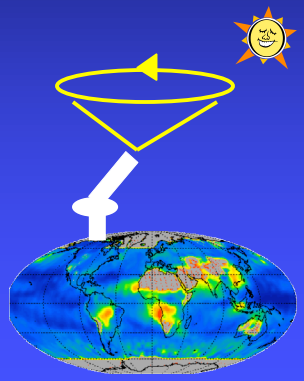
AERONET New Developments

Oleg Dubovik (NASA / GSFC, Code 614.4)

Outlines:

- ***Programmatic prospective (Brent Holben)***
- ***New aerosol retrieval developments***



AERONET Developments

- ~280 instruments
- ~150-180 Operational sites
- Network Partners
  - GSFC
  - Photons (France)
  - RIMA (Spain)
  - CSIRO (Australia)
  - AEROCAN (Canada)
- Expansion to Asia, Africa high latitudes and over water sites

B.N. Holben

AERONET Version 2 AOD

- Version 2 (AOD) implemented July 2005
  - Improved corrections: Satellite
    - TOMS (Monthly gridded O_3)
    - SCIAMACY (Monthly gridded NO_2)
  - Improved corrections: NCEP/NCAR Reanalysis
    - Dynamic Air Pressure for Rayleigh, CO_2 and CH_4 correction
  - Much improved and QA water vapor retrievals
  - Details: http://AERONET.gsfc.nasa.gov/version2-table.pdf

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AERONET Inversion 2

- Unified Inversion products from combined Sphere/Spheroid models
- Uncertainty Assessment w/ all products
- Dynamic surface reflectances
  - Modis & IGBP Ecosystem reflectance + BRDF (16 day product)
  - Cox-Munk for ocean sites (hybrid for coastal sites)
  - Snow and Ice from INSE product (daily)
- Inversion Products for PP retrievals
- Forcing computations

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AERONET-OCS (Ocean Color Segment)

- SeaPRISM (cimel)
- Normalized water leaving radiances (L_{wn})
- 3 yr validation w/ in water optics (Venice)
- Standard AOT and inversion products
- λ(nm): 412, 443, 490, 531, 551, 677, 870, 940, 1020

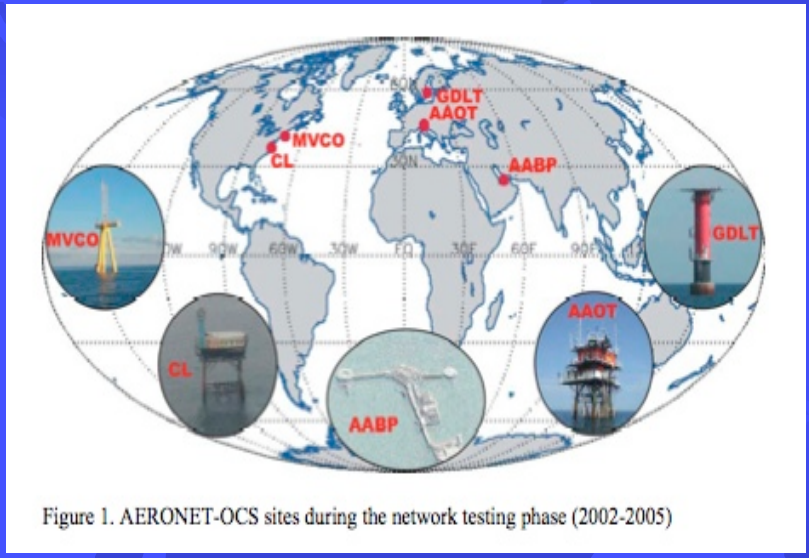

Figure 1. AERONET-OCS sites during the network testing phase (2002-2005)

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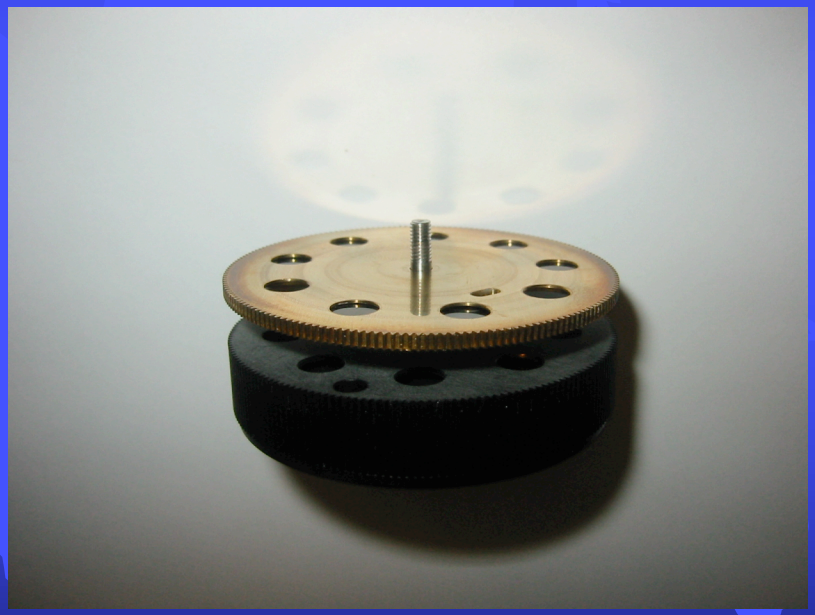
AERONET-MSP (multispectral polarization)

- Spectral Percent linear Polarization hourly
- Standard Products
- L(nm): 340, 380, 440, 500, 675, 870, 940, 1020, 1640
- AERONET testing (Feb. to May 2006)
- Operational products: June 2006



Dual filter wheel, top for polarizers bottom for IAD filters

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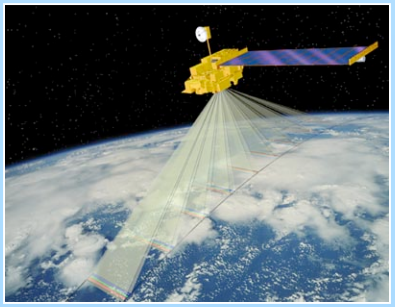
AERONET, etc. Inversion

MISR, POLDER
MODIS



Forward Model:

Single Scat: spheroid model

Multiple Scat: (scalar) Nakajima and Tanaka, 1988
(polarized) Deuze, et al. 1989

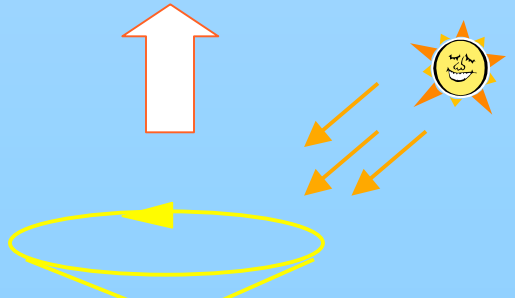
Lambertian (from Moody et al. 2005), BRDF

$\tau(\lambda)$, $I(\lambda,\Theta)$,$P(\lambda,\Theta)$

Numerical inversion:

-Accounting for uncertainty ($P(\lambda,\Theta)$!!!)

- Setting a priori constraints

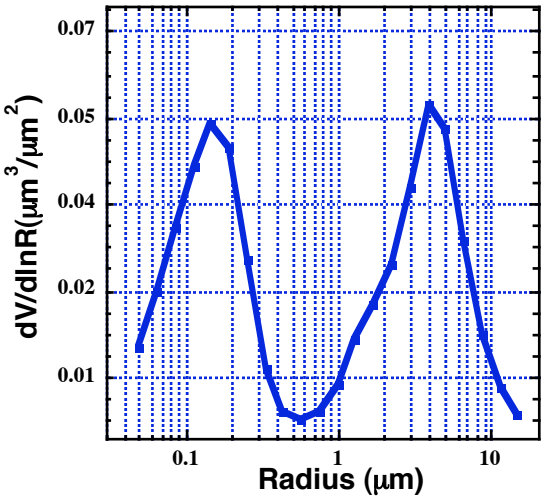


aerosol particle sizes,
complex refractive index,
aspect ratio distributions,
BRDF (*)

