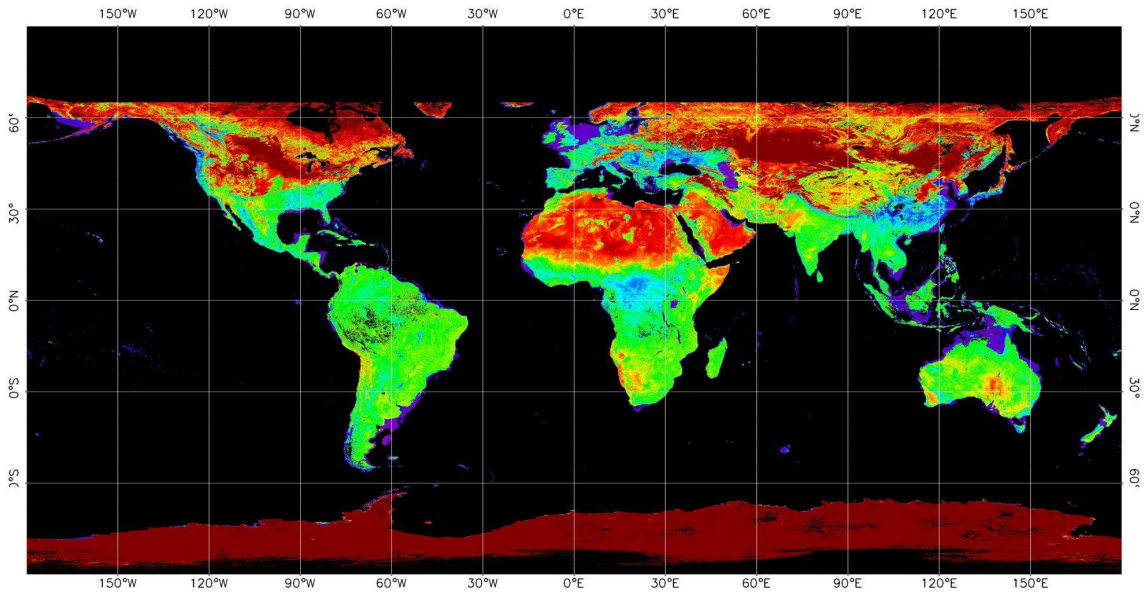
Zhang,X., M. A.Friedl, C. B. Schaaf, Global vegetation phenology from Moderate Resolution Imaging Spectroradiometer (MODIS): Evaluation of global patterns and comparison with in situ measurements ,J. Geophys. Res., 111, G04017,doi:10.1029/2006JG000217,2006

Daily Temporal NBAR-EVI of small area (30km by 30 km) centered on the Yucheng Experimental Site, China (YCES) for 2005

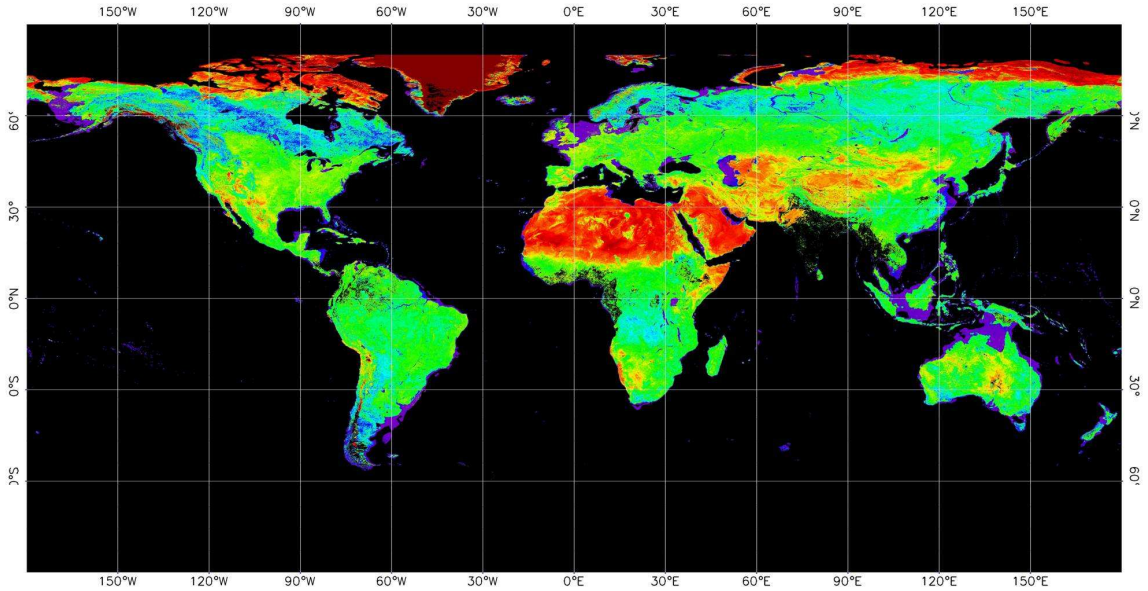


Standard MCD43 Broadband White-Sky Albedo (0.3-5.0mm)

Jan 2001



July 2001



No Data

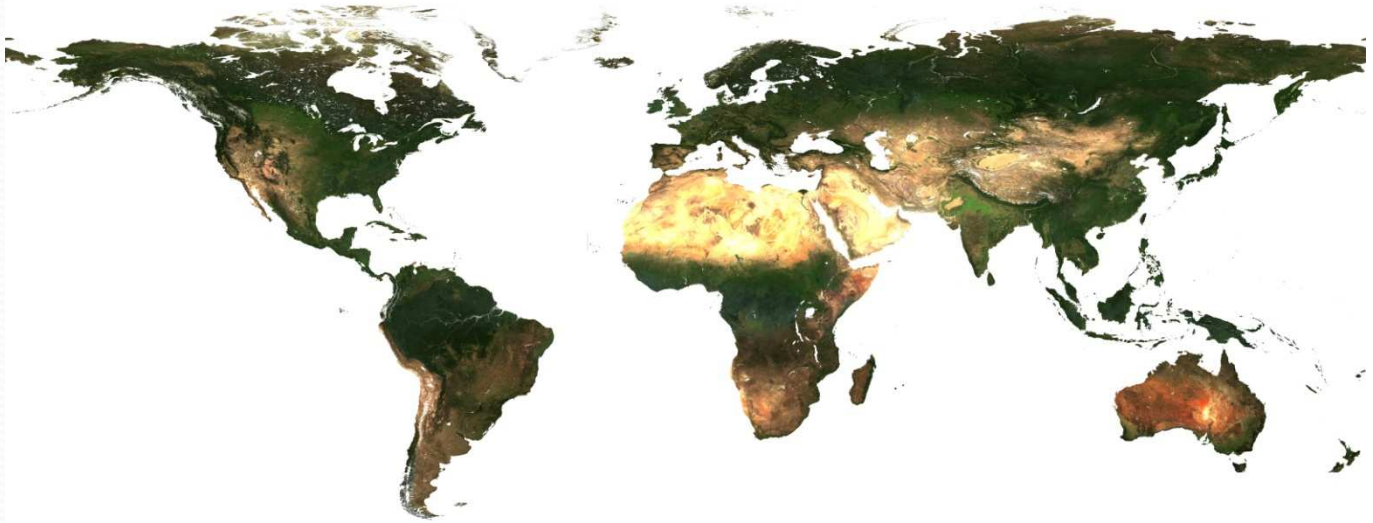
0 0.1 0.2 0.3 0.4 0.5

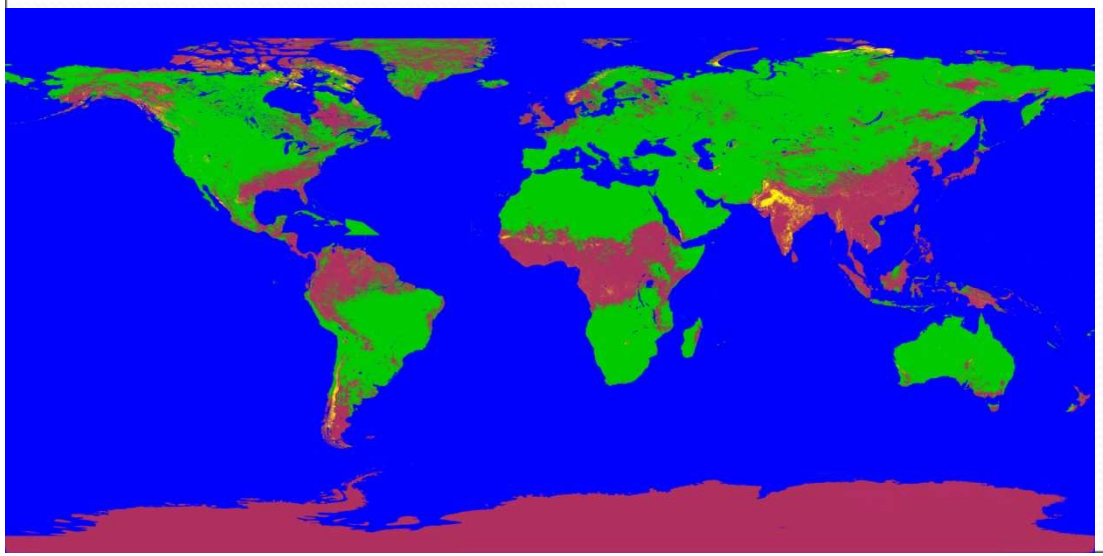
Albedo and Reflectance Anisotropy

- 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 productsRemote 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)

