LECTURE AND COMPUTER TUTORIAL ON MULTI-ANGLE IMAGING SPECTRORADIOMETER (MISR) SATELLITE IMAGE DATA PRODUCTS

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QUANTITATIVE RESEARCH METHODS IN HUMAN DIMENSIONS OF ENVIRONMENTAL CHANGE WITHIN EASTERN EUROPE

Vidzeme University College

Valmiera, Latvia, August 2010

Vidzemes Augstskola
UNIVERSITY OF APPLIED SCIENCES

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SESSION OUTLINE

1. MISR OVERVIEW, OBSERVATIONAL PRINCIPLES

EOS missions; rationale for multi-angle measurements; MISR standard products, basic principles and nomenclature; surface anisotropy; angular signature;

3. COMPUTER TUTORIAL ON MISR SATELLITE IMAGE DATA PRODUCTS

obtaining data, MISR browse tool and subsetting procedures; data extraction and processing; solving problems; information about reprojection tools

5. SUMMARY

Terra launch, 18 Dec., 1999

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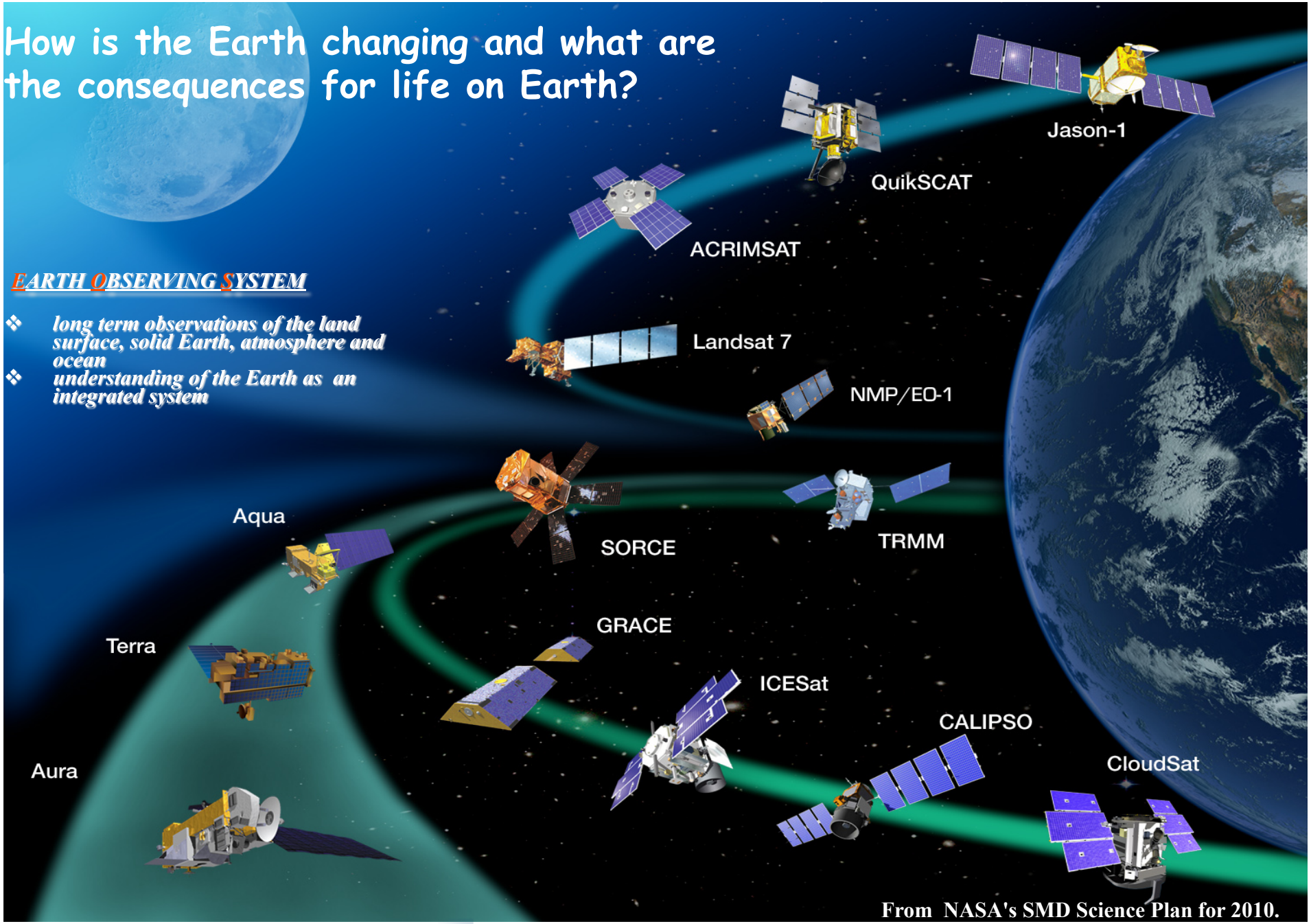
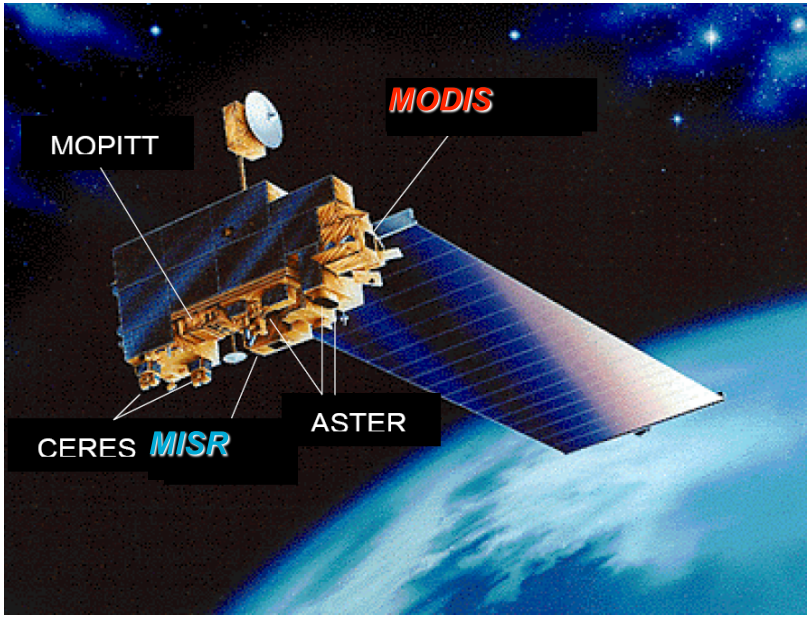
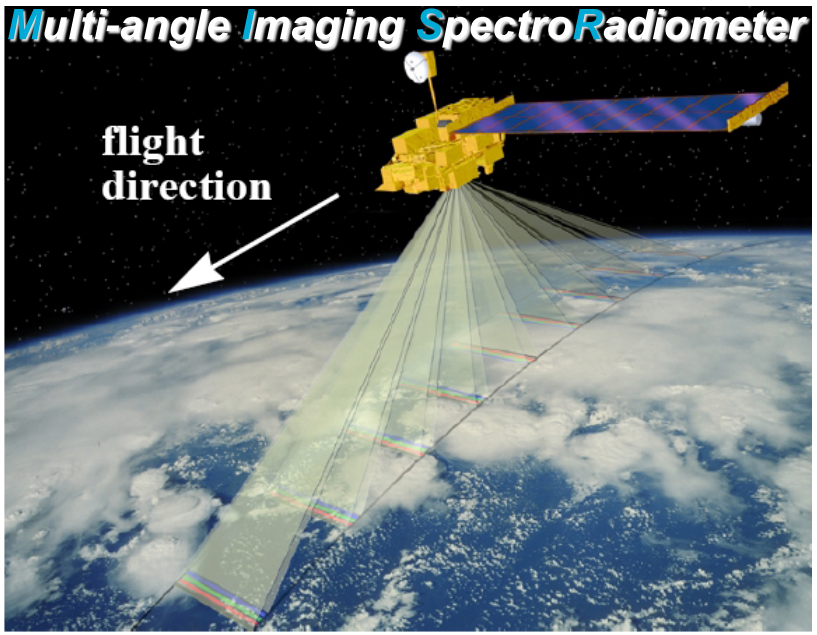
NASA OPERATING MISSIONS

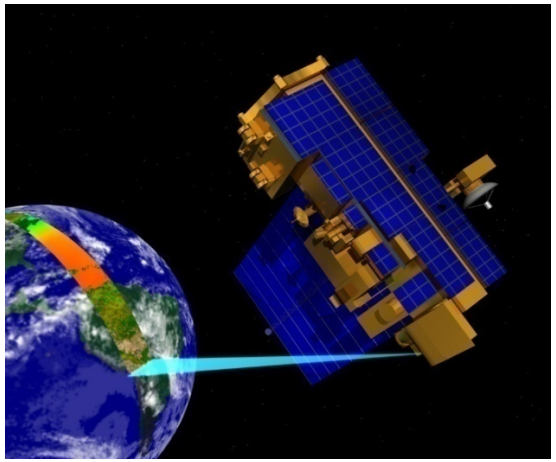


EOS TERRA MISSION





MODerate resolution Imaging Spectroradiometer



MODIS:

- measures reflected solar and emitted thermal radiation in 36 spectral bands
- 2300 km across track swath width
- global coverage every one to two days
- 250, 500 and 1000 m resolutions

MISR:

- measures reflected solar radiation at nine discrete viewing angles and four visible/near-infrared spectral bands
- 360 km swath width
- coverage in 9 days at the equator and 2 days near the poles
- 275, 550 and 1100 m resolutions