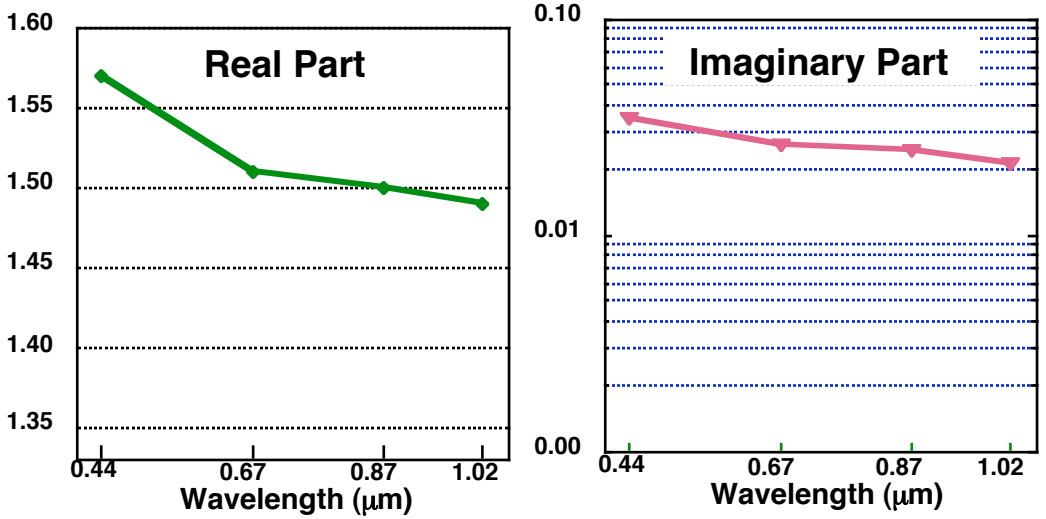
INPUT of Forward Model

Single scattering: aerosol particles - homogeneous spheres

Particle Size Distribution:
0.05 μm ≤ R (22 bins) ≤ 15 μm



Complex Refractive Index at
λ = 0.44; 0.67; 0.87; 1.02 μm



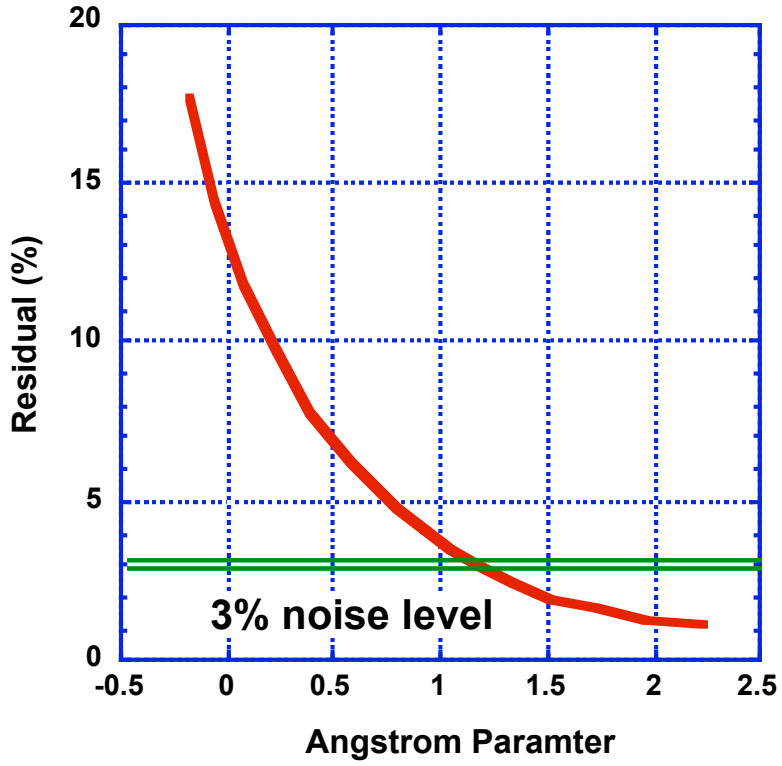
Multiple scattering:

scalar radiative transfer with Lambertian ground reflectance solved by DisOrds (Nakajima-Tanaka or Stamnes et al.)

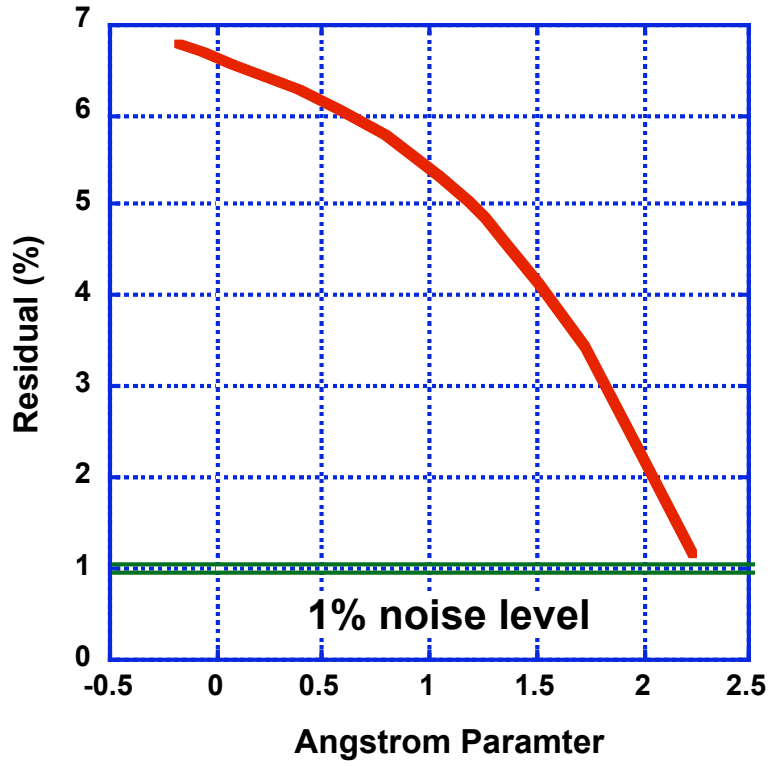
POLAZATION adds sensitivity to particle shape even for small particles:

(for AERONET measurements)

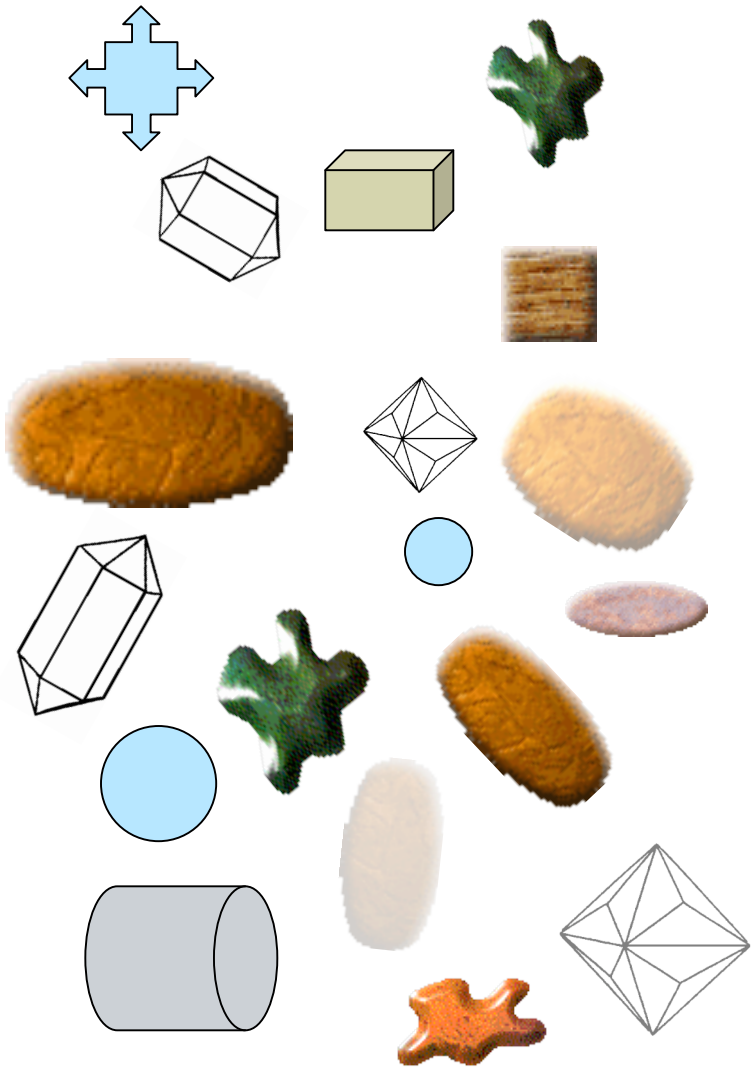
Intensity



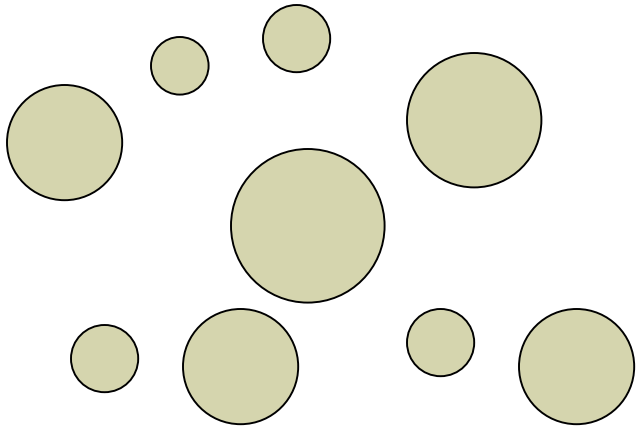
Polarization



AERONET model of aerosol

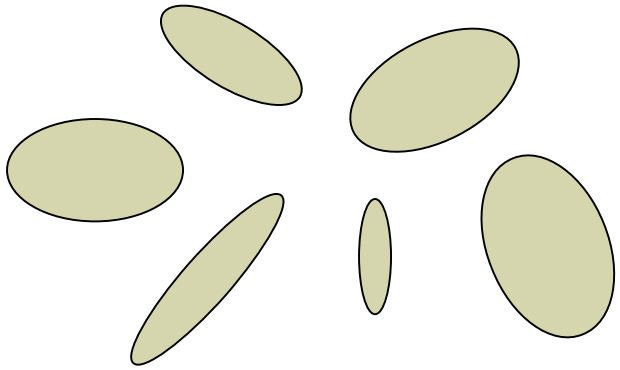


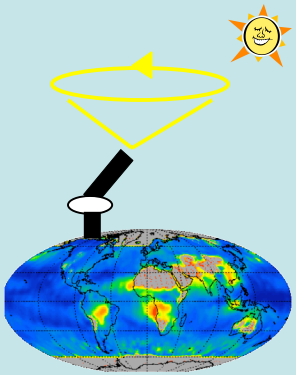
spherical:



Randomly oriented spheroids :

(Mishchenko et al., 1997)





spheroid kernels data base for operational modeling !!!

