

MODIS BRDF/ALBEDO PRODUCTS

Crystal B. SCHAAF, Alan H. STRAHLER, Feng GAO, Wolfgang LUCHT, Yufang JIN,
Xiaowen LI, Xiaoyang ZHANG, Elena TSVETSINSKAYA, Jan-Peter MULLER,
Michael BARNSELY, Philip LEWIS, Gareth ROBERTS, Christopher DOLL,
Shunlin LIANG, David ROY, and Jeffrey PRIVETTE

*Center for Remote Sensing, Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA
Tel. +617-358-0503, Fax +617-353-3200, e-mail:schaaf@bu.edu.*

*Potsdam-Institut für Klimafolgenforschung, Postfach 601203, D-14412 Potsdam, Germany
Research Center for Remote Sensing, Beijing Normal University, Beijing, China*

Dept. of Geomatic Engineering, University College London, Gower St., London, WC1E 6BT, UK

Department of Geography, University College London, Gower St., London, WC1E 6BT, UK

Department of Geography, University of Wales Swansea, Singleton Park, Swansea, SA2 8PP, UK

Department of Geography, University of Maryland, College Park, MD 20742, USA

NASA/Goddard Space Flight Center, Code 923, Greenbelt, MD 20771, USA



MODIS BRDF/ALBEDO PRODUCT

The MODIS BRDF/Albedo Product uses multitemporal, multispectral, cloud-cleared, atmospherically-corrected MODIS surface reflectances and a BRDF model to provide global measures of albedo, nadir surface reflectance and surface anisotropy every 16 days at a 1km gridded spatial resolution.

1. BRDF model parameters describe the anisotropy of the surface.

Albedo and surface reflectance measures can be computed at any desired view and illumination geometry.

2. Bihemispherical albedo (white-sky) and directional hemispherical albedo (black-sky) at local solar noon are computed.

Actual albedos can be estimated by interpolating the diffuse and direct beam albedos as a function of diffuse skylight.

3. Nadir BRDF-adjusted Reflectances (NBAR) at mean overpass.

Surface reflectances corrected to a common nadir viewing geometry.

MODIS BRDF/ALBEDO PRODUCT

The primary BRDF retrieval algorithm is bolstered by a robust back-up algorithm.

1. The full model inversion is used when sufficient high quality MODIS observations are available to sample the BRDF.
2. The lower quality magnitude inversion couples *a priori* knowledge of the surface anisotropy with any MODIS observations that are available.
3. Extensive Quality Assurance Flags are supplied with the product indicating both the quality of the product and the processing method used.

MOD43B MODIS BRDF/ALBEDO PRODUCT

Products at 1km

- MOD43B1: MODIS/Terra BRDF/Albedo Model-1 16-Day L3 Global 1km ISIN Grid
- MOD43B3: MODIS/Terra Albedo 16-Day L3 Global 1km ISIN Grid
- MOD43B4: MODIS/Terra Nadir BRDF-Adjusted Reflectance 16-Day L3 Global 1km ISIN Grid (NBAR)

Products at 5km

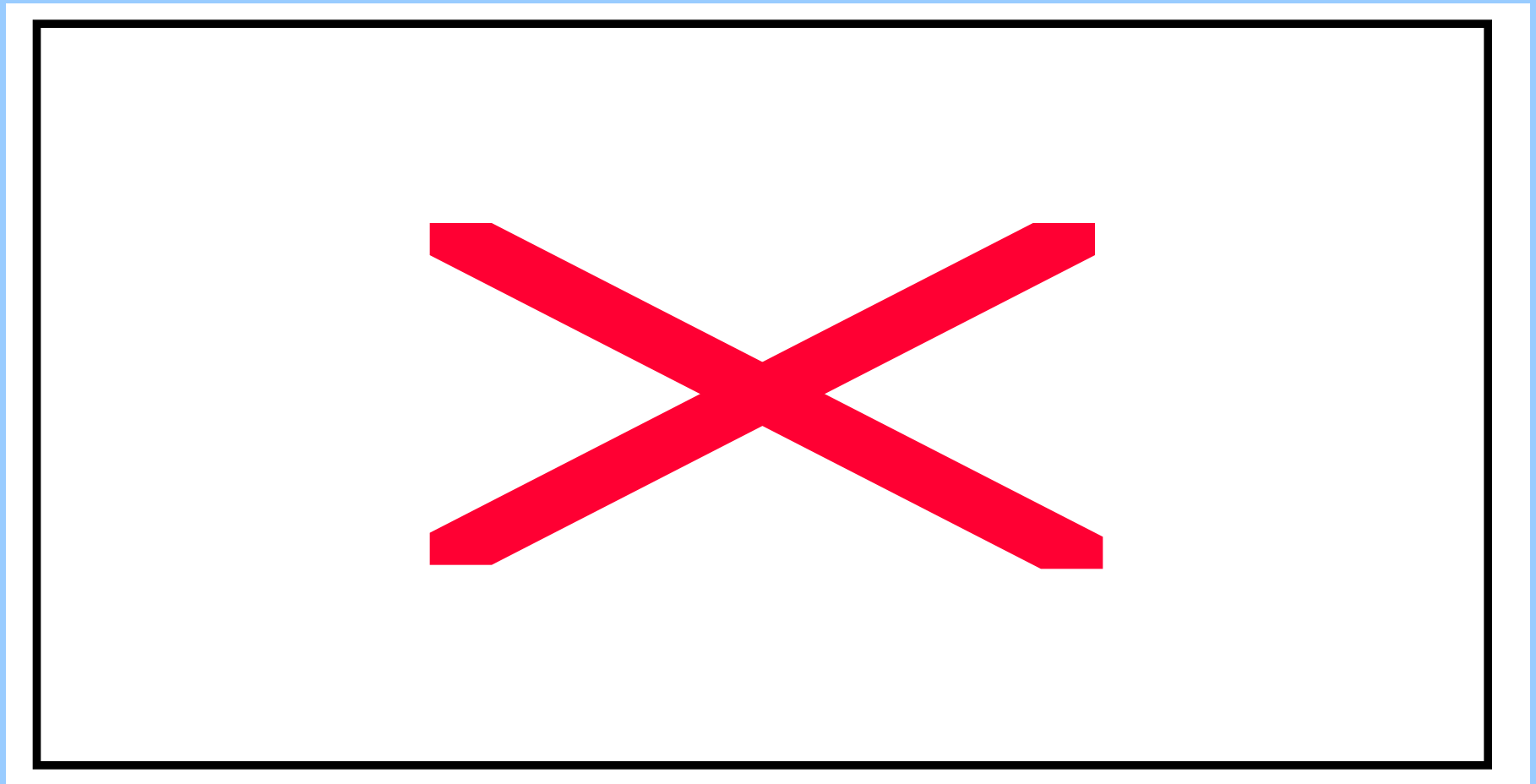
- MOD43B1C: MODIS/Terra BRDF/Albedo Model-1 16-Day L3 Global 5km ISIN Grid
- MOD43B3C: MODIS/Terra Albedo 16-Day L3 Global 5km ISIN Grid
- MOD43B4C: MODIS/Terra Nadir BRDF-Adjusted Reflectance 16-Day L3 Global 5km ISIN Grid

Products at 0.25 degree

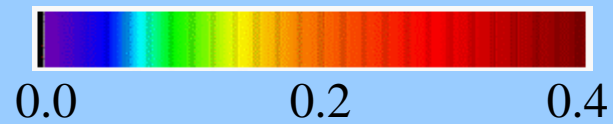
- MOD43C1: MODIS/Terra Albedo 16-Day L3 Global 0.25Deg CMG
- MOD43C2: MODIS/Terra BRDF/Albedo Parameters 16-Day L3 Global 0.25Deg CMG

Gao et al., Global Coarse Resolution Albedo from MODIS BRDF/Albedo Product for Climate Models (CMG), submitted Geophys. Res. Lett., 2002.

