Aerosol observations using multiangle imaging

MISR

Multi-angle Imaging SpectroRadiometer

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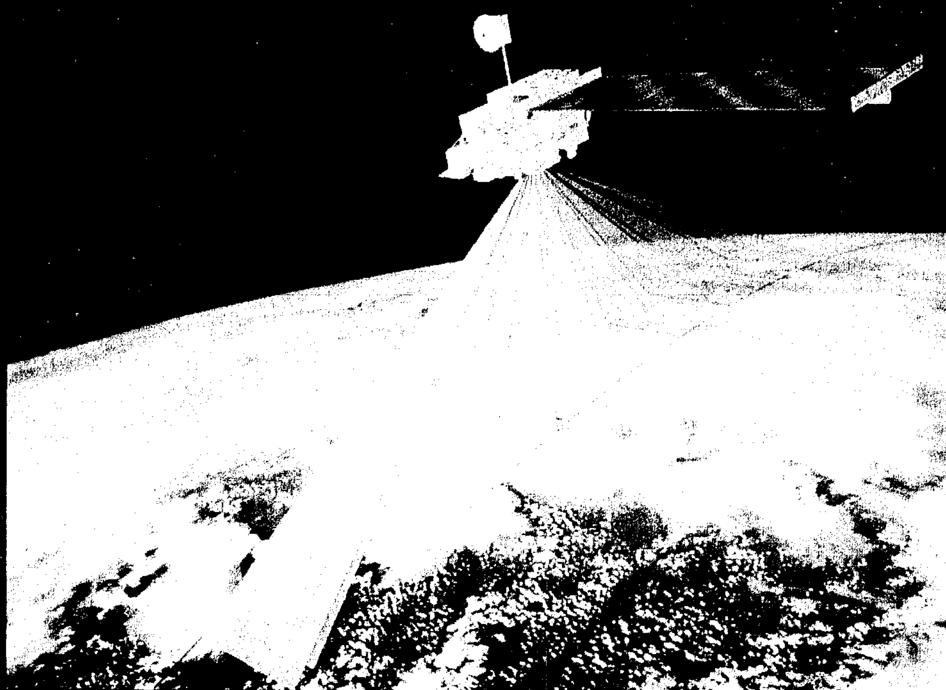
Aerosol workshop
September 15-18, 2003
Paris, France

MISR observing concept



9 view angles at Earth surface:
70.5º forward to 70.5º aftward

Multiple spectral bands at each angle:
MISR/Terra: 446, 558, 672, 866 nm

On-board calibration system

Continuous pole-to-pole coverage
on orbit dayside

400-km swath: 9-day global coverage

275 m - 1.1 km sampling

7 minutes to observe each scene
at all 9 angles

MISR is the first spaceborne instrument to provide global, multiangle observations at moderately high spatial resolution over a wide range of angles

The information content of this new type of data is being explored in two ways:
--Generation of global, standard products using “operational” algorithms
--Case studies using research algorithms

What capabilities is MISR demonstrating that can contribute to future missions?

Sensitivity to aerosols over a wide variety of surface types

Discrimination of particle properties

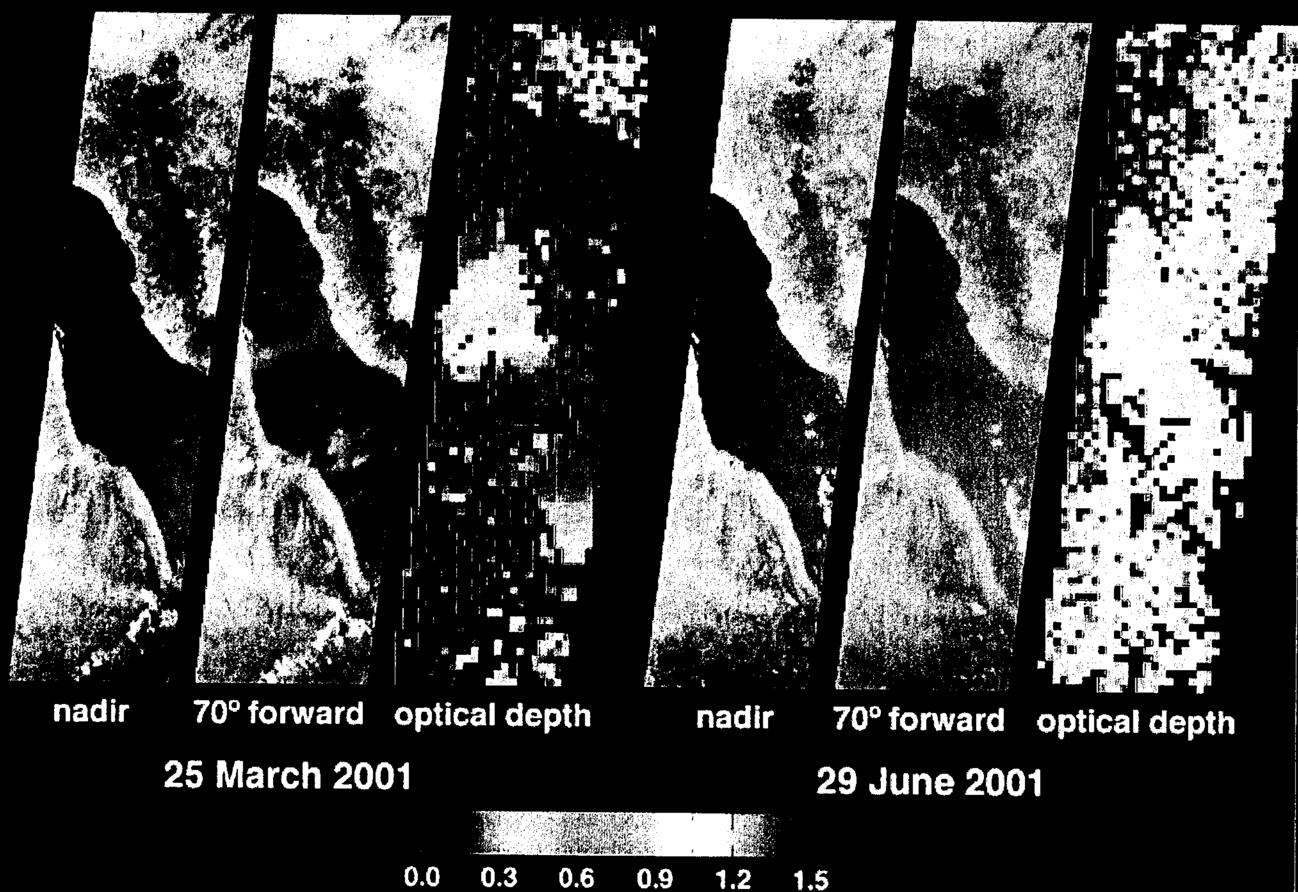
Captures sunglint and non-sunglint geometries near-simultaneously

Cloud identification and characterization

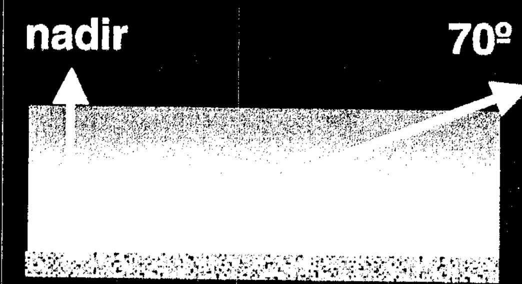
Measurements of aerosol and cloud effects on TOA albedo

