



# Using Multi-angle Imaging SpectroRadiometer (MISR) bidirectional reflectances for land surface studies

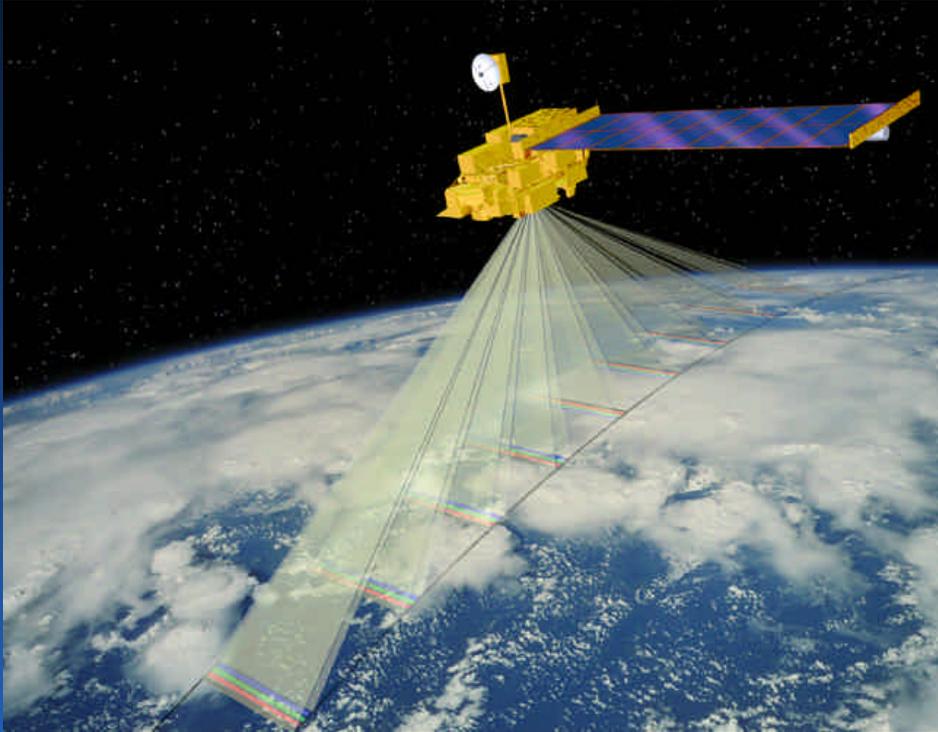


David J. Diner and  
John V. Martonchik  
Jet Propulsion Laboratory  
California Institute of Technology

COSPAR  
18 October 2002  
Houston, TX

MISR nadir image, 13 September 2000

# MISR observational attributes



“First-of-its kind” instrument

In polar orbit aboard Terra since December 1999

**9 view angles at Earth surface:  
nadir to  $70.5^\circ$  forward and backward**

**4 bands at each angle:  
446, 558, 672, 866 nm**

**Continuous pole-to-pole coverage  
on orbit dayside**

**400-km swath  
9 day coverage at equator  
2 day coverage at poles**

**275 m - 1.1 km sampling**

**7 minutes to observe each scene  
at all 9 angles**

## MISR Science Team

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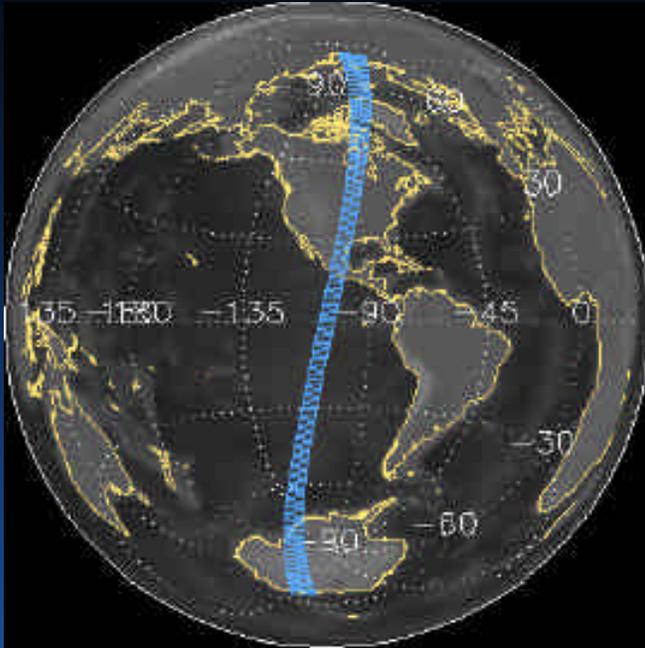
Joint Research Center

Piers Sellers

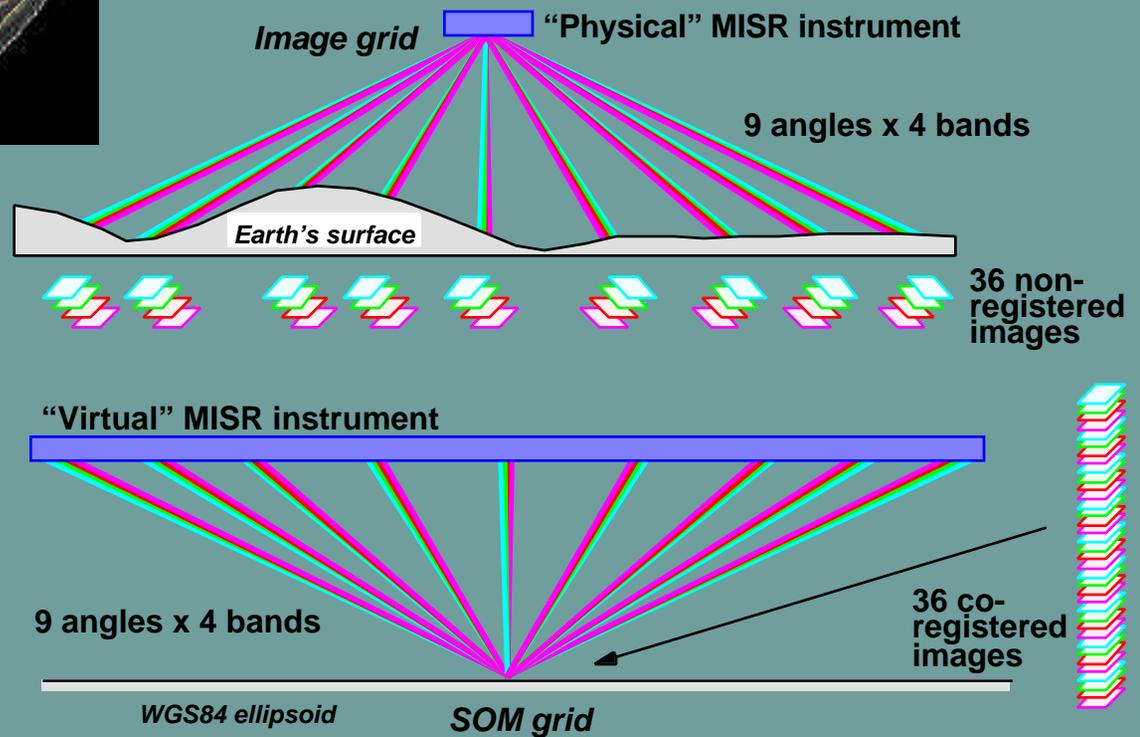
Johnson Space Center

Michel M. Verstraete

Joint Research Center



# Geometric calibration and image rectification





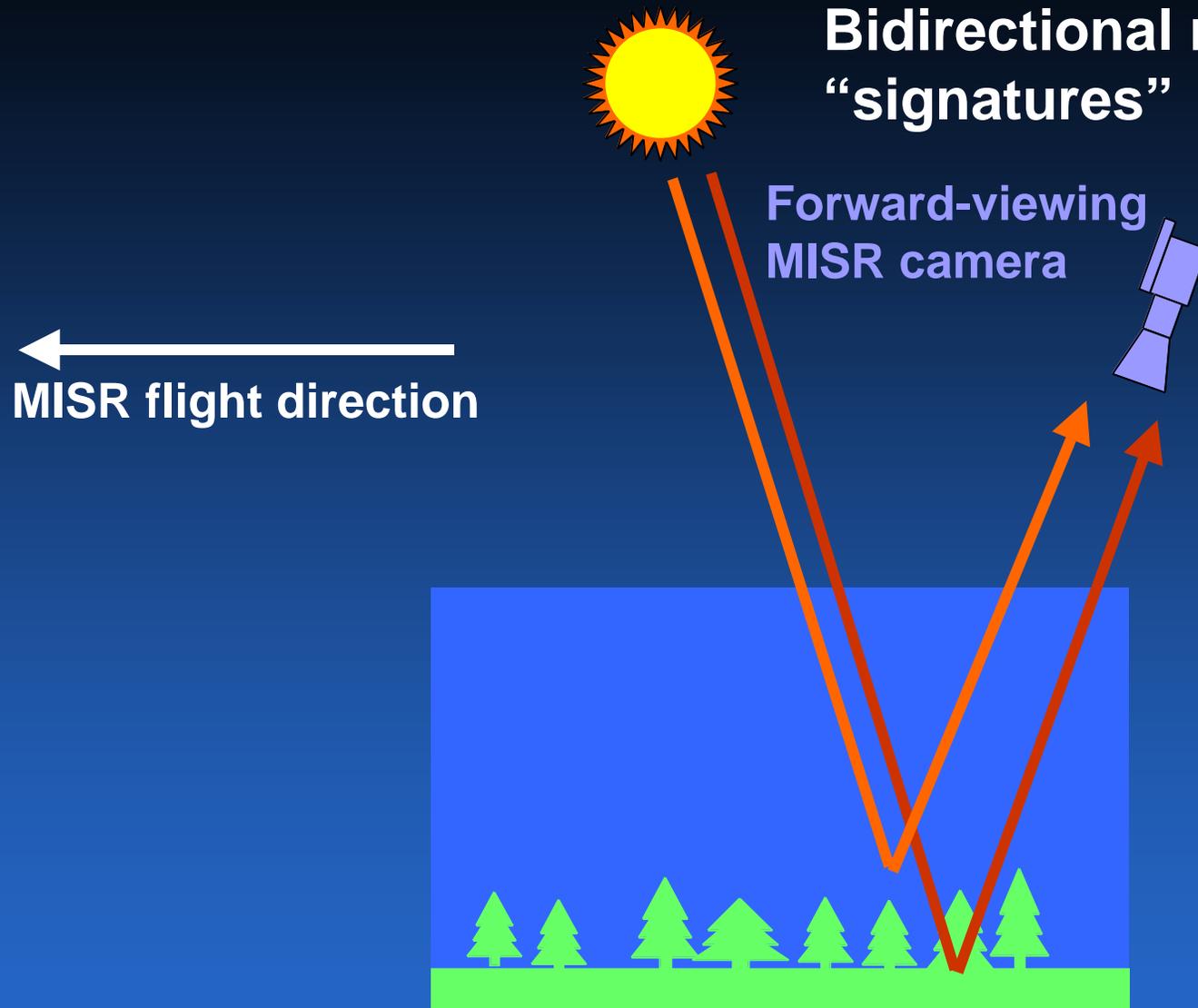
## **What climatically and environmentally important changes are occurring to the land surface?**

