We need to reconcile the single scattering albedo inferred from satellite or AERONET measurements (0.94-0.97 @ 550nm) with what modellers have assumed (0.89 to 0.92) from refractive indices measured by Volz and Patterson

Explain discrepancies in the imaginary part of the refractive index of dust between AERONET retrievals and Volz and Patterson measurements.

We have used

1) Studies of the mineralogy since refractive indices are defined over a much broader spectral interval for minerals:
Previous works include *Sokolik et al., 1999*; *Claquin et al, 1999; Claquin 2000 (Ph.D. thesis)*

2) Quantified the relative volumes of the main minerals

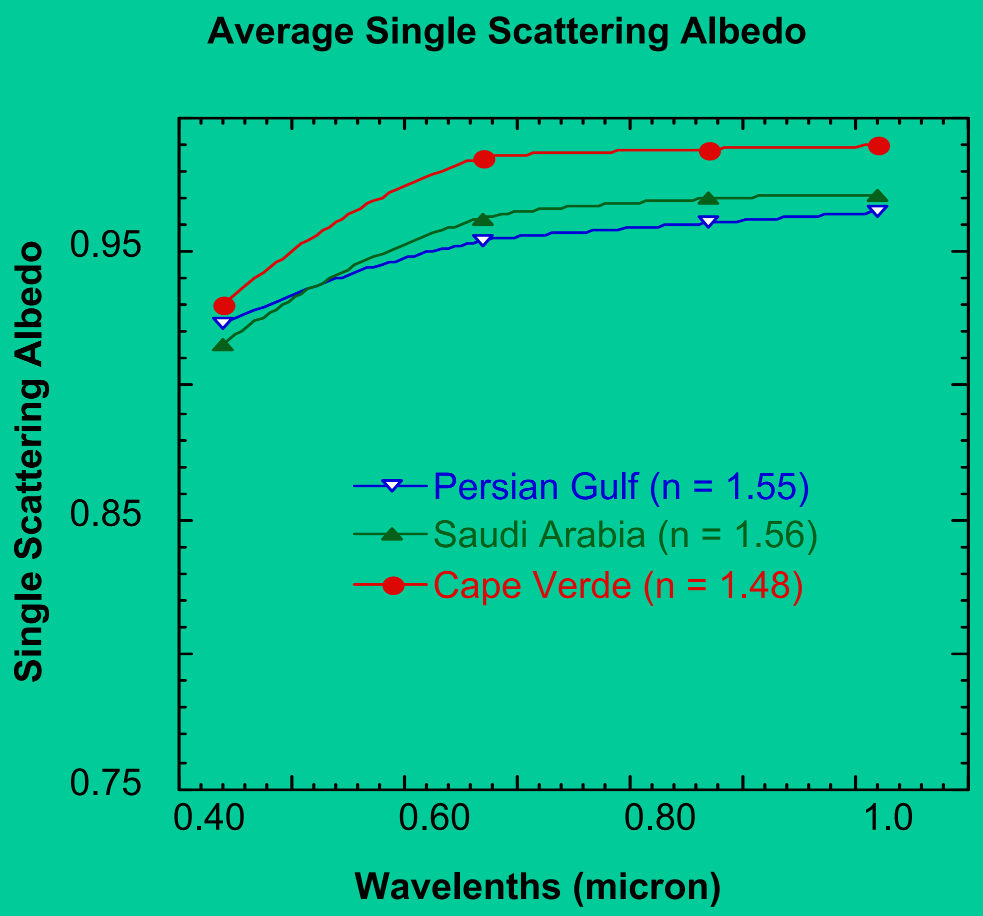
3) Applied a dielectric model to compute the refractive indices of the minerals As internal mixtures

4) Re-compute the perturbation flux and the direct radiative effect of Mineral dust

