# ABSORPTION from AERONET : Accuracy, Issues, Improvements

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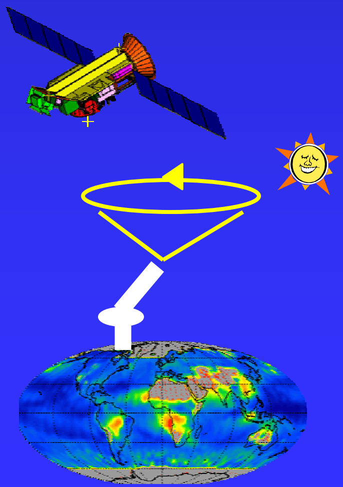

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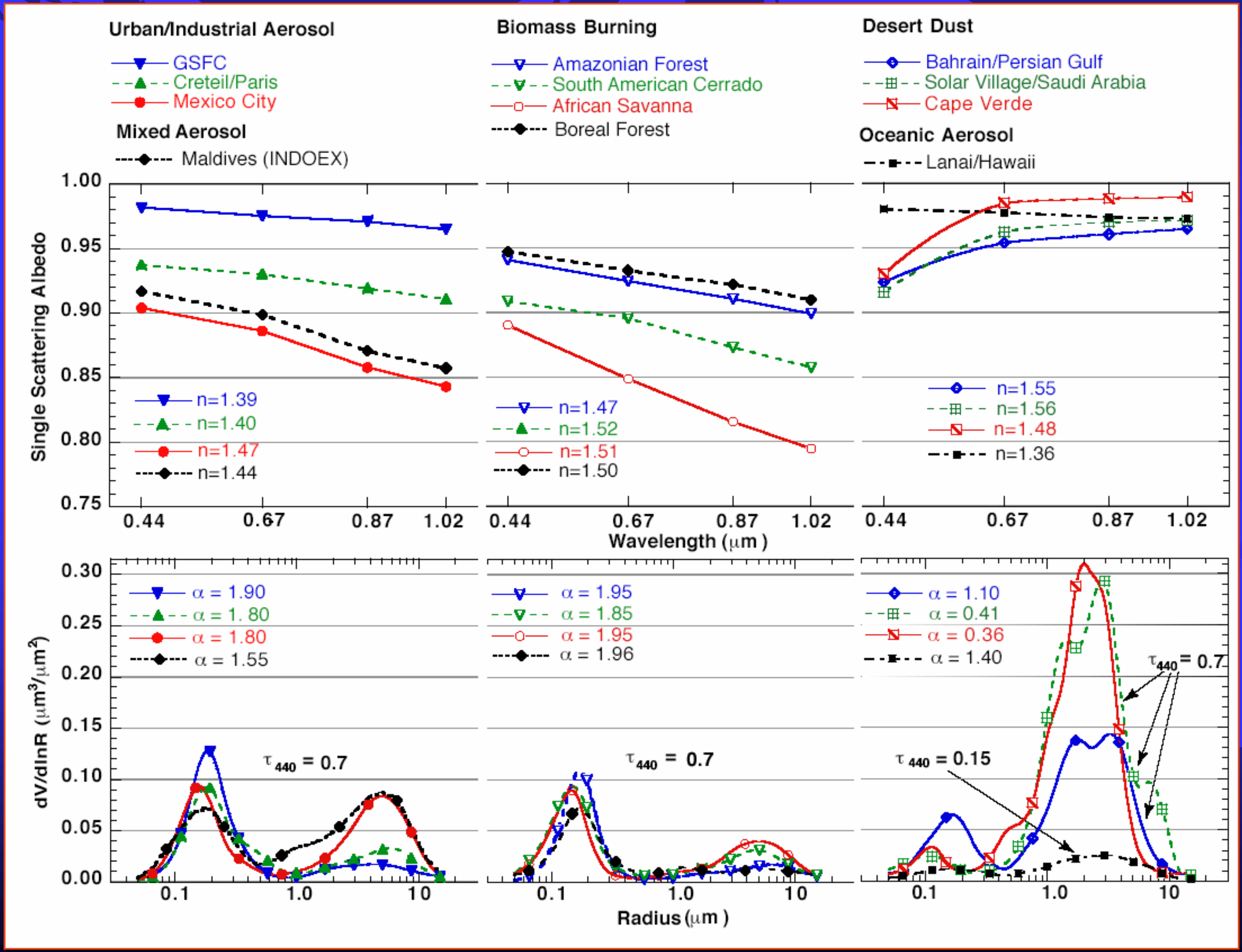
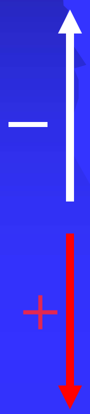
*2- Université de Sci. et Tech. de Lille , France (PHOTON)*