**MISR aerosol characterization enables surface retrieval (atmospheric correction) of hemispherical-directional and bidirectional reflectance factors**

**Integration of surface HDRF's and BRF's over angle yields albedos, (bihemispherical reflectance , BHR and directional-hemispherical reflectance , DHR)**

**Surface “angular signatures” provide a new dimension for characterizing land surface type, supplementing spectral information with a measure of surface physical structure**

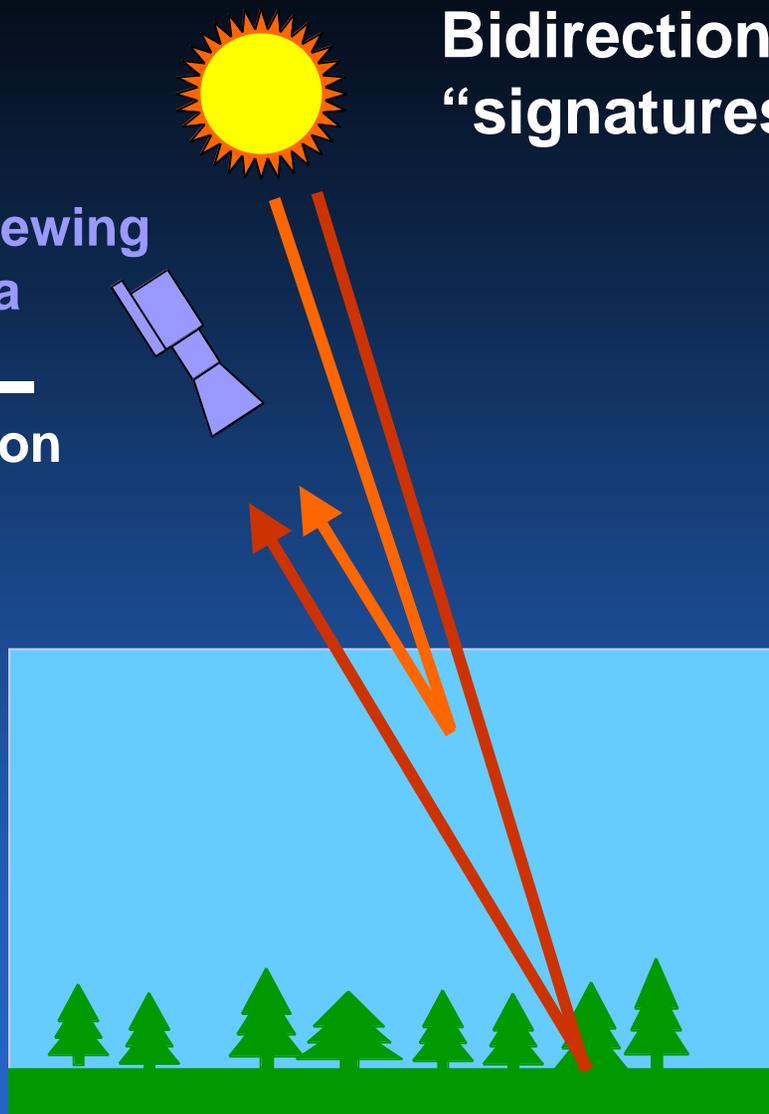
# Bidirectional reflectance “signatures”



# Bidirectional reflectance “signatures”

Backward-viewing  
MISR camera

MISR flight direction



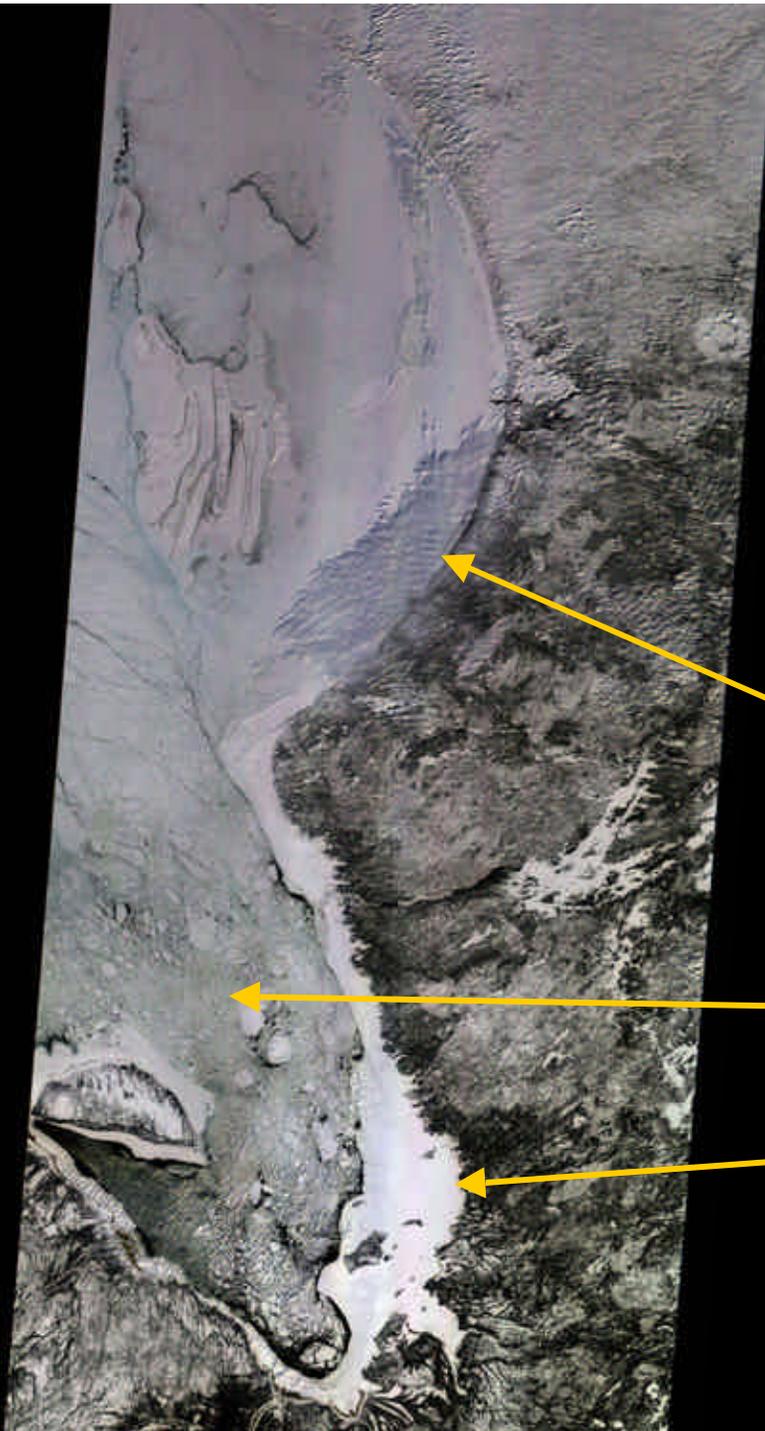
**Hudson and  
James Bays  
24 February 2000**