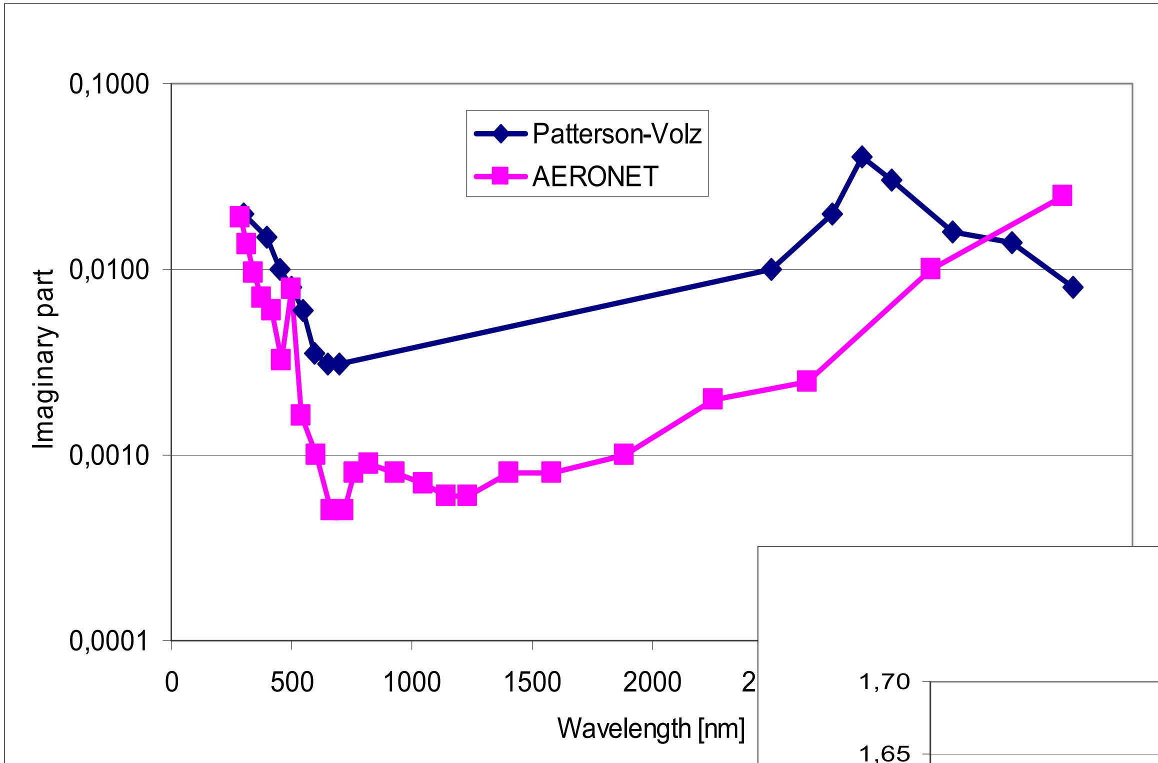
Retrieved Properties of Saharan Dust

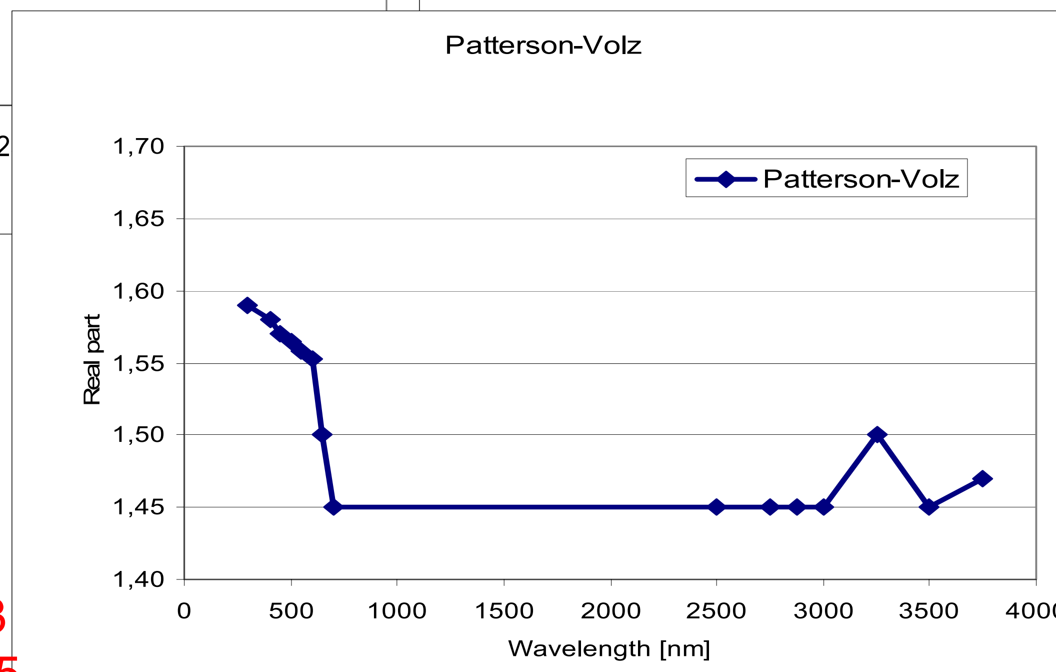
Angstrom < 0.75

Dubovik et al., 2002



Comparison of dust refractive indices from Patterson and Volz and retrieved from AERONET





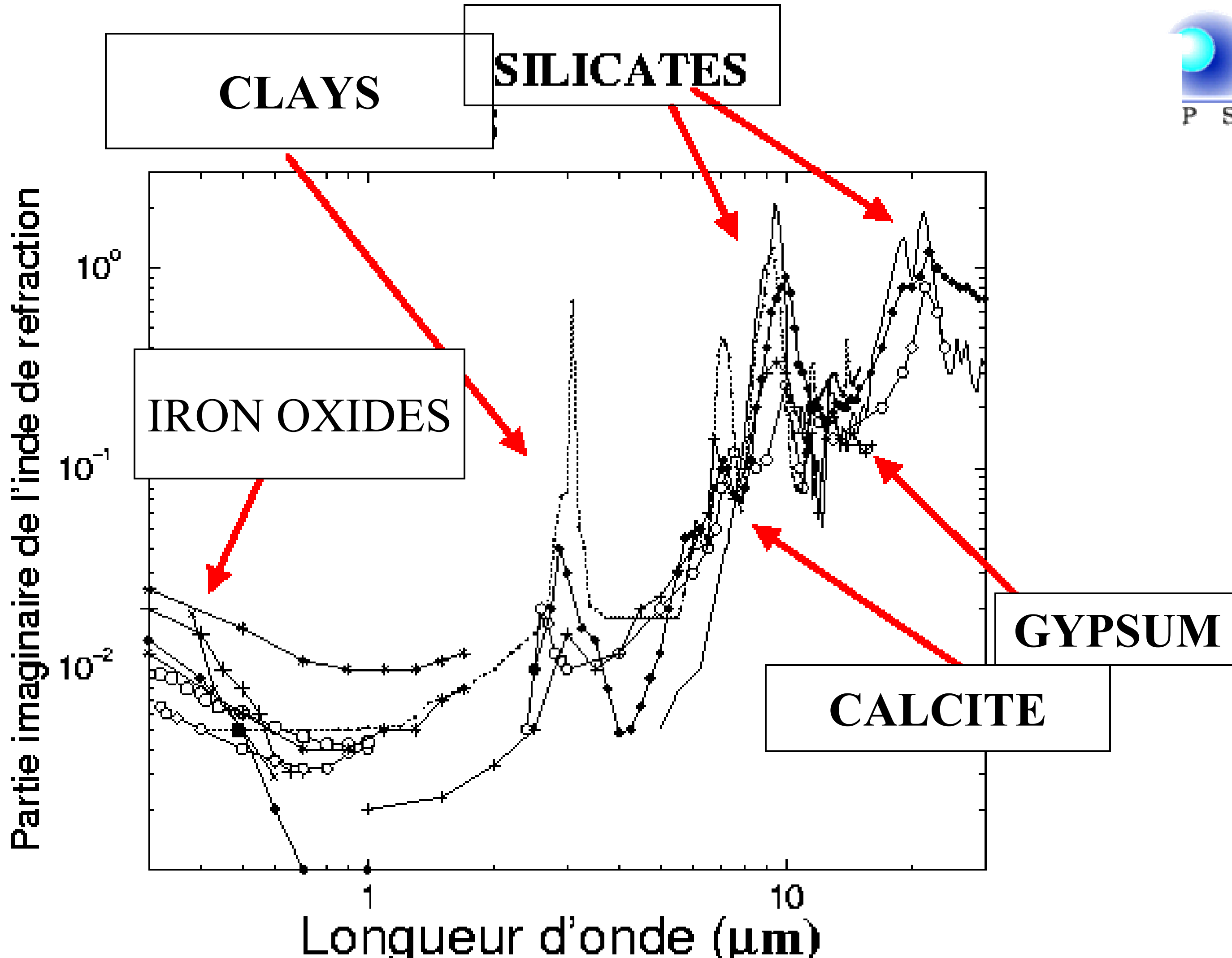
Dubovik (2002)