Albedo, NBAR, Reflectance Anisotropy

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



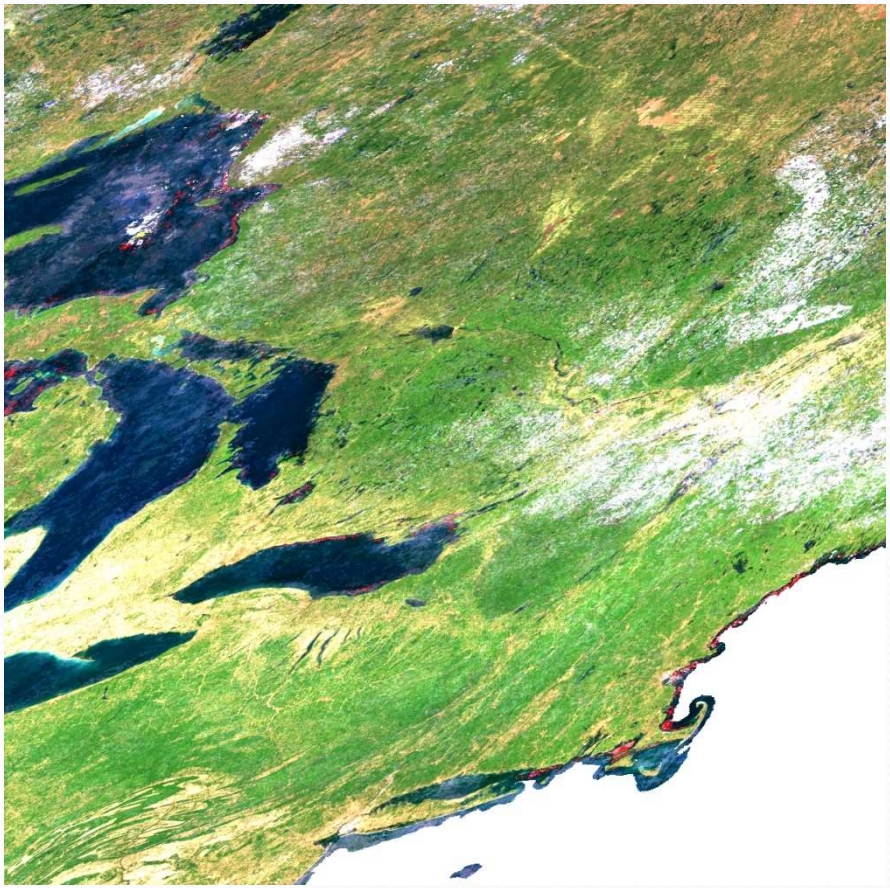


Gap-filled MODIS BRDF product
Day 185 2007

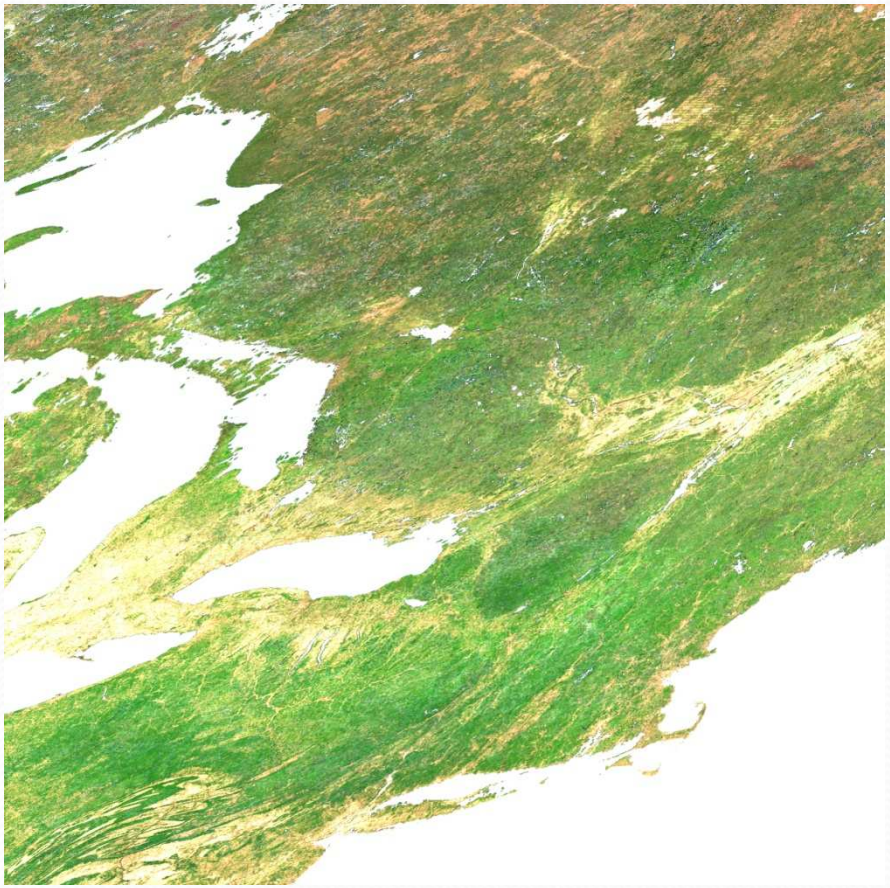
Green: high quality,
Magenta: temporal fill
Yellow :spatial fill

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.

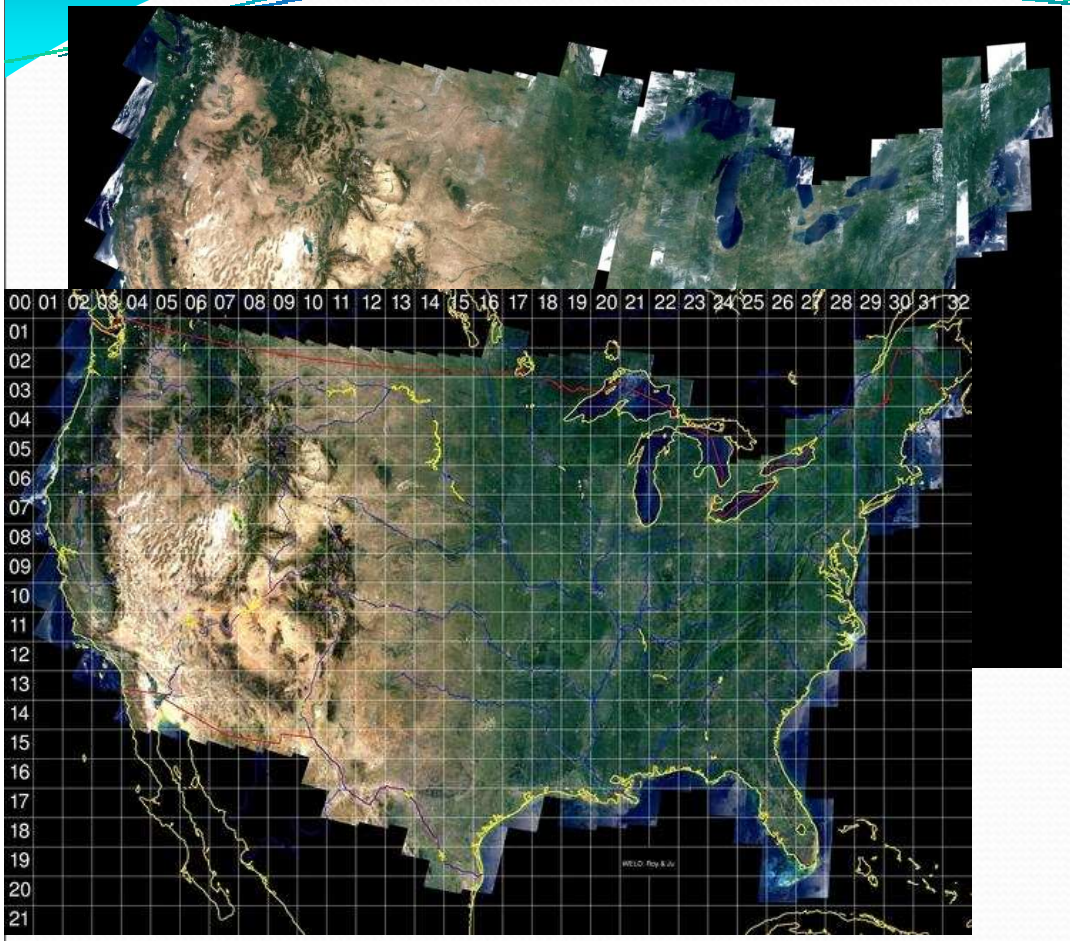


Gap-filled version

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, radiation/PAR, LST/emissivity
  - AATSR aerosol retrievals
  - MERIS GLOBABLEDO albedo precursor (Muller)
  - Surface structural quantities (Hill, Chopping)
  - Landsat corrected reflectance, albedo (Gao/Masek/Shuai, Roy)

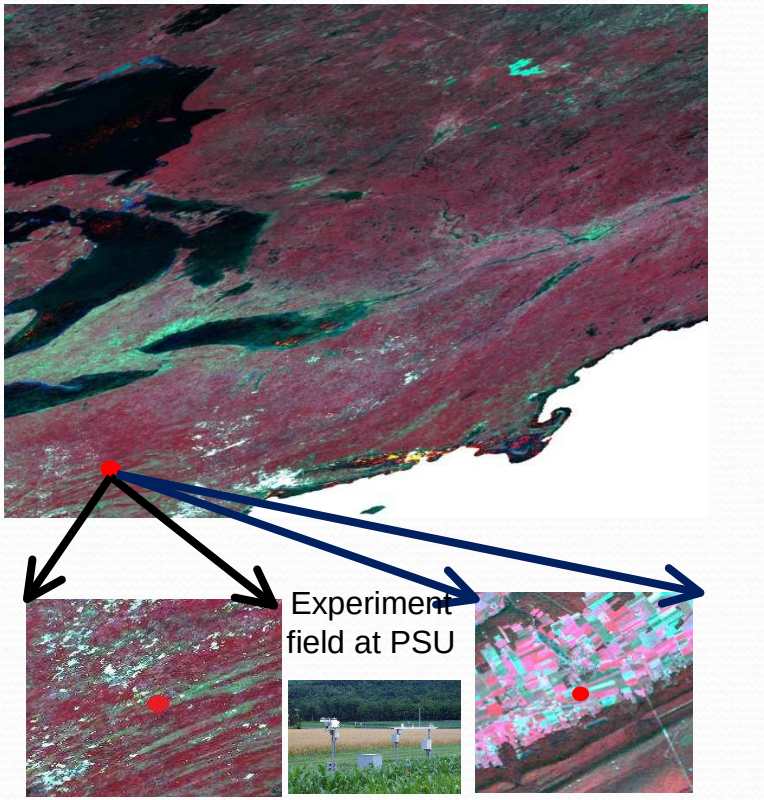
Albedo, NBAR, Reflectance Anisotropy



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

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



Shuai, Y., J. G. Masek, F. Gao, C.B. Schaaf, 2011, An Algorithm for the Retrieval of 30-m snow-free albedo from Landsat surface reflectance and MODIS BRDF, RSE in review.