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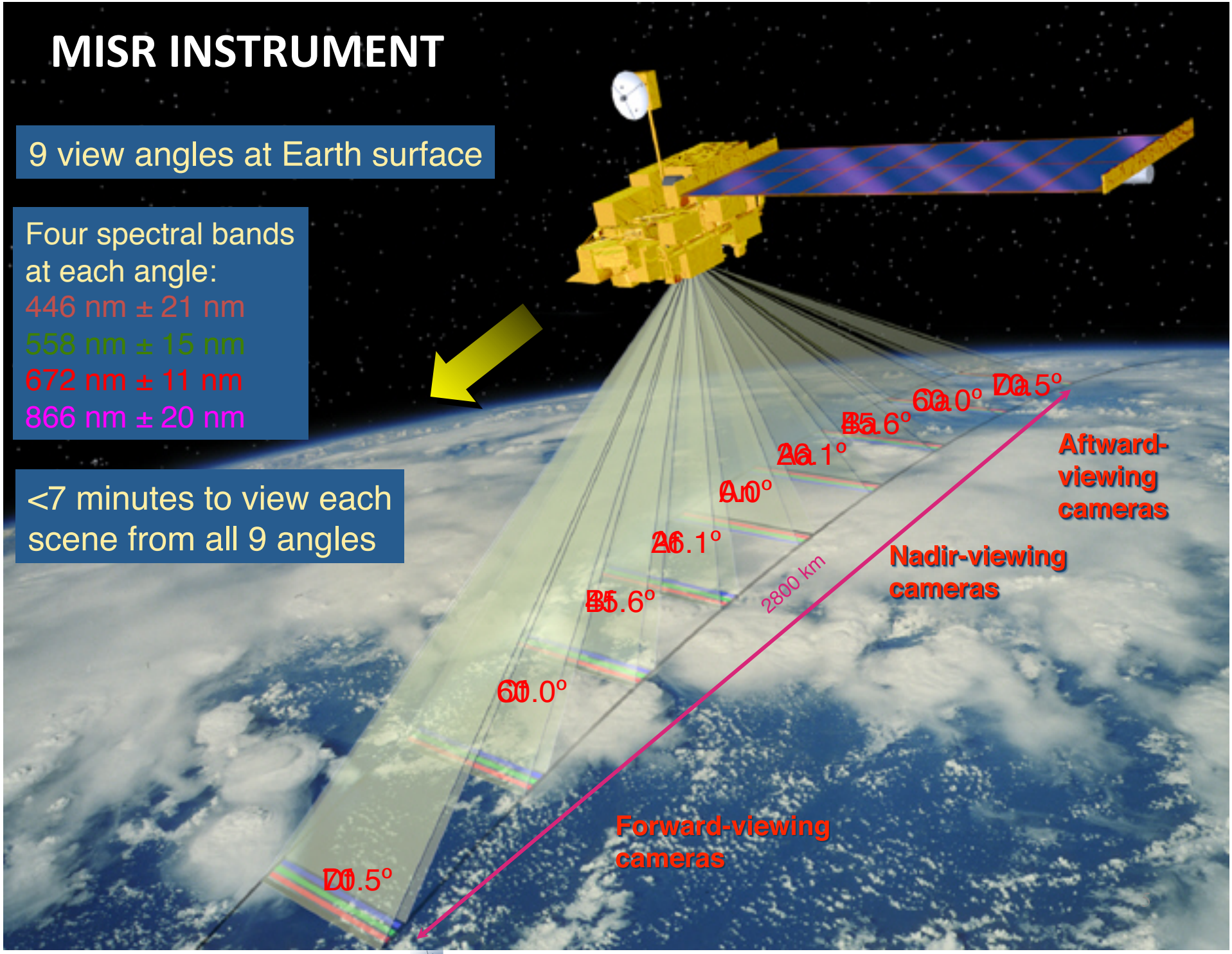
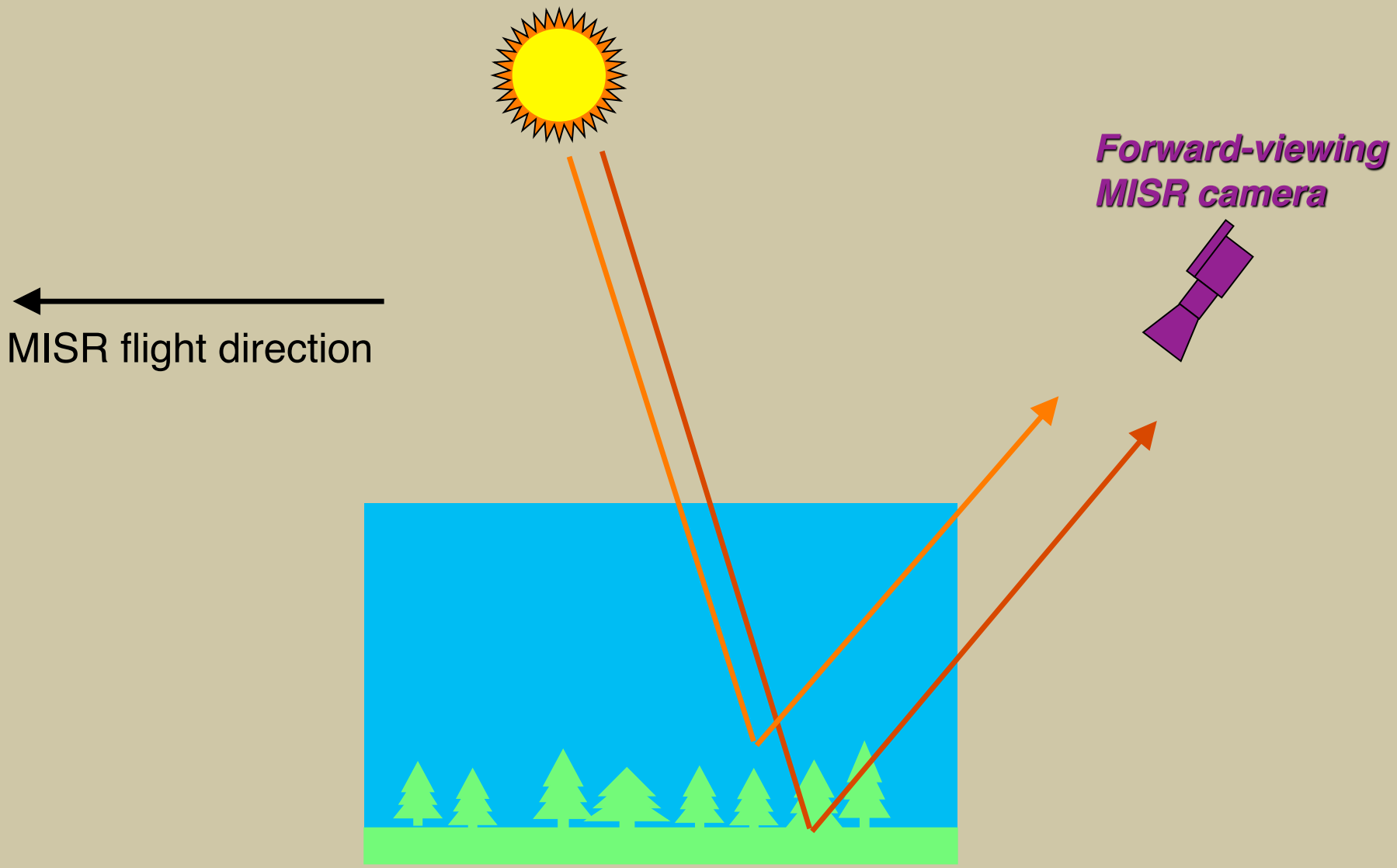

MISR INSTRUMENT
9 view angles at Earth surface
Four spectral bands at each angle:
446 nm ± 21 nm
558 nm ± 15 nm
672 nm ± 11 nm
866 nm ± 20 nm
<7 minutes to view each scene from all 9 angles
Aftward-viewing cameras
Nadir-viewing cameras
Forward-viewing cameras
2800 km

EFFECT: SCENE BRIGHTNESS CHANGES WITH ANGLE



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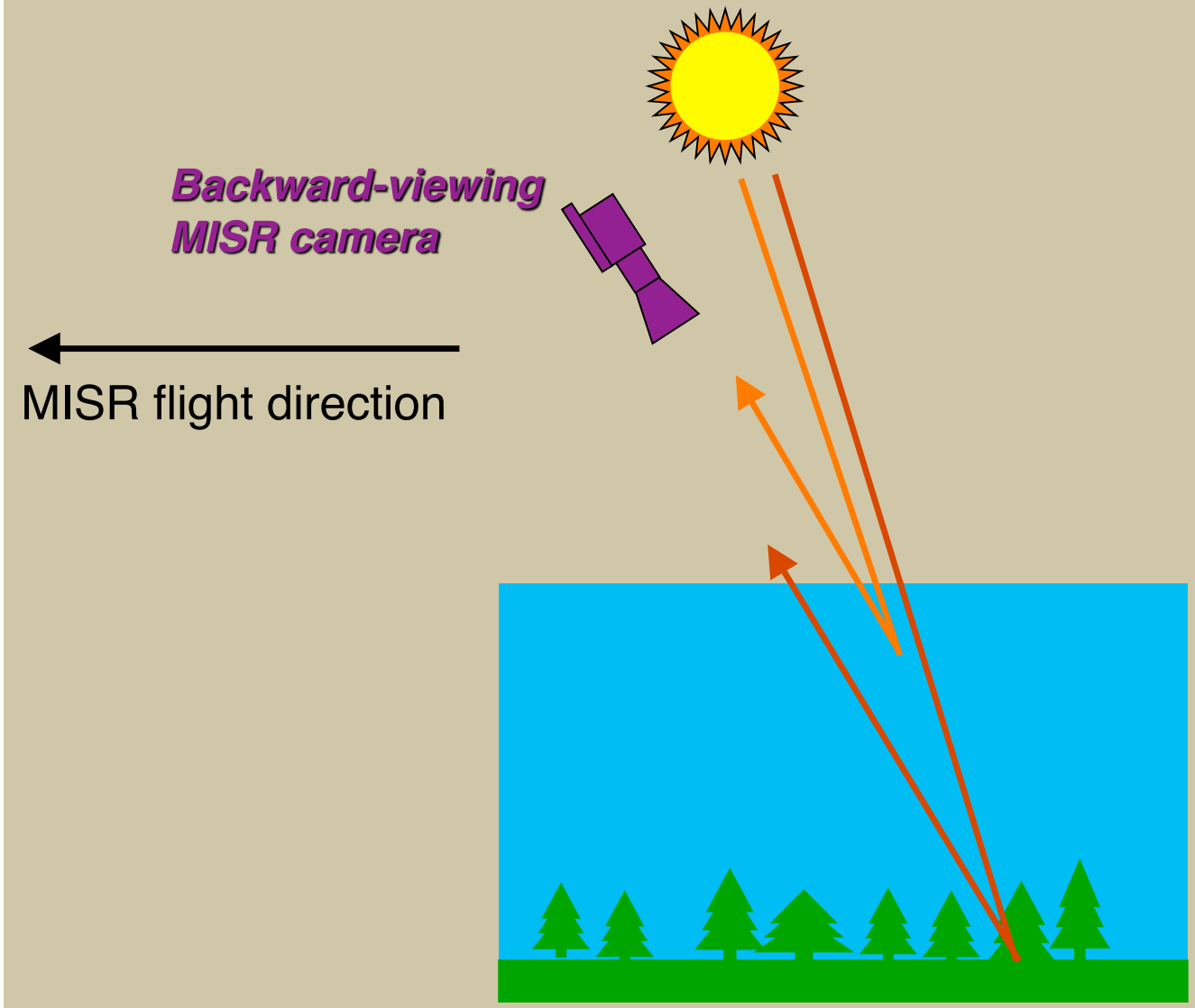
EFFECT: SCENE BRIGHTNESS CHANGES WITH ANGLE



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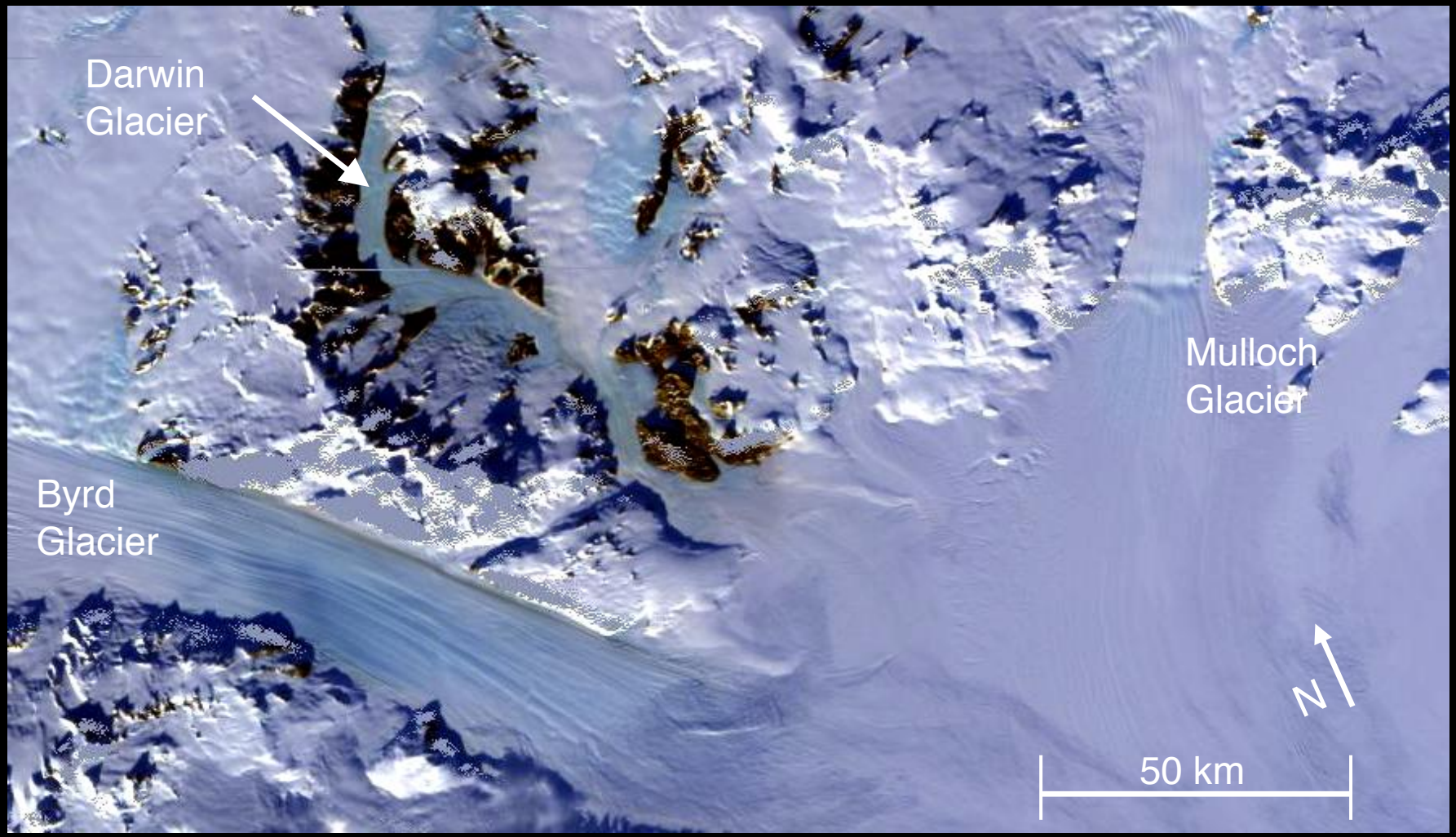
ANTARCTICA, 27 JANUARY 2001