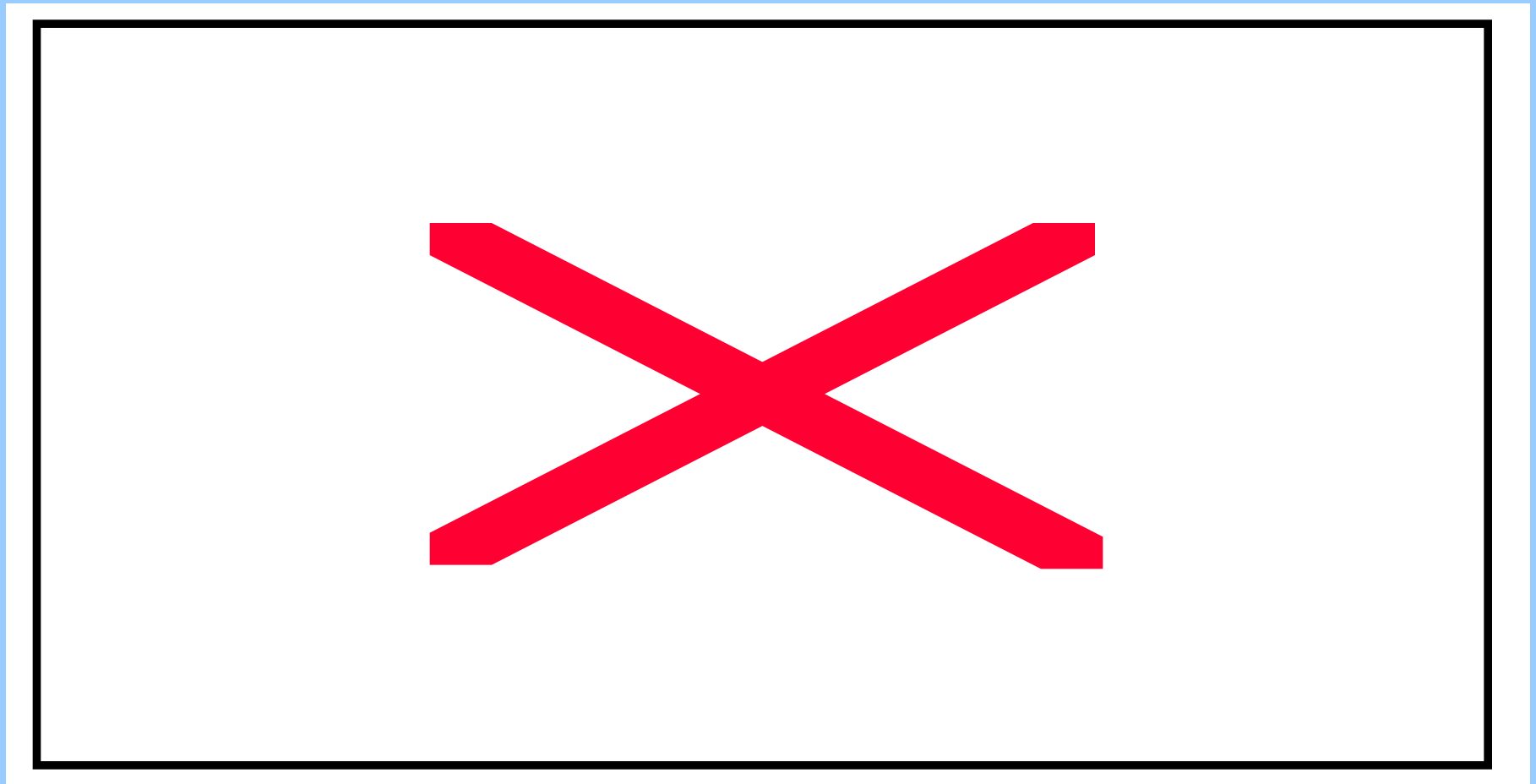
CMG Broadband White-Sky Albedo (0.3-5.0 μ m)
6 - 21 March, 2001



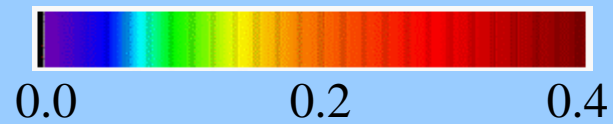

No Data



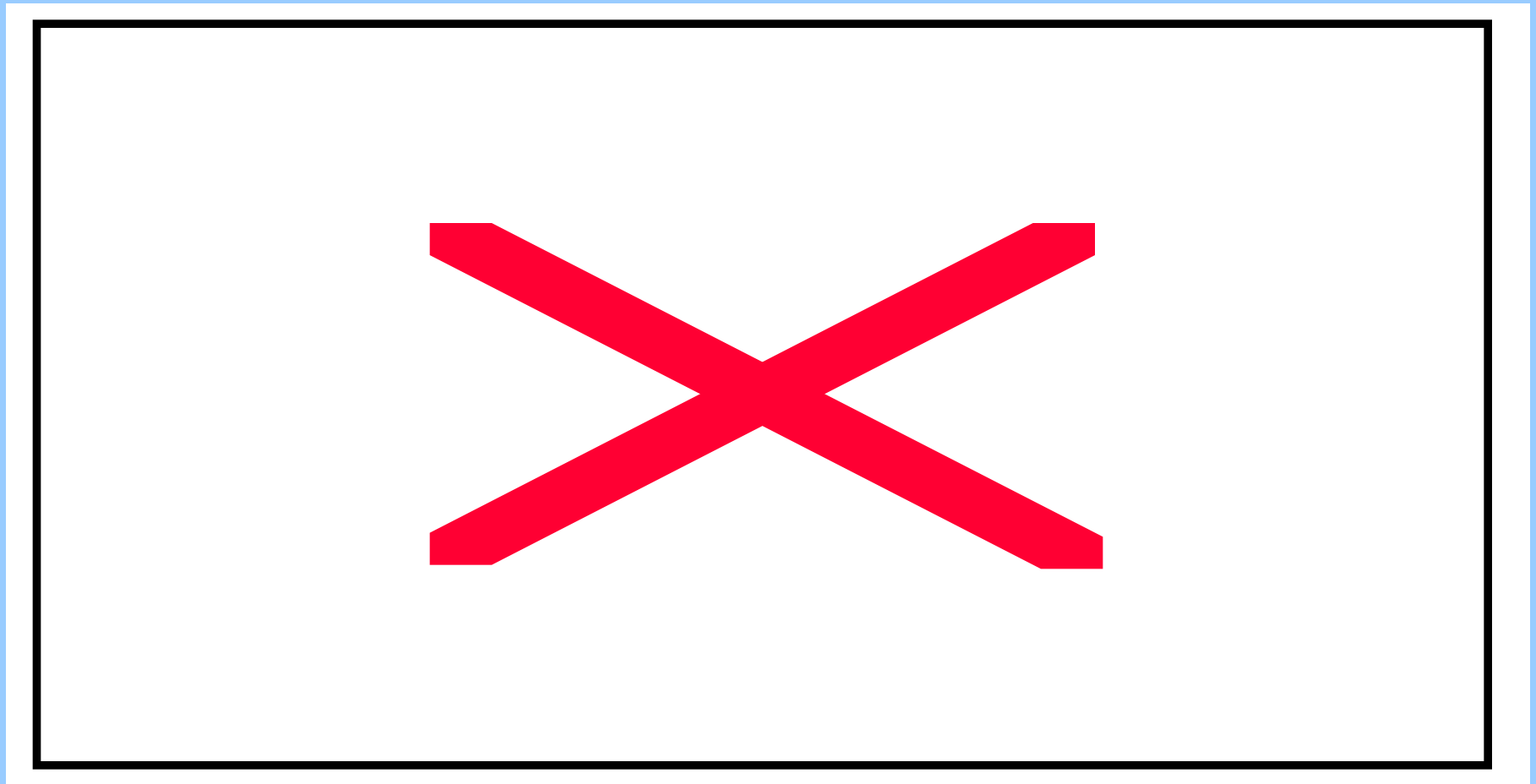
CMG Broadband White-Sky Albedo (0.3-5.0 μ m)
9 - 24 May, 2001



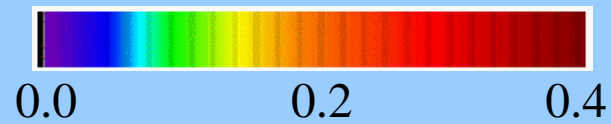

No Data



CMG Broadband White-Sky Albedo (0.3-5.0 μ m)
14 - 29 September, 2001




No Data



MOD43B MODIS BRDF/ALBEDO PRODUCT

AQUA code (actually AQUA + TERRA code) is delivered and baselined:

Gridded surface reflectances from both the TERRA MODIS sensor and the AQUA MODIS sensor are used to retrieve the 16-day BRDF parameters and compute albedos at local solar noon.

NBARs at both the TERRA overpass time and the AQUA overpass time are computed.

The TERRA only version and the TERRA+AQUA version will run in parallel during the shakeout period.

MODIS + MISR code has also been successfully proto-typed on several regional case studies.

STATUS of the MOD43B MODIS BRDF/ALBEDO PRODUCT

The MOD43B 1km products:

Operational production began in April 2000.