Validation and Evaluation

GODDARD SPACE FLIGHT CENTER | + NASA Homepage

CEOS WORKING GROUP ON CALIBRATION & VALIDATION

Committee on Earth Observation Satellites

Land Product Validation Subgroup

Home | Landcover | Biophysical | Surface Rad | Fire/Burn | LST/Emiss | Phenology | Soil Moisture

Current LPV Chair: Joanne Nightingale (GSFC)
Vice-Chair: Gabriela Schaepman-Strub (University of Zurich)

Announcing...

- Symposium - Recent Advances in Quantitative Remote Sensing: **RAQRS'III**, Sep/Oct 2010, Valencia, Spain.
- Land Surface Analysis SAF - **2010 User workshop**, 15-17 Nov, Toulouse, France
- **ESA-iLEAPS-EGU**: Earth observation for land-atmosphere interaction science, 3-5 Nov, Frascati, Italy
- The **LPV Soil Moisture** Focus Group will hold a joint meeting May 5, 2011 in Oxnard, CA.

LPV Mission

To foster quantitative validation of higher-level global land products derived from remote sensing data and to relay results so they are relevant to users

Validation **is the process of assessing, by independent means, the quality of the data products derived from the system outputs**

http://lpvs.gsfc.nasa.gov/ (Jaime Nickeson GSFC)

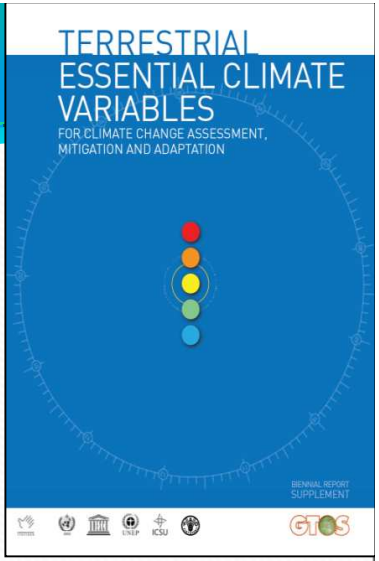
LPV Focus Groups

* ECV

Chair Joanne Nightingale (NASA GSFC)
Vice-Chair: Gabriela Schaepman-Strub (University of Zurich)

Focus Group Name	North American Co-lead	European (Non-NA) Co-lead
Land Cover *	**Mark Friedl** (Boston University)	**Martin Herold** (Wageningen University, The Netherlands)
Fire* (Active/Burned Area)	**Luigi Boschetti** (University of Maryland)	**Kevin Tansey** (University of Leicester, UK)
Biophysical (LAI*, fAPAR*)	**Richard Fernandes** (NR Canada)	**Stephen Plummer** (ESA, UK)
Surface Radiation (Reflectance, BRDF, Albedo*, Snow)	**Crystal Schaaf** (Boston University)	**Gabriela Schaepman-Strub** (University of Zurich, Switzerland)
LST & Emissivity (with IVOS)	**Simon Hook** (NASA/JPL)	**Jose Sobrino** (University of Valencia, Spain)
Soil Moisture*	**Tom Jackson** (USDA)	**Wolfgang Wagner** (Vienna University of Technology, Austria)
Phenology	**Jeff Morisette** (USGS)	**Jadu Dash** (University of Southampton, UK)

- Hold Workshops
- Development of Validation Protocol Documents
- Foster Collaboration
  - GOFC-GOLD ITs, GEOLAND, GLOBALBEDO, NPN, SMAP, SMOS…
  - Contributions to GTOS ECVs
  - Contributions to GCOS Implementation Plan



6.1.3. Monitoring at Terrestrial Reference Sites

Many, if not most, of the terrestrial ECVs (such as FAPAR, LAI, biomass, and albedo) are too heterogeneous spatially to make global *in situ* measurements practical. They are typically measured at a limited number of research sites or retrieved from space measurements over large areas. There are three key requirements for *in situ* measurements at reference sites in the context of long-term global climate measurements: (a) To ensure that a representative set of biomes are properly and consistently documented over long periods of time (decades or more). This will allow the details of natural vegetation changes and carbon stocks, including fluxes, to be carefully monitored at key locations; (b) to measure key meteorological ECVs to support interpretation of changes recorded at such sites; and (c) to optimize the joint use of these terrestrial reference sites with:

- a set of sites delivering essential ground data for the validation of satellite-derived products that provide extensive geographical coverage for these variables (see Action T29 dealing specifically with calibration/validation of FAPAR and LAI).
- key ecosystem sites (see Action T4).

It may be efficient to establish these reference sites by building on existing networks, such as the Flux and Energy Exchange Network (FLUXNET) and the Long-Term Ecological Research Network (LTER), and to seek overlap between those networks.

Action T3[93] *[IP-04 T3, T29]*[94]

Action: Development of a subset of current LTER and FLUXNET sites into a global terrestrial reference network for monitoring sites with sustained funding perspective, and collocated measurements of meteorological ECVs; seek linkage with Actions T4 and T29 as appropriate.
Who: Parties' national services and research agencies, FLUXNET organizations, the US National Ecological Observatory Network (NEON) and the European Integrated Carbon Observation System (ICOS), in association with CEOS WGCV, CGMS-GSICS, and GTOS (Terrestrial Carbon Observations Panel (TCO) and TOPC).
Time-frame: Implementation started by 2011, completed by 2014.
Performance Indicator: Plan for the development and application of standardised protocols for the measurements of fluxes and state variables.
Annual Cost Implications: 30-100M US$ (40% in non-Annex-I Parties).

http://www.wmo.int/pages/prog/gcos/Publications/gcos-138.pdf

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

IMPLEMENTATION PLAN FOR THE GLOBAL OBSERVING SYSTEM FOR CLIMATE IN SUPPORT OF THE UNFCCC

(2010 UPDATE)

August 2010
GCOS-138
(GOOS-184, GTOS-76, WMO-TD/No. 1523)

Table 13. Observing networks and systems contributing to the Terrestrial Domain

ECV	Contributing Network(s)	Status	Contributing Satellite Data	Status
Albedo	CEOS WGCV; MODLAND; Atmospheric Radiation Measurement sites.	No designated reference network.	Multi-angular sensors. Geostationary Polar orbiters. GCMPs applied to measurements.	Use of operational meteorological satellites (SCOPE-CM Pilot Project) and moderate-resolution optical polar orbiters; Continuation of multi-angular missions required

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- Background
- Products
- Meetings
- Case Studies
- Albedo Intercomparison

LPV Surface Radiation focus area leads

Crystal Schaaf of Boston University, Dept of Geography, MODIS Albedo/BRDF PI
Gabriela Schaepman-Strub of the University of Zurich, Institute of Environmental Sciences

Surface Radiation Focus Area Objectives

Current Activities

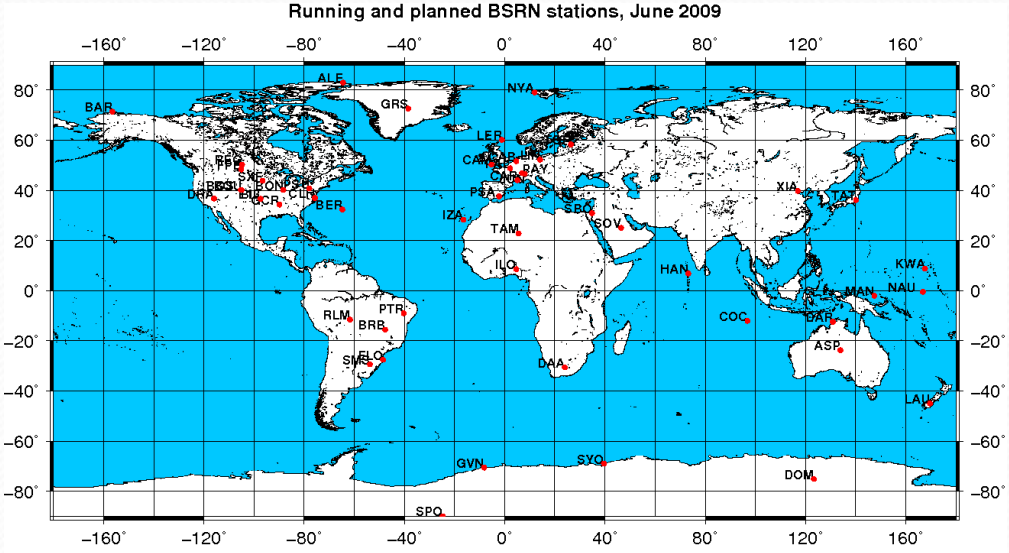
- **Albedo Validation Protocol** - in progress, draft due end of 2010
  - Homogeneous, heterogeneous locations, stressing conditions (snow, rapid change)
  - BSRN, Surfrad, ARM, Aeronet, Fluxnet sites
  - Implementation of online community validation (e.g. OLIVE, ORNL ISIS, NCDC SPEC)
  - Albedo in situ measurement standards defined and published (McArthur 2005 and Roman et al. 2010)
- Publication on available products and intercomparison results (in preparation)
- Collaboration with ESA-sponsored GLOBALBEDO project - Started Fall 2009 (Mueller)
- Collaboration with GMES Geoland2 Albedo validation effort - first test expected early 2011
- IEEE JSTARS special issue with Surface Radiation contributions published in August 2010

