MISR/MODIS intercomparisons and data fusion

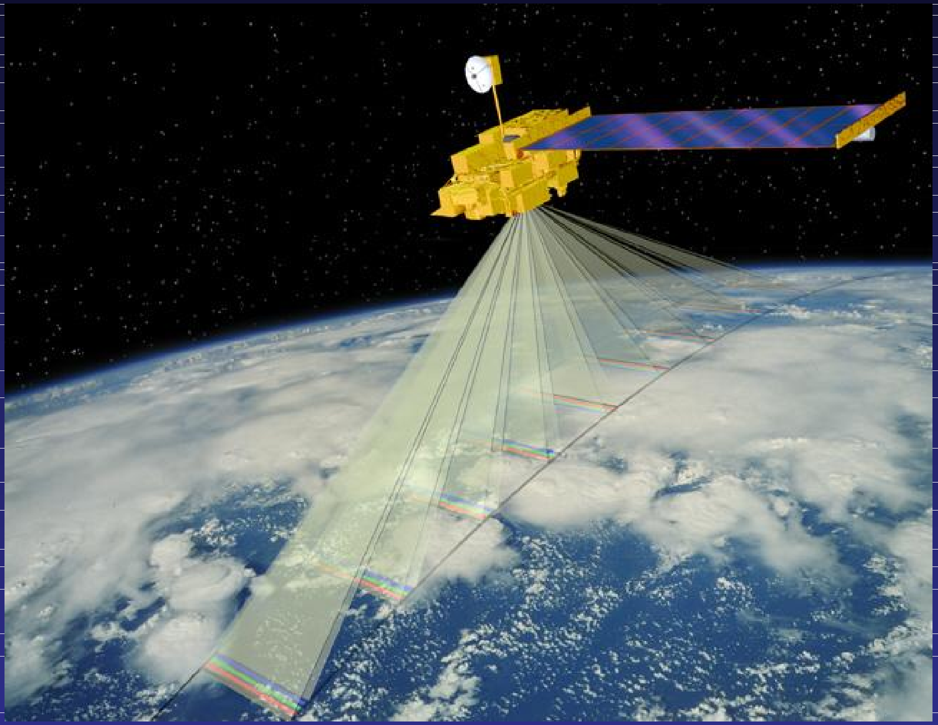
David J. Diner, MISR Principal Investigator

Jet Propulsion Laboratory,
California Institute of Technology

and the MISR team

MODIS Science Team Meeting
23 March 2005

MISR characteristics



Standard products are processed and archived at the NASA Langley Atmospheric Sciences Data Center
eosweb.larc.nasa.gov

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

Four spectral bands at each angle:
446 nm ± 21 nm
558 nm ± 15 nm
672 nm ± 11 nm
866 nm ± 20 nm

275 m sampling in all nadir bands and red band of off-nadir cameras
1.1 km for the other channels

400-km swath: Complete zonal coverage
9 days at equator
2 days at poles

7 minutes to observe each scene at all 9 angles

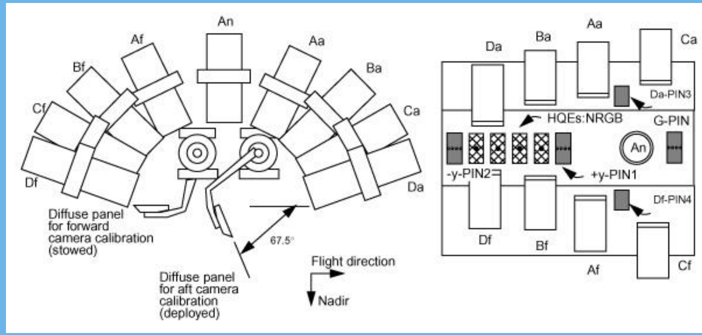
Digitization: 14 bits

Radiometry

MISR calibration

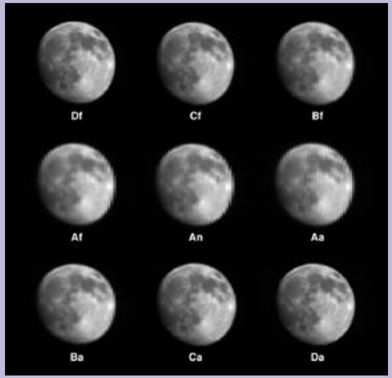
A comprehensive review of these data sources in 2003-2004 led to downward revision of the MISR radiances by 3% in the red and 2% in the NIR

MISR On-Board Calibrator



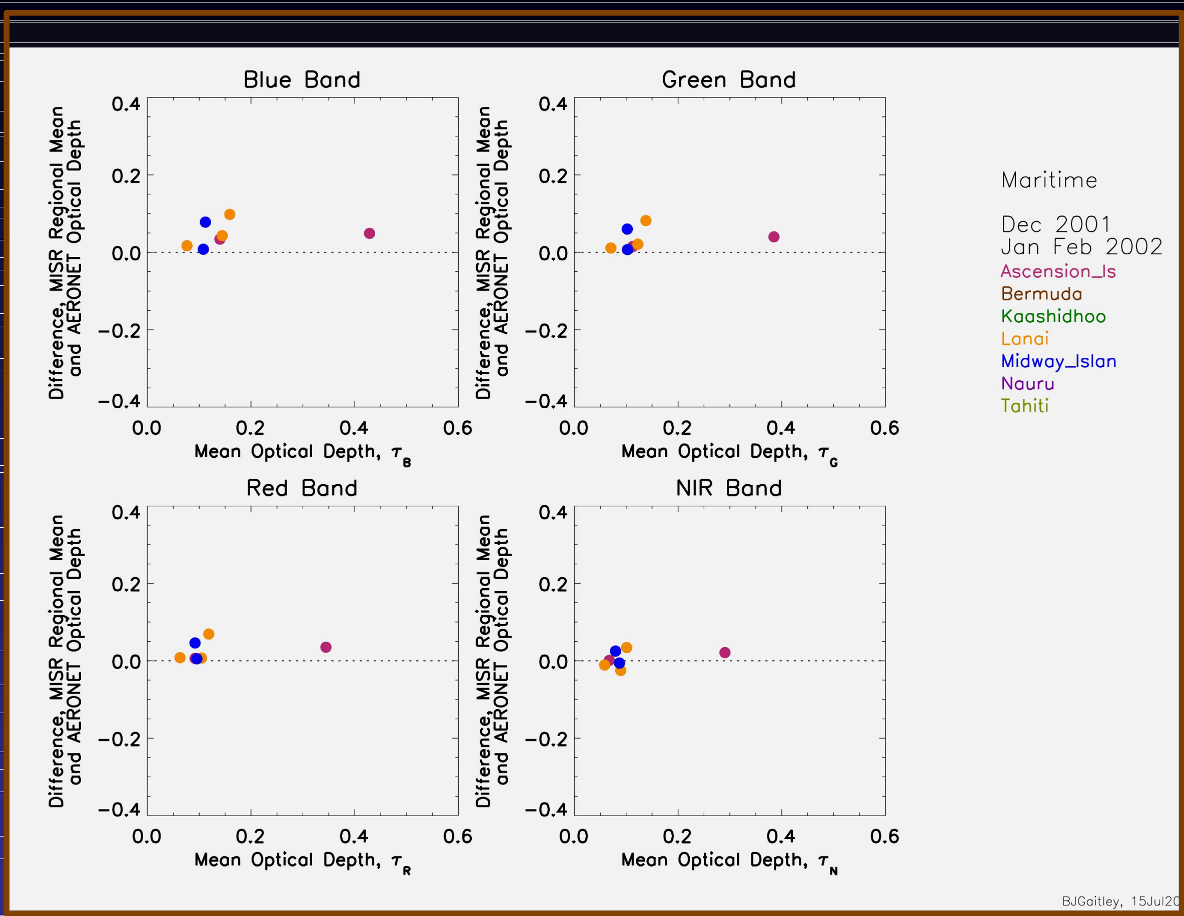
Vicarious calibrations and validations over desert playas and dark water sites

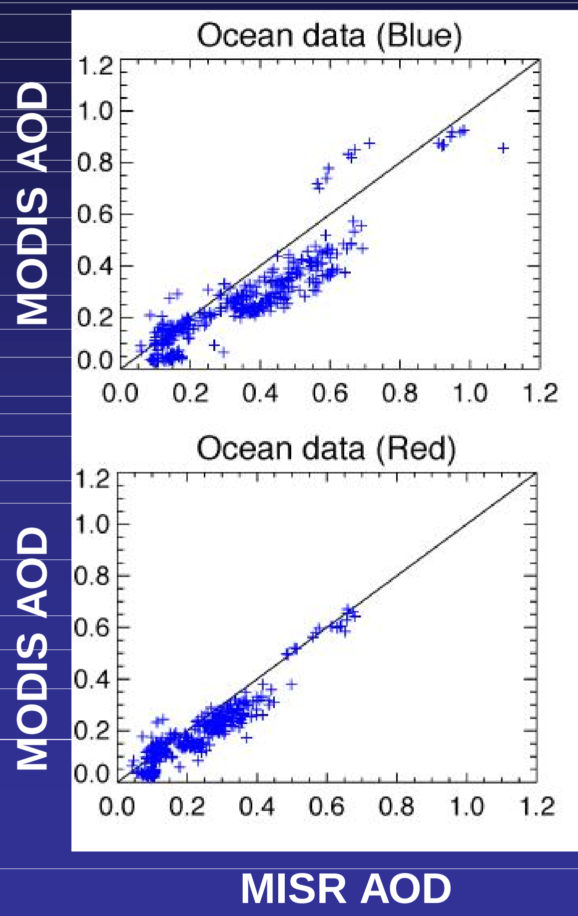
AirMISR



MISR lunar images

MISR ocean aerosol optical depths prior to 2004 calibration revision



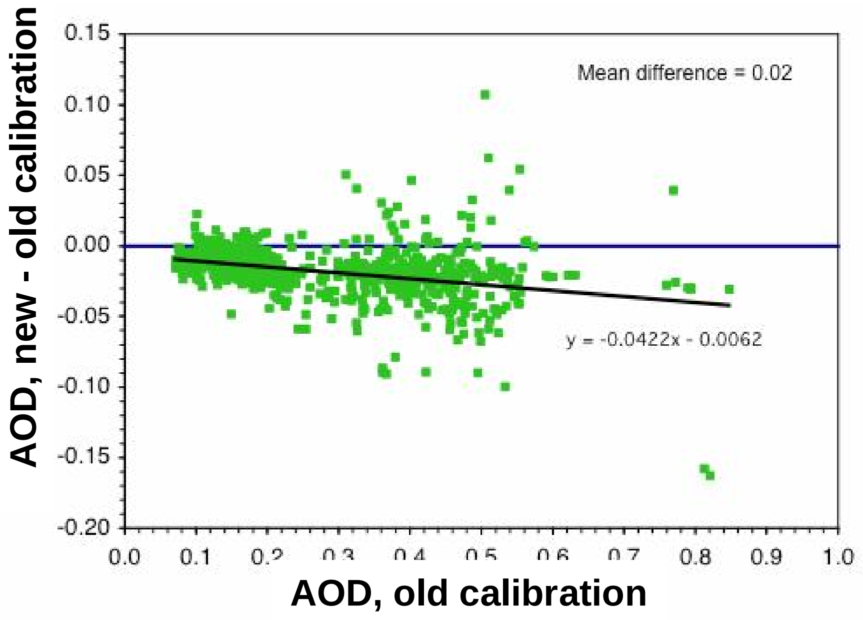


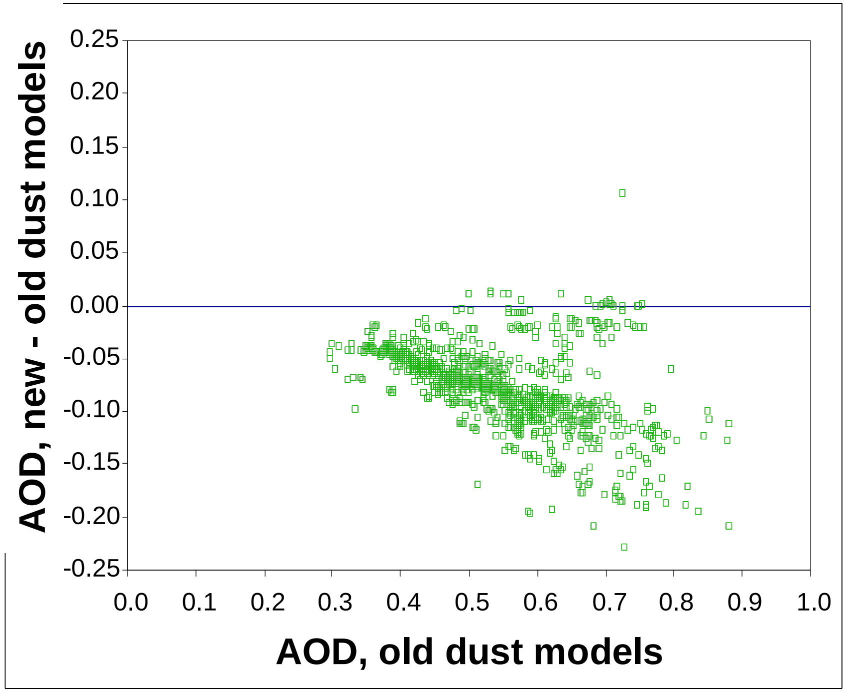
MISR-AERONET difference was ~0.05 at 558 nm