over spectral range 440-1020 nm

Bahrain (1020 meas.) n=1.55±0.03

Solar Village (250 meas.) n=1.56±0.03

Cap Verde (380 meas.) n=1.48 ±0.05

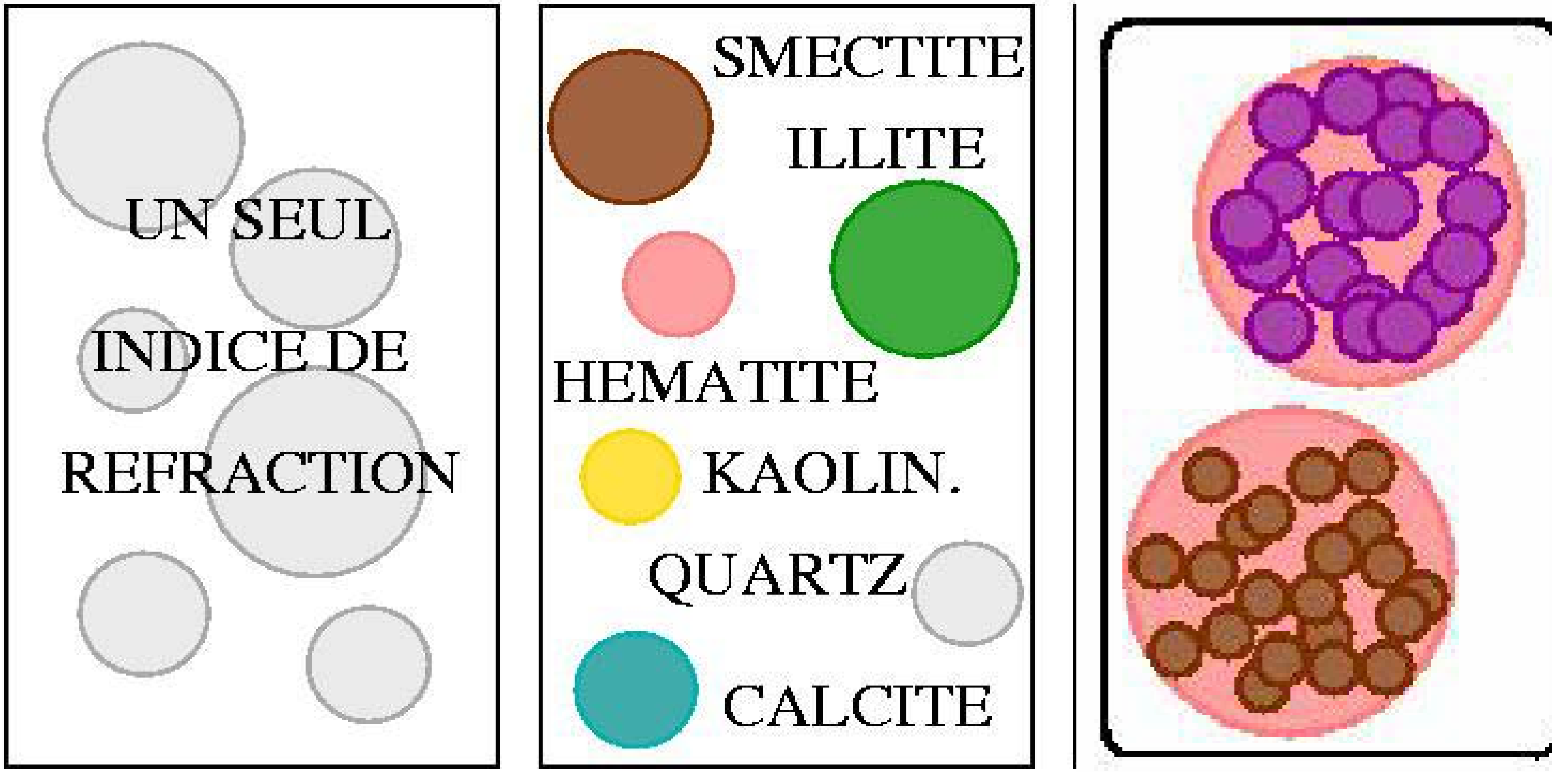


Measurementsfrom:
Toon et al. (76)
Sokolik et al. (93)
Ivlev et Popova (73)
Patterson (81)
Volz (73)
Carlson/Benjamin (80)
Levin et al. (79)
Grams et al. (74)
Lindberg/Gillepsie (77)

Mineralogy: quartz, clays, calcite, gypsum, iron oxides

Claquin et al. (1998)