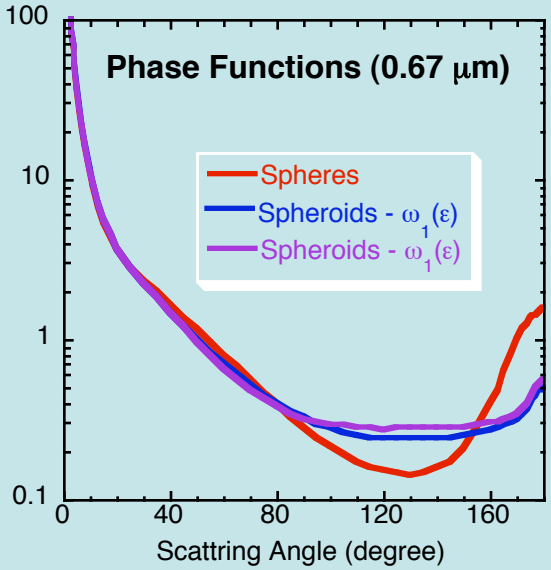
K - pre-computed kernel matrices:
Input: n and k

Input: ω_p (N_p =11), $V(r_i)$ (N_i =22 -26)

Basic Model by Mishchenko et al. 1997:

- randomly oriented homogeneous spheroids
- $\omega(\varepsilon)$ - size independent shape distribution

$$\tau(\lambda),\mathbf{F}_{11},\ldots,\mathbf{F}_{44} \approx \sum_{(i;p)} \mathbf{K}_{ip}(\ldots;n;k)\,\omega_p\,V(r_i)$$



Time: < one sec.
Accuracy: < 1-3 %
Range of applicability:
$0.15 \le 2\pi r/\lambda \le 280$ (26 bins)
$0.4 \le \varepsilon \le 2.4$ (11 bins)
$1.33 \le n \le 1.6$
$0.0005 \le k \le 0.5$

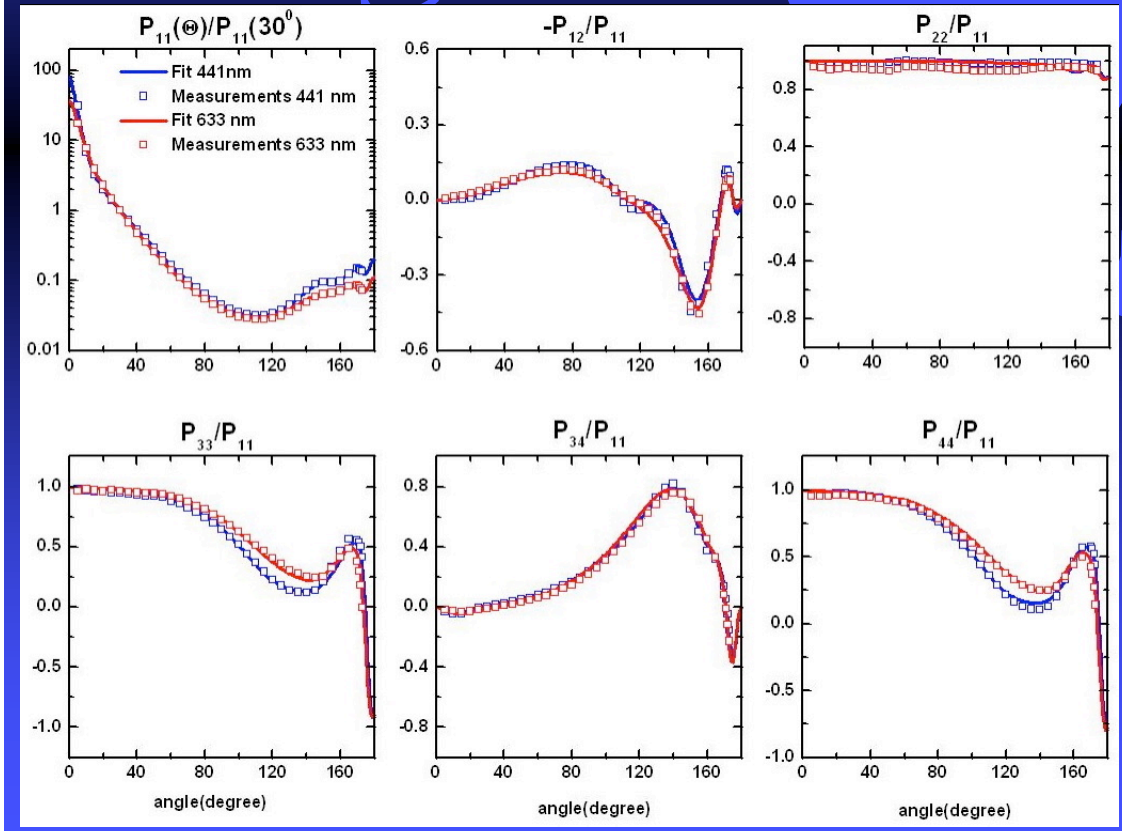
Output: $\tau(\lambda)$, $\omega_0(\lambda)$, $F_{11}(\Theta)$, $F_{12}(\Theta)$, $F_{22}(\Theta)$, $F_{33}(\Theta)$, $F_{34}(\Theta)$, $F_{44}(\Theta)$

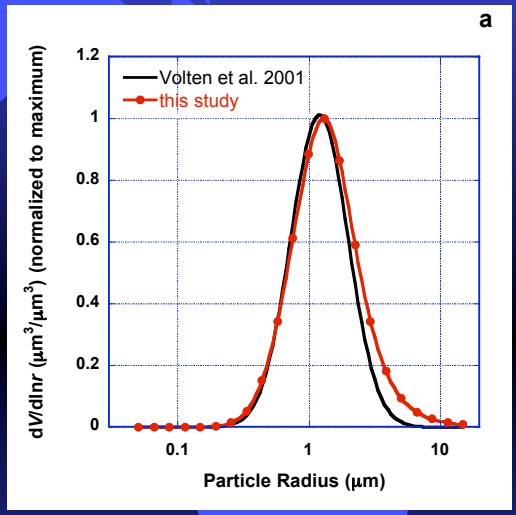
Optics ⟷ Microphysics

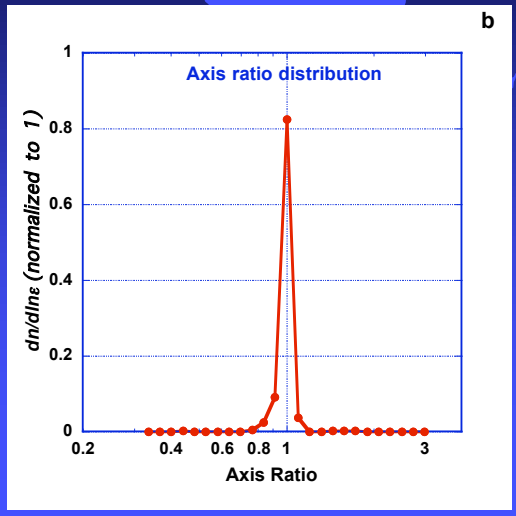
Dubovik et al. (2006)

Water Droplets:

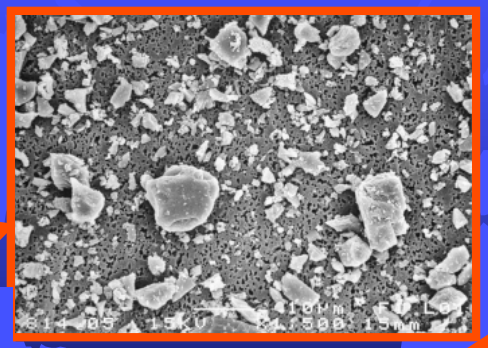
Volten, Munoz et al.