Cloud and aerosol plume 3-D structure and advection measurements

Sensitivity to aerosols over a wide variety of surface types



Thin haze over land is difficult to detect in the nadir view due to the brightness of the land surface

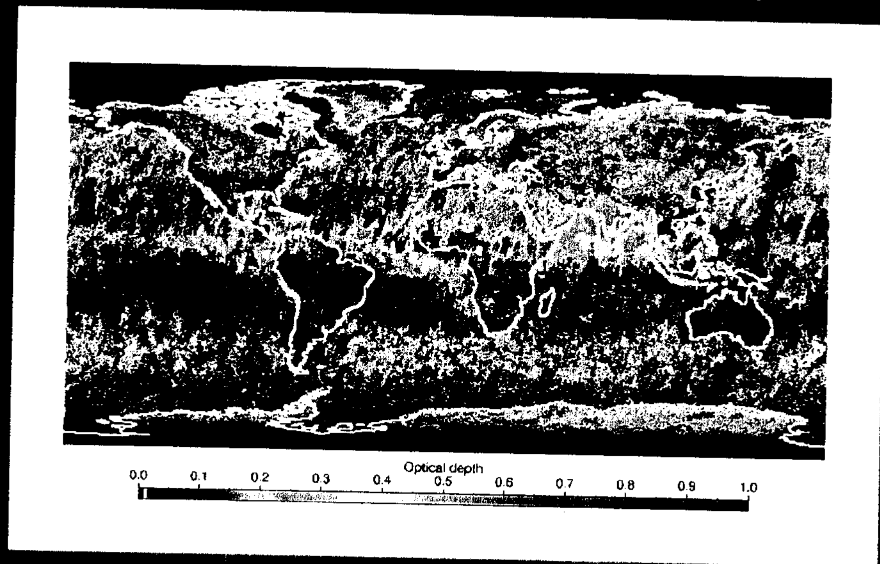


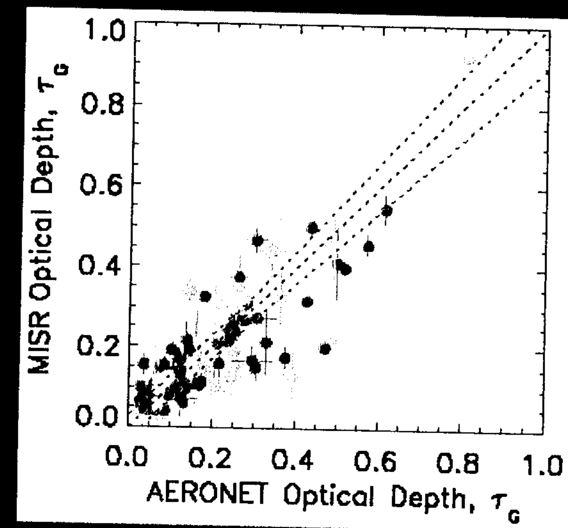
Saudi Arabia,
Red Sea,
Eritrea

Global optical depth retrievals and AERONET comparisons

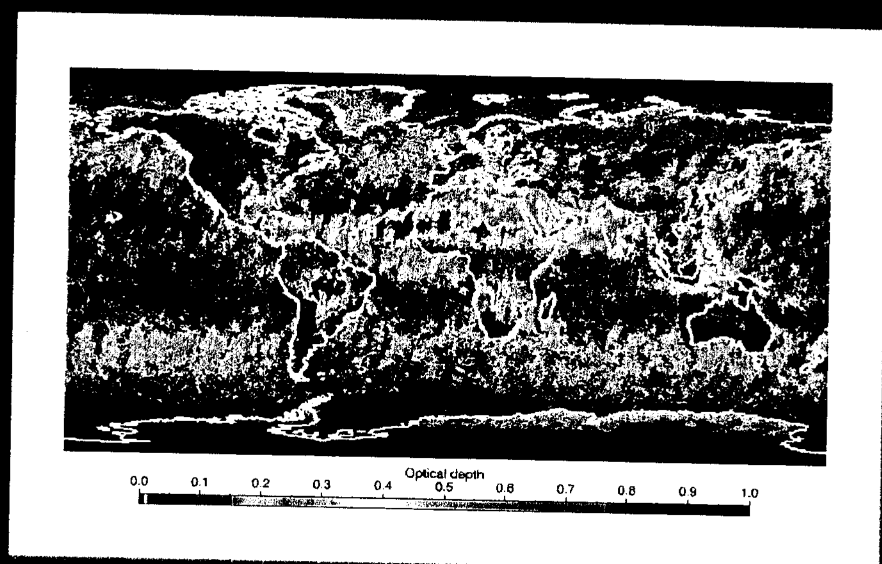
MISR optical depths (558 nm)