MODIS Albedo Validation Protocol

- Validation Strategy
  - Satellite Product Intercomparisons (CEOS/WGCV/LPV)
    - MODIS standard Products
    - MODIS daily Direct Broadcast algorithm
  - Direct Comparisons with Tower Data
    - Range of land covers
    - Tower data **must be spatially representative**
    - Height of growing season
    - Seasonality (usually more heterogeneous)
    - Snow albedo (challenging)
  - Field campaigns of opportunity
    - SAFARI 2000 Skukuza,South Africa;Mongu,Zambia Towers, CAR (Romάn)
    - CLASIC 2007 ARM SGP Towers, CAR (Román)
    - ARCTAS (Arctic Research of Composition of Troposphere from Aircraft and Satellites)
      - 2008 winter field campaign (Kahn/Lyapustin)
      - Solar Spectral Flux Radiometer SSFR (Schmidt)
      - Cloud Absorption Radiometer CAR, BRDF validation (Gatebe)

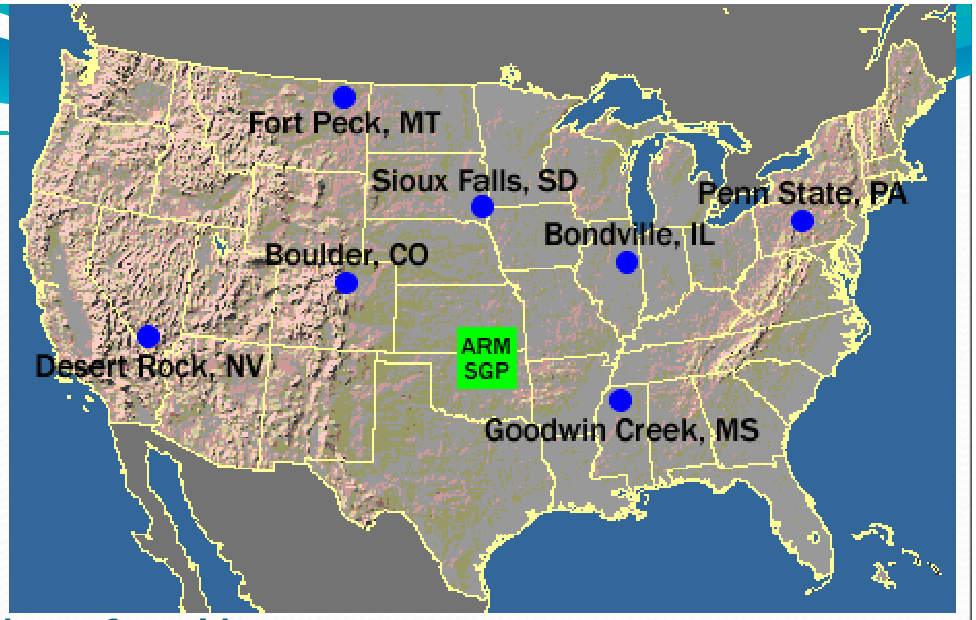
MODIS Albedo Validation Protocol

- Tower Validation Data
  - Baseline Surface Radiation Network (BSRN)
  - WCRP (World Climate Reseasrch Programme)
  - GEWEX (Global Energy and Water Cycle Experiment)
  - Archived at World Radiation Monitoring Center (WRMC) , Alfred Wegener Institute, Bremerhaven, Germany
  - http://www.bsrn.awi.de/en/home/
  - 58+ sites (albedo at ~half)
  - CERES Team hosts data
  - http://www-cave.larc.nasa.gov/cave/
  - BSRN, SURFRAD, GMD, ARM



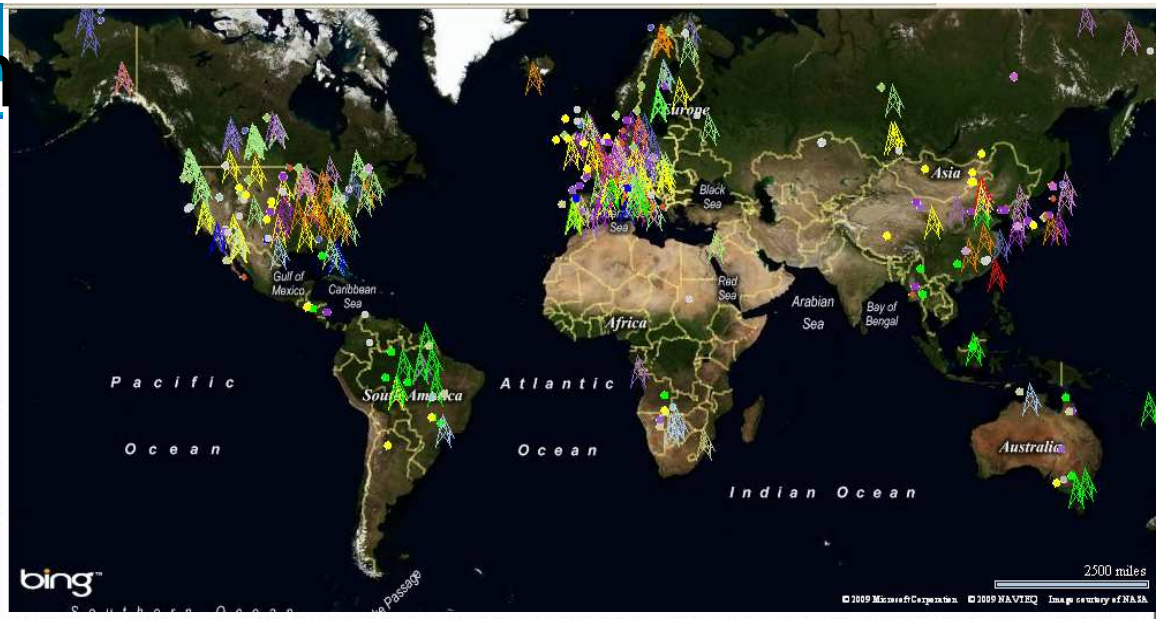
- GCOS/GTOS Standard
  - Field instrumentation and calibration
  - (BSRN Operations Manual, McArthur, 2005)
  - http://www.bsrn.awi.de/fileadmin/user_upload/Home/Publications/McArthur.pdf

MODIS Validation



- Tower Validation Data
- US Contributors to BSRN
  - NOAA SURFRAD (7)
    - http://www.srrb.noaa.gov/surfrad/
  - NOAA GMD http://www.esrl.noaa.gov/gmd/grad/field.html
    - Barrow, Boulder (Spectral Albedo)
  - DOE ARM (Atmospheric Radiation Measurement)
    - http://www.arm.gov/
    - ARM Climate Research Facility ACRF
      - Southern Great Plains (SGP)
      - North Slope Alaska (Barrow)
      - Tropical Western Pacific
      - Mobile Sites

MODIS Validation



- Tower Validation
- Ameriflux (87 sites)
  - http://public.ornl.gov/ameriflux/
  - Albedo not always contributed to archive
- Fluxnet
  - Network of regional networks
  - http://www.fluxdata.org/default.aspx
  - 138 sites with albedo from the Synthesis or “La Thuile”dataset
  - 53 sites eventually used in Fluxnet-MODIS evaluation
- LTER/ILTER, 20 NEON domains
  - http://www.lternet.edu/
  - http://www.neoninc.org/

•MODIS Validation (Stage 2)

•Cescatti, A., B. Marcolla; S.K Santhana Vannan; J.Y. Pan; P. Ciais; R.B Cook; B. E Law; G. Matteucci; M. Migliavacca; E. Moors; A. D Richardson; G. Seufert; C. B Schaaf, Intercomparison of MODIS albedo retrievals and in situ measurements across the global FLUXNET network, Rremote Sensing Environment submitted

•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, 114, 738-760,2010.

•Román, M. O., C. B. Schaaf, C E. Woodcock, A. H. Strahler, et al., 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.

•Salomon, J., C. B. Schaaf, A. H. Strahler, F. Gao, Y. Jin, Validation of the MODIS Bidirectional Reflectance Distribution Function and Albedo Retrievals Using Combined Observations from the Aqua and Terra Platforms, IEEE Trans. Geosci. Remote Sens. Vol. 44, No. 6, June 2006.

•Stroeve, J., J. Box, F. Gao, S. Liang, A. Nolin, C. Schaaf, Accuracy Assessment of the MODIS 16-day Albedo Product for Snow: Comparisons with Greenland in situ Measurements, Remote Sens. Environ., 94, 46-60, doi:10.1016/j.rse.2004.09.001, 2005.

•Roesch, A., C. Schaaf and F. Gao, Use of Moderate-Resolution Imaging Spectroradiometer bidirectional reflectance distribution function products to enhance simulated surface albedos, J. Geophys. Res., 109, D12, doi: 10.1029/2004JD004552, 2004.