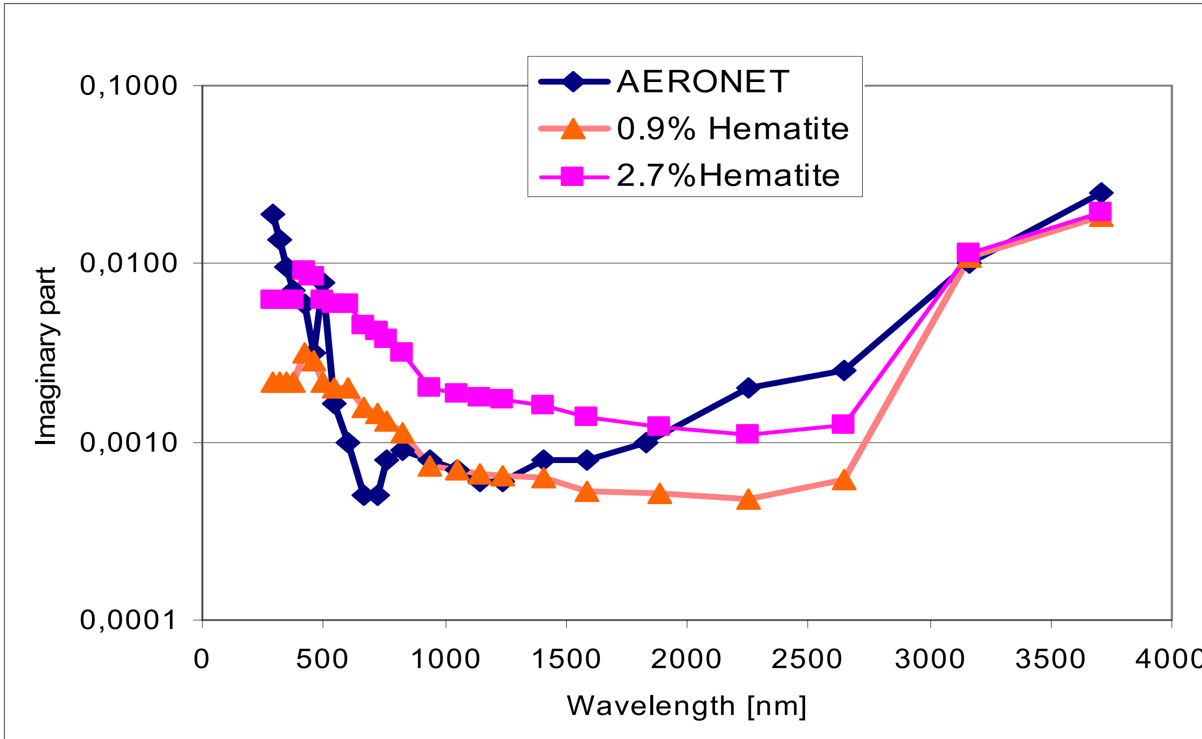
Three experiments

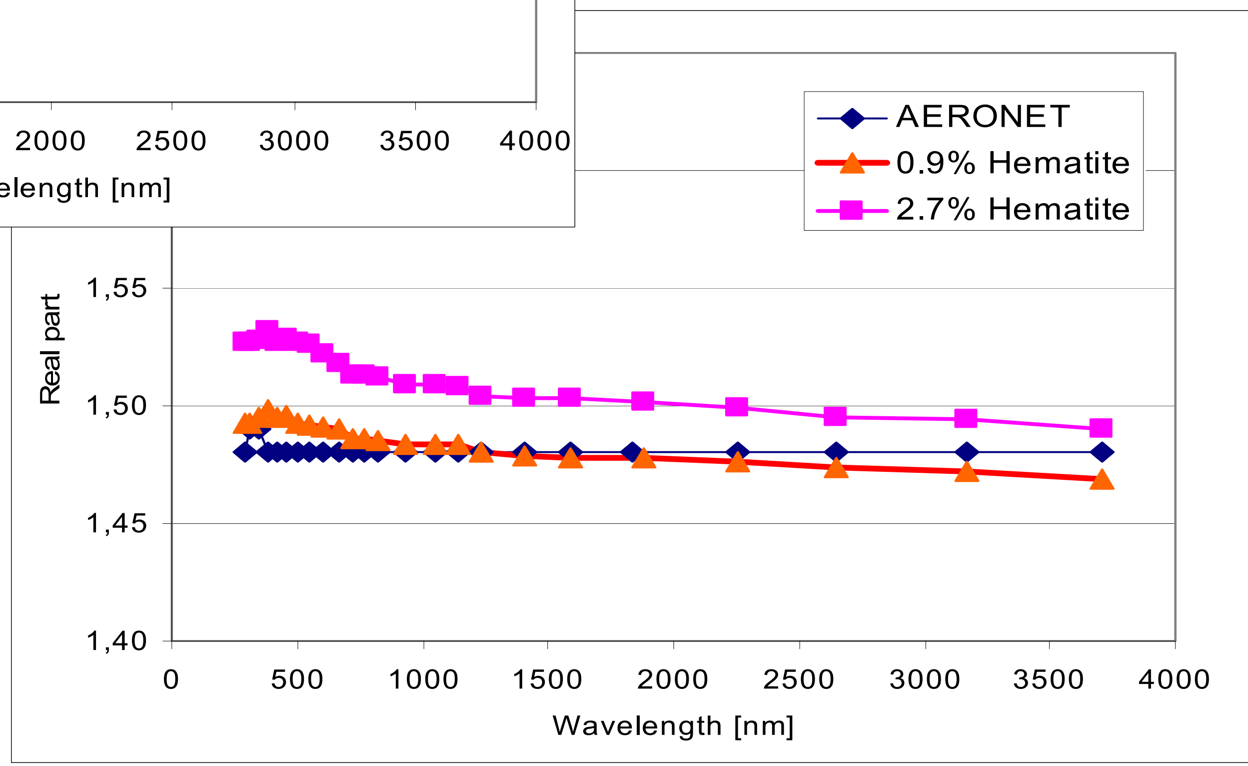


Unique Refractive Index	6 Minerals Externally Mixed	Hematite Inclusions in Each Mineral

Pourcentage Volume OF THE 6 MINERALS From Which Refractive Index Is Derived

	LOW HEMATITE	MEDIUM HEMATITE	HIGH HEMATITE
QUARTZ	14.0	14.0	14.0
CALCITE	6.0	6.0	6.0
HEMATITE	0.9	1.5	2.7
ILLLITE	32.1	31.5	30.3
KAOLINITE	24.0	24.0	24.0
MONTMOTILLONITE	23.0	23.0	23.0


AERONET
0.9% Hematite
2.7%Hematite
Imaginary part
0,1000
0,0100
0,0010
0,0001
0
500
1000
1500
2000
2500
3000
3500
4000
Wavelength [nm]


AERONET
0.9% Hematite
2.7% Hematite
Real part
1,55
1,50
1,45
1,40
0
500
1000
1500
2000
2500
3000
3500
4000
Wavelength [nm]