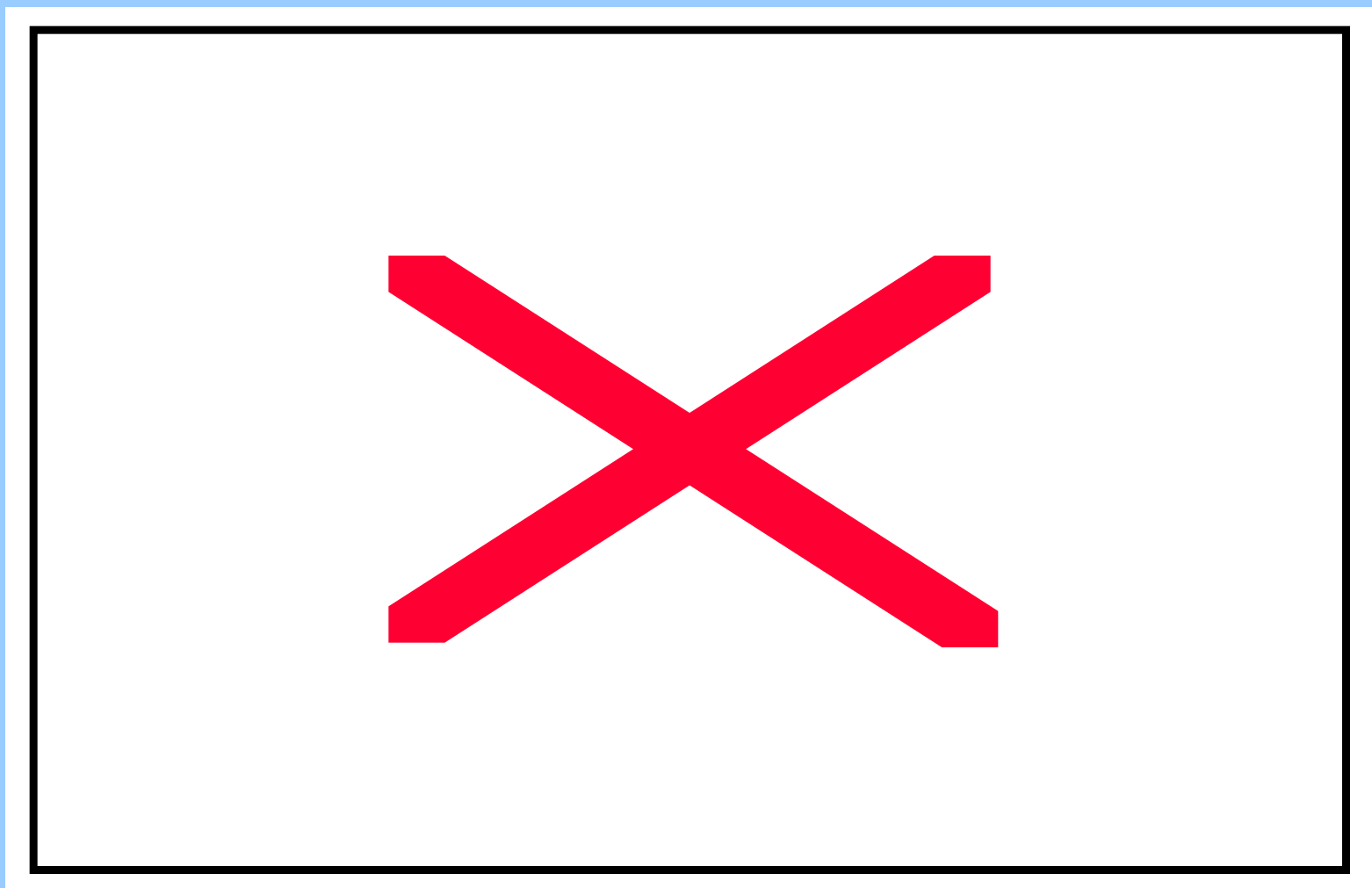
Beta Products were released in July 2000.

Provisional Products were released in November 2000.

The MOD43C CMG \pm degree Products are just entering production (July 2001 onward).

Currently awaiting evaluation of the reprocessed data for final characterization of the product variability and for final comparisons with field data before assigning product quality assessments and releasing the data as Validated Products.

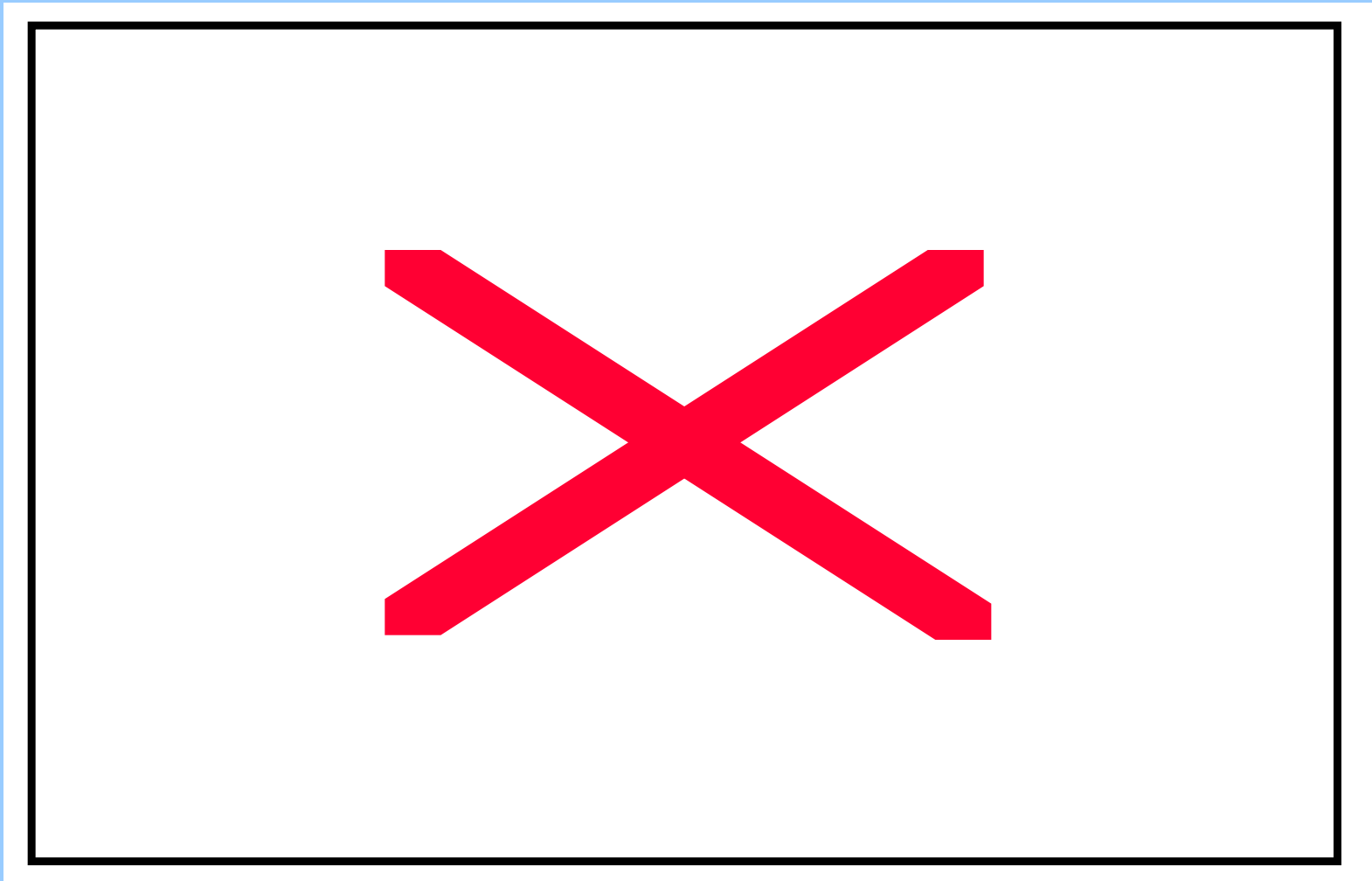
North American Nadir BRDF-Adjusted Reflectance (NBAR)
31 October - 15 November, 2000




No Data

NIR (0.1-0.4) Red (0.0-0.16) Green (0.0-0.18)

North American Nadir BRDF-Adjusted Reflectance (NBAR)
31 October - 15 November, 2000
Reprocessed




No Data

NIR (0.1-0.4) Red (0.0-0.16) Green (0.0-0.18)

MOD43B MODIS BRDF/ALBEDO PRODUCT EVALUATION

The Team Evaluation is focused on:

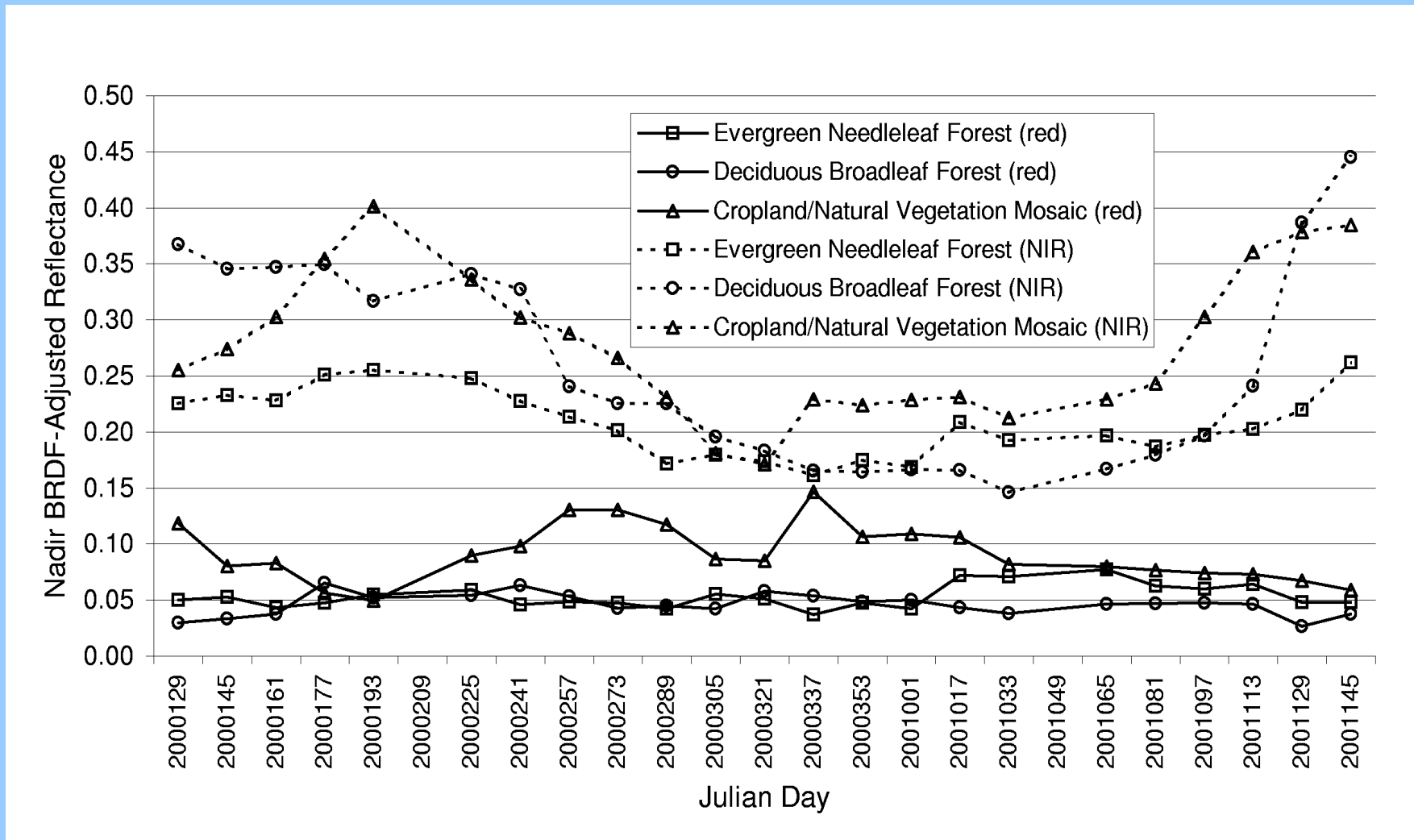
MOD43B Quality Assurance Flags.

Variability of products by cover type.

Temporal stability and consistency of products.

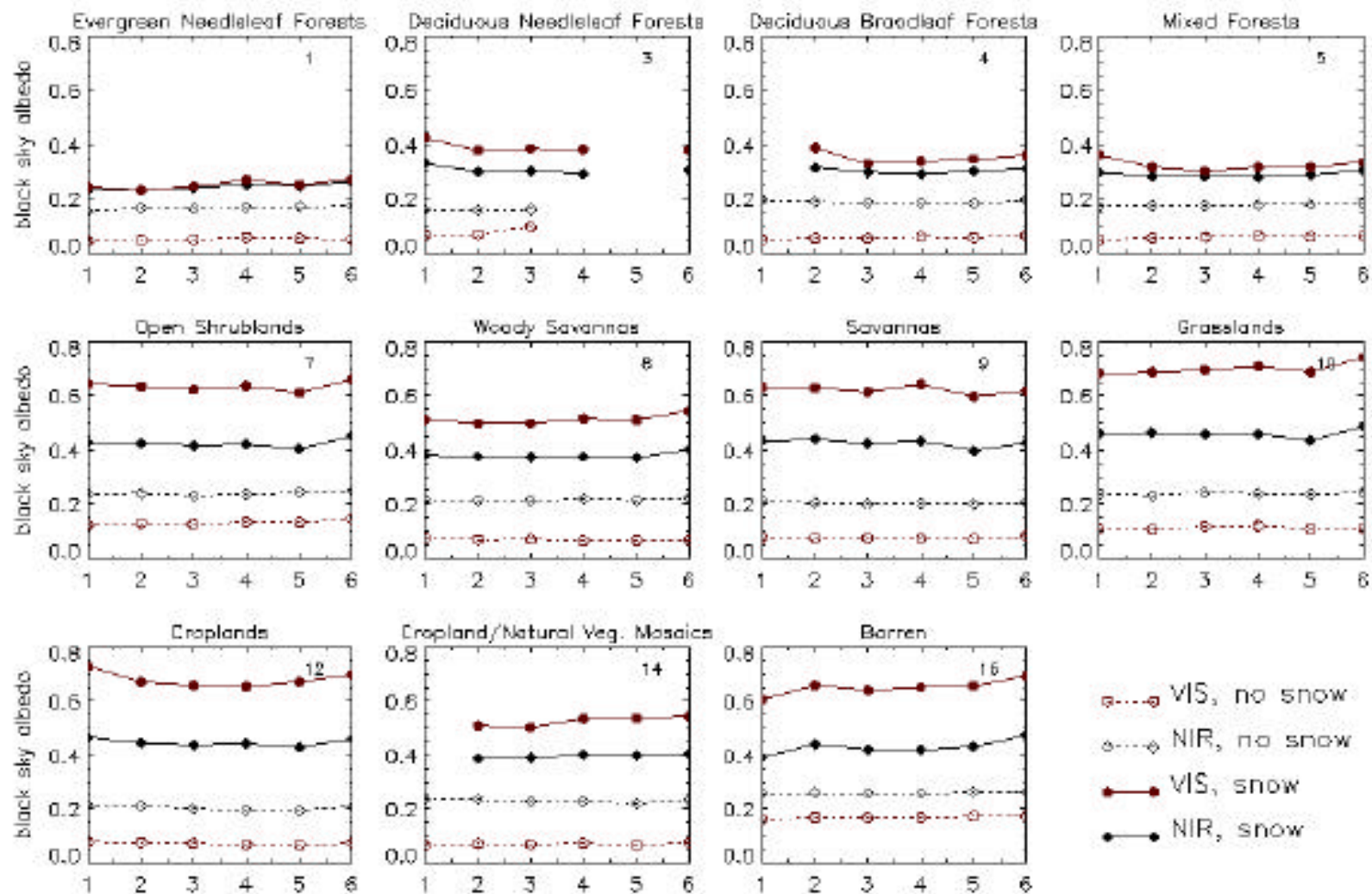
Predictive capability of BRDF parameters.

NBAR from Land Cover Training Sites in the Southern US



Schaaf et al., First Operational BRDF, Albedo and Nadir Reflectance Product from MODIS, in press, Remote Sensing Environ., 2002

Snow versus Non-snow Albedos 40-50°N Nov00-Jan01



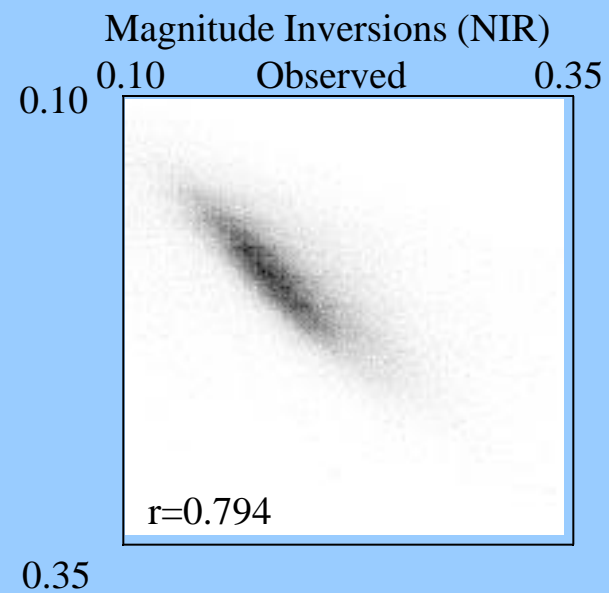
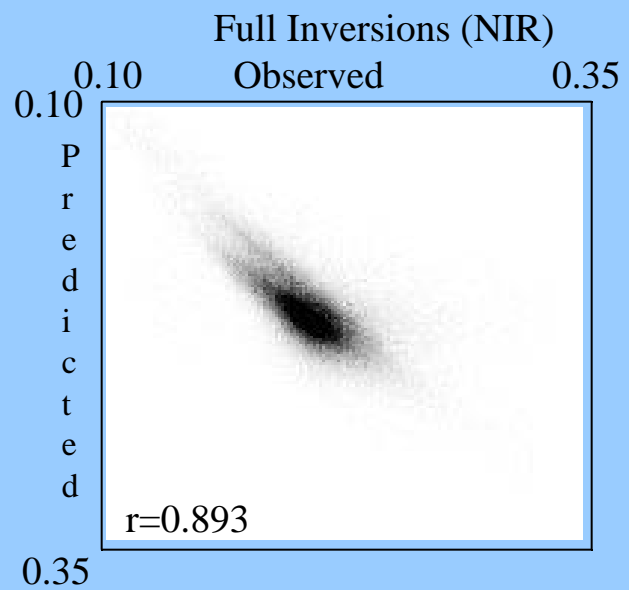
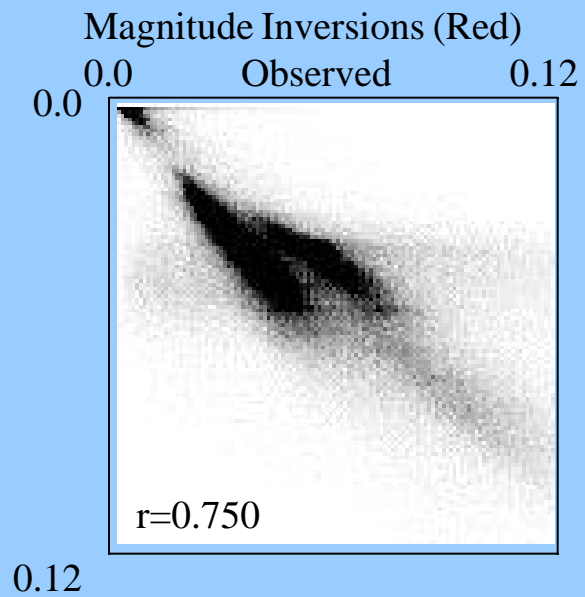
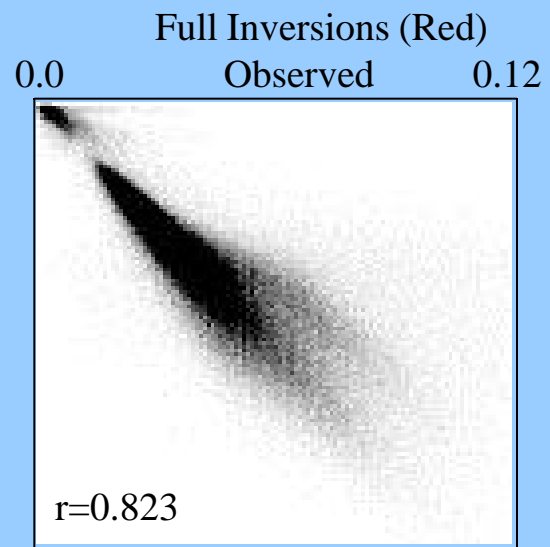
Jin et al., How does Snow Impact the Albedo of Vegetated Land Surfaces as Analyzed with MODIS Data?, in press, Geophys. Res. Lett., 2002