**Nadir true color  
RGB = red, green, blue**

**stratocumulus cloud**

**pack ice**

**fast ice**

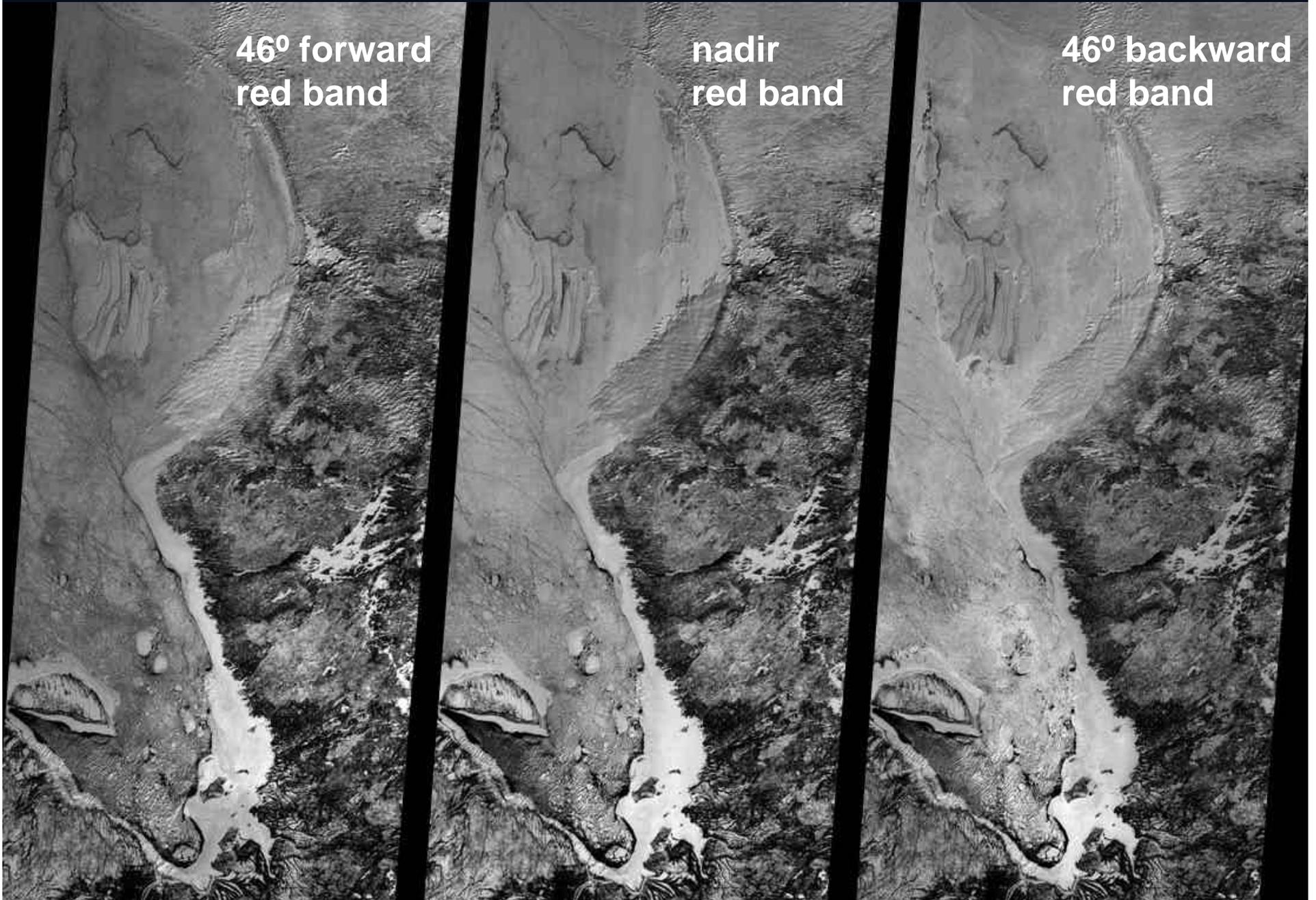


# Hudson and James Bays, 24 February 2000

46° forward  
red band

nadir  
red band

46° backward  
red band

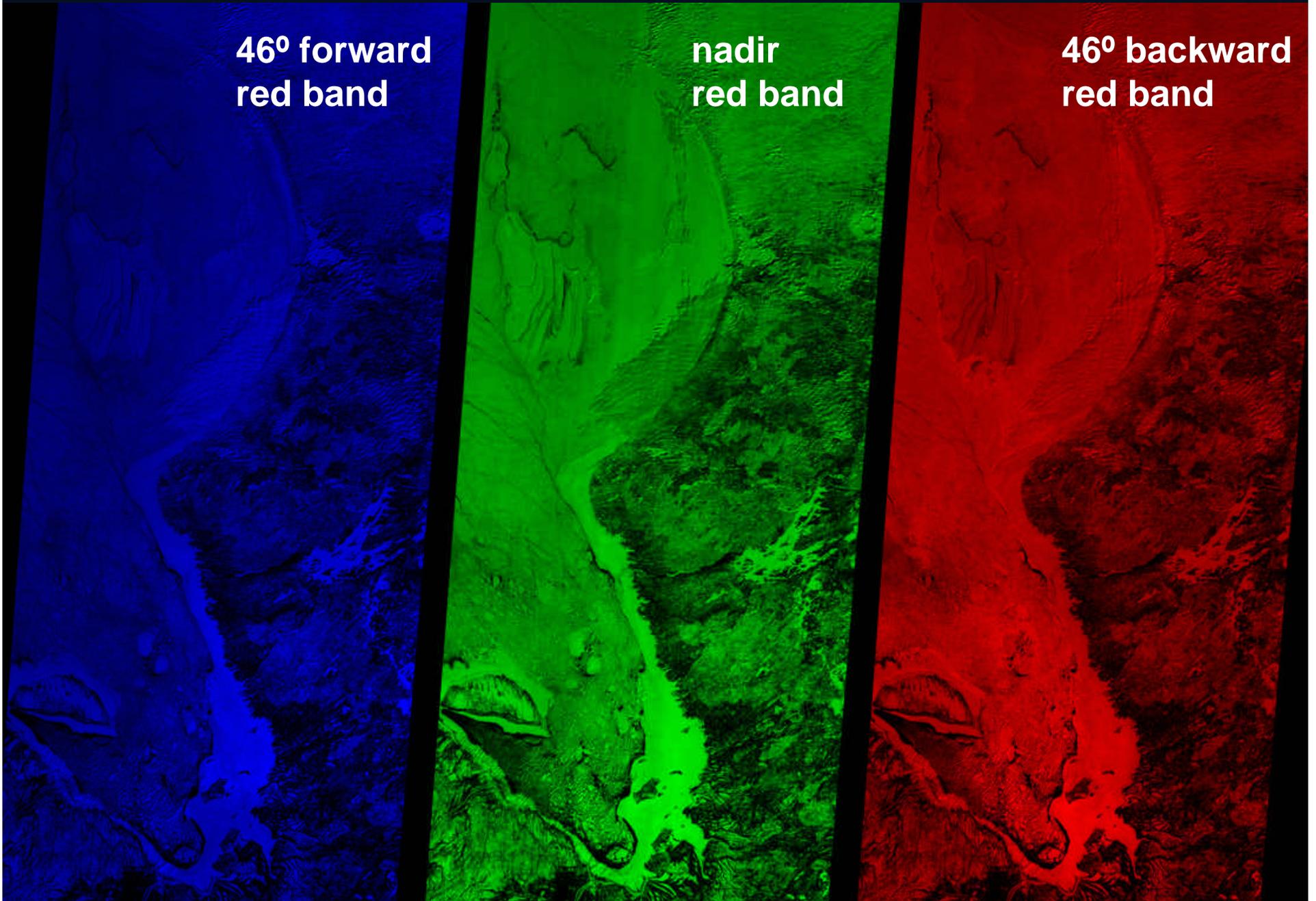


# Hudson and James Bays, 24 February 2000

46° forward  
red band

nadir  
red band

46° backward  
red band



**Nadir true color**

**RGB = red, green, blue**

**Multi-angle false color**

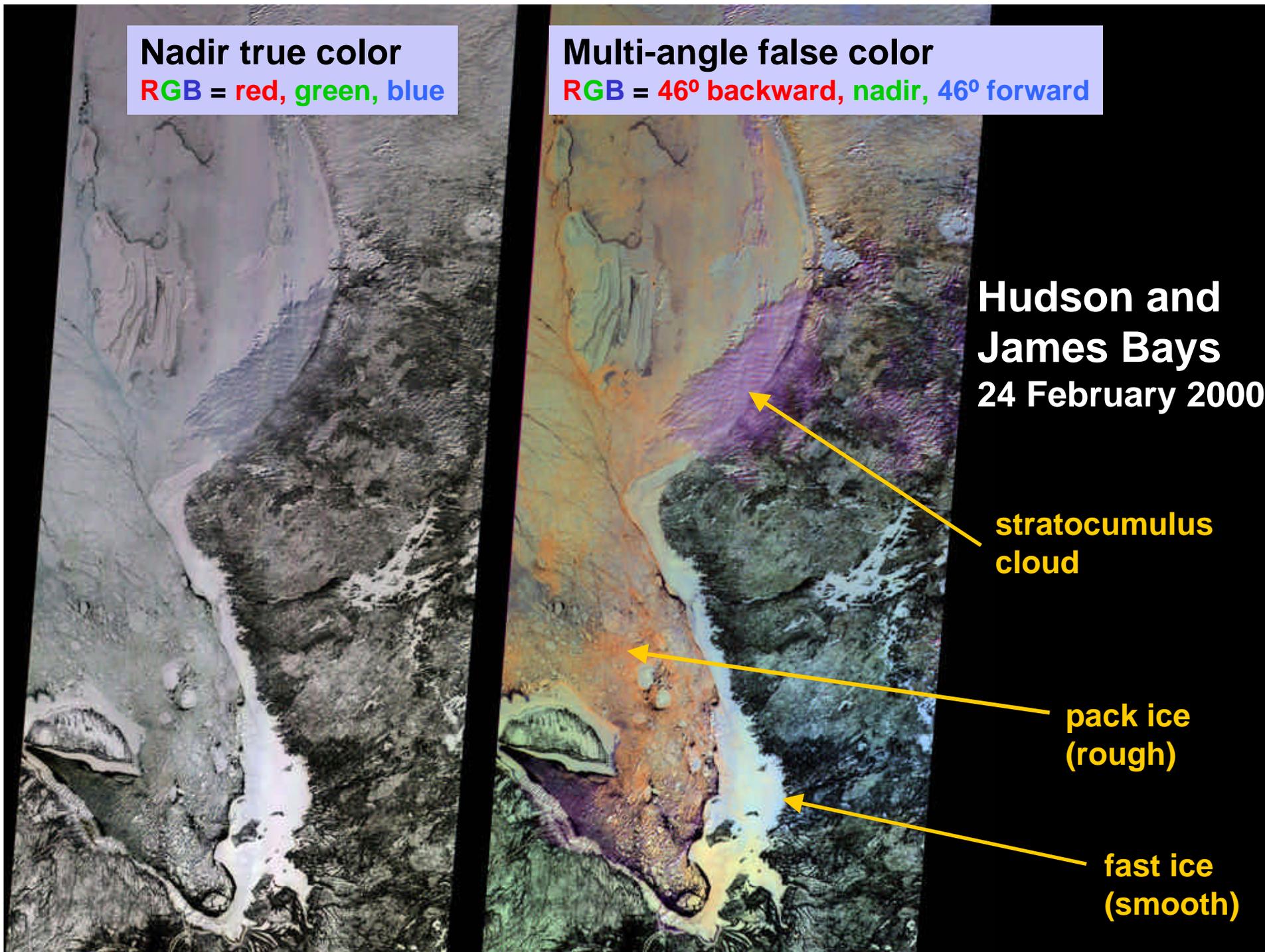
**RGB = 46° backward, nadir, 46° forward**