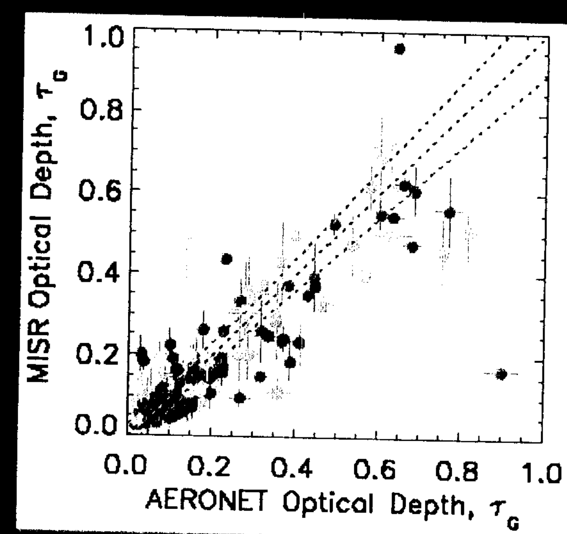
March 2002



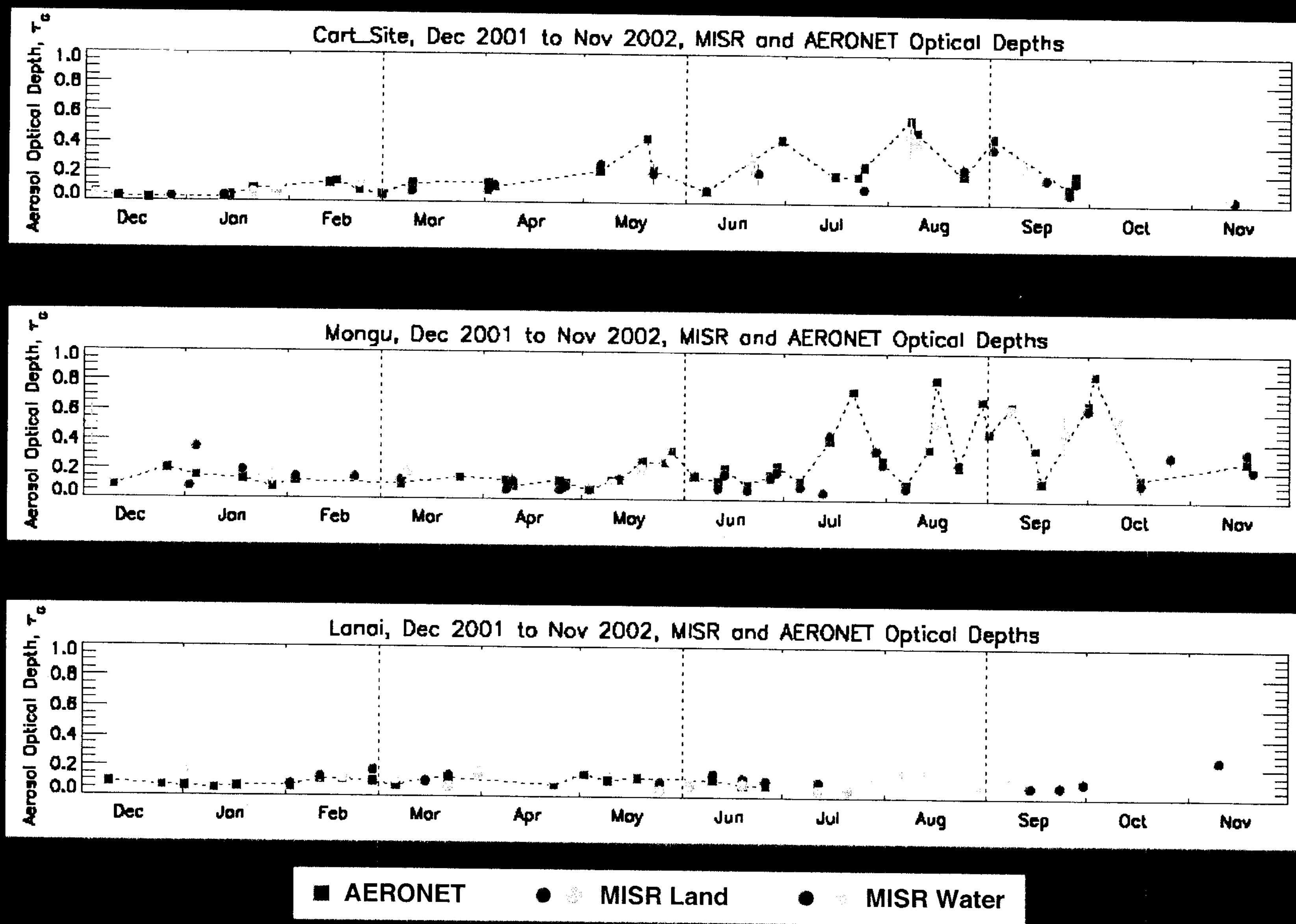


September 2002

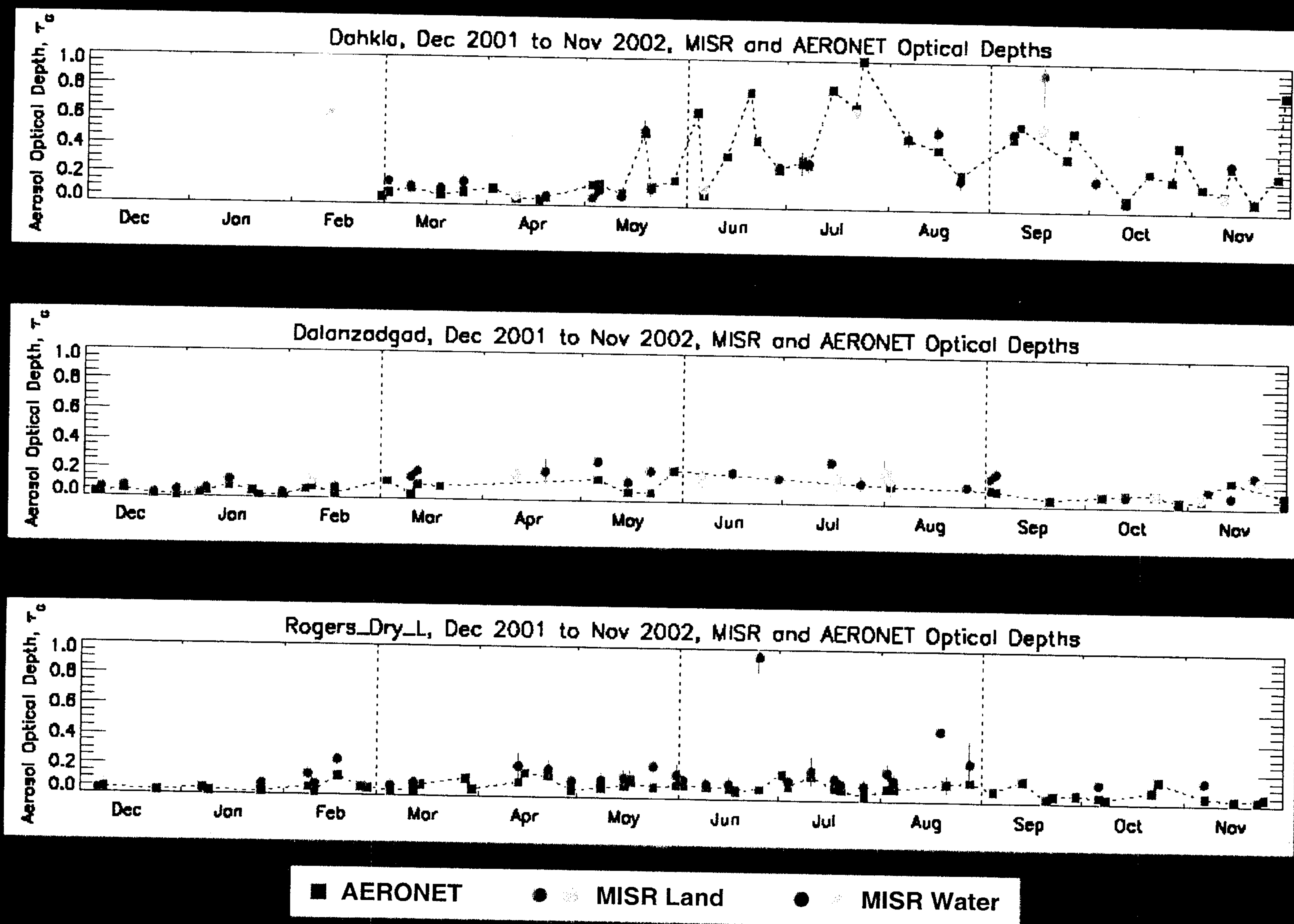




MISR-AERONET time series, dark surfaces



MISR-AERONET time series, bright surfaces



Discrimination of particle properties

Cirrus, Dust, and Background Maritime Particles during CRYSTAL-FACE in the Caribbean off Yucatan, July 9, 2002

The MISR research retrieval returned three aerosol components:
a background maritime medium, spherical, non-absorbing particle
thin cirrus (measured independently, at the same time, by the MAS instrument)
Sahara dust (predicted by the NAPS model and measured by the PALMS instrument, with about the same optical depths as retrieved by MISR)