# The averaged optical properties of various aerosol types (Dubovik et al., 2002, JAS)





# ABSORPTION of SMOKE

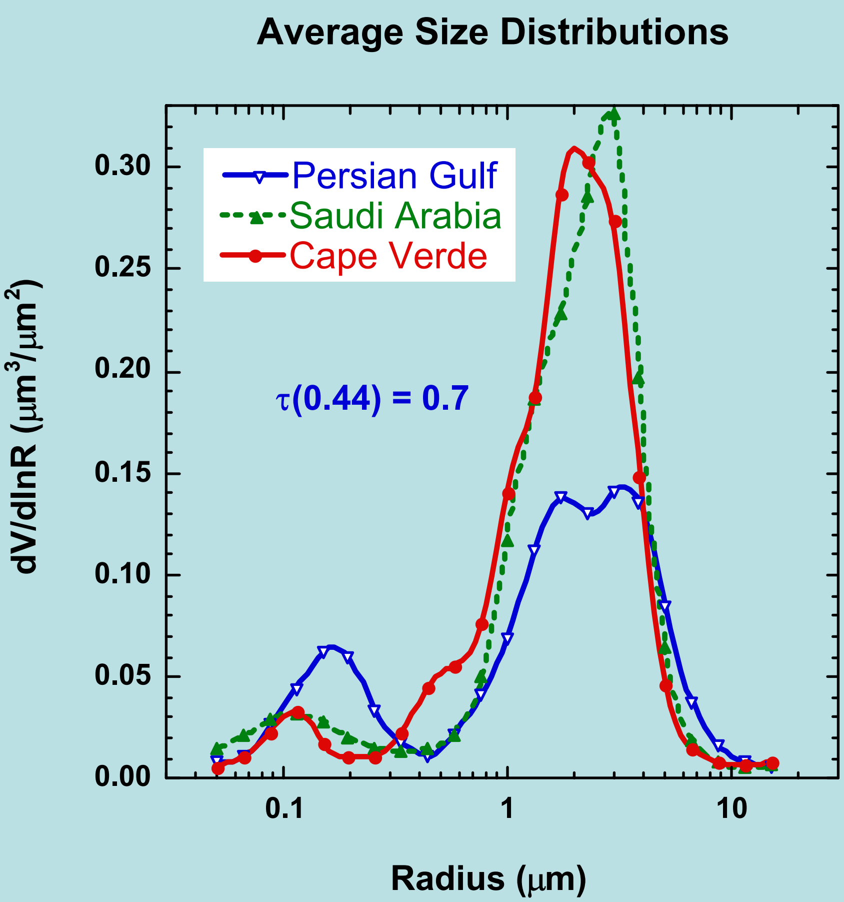
flaming combustion
Rio Branco, Brazil

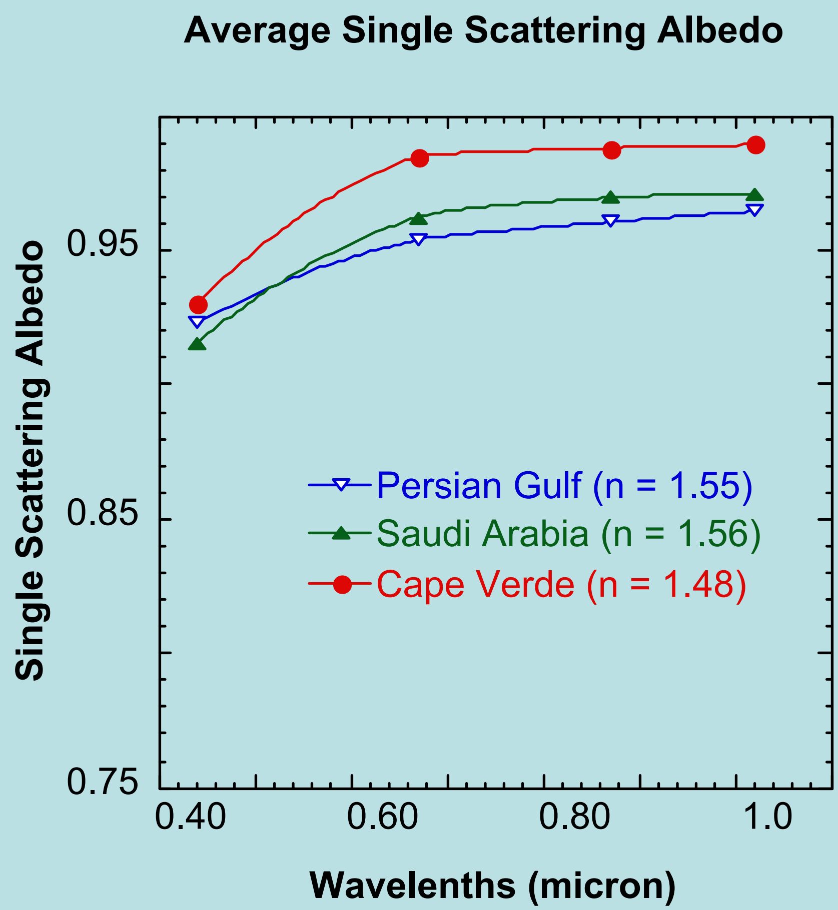
smoldering combustion
Quebec fires, July 2002

# Retrieved Properties of Saharan Dust

## Angstrom < 0.75

*Dubovik* et al., 2002

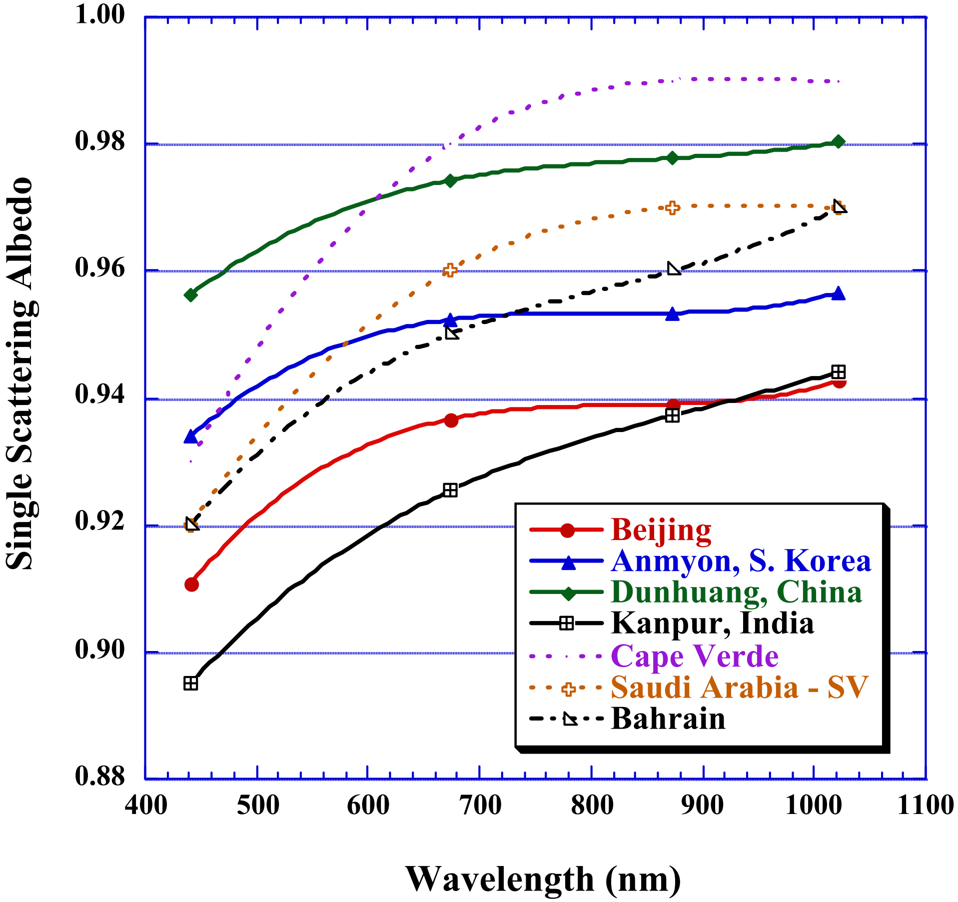


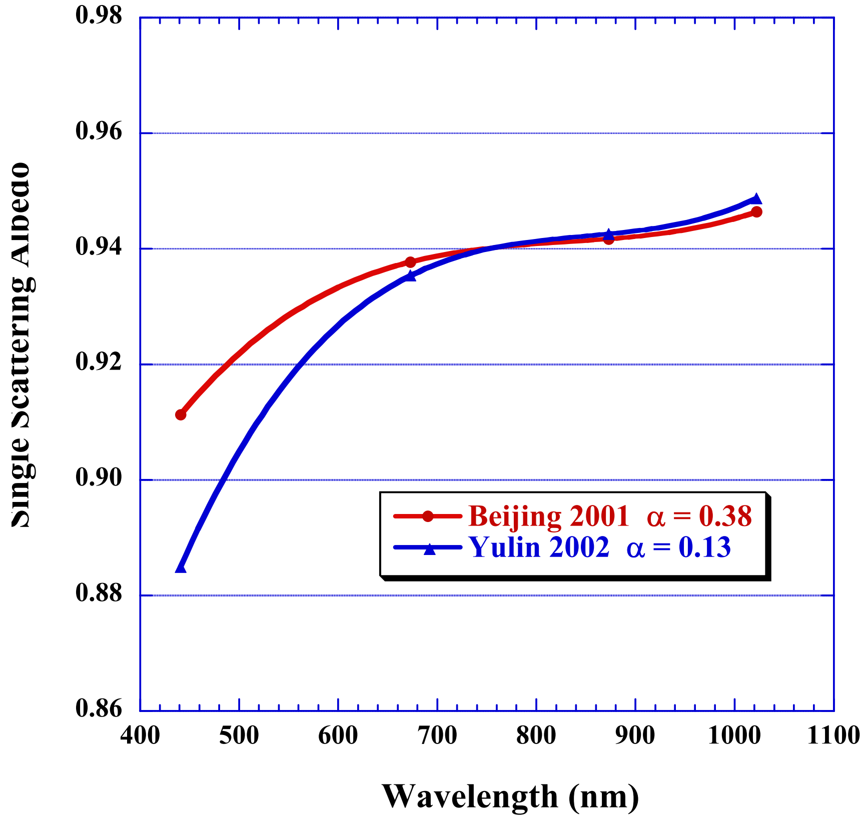
# AERONET Observations of Asian Dust Single Scattering Albedo