**Hudson and  
James Bays  
24 February 2000**

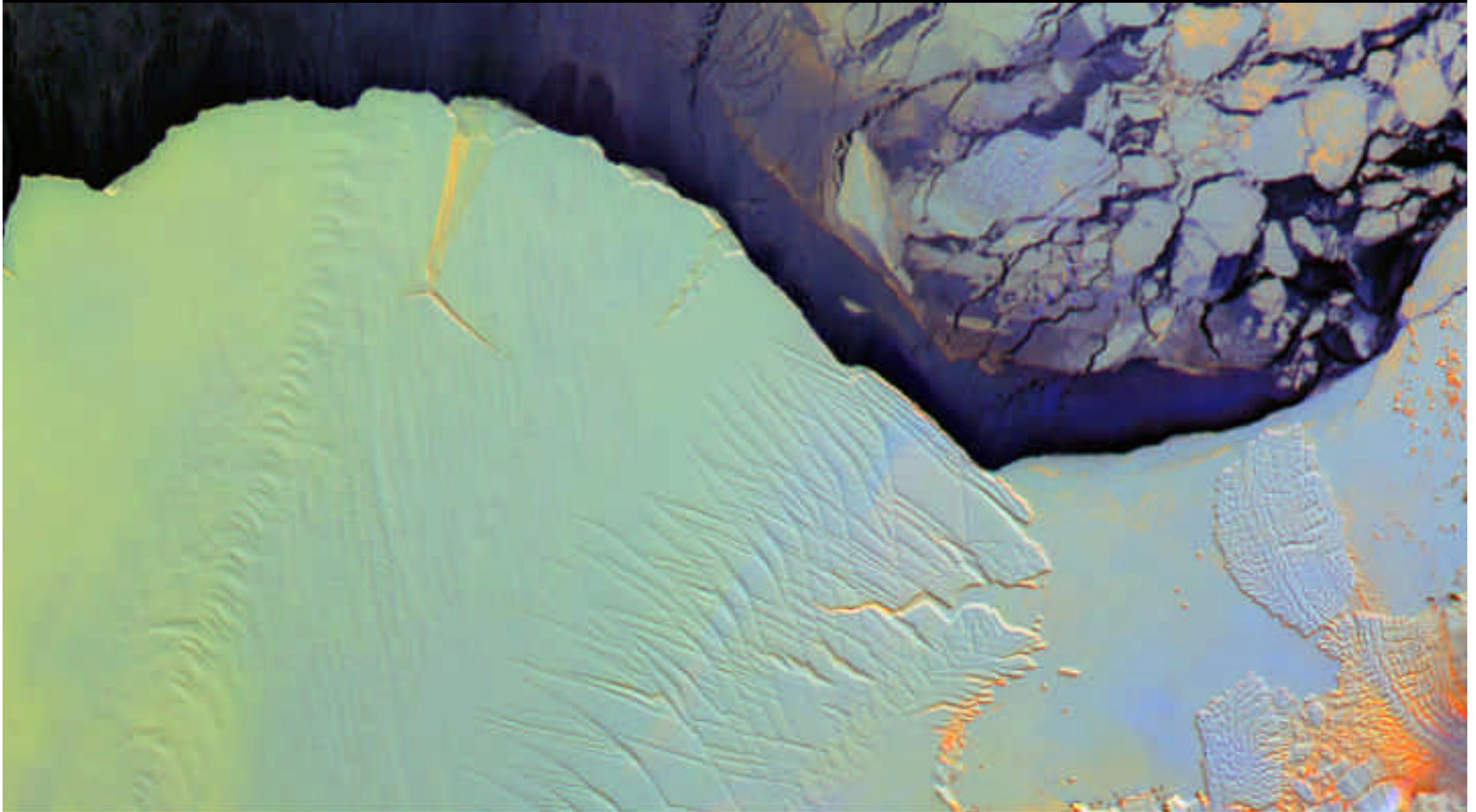
**stratocumulus  
cloud**

**pack ice  
(rough)**

**fast ice  
(smooth)**

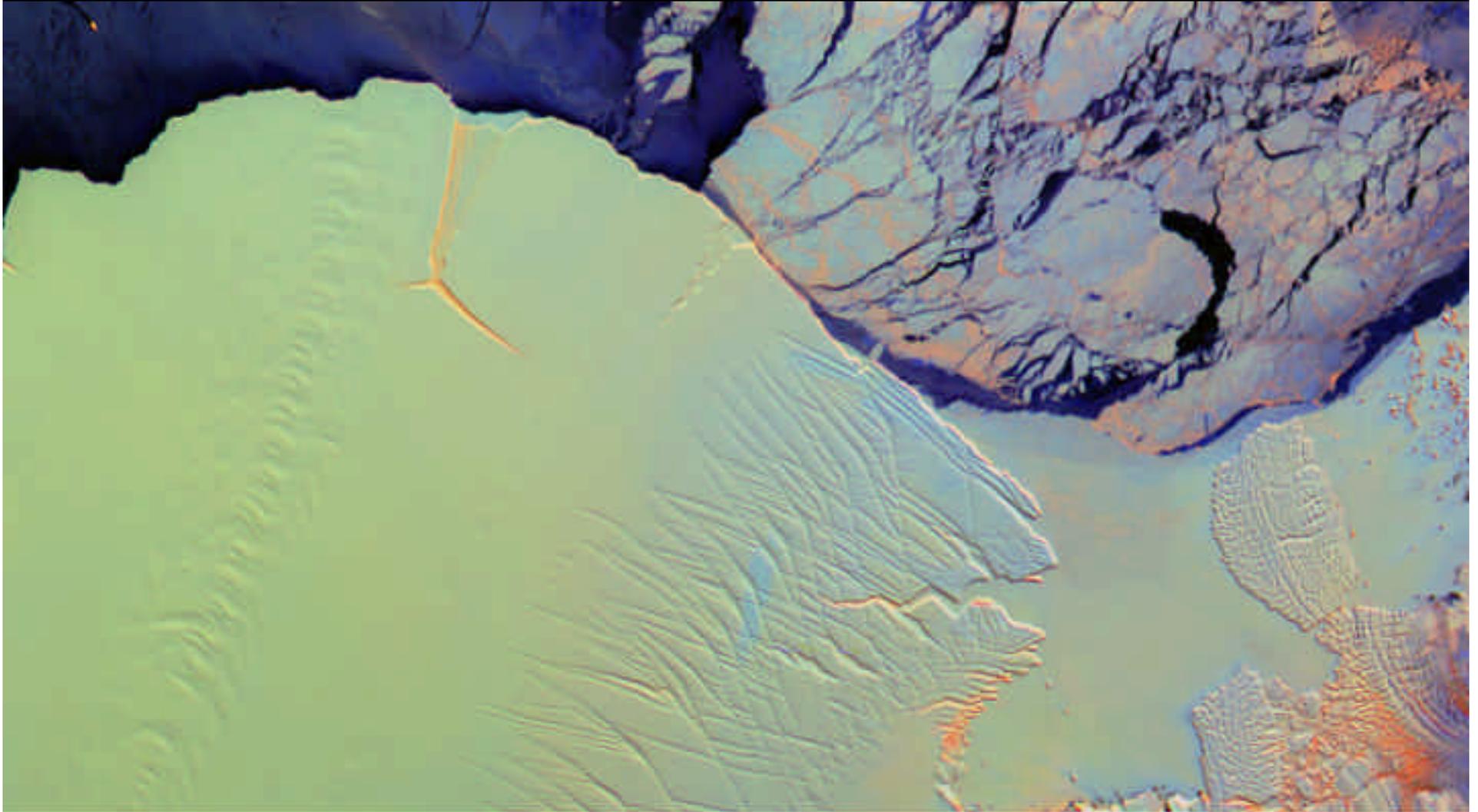


# Amery Ice Shelf, East Antarctica



October 6, 2001

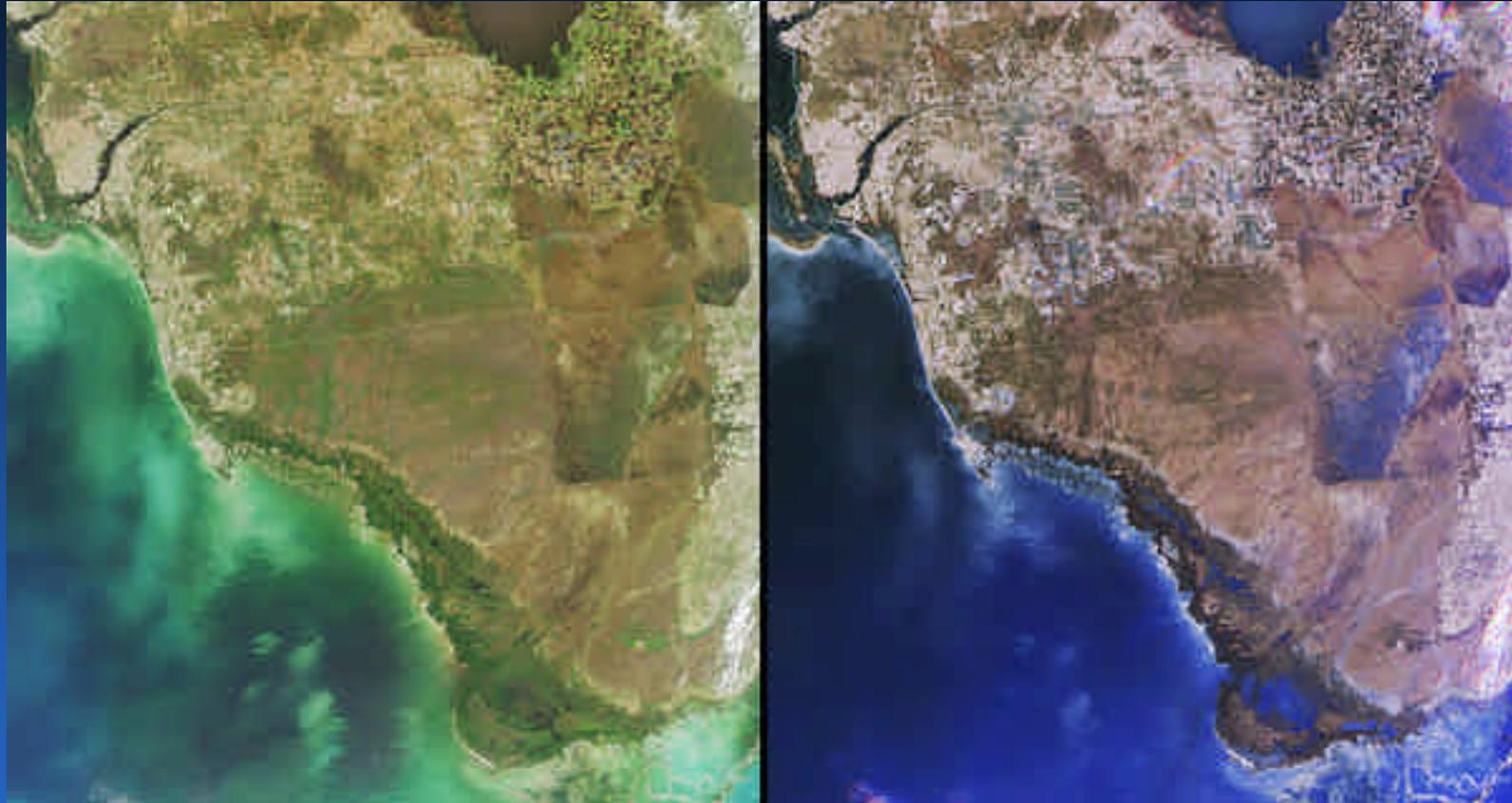
# Amery Ice Shelf, East Antarctica



September 29, 2002

# Southern Florida's River of Grass

16 January 2002



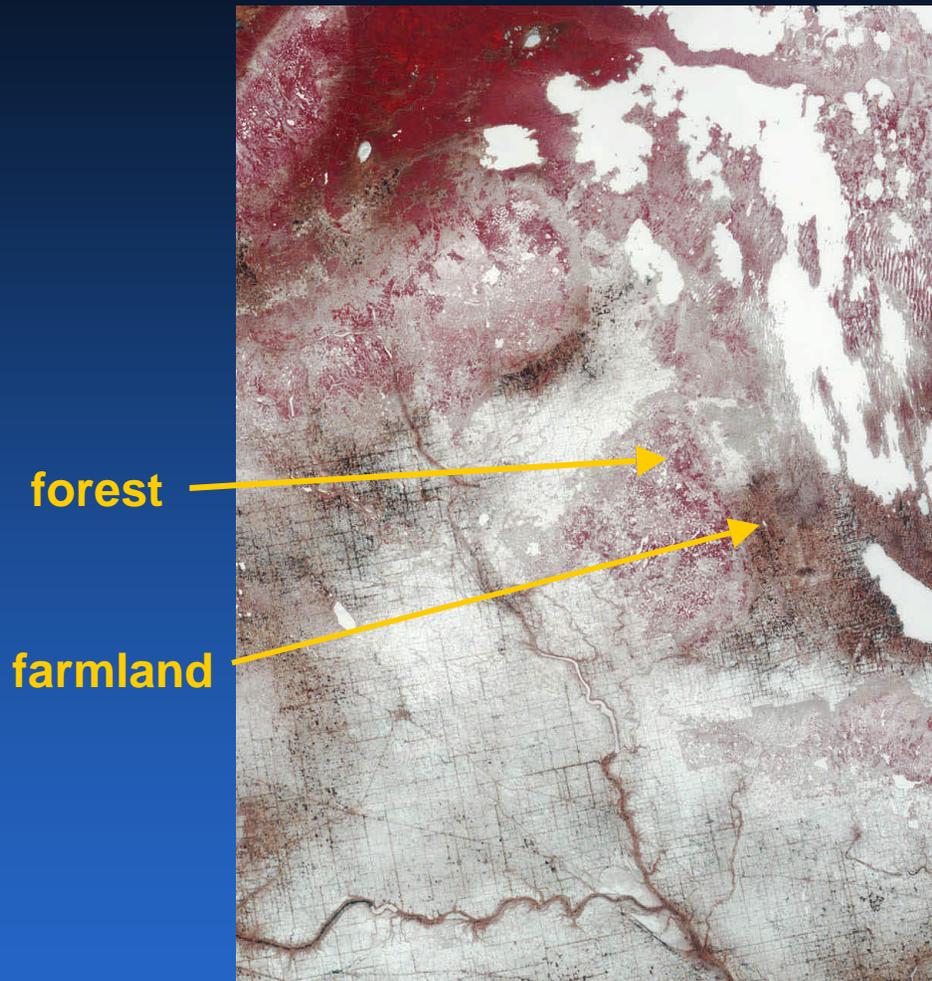
**Nadir true color**

**RGB = red, green, blue**

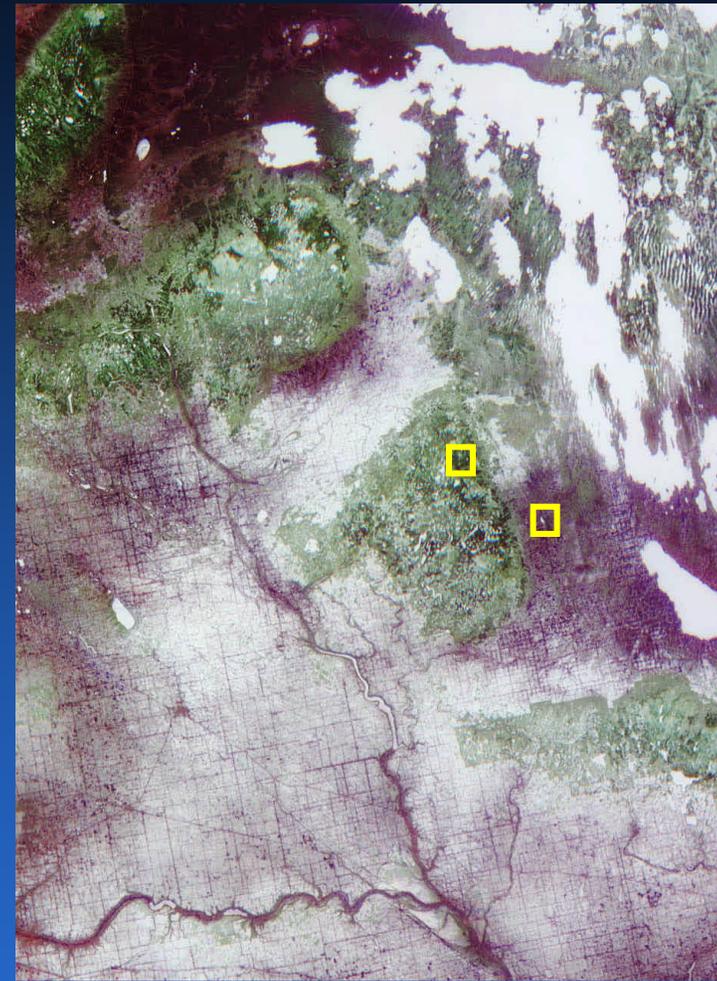