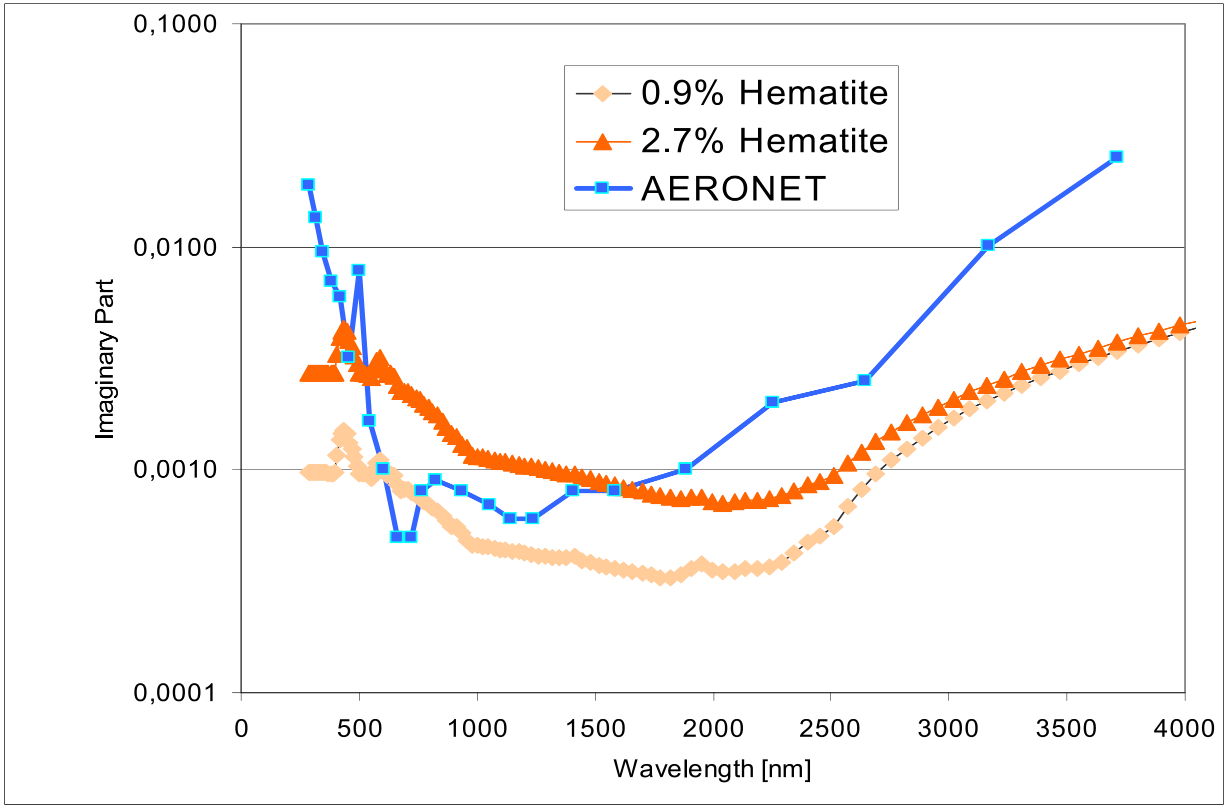
The dielectric model for refractive indices

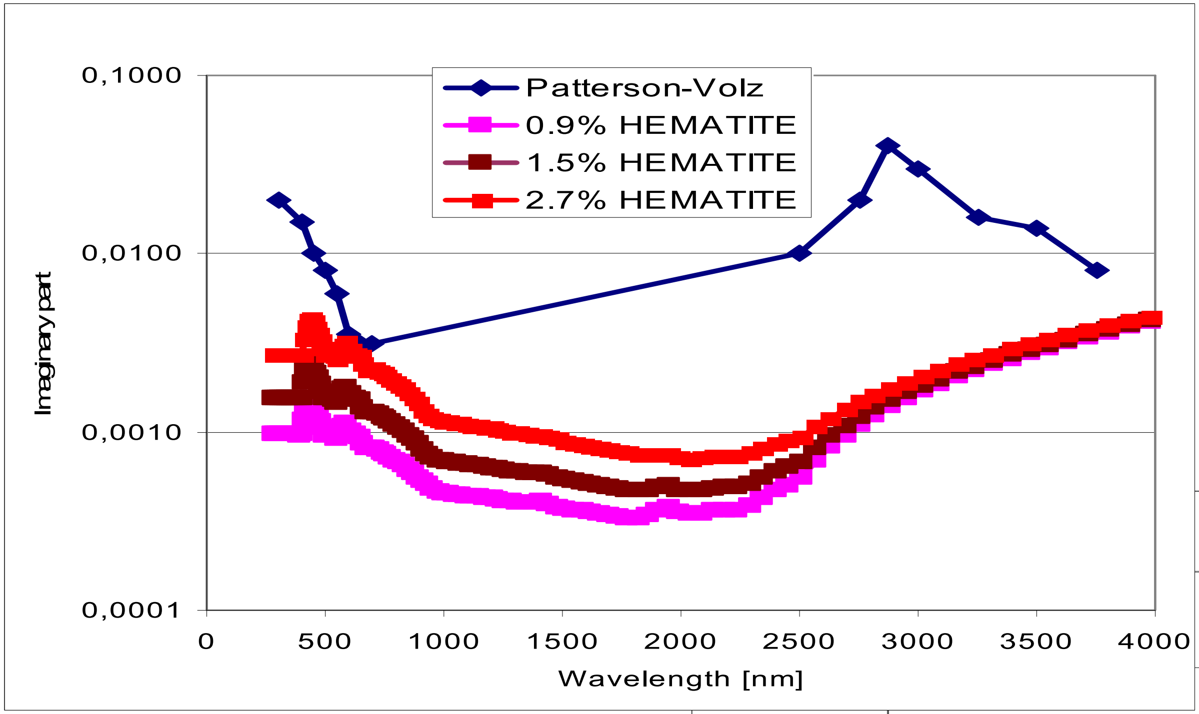
For a two-component mixture composed of inclusions embedded
In a homogeneous matrix it can be shown for spheres that the resulting
Refractive index is:

$$\varepsilon_{eff} = \varepsilon_m \{1 + [3\, v_1 (\varepsilon - \varepsilon_m)/ (\varepsilon + 2\, \varepsilon_m)]/[1 - v_1 (\varepsilon - \varepsilon_m)/(\varepsilon + 2\, \varepsilon_m)]\}$$