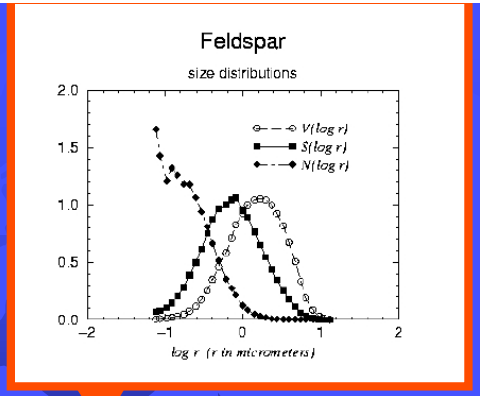


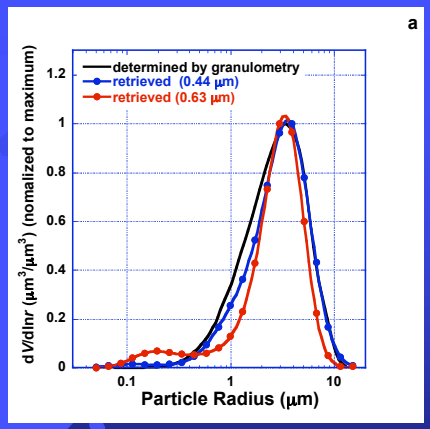


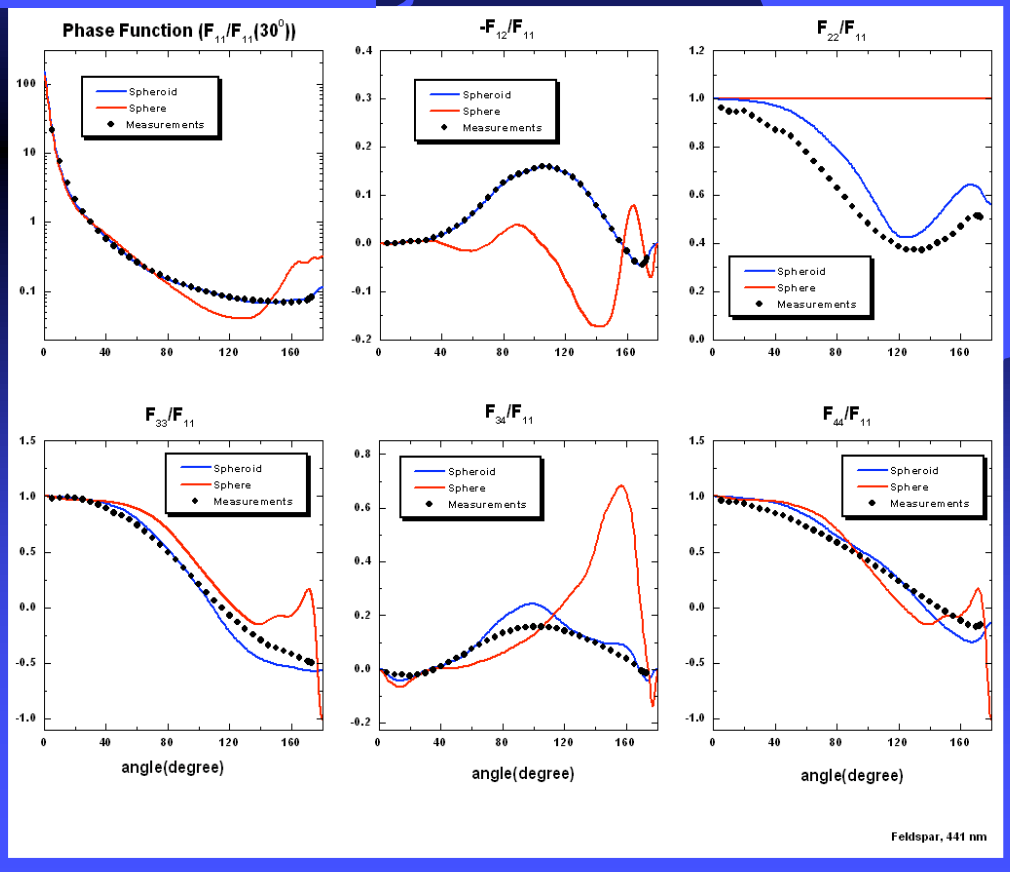
Optics ⟷ Microphysics

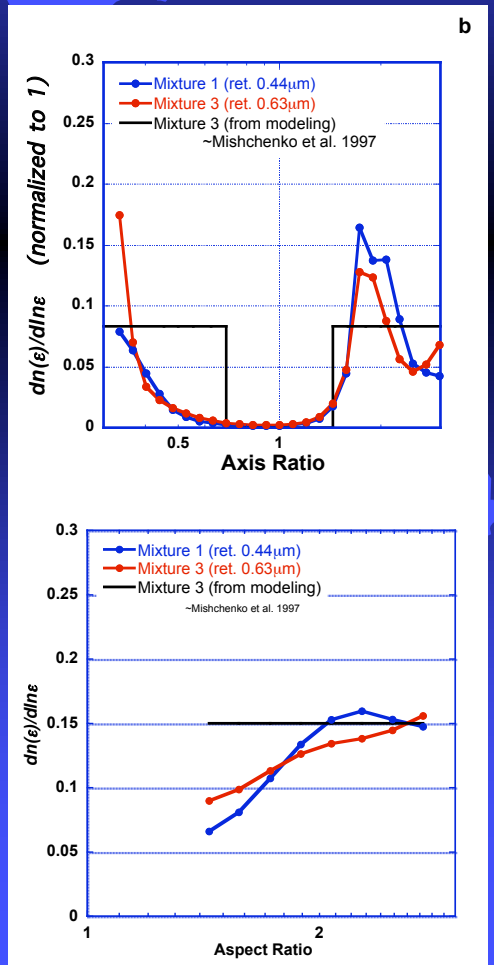


Volten et al.