Similar differences were seen with airborne sunphotometer (AATS-14) data and with MODIS

R. Kahn, W-H. Li, W. Abdou, L. Remer

Effect of recent product revisions on retrieved MISR AOD over water





Calibration revisions

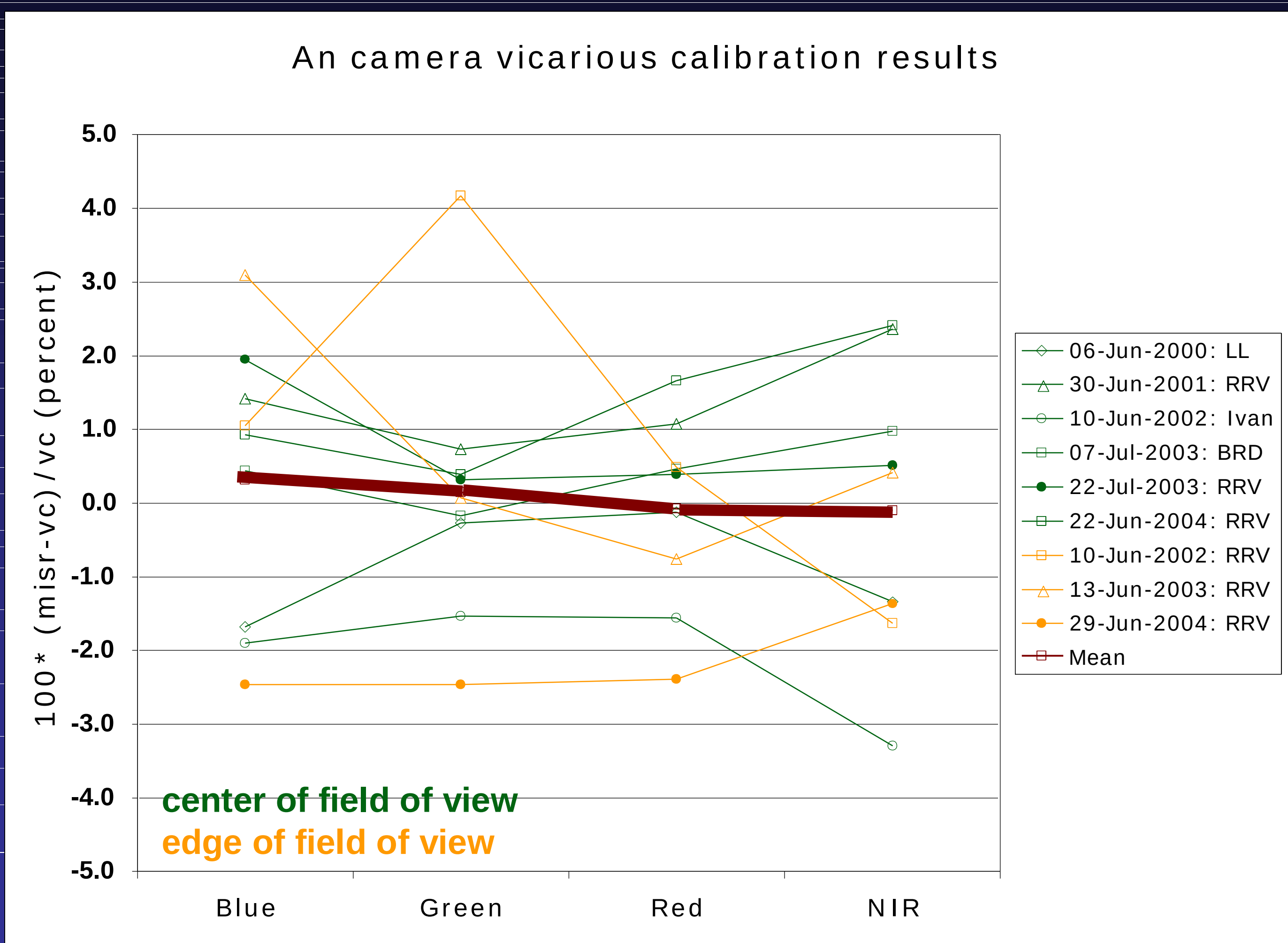
Initial MISR-AERONET-AATS 14 comparisons suggest that the MISR ocean AOD bias has been eliminated

New dust models

Medium-sized weakly-absorbing (1% hematite) grain-shaped dust models provide the best fit to MISR radiances over dust plumes

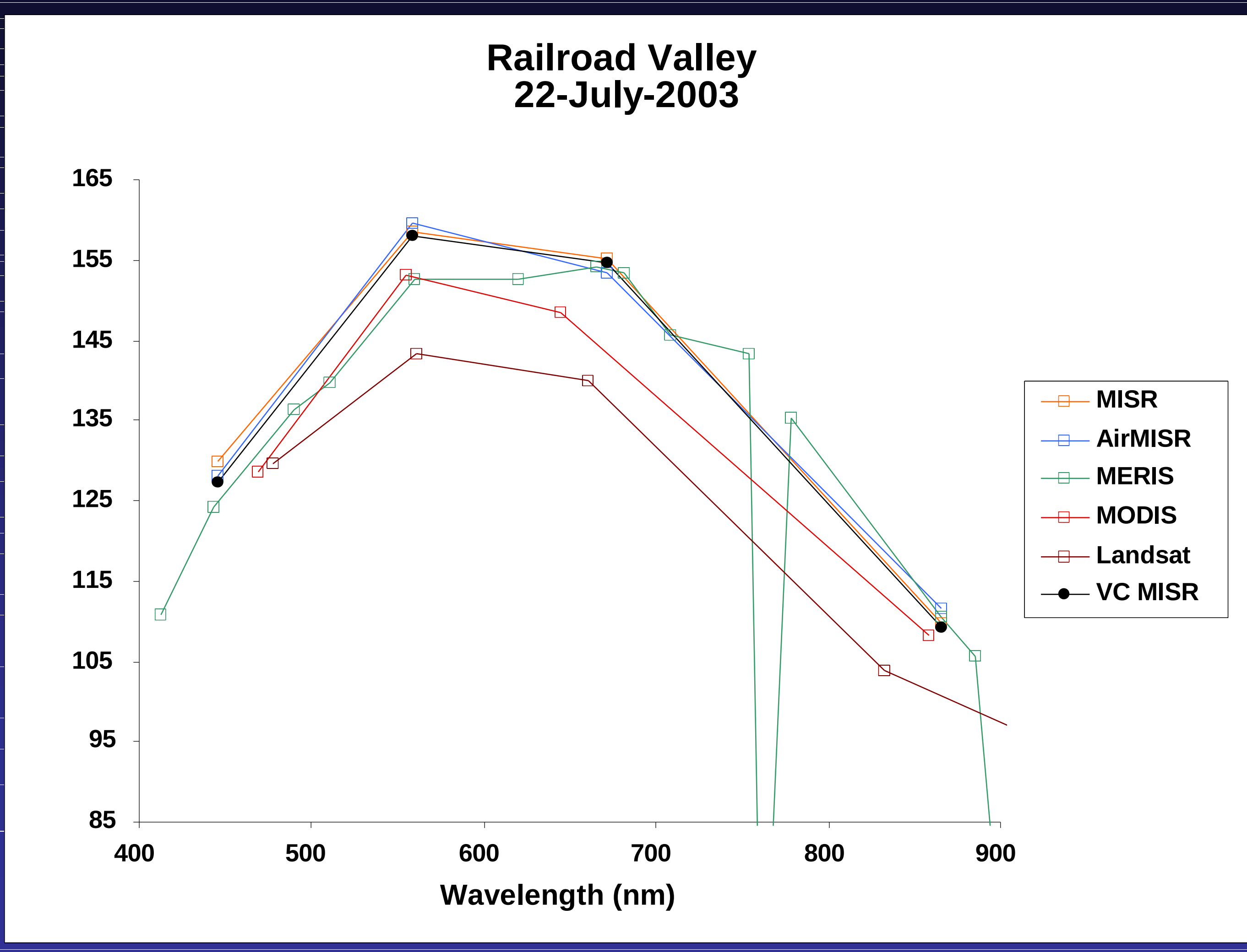
R. Kahn, O. Kalashnikova, D. Diner

Comparison of revised radiometric scale with 5 years of MISR vicarious calibration history



C. Bruegge, W. Abdou

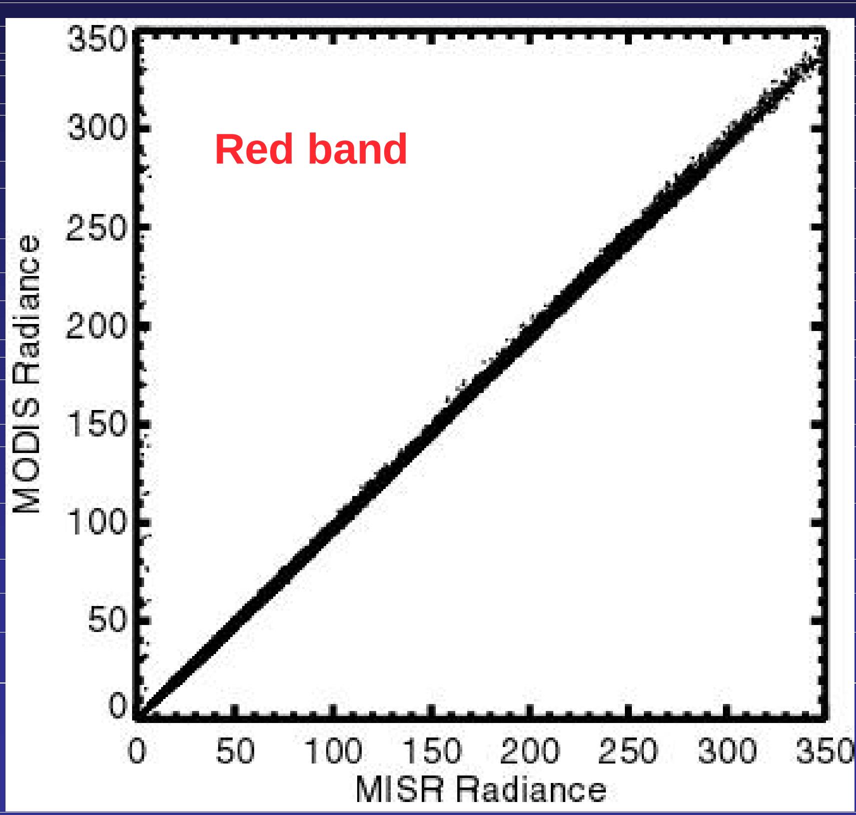
MISR revised calibration compared to MODIS and other sensors

