MODIS aerosol products and aerosol radiative forcing of climate

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Why do we care? **Biggest uncertainty in radiative forcing of climate**
Health impacts from forest fires
Dust and Asian pollution confuses EPA standards
and ..... atmospheric corrections

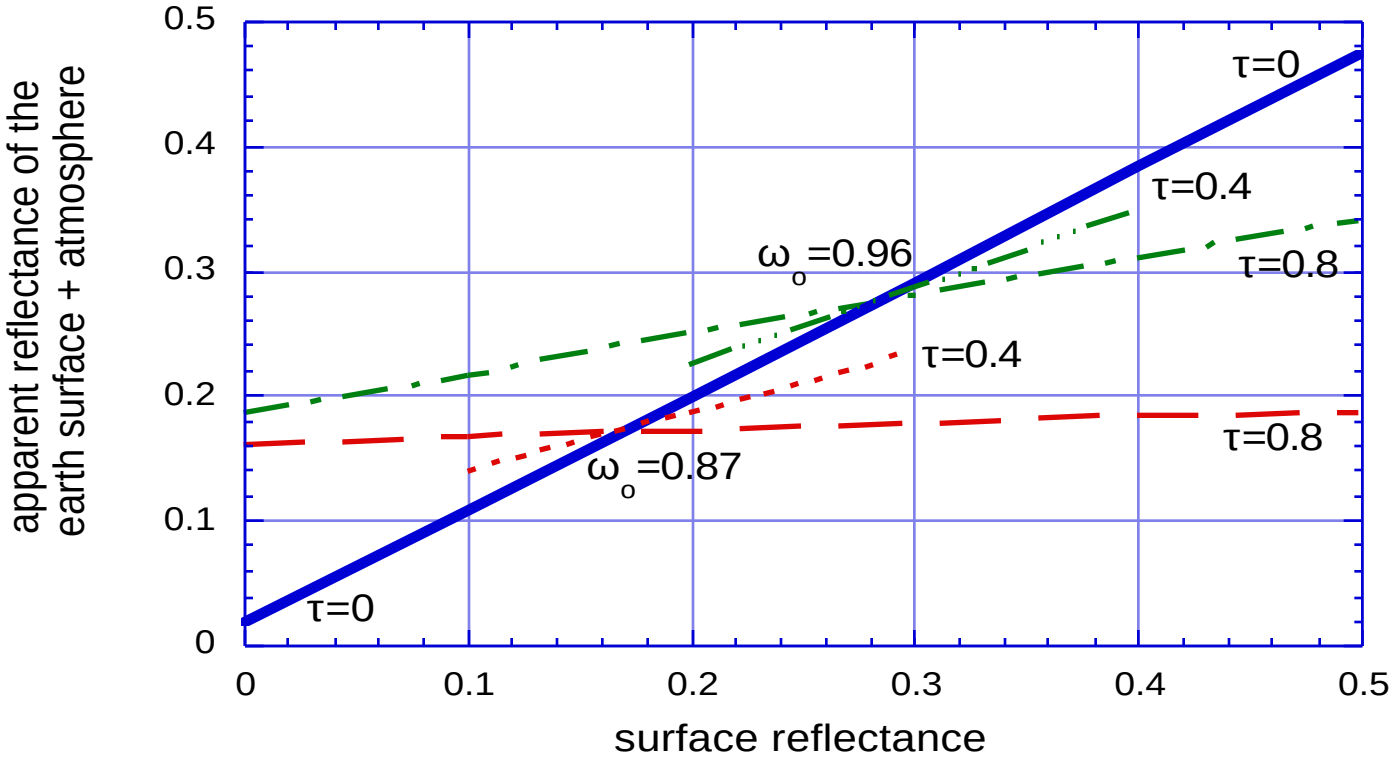
What do we offer ? **First aerosol AOT & mass loading over land**
First aerosol size estimation over oceans
***** Lorraine Remer talk ******

Why this is insufficient ? **No clear pathway to radiative forcing**
No measure of aerosol absorption

What else may be wrong ?
What fraction of global radiative forcing can MODIS see ?

Why this is insufficient ?