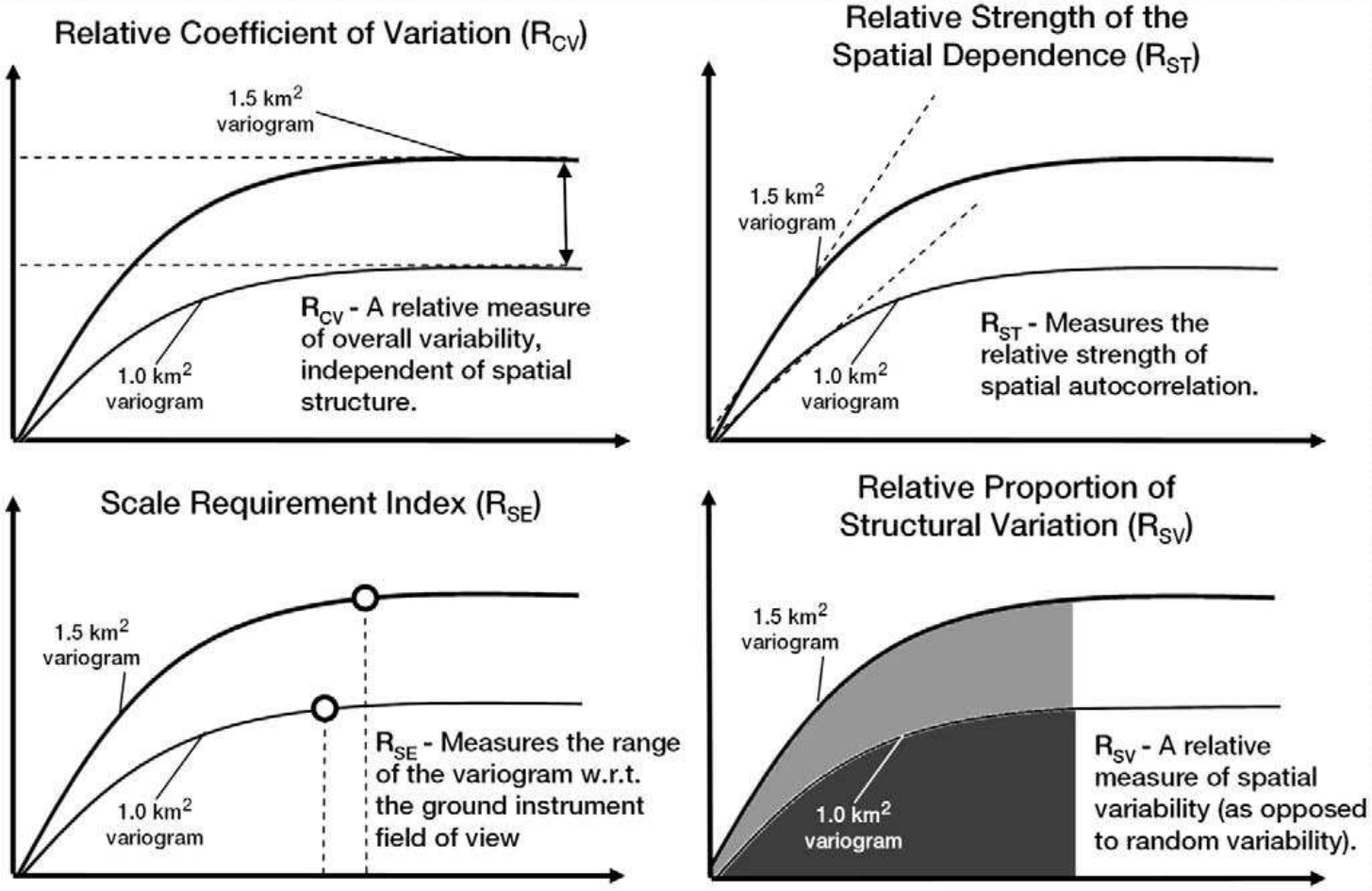
•Jin, Y., C. B. Schaaf, C. E. Woodcock, F. Gao, X. Li, A. H. Strahler, W. Lucht, S. Liang, Consistency of MODIS surface BRDF/Albedo retrievals: 2. Validation, J. Geophys. Res., 108(D5), 4159, doi:10.1029/2002JD002804, 2003.

•Liang, S., H. Fang, M. Chen, C. J. Shuey, C. Walthall, C. Daughtry, J. Morisette, C. Schaaf and A. Strahler, Validating MODIS Land Surface Reflectance and Albedo Products: Methods and Preliminary Results, Remote Sens. Environ., 83, 149-162, 2002.

MODIS Albedo Validation Protocol

- Geostatistical Measures of Spatial Representativeness

  Román et al., 2009; 2010



Derive ST_{SCORE}

$$ST_{score} = \left(\frac{|R_{CV}| + |R_{ST}| + |R_{SV}|}{3} + R_{SE} \right)^{-1}$$