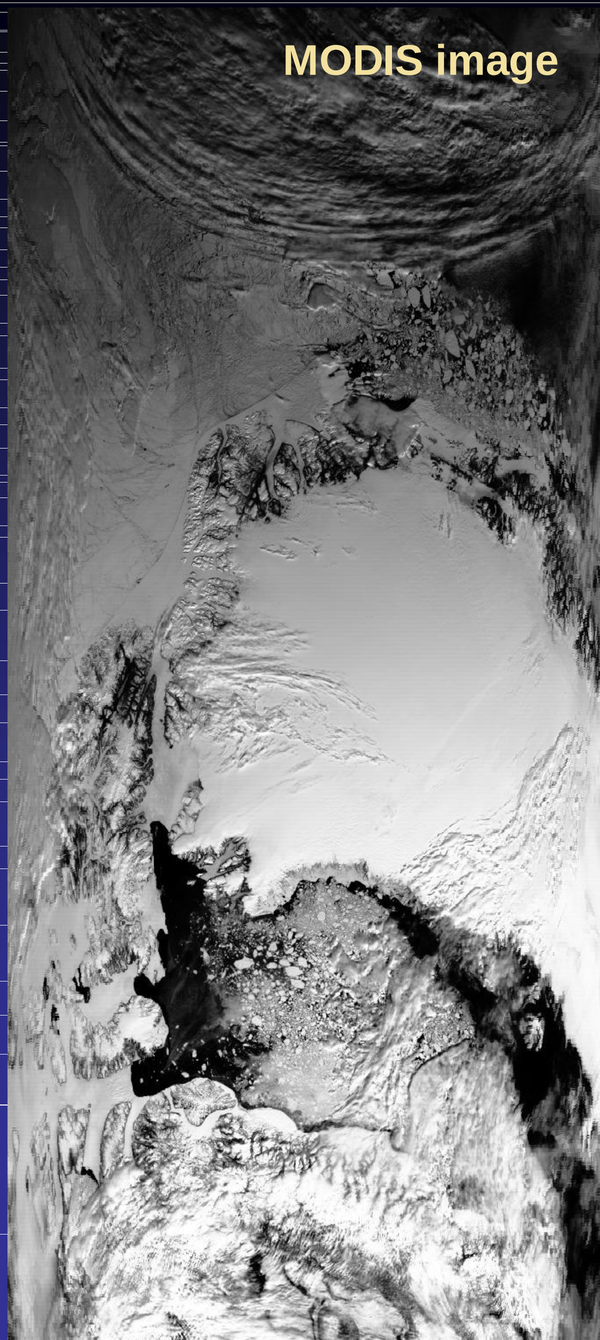


C. Bruegge, W. Abdou

MISR/MODIS radiance intercomparison in the Arctic

Arctic Ocean/Greenland/Baffin Bay/Baffin Island
Terra path 26—15 orbits from 2002

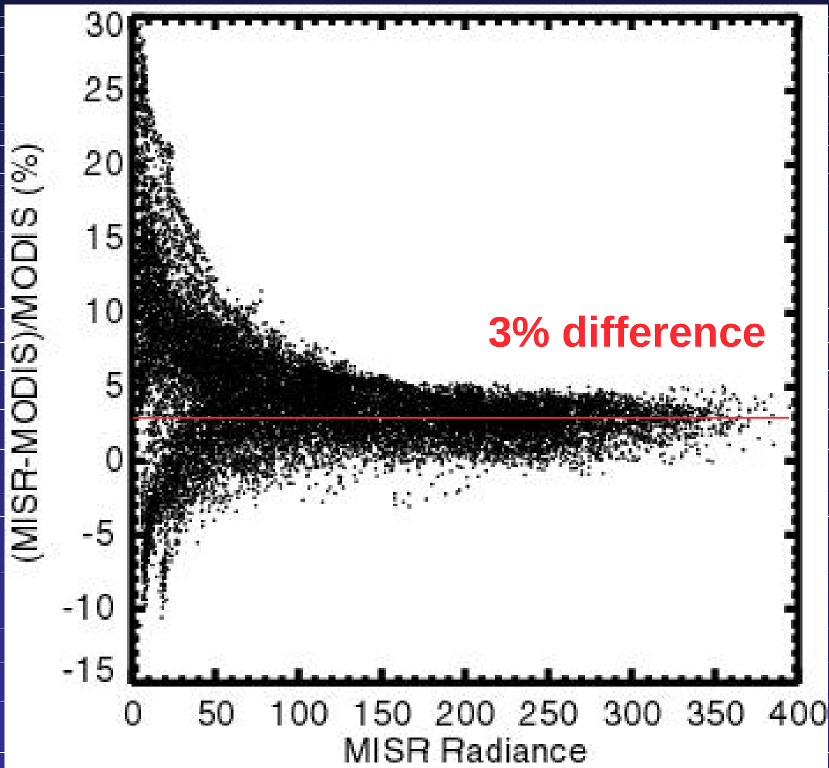




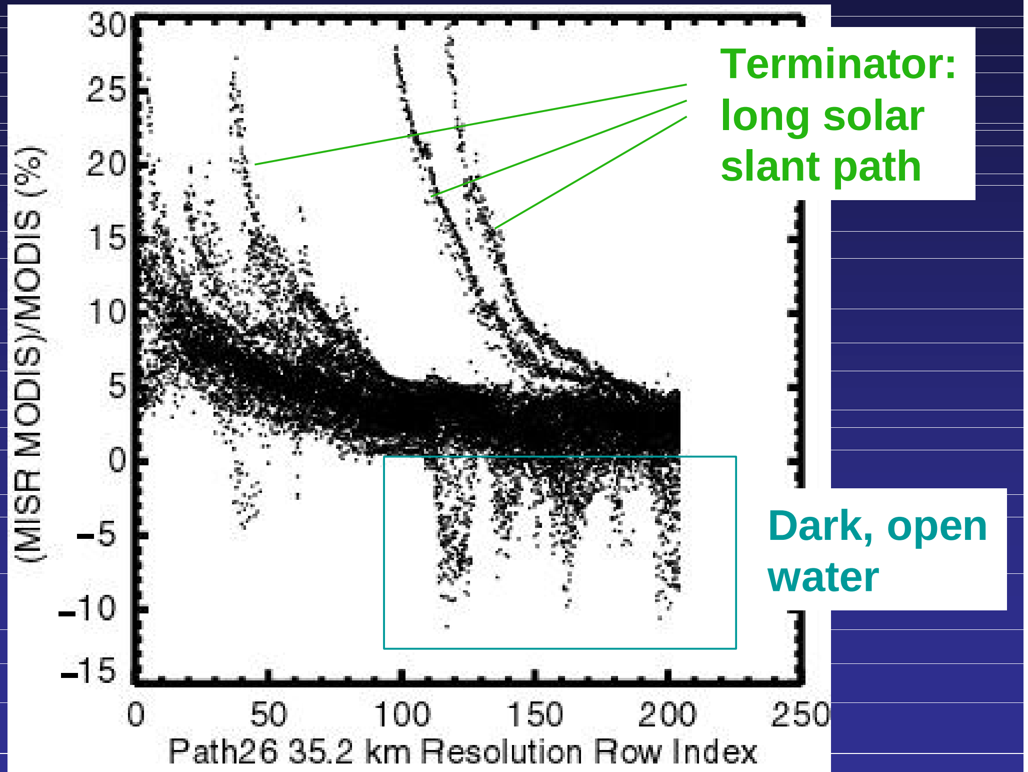
E. Clothiaux

Details of MISR/MODIS radiance intercomparison

MISR: 672 nm
MODIS: 645 nm
Not adjusted for spectral shift, ozone



MISR-MODIS difference (%) as function of radiance

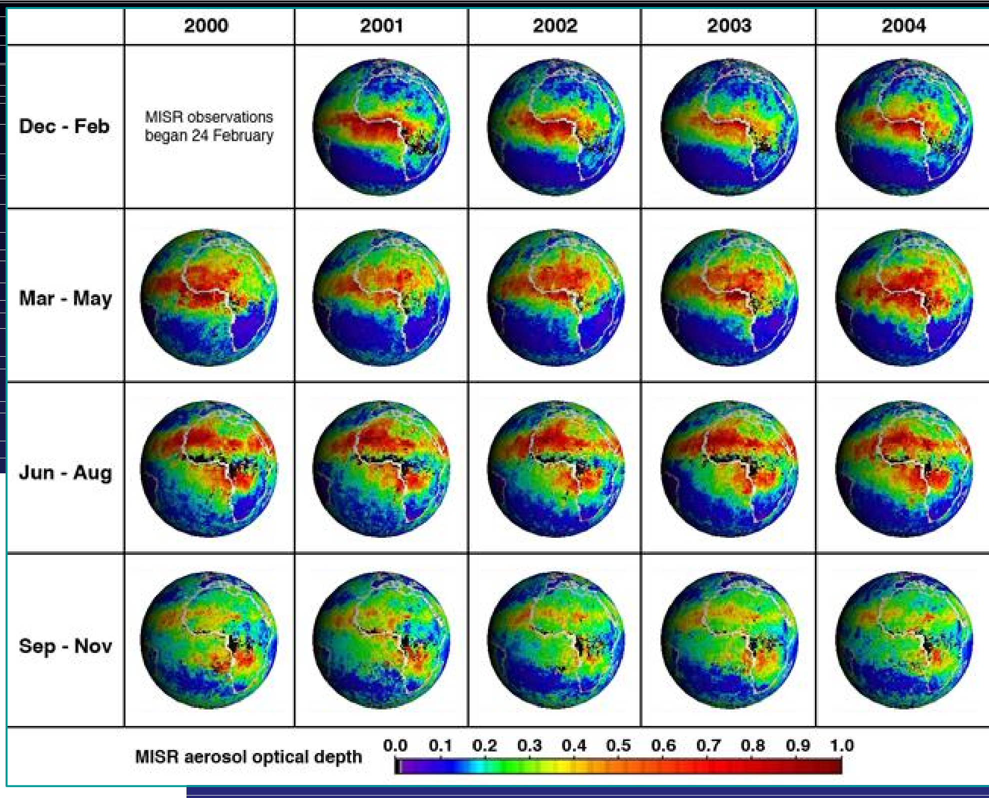


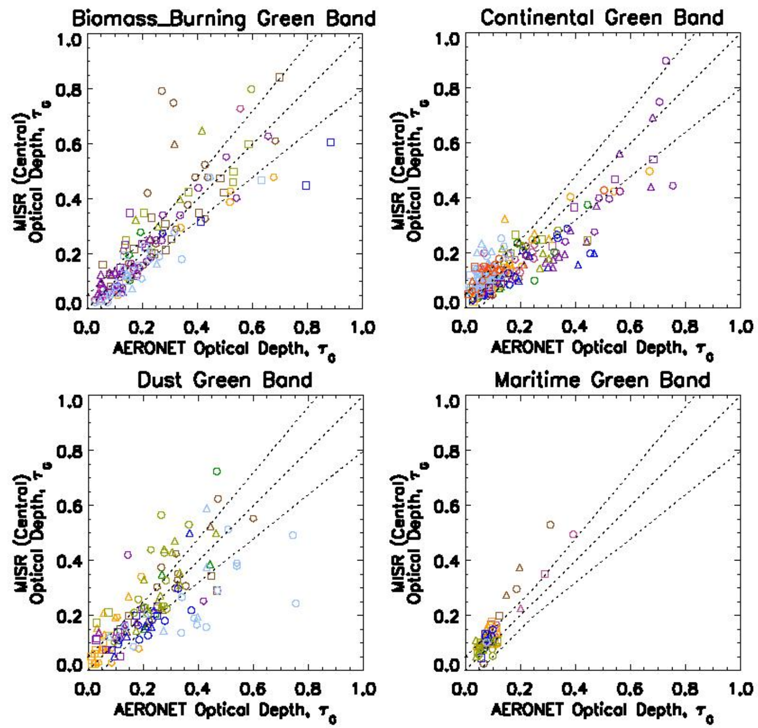
MISR-MODIS difference (%) as function of location

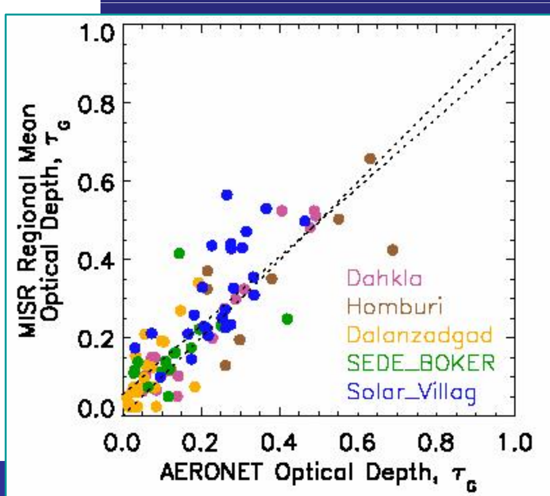
E. Clothiaux

Aerosols and cirrus

MISR/MODIS standard product complementarity: MISR retrievals over bright surfaces