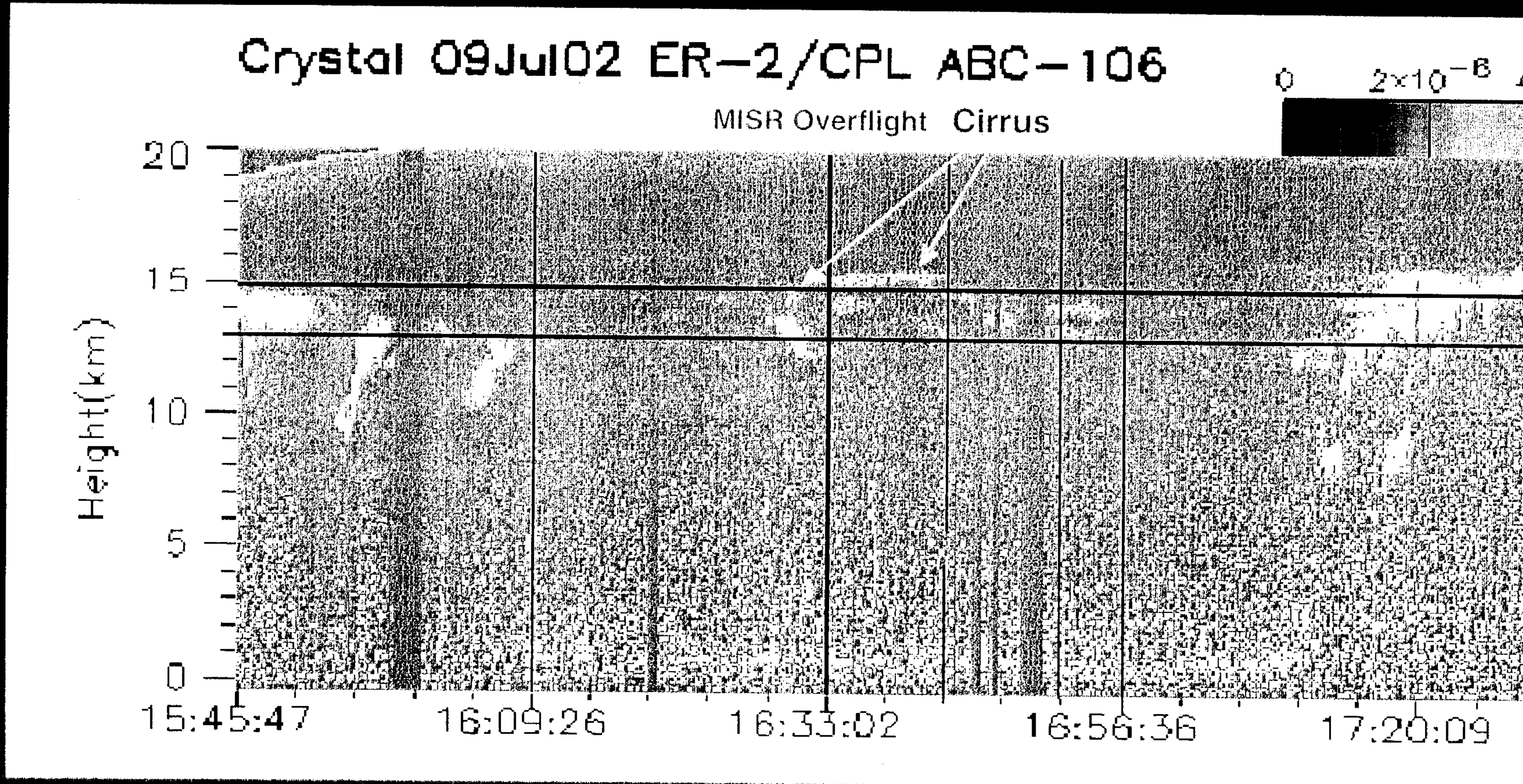
Urban Pollution and Background Maritime Particles over Galveston Bay, near Houston, TX, September 12, 2002

The MISR research retrieval returned selected mixtures of
small and medium, spherical, low-absorbing particles
(in agreement with field results measured upwind [Engle-Cox, Haymet, et al])

Amounts decrease systematically with distance from the source region

Mineral dust; large, spherical particles; and absorbing particles (albedo <~0.85) were all rejected