A. Nolin et al. (2002) IEEE TGARS 40

nadir true color

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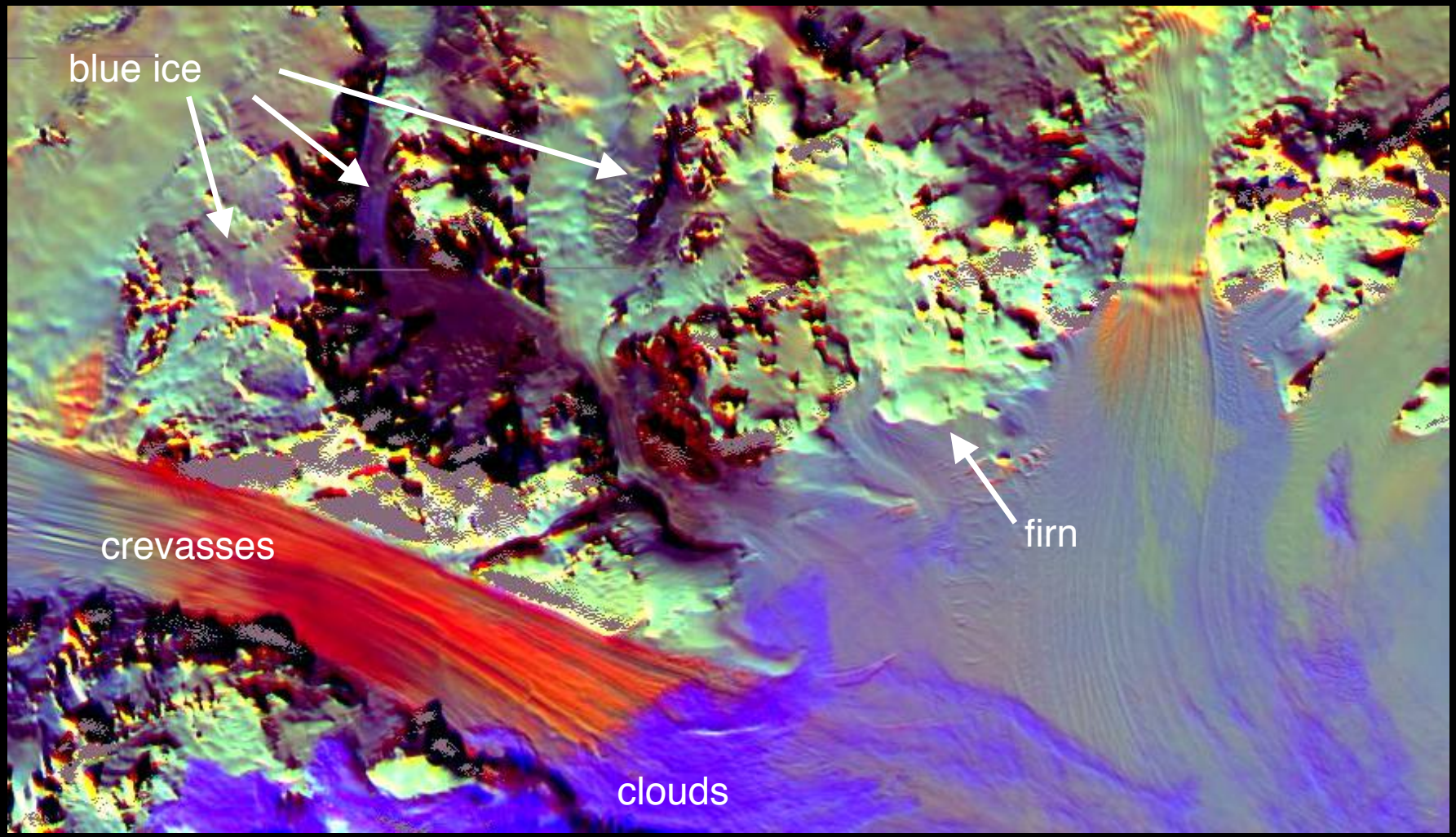
ANTARCTICA, 27 JANUARY 2001



red = +70.5° green = 0° blue = -70.5°

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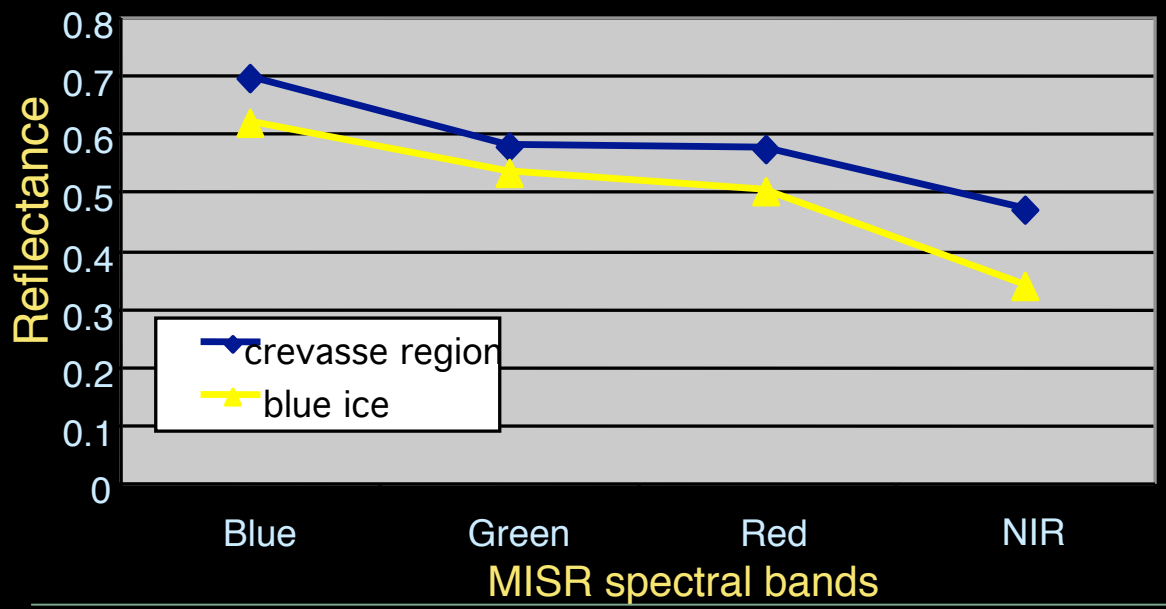
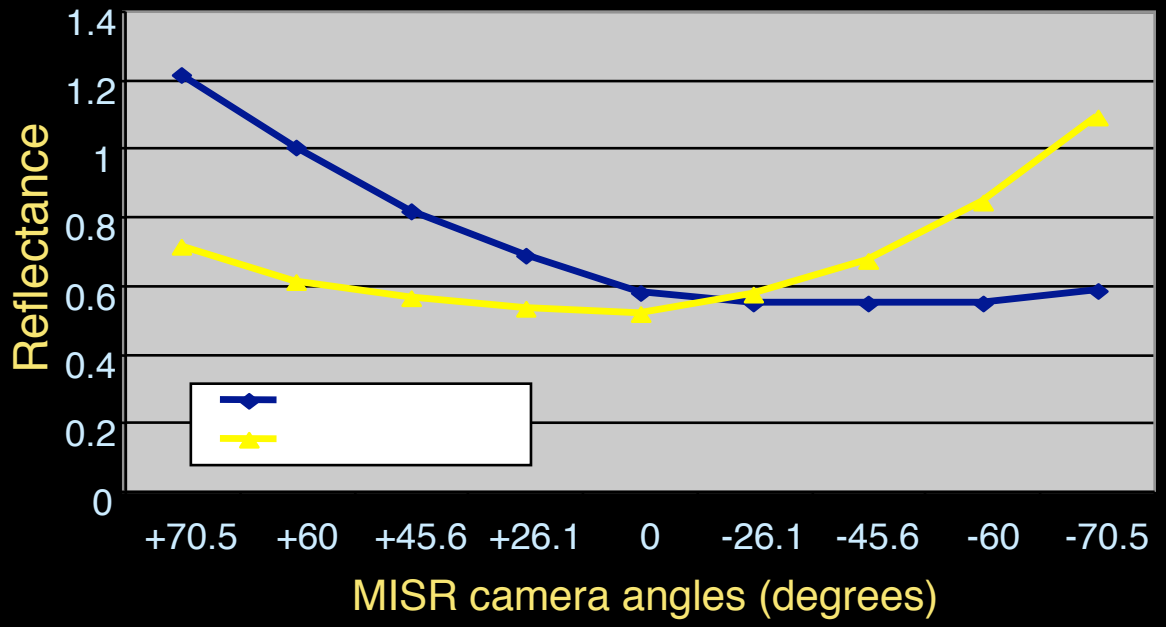
SPECTRAL VS. ANGULAR SIGNATURES OF ICE



Spectral
Little difference between blue ice and crevasse region



Angular
Strong difference between blue ice and crevasse region

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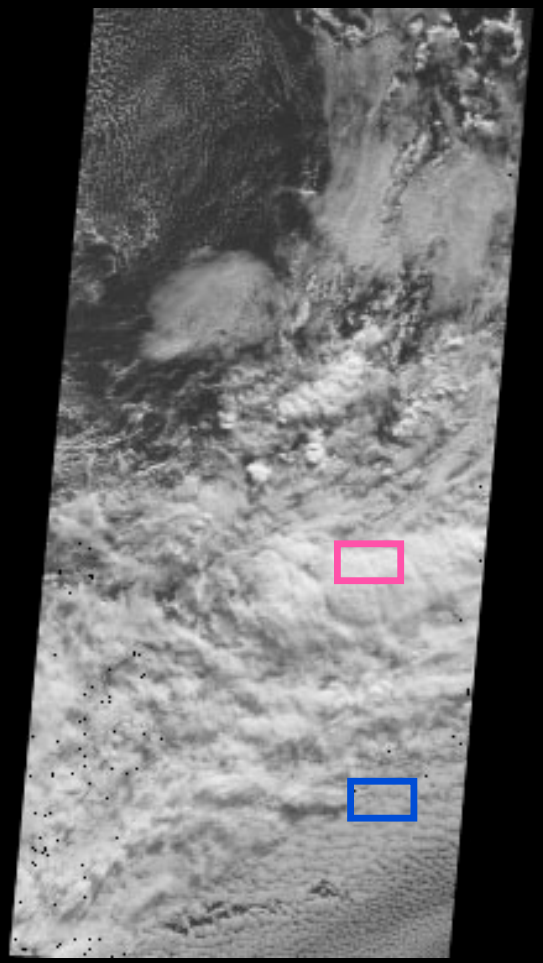
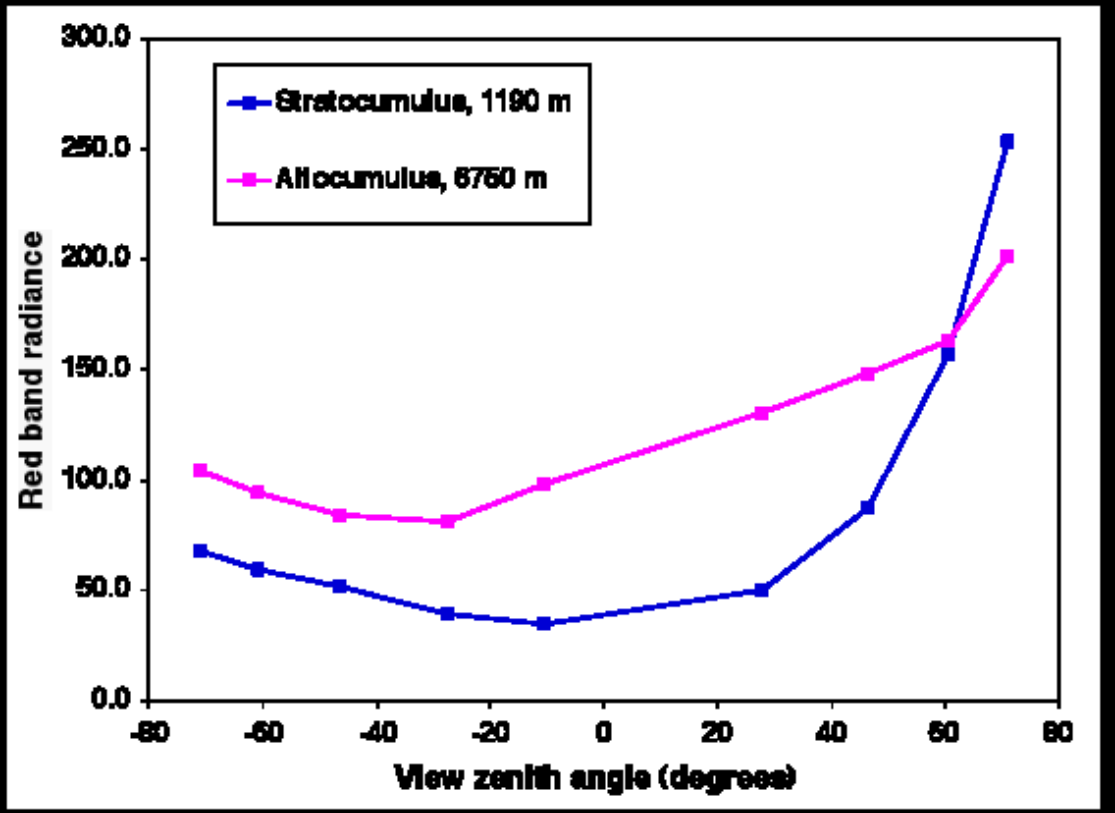
ANGULAR SIGNATURE OF CLOUDS