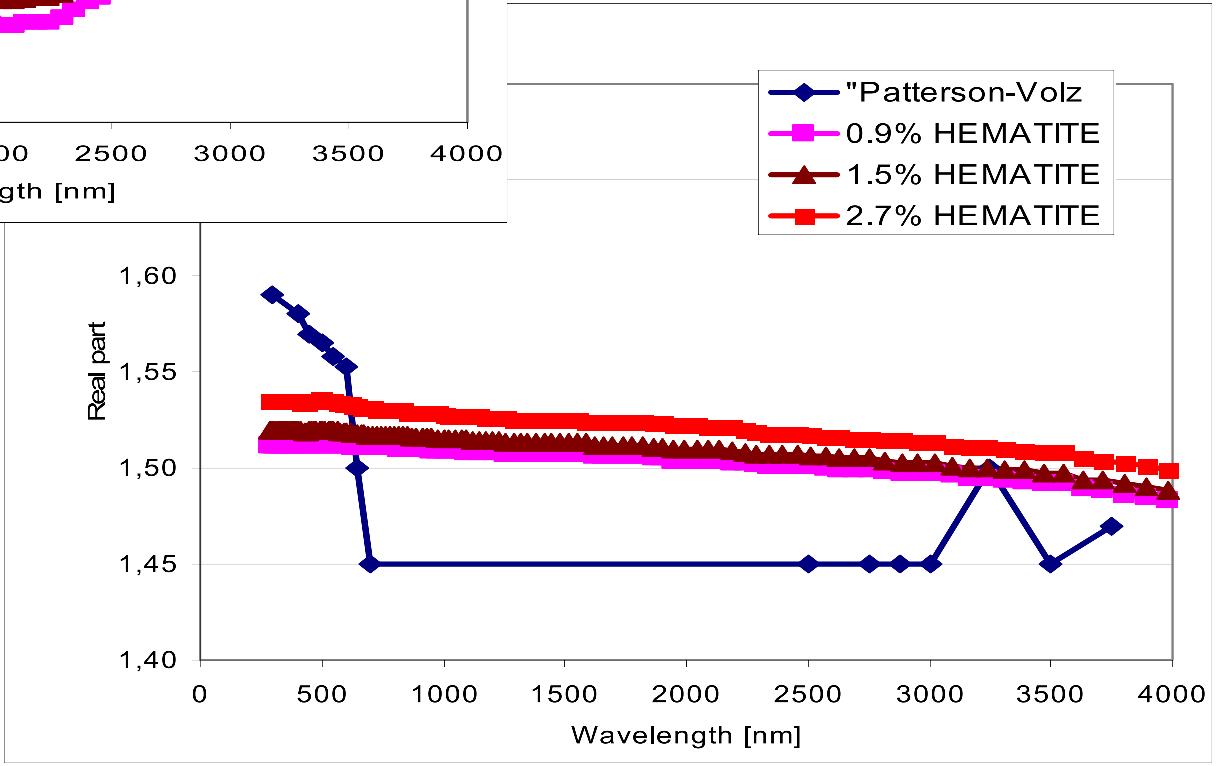
Where ε_m and ε are the complex refractive indices of the matrix and of
The includion

Here the refractive index of the mineral mixture is computed With the assumption of a dielectric



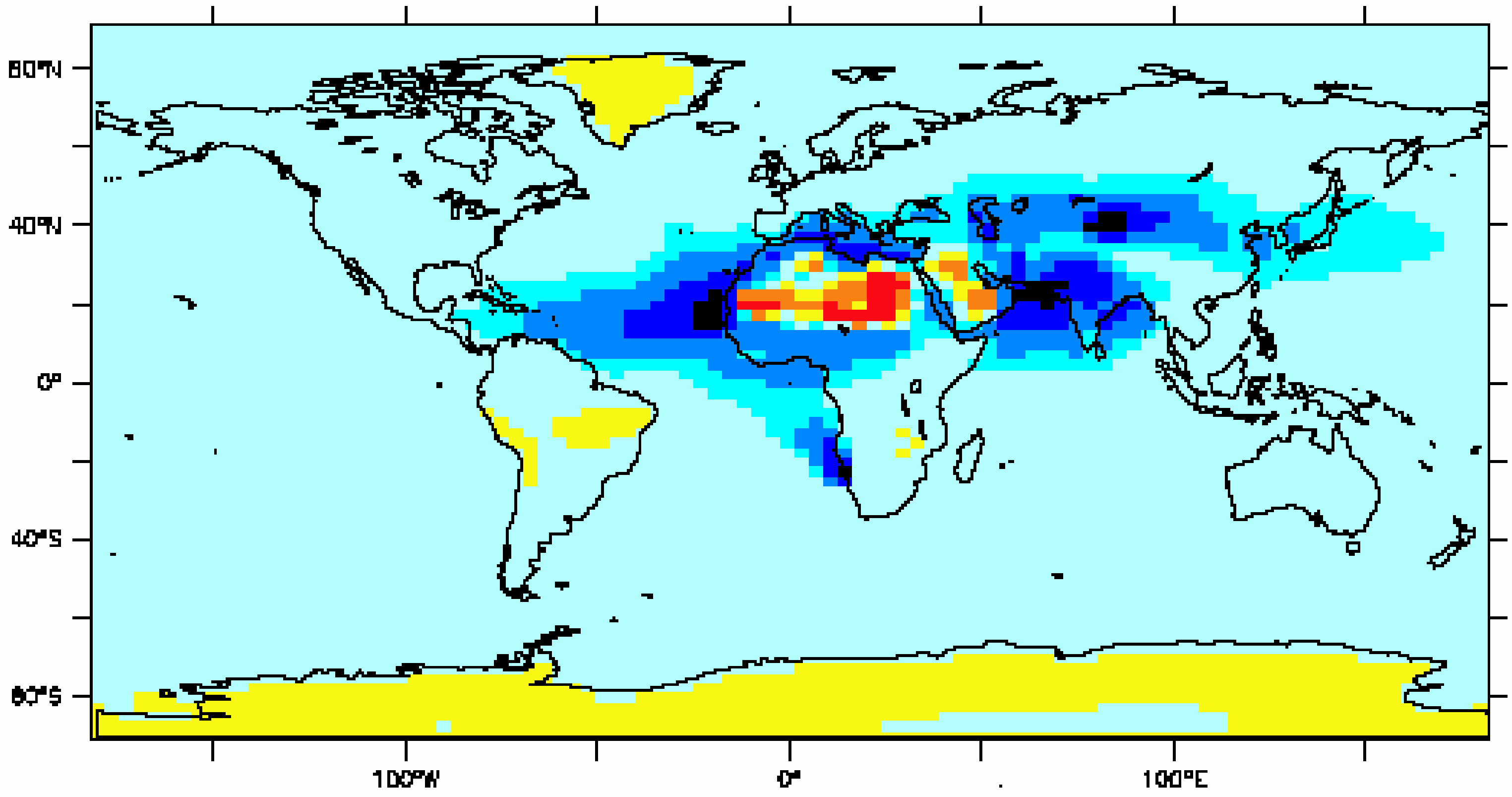


Patterson-Volz
0.9% HEMATITE
1.5% HEMATITE
2.7% HEMATITE
0,1000
0,0100
0,0010
0,0001
Imaginary part
0
500
1000
1500
2000
2500
3000
3500
4000
Wavelength [nm]