Derive RAW_{SCORE}

$$RAW_{score} = |2R_{CV}|^{-1}$$

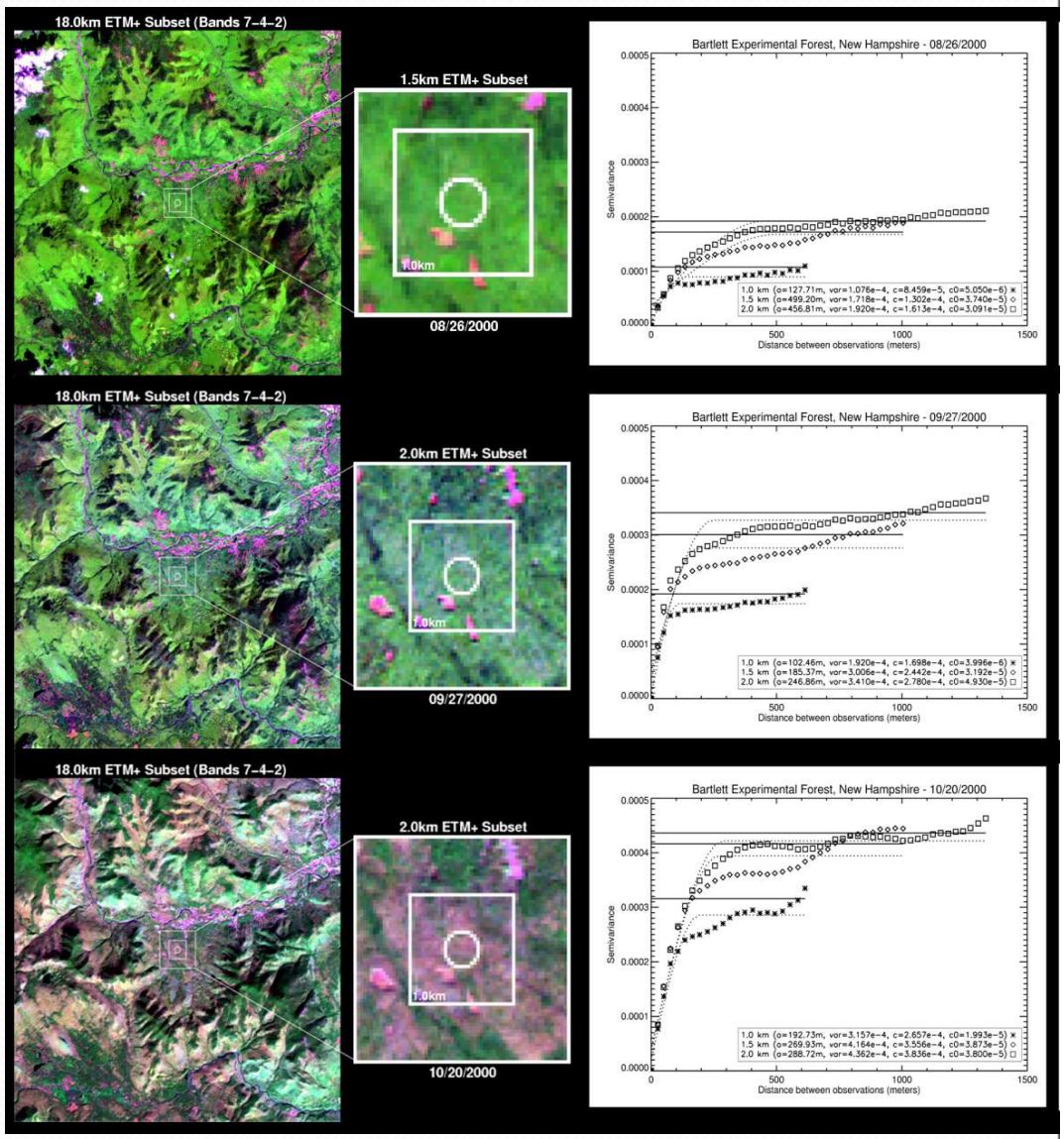
Estimate Optimal Tower Height

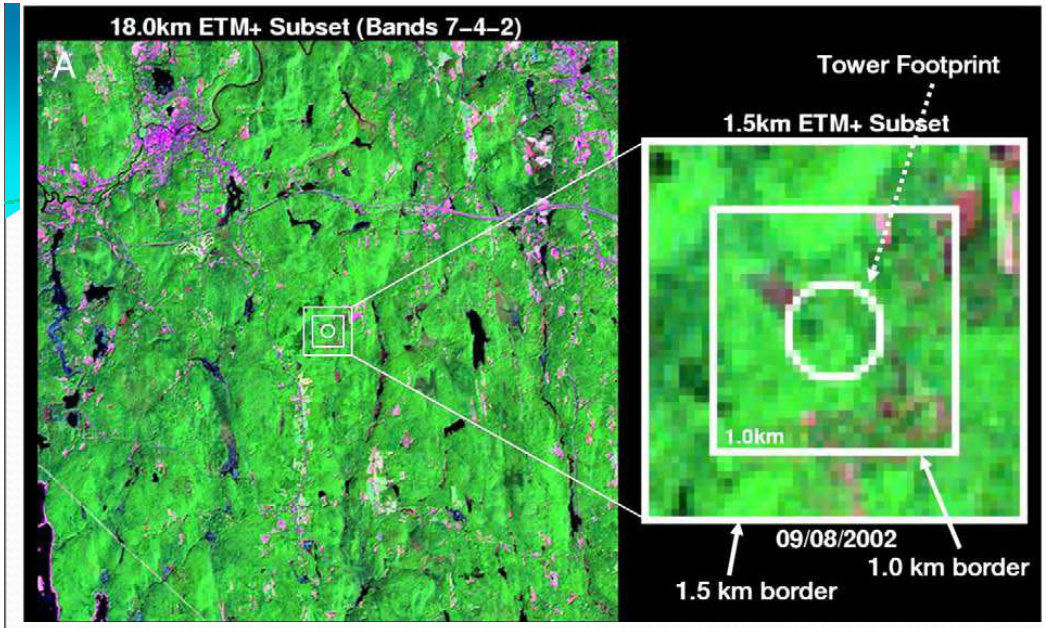
$$\min(g)$$

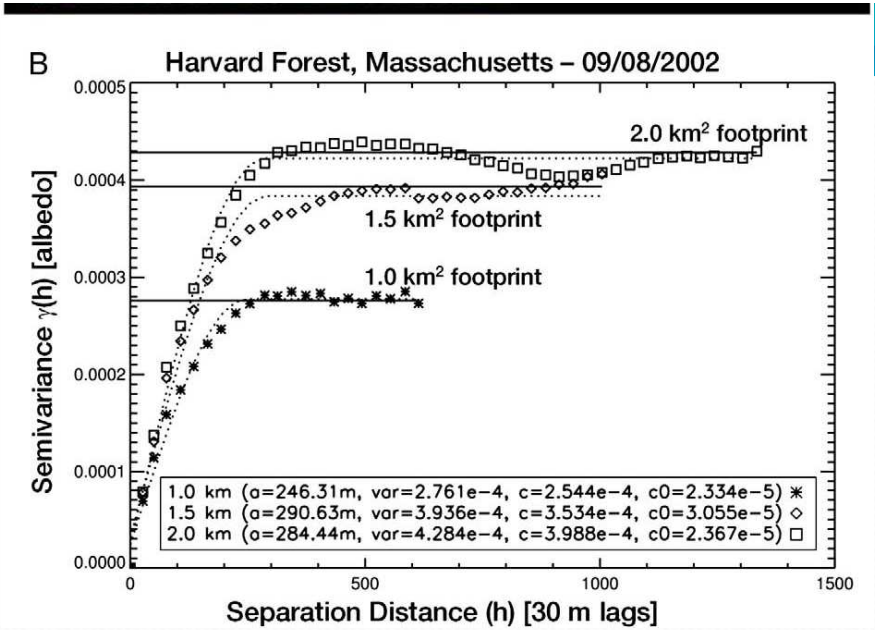
$$R_{SE} \in [e^{-\sqrt{2}}; \infty]$$

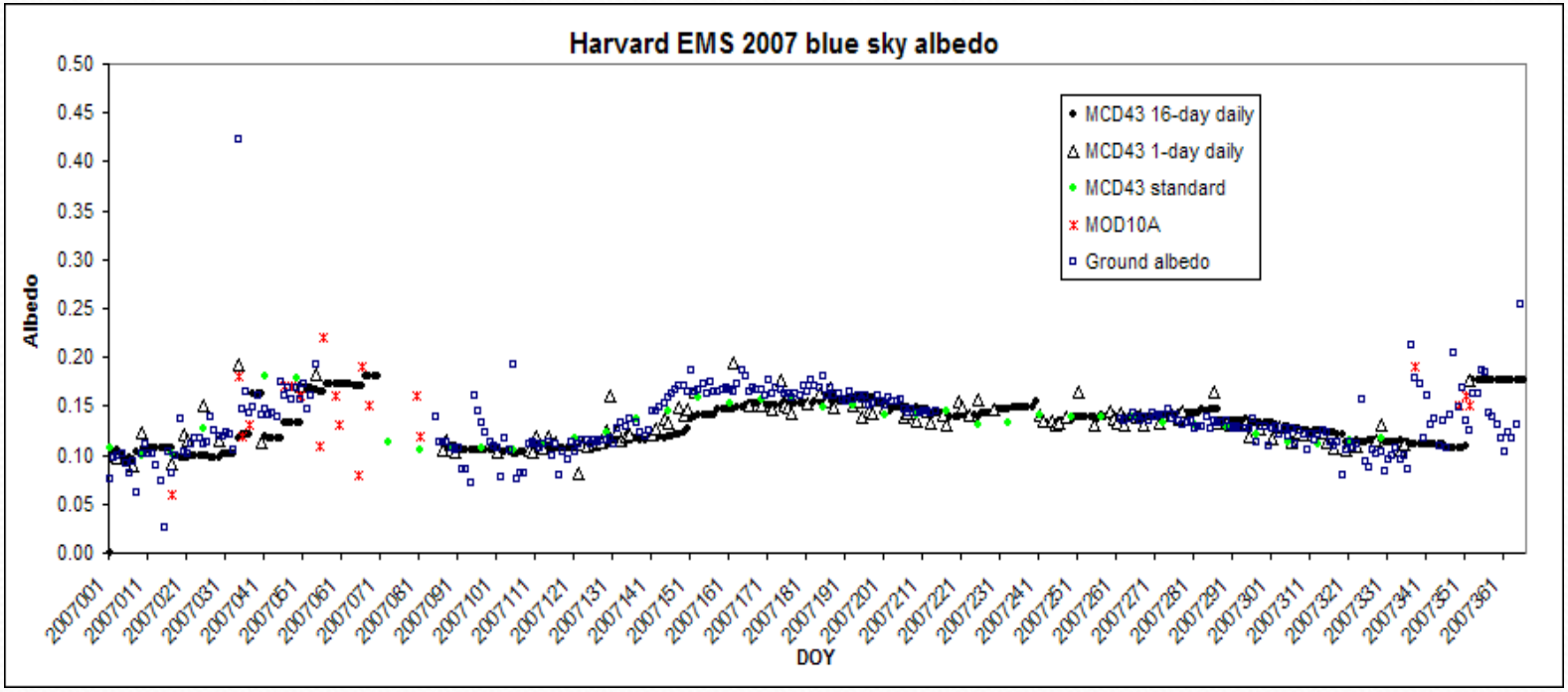
MODIS Albedo Validation Protocol

- Spatial Representativeness
- Over 100 sites leaf on, leaf off; initial snow evaluations
- ARM, Ameriflux, LaThuile data, SURFRAD,GMD,BSRN

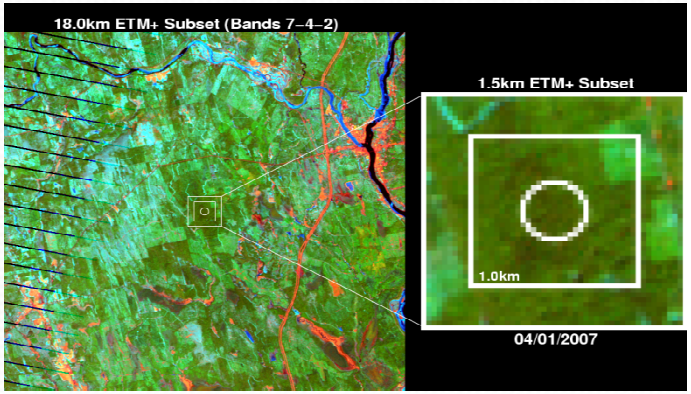


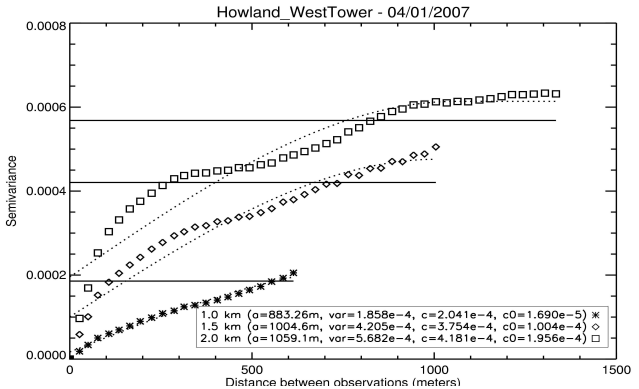

18.0km ETM+ Subset (Bands 7–4–2)
A
Tower Footprint
1.5km ETM+ Subset
1.0km
09/08/2002
1.0 km border
1.5 km border

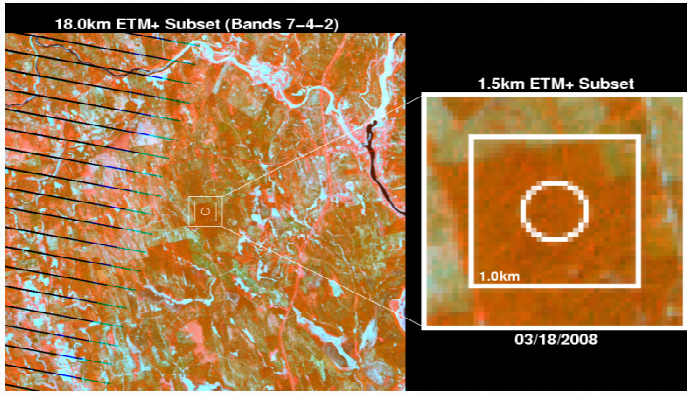

B
Harvard Forest, Massachusetts – 09/08/2002
Semivariance γ(h) [albedo]
Separation Distance (h) [30 m lags]
2.0 km² footprint
1.5 km² footprint
1.0 km² footprint
1.0 km (a=246.31m, var=2.761e−4, c=2.544e−4, c0=2.334e−5)
1.5 km (a=290.63m, var=3.936e−4, c=3.534e−4, c0=3.055e−5)
2.0 km (a=284.44m, var=4.284e−4, c=3.988e−4, c0=2.367e−5)

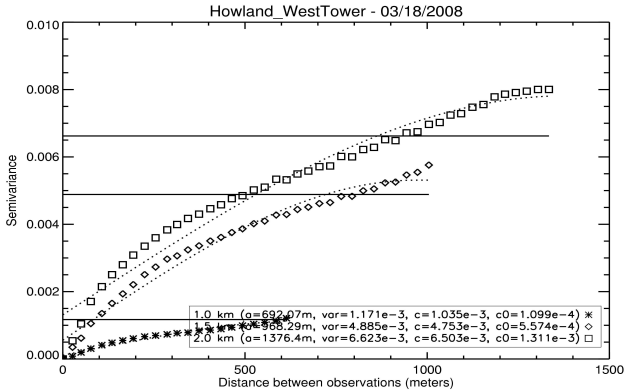

Harvard EMS 2007 blue sky albedo
Albedo
DOY
MCD43 16-day daily
MCD43 1-day daily
MCD43 standard
MOD10A
Ground albedo