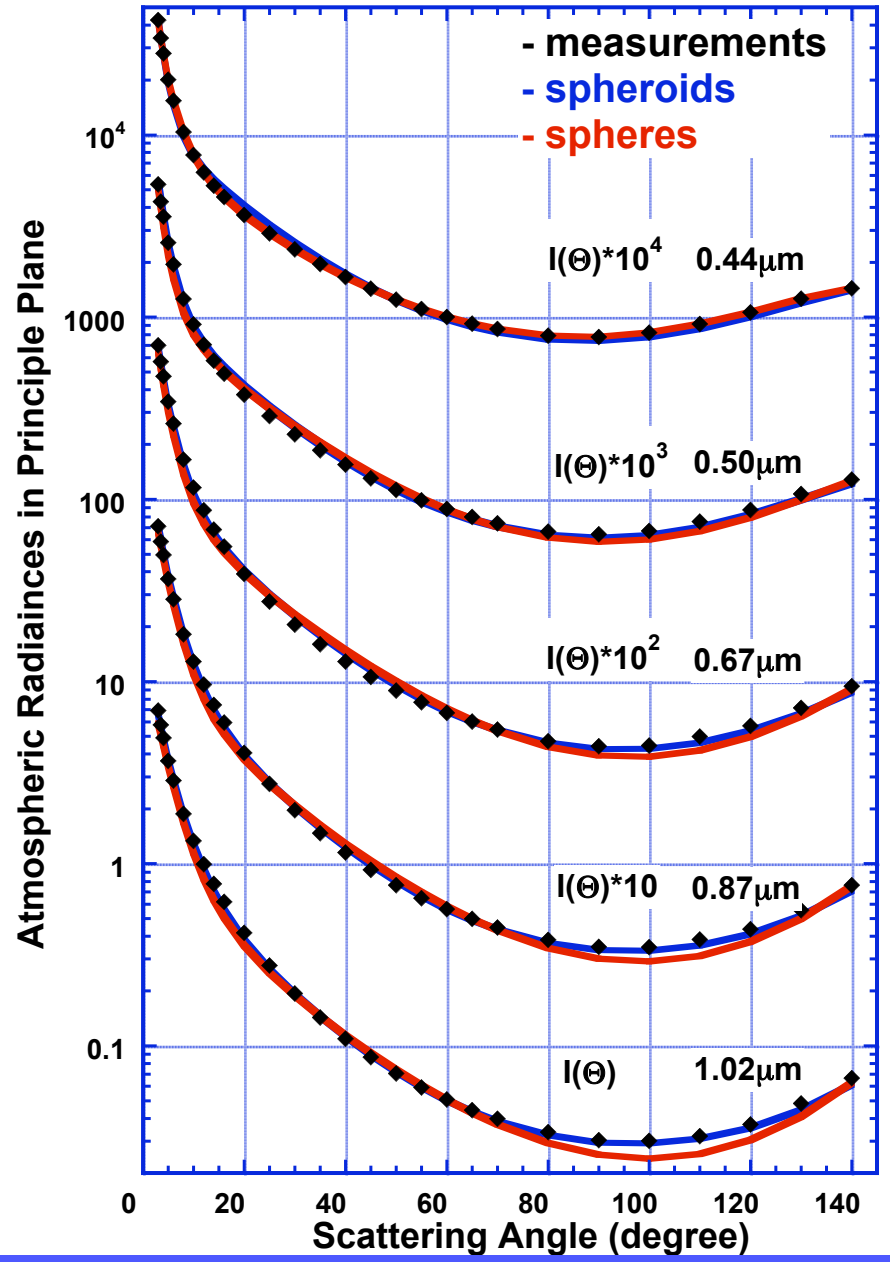




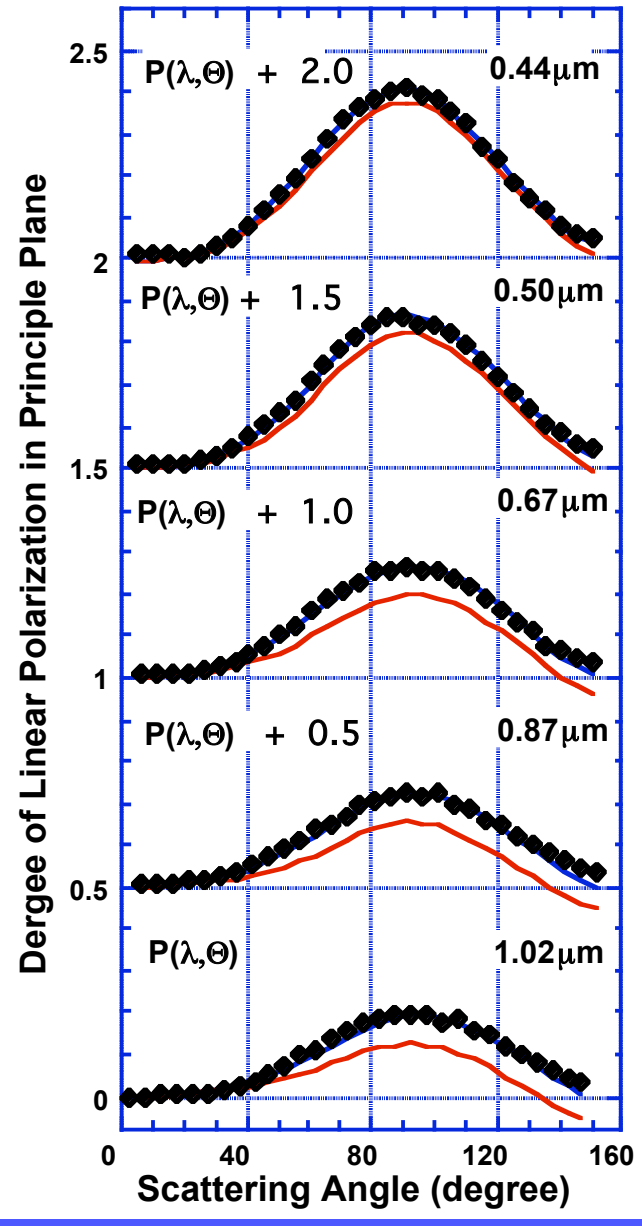




ε(spheroids)~ 5%; ε(spheres)~ 10%

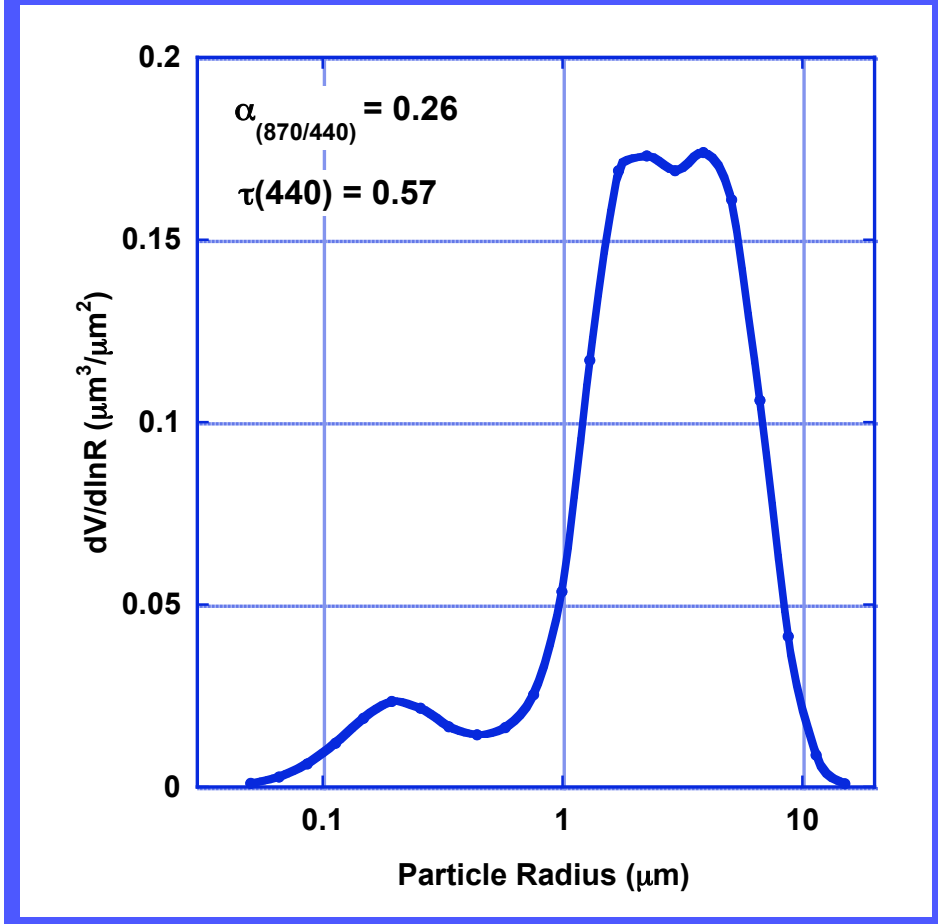


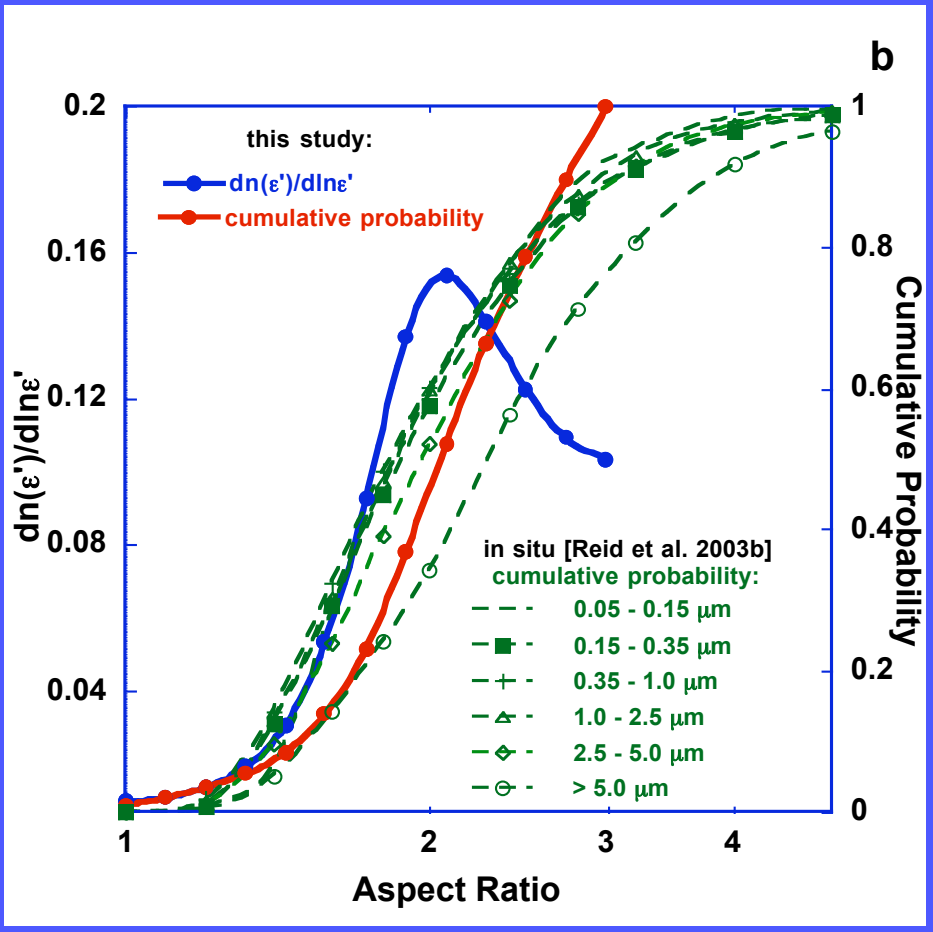