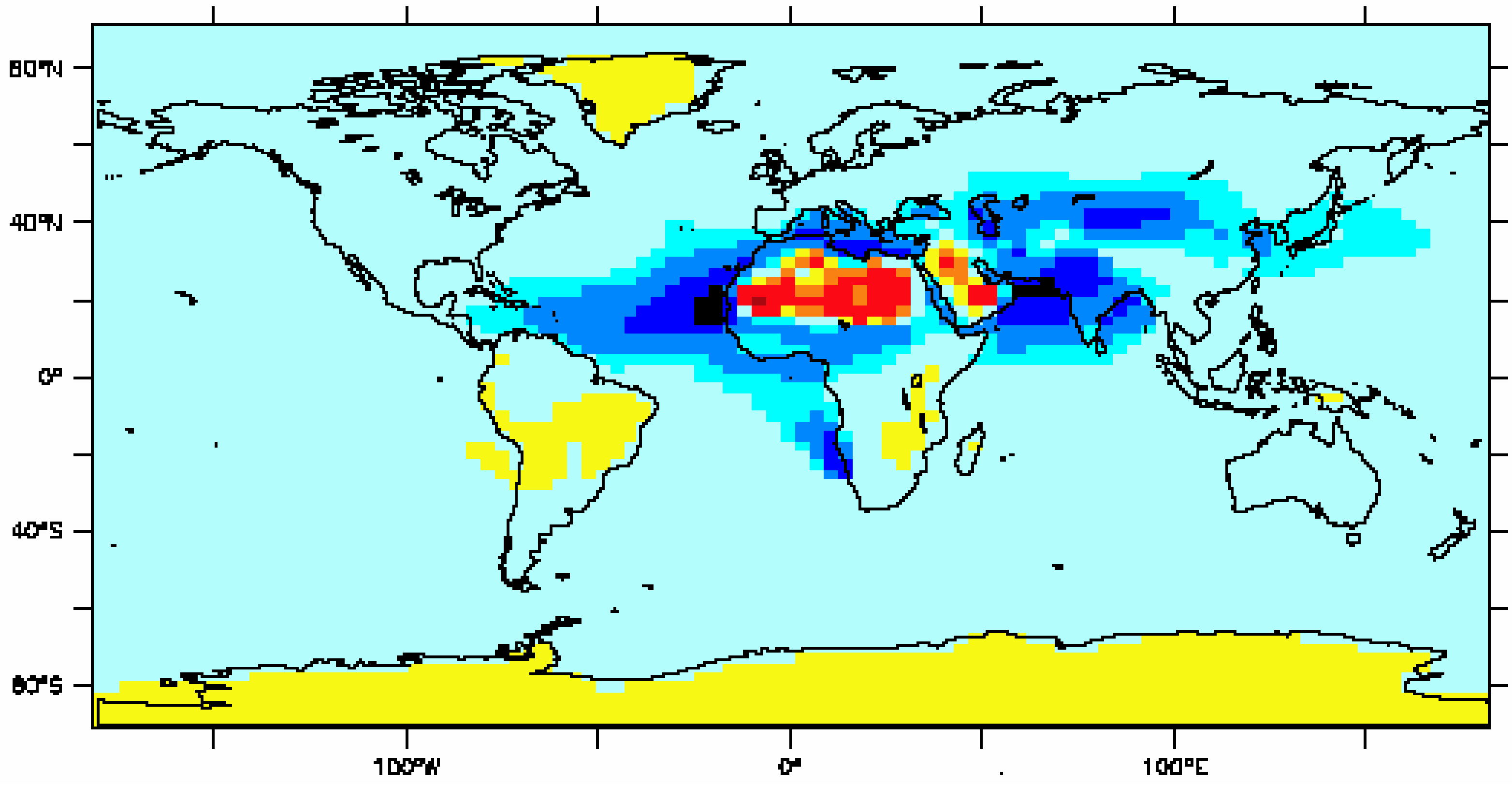


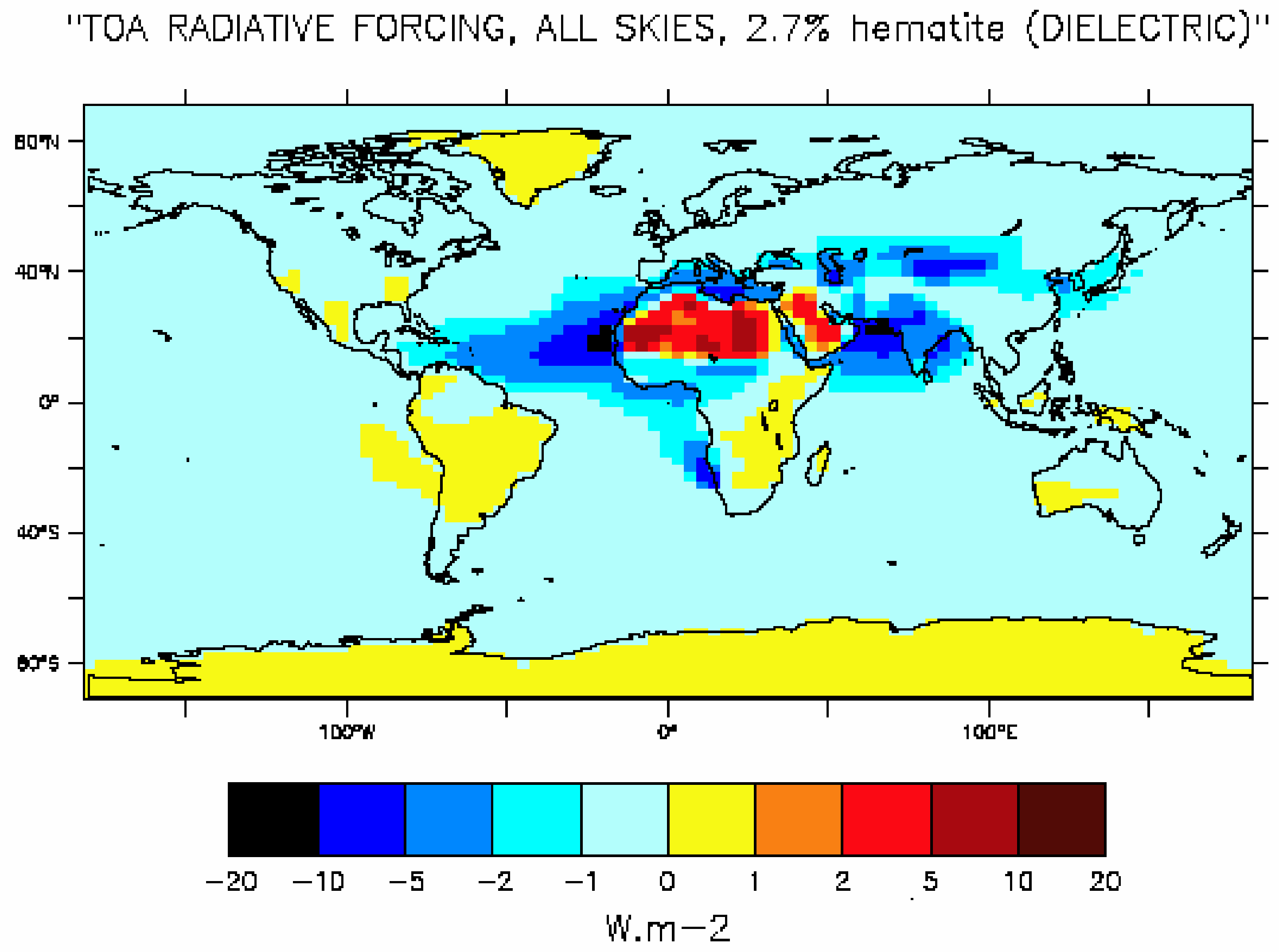
"Patterson-Volz
0.9% HEMATITE
1.5% HEMATITE
2.7% HEMATITE
1,60
1,55
1,50
1,45
1,40
Real part
0
500
1000
1500
2000
2500
3000
3500
4000
Wavelength [nm]