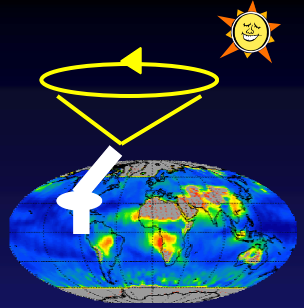
***Eck et al., submitted***

**Comparison of Asian Dust Single Scattering Albedo versus Saharan and Saudi Arabian Dust**




**Comparioson of Asian dust in different locations and different years**

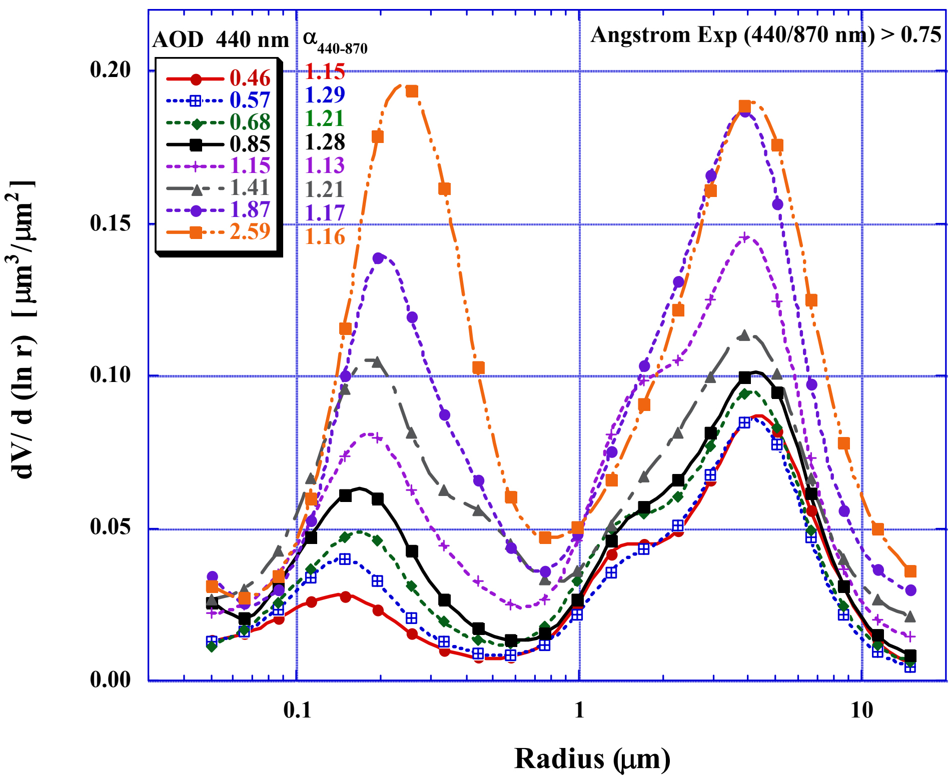




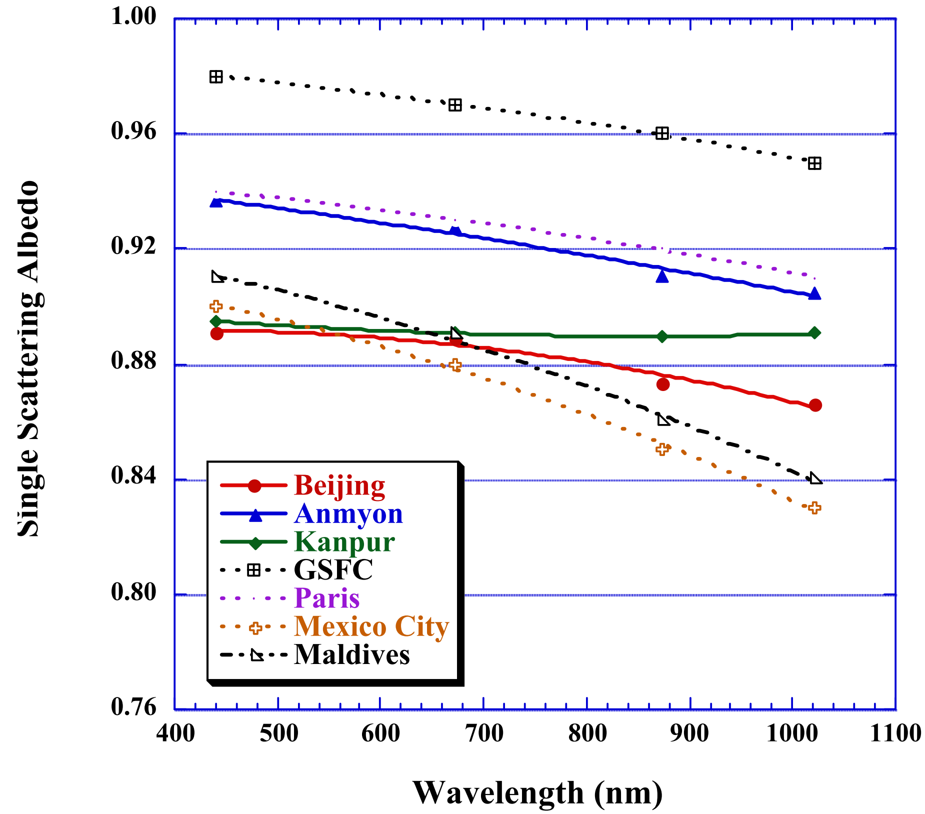
# Urban Pollution in Beijing

***Eck et al, accepted***

**Beijing, China 2001 & 2002 AOD>0.4**
**Mean of 31 almucantars / AOD level**
**Spheroid Model Inversions Sky Error < 7%**




**Comparison of Asian 'Urban' Single Scattering Albedo versus Other Urban/Industrial Sites**




GSFC, Paris, Mexico City, Maldives data from *Dubovik et al.* [2002] Table 1.

# Accuracy ???

# Retrieval accuracy and limitations

Sensitivity tests by Dubovik et al. 2000

Effective

wide angular coverage

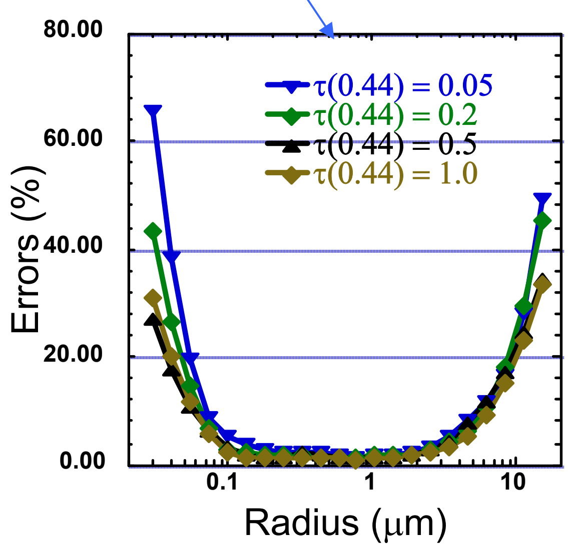
bias $\Delta\tau = \pm 0.01$

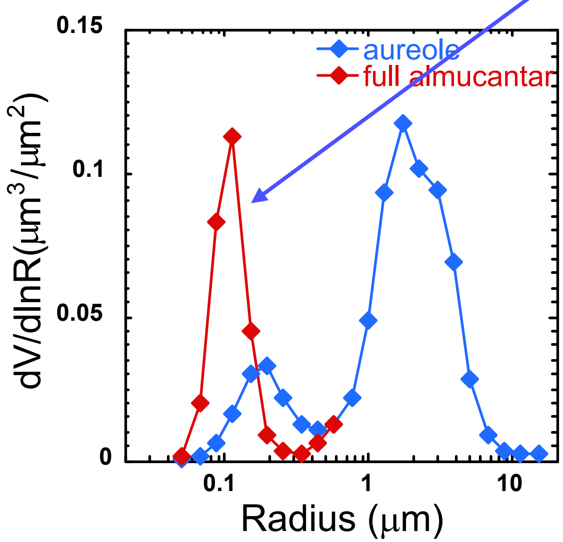
| | $\tau(0.44) \leq 0.2$ | $\tau(0.44) \geq 0.5$ |
|---|---|---|
| **Real Part** | 0.05 | 0.025 |
| **Imaginary Part** | 80-100% | 50% |
| **SSA** | 0.05-0.07 | **0.03** |