**Multi-angle false color**

**RGB = 46° backward, nadir, 46° forward**

# Manitoba and Saskatchewan, 17 April 2001

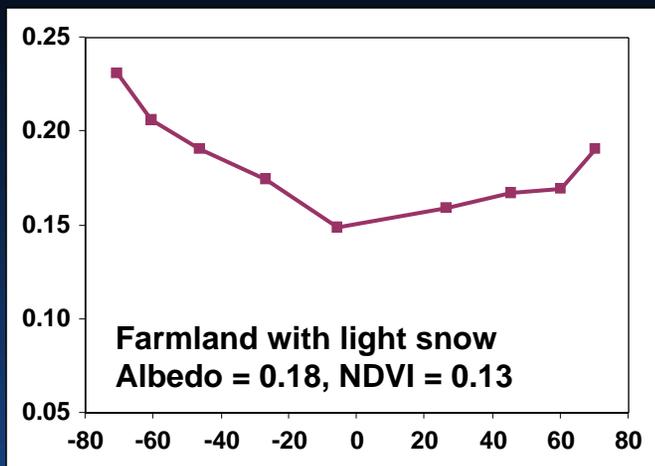


Nadir false-color composite:  
RGB = near-IR, red, green

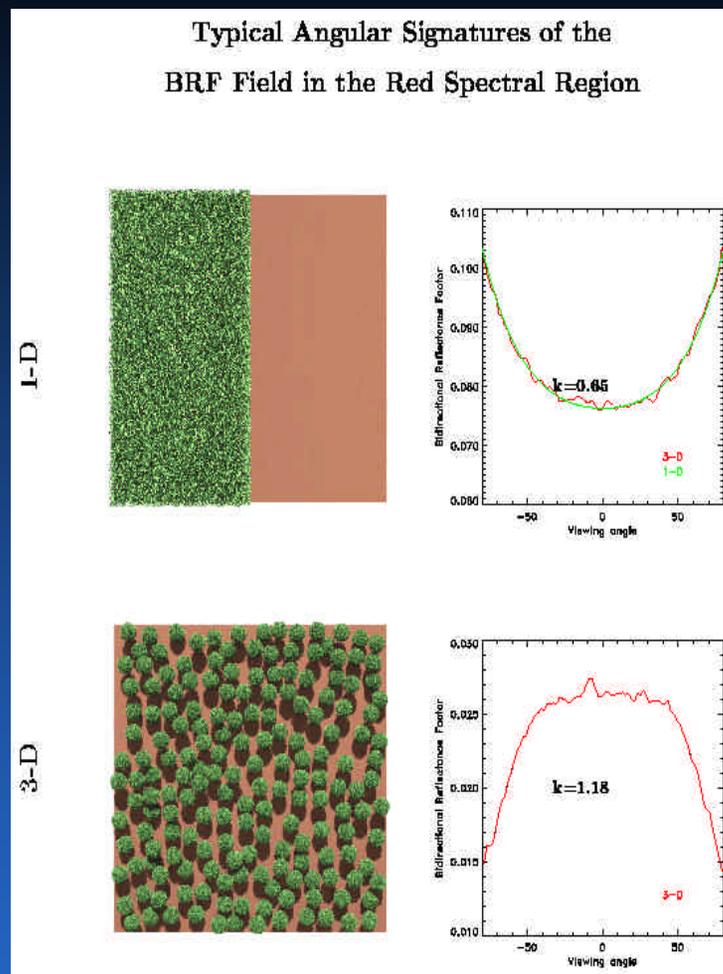
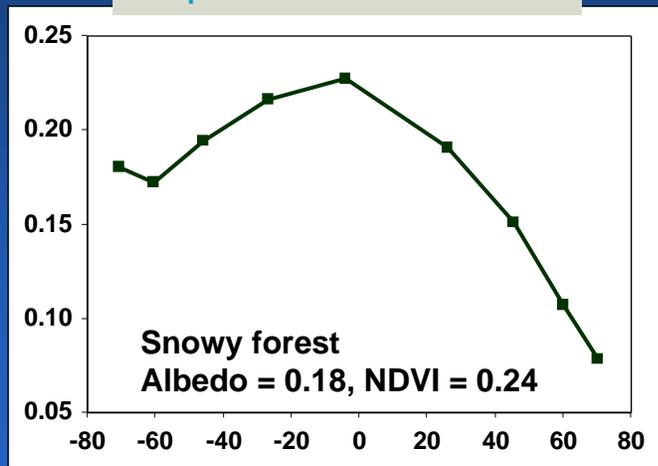


Multi-angle red band composite:  
RGB = 60° backward, nadir, 60° forward

# Bidirectional reflectances of surface vegetation



Manitoba and Saskatchewan,  
17 April 2001

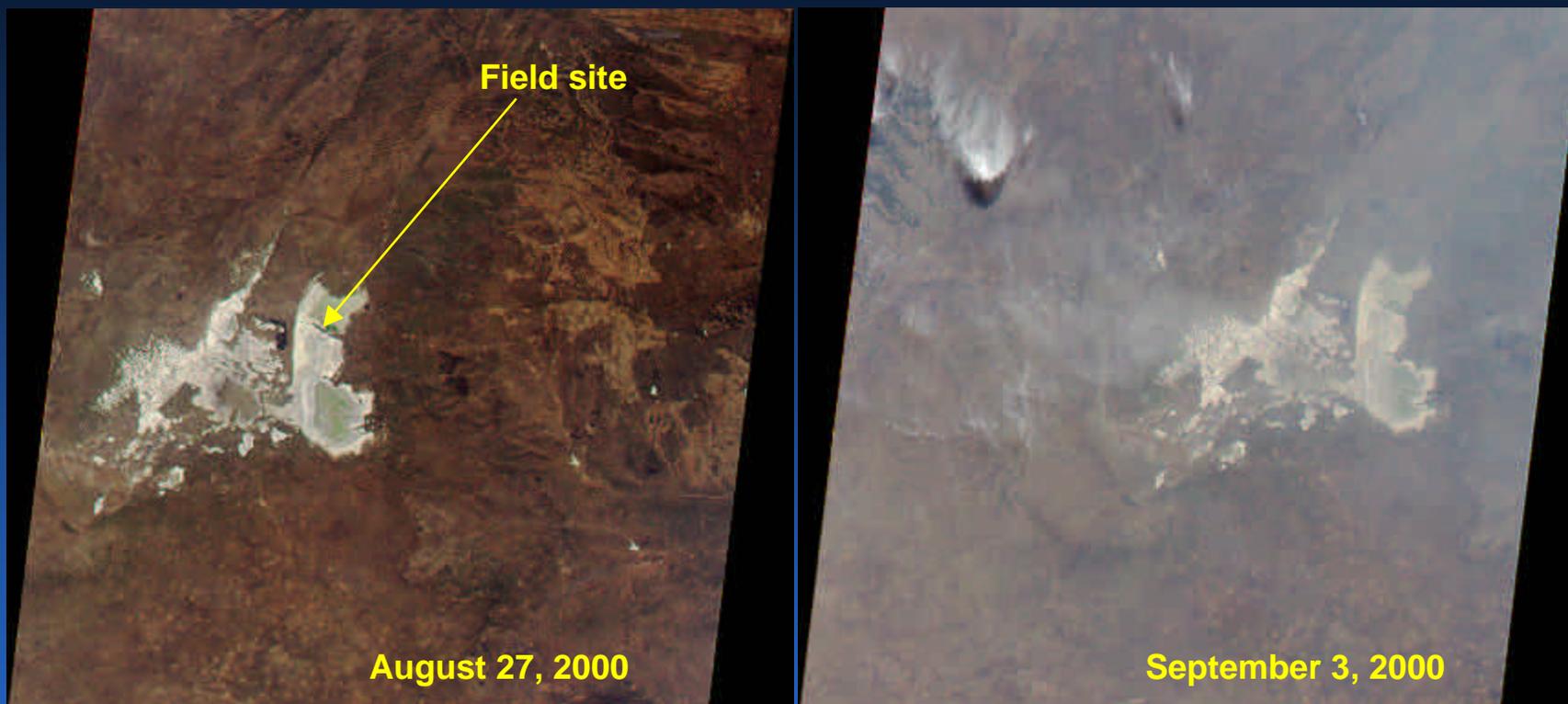


MISR characterizes the heterogeneity of land surface vegetation. Vegetation “clumpiness” is an important parameter in ecological models.

