

# MODIS BRDF/Albedo Product: Evaluation, Validation, and Applications

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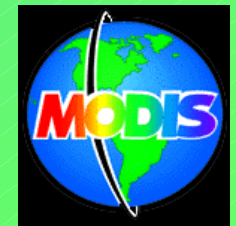
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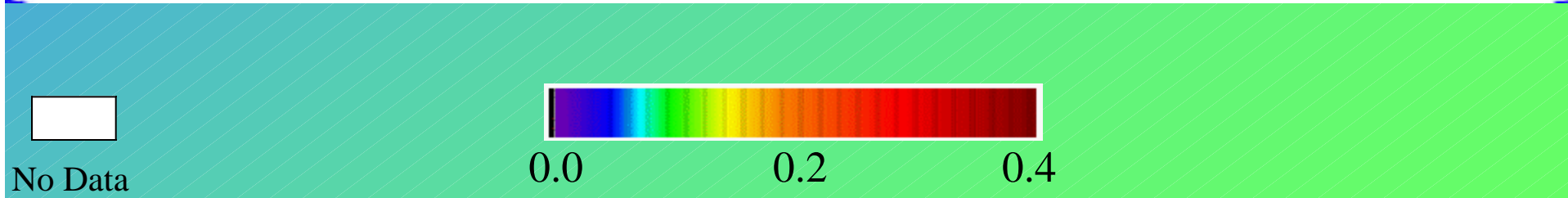
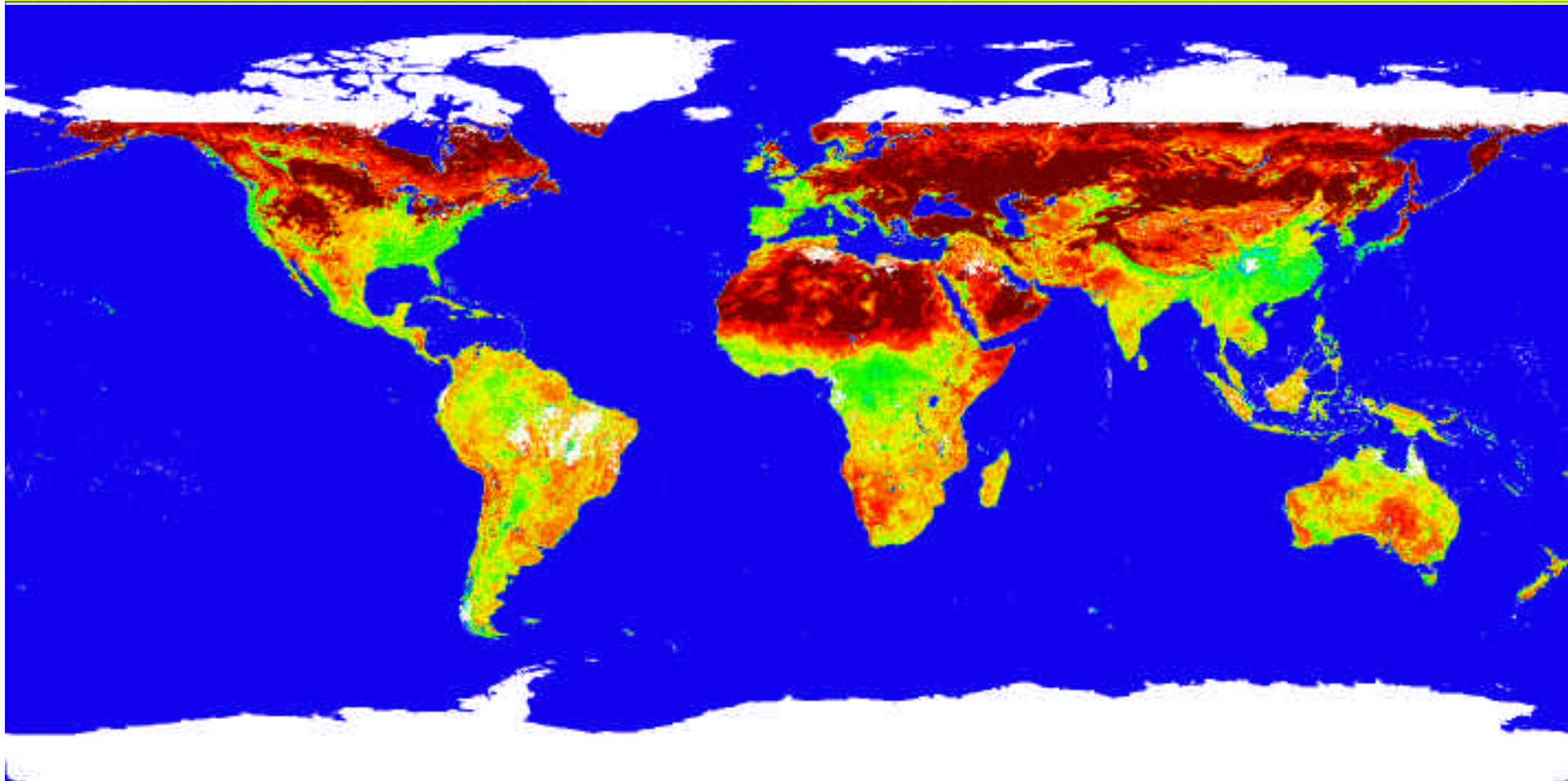


# Product Overview

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

- BRDF model parameters describe the surface anisotropy. Albedo and surface reflectance can then be computed at any desired view and illumination geometry.
- 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.
- Nadir BRDF-adjusted Reflectances (NBAR) at mean overpass solar zenith angle. Surface reflectances corrected to a common nadir viewing geometry

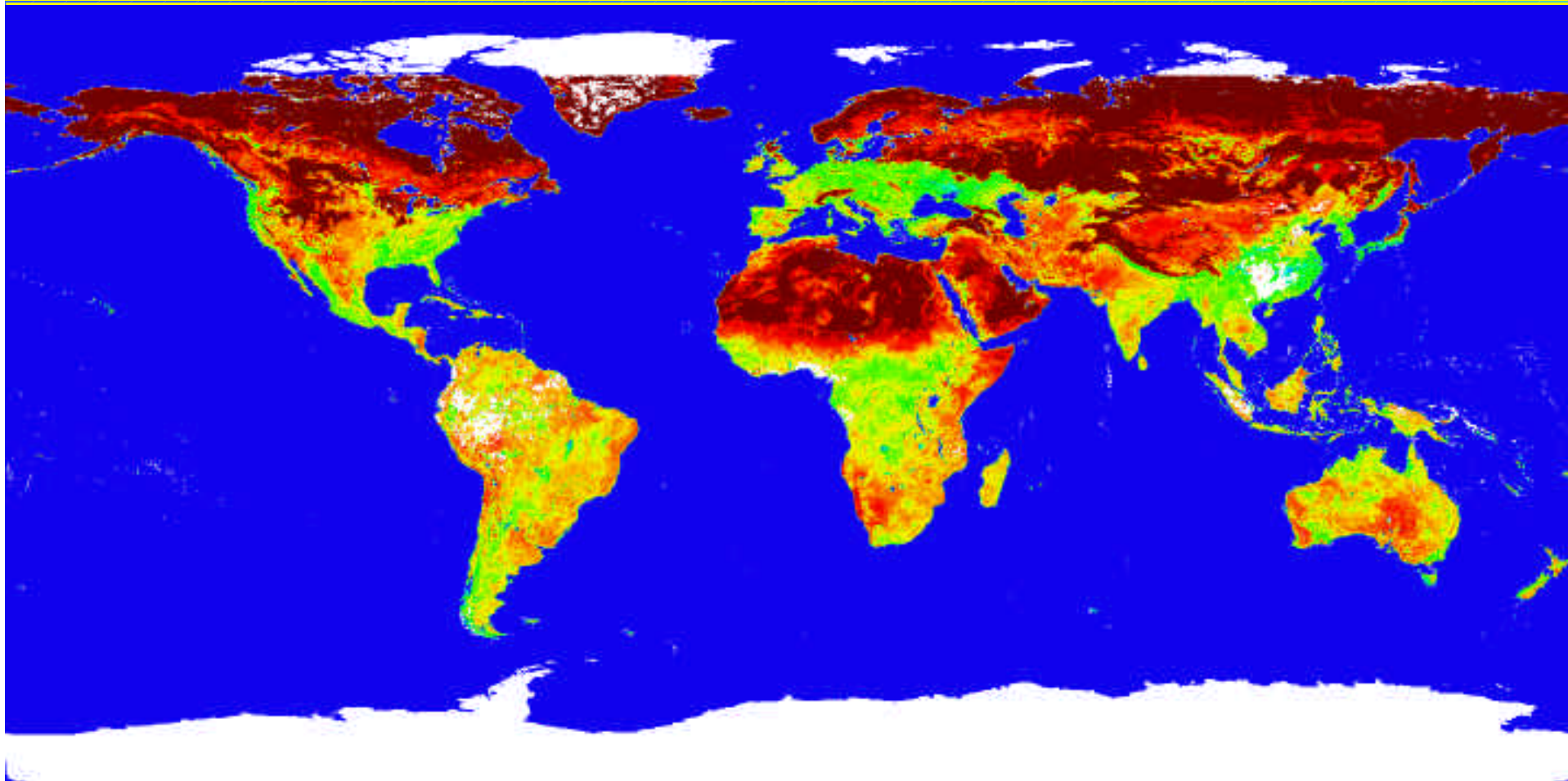
# CMG Broadband White-Sky Albedo (0.3-5.0mm) 1 - 16 January, 2002