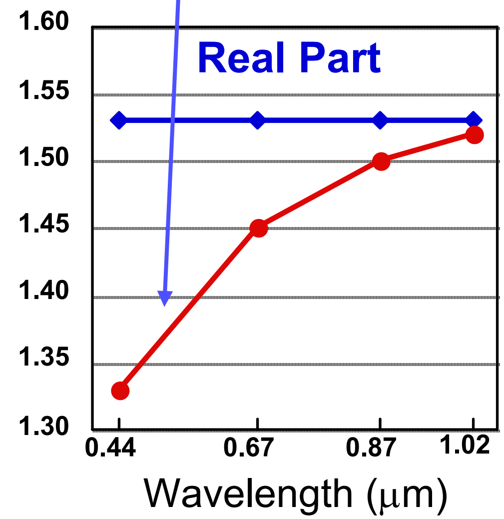
**Size Distribution:**

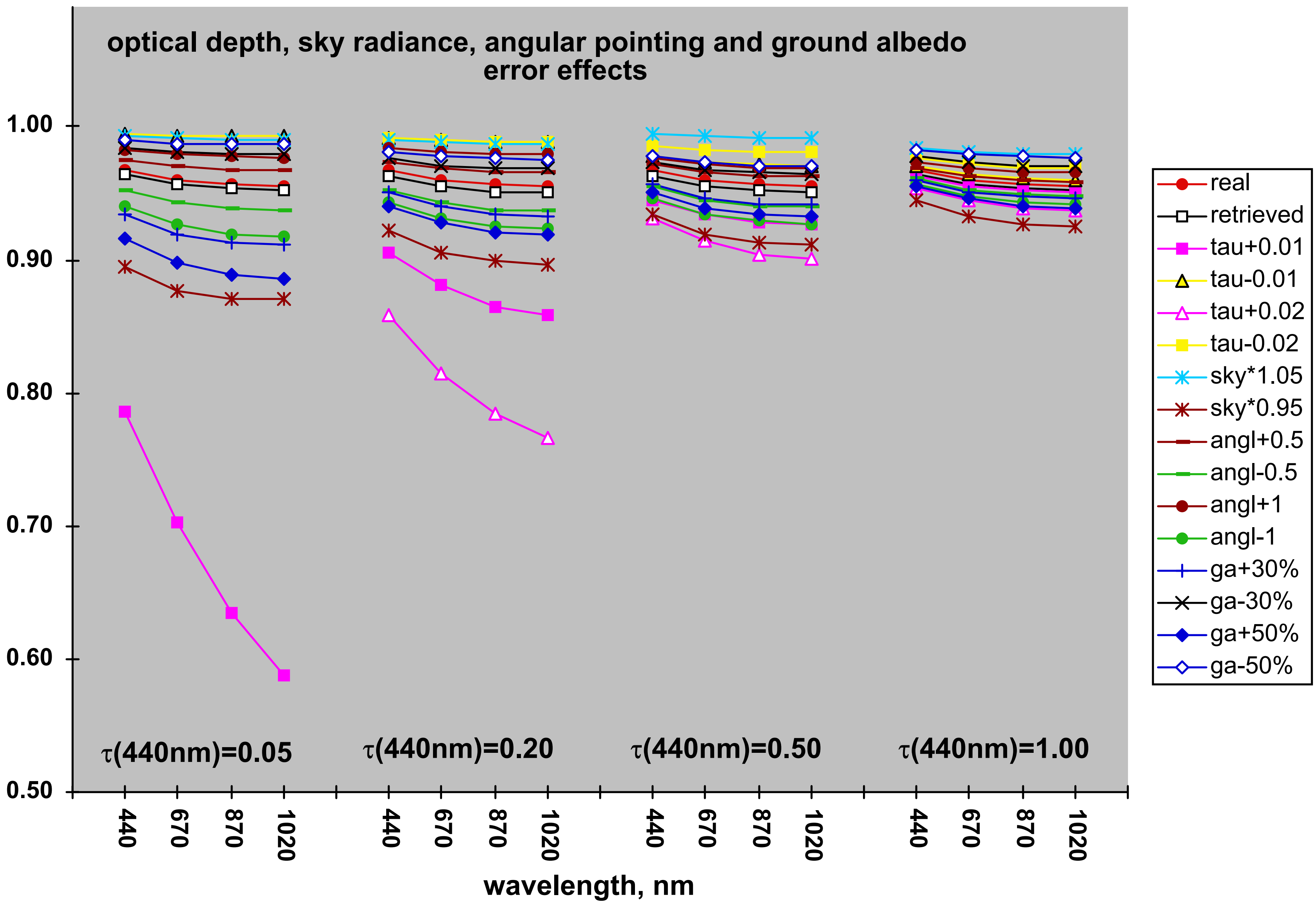
Random errors

Nonsphericity biases





optical depth, sky radiance, angular pointing and ground albedo
error effects
1.00
0.90
0.80
0.70
0.60
0.50
τ(440nm)=0.05
τ(440nm)=0.20
τ(440nm)=0.50
τ(440nm)=1.00
440
670
870
1020
wavelength, nm
real
retrieved
tau+0.01
tau-0.01
tau+0.02
tau-0.02
sky*1.05
sky*0.95
angl+0.5
angl-0.5
angl+1
angl-1
ga+30%
ga-30%
ga+50%
ga-50%

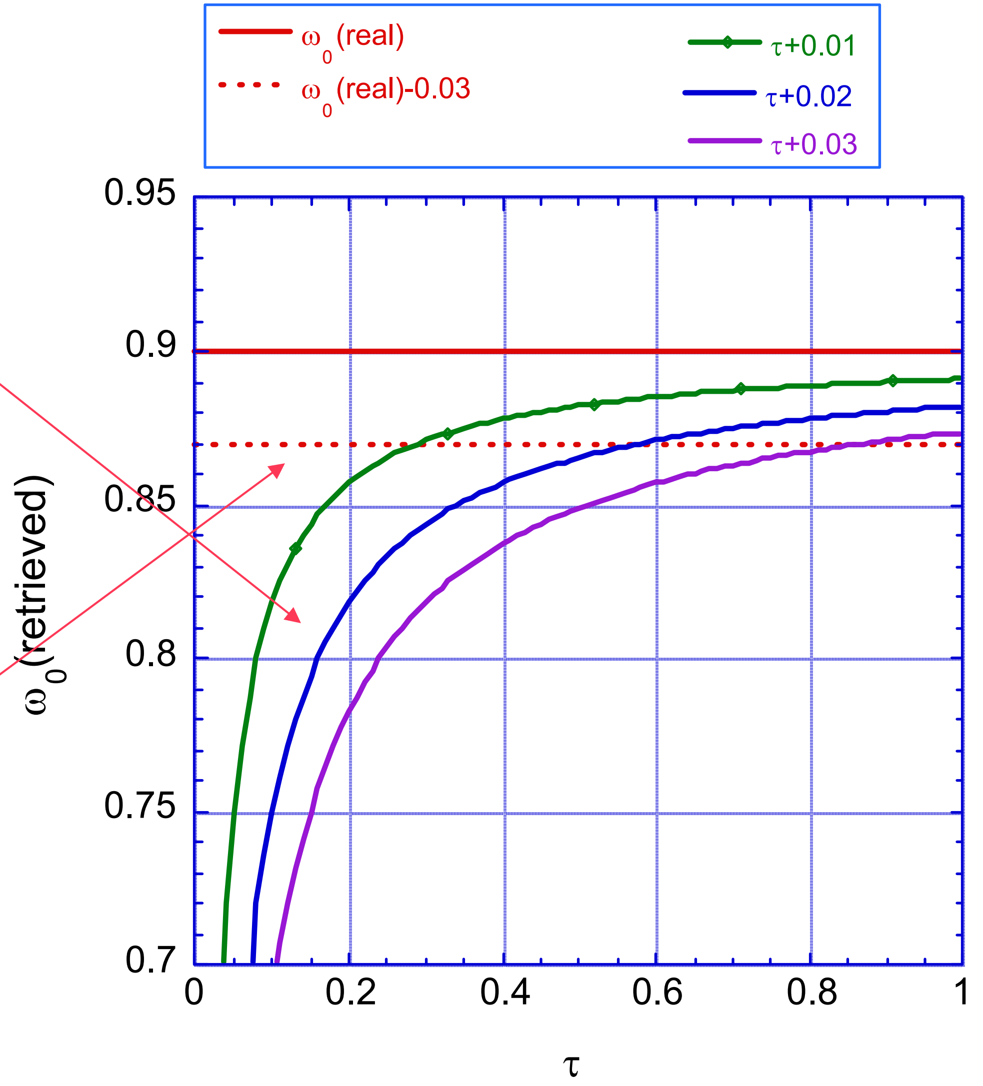
# $\Delta\tau$ bias influence at $\Delta\omega_0$