ε(spheroids) < 0.01; ε(spheres)~ 0.05



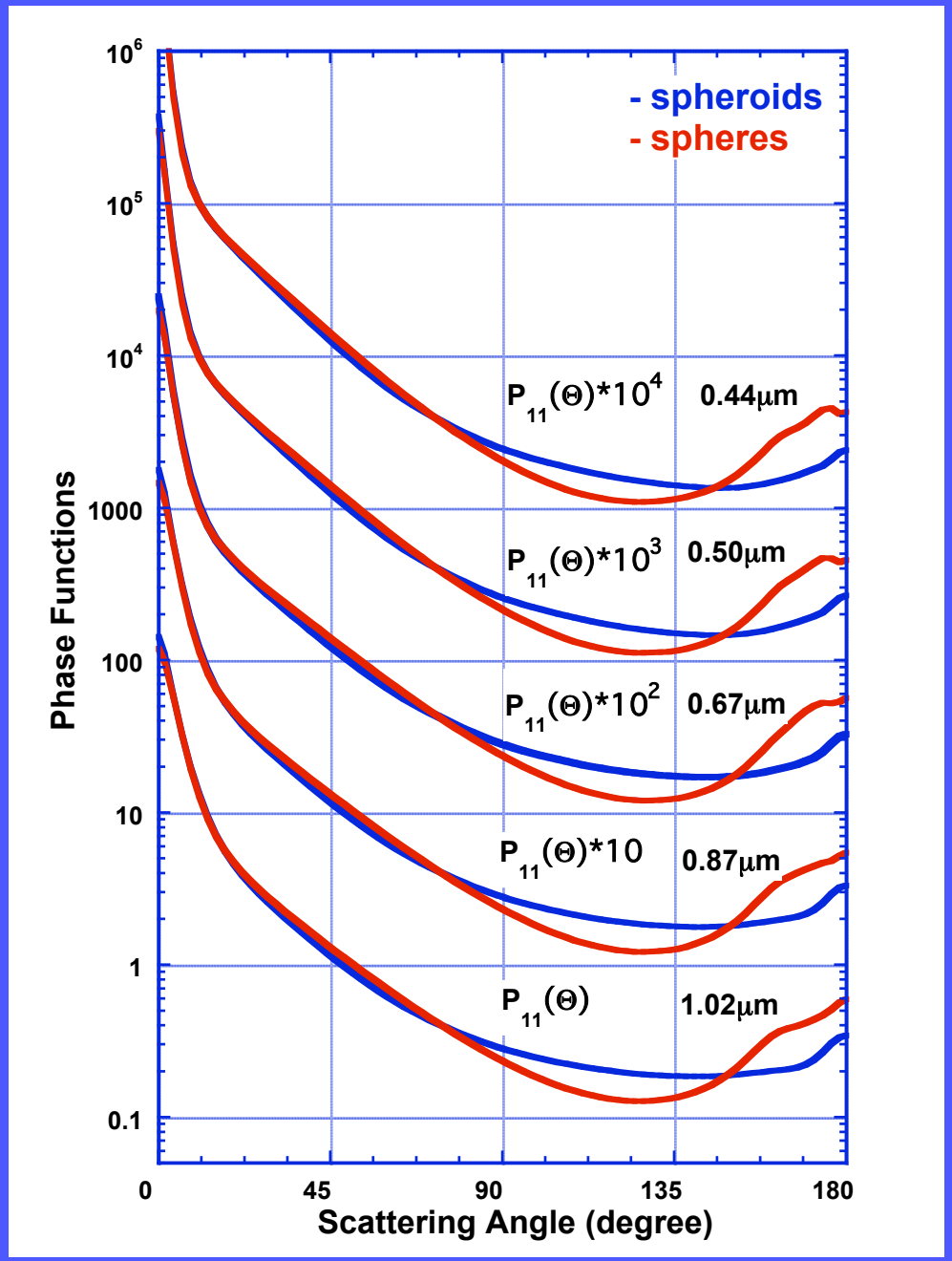
Simultaneous Inversion of intensity and Polarization measured in principle plane at 5 channels (0.44; 0.5; 067; 0.87; 1.02)