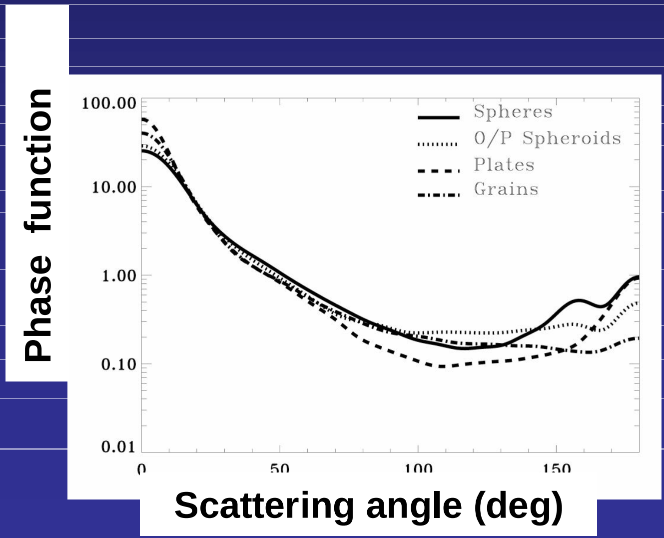


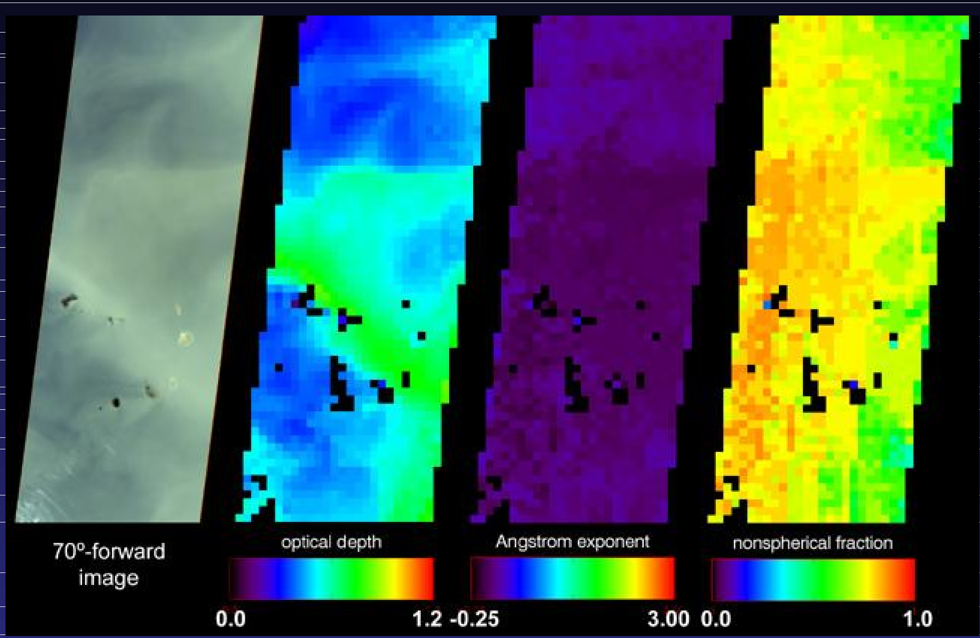
R. Kahn, J. Martonchik, W. Abdou, B. Gaitley, D. Diner

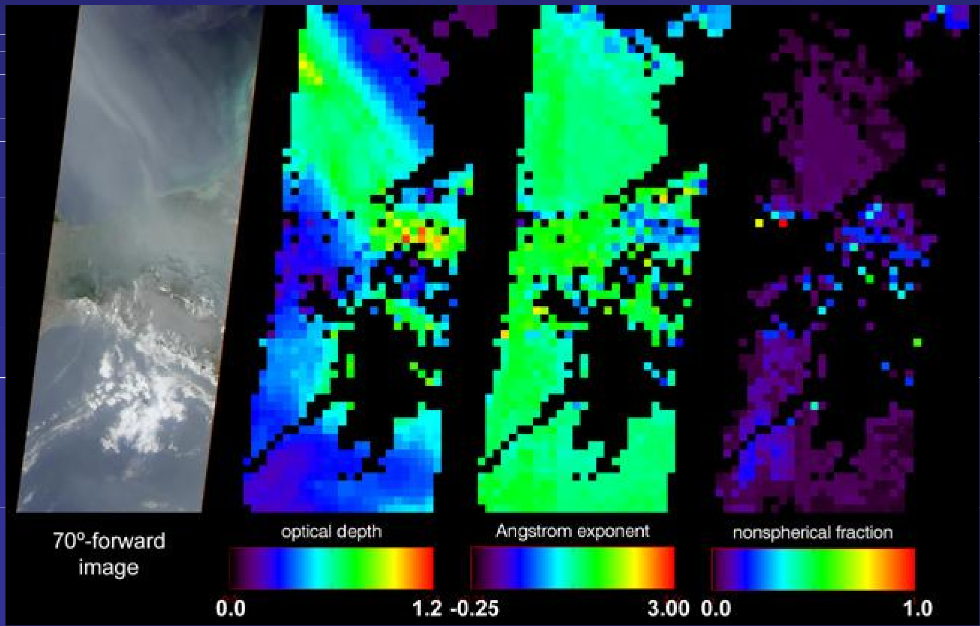
Synergistic sensitivities to aerosol particle properties

MODIS: broad spectral coverage enhances sensitivity to size, particularly coarse mode

MISR: multiangle data provides sensitivity to shape

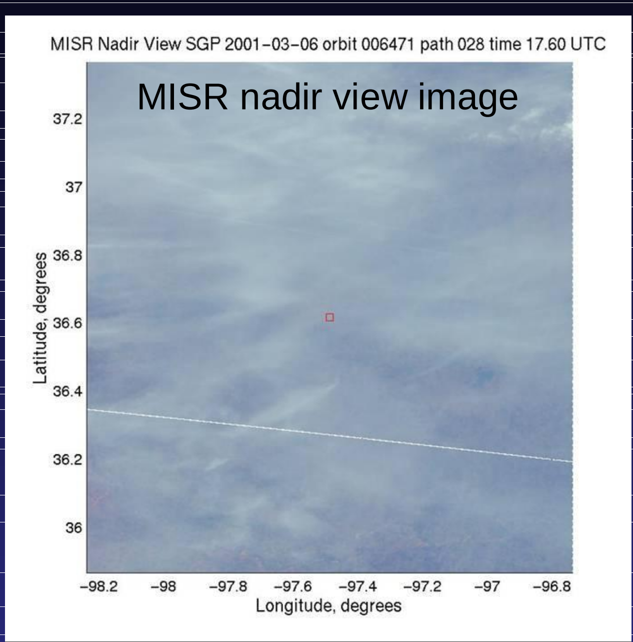


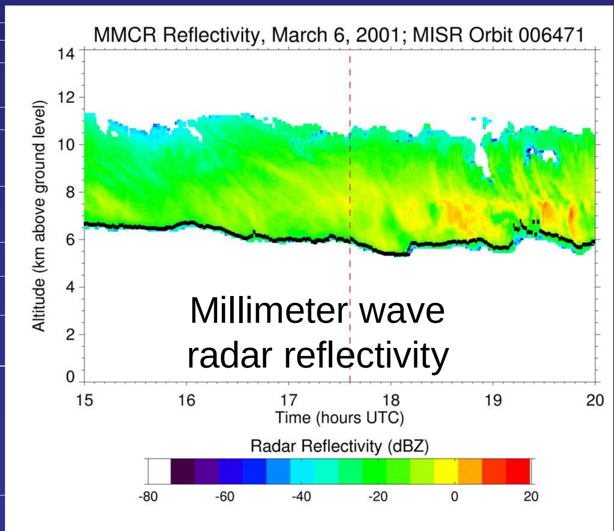


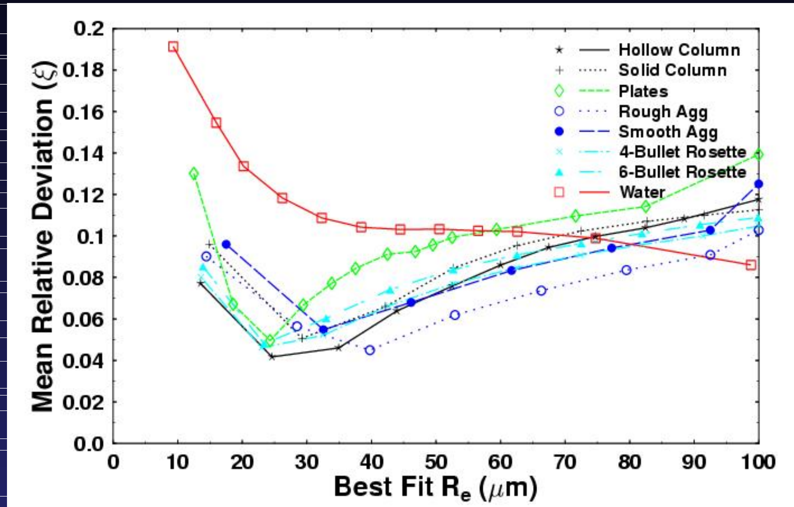


O. Kalashnikova, R. Kahn, D. Diner

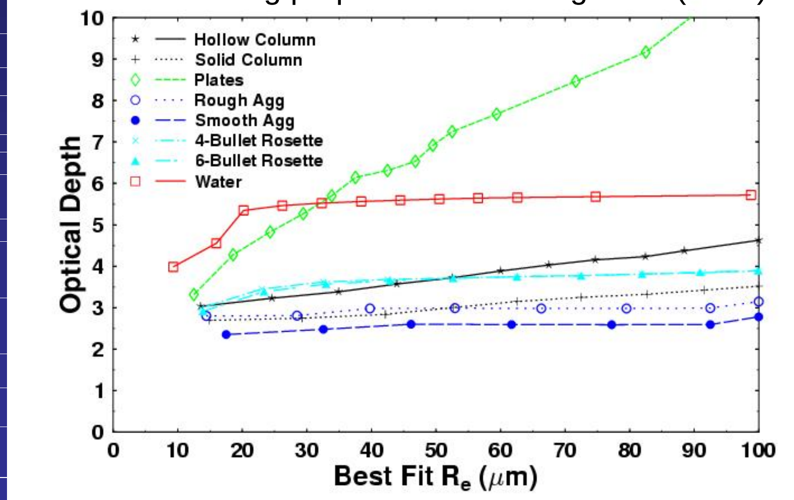
MISR/MODIS cirrus case study at ARM Oklahoma site







Ice scattering properties from Yang et al. (2000)