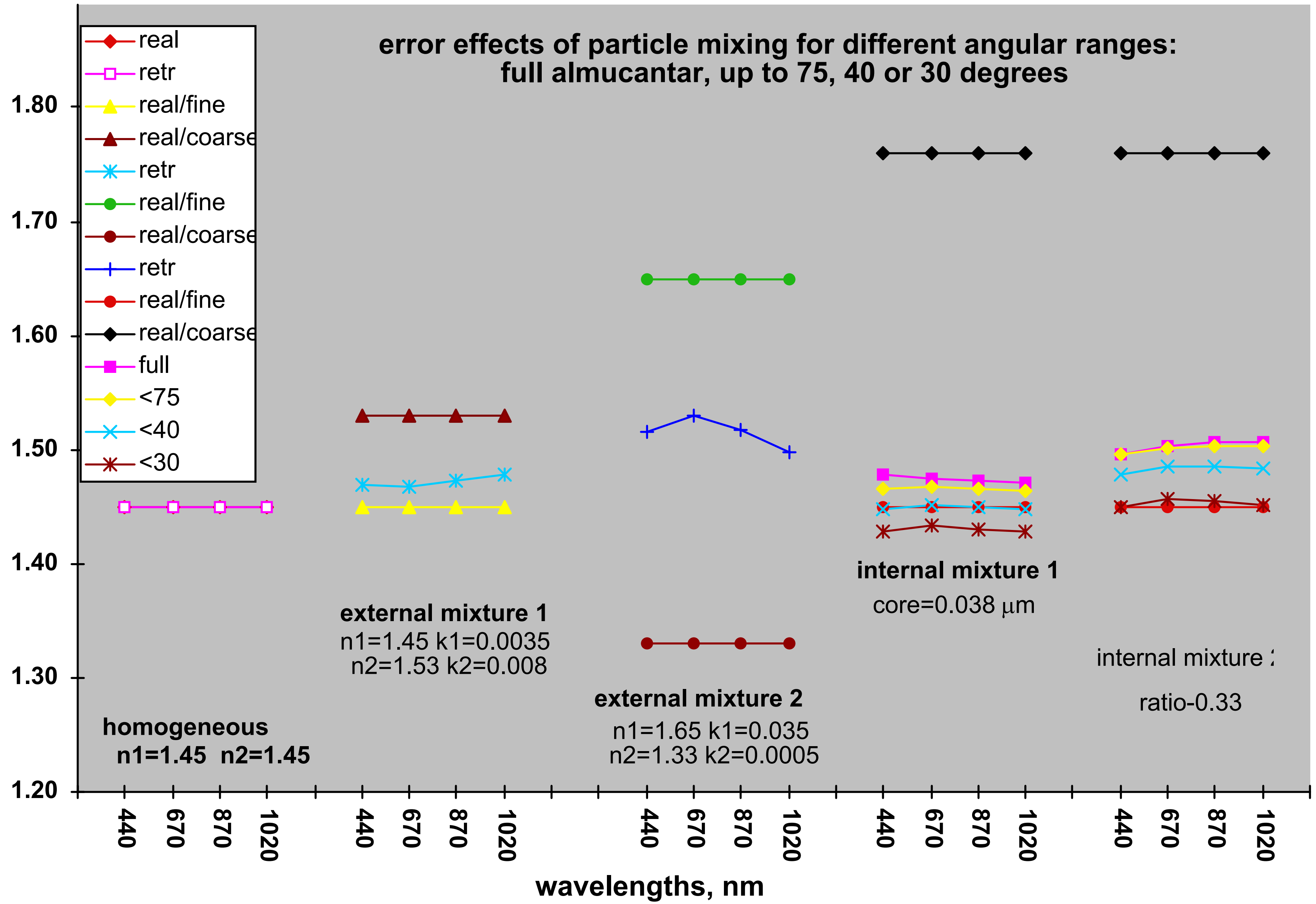
## $\Delta\tau$ bias:

$$\tilde{\omega}_0 = \frac{\tau_{scat}}{\tau_{ext} + \Delta\tau}$$

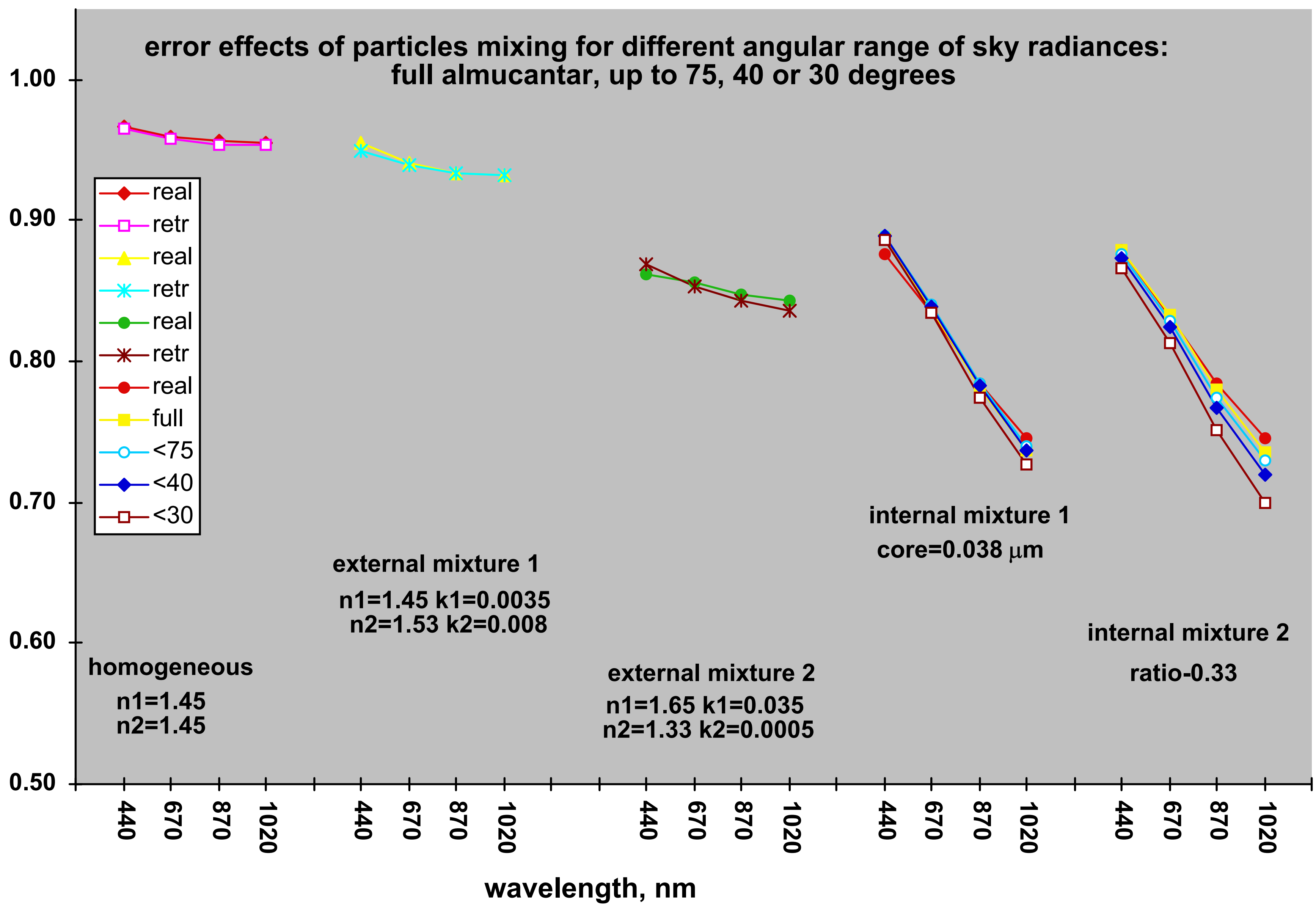
## Sky Radiance bias:

$$\tilde{\omega}_0 = \frac{\tau_{scat}\,(1 - \Delta)}{\tau_{ext}} = \omega_0(1 - \Delta)$$





error effects of particle mixing for different angular ranges:
full almucantar, up to 75, 40 or 30 degrees
real
retr
real/fine
real/coarse
retr
real/fine
real/coarse
retr
real/fine
real/coarse
full
<75
<40
<30
1.80
1.70
1.60
1.50
1.40
1.30
1.20
homogeneous
n1=1.45 n2=1.45
external mixture 1
n1=1.45 k1=0.0035
n2=1.53 k2=0.008
external mixture 2
n1=1.65 k1=0.035
n2=1.33 k2=0.0005
internal mixture 1
core=0.038 μm
internal mixture
ratio-0.33
440
670
870
1020
wavelengths, nm



error effects of particles mixing for different angular range of sky radiances:
full almucantar, up to 75, 40 or 30 degrees
1.00
0.90
0.80
0.70
0.60
0.50
real
retr
real
retr
real
retr
real
full
<75
<40
<30
homogeneous
n1=1.45
n2=1.45
external mixture 1
n1=1.45 k1=0.0035
n2=1.53 k2=0.008
external mixture 2
n1=1.65 k1=0.035
n2=1.33 k2=0.0005
internal mixture 1
core=0.038 µm
internal mixture 2
ratio-0.33
440
670
870
1020
wavelength, nm