Acknowledgment:

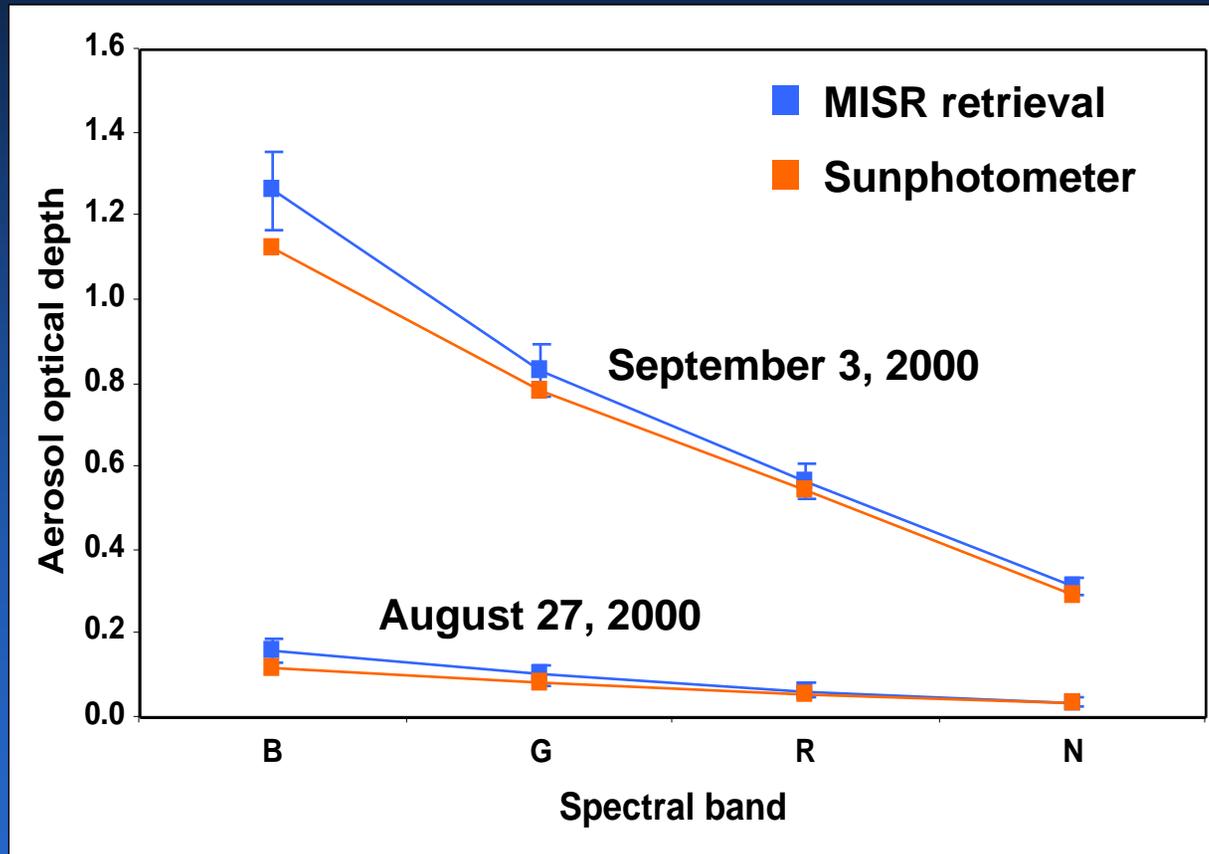
B. Pinty, N. Gobron, J-L. Widlowski, M. Verstraete, JRC

## Vicinity of Sua Pan, Botswana



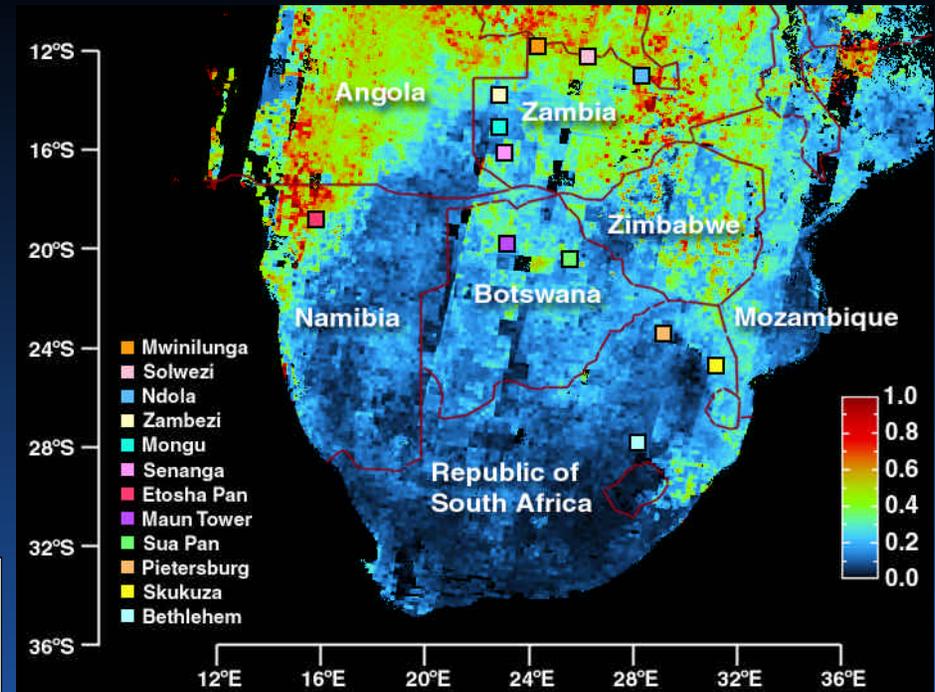
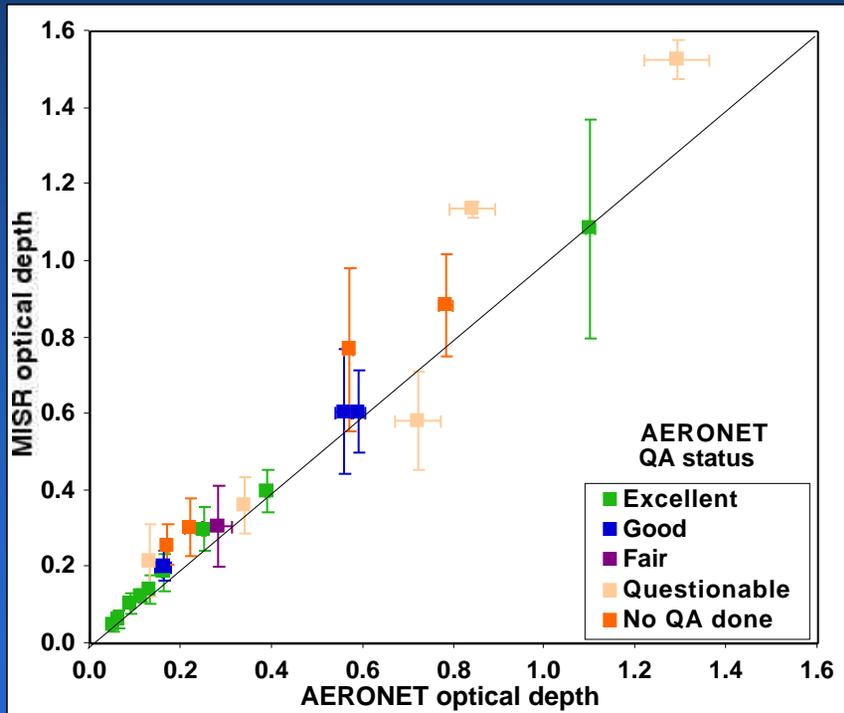
46°-aft MISR top-of-atmosphere images

# MISR optical depth retrieval Sua Pan, Botswana



# MISR optical depth retrievals

Southern Africa  
14 August - 29 September 2000



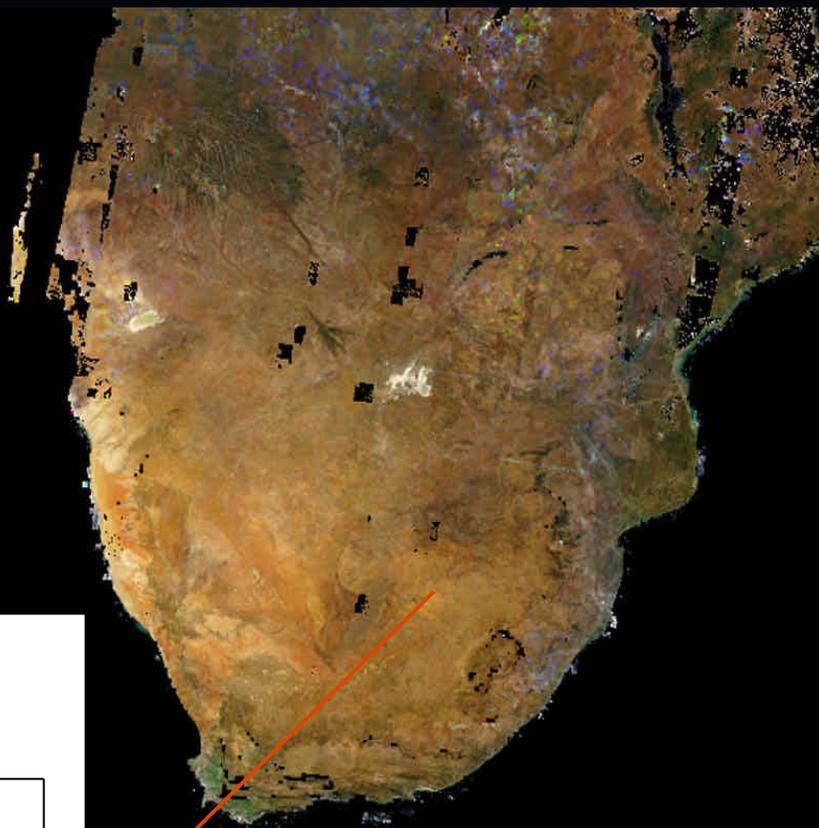
558-nm optical depths

*AEROSOL ROBOTIC NETWORK*

AERONET data: B. Holben and M. Helmlinger

# Retrieved surface albedo and directional reflectance

Southern Africa  
14 August -29 September 2000

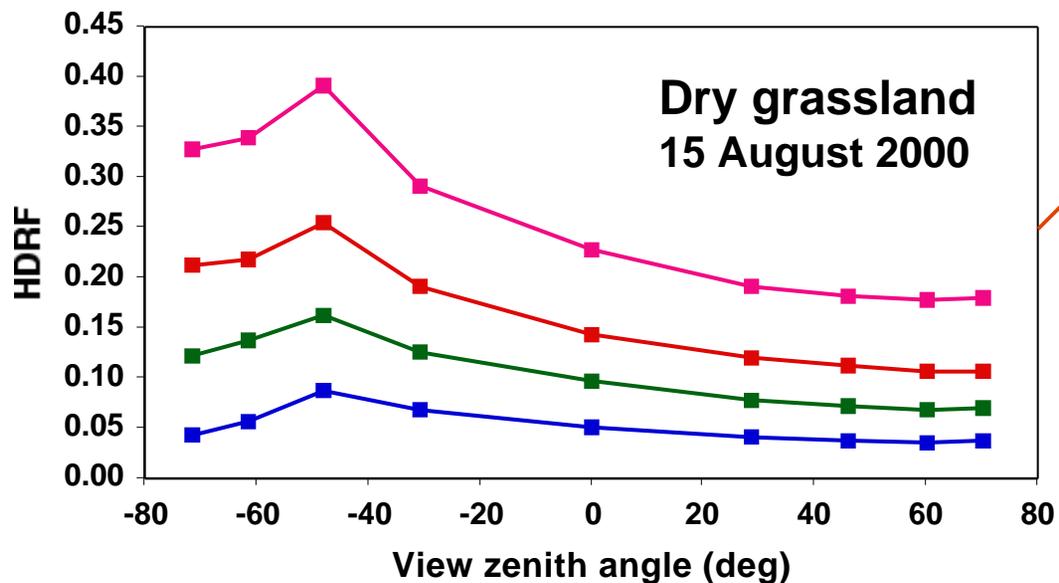


directional hemispherical reflectance (albedo)

hemispherical-directional reflectance factor (HDRF) shows canopy "hot spot"