South Pacific
11 June 2000

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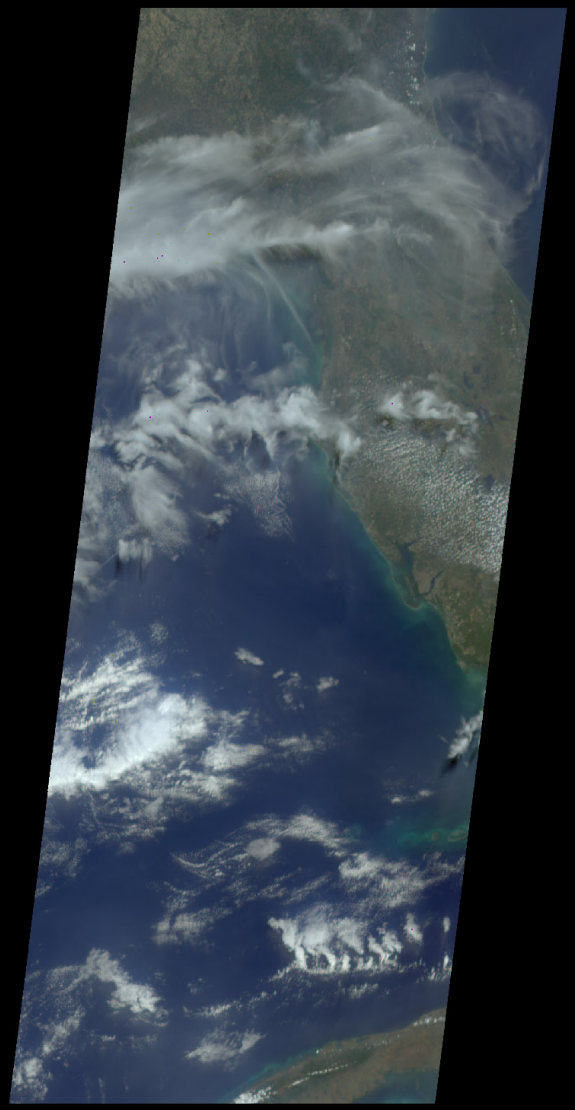

Clouds over
Florida and Cuba

6 March 2000

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Hurricane Carlotta thunderclouds

19 August 2000

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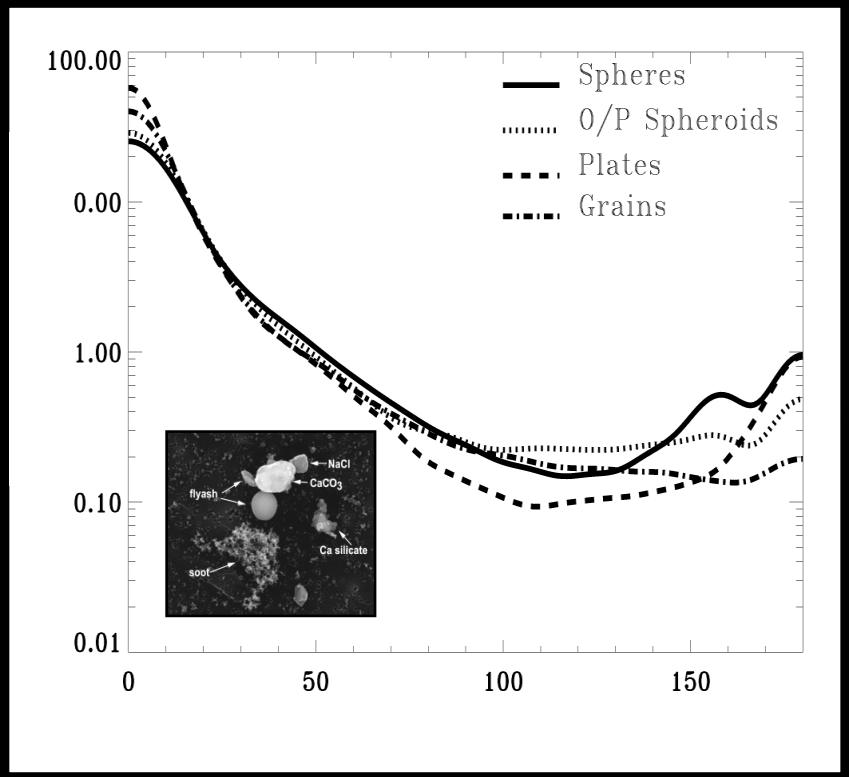
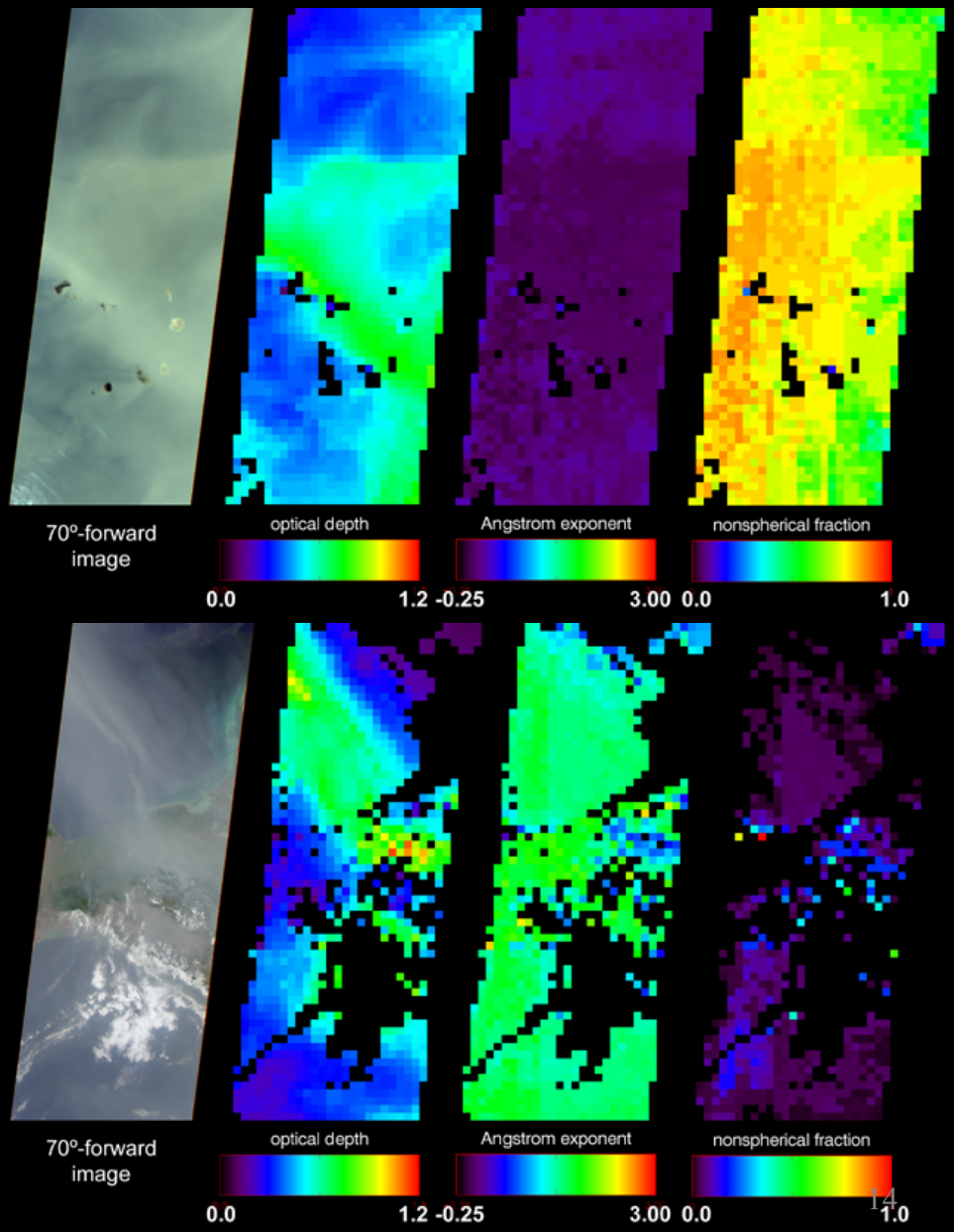
MISR SENSITIVITY TO AEROSOL PARTICLE PROPERTIES





O. Kalashnikova et al. (2005), JGR

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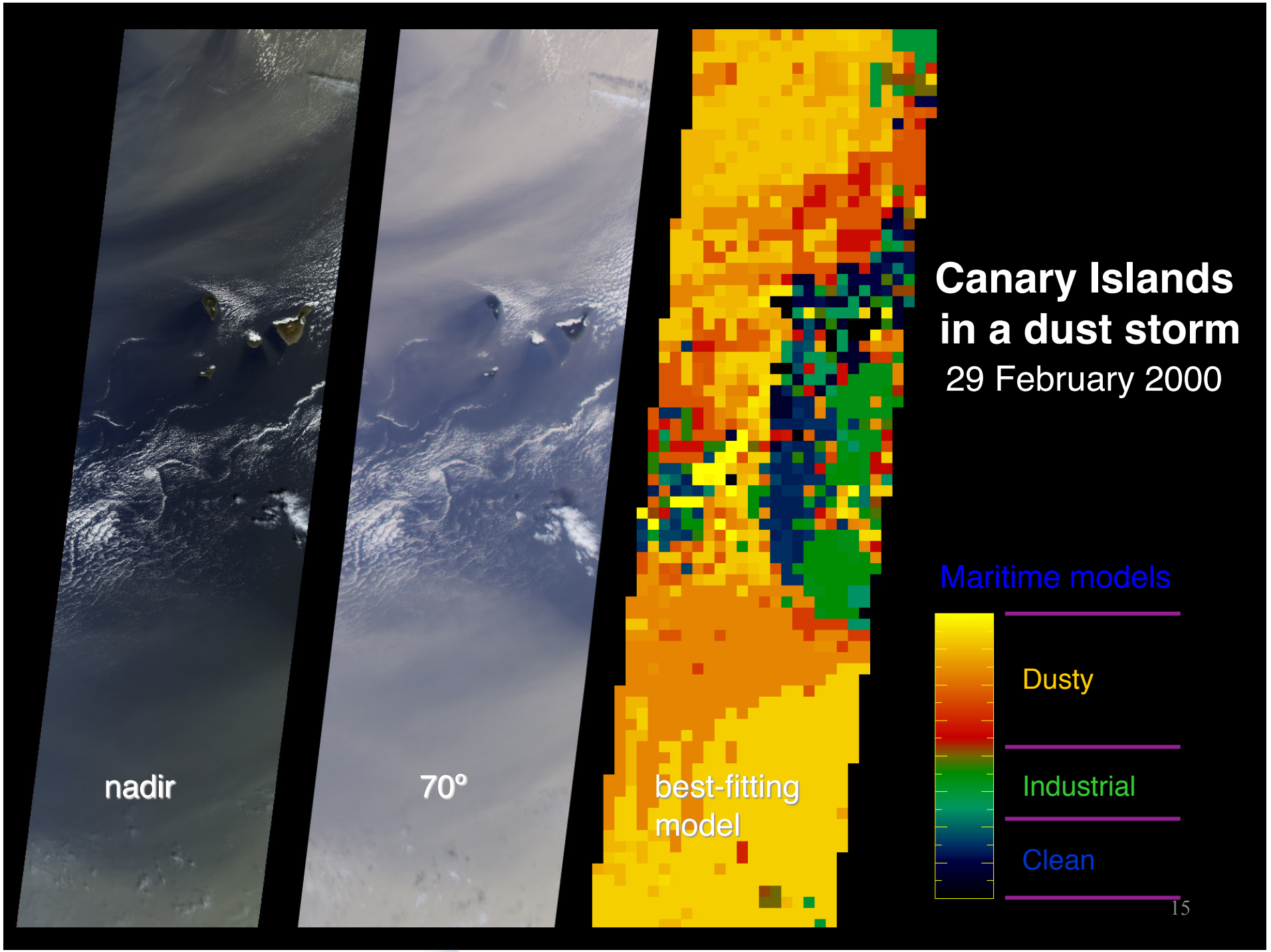