No clear pathway to radiative forcing
No aerosol absorption product



Basic relationship

Aerosol properties:

optical thickness - τ,

Phase function - P, β - aerosol size

single scattering albedo - ω_0

Radiance measured by MODIS:

$$L=C_1\omega_0 P\tau + \rho[1-C_2\tau(1-\omega_0-\beta)]$$

Flux affecting climate:

$$F=D_1\omega_0\beta\tau + \rho[1-D_2\tau(1-\omega_0-\beta)]$$

$L_\lambda(\tau,\rho)$ ==[ω_0, **ref. index**]==> τ, aerosol size

τ, aerosol size ===[ω_0, **ref. index**]==> F

We do have error cancellation, but we also have to develop methods for: ω_0, ref. index

MODIS can detect aerosol within a given accuracy:

Ocean: $\Delta\tau = \pm 0.03 \pm 0.05\tau$

Land: $\Delta\tau = \pm 0.05 \pm 0.15\tau$

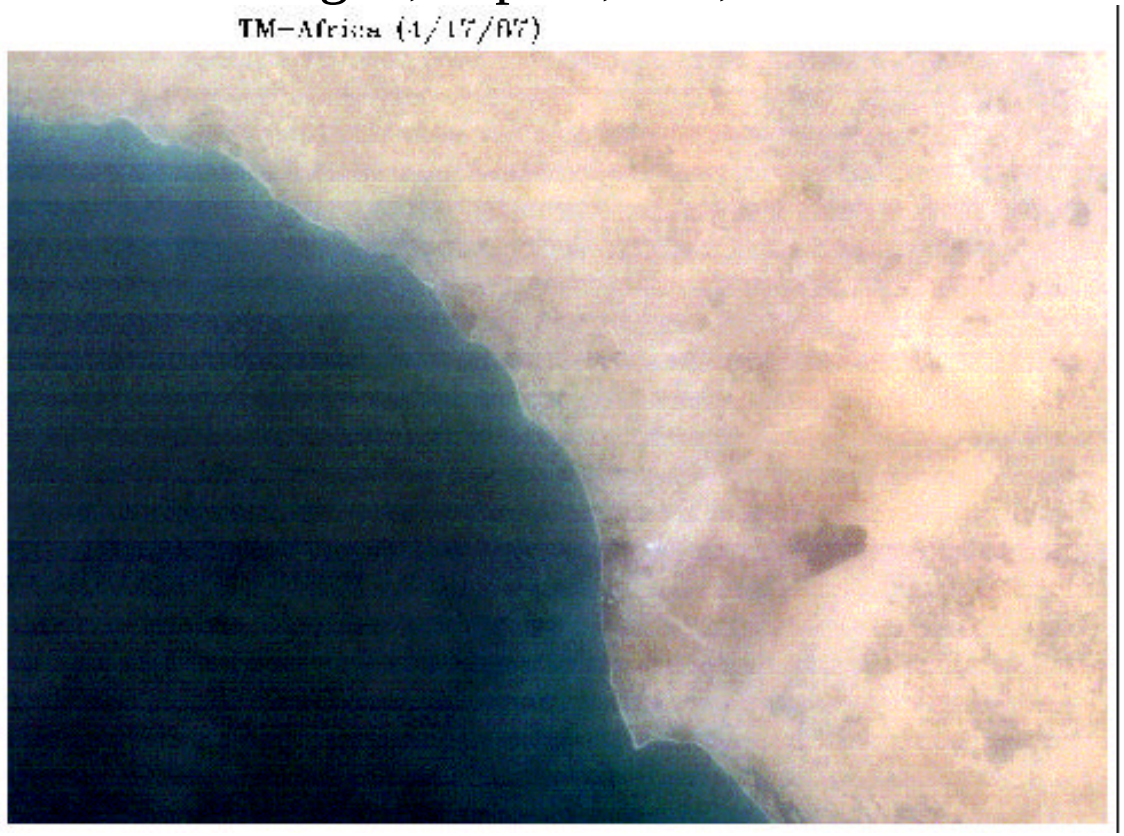
How well can we estimate the global direct forcing?