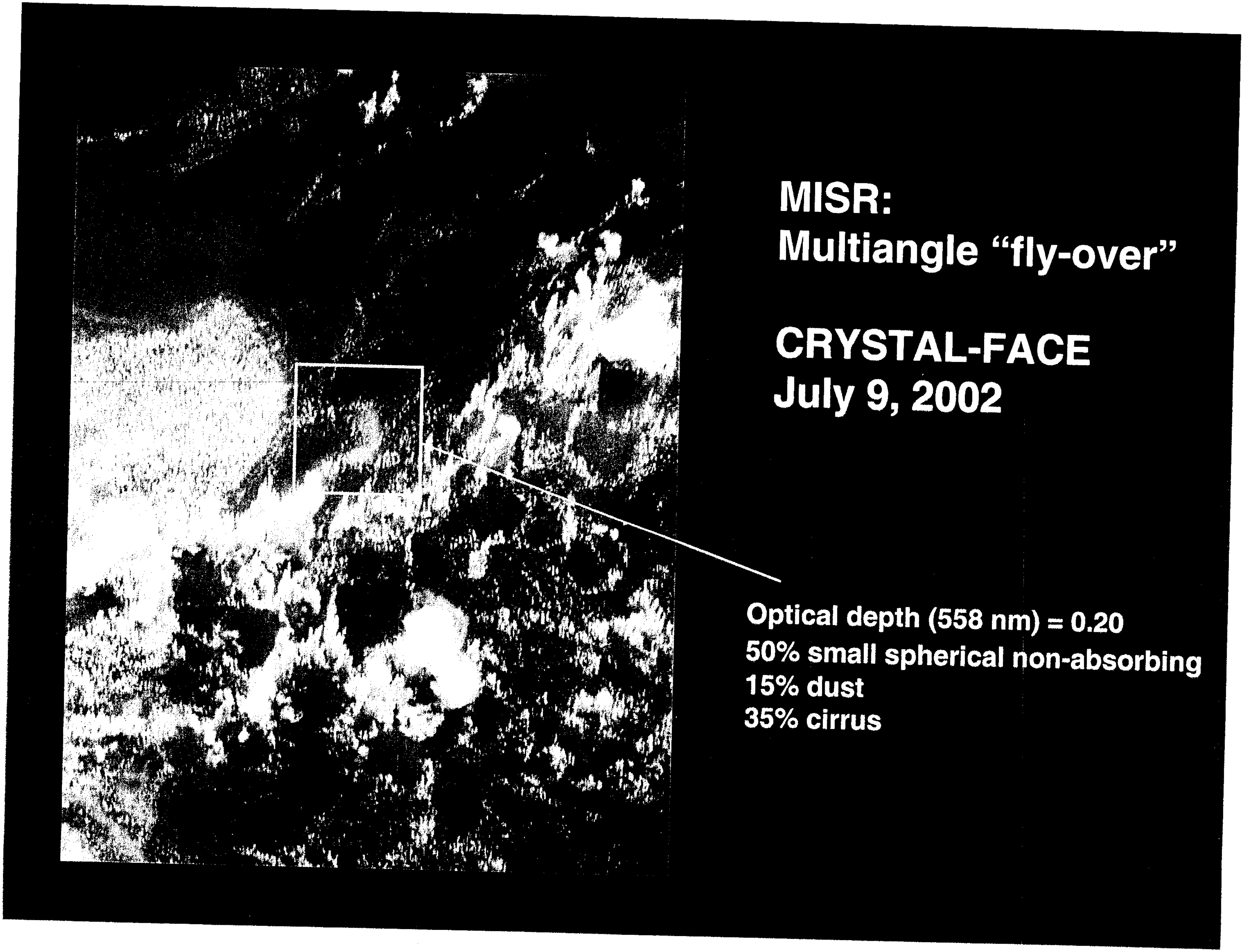
CPL: Cloud Physics LIDAR - ER-2



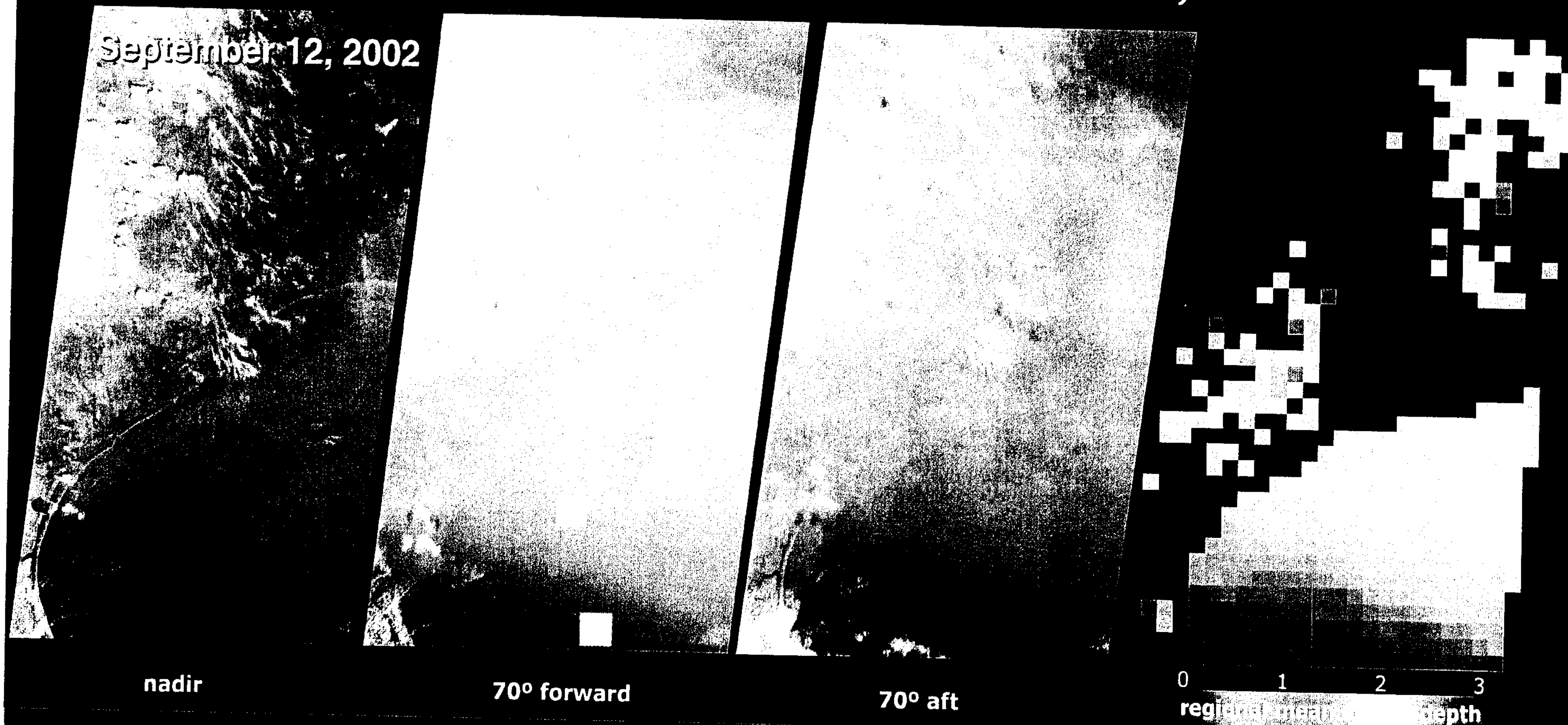
MISR:
Multiangle "fly-over"

CRYSTAL-FACE
July 9, 2002

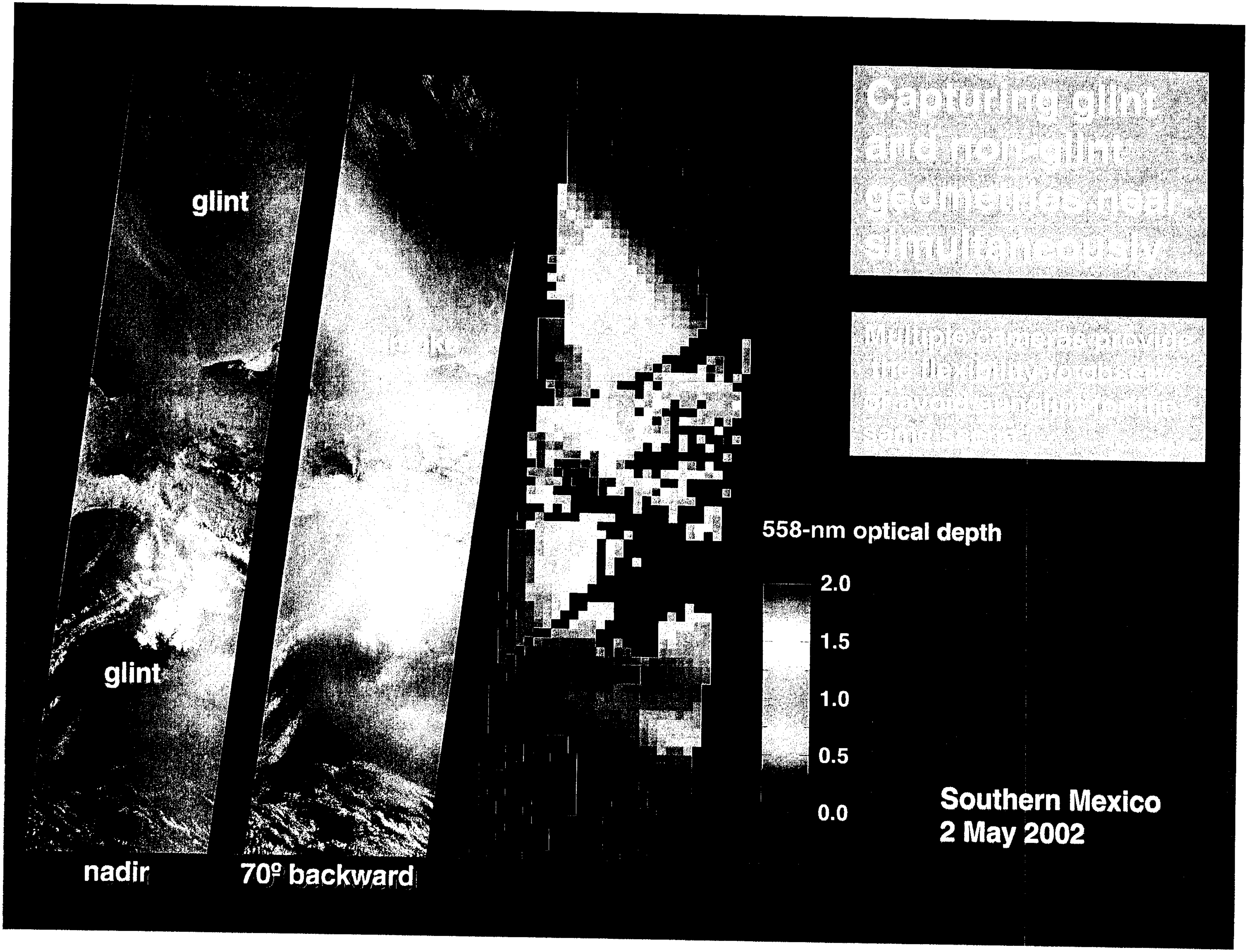
7 angles
(2 angles are
glint-contaminated)


MISR:
Multiangle "fly-over"
CRYSTAL-FACE
July 9, 2002
Optical depth (558 nm) = 0.20
50% small spherical non-absorbing
15% dust
35% cirrus

Urban pollution and background maritime particle study over Galveston Bay near Houston, TX