# CMG Broadband White-Sky Albedo (0.3-5.0mm)

## 18 February - 5 March, 2002



No Data



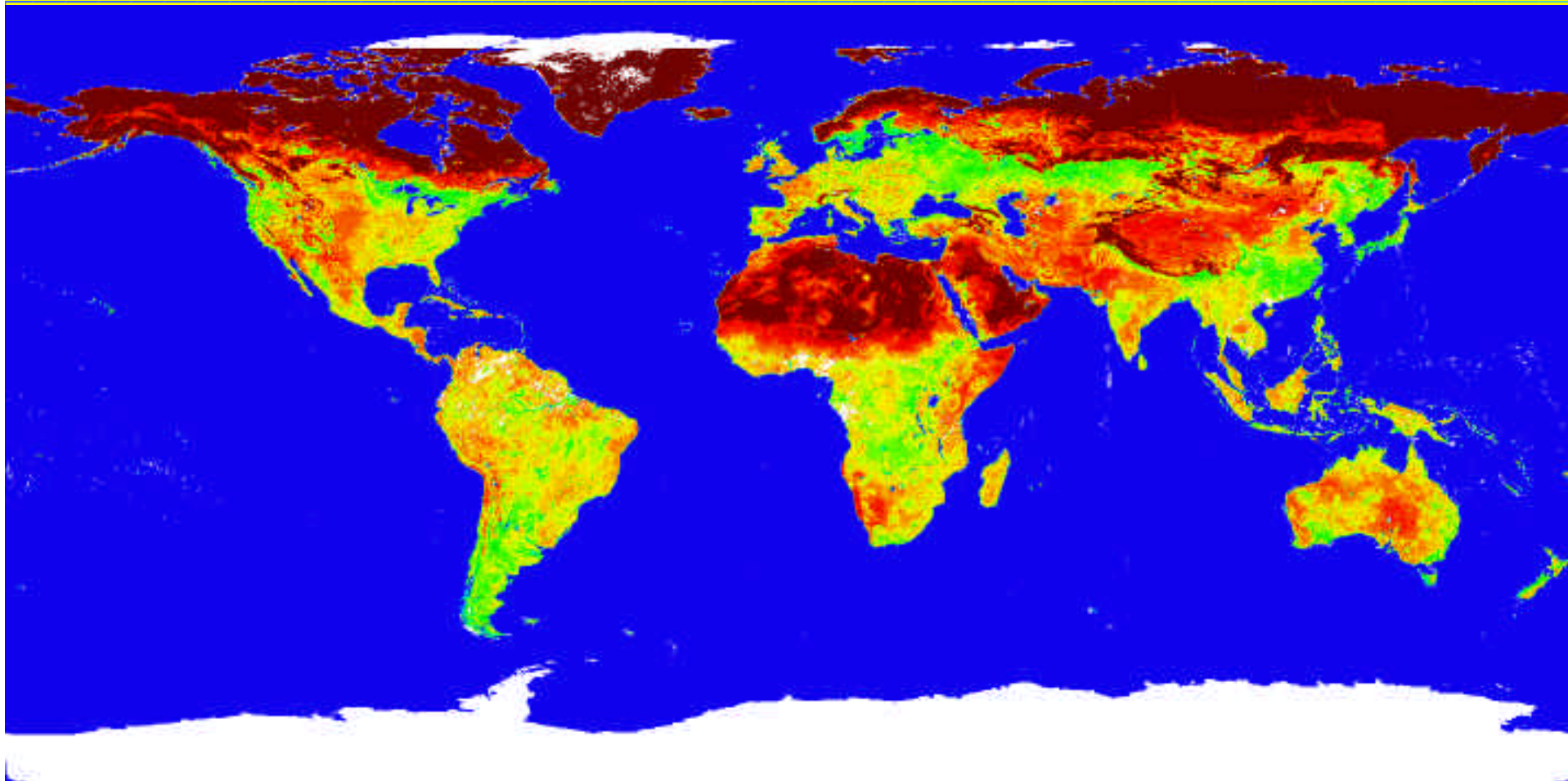
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0.2