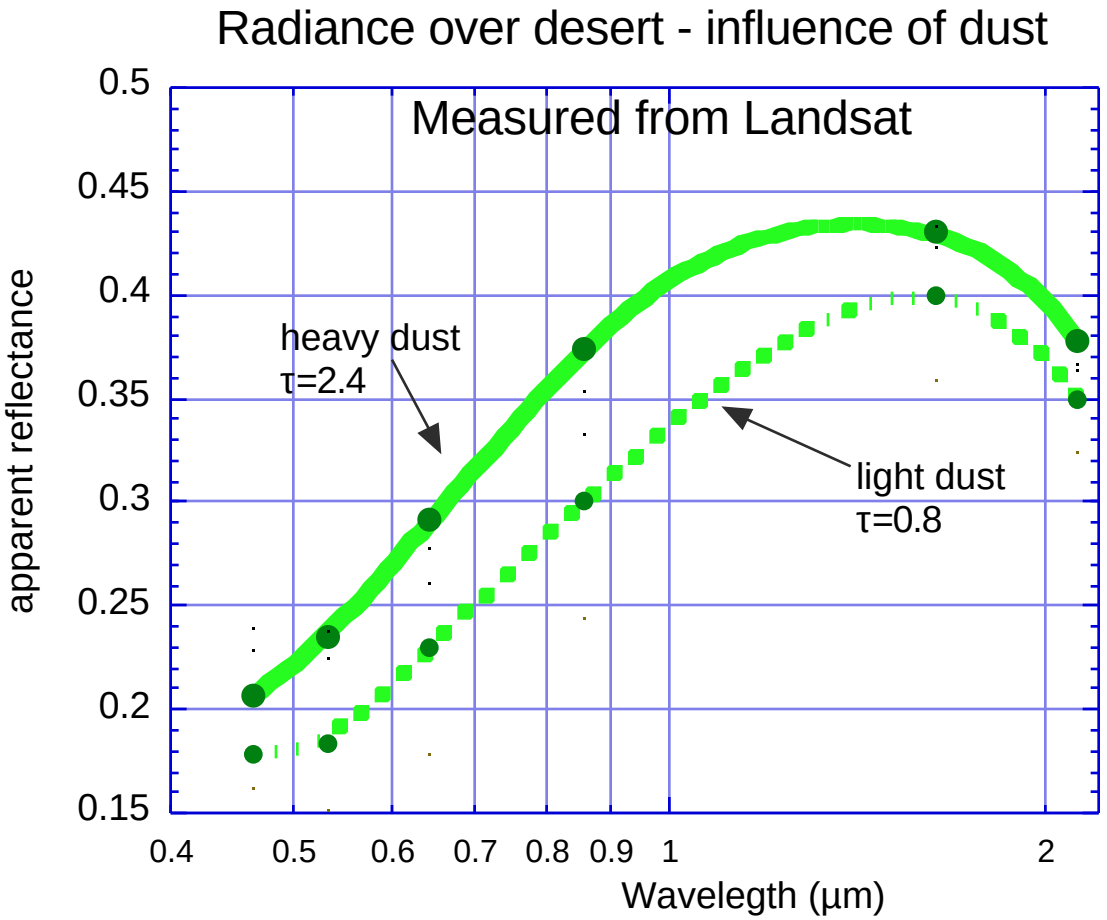
the global indirect forcing?