Using BRDF Parameters to Predict Future Surface Reflectances

Observed 1km Surface Reflectances
20 November, 2000 (Day 325)

Predicted 1km Surface Reflectances
for 20 November, 2000, using BRDF
Parameters from 31 Oct - 15 Nov, 2000

NIR (0.1-0.35) Red (0-0.12) Green (0-0.12)



MOD43B MODIS BRDF/ALBEDO PRODUCT VALIDATION

BARC Field Campaigns -- S. Liang (UMD)

SAVE/SAFARI Field Campaigns -- J. Privette (GSFC)

Barton Bendish Field Campaigns -- M. Barnsley (UWales, Swansea)

China Field Campaigns -- X. Li (BU & Beijing Normal U.)

SURFRAD Comparison -- Y. Jin (BU)

BARC Validation Efforts

Albedometer measurements from a 10m tower and sun photometer measurements are routinely collected at the USDA Agricultural Research Service Beltsville Agricultural Research Center (BARC) in Beltsville, Maryland, USA.

A number of ground campaigns (ASD, LAI, leaf optics) have been completed.

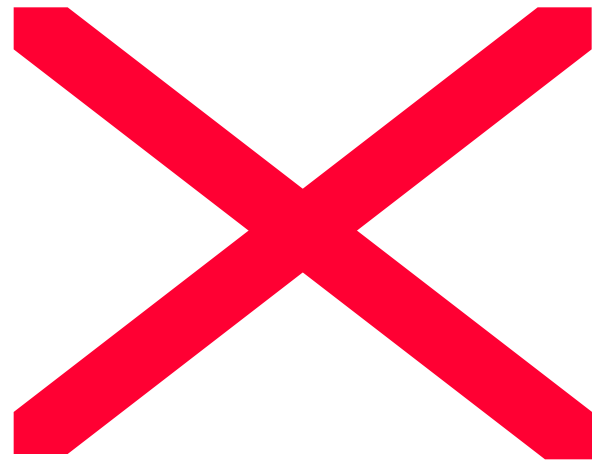


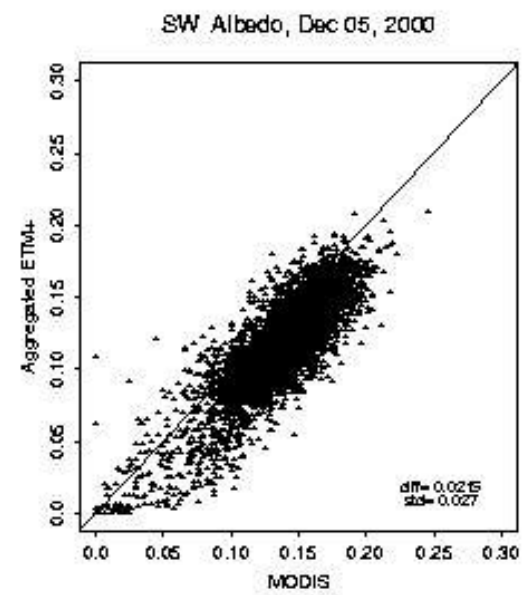
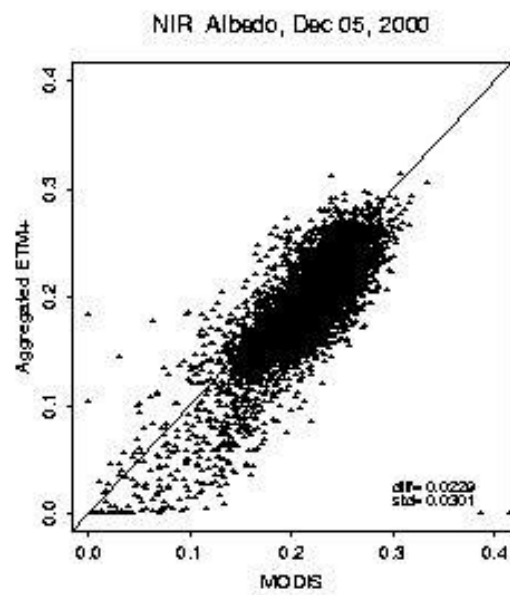
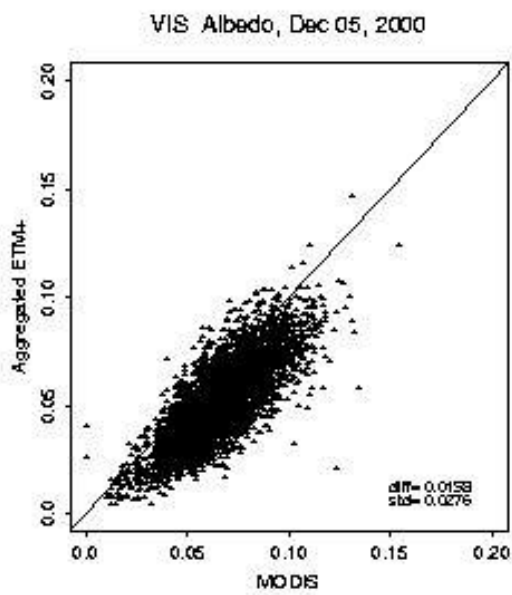
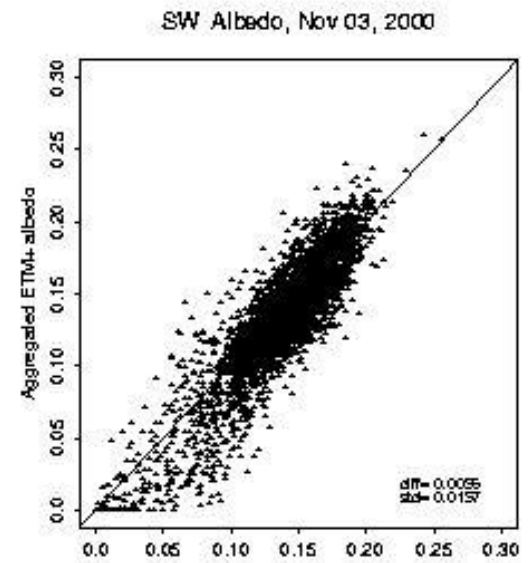
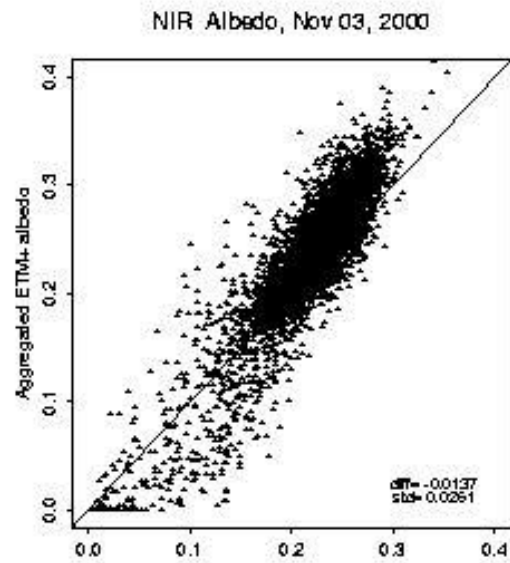
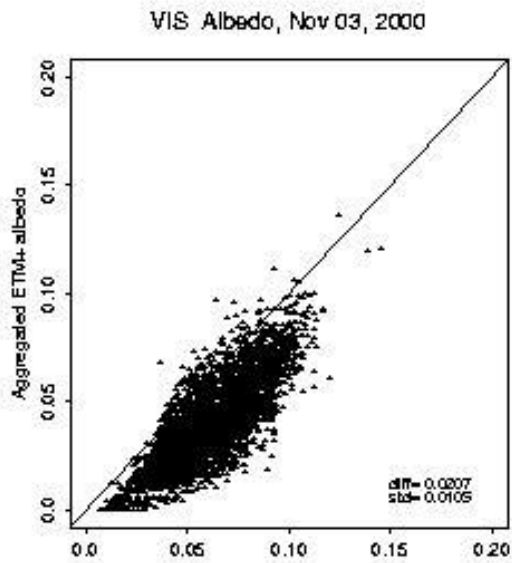
BARC Validation Efforts