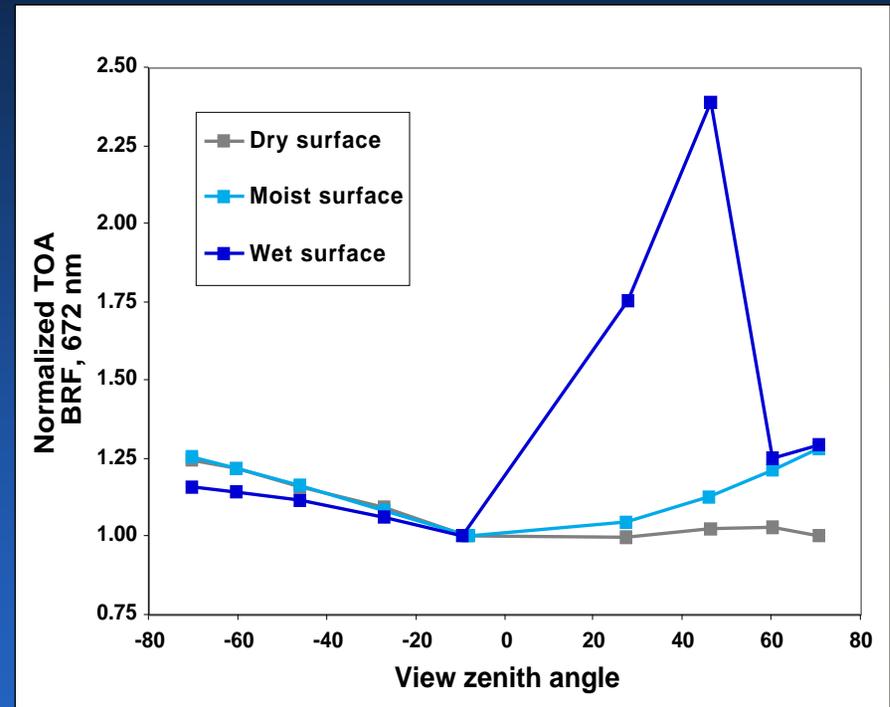
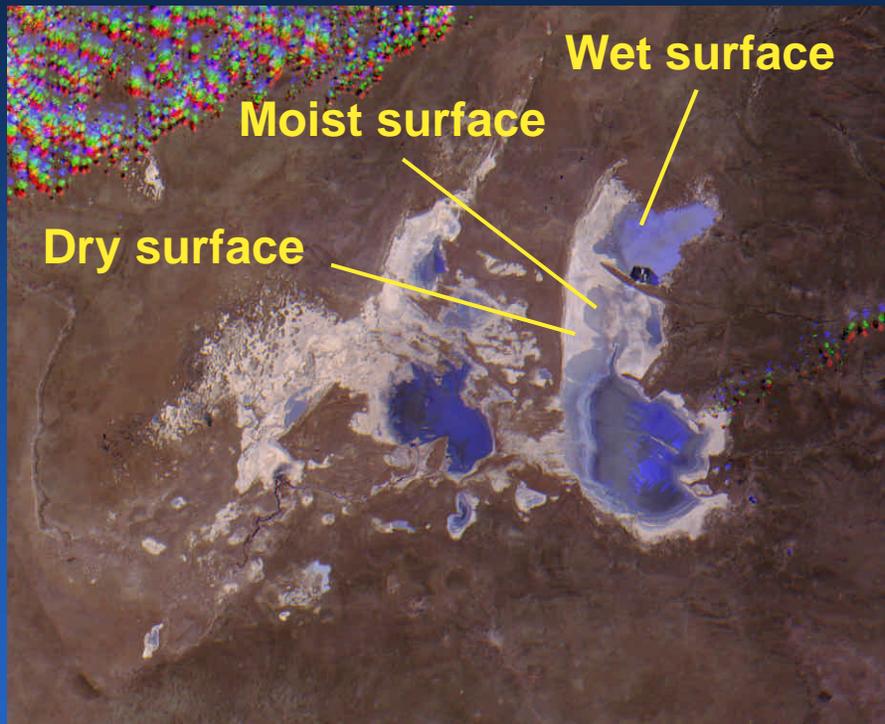
DRY GRASSLAND, SOUTH AFRICA

Blue Green Red Near-IR



# Surface wetness effects on bidirectional reflectance

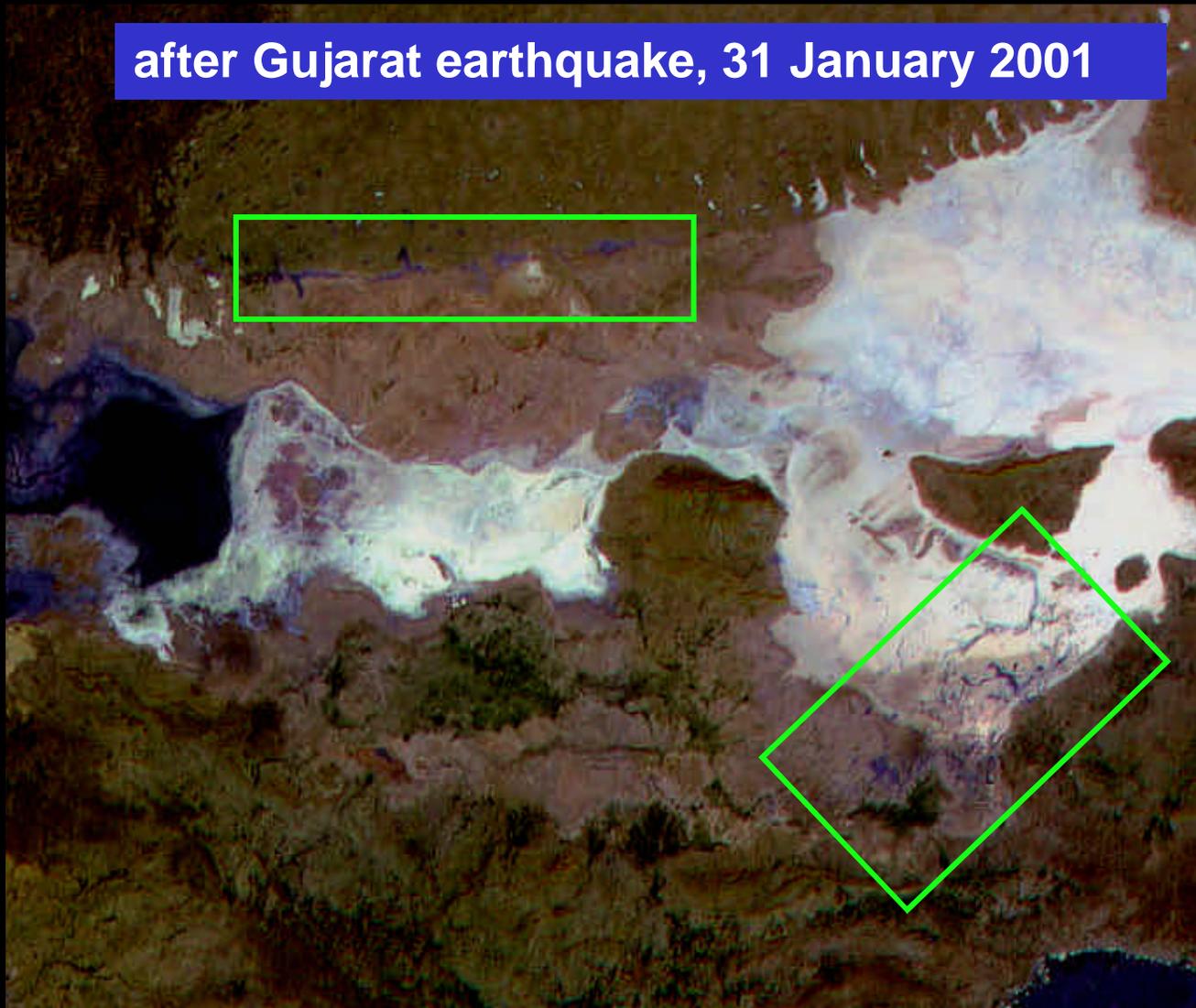
## Sua Pan, Botswana, 18 August 2000



Multi-angle false color

RGB = backscatter, nadir, forward scatter

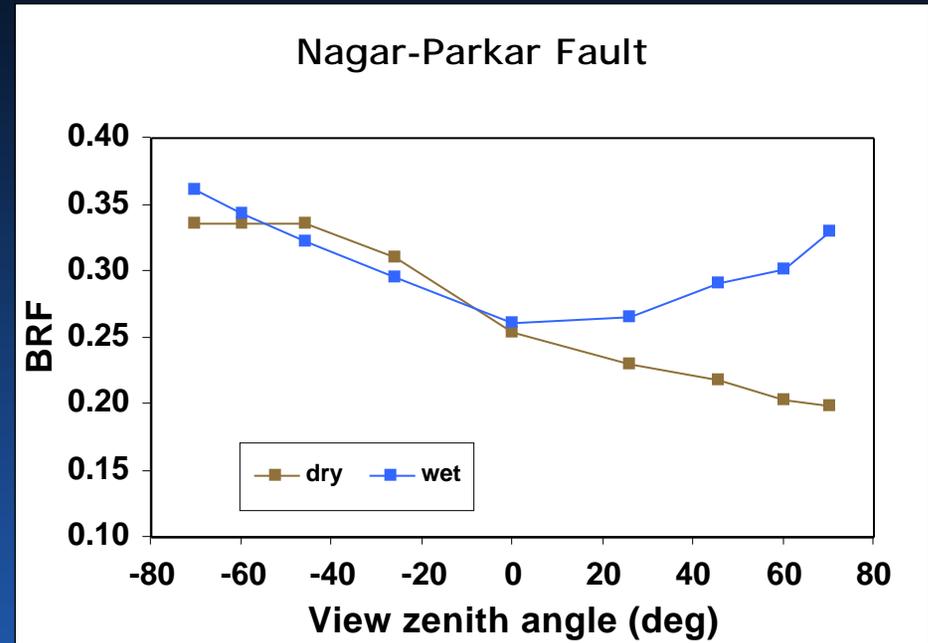
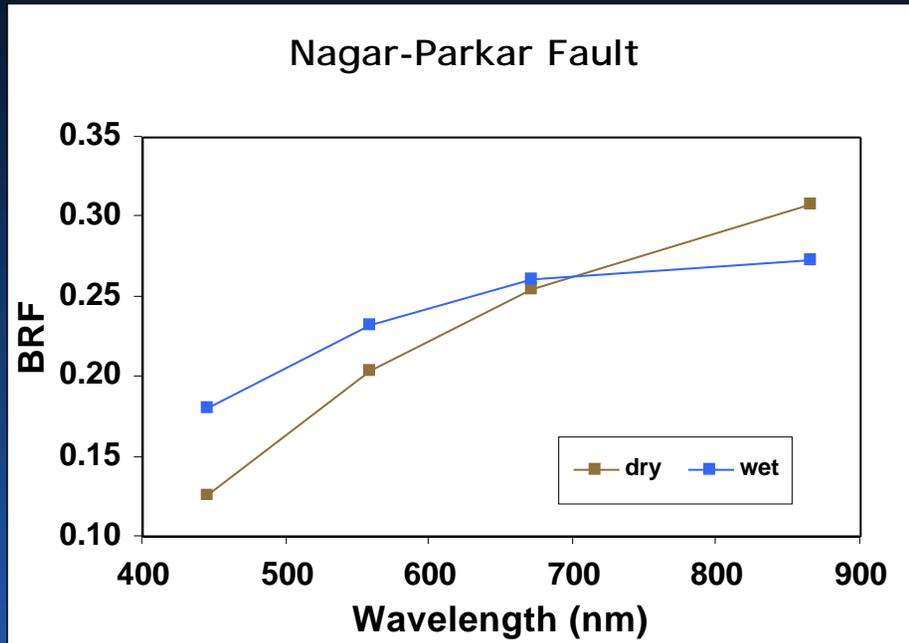
after Gujarat earthquake, 31 January 2001



Thar Desert,  
Pakistan  
and  
the Rann of  
Kachchh, India

RGB = 70° backward, nadir, 70° forward

# Identifying surface liquefaction



“Wet” denotes an area where suspected liquefaction was present in imagery from 9 February 2001 and absent on 24 January

“Dry” is a nearby background area

Surface water provides a forward scattering signal which is readily detectable in MISR bidirectional reflectances.