# Retrieval using combinations of up-looking Ground-based and down-looking satellite observations

***Retrieved:***

*__Aerosol Properties__:*

*- size distribution*

*- real ref. ind.*

*- imag. ref. ind*

*(AERONET sky channels)*

*__Surface Parameters__:*

*-BRDF (MISR channels)*

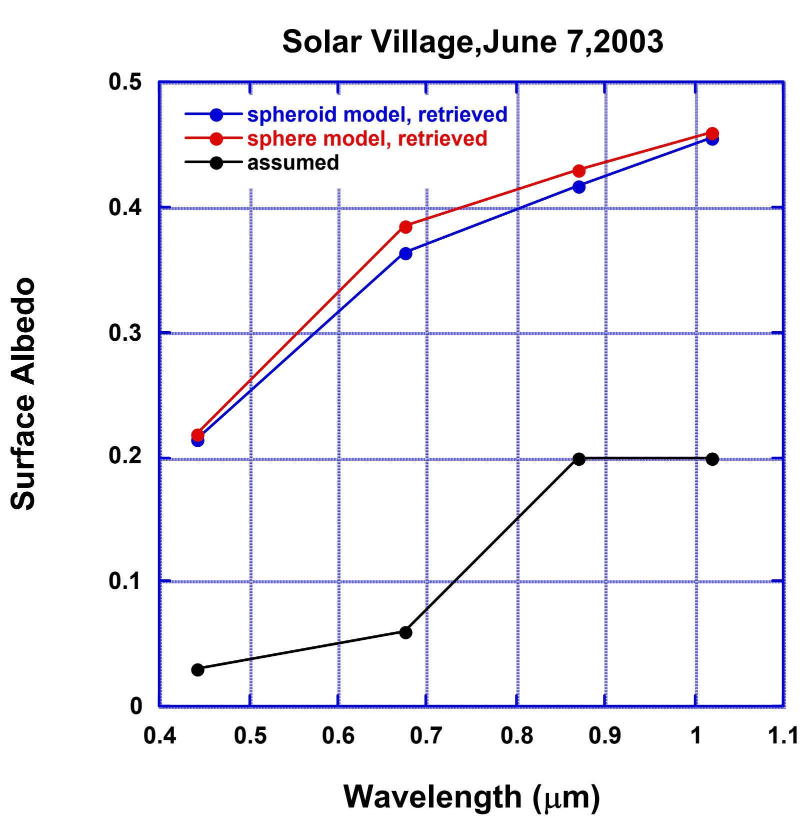
*-Albedo (MODIS IR channels)*

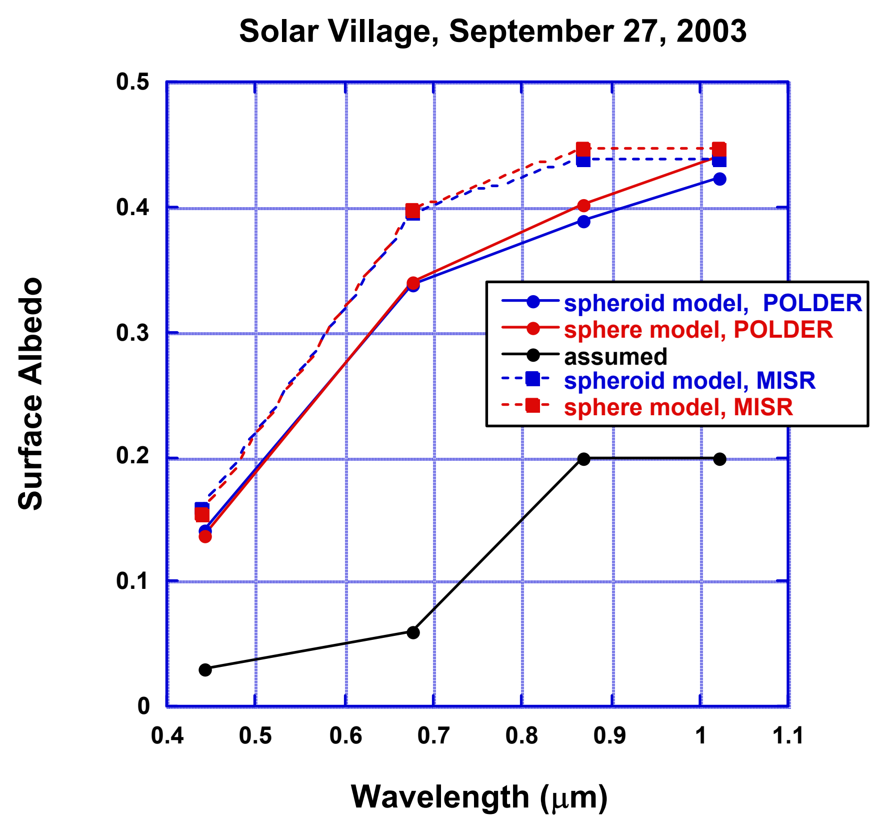
# Comparisons of Surface Retrievals (Albedo)