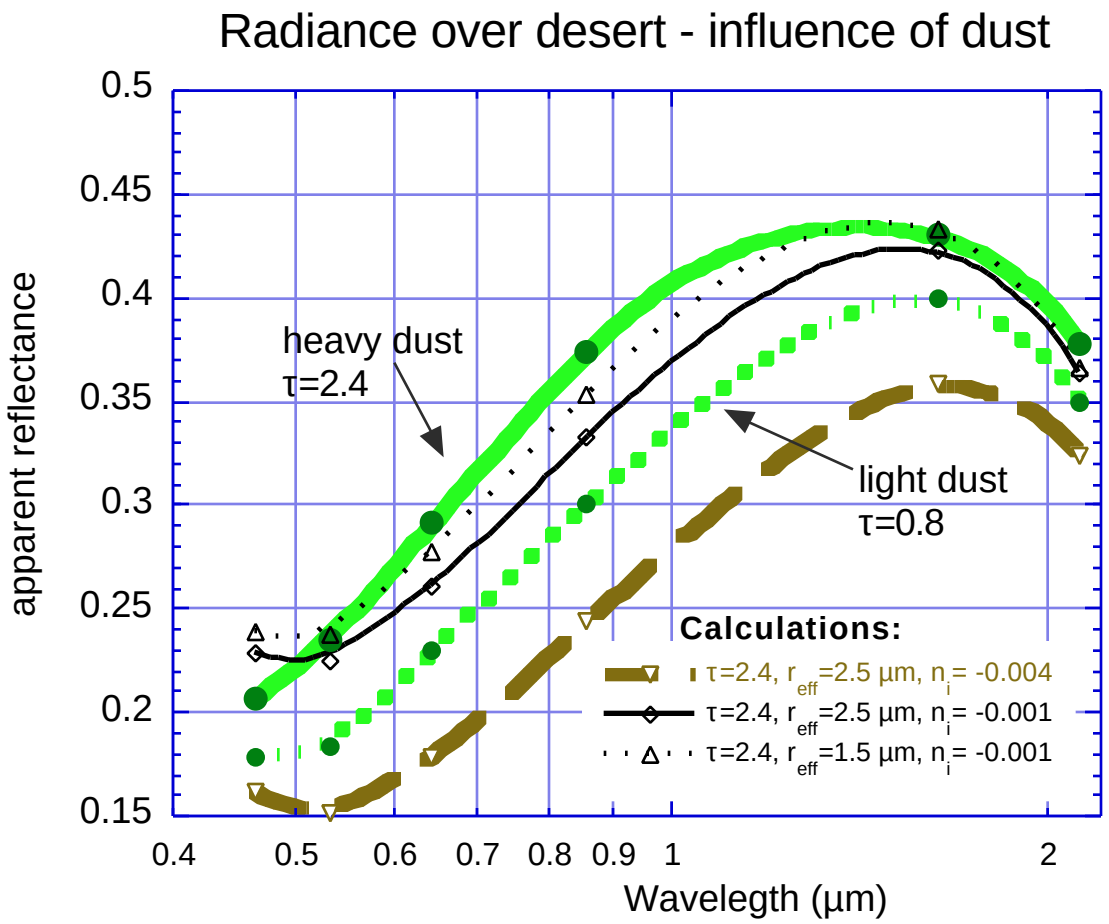
**** Lorraine estimates based on models *****

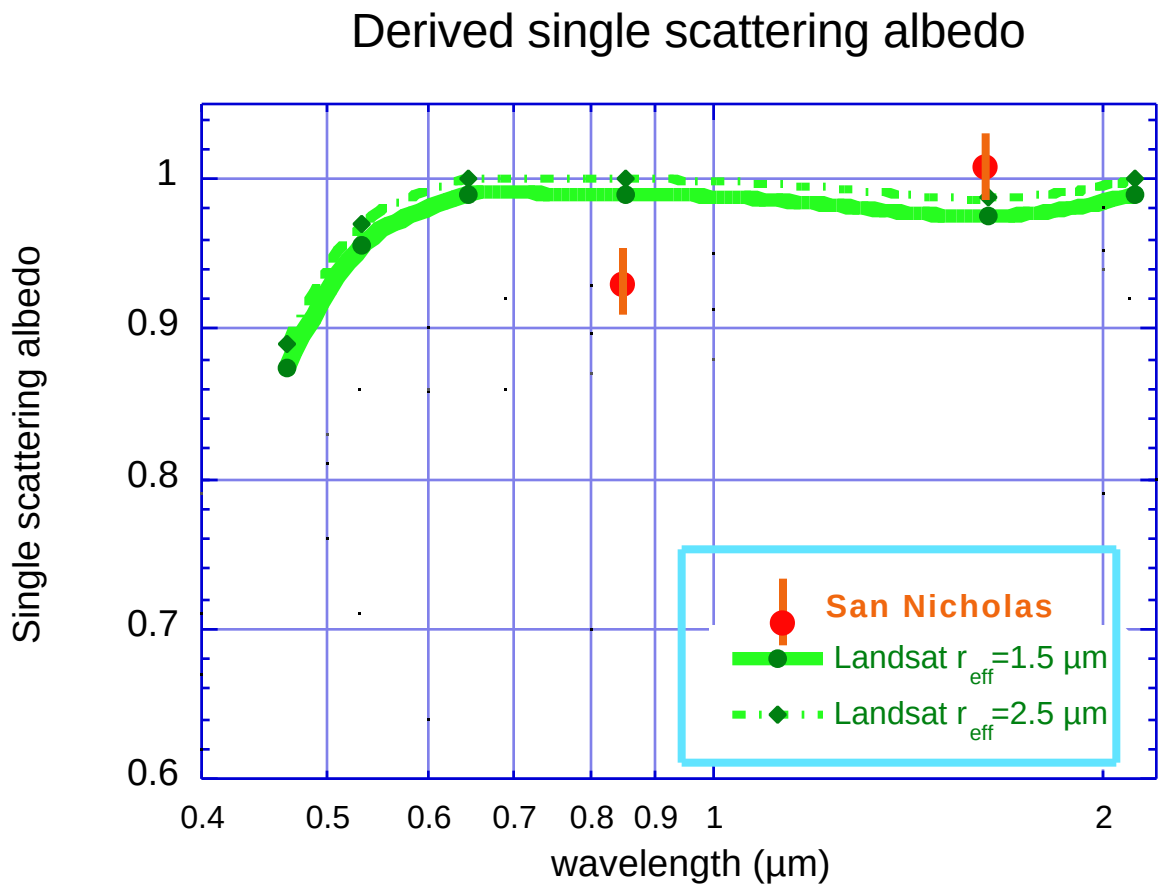
Remote sensing of aerosol absorption - ω_o