# Differentiating surface vegetation via angular signatures

Gulf coast wetlands along the Pascagoula, Mobile-Tensaw, and Escambia Rivers are *spectrally* similar to surrounding vegetation but have a distinctive *angular* signature.



nadir  
true color



nadir  
near-infrared  
false color

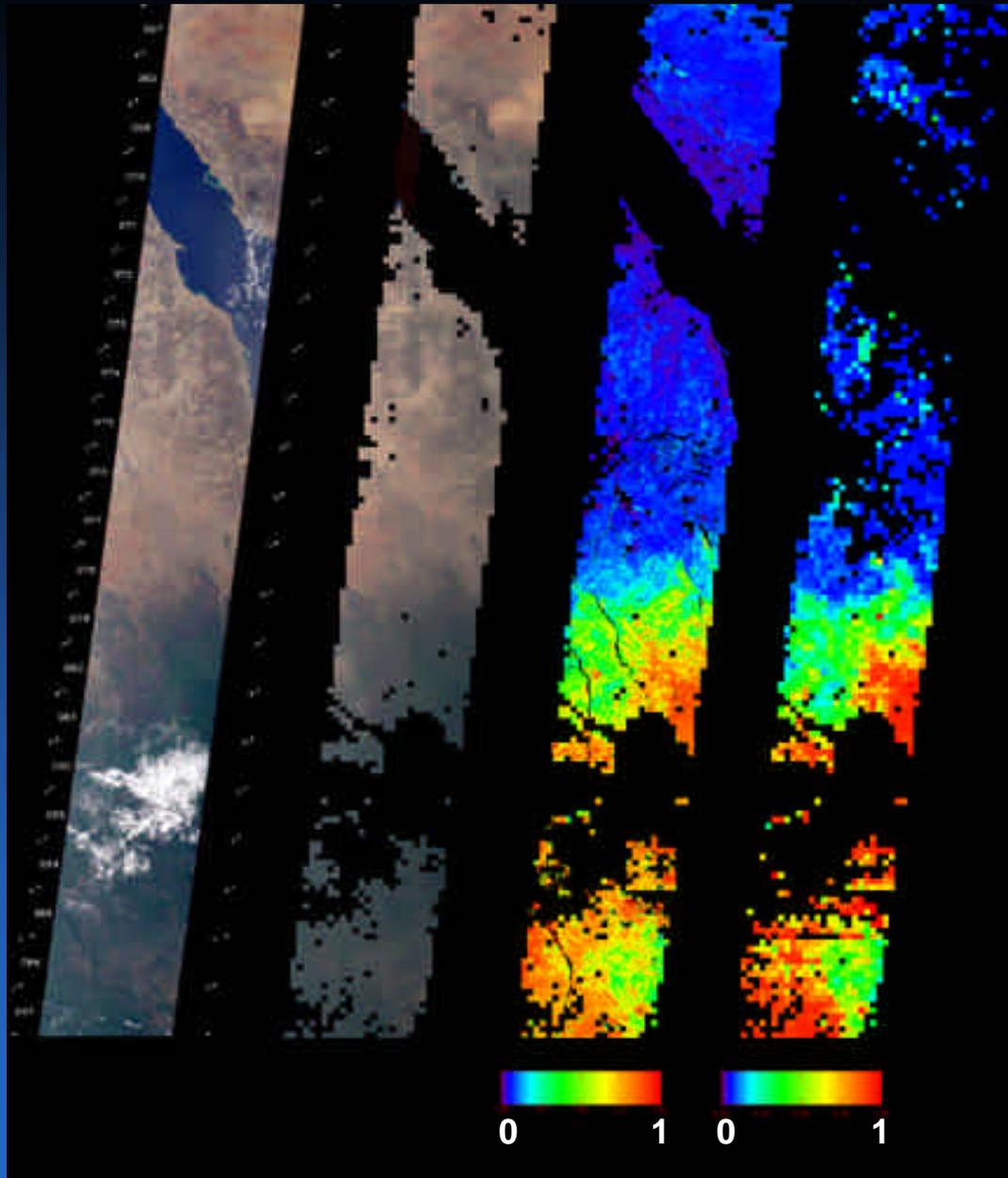


multi-angle  
false color  
60° fwd,  
nadir,  
60° backwd

Mississippi, Alabama, Florida  
15 October 2001

# Saudi Arabia and Sudan

18 September 2002



A

B

C

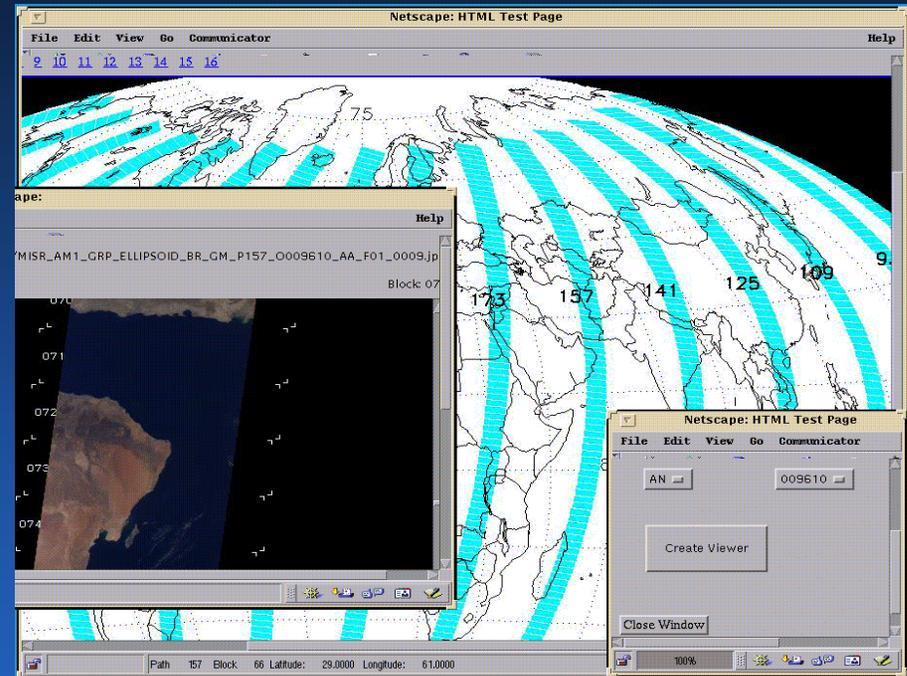
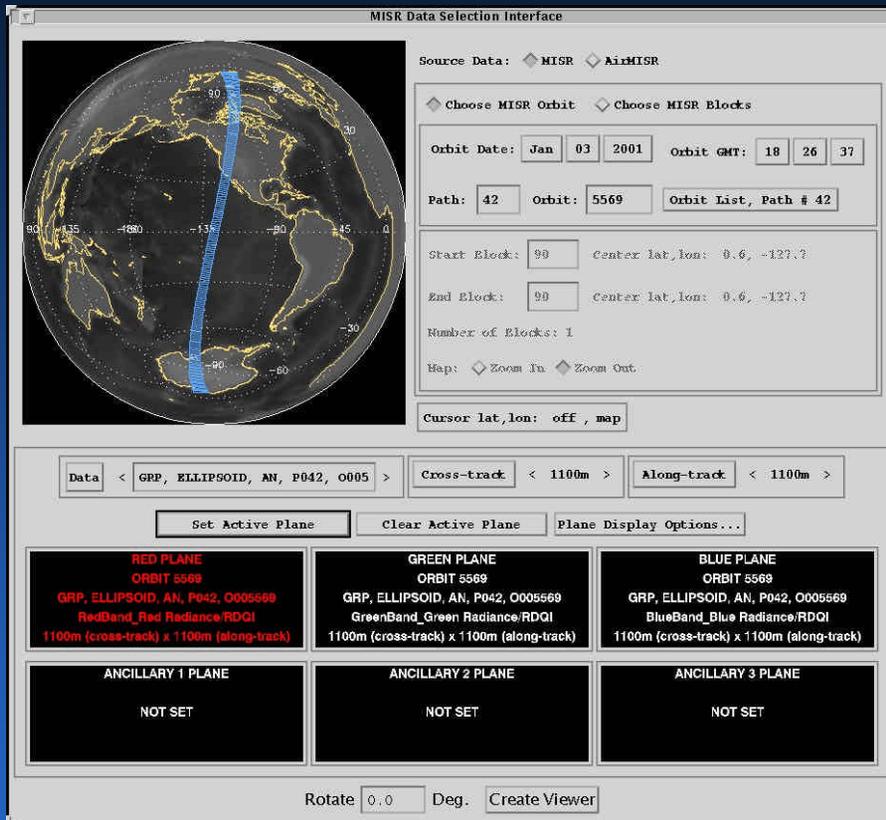
D

- A. Nadir TOA radiance
- B. Cloud-screened nadir TOA reflectance
- C. Retrieved albedo-based NDVI
- D. Retrieved FPAR

MISR FPAR retrievals are independent of NDVI

Use retrieved albedos, bidirectional reflectances, and vegetation canopy models

# Data visualization and analysis tools



Color, multi-angle browse products  
and on-line interactive viewer  
<http://eosweb.larc.nasa.gov/MISRBR/>

- **misr\_view (IDL-based)**
- **HDF-to-binary converter**
- **HDF-EOS to GeoTIFF converter**

[http://eosweb.larc.nasa.gov/PRODOCS/misr/misr\\_tools.html](http://eosweb.larc.nasa.gov/PRODOCS/misr/misr_tools.html)

# Conclusions



**Multi-angle remote sensing using bidirectional reflectance imagery is a new technique with many remote sensing applications**

**MISR data products and tools are publicly available through the NASA Langley Atmospheric Sciences Data Center**  
***<http://eosweb.larc.nasa.gov>***

**For more information about MISR:**  
***<http://www-misr.jpl.nasa.gov>***

**To get help: LaRC DAAC User Services**  
***[larc@eos.nasa.gov](mailto:larc@eos.nasa.gov)***

**To learn more:**

**“Special Section on MISR” in July 2002**  
***IEEE Transactions on Geoscience and Remote Sensing***  
**17 papers about the instrument, data products, calibration, retrieval methods, and results**