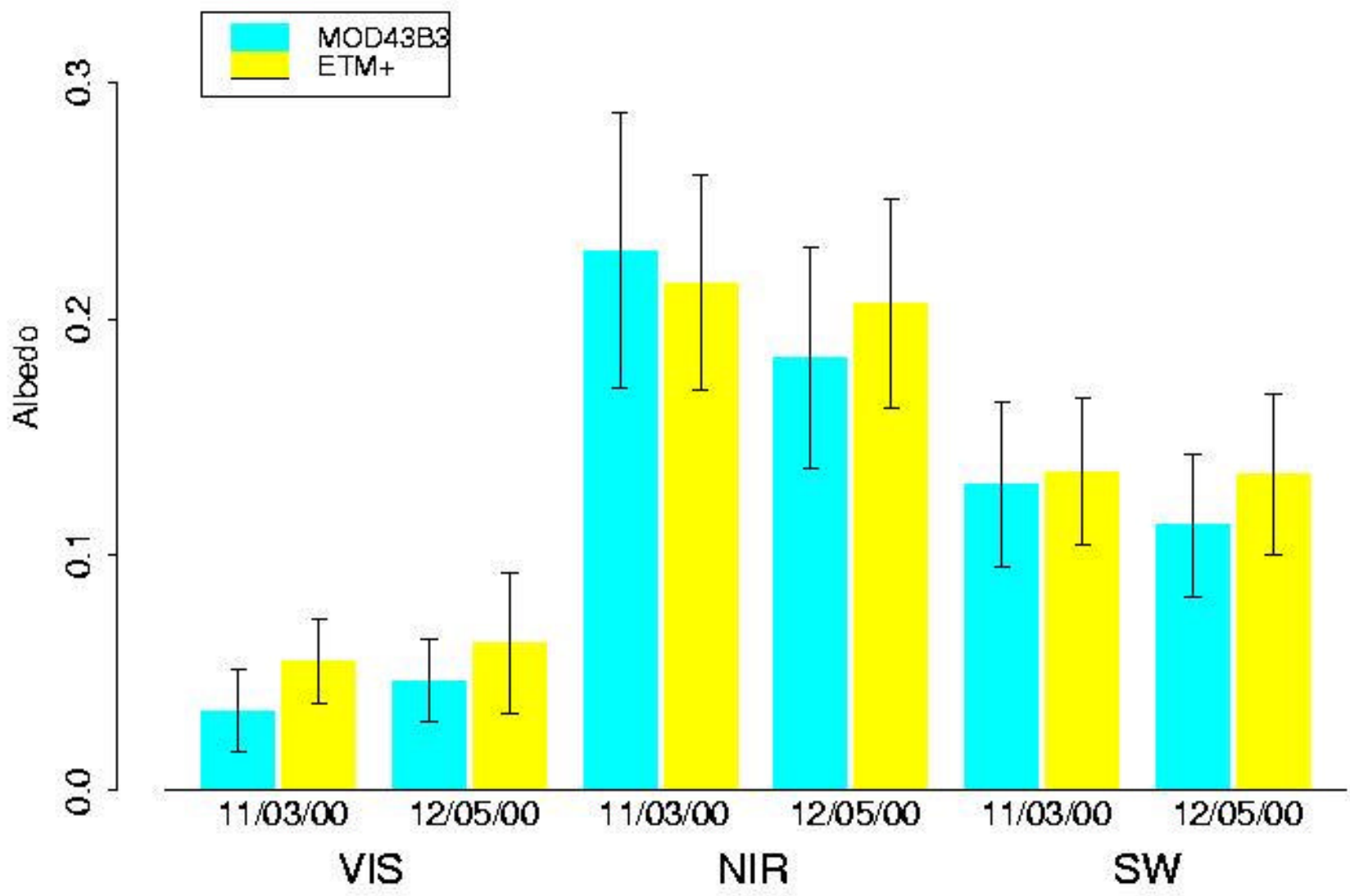
ETM+ imagery is used to scale Ground and Tower measurements up to MODIS spatial resolutions.

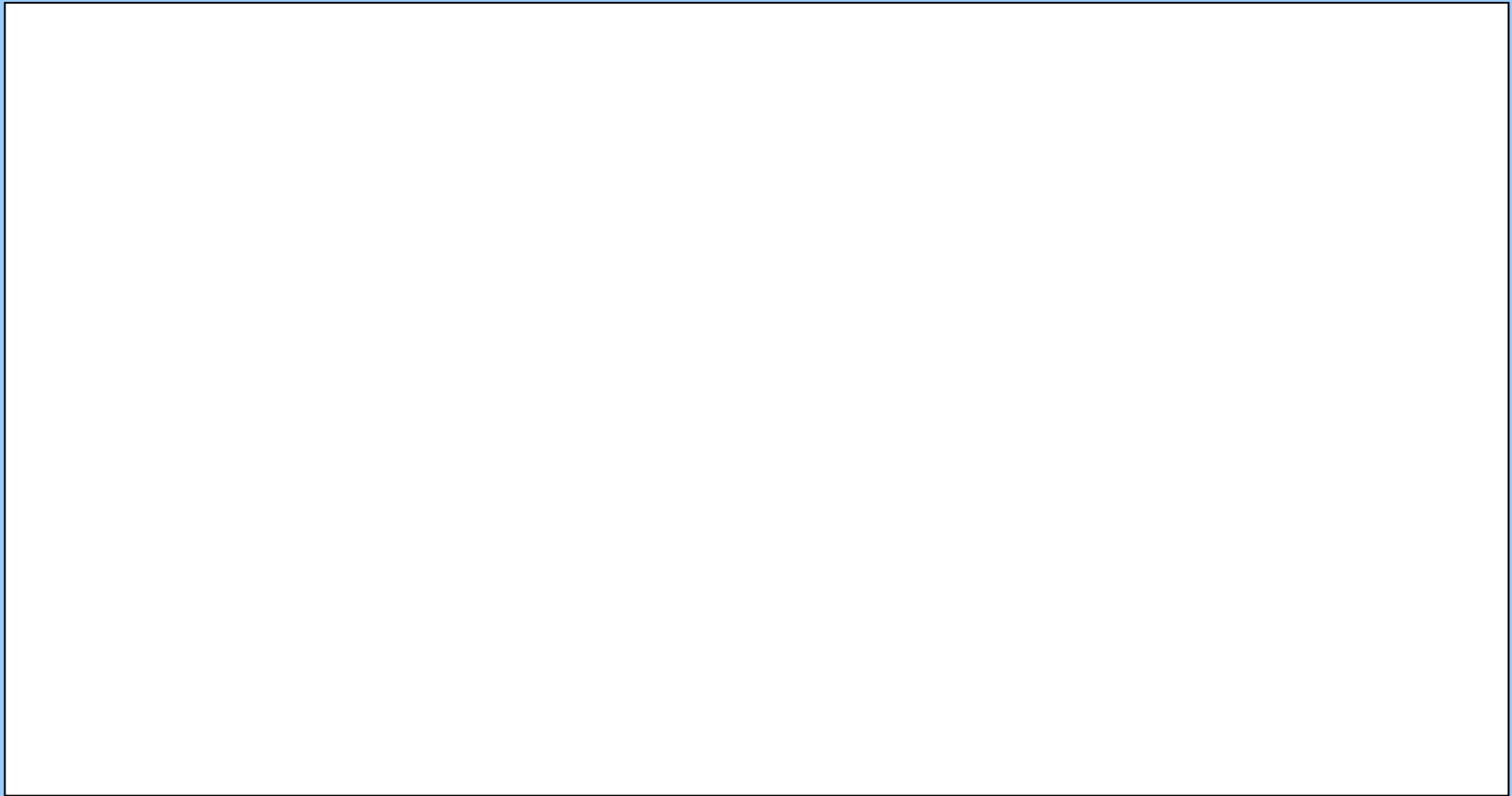
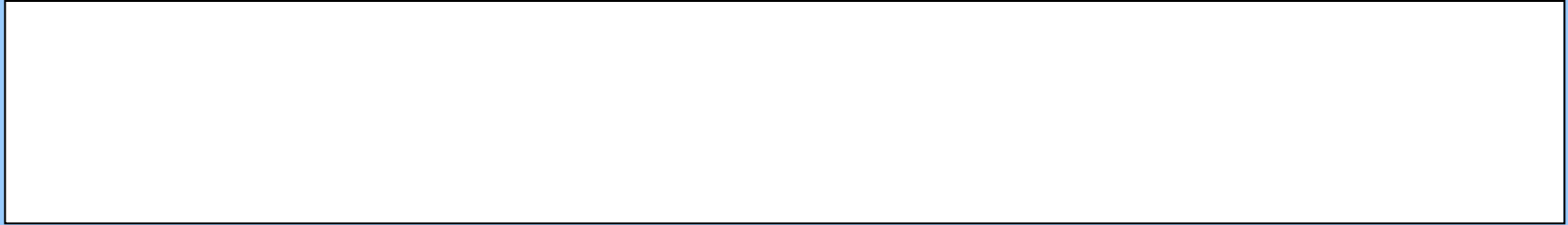
Initial validation results from November and December 2000 show that these products are quite accurate with less than a 5% error.