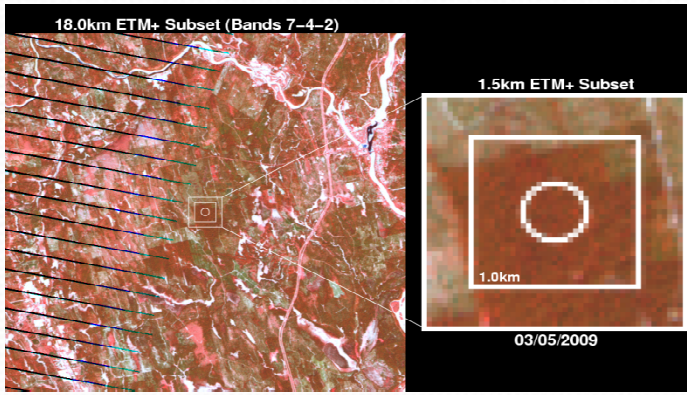
Howland Forest, ME

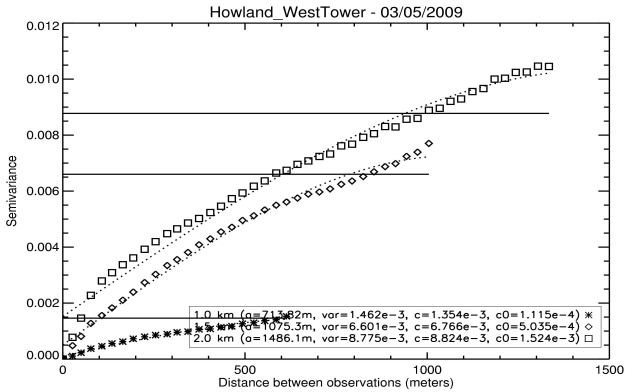


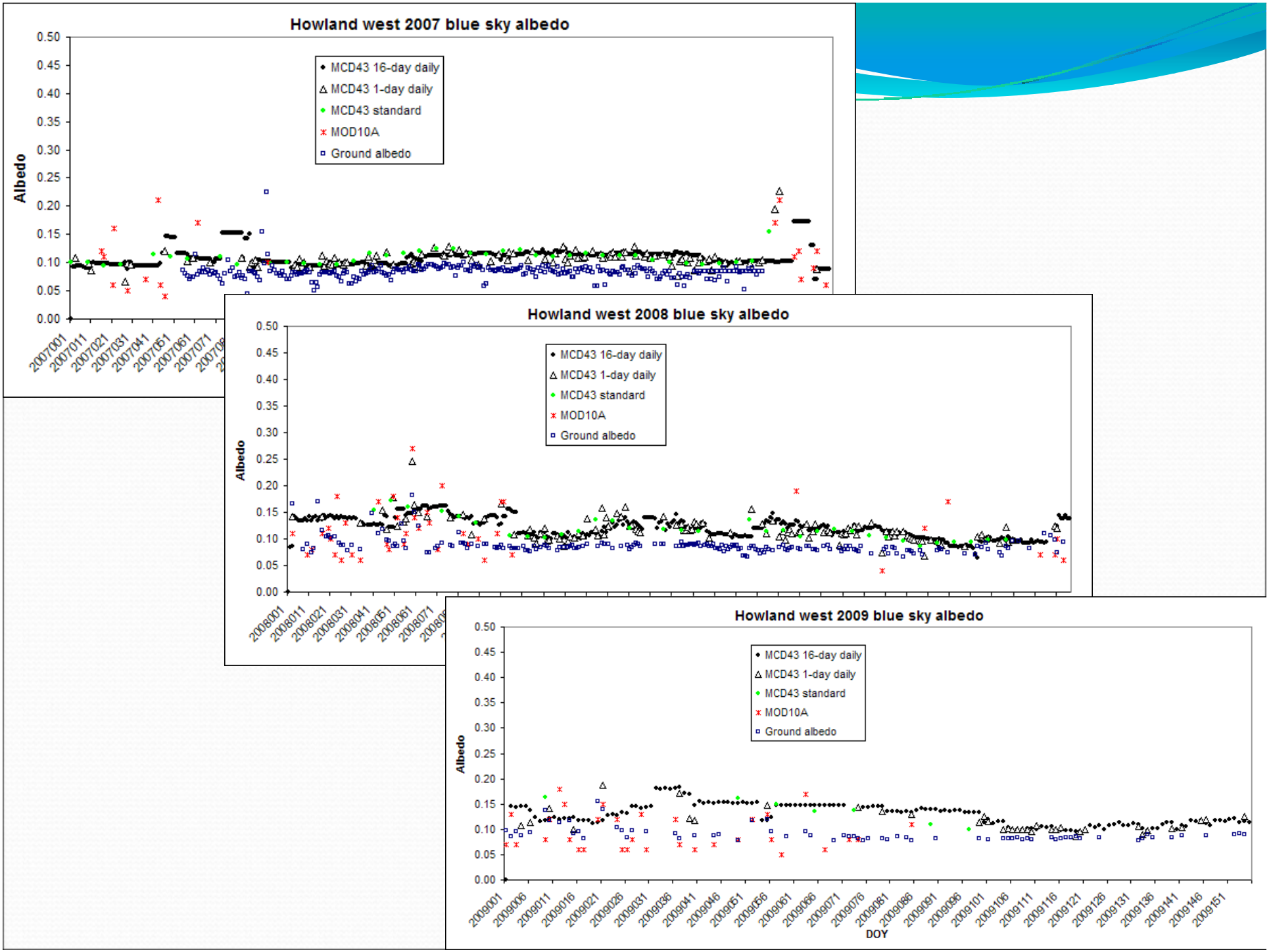






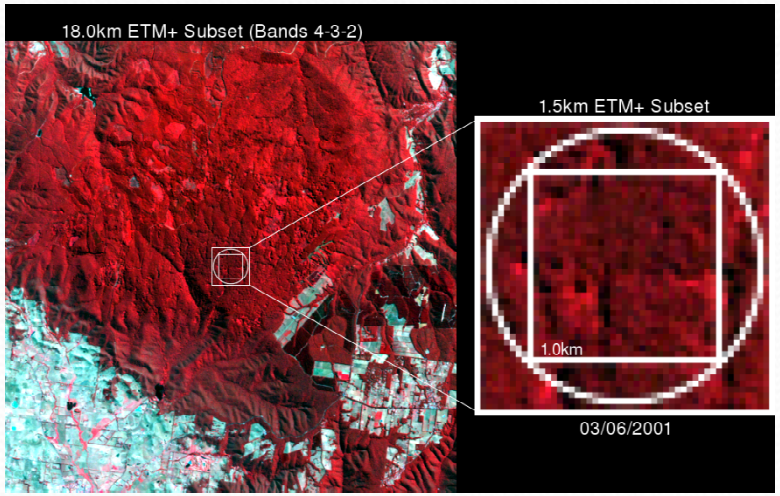


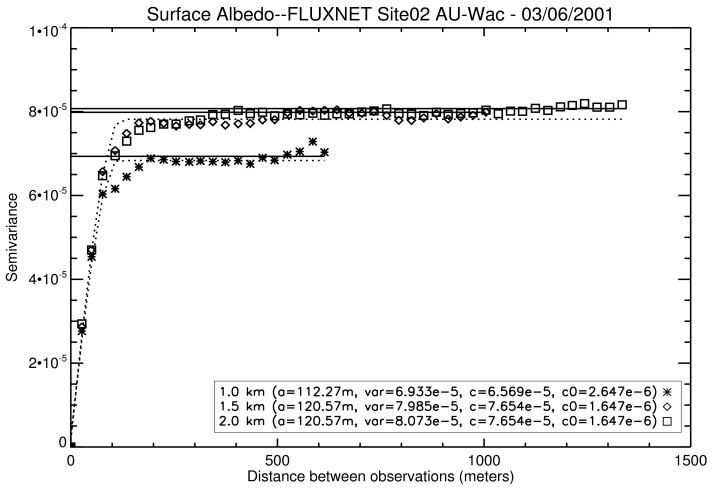


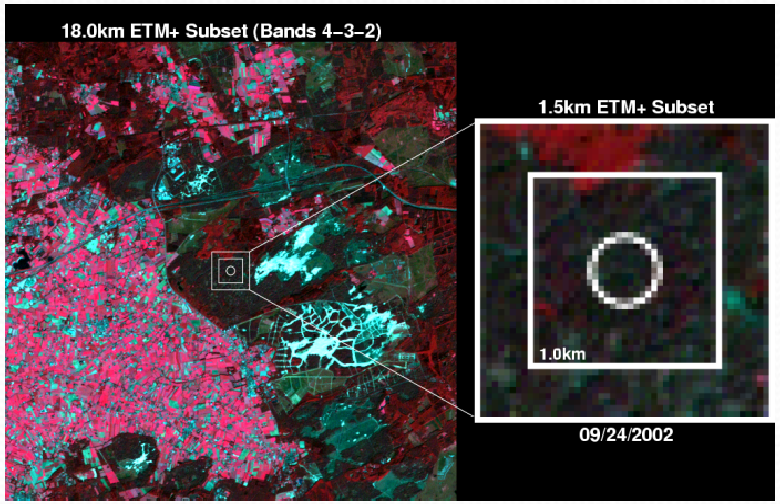

Howland west 2007 blue sky albedo
Albedo
MCD43 16-day daily
MCD43 1-day daily
MCD43 standard
MOD10A
Ground albedo
Howland west 2008 blue sky albedo
Albedo
MCD43 16-day daily
MCD43 1-day daily
MCD43 standard
MOD10A
Ground albedo
Howland west 2009 blue sky albedo
Albedo
MCD43 16-day daily
MCD43 1-day daily
MCD43 standard
MOD10A
Ground albedo
DOY