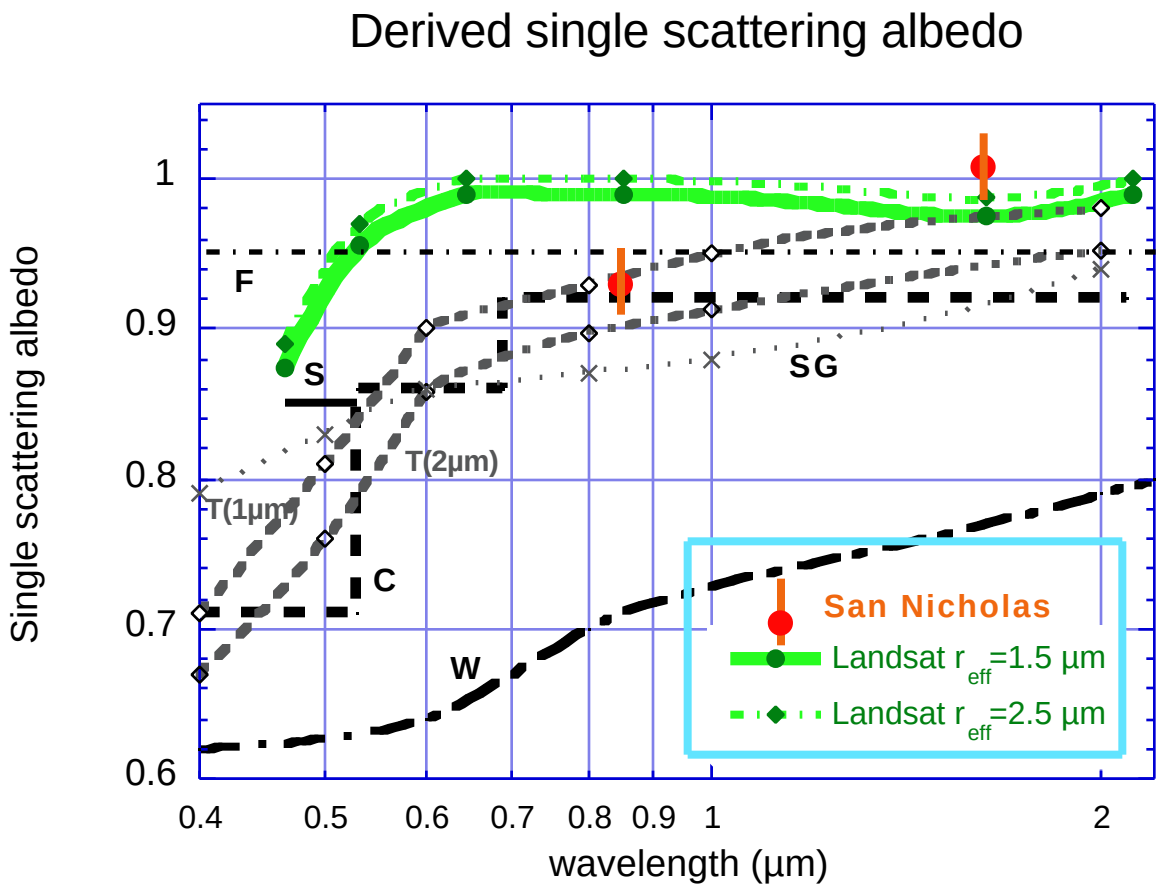
Senegal, April, 