MISR: September 27, 2003
$\tau(0.44) \sim 0.24$ , SZA=$31^0$

POLDER: June 7, 2003
$\tau(0.44) \sim 0.67$ , SZA=$23^0$

POLDER: September 27, 2003
$\tau(0.44) \sim 0.24$ , SZA=$34^0$



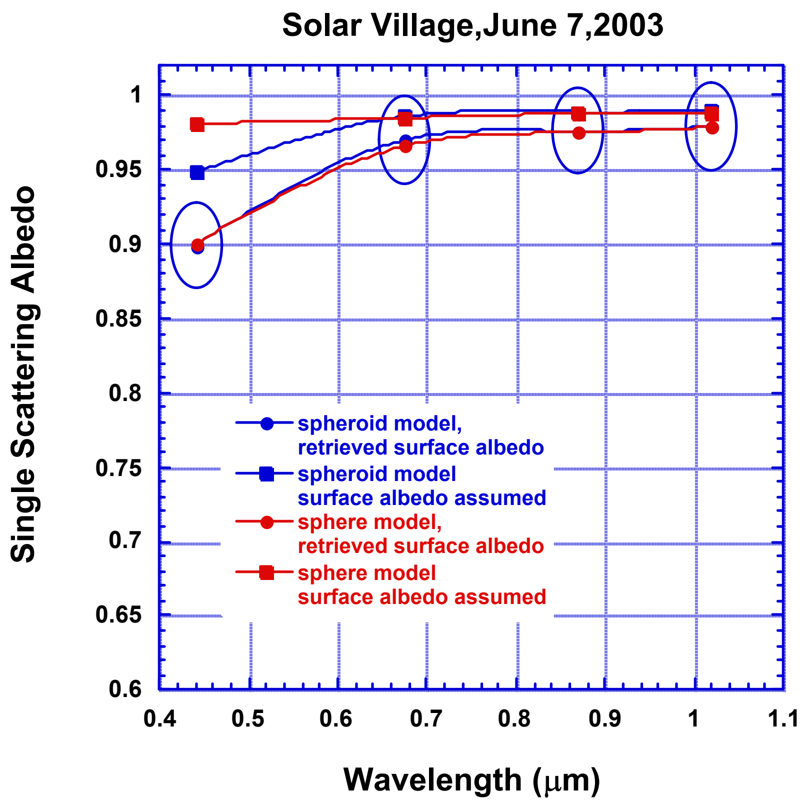



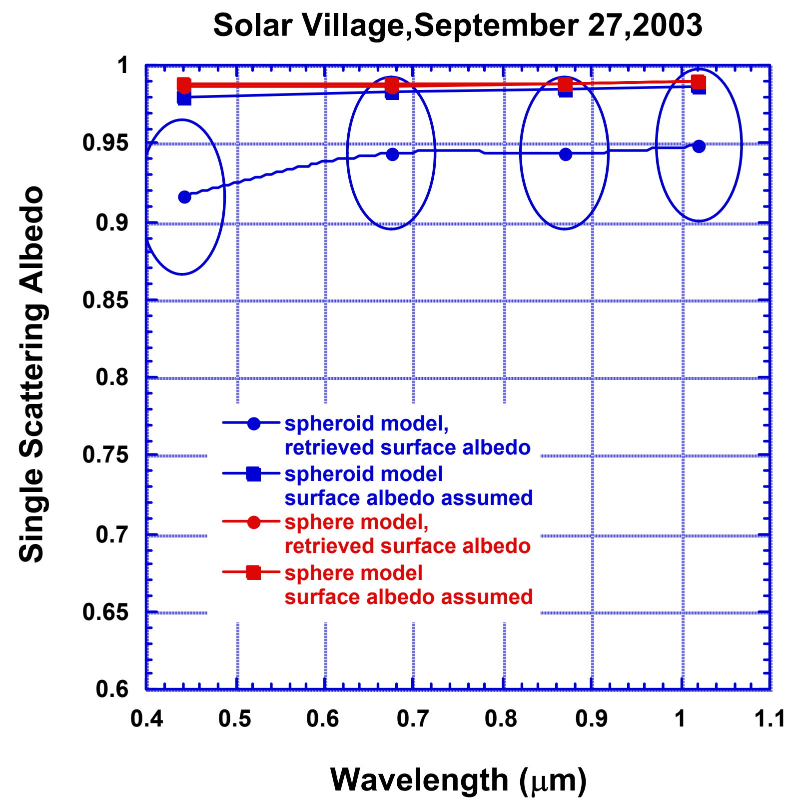
# Surface Effect on the Retrievals of Single Scattering Albedo

(Almucantar inversion with corrected surface)

POLDER: June 7, 2003
$\tau(0.44) \sim 0.67$ , SZA=$70^0$

POLDER: September 27, 2003
$\tau(0.44) \sim 0.24$ , SZA=$70^0$



# Validation

***Studies of:***

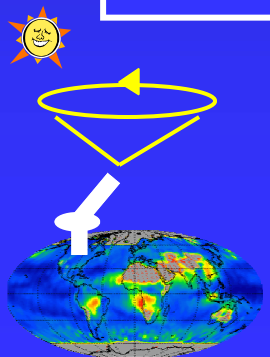
- Haywood, et al. (2003,…
- Muller , et al. (2003, 2004)
- Reid, et al. (2003, 2004?)
- Mallet, et al. (2003, 2004,…)
- Osborne, S. R., J.M. Haywood, et al. (2004)
- Shuster G., et al.
- P. Formenti, et al.
- S. Despiau, Mallet, et al
- M. Companelli, et al.
- ….

# ***Error estimates:***

*Important Error Factors:*

*- Aerosol Loading*
*- Scattering Angle Range*
*- Number of Angles (homogeneity)*
*- Number of spectral channels*
*- Aerosol Type*
*etc.*

***New strategy**: Errors are to be provided in each single retrievals for all retrieved parameters*



# Rigorous ERRORS estimates:

## General case: *large number of unknowns and redundant measurements*

$$\left\langle \left(\Delta \hat{x}_i\right)^2 \right\rangle \approx \left\langle \left(\Delta \hat{x}_i^{random}\right)^2 \right\rangle + \left(\Delta \hat{x}_i^{bias}\right)^2$$

$$\mathbf{C}_{\Delta \hat{\mathbf{x}}^{random}} = \left(\mathbf{U}^T \mathbf{C}^{-1} \mathbf{U}\right)^{-1}$$

$$\Delta \hat{\mathbf{x}}^{bias} = \left(\mathbf{U}^T \mathbf{C}^{-1} \mathbf{U}\right)^{-1} \mathbf{U}^T \mathbf{C}^{-1} \Delta \mathbf{I}^{bias}$$

**U** - matrix of partial derivatives in the vicinity of solution $\hat{\mathbf{x}}$

Above is valid:

- in linear approximation
- for Normal Noise
- no a priori constraints

# ERRORS estimates with a priori constraints

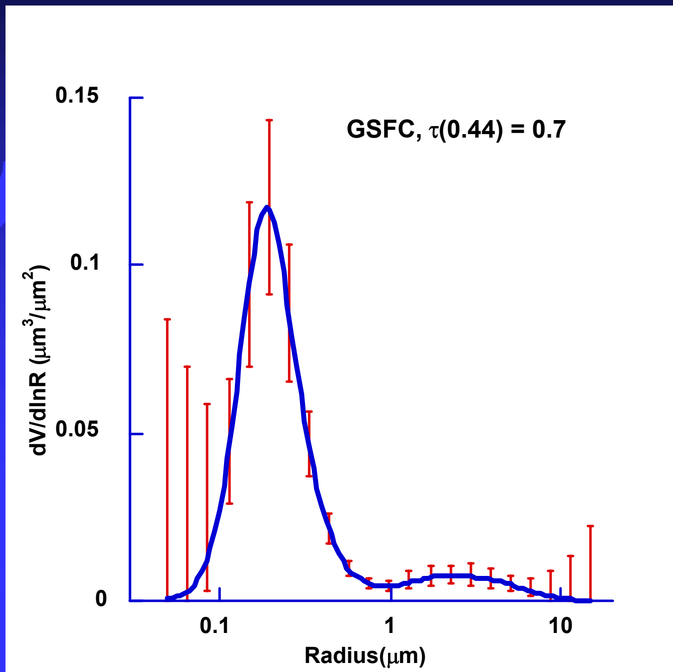
$$\mathbf{C}_{\Delta\hat{\mathbf{x}}^{random}} = \left(\mathbf{U}^T\mathbf{C}^{-1}\mathbf{U} + \mathbf{U}_a^T\mathbf{C}_a^{-1}\mathbf{U}_a\right)^{-1}$$

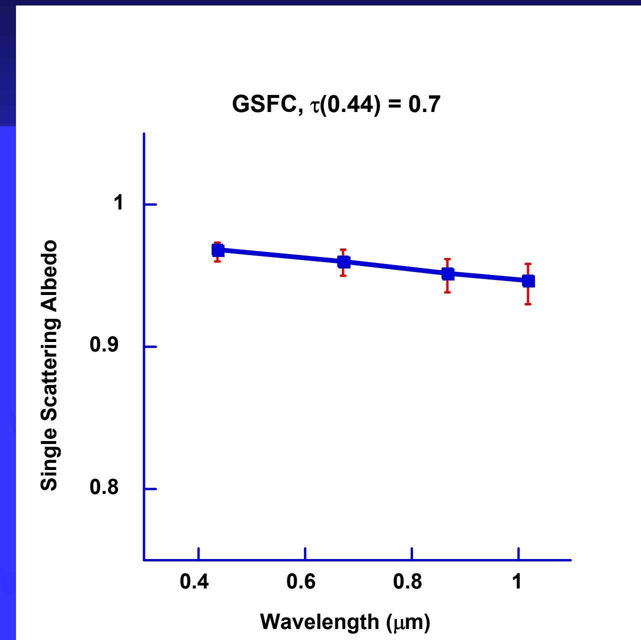
$$\Delta\hat{\mathbf{x}}^{bias} = \left(\mathbf{U}^T\mathbf{C}^{-1}\mathbf{U} + \mathbf{U}_a^T\mathbf{C}_a^{-1}\mathbf{U}_a\right)^{-1}\left(\mathbf{U}^T\mathbf{C}^{-1}\Delta\mathbf{I}^{bias} + \mathbf{U}_a^T\mathbf{C}_a^{-1}\Delta\mathbf{I}_a^{bias}\right)$$

ISSUES:

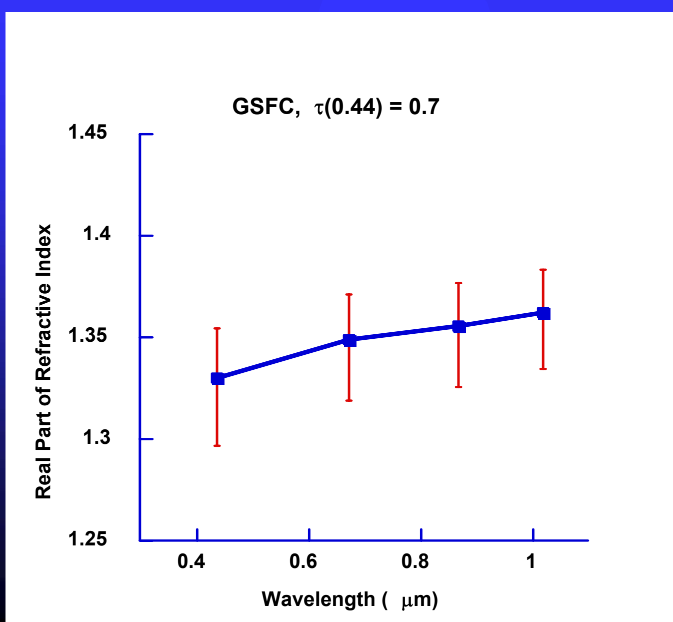
- in linear approximation
- for Normal Noise
- strongly dependent on a priori constraints
- very challenging in most interesting cases

# Examples of error estimates

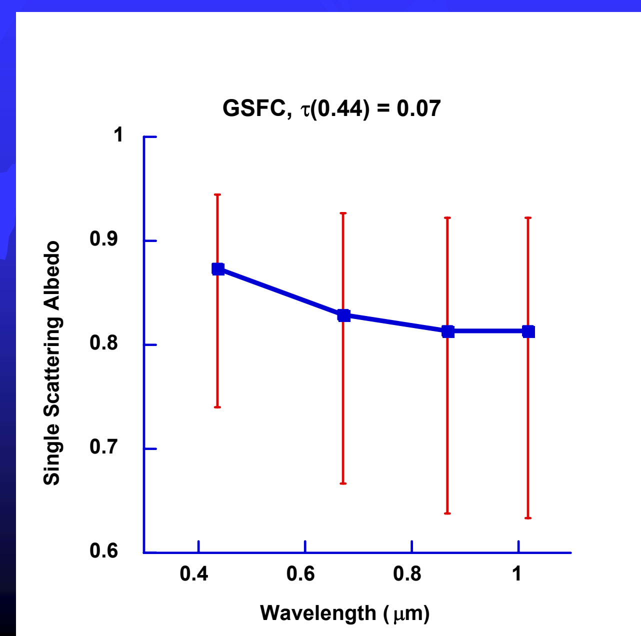



high loading




low loading



# AERONET inversion developments

*Forward model:*
- accounting for particle shape
- using non-lambertian surface
- modeling polarization

*Output improvements:*
- detailed phase function
- degree of polarization
- flexible separation of modes
- fluxes and forcing
- details of fitting (*biases and random*)

*Retrieval flexibility:*
- additional spectral channels
- different geometries

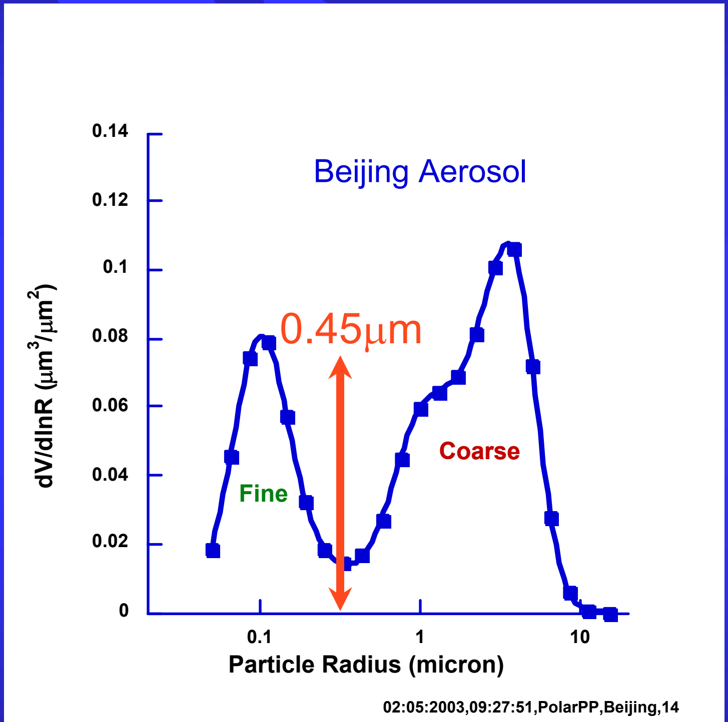
*Errors estimation:*
- for individual retrieval
- for absorption optical thickness
- for phase functions, etc.

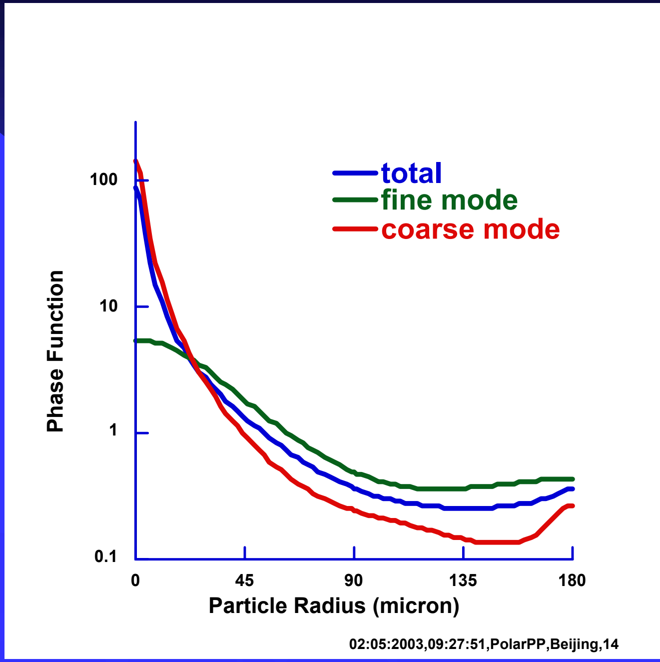
*Inversion of combined data:*
- different geometries
- combining with satellite
- combining with aircraft

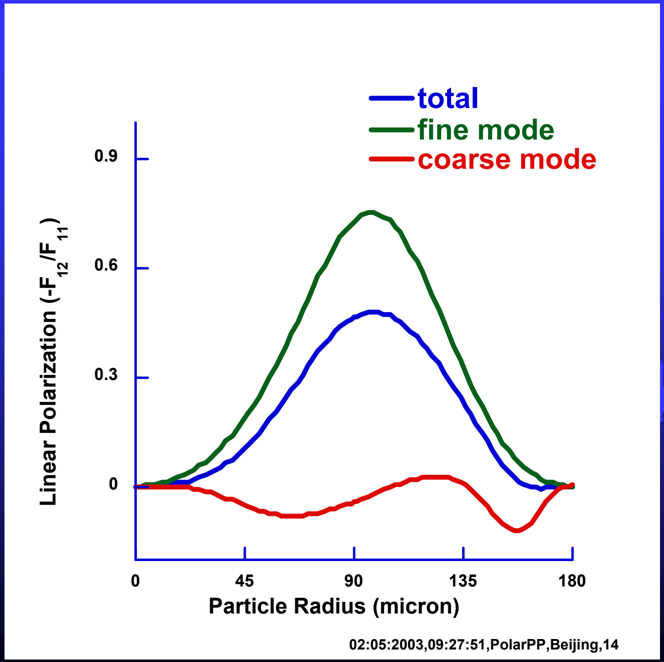
*Perspectives:*
- assuming bi-component aerosols
- combining with polarimetric satellite observations
- retrieval of shape distribution

# Fine and Coarse modes separations

*Beijing aerosol*




Flexible separation between fine and coarse modes (currently: ~0.6 µm)