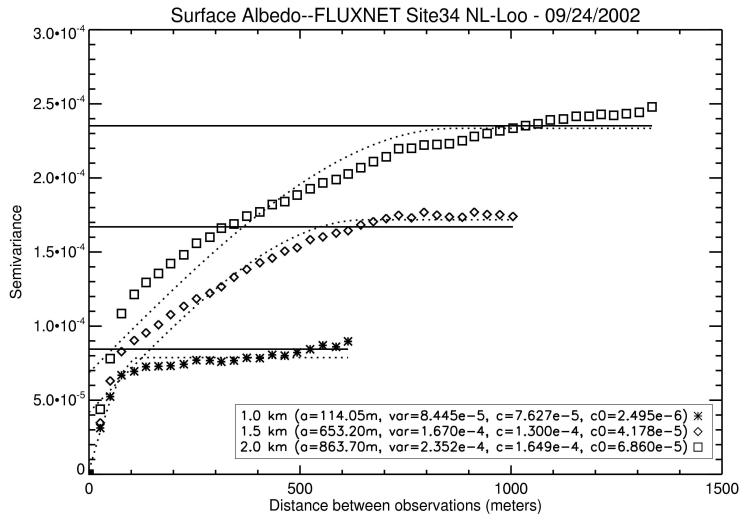
MODIS Validation Protocol

AU-Wac - Australia - Wallaby Creek







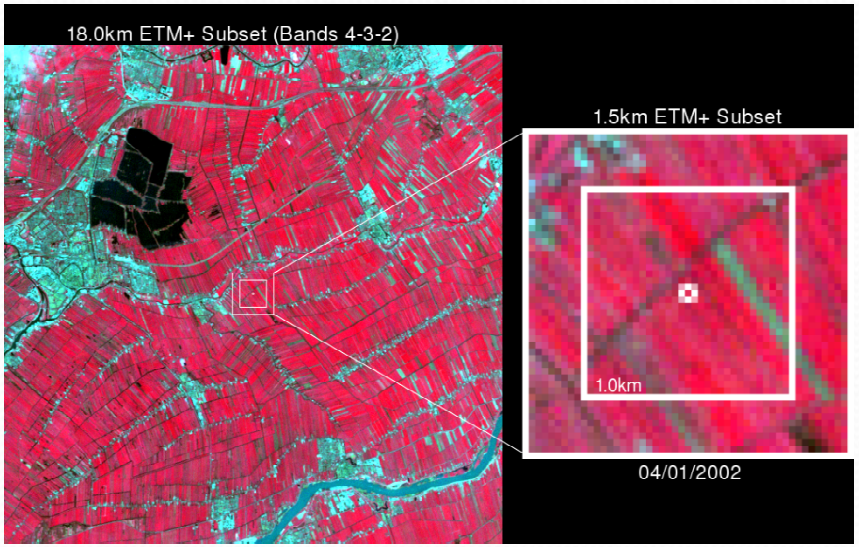


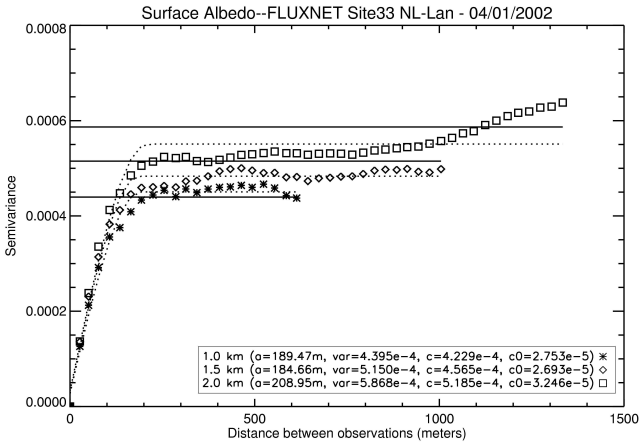
NL-Loo - Netherlands - Loobos

Evergreen Forest

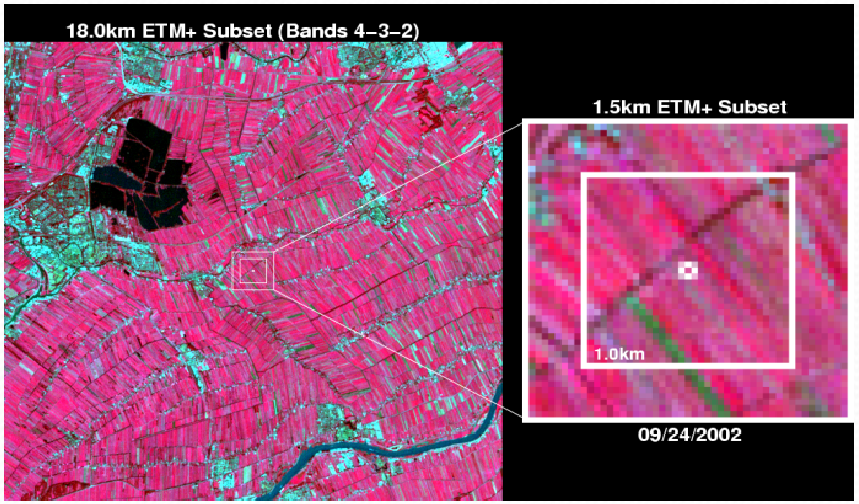
Rank	No.	Site ID	Date	Rcv	Rse	Rsv	Rst	STscore
1	Site02	AU-Wac	3/6/2001	7.00%	0.00%	-3.72%	14.83%	11.743
2	Site01	AU-Tum	8/25/2002	8.46%	0.02%	-1.87%	20.30%	9.776
3	Site07	CA-Ca1	10/3/2001	4.70%	1.86%	-9.00%	12.62%	9.407
4	Site03	BR-Cax	8/1/2001	0.82%	11.30%	-2.26%	10.83%	6.273
5	Site29	IT-SRo	1/19/2000	9.04%	2.06%	42.39%	5.96%	4.720
6	Site17	DE-Tha	10/13/2001	6.86%	2.99%	13.74%	40.44%	4.284
7	Site24	GF-Guy	10/18/2001	26.64%	12.73%	-17.47%	44.18%	2.372
8	Site18	DE-Wet	9/4/1999	12.42%	30.81%	-18.58%	39.91%	1.837
9	Site27	IT-Bon	10/20/2002	27.08%	8.89%	61.62%	72.97%	1.593
10	Site38	UK-Gri	7/17/2000	30.86%	35.20%	8.38%	78.31%	1.344
11	Site23	FR-Pue	8/16/2002	18.82%	56.59%	-43.79%	7.75%	1.249
12	Site35	PT-Esp	8/27/2000	38.12%	40.80%	2.37%	106.49%	1.114
13	Site34	NL-Loo	9/24/2002	35.86%	4.81%	401.39%	142.33%	0.505
14	Site08	CA-Ca3	4/29/2002	111.89%	28.88%	151.54%	596.03%	0.317

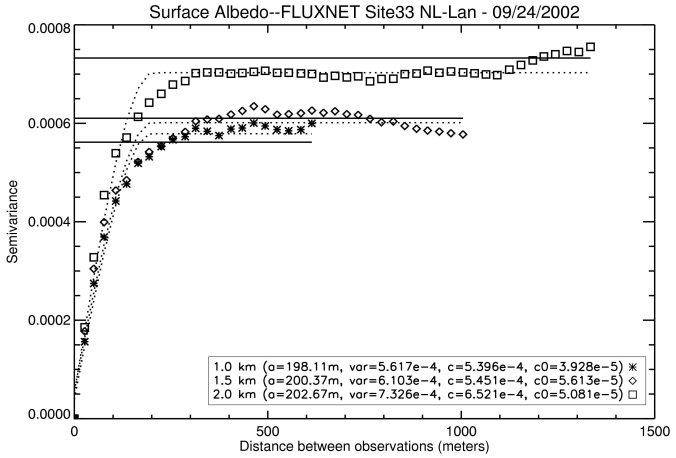
Albedo and Reflectance Anisotropy





NL-Lan - Netherlands – Langerak agriculture



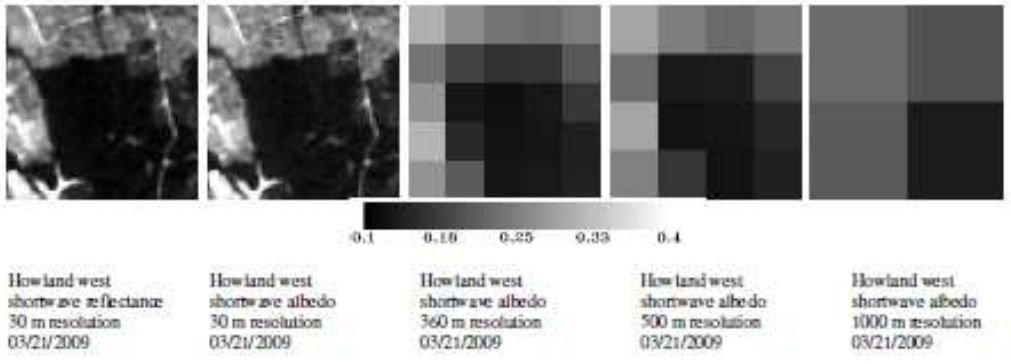


Spatially Representative sites:

Site01	AU-Tum
Site02	AU-Wac
Site03	BR-Cax
Site04	BW-Ghg
Site06	BW-Ma1
Site07	CA-Ca1
Site11	CA-SF3
Site17	DE-Tha
Site29	IT-SRo
Site31	KR-Kw1
Site33	NL-Lan
Site37	SE-Nor
Site45	BR-Sa3
Site48	US-Fmf
Site50	US-Fuf
Site51	US-MMS
Site52	US-MOz

Non representative sites:

Site08	CA-Ca3
Site12	CA-WP1
Site16	DE-Kli
Site21	FR-Fon
Site25	HU-Bug
Site25	HU-Bug
Site34	NL-Loo
Site36	RU-Che
Site40	US-Bn1
Site41	US-IB1
Site43	US-SRM



The rest of the 53 Fluxnet sites fall somewhere in between
Candidates for scaling up exercises (Landsat derived albedo)