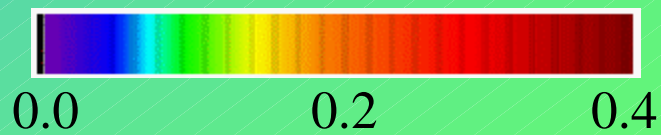
0.4

# CMG Broadband White-Sky Albedo (0.3-5.0mm)

## 7 - 22 April, 2002

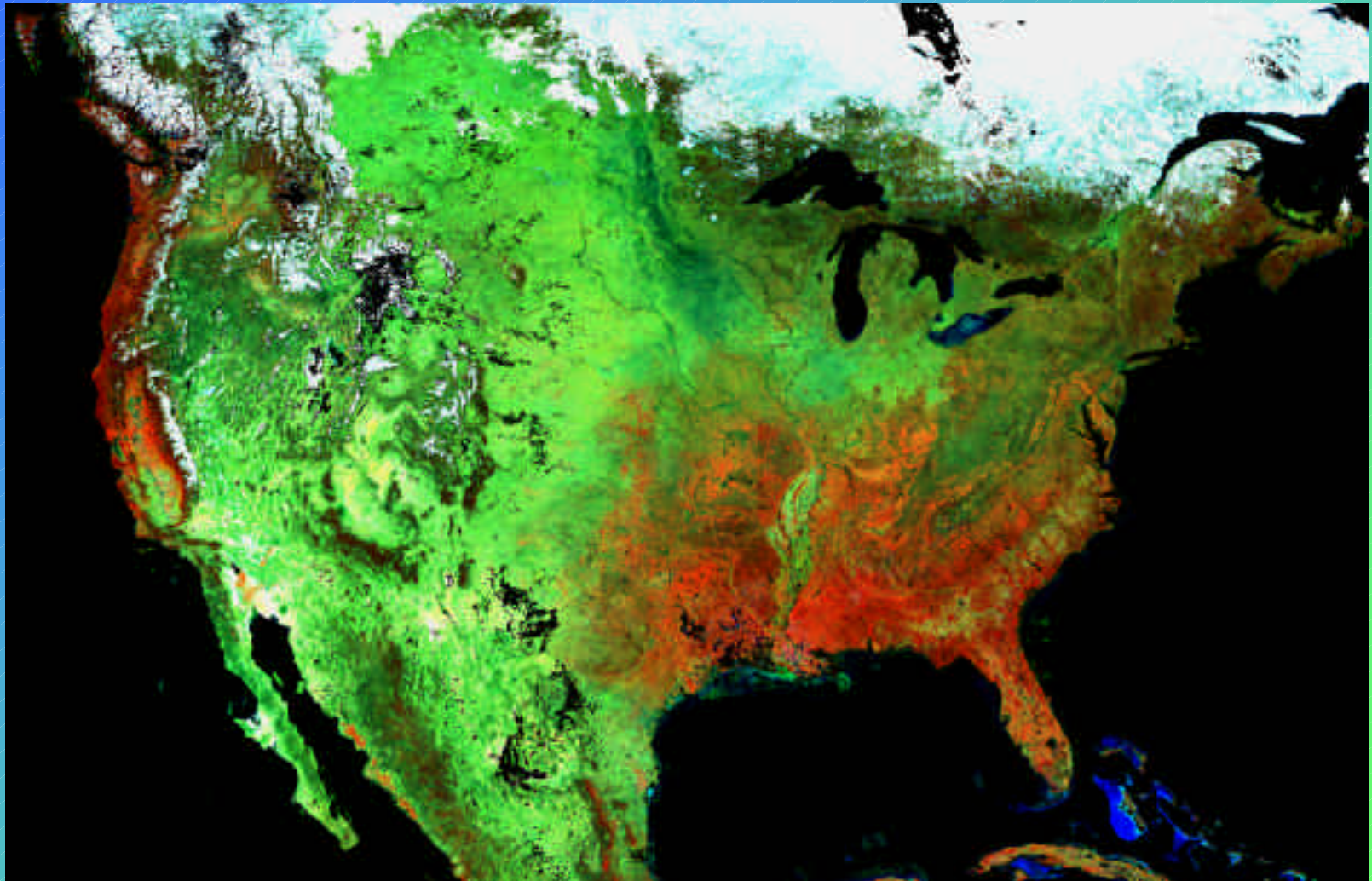


  
No Data





# White Sky Albedo 7 - 22 April, 2002



No Data

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

# Nadir BRDF-Adjusted Reflectance (NBAR)

## 7 - 22 April, 2002

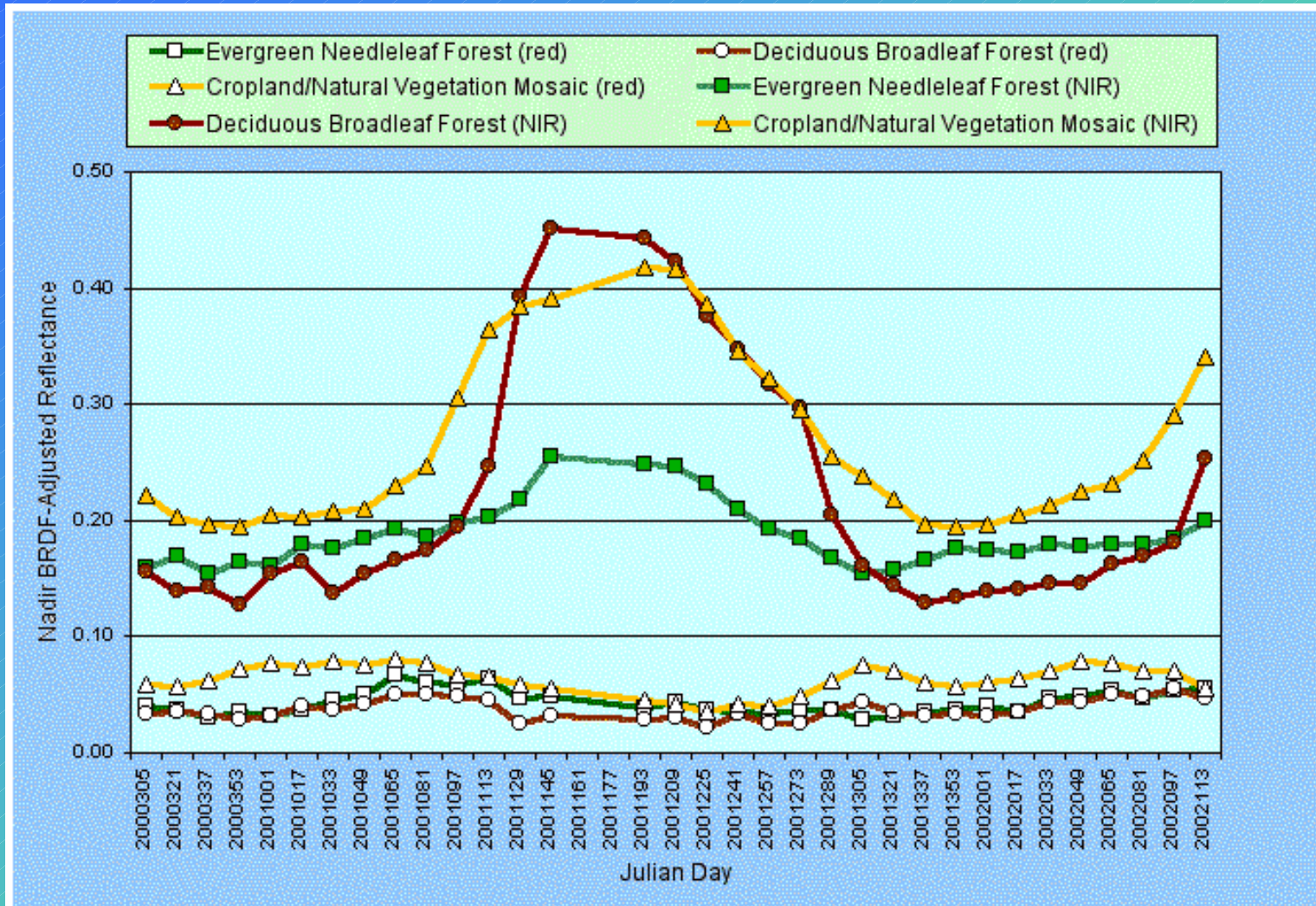
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No Data

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

# NBAR from Land Cover Training Sites in the Southern US



NBAR represent the primary input to MOD12Q1 MODIS Land Cover Product



# MOD43B Quality Assurance Flags

MOD43B 1km ISG products contain two 32 bit-packed words:

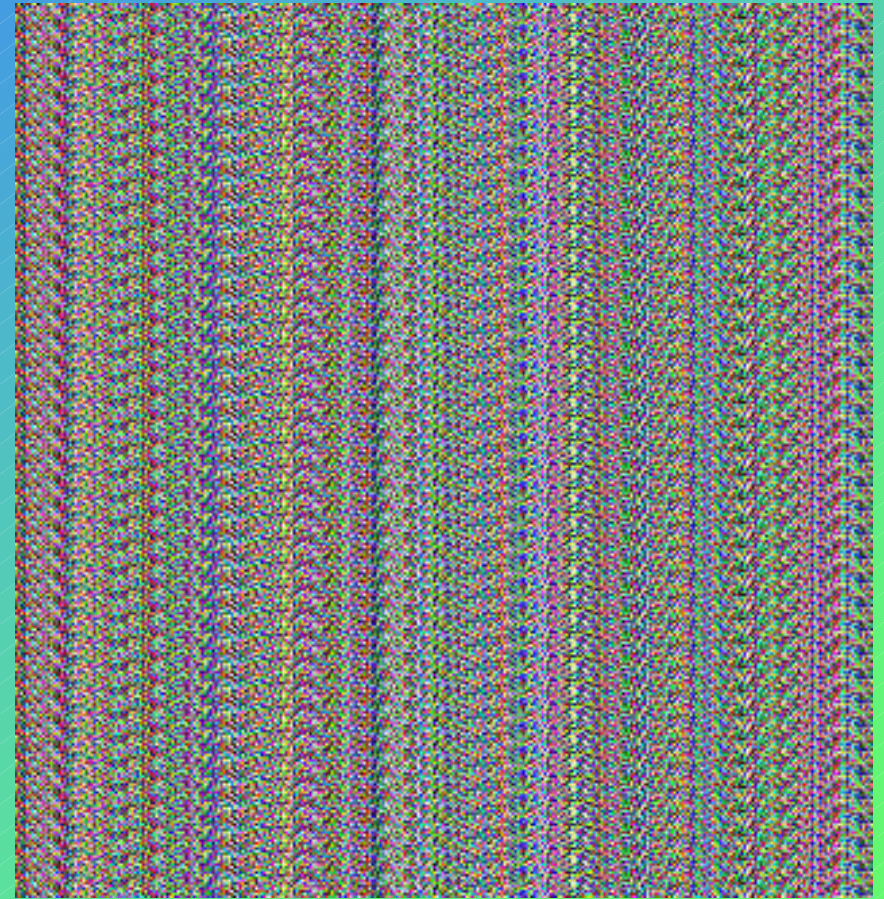
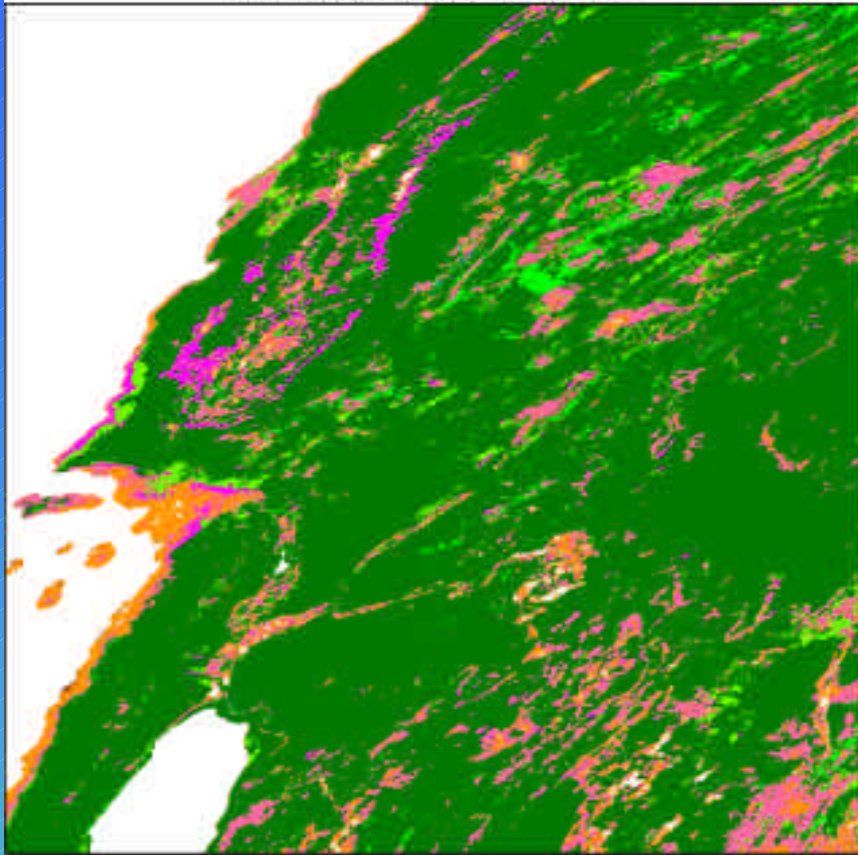
- First Word (Band Independent): Mandatory QA, Period, Land/Water, Sensor, **Snow/NoSnow**, Solar Zenith Angle
- Second Word (Band Dependent):BRDF retrieved with the highest quality Full Inversion (0-7) or the lower quality Magnitude Inversion (8-10)