Liang et al., Validating MODIS Land Surface Reflectance and Albedo Products: Methods and Preliminary Results, in press, Remote Sensing Environ., 2002.









South African Validation of EOS (SAVE)

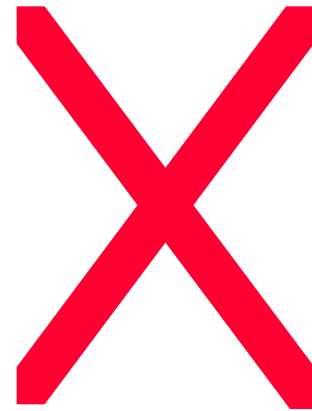
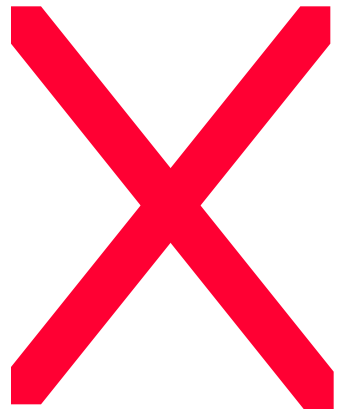
Tower data are being collected at the Mongu, Zambia woodland site and the Skukuza, South Africa savanna site.

Ground measurements were collected during the SAFARI IFCs.

Comparisons with MODIS Surface Reflectance and Albedo Products are currently underway.



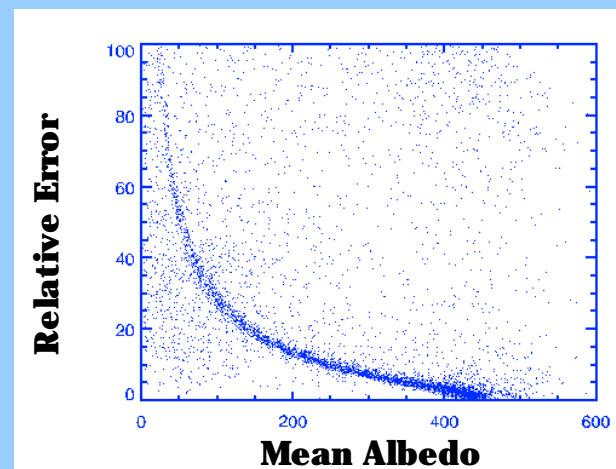
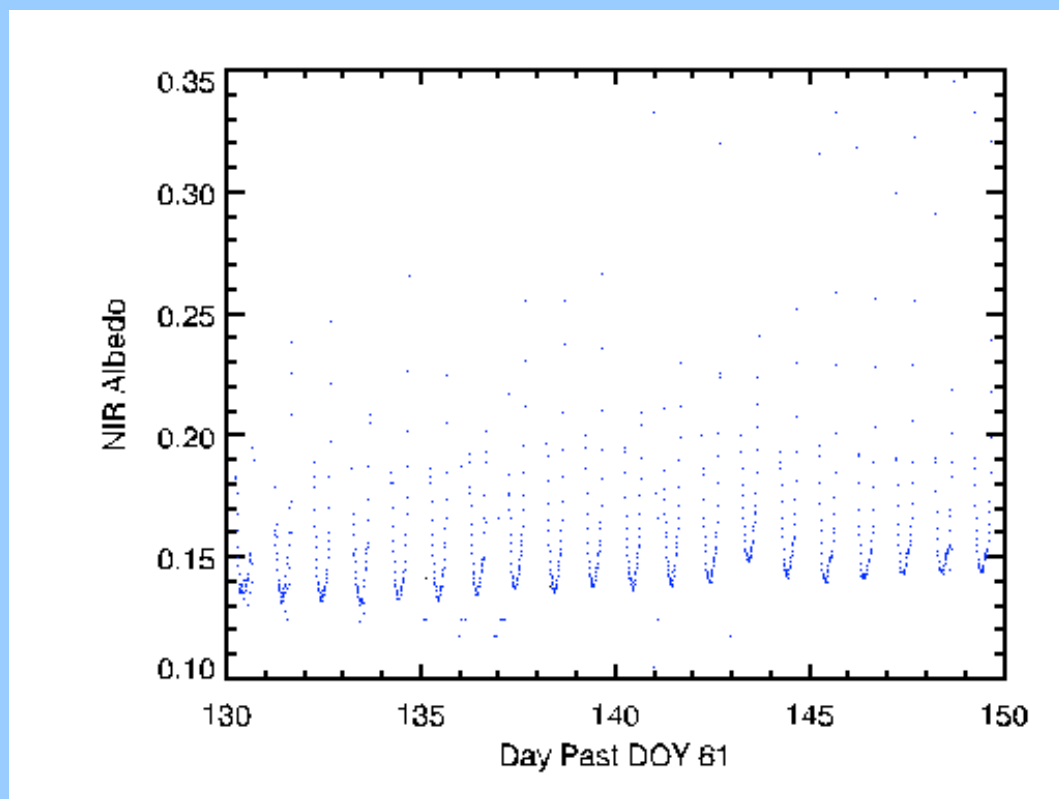
South African Validation of EOS (SAVE)



South African Validation of EOS (SAVE)

NIR Albedo from the Mongu Tower

Diurnal and Seasonal Variability



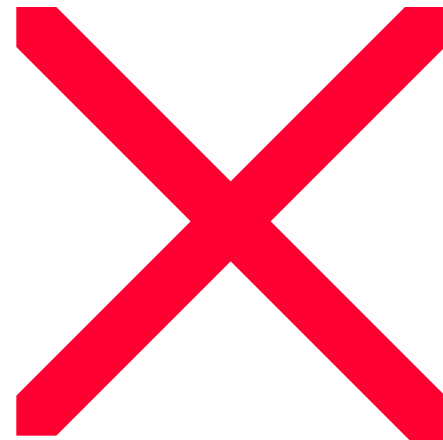
Quality Control

Time Series:
March 2000 to
present

Barton Bendish Field Validation Efforts

LAI and albedo data were collected at the agricultural site at Barton Bendish, East Anglia, UK during the 2000 and 2001 growing seasons.

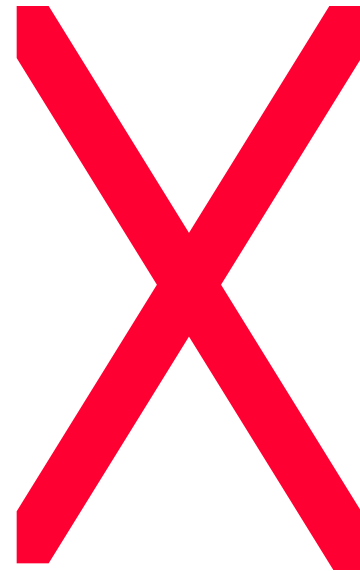
ETM+ data are used to scale up to coarser spatial resolutions.



Barton Bendish Field Validation Efforts

BRDF Model Parameters
Composite -- derived from
SPOT-VGT data of the UK.

Reprocessed MODIS data
from summer 2001 has just
become available for
validation effort.



Barton Bendish Field Validation Efforts

Additional hyperspectral imagery of Barton Bendish and other EOS core validation sites is being obtained from the Compact High Resolution Imaging Spectrometer (CHRIS) launched on the Project for On Board Autonomy (PROBA) in Oct 2001.