Maarco, August 8, 2004

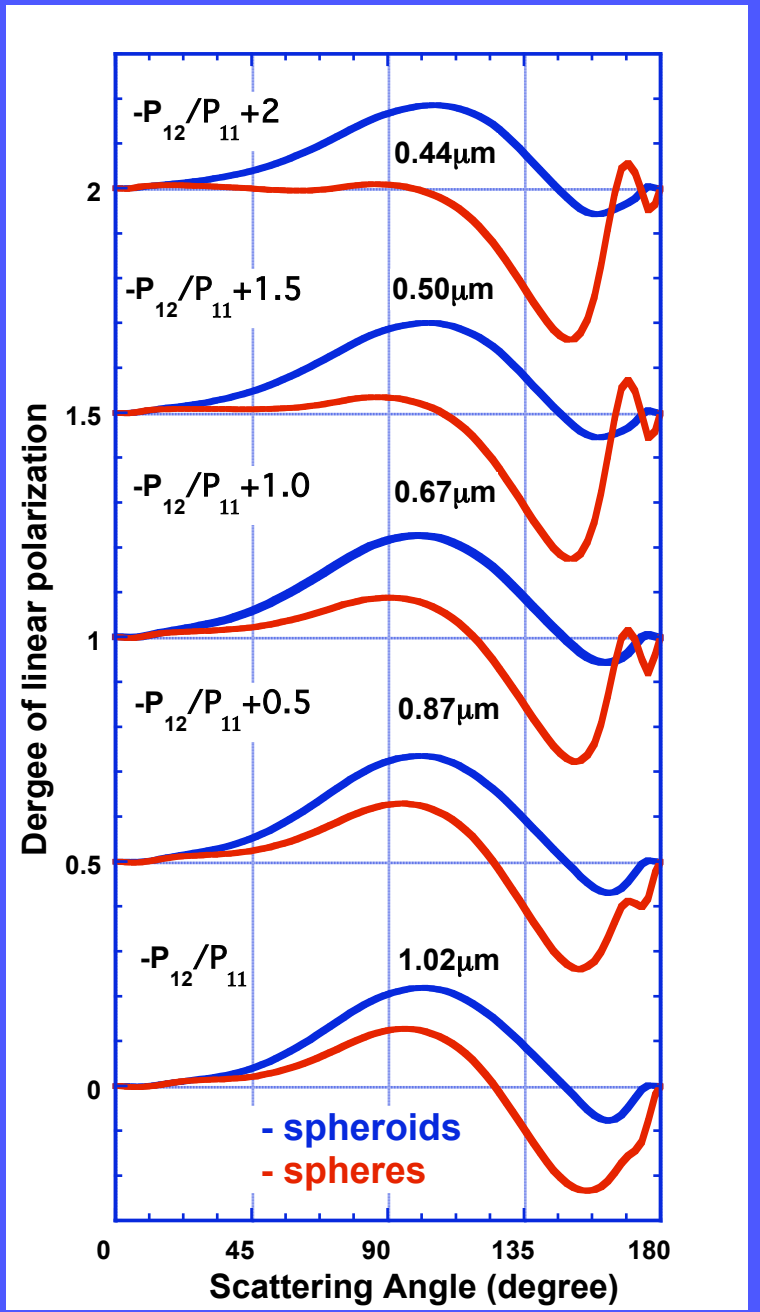




Retrieved Phase Function

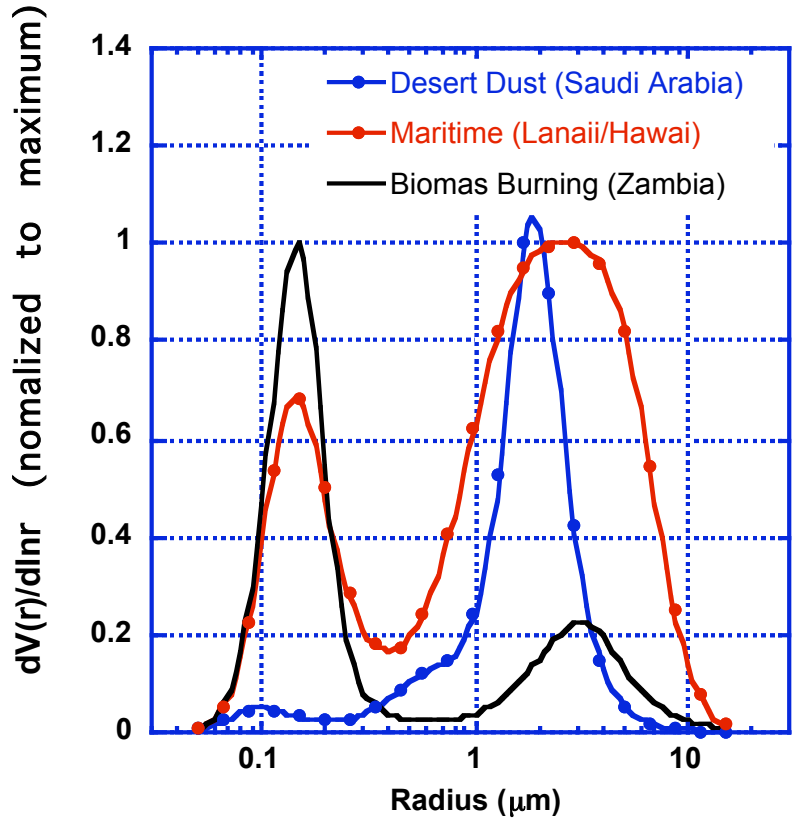


Retrieved Linear Polarization

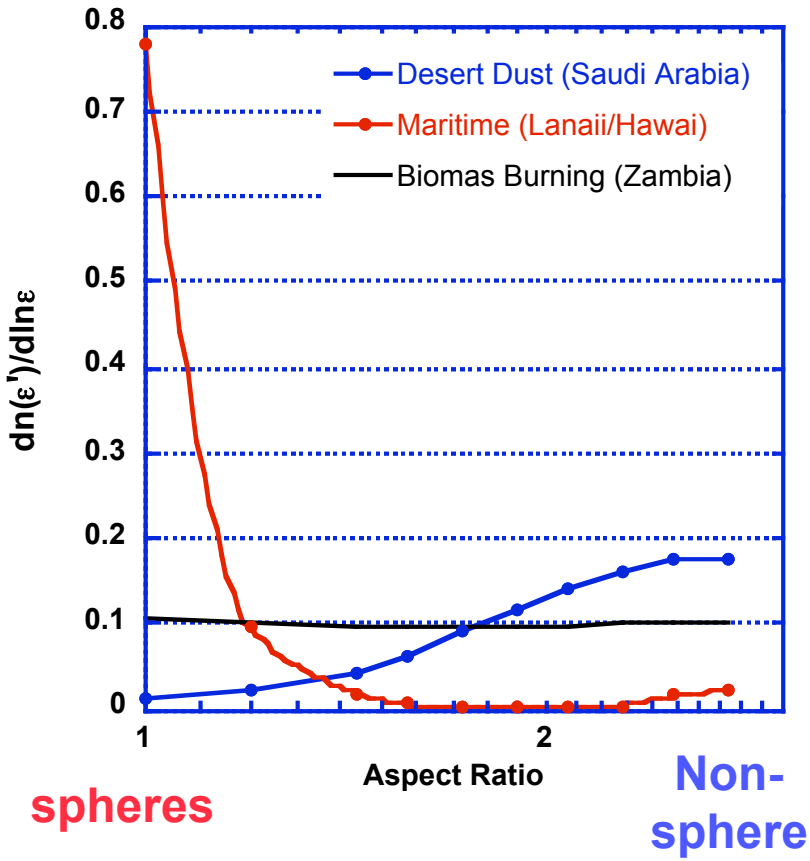


NEW CONCEPT - retrieving degree of non-sphericity as an additional parameter

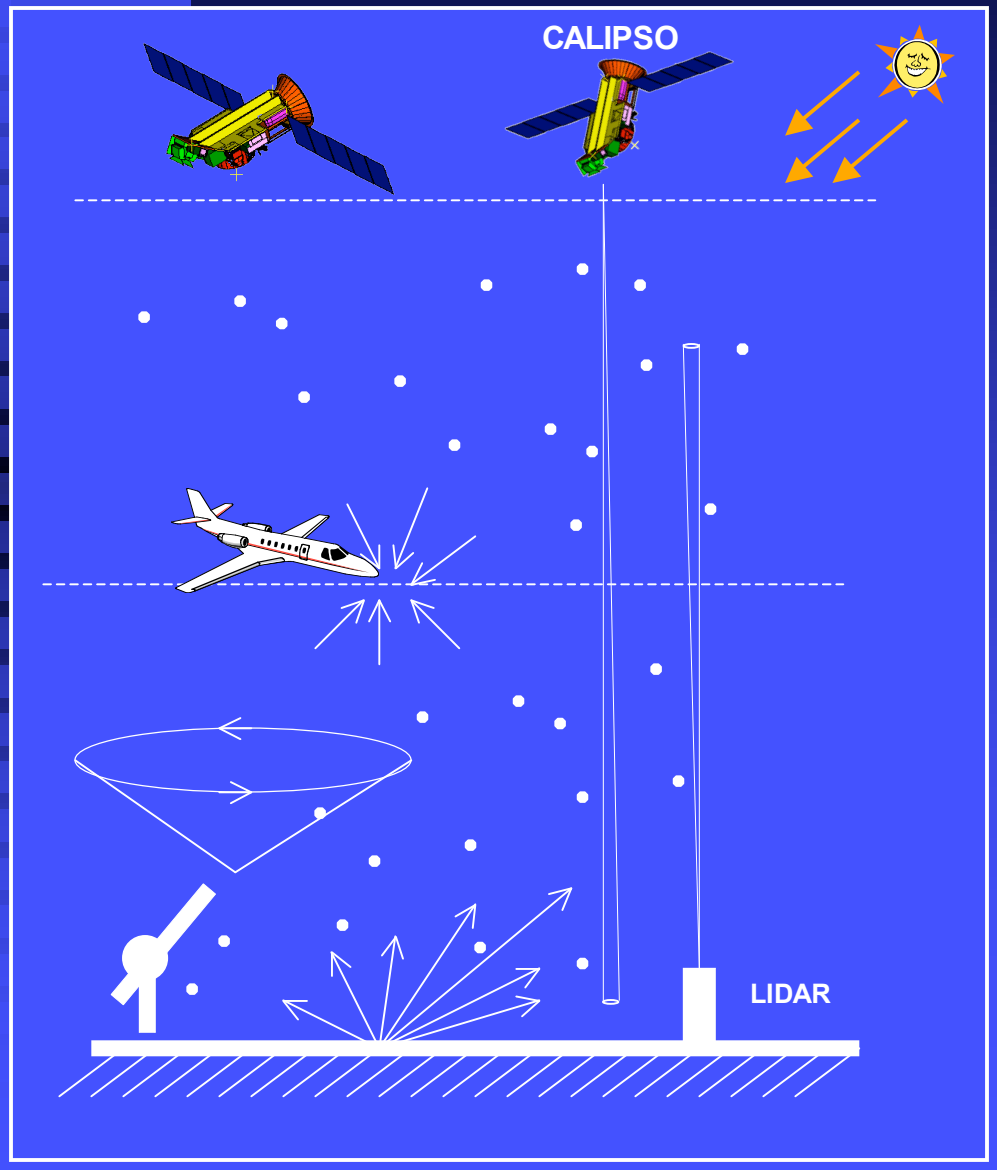
The retrieval is possible for aerosols with pronounced coarse fraction, i. e. desert dust and maritime (α < ~ 1.2)



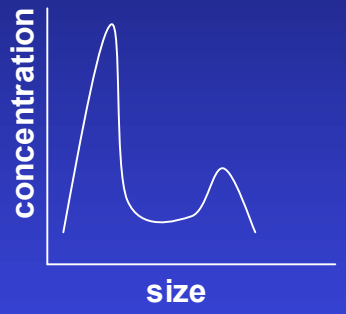
Retrieved aspect ratio



Combining of observations: satellite, ground-based and aircraft

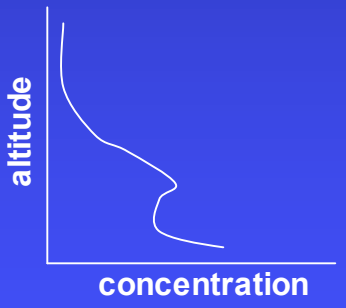


Retrieved:

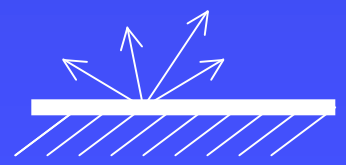


AEROSOL:

- *Size Distribution*
- *Real Refractive Index*
- *Absorption*



- *Vertical variability*



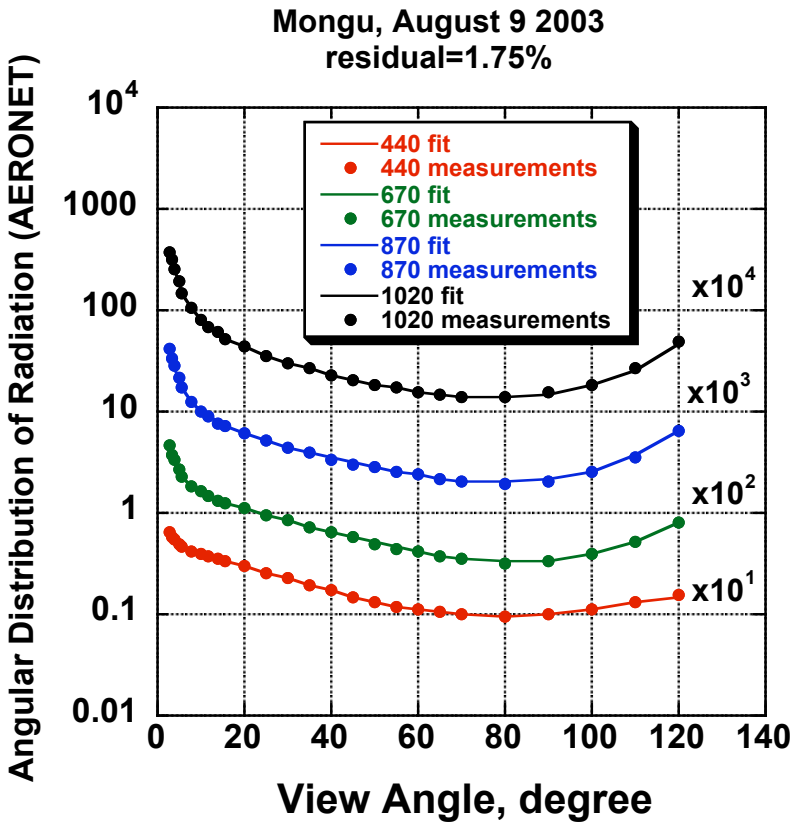
SURFACE :