"TOA RADIATIVE FORCING, ALL SKIES, 0.9% hematite (DIELECTRIC)"



"TOA RADIATIVE FORCING, ALL SKIES, 1.5% hematite (DIELECTRIC)"

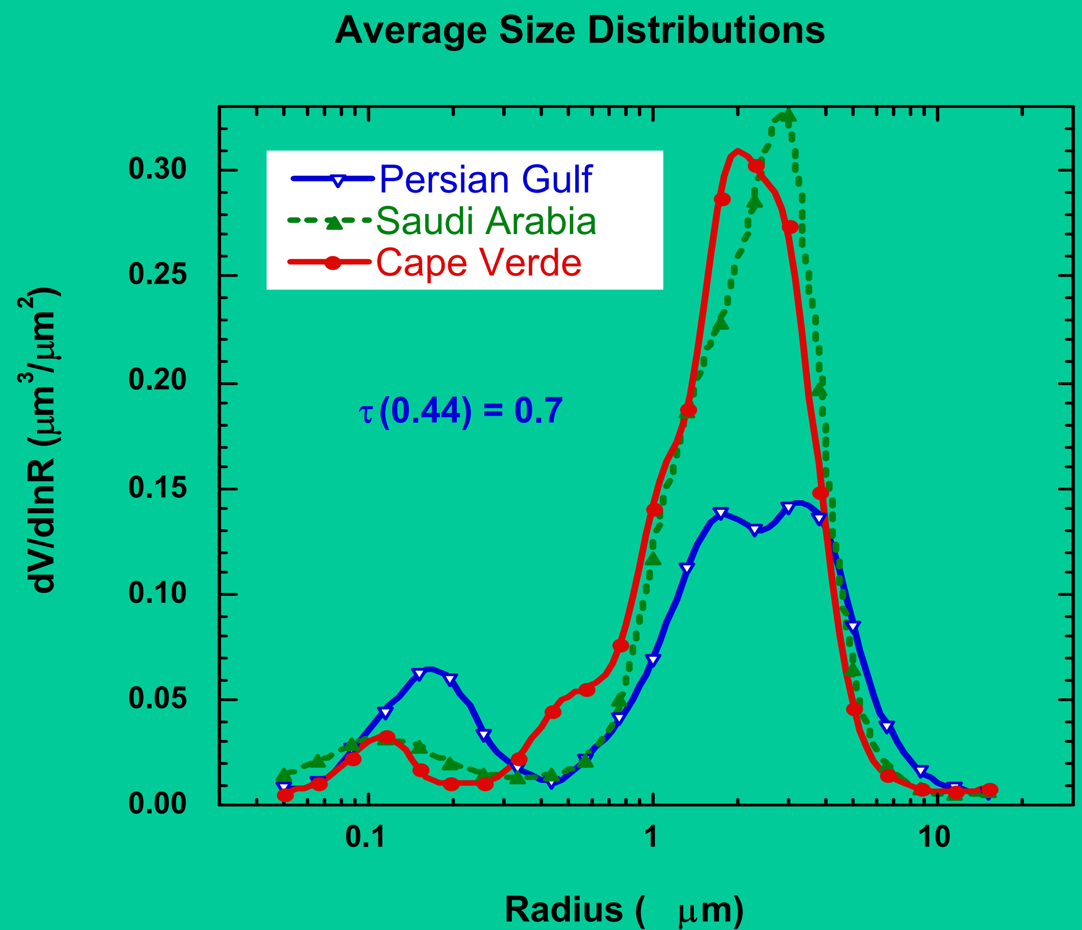



"TOA RADIATIVE FORCING, ALL SKIES, 2.7% hematite (DIELECTRIC)"
80°N
40°N
0°
40°S
80°S
100°W
0°
100°E
−20
−10
−5
−2
−1
0
1
2
5
10
20
W.m−2

Retrieved Properties of Saharan Dust

Angstrom < 0.75

Dubovik et al., 2002



PERTURBATION TO THE RADIATIVE FLUX (TOP OF ATMOSPHERE)

	EXTERNAL Mixture	INTERNAL VOL. WEIGHED	INTERNAL DIELECTRIC
LOW Hematite CASE	NA	-0.68	-0.62
MEDIUM Hematite CASE	-0.54	-0.46	-0.55
High Hematite CASE	NA	-0.23	–0.41

DUST FORCING (TOP OF ATMOSPHERE)

	EXTERNAL Mixture	INTERNAL VOL. WEIGHED	INTERNAL DIELECTRIC
LOW Hematite CASE	NA	-0.10 to -0.34	-0,09 to -0.31
MEDIUM Hematite CASE	-0.08 to –0.27	-0.07 to -0.23	-0.08 to -0.23
High Hematite CASE	NA	-0.03 to -0.12	-0.06 to –0.21

Conclusions

• We have identified why dust models assumed more absorbing aerosols than the satellite retrievals indicate

• A mineralogical approach with realistic values for the composition in iron oxides has given the basis to better constrain the direct forcing for mineral dust

• We conclude that this forcing is an overall negative forcing in the range [-0.26 to –0.05 W.m-2]. Previous uncertainty in TAR ranged from –0.7 to +0.2 W.m-2 for dust.

•We are varying the size distribution for additional sensitivity studies