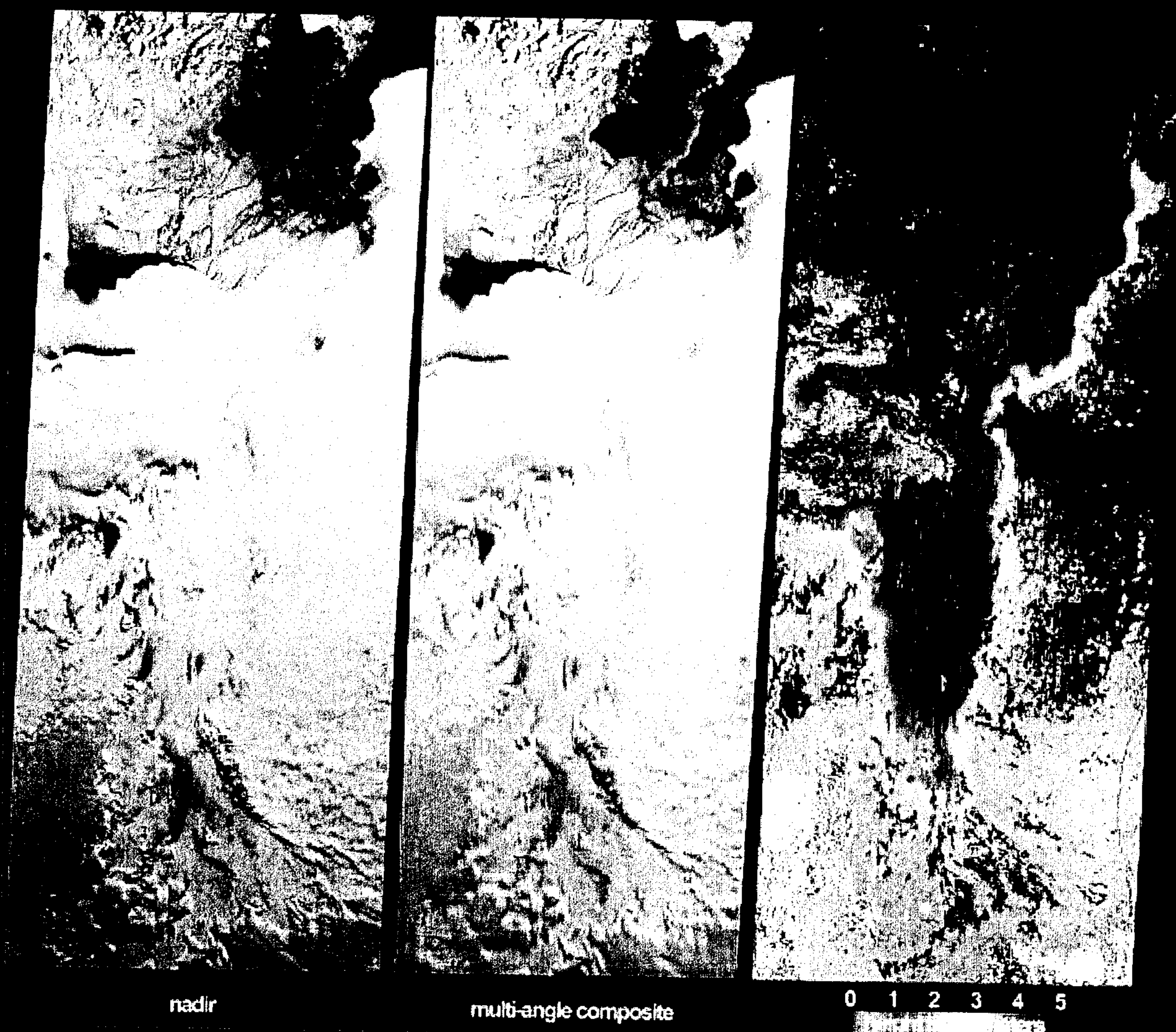


Optical depth (558 nm)	Component 1	Component 2	Component 3
0.60	60% spherical $r_{eff} = 0.12\ \mu m$	35% spherical $r_{eff} = 0.26\ \mu m$	5% cirrus
0.45	85% spherical $r_{eff} = 0.12\ \mu m$	15% spherical $r_{eff} = 0.57\ \mu m$	--
0.25	85% spherical $r_{eff} = 0.12\ \mu m$	15% spherical $r_{eff} = 0.57\ \mu m$	--



Capturing glint and non-glint geometries near-simultaneously
Multiple cameras provide the flexibility to observe or avoid sunglint for the
glint
glint
nadir
70º backward
558-nm optical depth
2.0
1.5
1.0
0.5
0.0
Southern Mexico
2 May 2002

Cloud identification and characterization

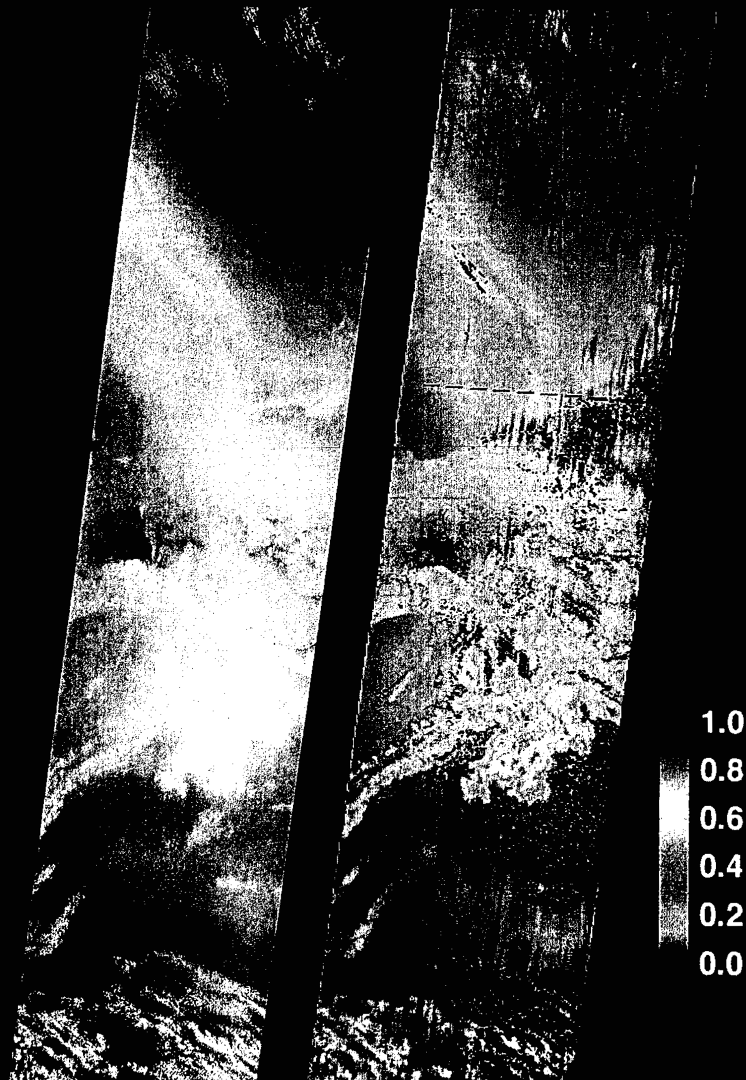


Discerning clouds from ice or snow is straightforward with MISR angular signatures and [illegible]