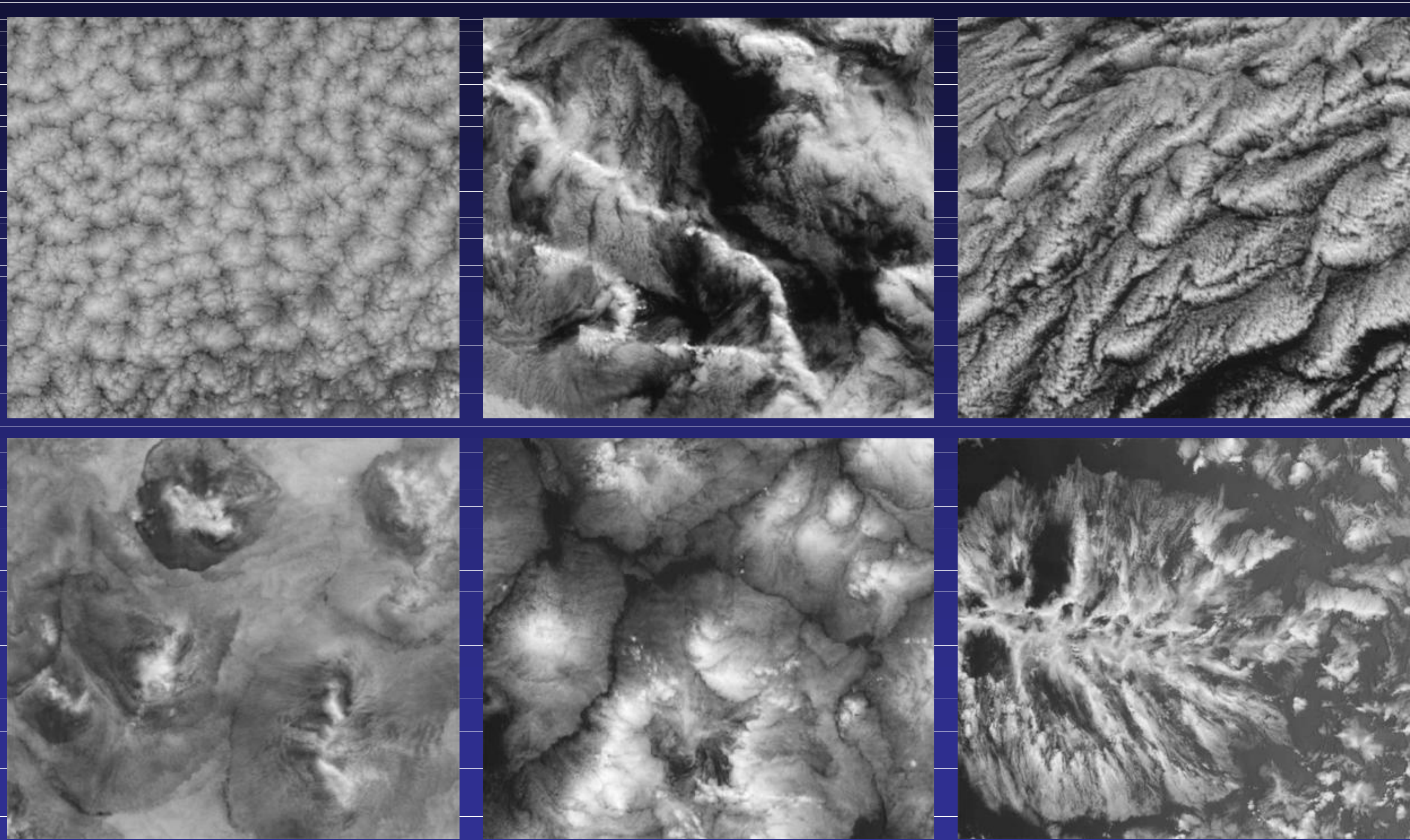


MISR is sensitive to particle shape
MODIS is sensitive to particle size

S. McFarlane, R. Marchand, T. Ackerman

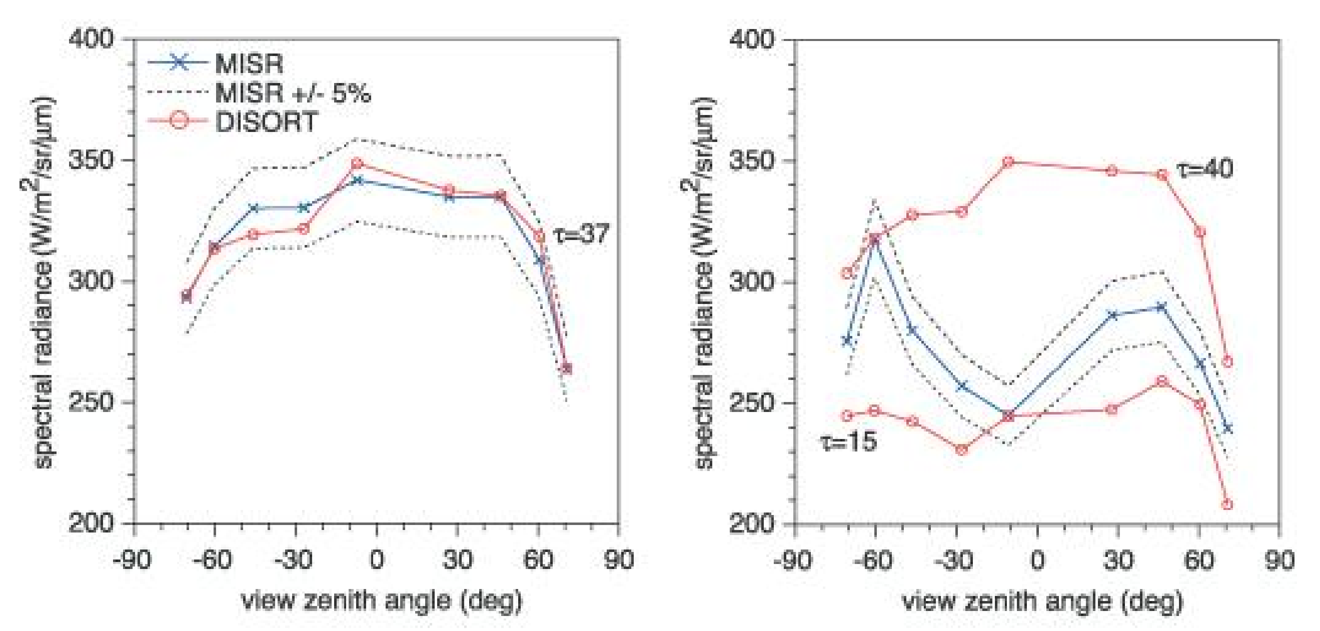
Cloud structure, heights, and detection

Morphological diversity of marine stratocumulus clouds



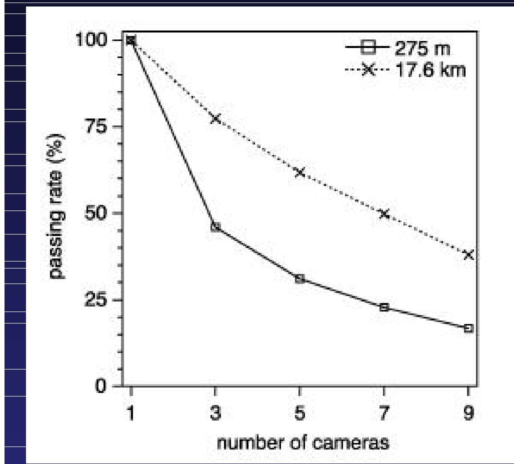
R. Davies

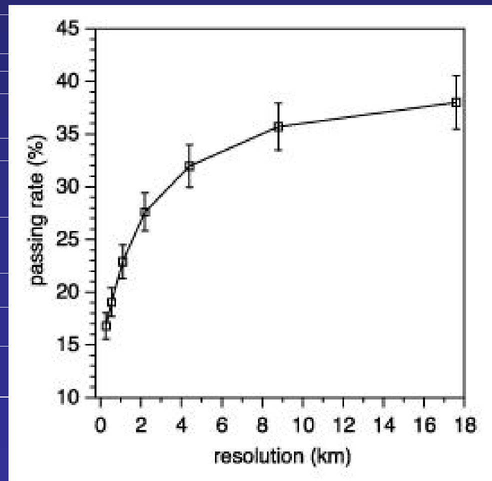
Multiangle tests of cloud homogeneity



1-D theory fits MISR observations

1-D theory does not fit MISR observations



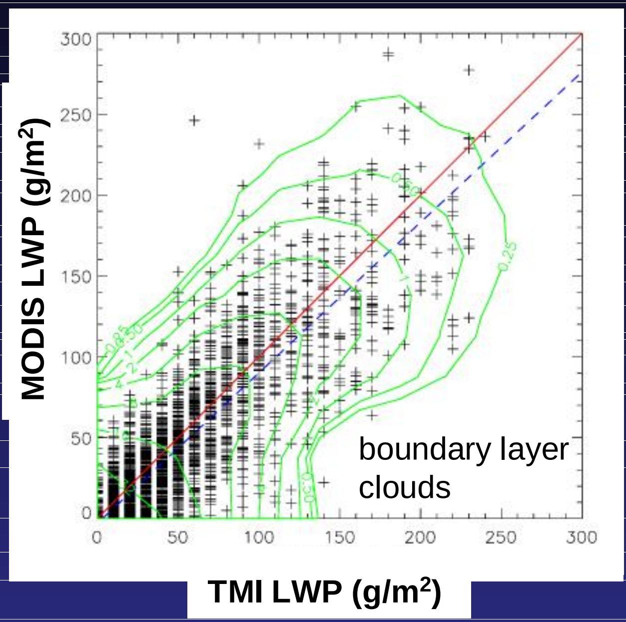


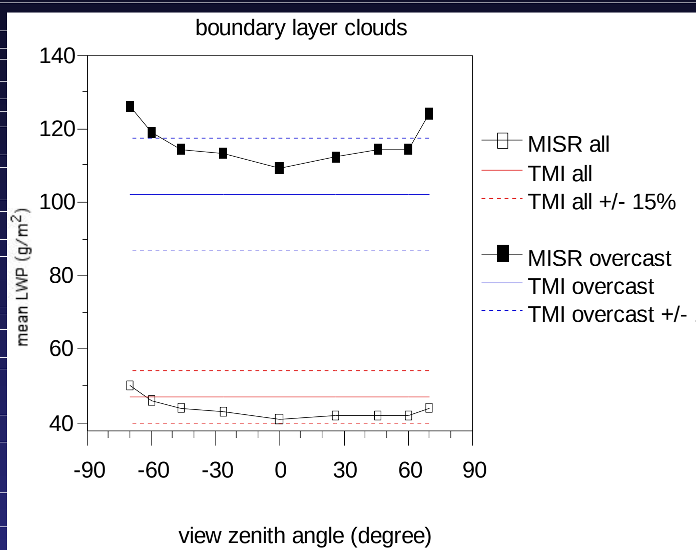
Multiangle data provides a physical consistency check on MODIS 1-D cloud retrieval assumption

Cloud morphology, along with cloud microphysics, plays a major role in determining TOA bidirectional reflectance

A. Horvath, R. Davies

Application to retrievals of cloud liquid water: MODIS/MISR/TMI fusion





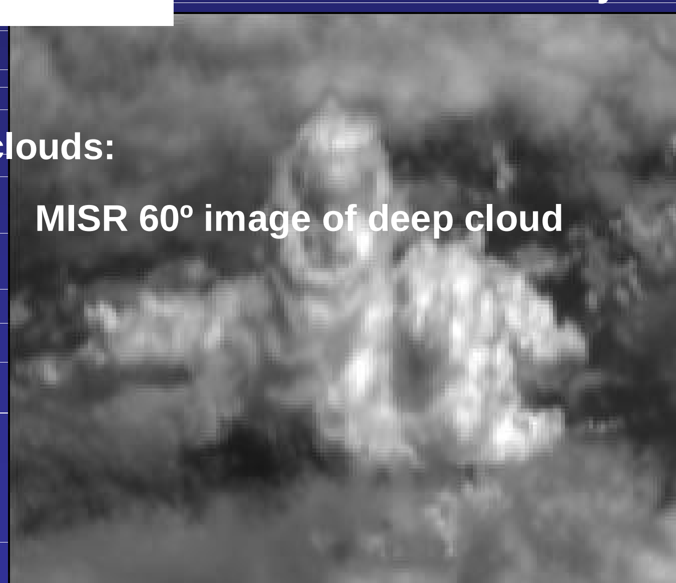
Reasonable consistency (±25%) is obtained between MODIS and TRMM Microwave Imager (TMI) LWP for shallow, boundary layer clouds.

MISR is used as a check on the applicability of 1-D retrieval theory.

MODIS/TMI consistency is

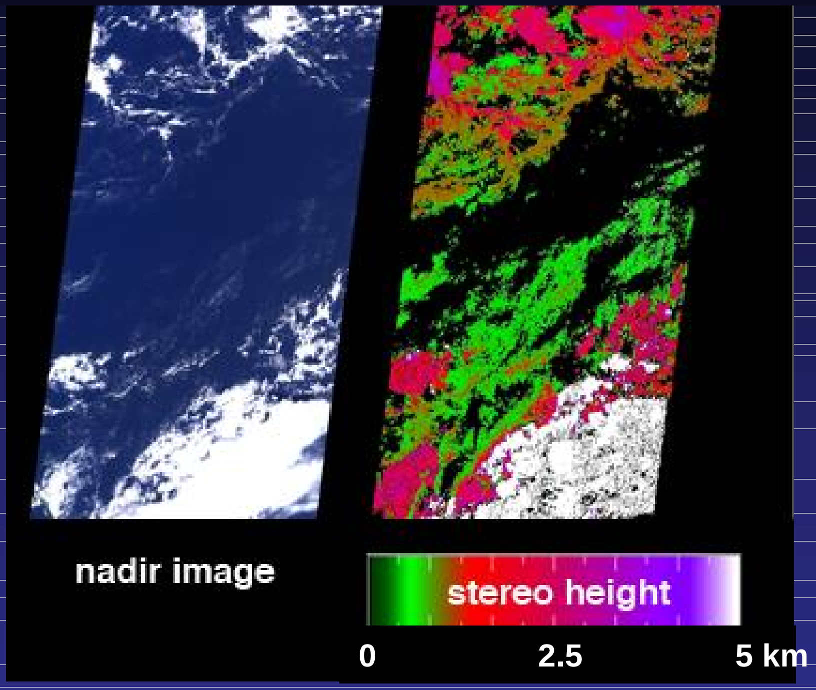
Oblique views make it possible to scan down the sides of deep clouds:

	nadir only	nadir+60°
cloud vertical extent	no information	10.5 ± 0.8 km
extinction coefficient	no information	8 - 22 km^{-1} (higher at base)
cloud optical depth	> 60	150 ± 30