- *Albedo*
- *Bi-directional reflectance*

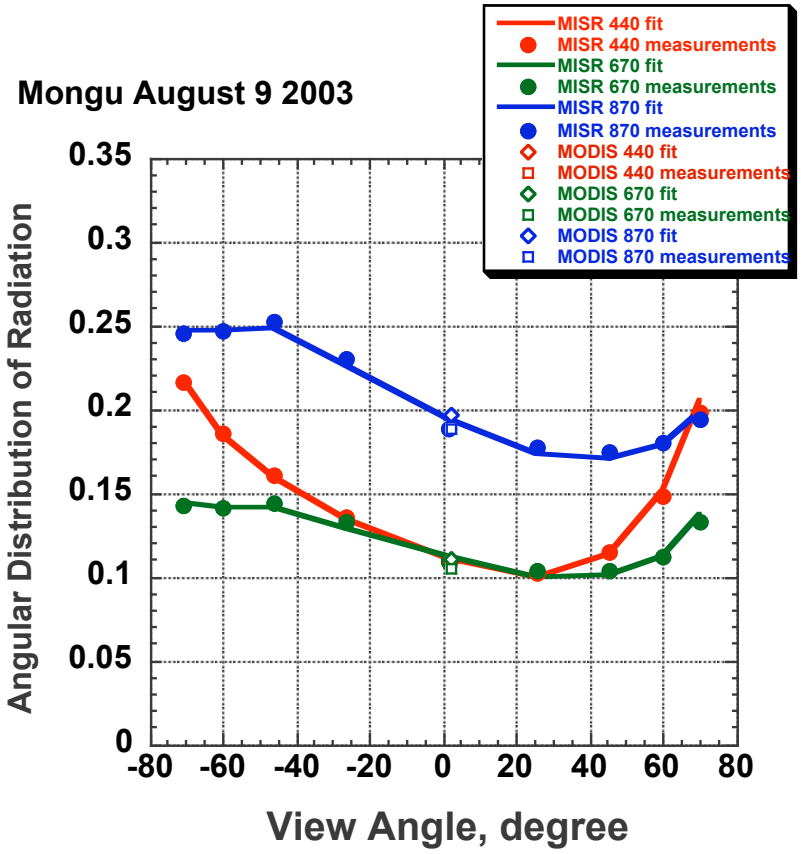
Simultaneous fitting

August 9, 2003
$\tau(0.44) \sim 0.3$

AERONET

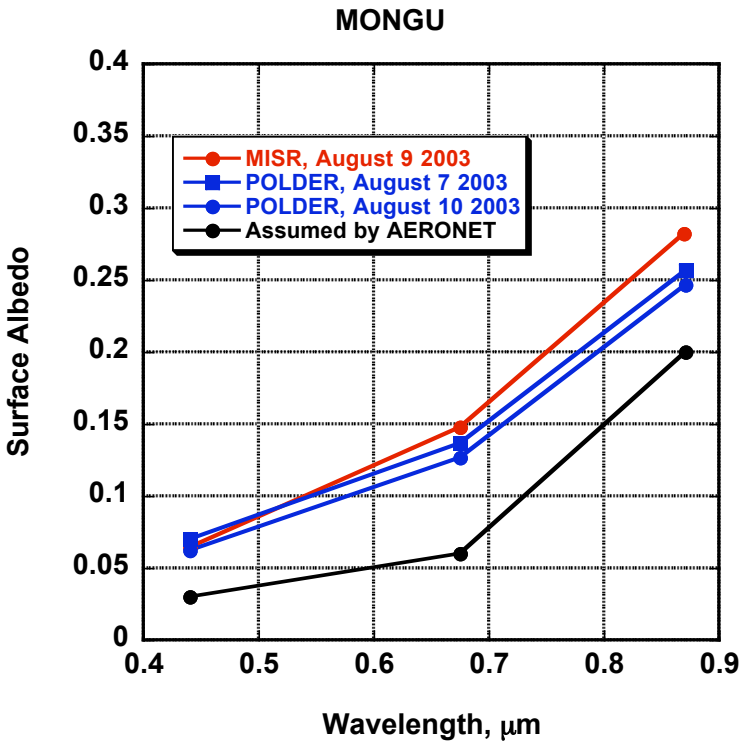


MISR-MODIS

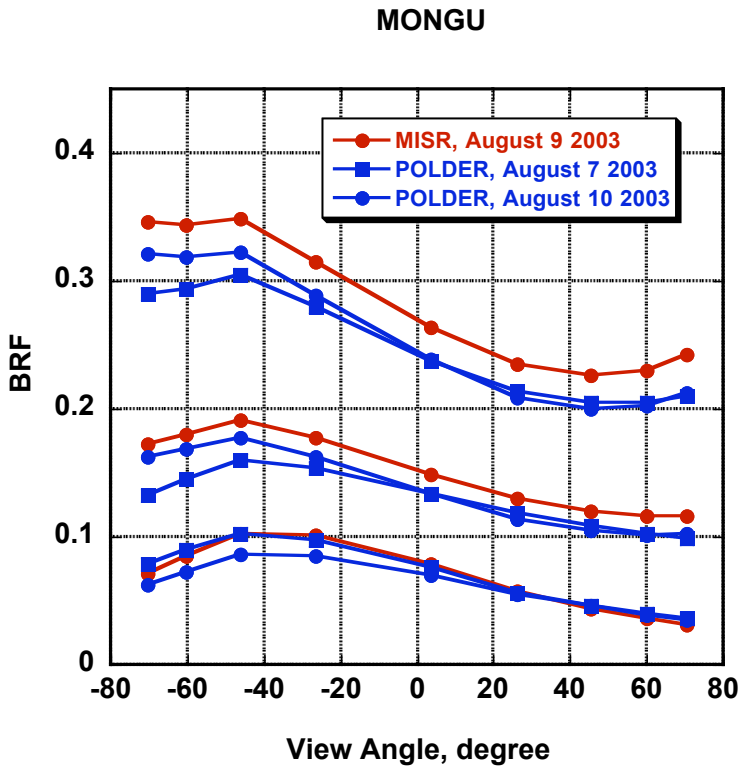


Comparisons of Surface Retrievals (with improved vertical profile)

Surface Albedo:



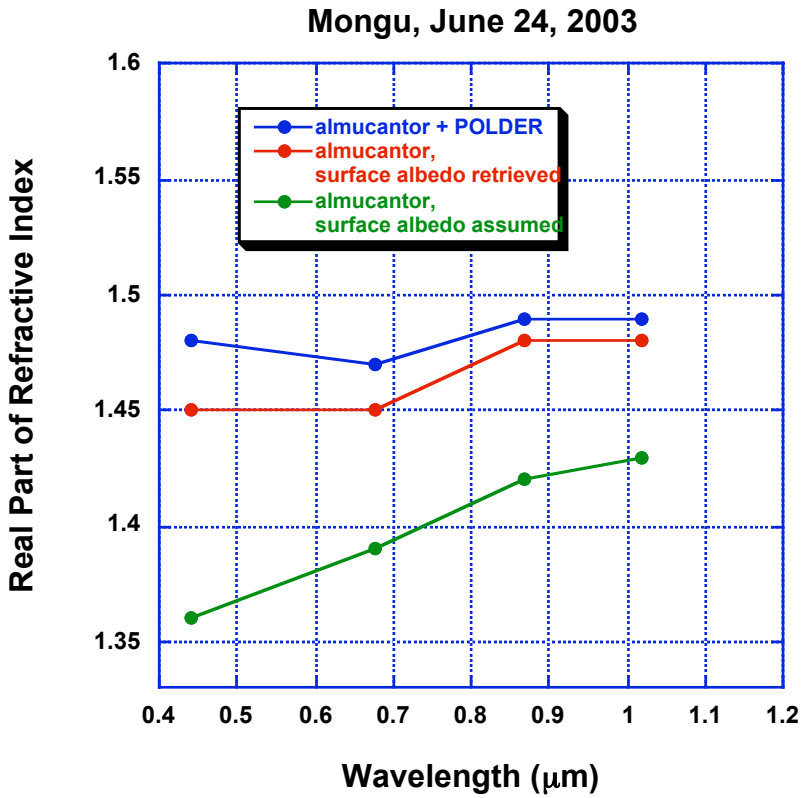
Surface BRDF:

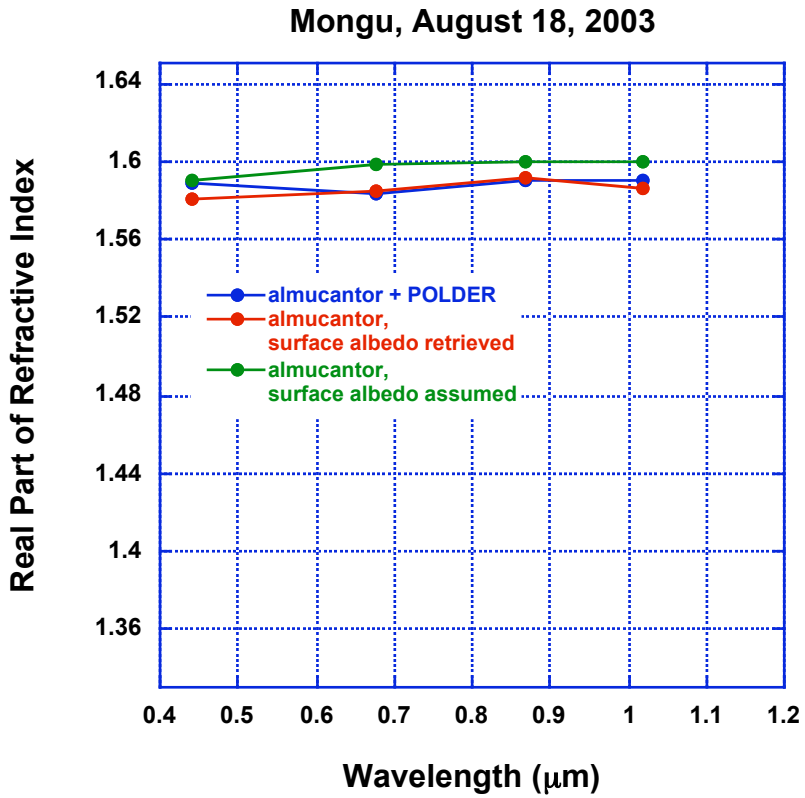


Surface Effect on Retrievals of the Refractive Index (low aerosol loading)

POLDER: June 24, 2003
$\tau(0.44) \sim 0.26$, SZA=47^0

POLDER: August 18, 2003
$\tau(0.44) \sim 0.63$, SZA=35^0





Surface Effect on the Retrievals of the Size Distribution (low aerosol loading)

POLDER: June 24, 2003
$\tau(0.44) \sim 0.26$, SZA=47^0

POLDER: August 18, 2003
$\tau(0.44) \sim 0.63$, SZA=35^0