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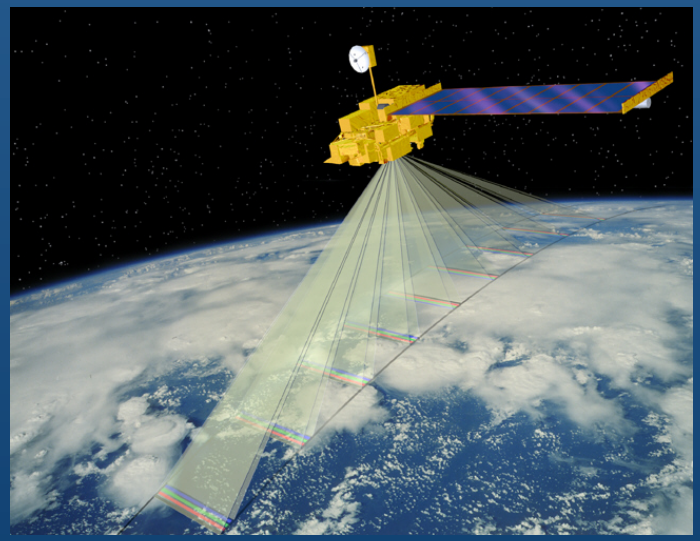
RATIONALE FOR MULTI-ANGLE MEASUREMENTS

1. Change in reflectance with angle distinguishes different types of aerosols, and surface structure



2. Oblique slant paths through the atmosphere enhance sensitivity to aerosols and thin cirrus

3. Stereo imaging provides geometric heights of clouds and aerosol plumes

4. Time lapse from forward to backward views makes it possible to use clouds as tracers of winds aloft

5. Different angles of view enable sunglint avoidance or accentuation

6. Integration over angle is required to accurately estimate hemispherical reflectance (albedo)

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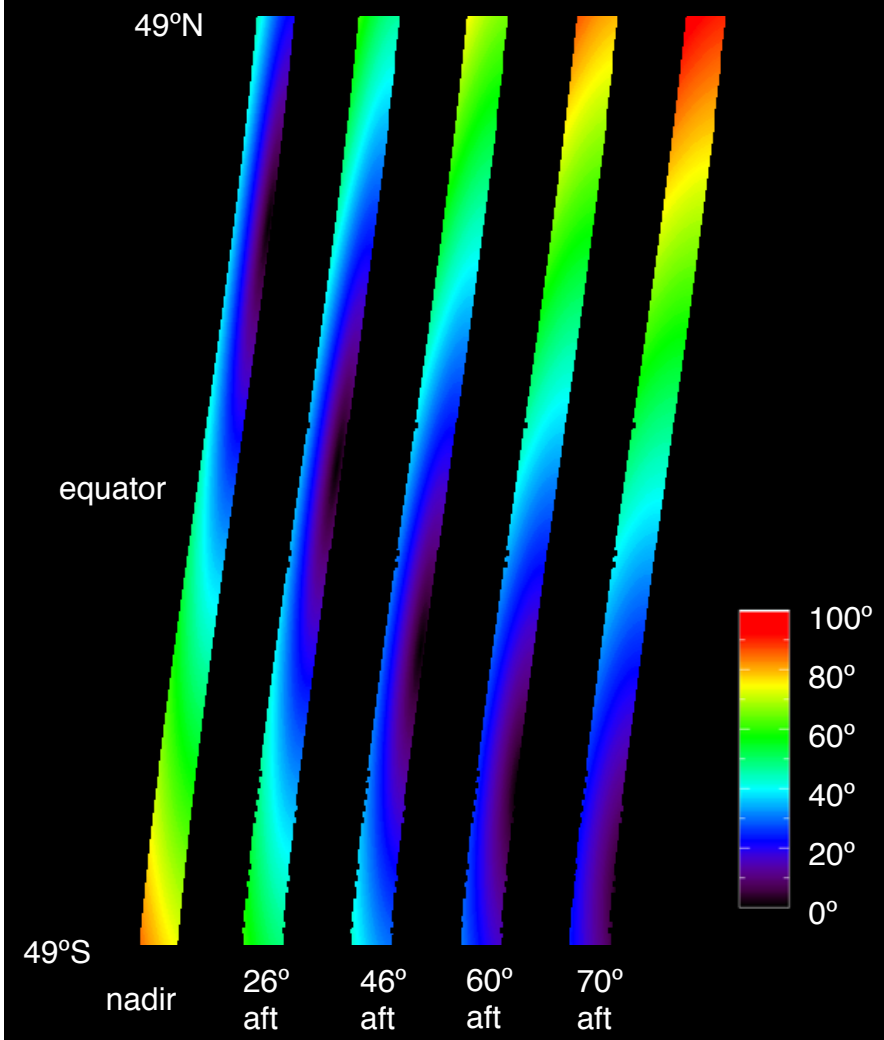
L1B2 Geometric Parameters

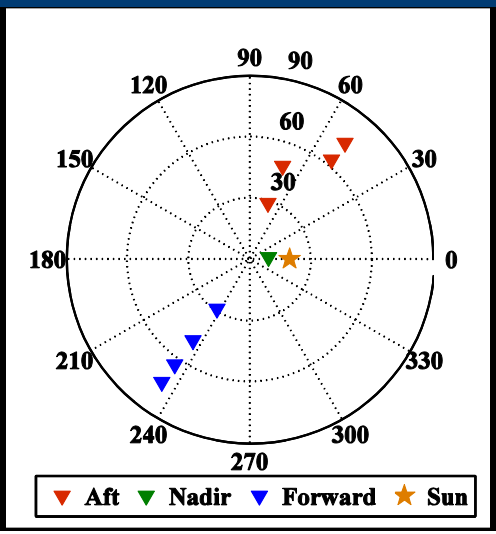
Provided on 17.6-km centers



CONTENTS

- View zenith and azimuth angles per camera; azimuths measured relative to local north
- Solar zenith and azimuth angles correspond to midpoint viewing time of only those cameras which observed the point
- Scatter and glitter angles also included in product

Example of glitter angle July 3



Level 2 Standard Products

Level 2 standard products

- Level 2TC stereo
- Level 2TC cloud classifiers
- Level 2TC top-of-atmosphere albedo
- Level 2AS aerosol
- **Level 2AS land surface**

Level 2 processing uses multiple cameras simultaneously

- Angular radiance signatures
- Geometric parallax
- Time lapse

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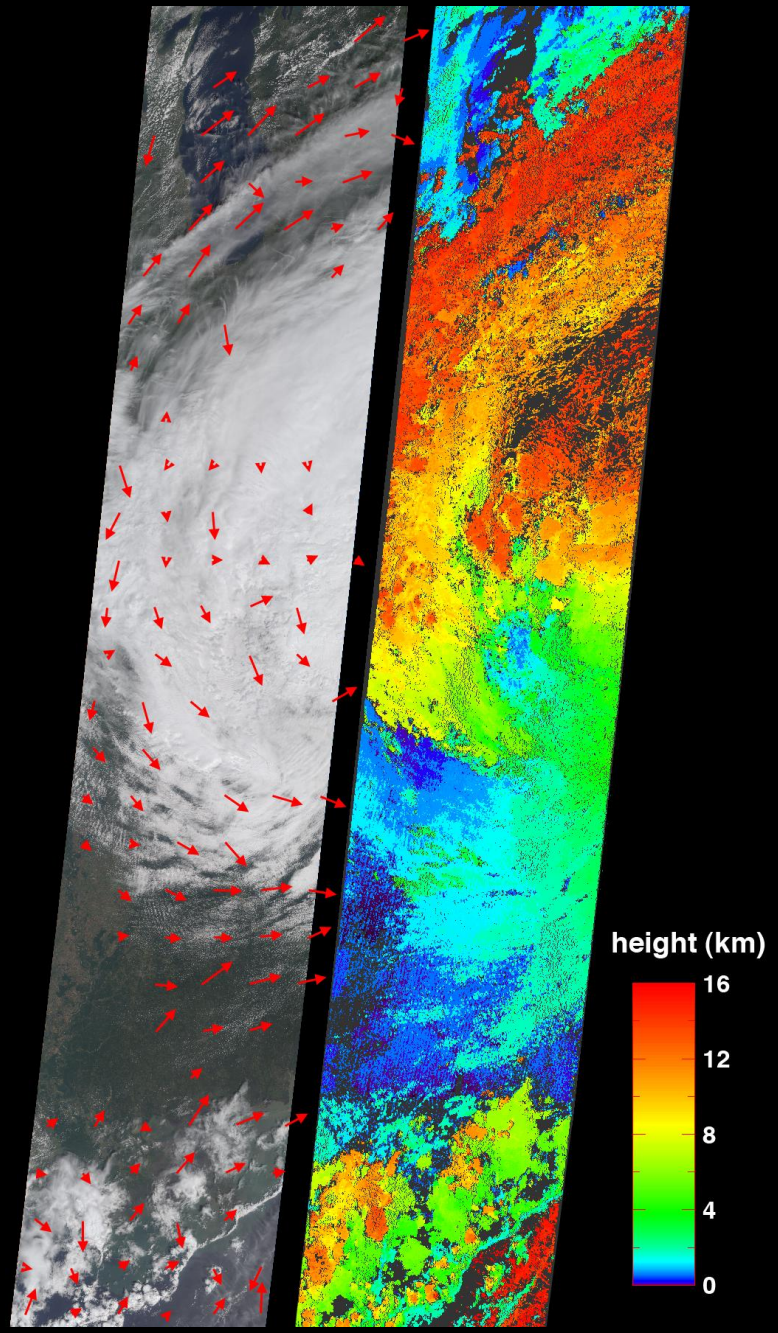
L2 TOA/Cloud Stereo Product

Cloud heights and cloud-tracked winds



HEIGHT ATTRIBUTES

- 1.1-km resolution
- Purely geometric retrievals of height
- Independent of temperature profiles and cloud emissivity
- Independent of radiometric calibration
- Accuracy 500 -1000 m

WIND ATTRIBUTES

- 70.4-km resolution
- Uses stereo triplets
- Accuracy 1-3 m/s with 300 m height resolution

Hurricane Katrina
30 August 2005

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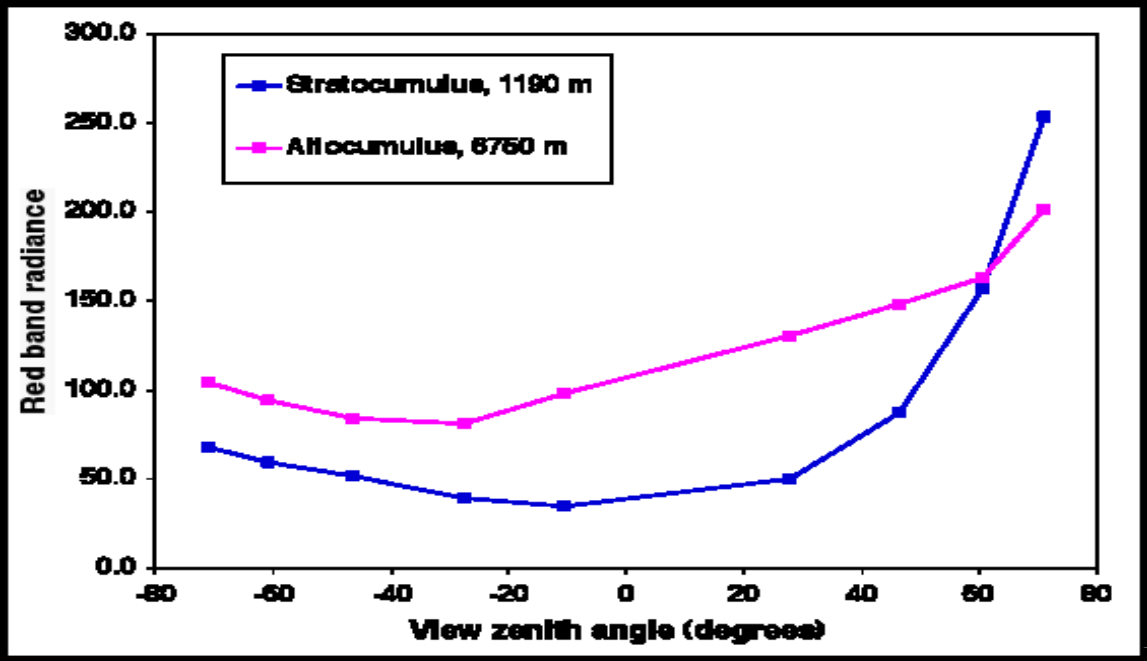
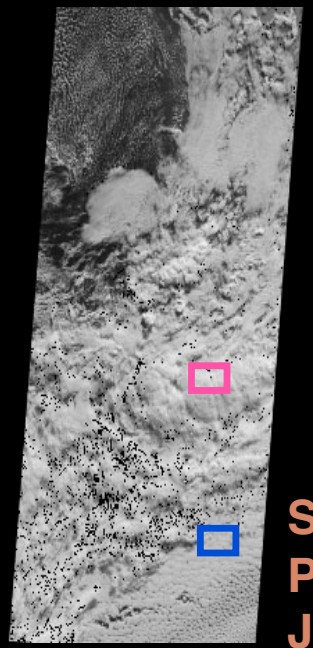
L2 TOA/Cloud Albedo Product