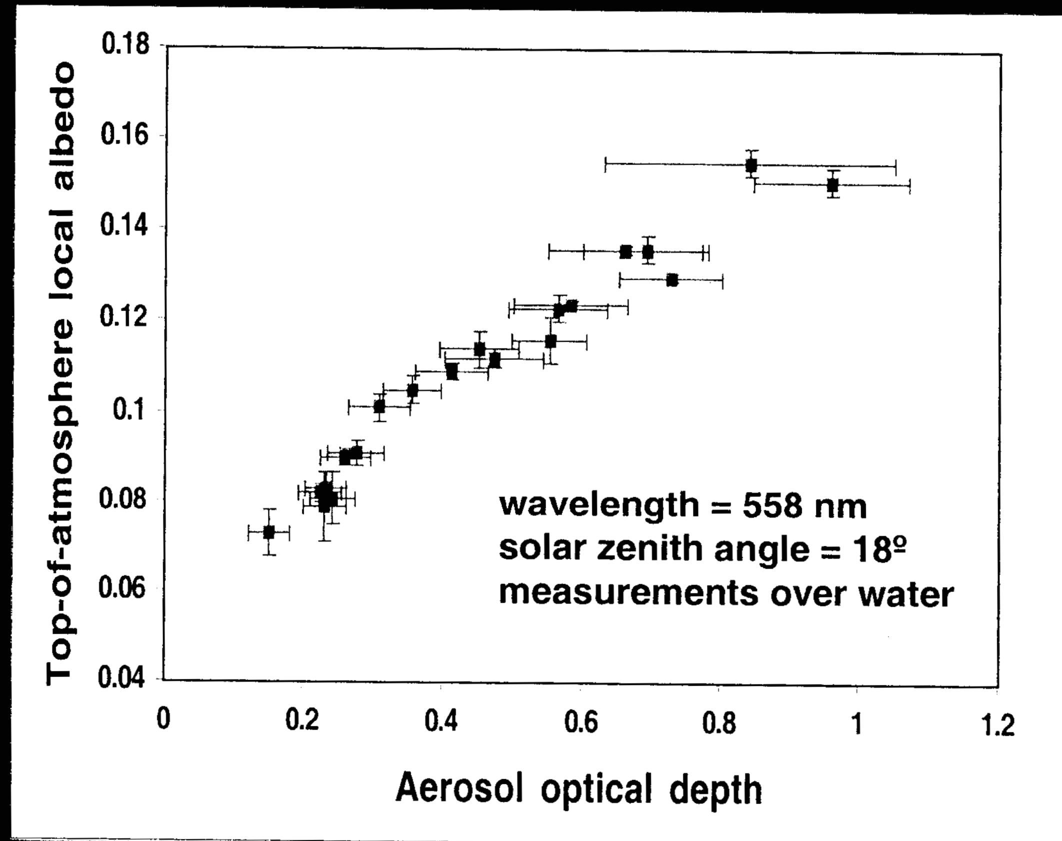
Lambert-Amery System, East Antarctica

October 25, 2002

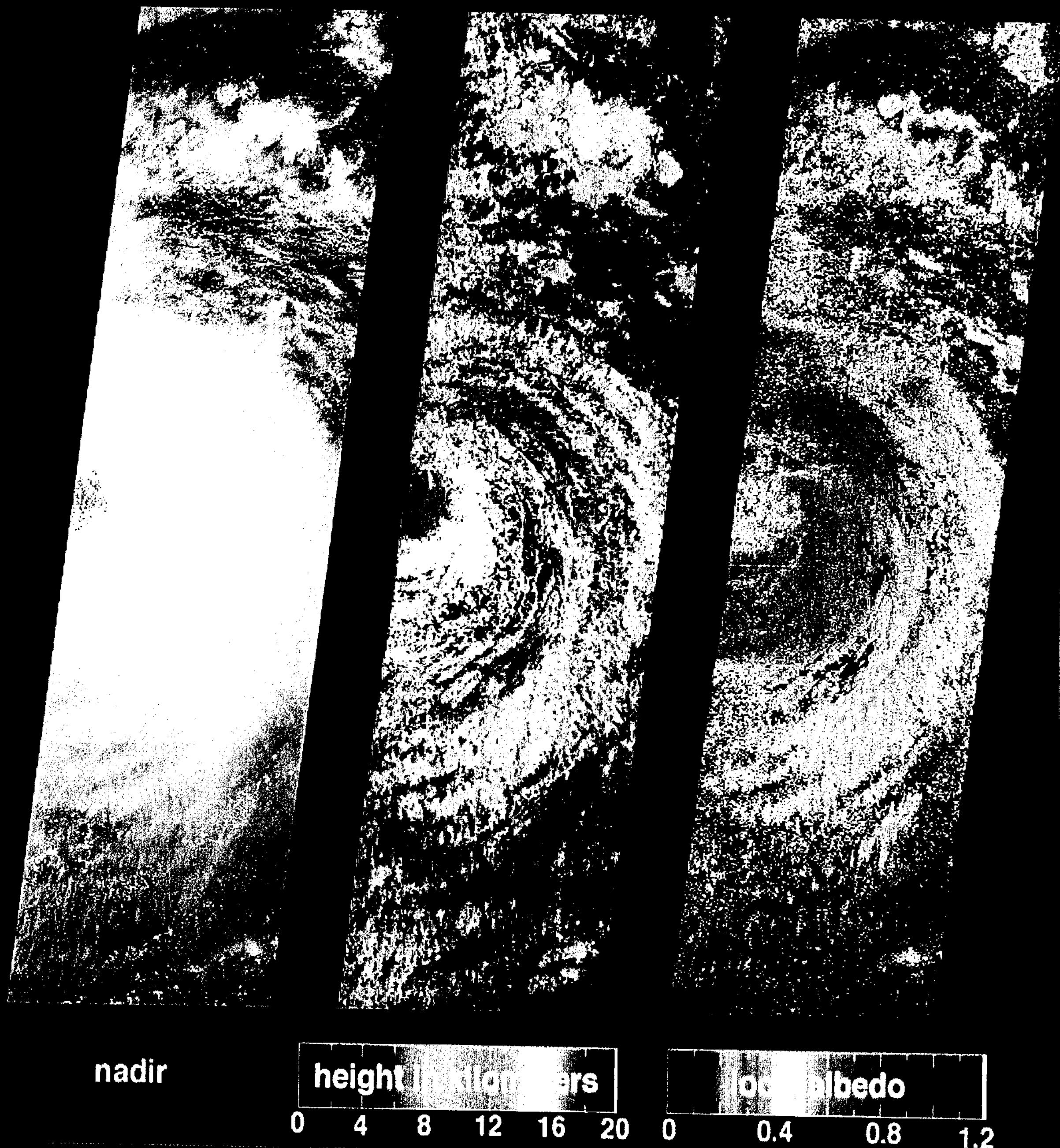
Measurements of aerosol and cloud effects on TOA albedo



70º backward TOA local albedo



Southern Mexico
2 May 2002



Stereoscopic height retrievals are used to co-register bidirectional reflectances at the cloud tops

This makes possible retrieval of cloud albedos at local scales

Typhoon Sinlaku
September 5, 2002

Cloud and aerosol plume 3-D structure and

Eruption of Mt. Etna, Sicily
27 October 2002

Stereoscopic retrievals of the height of the top of aerosol layers is possible when they have identifiable texture

What MISR attributes would be preserved in a successor instrument?

Wide range of view angles covering airmass factors 1 - 3

-- multiple cameras insure having several angles that do not see glint
-- oblique views are necessary to achieve aerosol sensitivity and provide wind correction to stereoscopic height retrievals
-- a range of scattering and view angles is required to operate aerosol retrieval algorithms over land
-- wide range of view angles is required for estimation of top-of-atmosphere albedo

Spatial resolution: few hundred meters to ~1 km

-- needed for stereo height retrievals, cloud identification and screening
-- necessary for application of land aerosol retrieval algorithms
-- propose operating a single band at all angles (e.g., red) at high resolution, with the remaining channels at ~1 km resolution

Calibrated: Yes

-- accurate absolute, angular, and spectral radiometry is essential
-- need to flat-field the camera imagery
-- changes in instrument performance with time must be accounted for

How would a successor instrument differ from MISR?