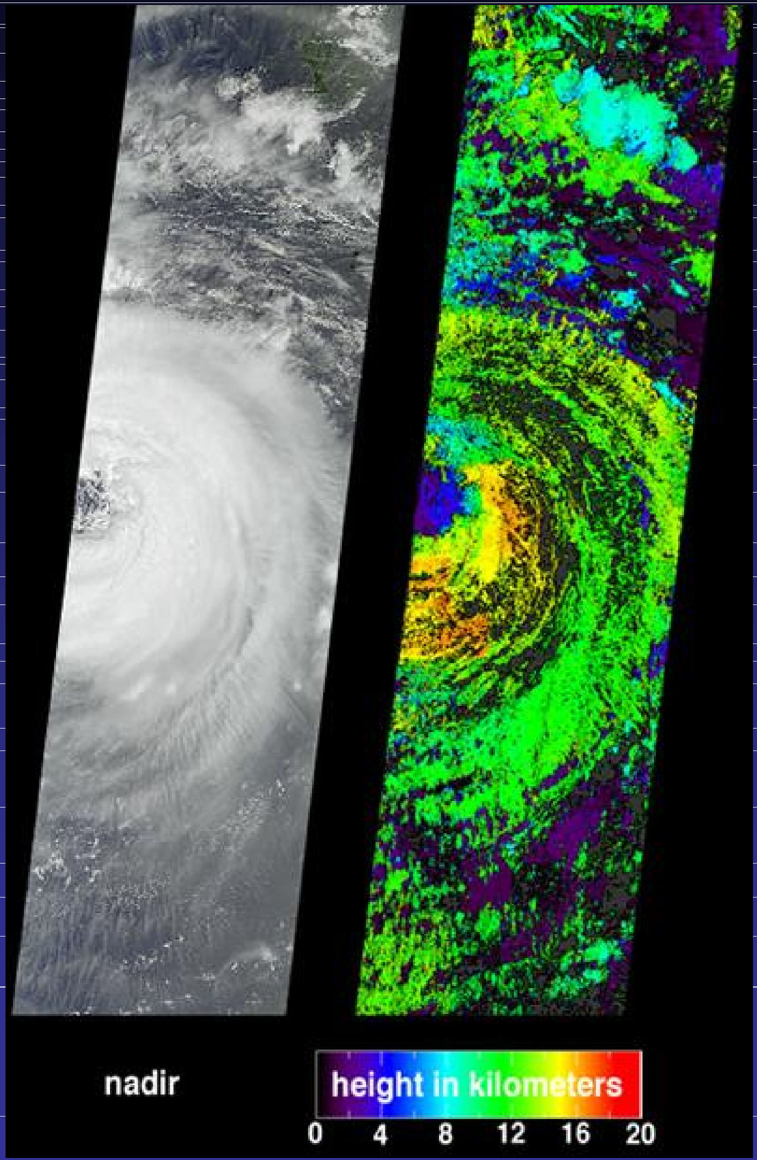
A. Horvath, R. Davies

MISR stereo retrievals of cloud top heights (CTH)



Trade wind cumuli: high sensitivity

MISR cloud heights
--independent of radiometric calibration, atmospheric temperature profiles, cloud emissivity

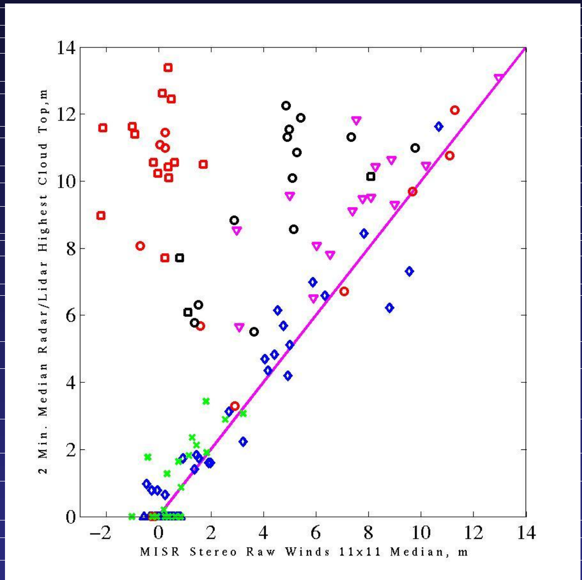


Typhoon Sinlaku

Comparison of MISR stereo heights with radar/lidar

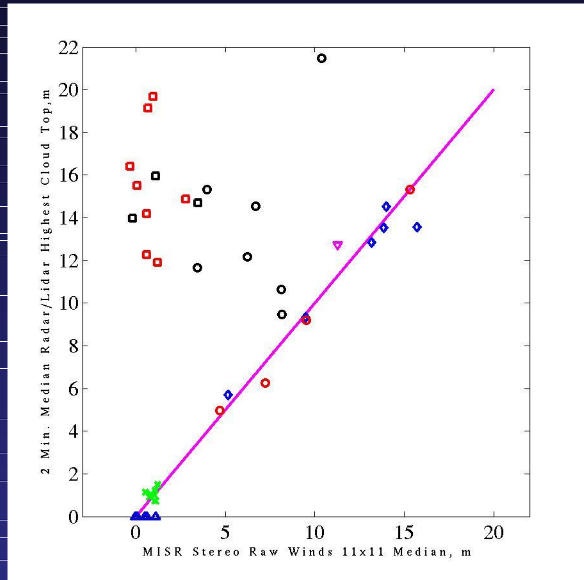
Radar/lidar maximum height

ARM SGP



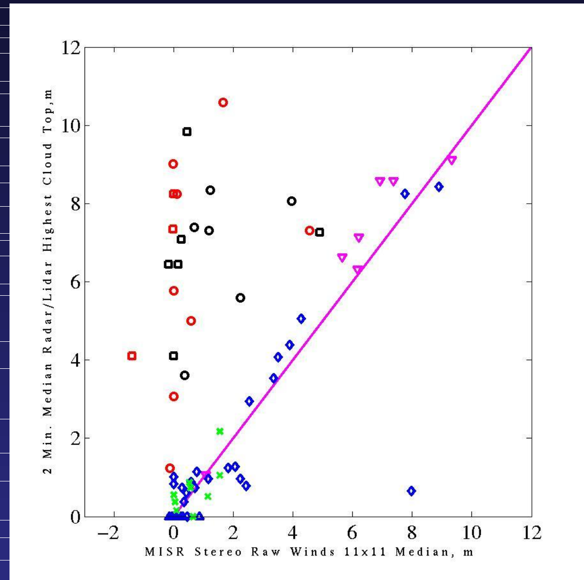
MISR stereo height

ARM Nauru



MISR stereo height

ARM Barrow



MISR stereo height

Clear-sky or opaque cloud top

Broken boundary layer clouds

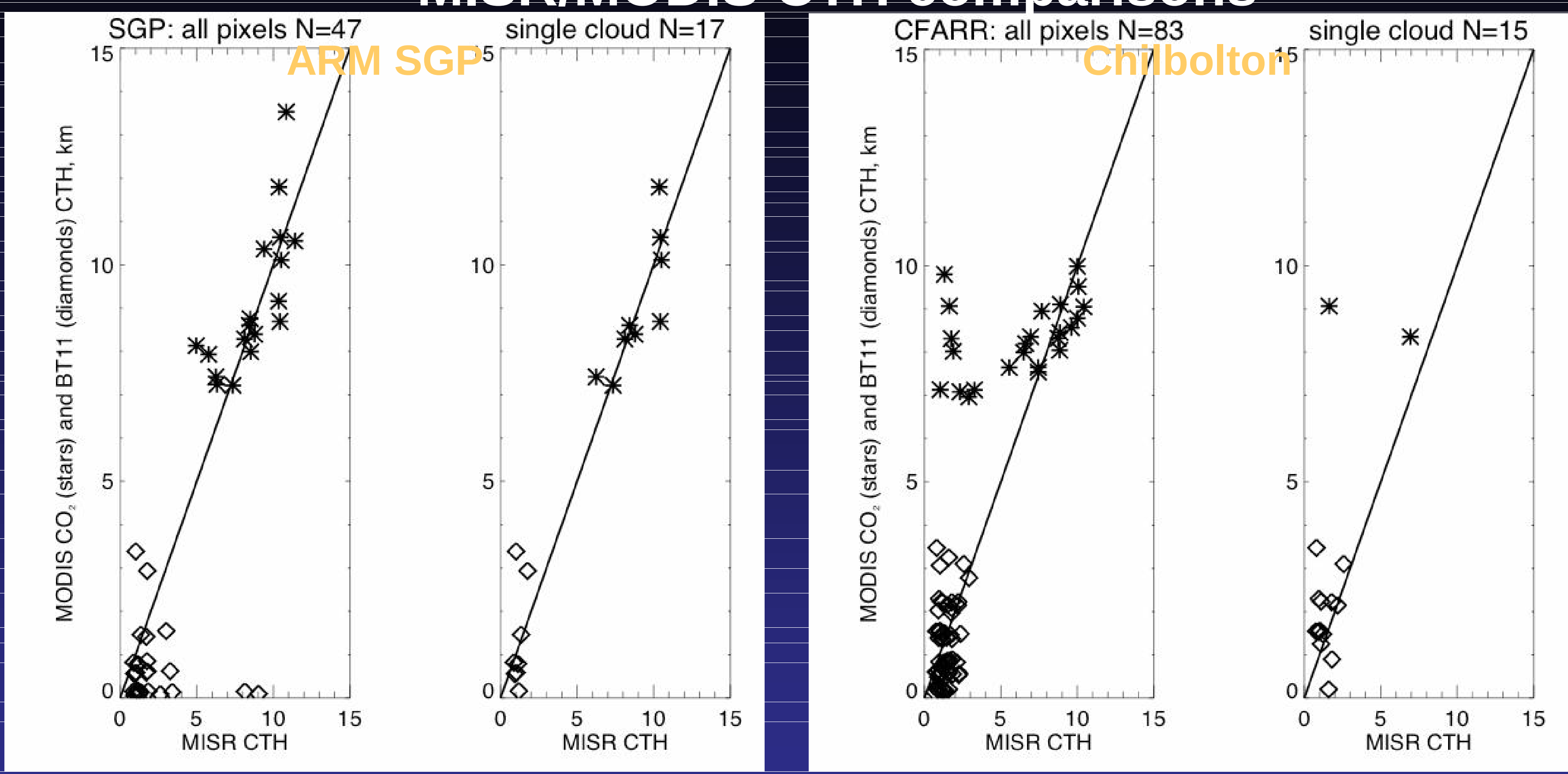
Semi-opaque cirrus

Thin cloud over other clouds (MISR determines the height of the lower cloud tops)

Thin cloud over surface

R. Marchand, T. Ackerman

MISR/MODIS CTH comparisons



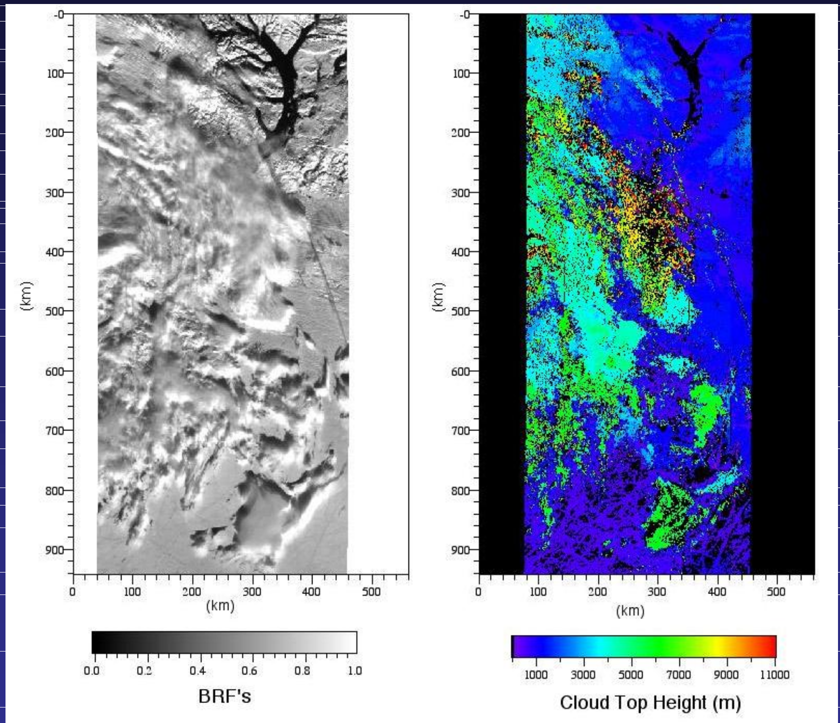
- MISR and MODIS in good agreement for single-level mid-high clouds (accuracy ~500 m)
- MISR performs well for low clouds, MODIS 11 μm brightness temperatures problematic
- Multi-layer situations problematic for MISR operational (near-nadir) stereo, altitude detected depends on high cloud optical depth
- Typically MODIS CTH > MISR CTH (difference ~600 m)