Cloud-top-projected TOA albedo and bidirectional reflectance





Southern Pacific Ocean, June 11, 2000

CONTENTS

- "Feature-referenced" top-of-atmosphere bidirectional reflectances
- Includes TOA albedos at fine (2.2. km) resolution for scene classification, and coarse (35.2 km resolution) for mesoscale radiation budget

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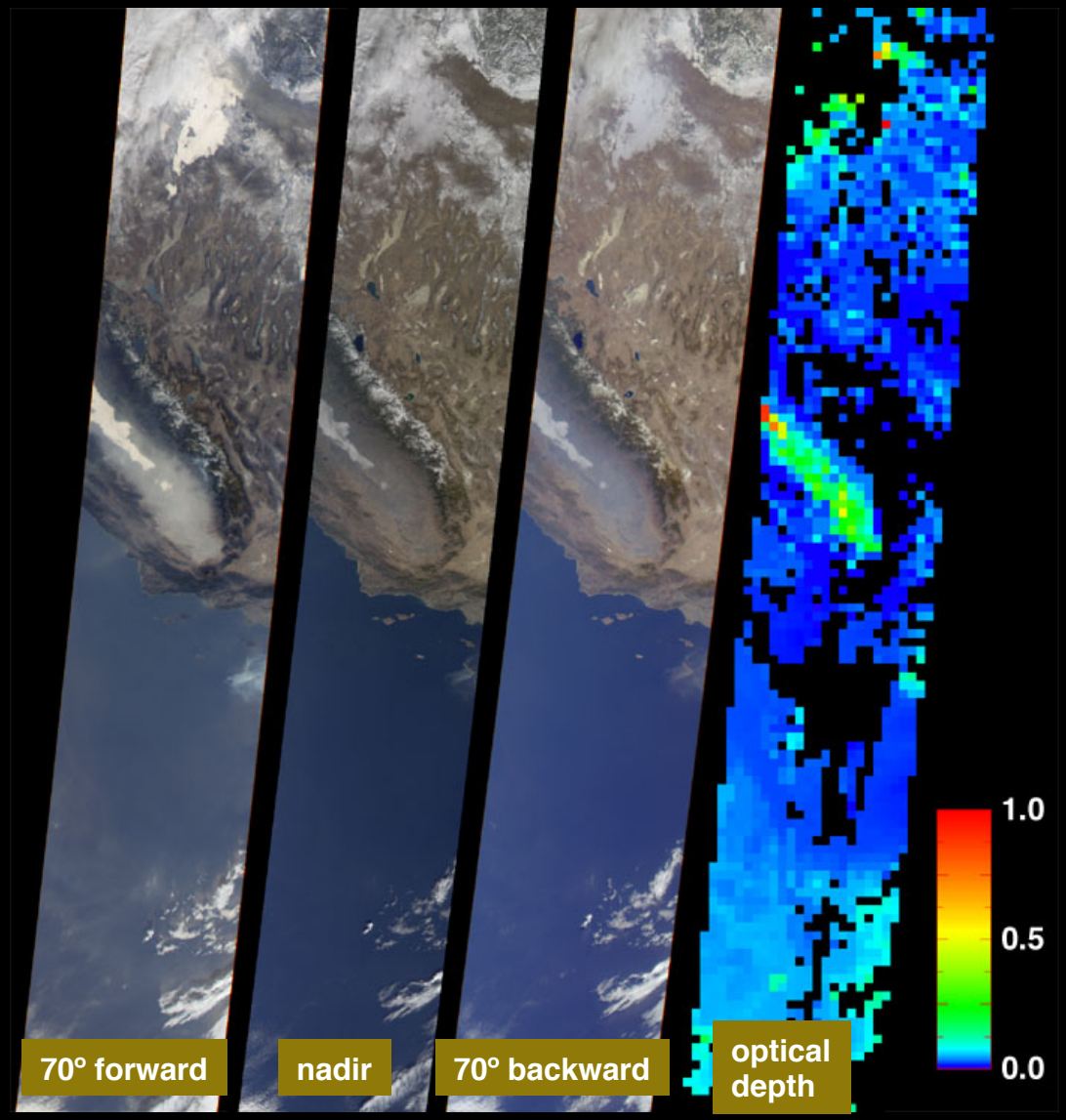
L2 Aerosol/Surface Product

Aerosol parameters



J. Martonchik et al. (2002), TGARS

ATTRIBUTES

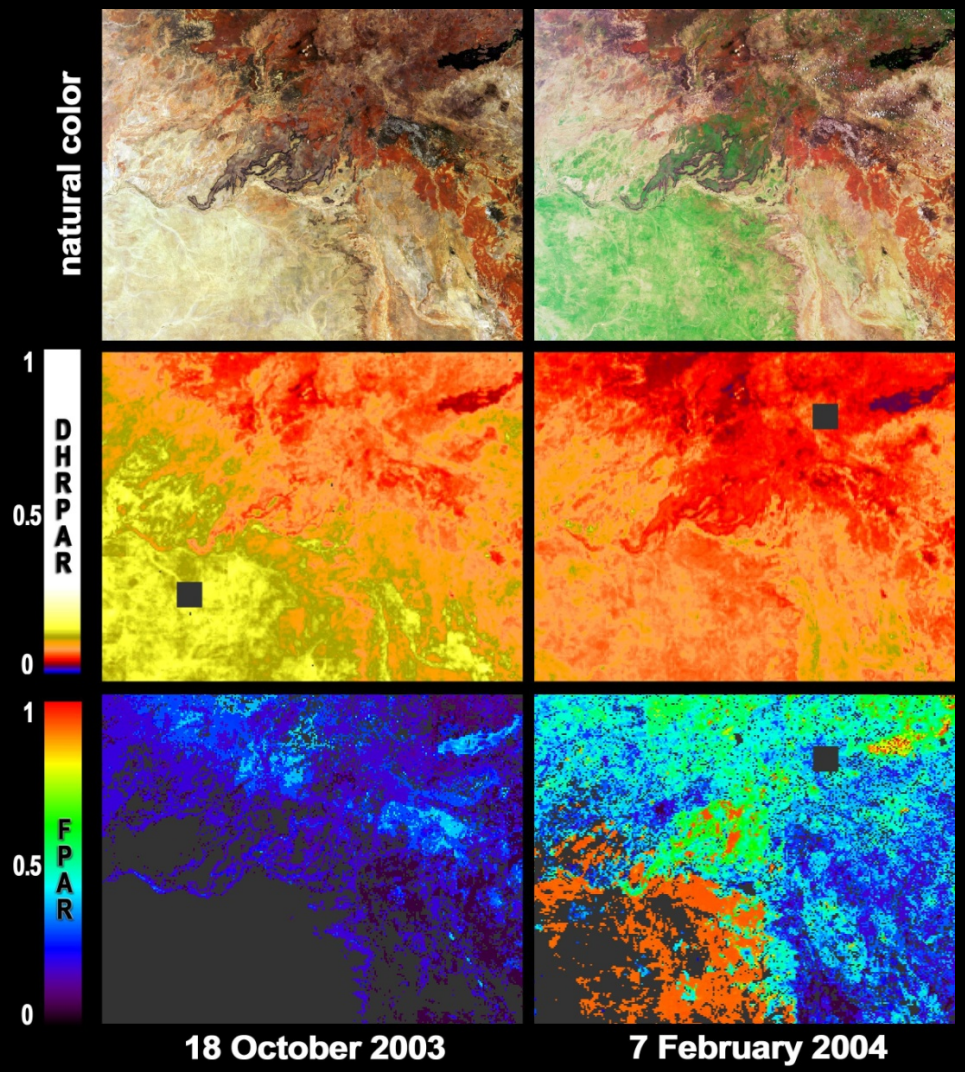
- Validation and quality assessment of aerosol optical depth performed
- Validation of aerosol particle properties in progress

  --Angstrom exponent
  --Size binned fractions
  --Single-scattering albedo
  --Sphericity

Southern California and Southwestern Nevada
January 3, 2001

L2 Aerosol/Surface Product

Surface parameters



CONTENTS AND ATTRIBUTES

- Radiometric surface parameters (directional reflectances, albedos)

  Derived from single overpass-- no temporal compositing

  Atmospherically corrected

- Vegetation-related quantities (albedo-based surface NDVI, LAI, FPAR)

  LAI-FPAR retrievals are based on 3-D RT models

  Prescribed biome map is not required

- BRF model parameters

Surface greening from summer rains in Northern Queensland

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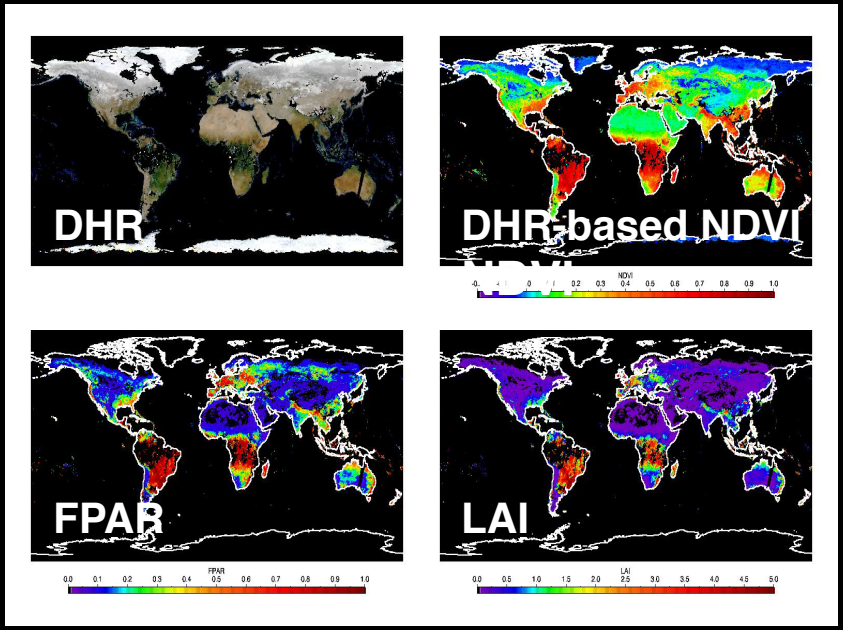
MISR Level 3 Global Data Products

(http://www-misr.jpl.nasa.gov/ click "VISUALIZATIONS")

- Means, variances, and covariances of select MISR Products over daily, monthly seasonal and annular time periods
- Reported on 0.5º x 0.5º and 1º x 1º rectangular grids



L3 Gridded Surface Properties

L3 Gridded

- Radiances
- Height-Resolved Winds
- Aerosol Properties
- **Surface Properties**

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basis

- Almost all natural terrestrial surfaces and media scatter shortwave radiation into an ANGULAR REFLECTANCE PATTERN whose magnitude and angular shape is governed by the *COMPOSITION*, *DENSITY*, *AND GEOMETRIC STRUCTURE* of the reflecting medium

- The term "reflectance" refers to the relative amount of scattering by a surface and is a function of the illumination and direction of reflected radiation.

- Standard nomenclature dictates that the angular characteristics of the illumination are mentioned first, followed by the angular characteristics of the reflected radiance.

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ILLUMINATION FROM A SINGLE DIRECTION

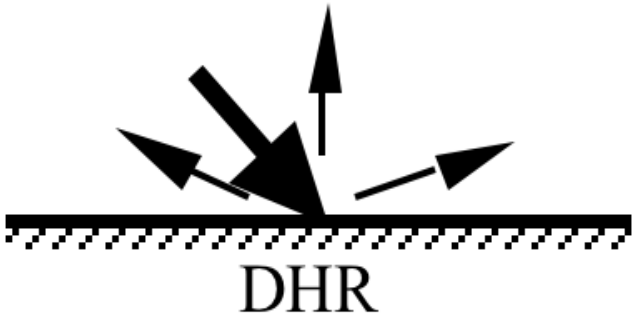
BRF, BRDF

BRF: Bidirectional Reflectance Factor (dimensionless)

the ratio of the reflected flux from a surface area in a particular direction to the reflected flux from an ideal lambertian surface of the same area and under the same conditions of reflection and illumination.