For Example: Between 60°N - 60 °S for September, 2001

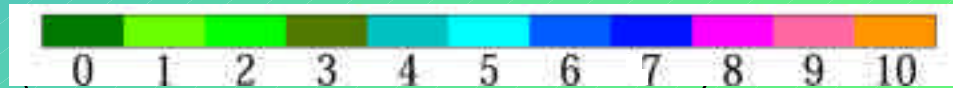
- 47% of all land pixels were retrieved with a full inversion
- 45% with a magnitude inversion (a priori BRDF shape)
- 8% were not retrieved due to an absence of quality obs.

# MOD43B Quality Assurance Flags

a). h08v05 (2001.145-160)



Southwestern  
North America



West Africa—Sahel

Good

Moderate

Poor

Bad

Full Inversion Quality Magnitude Inversion Quality



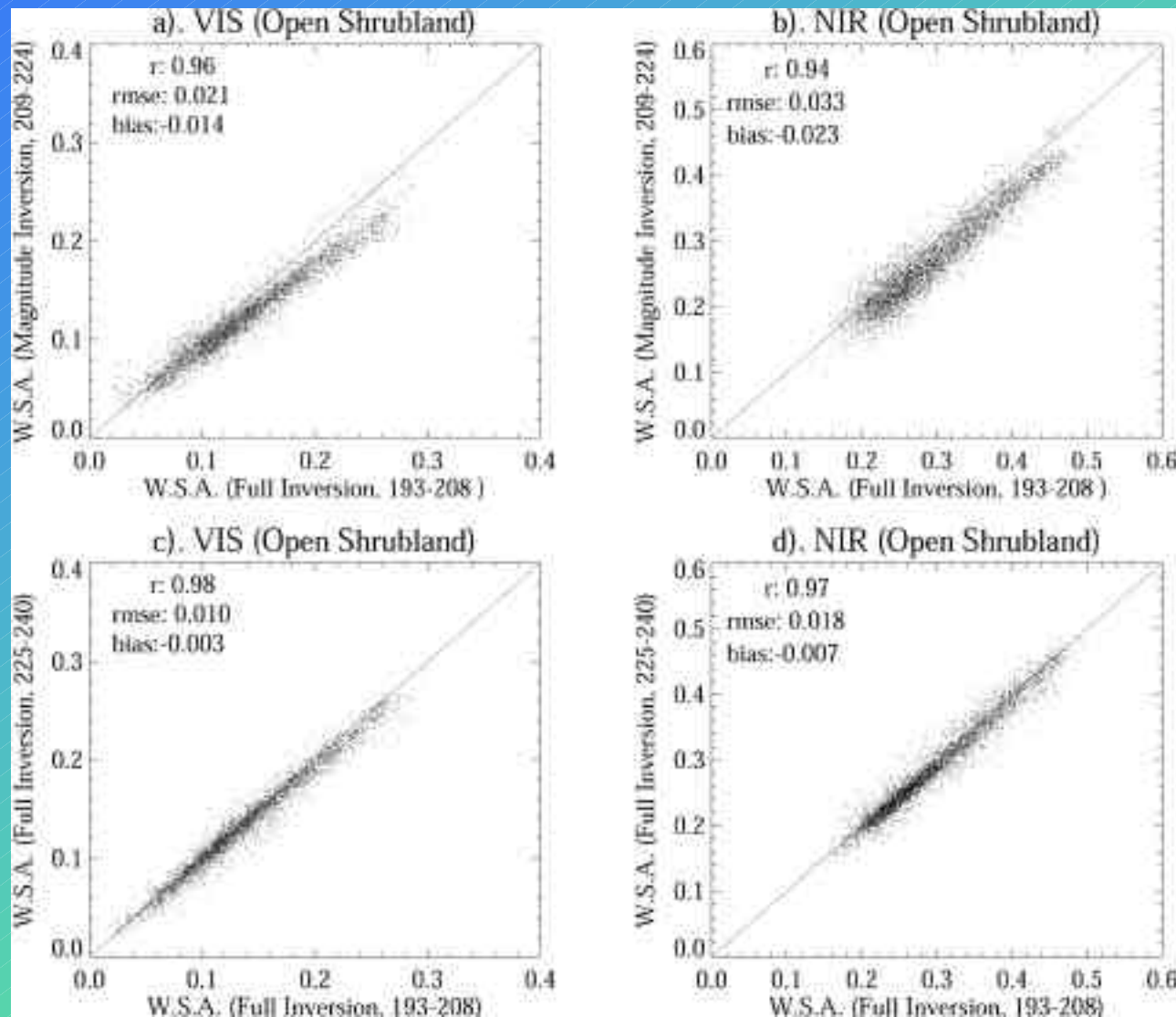
# Full vs. Magnitude Inversions, Baja Tile

Dates:

193–208: Clear,  
full inversion  
pixels

209–224: Many  
cloudy dates,  
magnitude  
inversion pixels

225–240: Clear,  
full inversion  
pixels





# Terra-only NBAR June/July, 2002



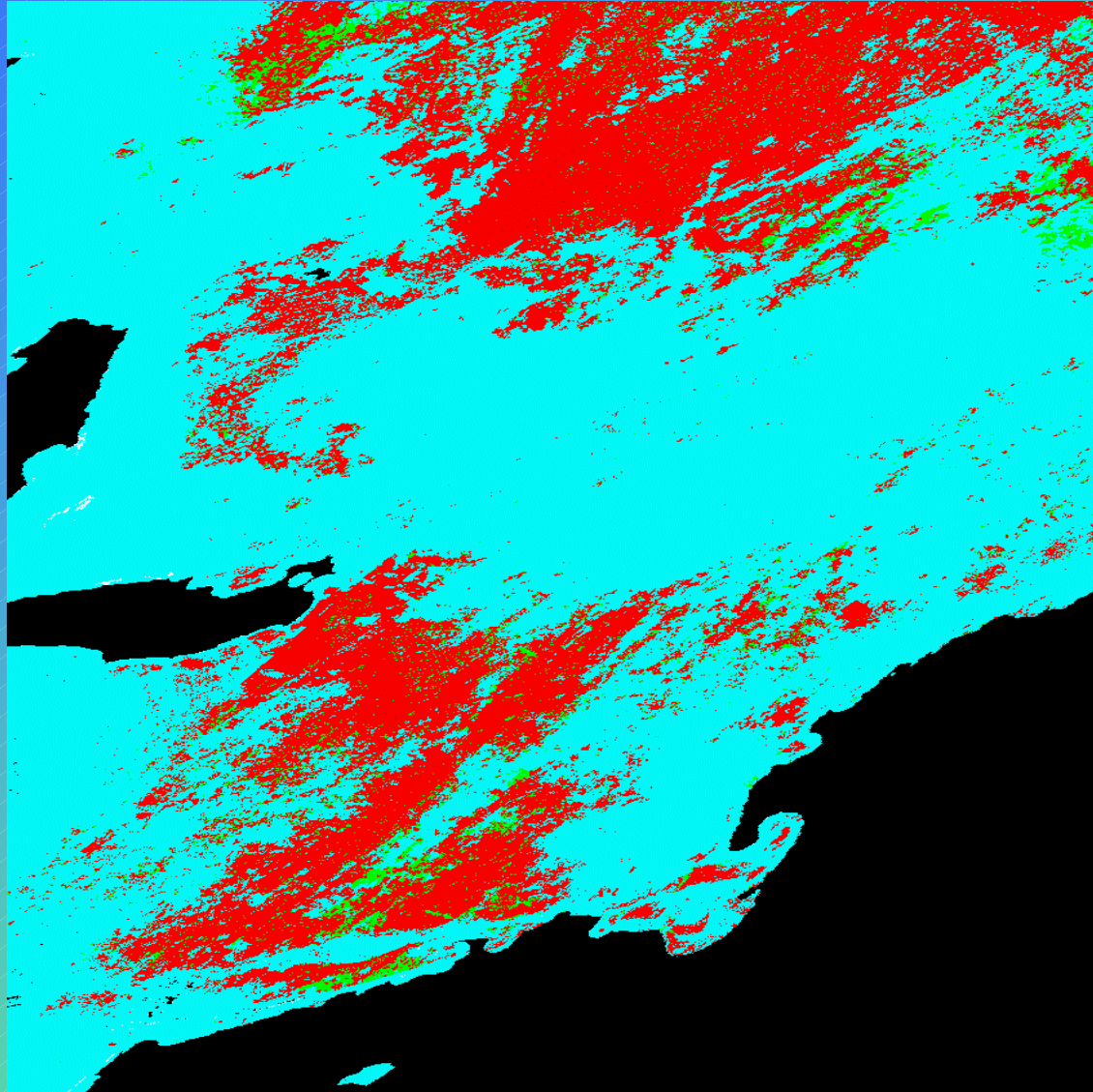
# Terra+Aqua NBAR June/July 2002



# Terra-only Quality Flags

Red:  
High  
quality

Cyan:  
Low  
quality

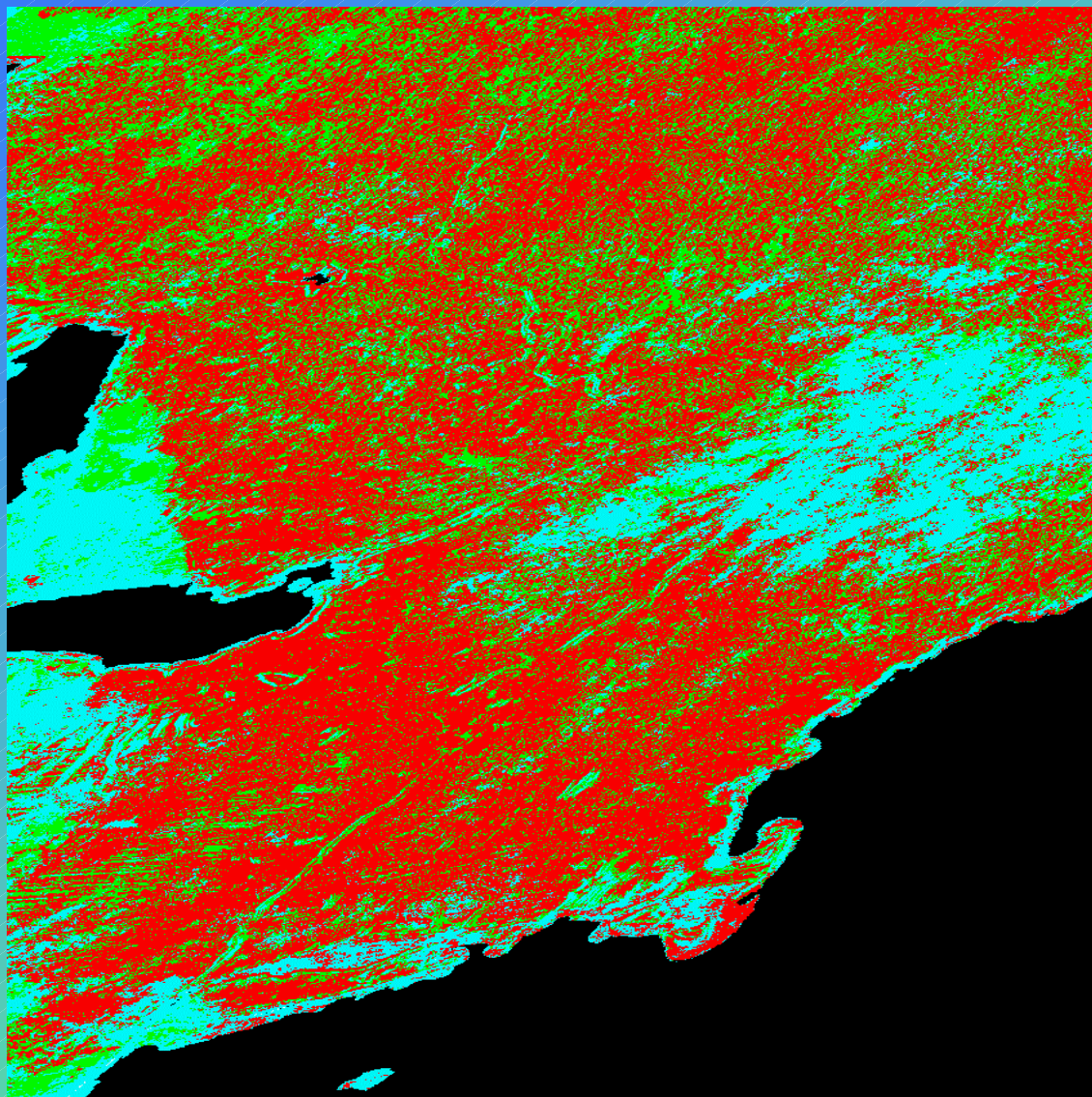




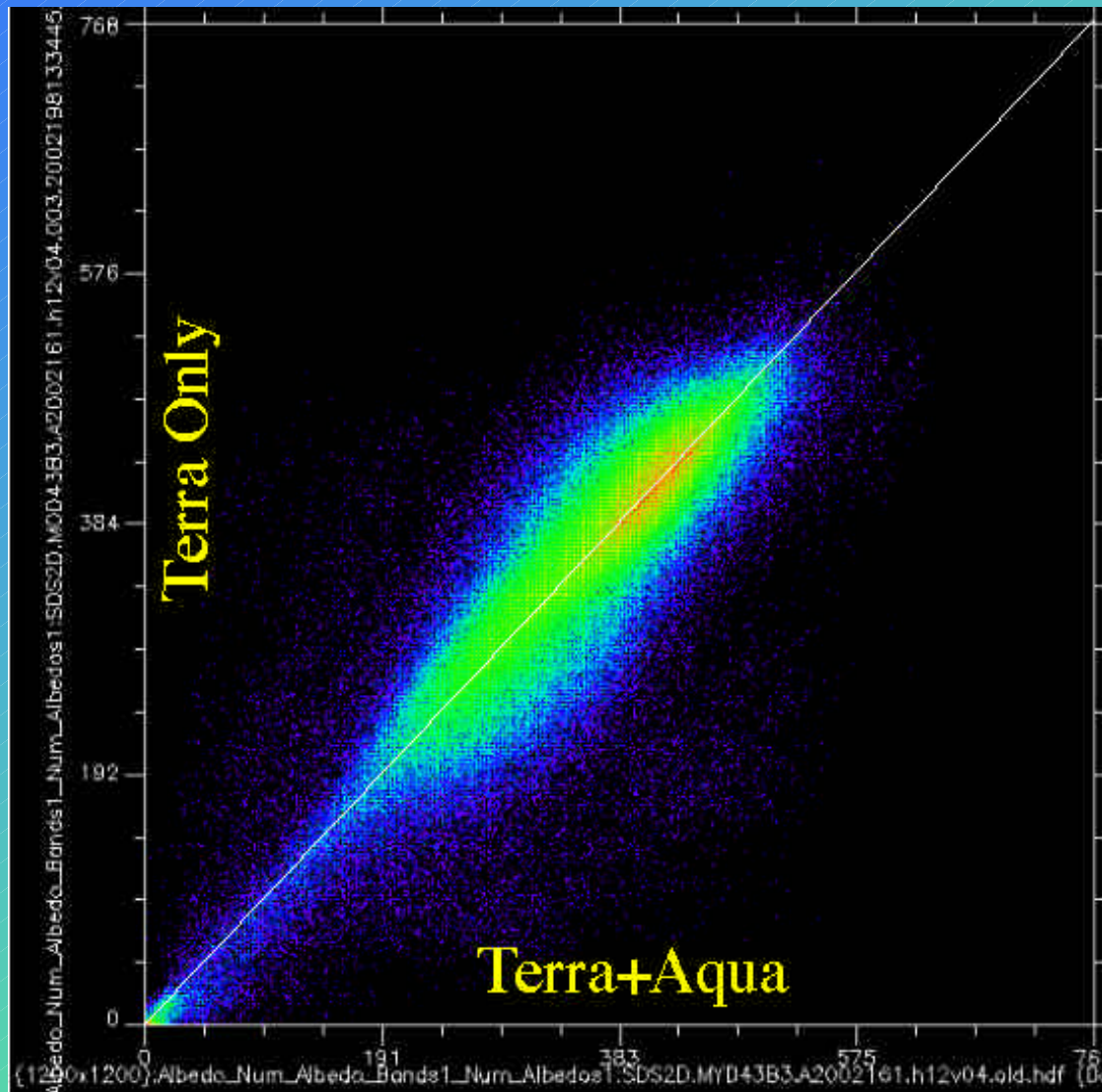
# Terra + Aqua Quality Flags

Red:  
High  
quality

Cyan:  
Low  
quality