C. Naud, J-P. Muller, E. Clothiaux

Discriminating polar clouds from snow and ice with MISR

Stereo

Arctic, near Queen Elizabeth Islands, 28 August 2000

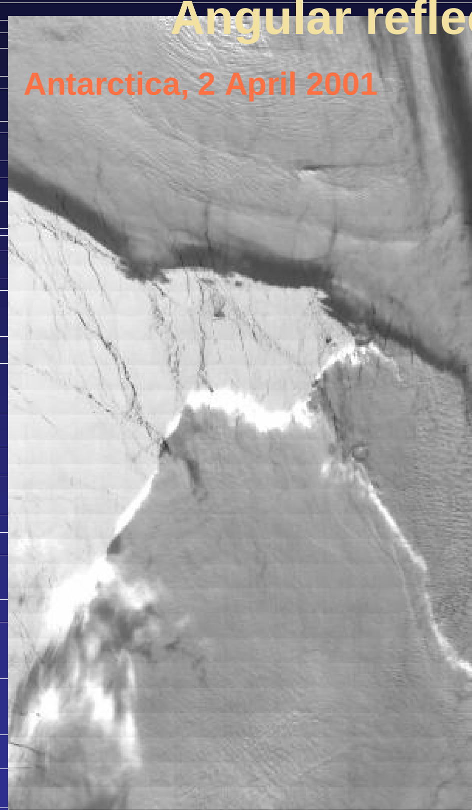


Bidirectional reflectance factor

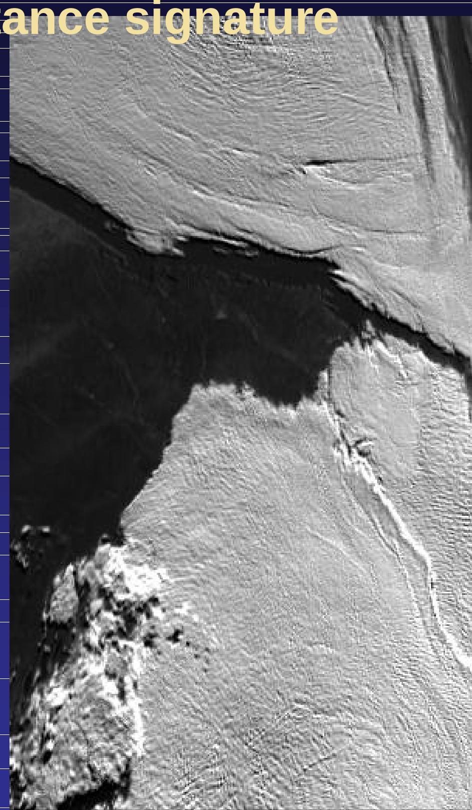
Stereoscopically-derived cloud-top height

Angular reflectance signature

Antarctica, 2 April 2001



Red band bidirectional reflectance factor



Band-differenced angular signature

L. Di Girolamo, M. Wilson, C.Moroney

Strength of MISR/MODIS fusion for polar clouds

Overall classification accuracies relative to "expert" labels

Arctic Ocean/Greenland/Baffin Bay/Baffin Island
Terra path 26—15 orbits from daylight season of 2002

MODIS: 86% [detects the highest cloud, whether optically thick or thin]

MISR stereo only: 75% [locates the first (from space) optically thick surface; thin clouds problematic for near-nadir stereo]

MISR stereo + angular signatures: 92%

MISR + MODIS: 95-97%

Terra CERES-MISR-MODIS fusion

Capitalizes on excellent separation of clouds from ice for understanding polar radiation budget

CALIPSO and CloudSat synergy can be used to quantify cloud optical depths giving rise to MODIS high cloud/MISR low cloud detections

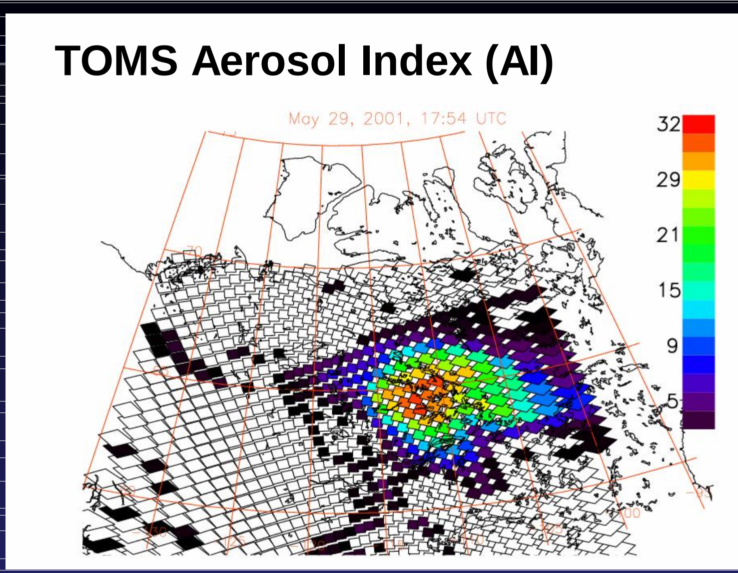
T. Shi, B. Yu, A. Braverman, D. Groff, E. Clothiaux

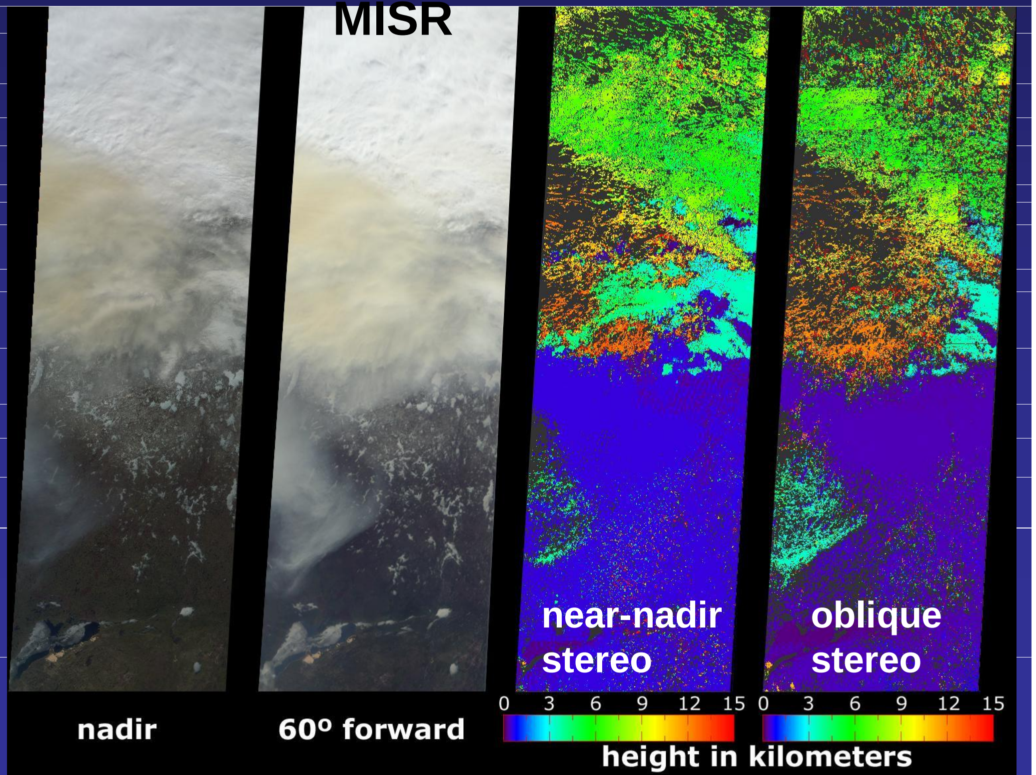
Fires and smoke

Direct height retrieval of UT/LS smoke from the Chisholm fire, 29 May 2001

MODIS

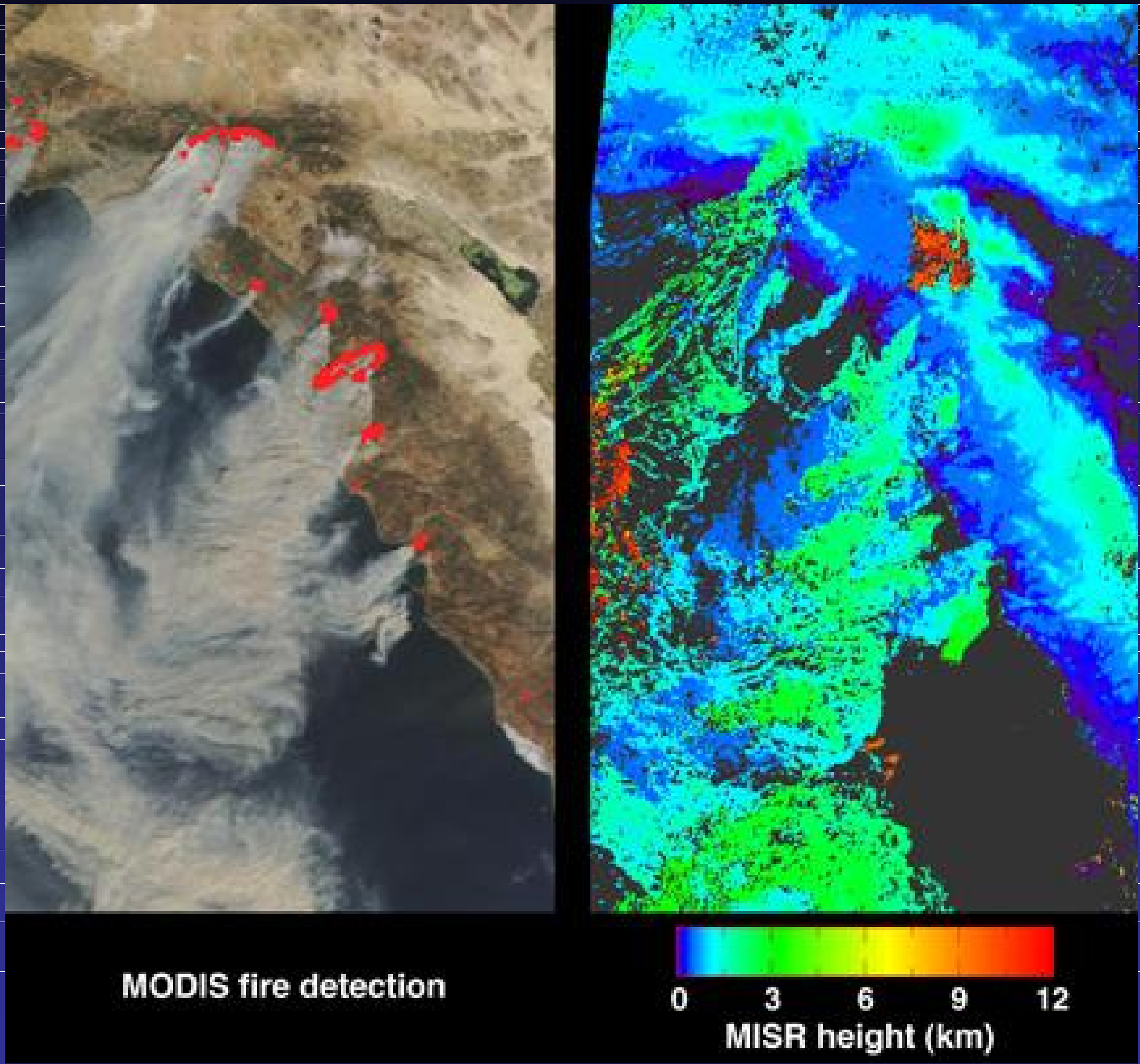
QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.