BRDF: Bidirectional Reflectance Distribution Function (in sr^{-1})

is just BRF multiplied by the reflectance of the reference lambertian surface. BRF and BRDF are independent of the atmosphere.



DHR

DHR: Directional-Hemispherical Reflectance (dimensionless)

the ratio of the flux for light reflected by a surface area into a hemisphere to the illumination flux when the target is illuminated with a parallel beam of light from a single direction.

BRF, BRDF and DHR are independent of the atmosphere

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ILLUMINATION FROM THE ENTIRE HEMISPHERE

HDRF: Hemispherical-Directional Reflectance Factor (dimensionless)

similar in definition to the BRF except that illumination is allowed from the entire upper *hemisphere* of the illumination and on the surface intrinsic scattering properties

- **At the surface level the illumination is superposition of two components: mono-directional beam attenuated by the atmosphere (direct solar radiation from a single direction) and radiation scattered by the atmosphere (diffuse sky illumination)**

BHR: BiHemispherical Reflectance Factor (dimensionless)

is the ratio of the flux of light reflected from a surface area into a hemisphere to the incident flux when the area is illuminated by an arbitrary radiation field.

HDRF and BHR characterizes surface reflective properties under ambient atmospheric condition and depends both on the angular distribution of the illumination and on the surface intrinsic scattering properties

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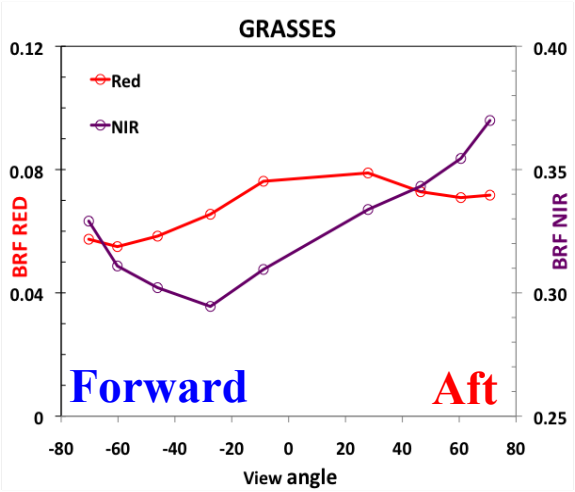
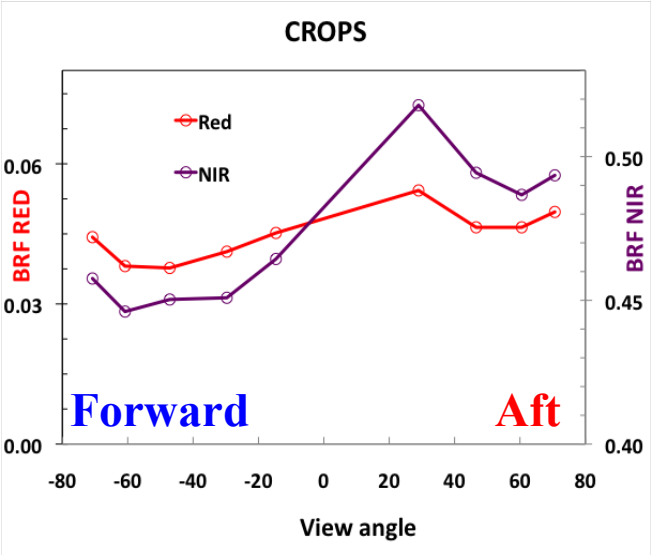
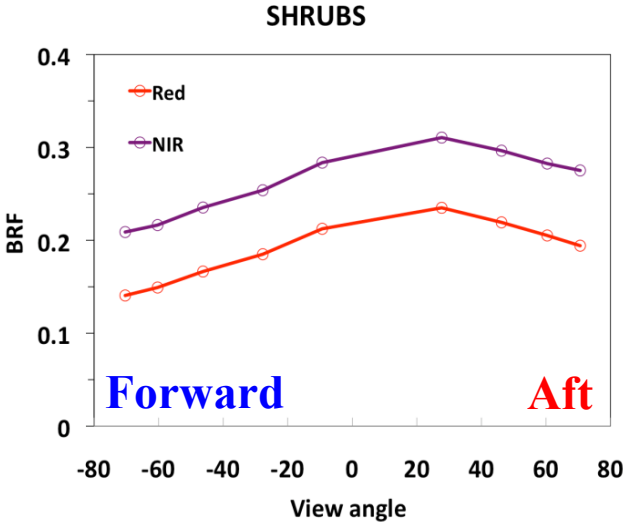
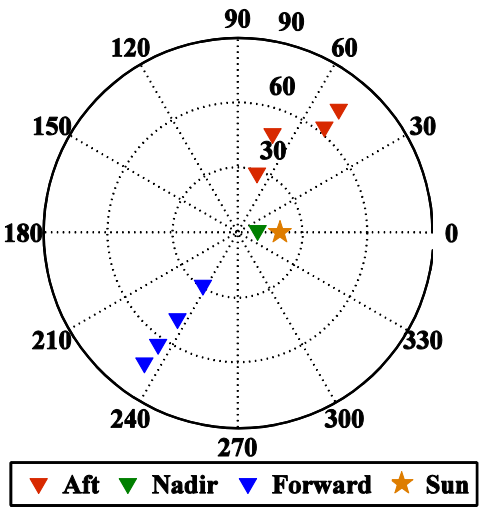
BRF OF LAND COVERS

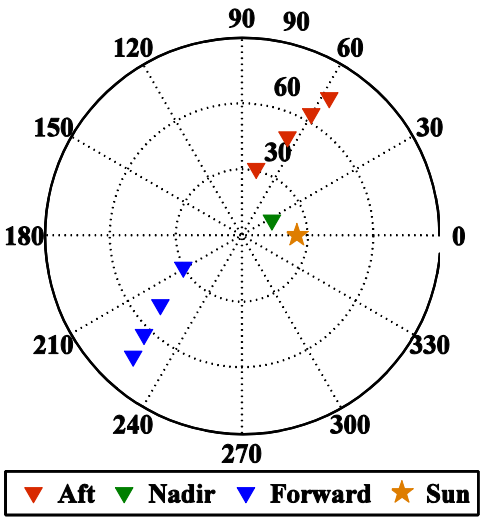




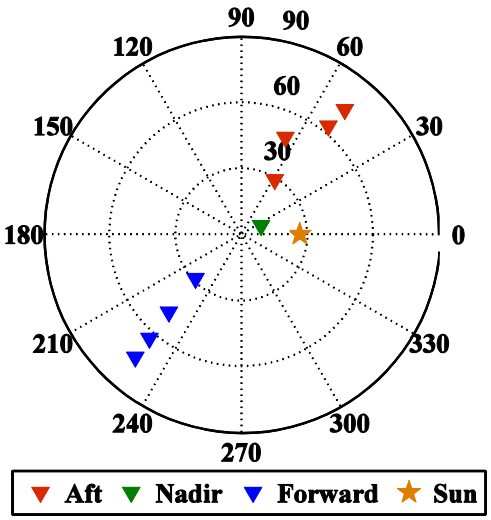




SZA=18.6º



SZA=23.8º



SZA=25.3º

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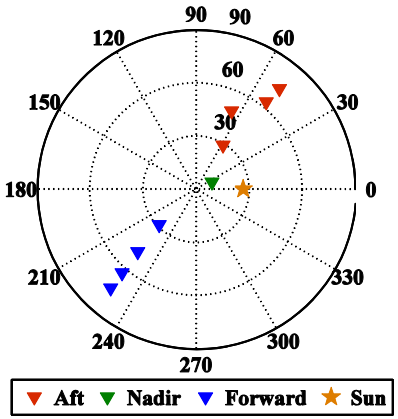
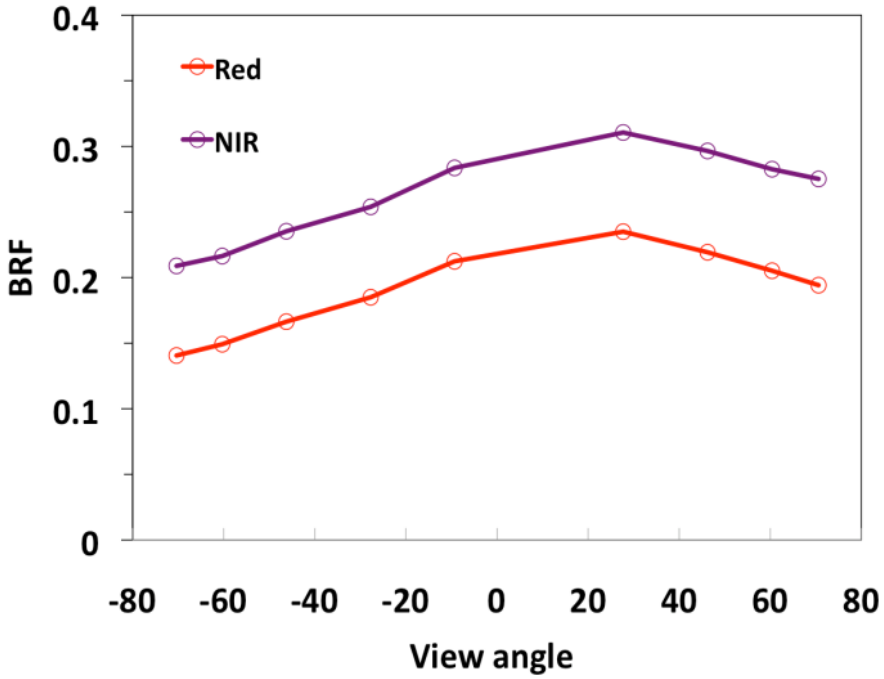
ANGULAR SIGNATURE OF LAND COVERS: SHRUBS

Forward

Aft





- Sensitivity to vegetation structure due to shadow effects
- Ability to distinguish canopy and understory due to contrast between nadir and oblique views

M. Chopping

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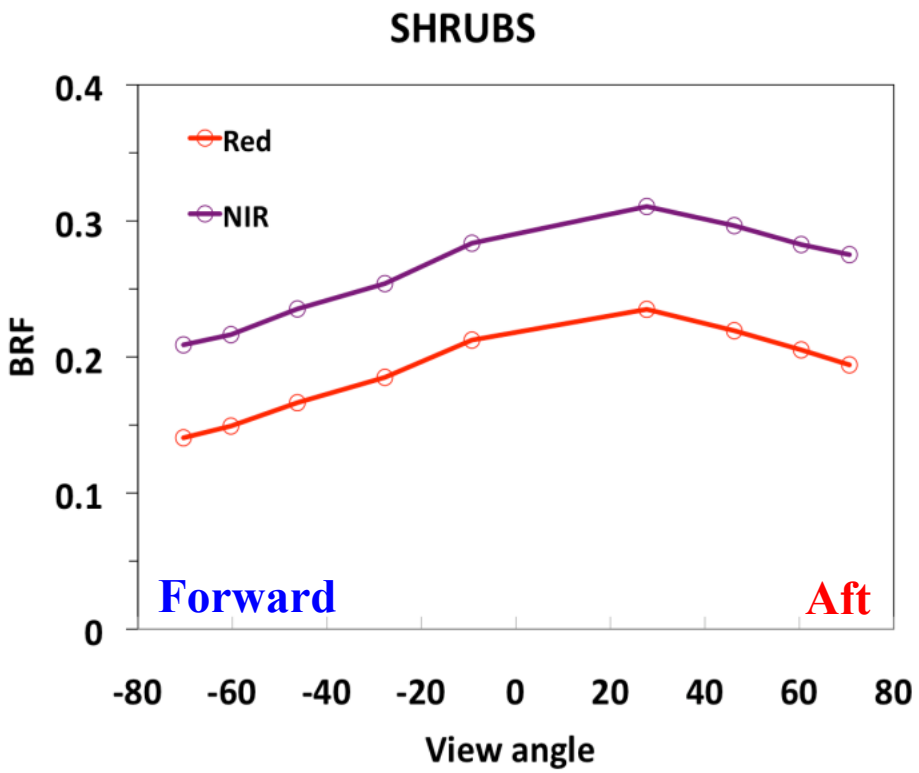
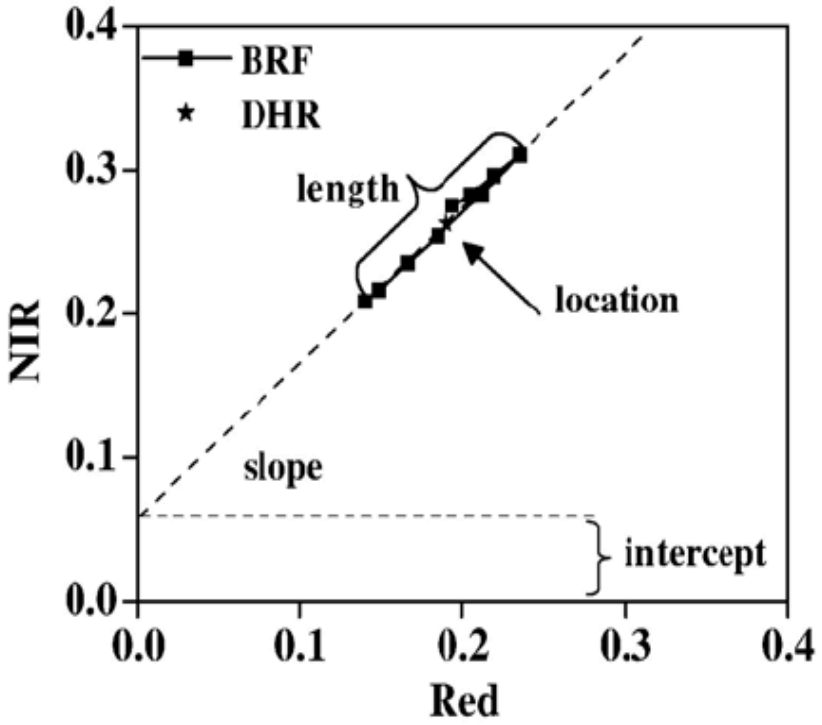
INFORMATION CONTENT OF MULTI ANGLE SPECTRAL DATA