# Terra and Aqua NIR White Sky Albedo Comparison



# MOD43B MODIS BRDF/ALBEDO PRODUCT VALIDATION

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SURFRAD/ARM Comparisons -- Y. Jin (BU)

BARC Field Campaigns -- S. Liang (UMD)

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

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

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

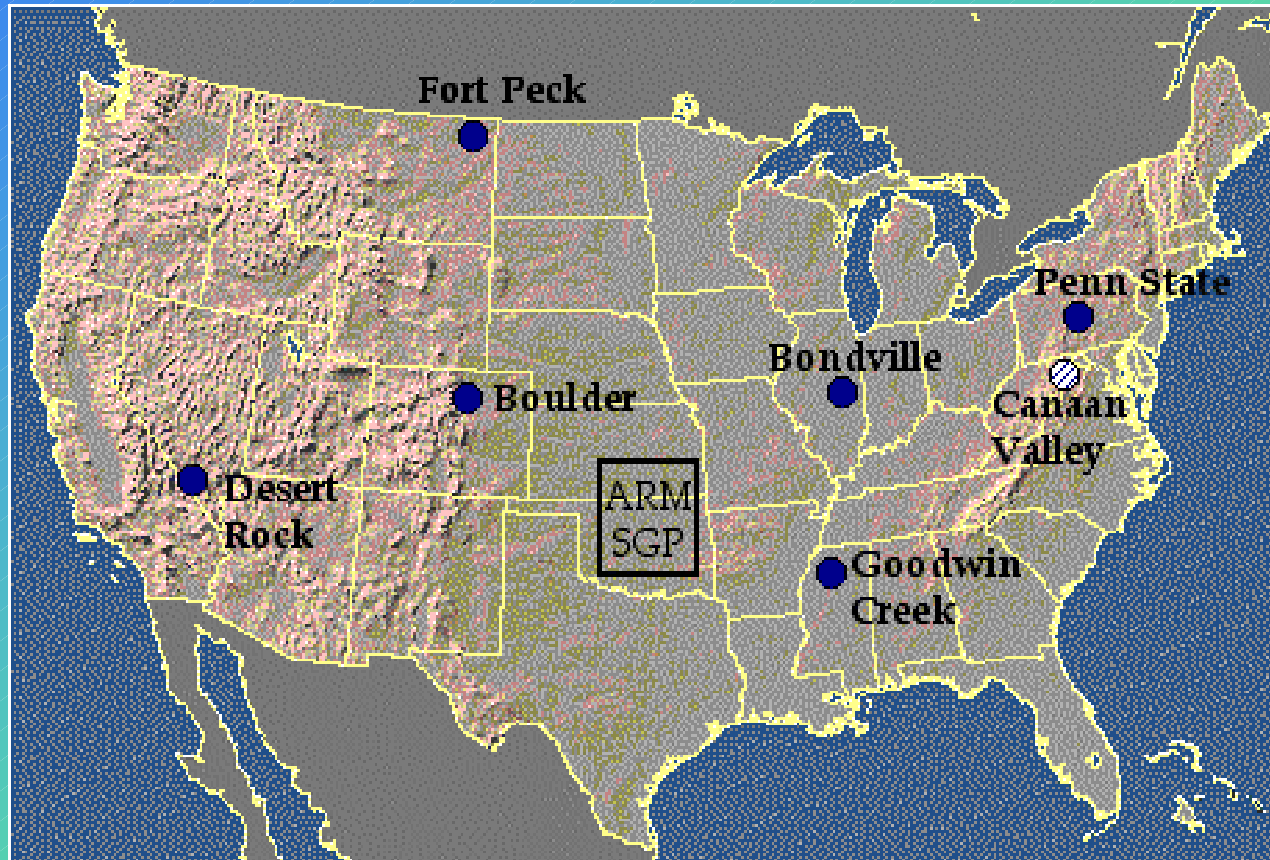


# Surface Radiation Budget Network (SURFRAD)

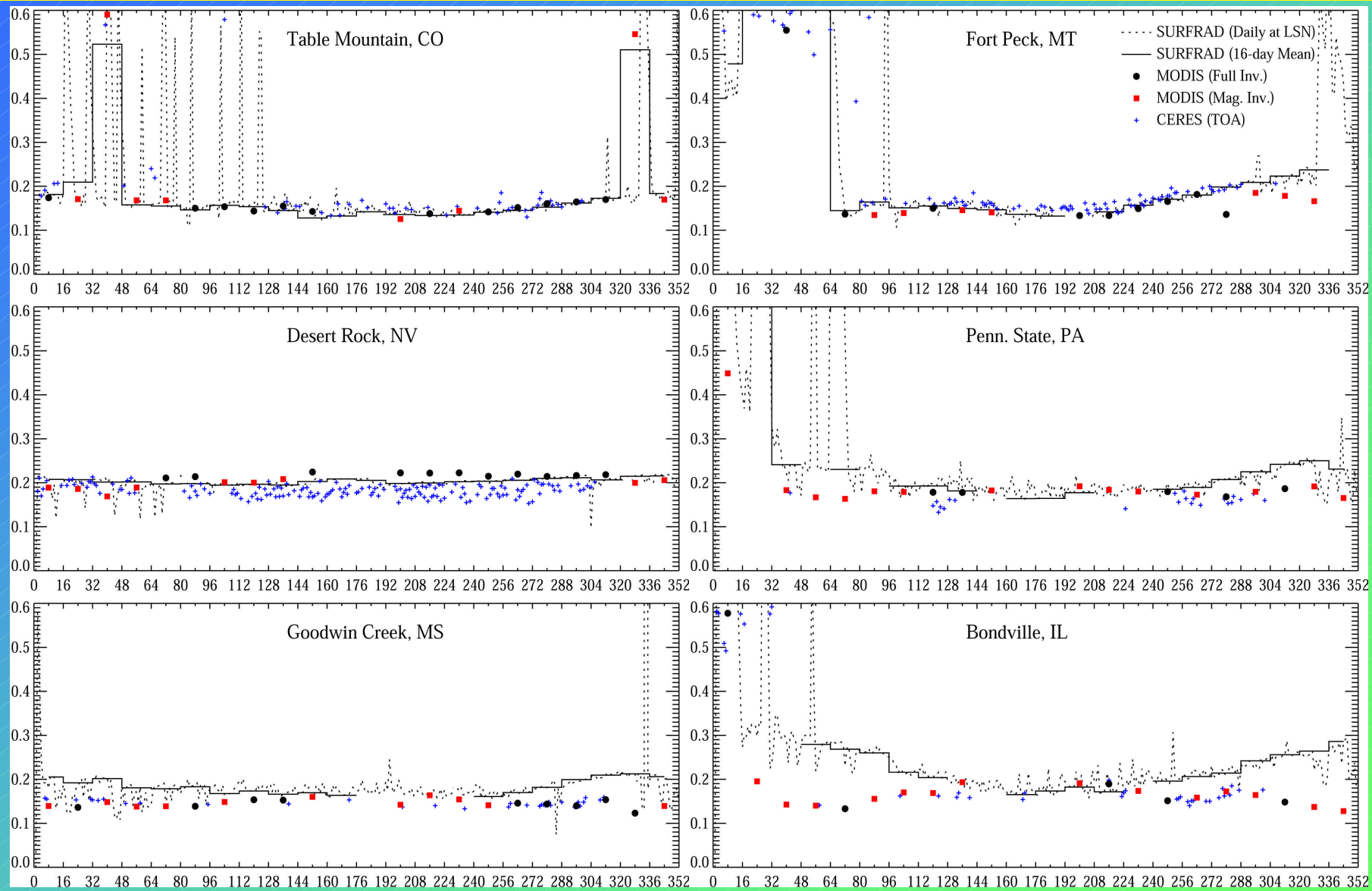
## US participation in BSRN

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) for 2001.