M. Fromm, D. Diner, C. Moroney, C. Averill

MODIS fire/MISR stereo fusion for wildfire studies



MODIS:
Thermal channels pinpoints fire locations

MISR:
Oblique views enhance plume sensitivity

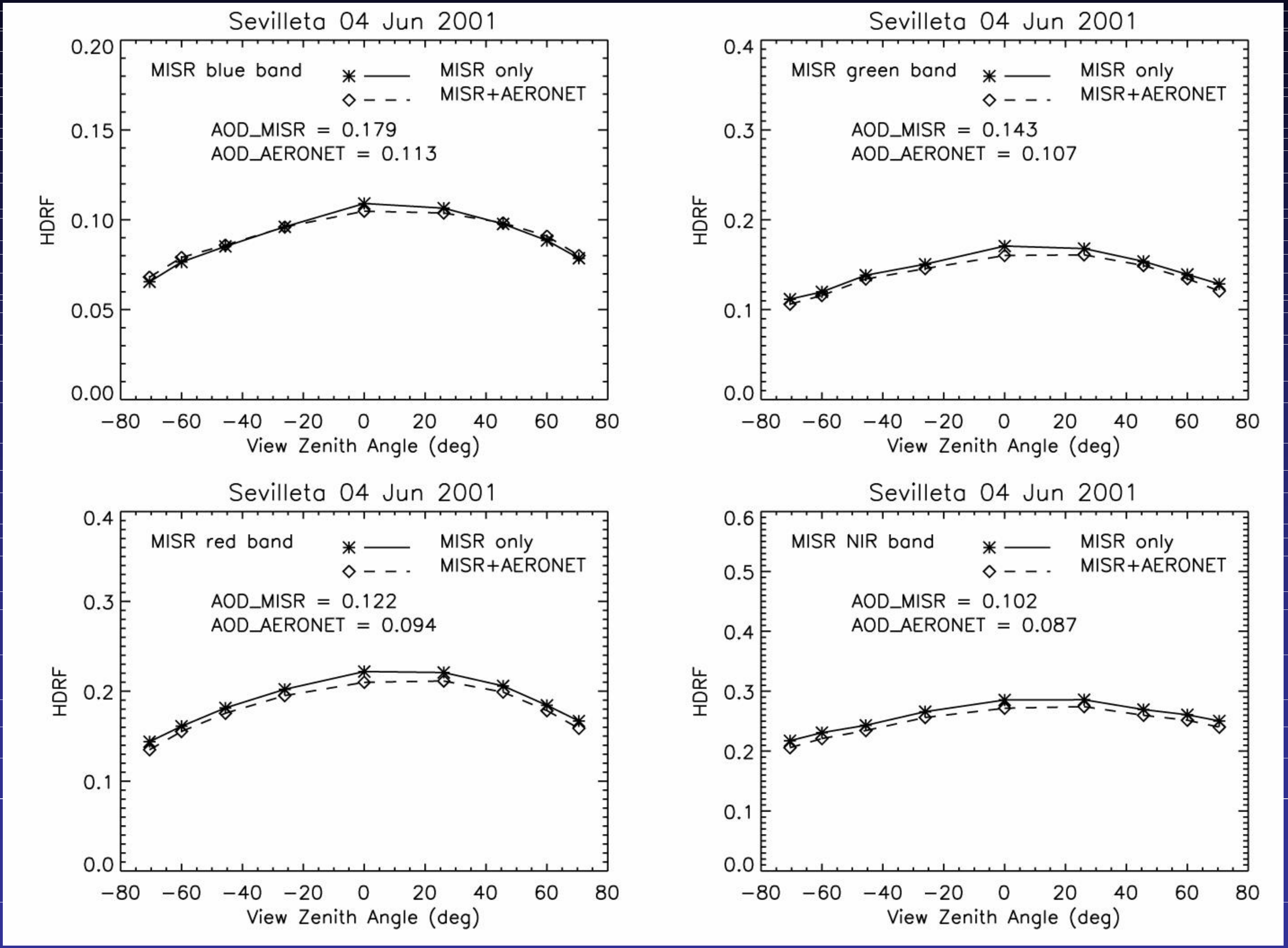
Stereo retrieves plume heights

Provides smoke injection data for CTMs

Southern California, 26 October 2003

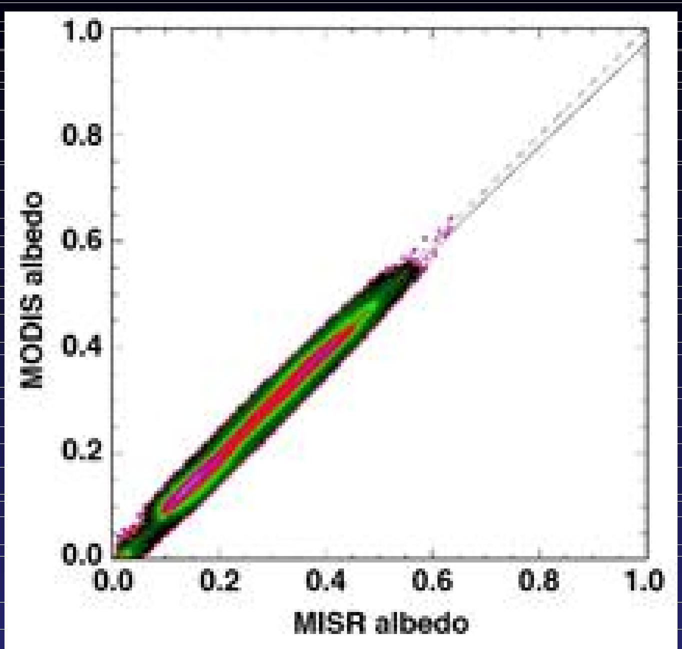
Vegetation

Example of MISR surface directional reflectance retrieval



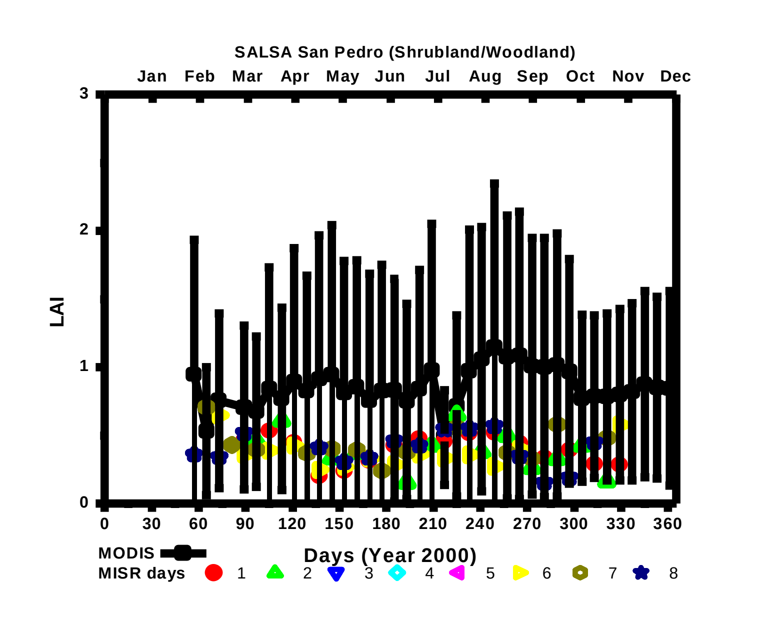
J. Martonchik

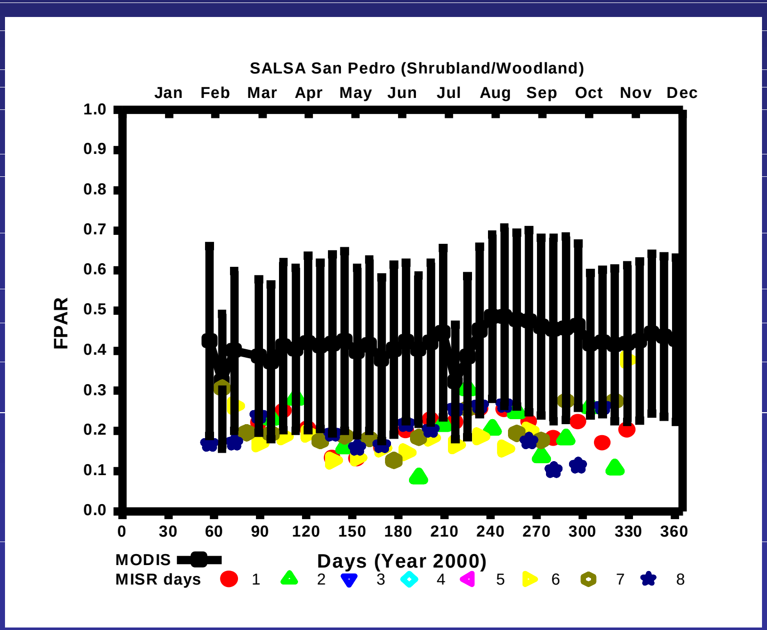
MISR/MODIS land surface product intercomparisons



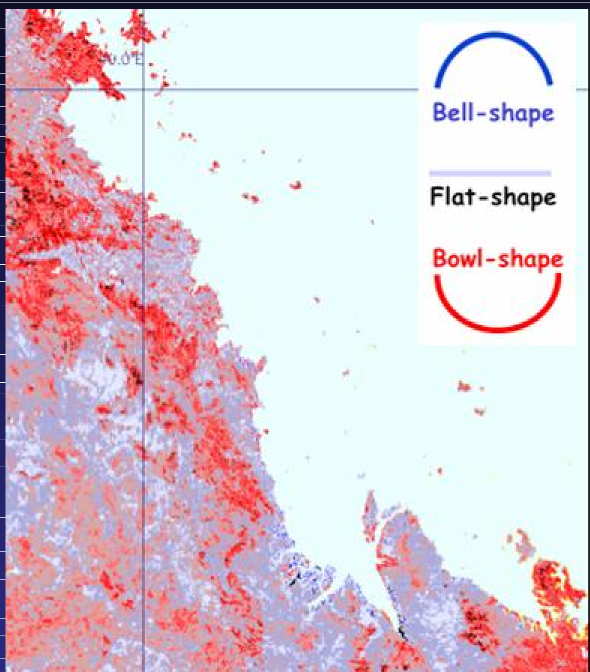
Land surface albedo
(B. Pinty, S. Liang, H. Fang)

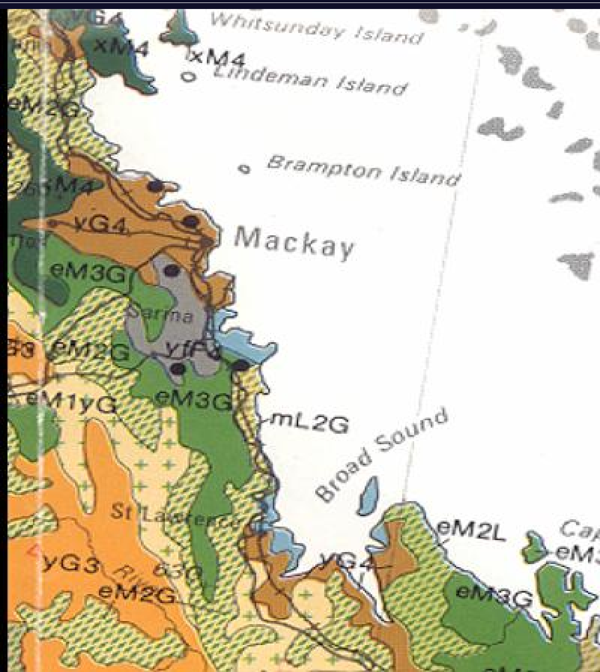
LAI/FPAR over sparsely vegetated land (shrubs account for 25% of global vegetation)
(R. Myneni, Y. Knyazikhin, J. Hu)





MISR/MODIS synergy/fusion over land surfaces





Bell-shaped BRF:
Tree crowns of medium-high density against bright background

Bowl-shaped BRF:
Sparse vegetation and dense, closed canopies

Map: Australian Surveying and Land Information Group

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

MISR along-track multiangle data provide independent structural information

MISR/MODIS fusion studies:
B. Braswell et al.: Amazon deforestation and regrowth
M. Chopping et al.: Woody biomass incursion into arid grasslands

Conclusions

Simultaneous broad spectral coverage from MODIS and wide angular coverage from MISR makes a uniquely valuable combination:

- Having independent retrievals of related parameters from each sensor using different methodologies is a key element of a robust observing system.
- Data fusion capitalizes on complementary sensitivities to aerosol, cloud, and surface properties.

MISR/MODIS data fusion is currently being done in research mode

- Products using joint retrievals can be considered—
  - Aerosols
  - Polar clouds
  - Fires
  - Land surface
- Some of these were described in the Terra extension proposal (Senior Review).
- Joint data analysis tool development would also be a great benefit to the scientific community.