Location: sensitive to biome type; basic source of information about the surface conveyed by single-angle multi-spectral satellite data

Length: surface heterogeneity; anisotropy of the reflected signal

Slope & Intercept: impact of canopy background

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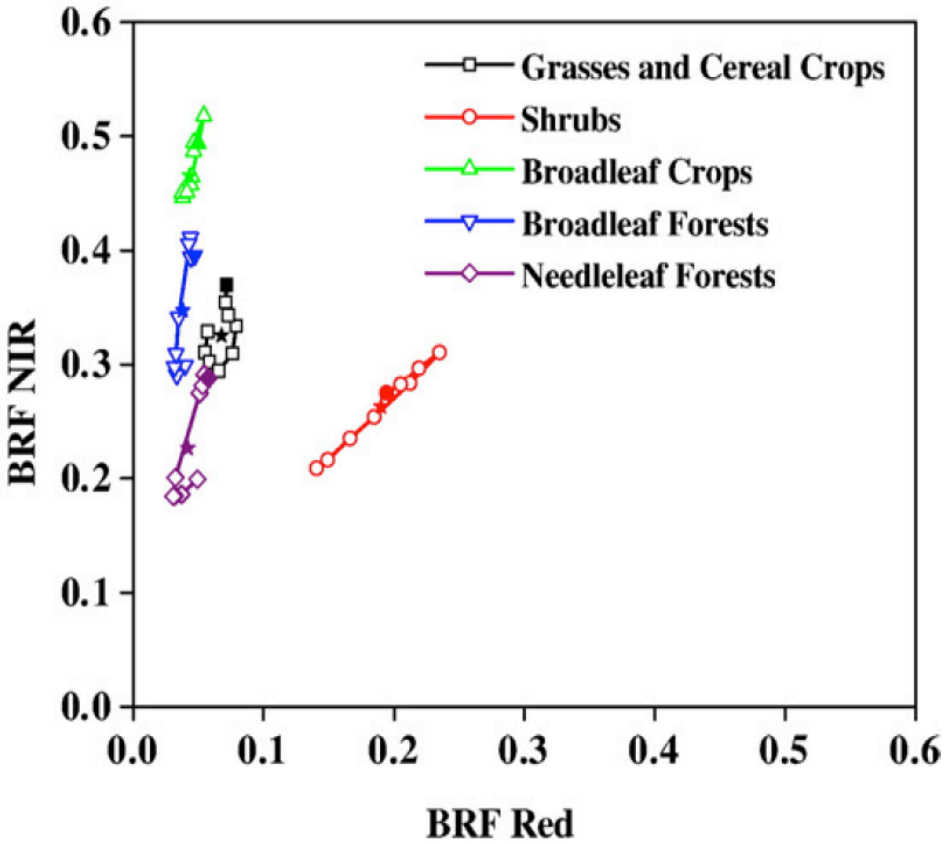
ANGULAR SIGNATURE IN SPECTRAL SPACE



Location: sensitive to biome type; basic source of information about the surface conveyed by single-angle multi-spectral satellite data

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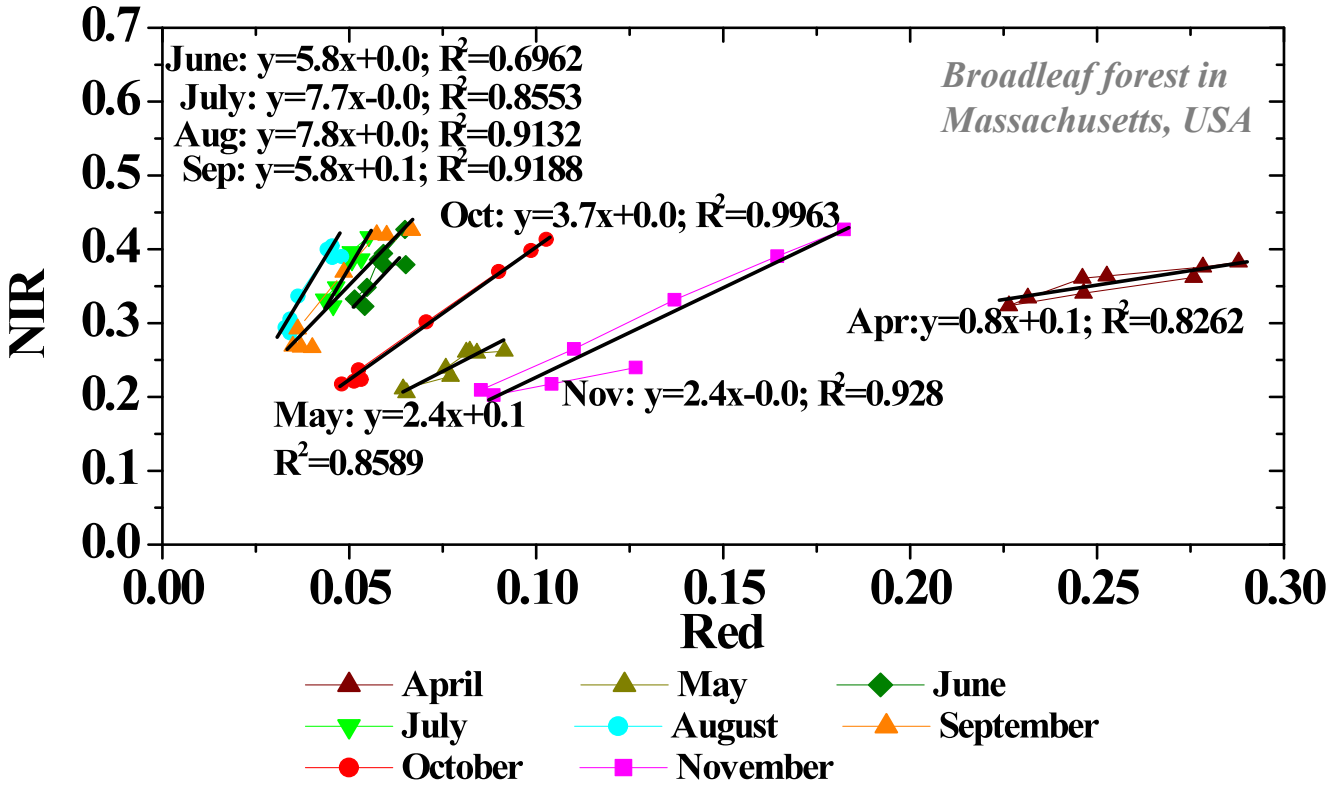
CHANGES IN VEGETATED SURFACE



Location: sensitive to biome type; basic source of information about the surface conveyed by single-angle multi-spectral satellite data

Length: surface heterogeneity; anisotropy of the reflected signal

Slope & Intercept: impact of canopy background

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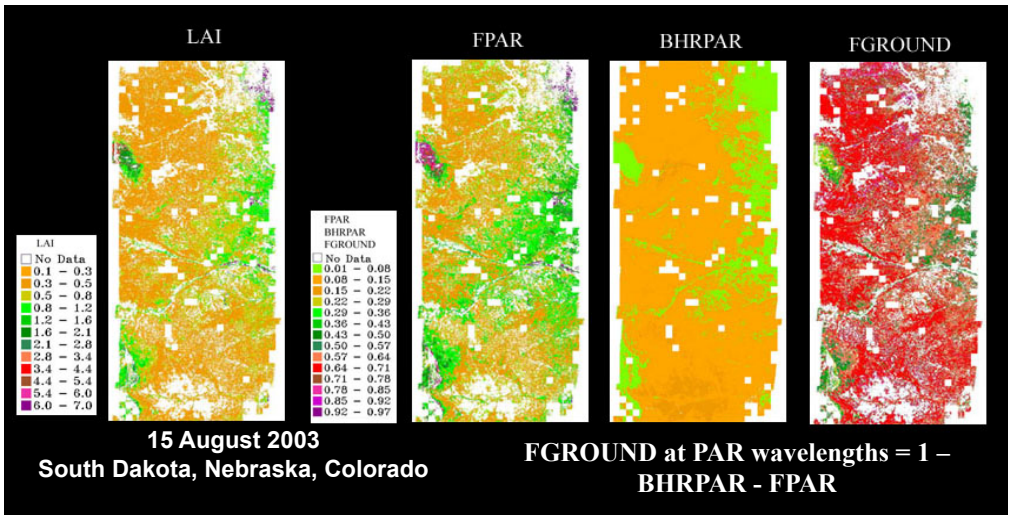
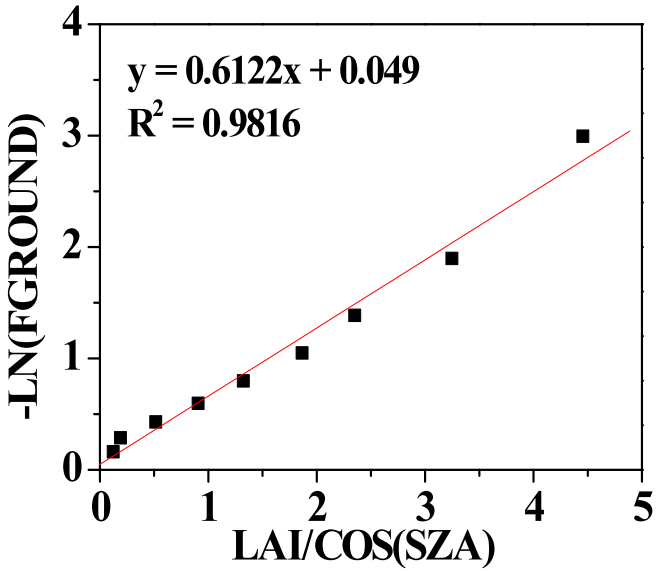
NEW INFORMATION ON CANOPY STRUCTURE FROM MISR PRODUCTS





FGROUND with independent estimates of LAI can be used to derive at least three measures of canopy structure:
(1)extinction coefficient for use in ecological models
(2)estimates of mean leaf inclination and
(3)the gap fraction

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COMPUTER TUTORIAL

1. MISR OVERVIEW, OBSERVATIONAL PRINCIPLES

EOS missions; rationale for multi-angle measurements; MISR standard products, basic principles and nomenclature; surface anisotropy; angular signature;

3. COMPUTER TUTORIAL ON MISR SATELLITE IMAGE DATA PRODUCTS

- ***obtaining data, MISR browse tool and subsetting procedures***
- ***data extraction and processing***
- ***solving problems***
- ***information about re-projection tools***

5. SUMMARY

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http://eosweb.larc.nasa.gov

http://www-misr.jpl.nasa.gov/

Where to get help and information

LaRC DAAC User Services
larc@eos.nasa.gov

Langley Atmospheric Sciences Data Center DAAC
http://eosweb.larc.nasa.gov

MISR home page
http://www-misr.jpl.nasa.gov

We welcome your feedback and questions!
"Ask MISR" feature on the MISR web site