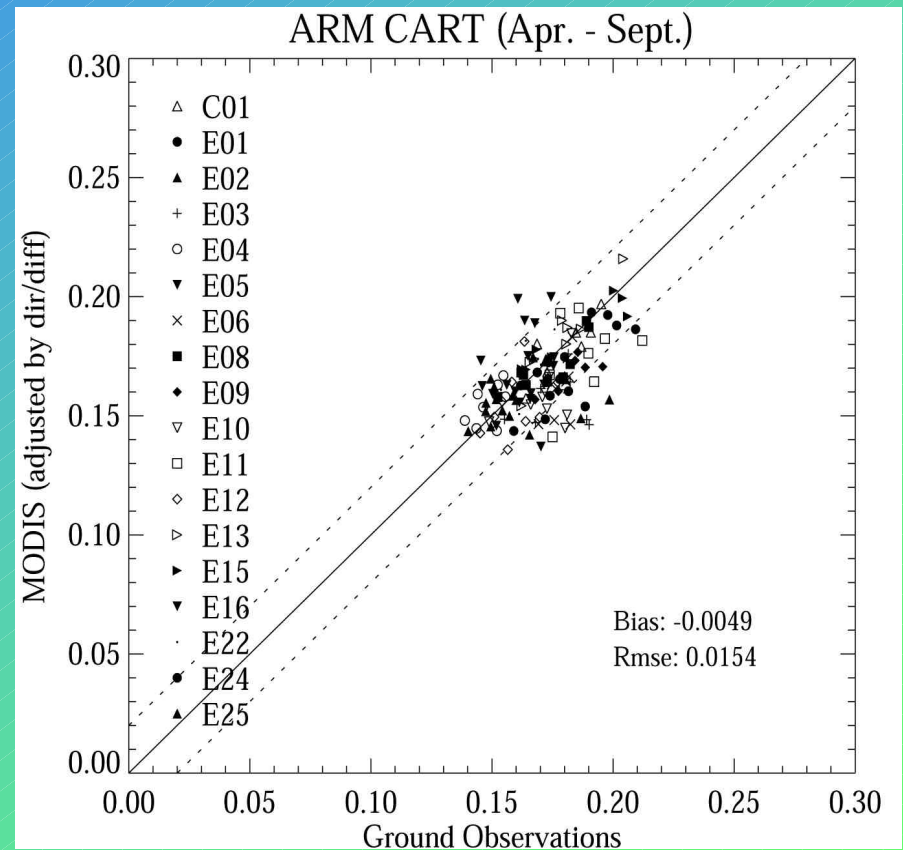
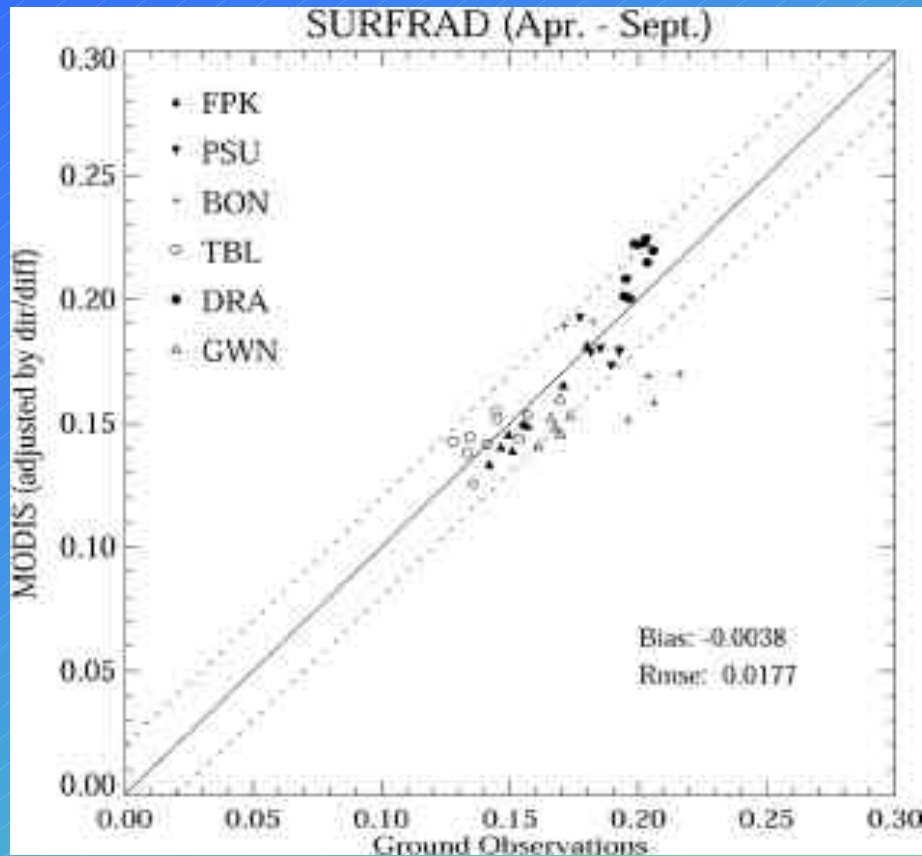


# MODIS, SURFRAD, and CERES Comparisons



# MODIS vs SURFRAD

## Growing Season Results (2001)





# Current Product Status

The Team evaluation has focused on the temporal stability and consistency of the products, on the variability by land cover and on the MOD43B Quality Assurance Flags.

MODIS-Aqua directional reflectances will be added to MODIS-Terra values to increase sampling and improve quality of retrieved BRDFs.

Reprocessed 1km MOD43B BRDF/Albedo products are available from November 2000 onward (in ISG in  $10^\circ$  tiles). Products were upgraded to a Validated Level-1 status as of 6/11/02.

The MOD43C CMG 1/4 degree products are also available from July 2001 onward (in a geographic Lat/Lon projection in global files).

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

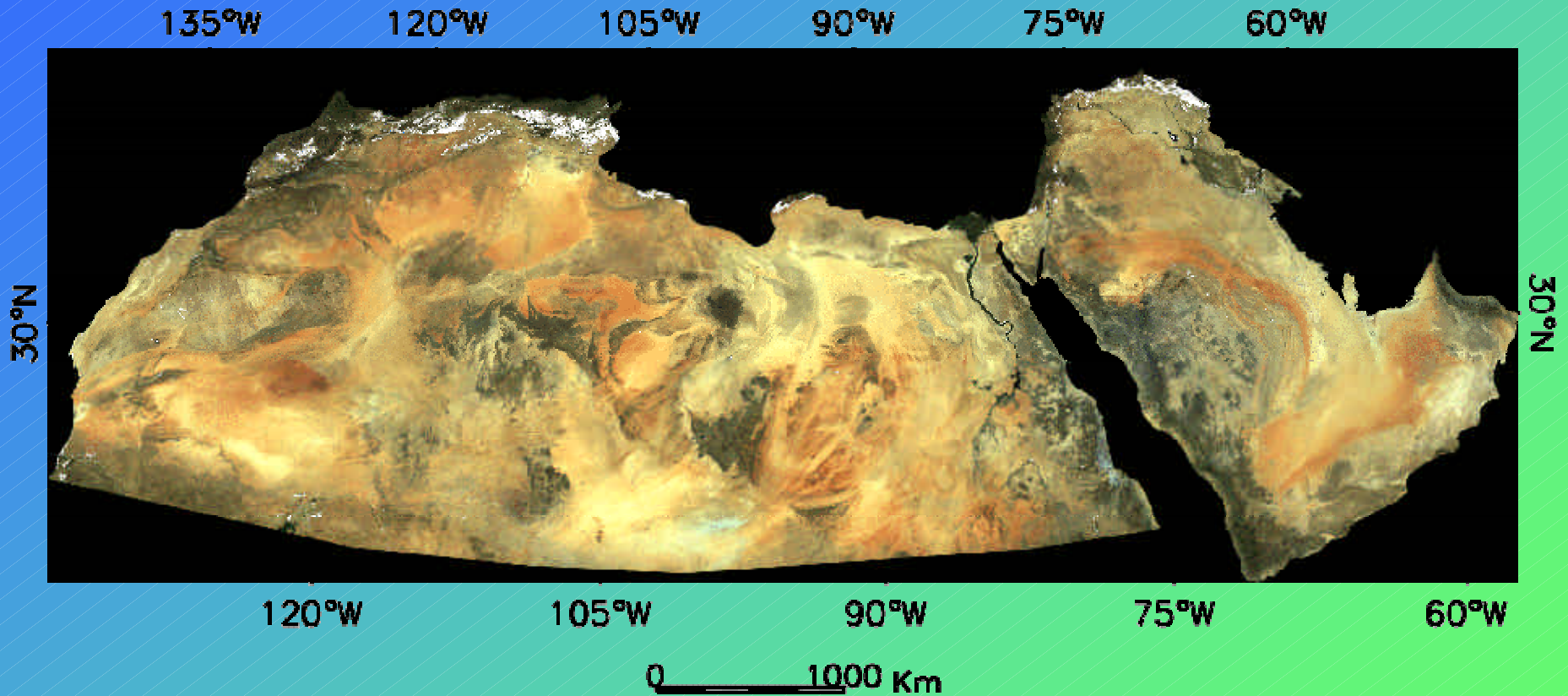
# Research Efforts Utilizing MODIS Albedo/BRDF CMG Products