Future enhancements are envisioned to extend current MISR capabilities:

-- better sensitivity to large (> 1 μm) particles

-- quantitative improvements in retrieval of aerosol absorption

Enhanced spectral coverage

-- addition of shorter and longer wavelengths to current 446 - 866 nm range:

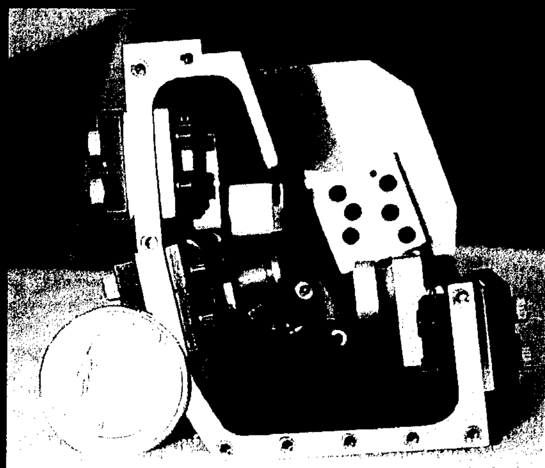
380/412 nm: Increase sensitivity to aerosol absorption and possibly height

1375 nm: Permits multi-angle observations of cirrus scattering characteristics

1640/2100 nm: Extends aerosol sensitivity to larger particles

Reduced mass, volume, power, and cost relative to MISR/Terra

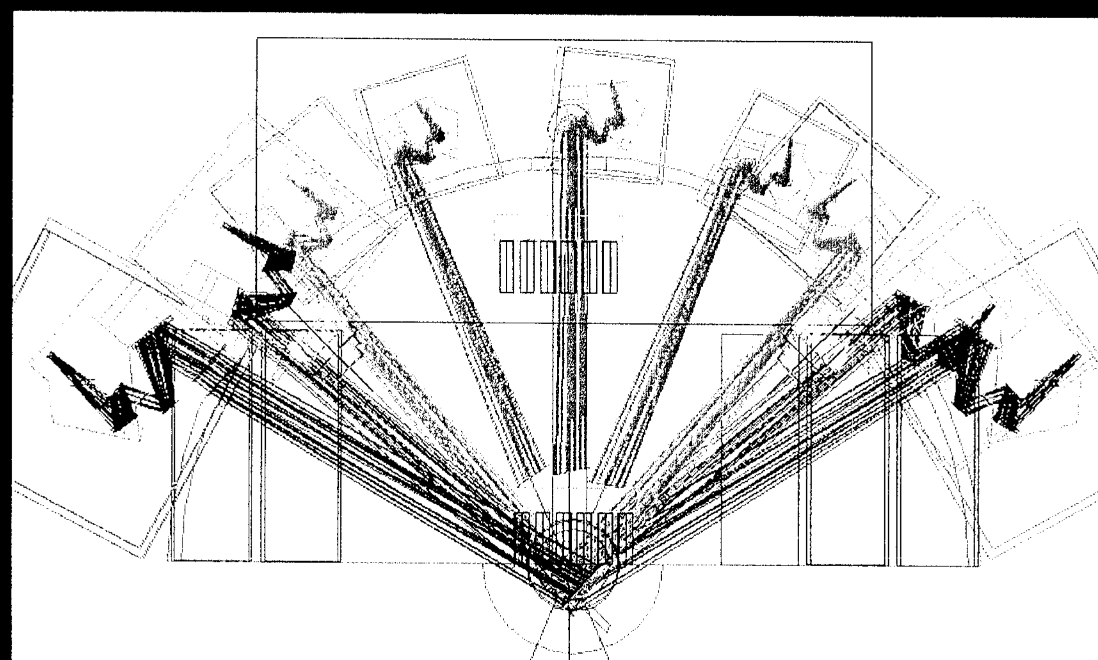
Future instrument concept



Miniaturized, advanced camera prototype

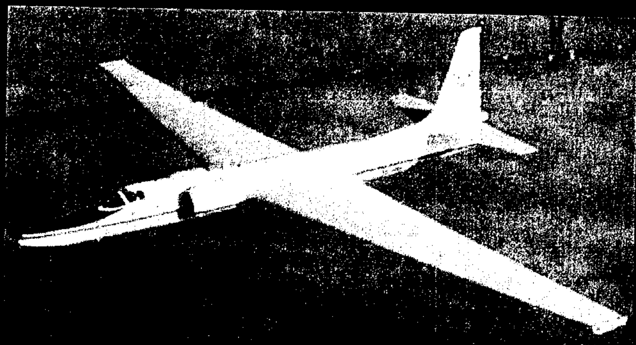
An all-reflective, miniaturized design for MISR-like cameras was developed under the NASA Instrument Incubator Program

Using this new design, a much smaller successor instrument can be built

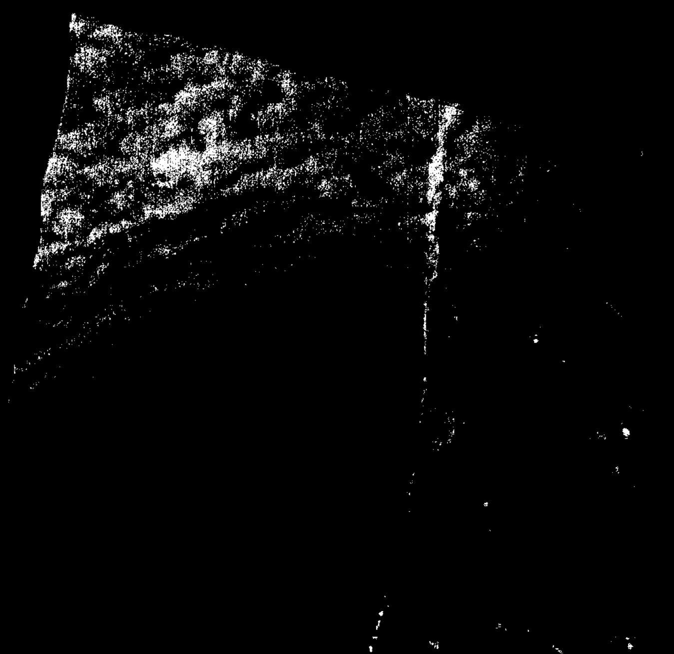


Mass reduced 3x, volume 6x, and power 3x compared to MISR/Terra

AirMISR: A unique asset for aerosol/cloud studies



Flies on the NASA ER-2
Uses gimballed camera of same design as MISR
Georectified spatial resolution is 27 m
Room is available for an advanced camera



nadir

Monterey, California
June 1999

70º

Summary

Multiangle imaging makes possible new methodologies for aerosol and cloud radiation research

A spectrally enhanced MISR instrument would bring a broad set of capabilities and unique strengths to future missions

A concept for an instrument with significantly reduced mass, volume, and power relative to MISR/Terra, but with enhanced spectral capability, has been developed

AirMISR is a valuable resource for aerosol-cloud interaction studies and can serve as a testbed for advanced multiangle instrument Concepts

MISR and AirMISR data are publicly available at the NASA Langley Atmospheric Sciences Data Center