Field Campaign for Quantitative Remote Sensing in Beijing (2001)

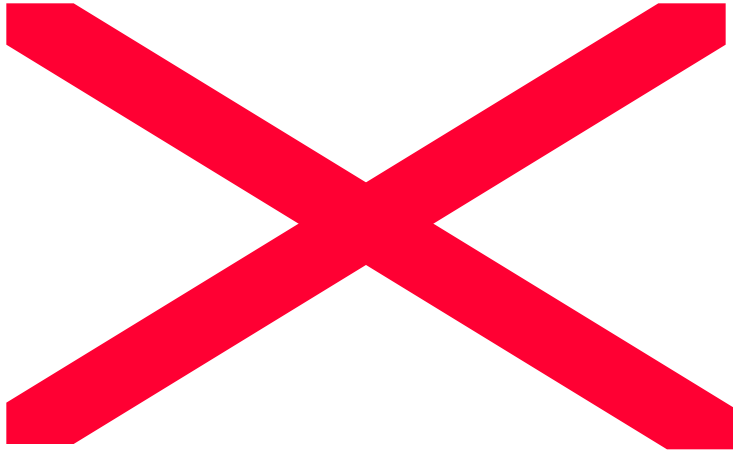
Institute of Remote Sensing
Application (Chinese
Academy of Sciences) and
Beijing Normal University.



Agricultural field sites in
Shunyi, Yucheng, and
Luncheng, China.

Extensive ground
measurements, some
airborne data and various
satellite imagery have been
collected since October,
2000.

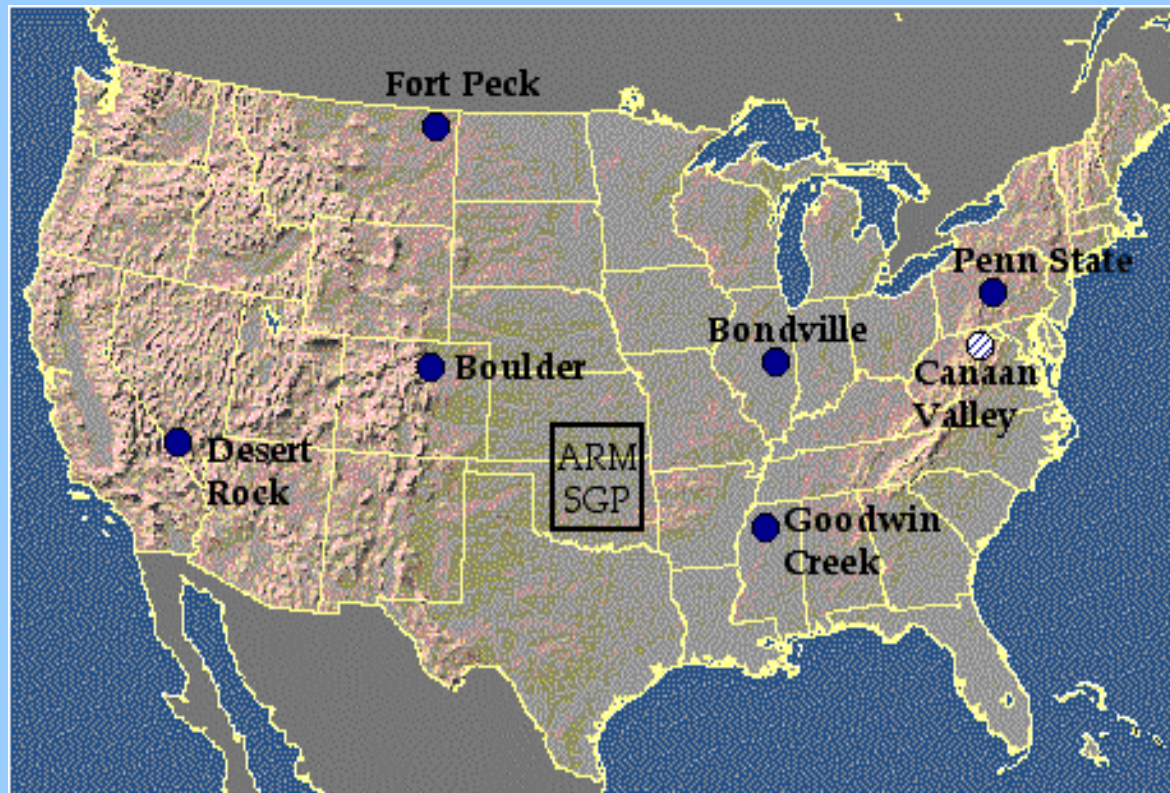
Field Validation Efforts in China



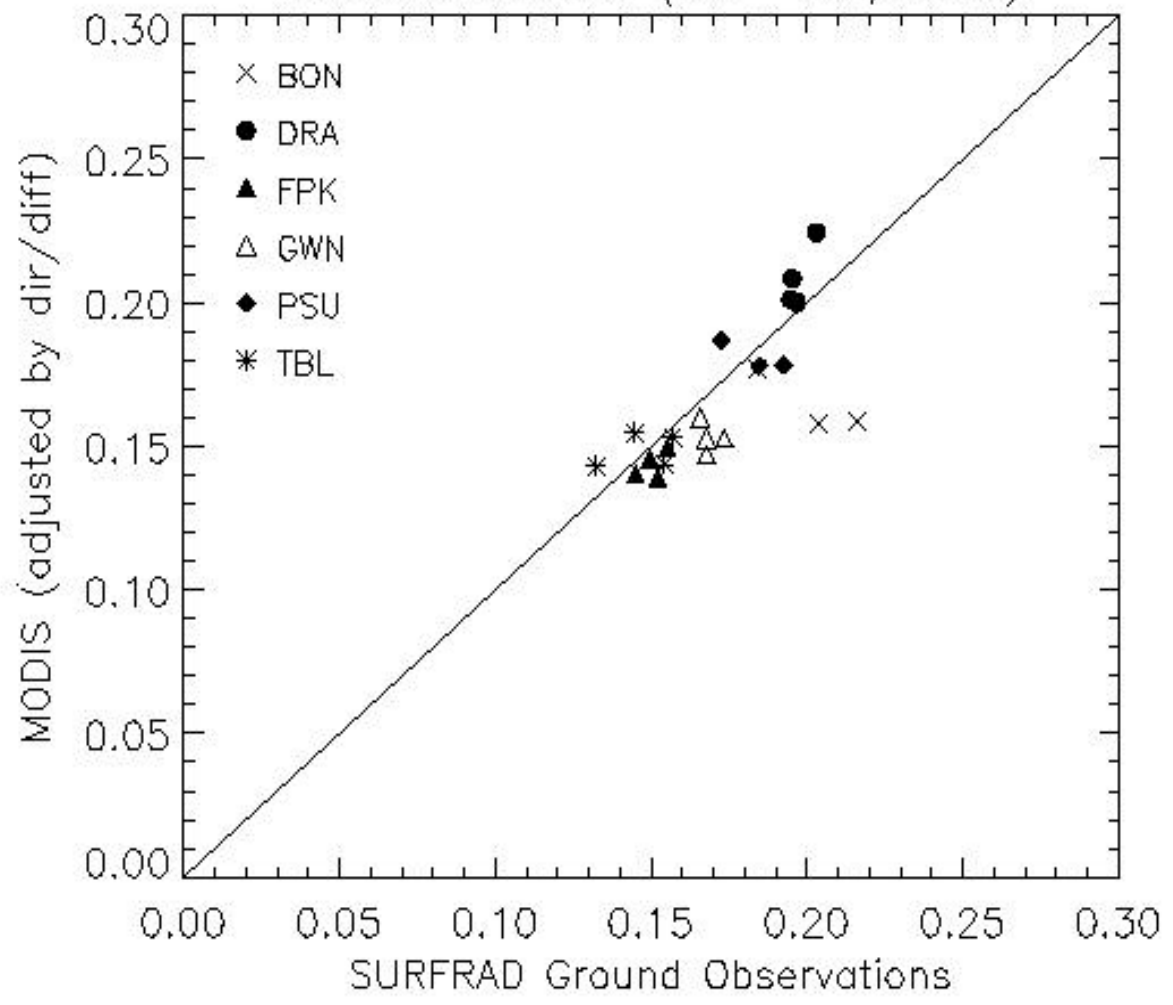
Surface Radiation Budget Network (SURFRAD)

Six instrumented sites continuously measuring solar radiation (including PAR, direct and diffuse).

Data packaged and distributed as half hour values by the CERES/ARM Validation Experiment (CAVE).



Shortwave Albedo (097–160, 2001)



MOD43B MODIS BRDF/Albedo Product Summary

Initial evaluations indicate that the MOD43B algorithms have performed well throughout 2000 and 2001. Data (particularly the reprocessed data) appear temporally stable and consistent.

Initial validations and comparisons are very encouraging with errors of less than 10%.

Team is awaiting completion of the reprocessed data to have a relatively consistent annual cycle before finalizing validation efforts and posting error and variability estimates.

We expect to upgrade reprocessed data to “Validated” status during the first half of 2002.

MOD43B MODIS BRDF/ALBEDO PRODUCT

Provisional and Reprocessed Products (starting with the 16 day period beginning on Day 305 -- 31 October 2000) are available from EDC at <http://edcdaac.usgs.gov/main.html>

Users Guide is available at <http://geography.bu.edu/brdf/userguide/index.html>

Browse images (based on 5km resolution products) can be viewed at <http://modland.nascom.nasa.gov/browse/>

Global CMG Products on a $\frac{1}{2}$ degree resolution Geographical Grid will be available from EDC in the new year.