## Collaborative Efforts Underway:

- Community Climate Systems Model (CCSM):  
(Dickinson/Bonan/Zeng/Yang/Houser)
  - Albedo variation in arid lands
  - Albedo variation of snow-covered vegetation
- European Center - Hamburg (ECHAM4):  
(Knorr/Kinne/Wild/Roesch)
  - Albedo parameterization
- Lund-Potsdam-Jena (LPJ): (Lucht)
  - Phenology/Albedo variations

# Desert Albedo

## True-color White-sky Spectral Albedo from MODIS



Desert albedos are clearly nonuniform, with implications for global climate modeling (*Tsvetsinskaya et al., GRL, 2002; Nature, N&V, 2002*).



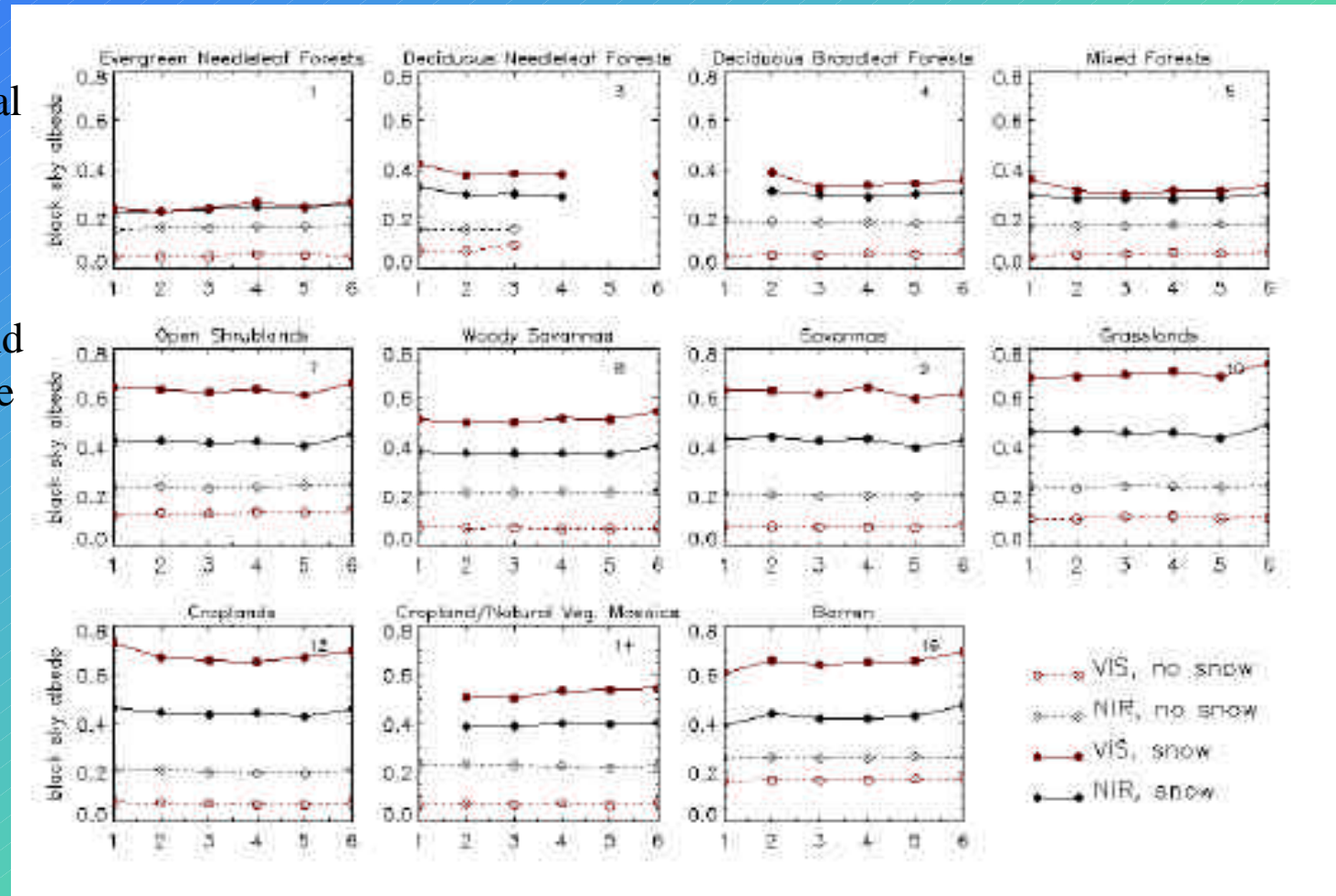
# Snow versus Non-snow Albedos

## 40–50°N Nov 00–Jan 01

Temporal consistency and magnitude of spectral albedos compare well with published results.

Narrow to broadband conversion over pure snow backgrounds result in low broadband values.

Collaborative effort to address this is underway (Stroeve, Liang, Nolin, Gao, Klein).



# Utilization of MODIS BRDF/Albedo Standard Products

- Additional Validation Sites
  - GSFC, UNH
  - BSRN
- MODIS Processing
  - MODIS Cloud Products (King/Moody/Baum)
  - MODIS Land Cover, LST (Wan)
  - MODIS Surface Reflectance - vis, NIR, MIR (Vermote)
  - Burn Scar (Roy)
- Community Outreach
  - Workshops

# **MODIS Workshop on Surface Radiation Budget Variables and Snow and Ice Products, 21-23 October, 2002, Boston University**

**Goals:** Introduce users to the characteristics and applications of the MODIS land radiation products: Surface Reflectance, LST, BRDF/Albedo, Snow albedo, Snow/Ice extent

Agenda and details posted at <http://geography.bu.edu/brdf/>

Contact Alan Strahler (alan@bu.edu), Crystal Schaaf (schaaf@bu.edu)

## **CEOS/WGCV Land Product Validation Workshop on Albedo 23-24 October, 2002, Boston University**

**Goals:** Foster communication between the field measurement community and the producers and users of satellite derived albedo data sets. Identify challenges and discuss ways to move forward.

Contact Crystal Schaaf (schaaf@bu.edu), Jeff Privette (jeff.privette@gsfc.nasa.gov)



# MOD43B MODIS BRDF/Albedo Product Summary

Evaluations indicate that the MOD43B algorithms have performed well throughout 2000, 2001 and into 2002.

- Reprocessed Terra albedo measures appear temporally stable and consistent.
- Indications are that the QA flags are appropriate--- (users must consult flags to determine whether snow or non-snow albedos).
- Initial validations and comparisons over sites in the US are encouraging with errors of less than 10% in the growing season.

Based on these analyses, MOD43B products have been upgraded to a status of “Validated (level 1)” .

Further increases in quality are expected with the addition of Aqua surface reflectances.

# MOD43B MODIS BRDF/ALBEDO PRODUCT

Reprocessed (V003) Standard Products (starting with the 16 day period beginning on Day 2000305 -- 31 October 2000) are available from EDC at <http://edcdaac.usgs.gov/main.html>

Global CMG Products on a 1/4 degree resolution Geographical Grid (starting with Day 2001193 in July, 2001) are also 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/>