17, 1987

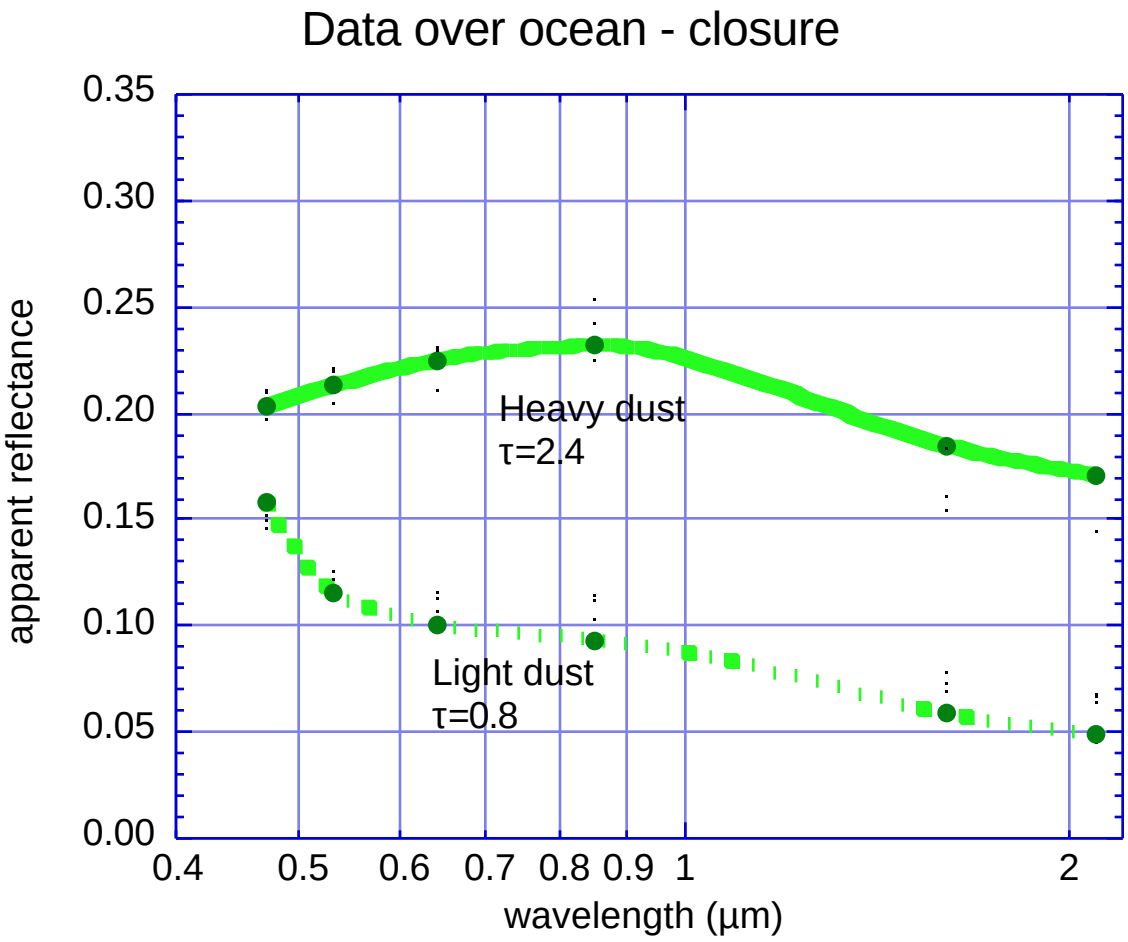


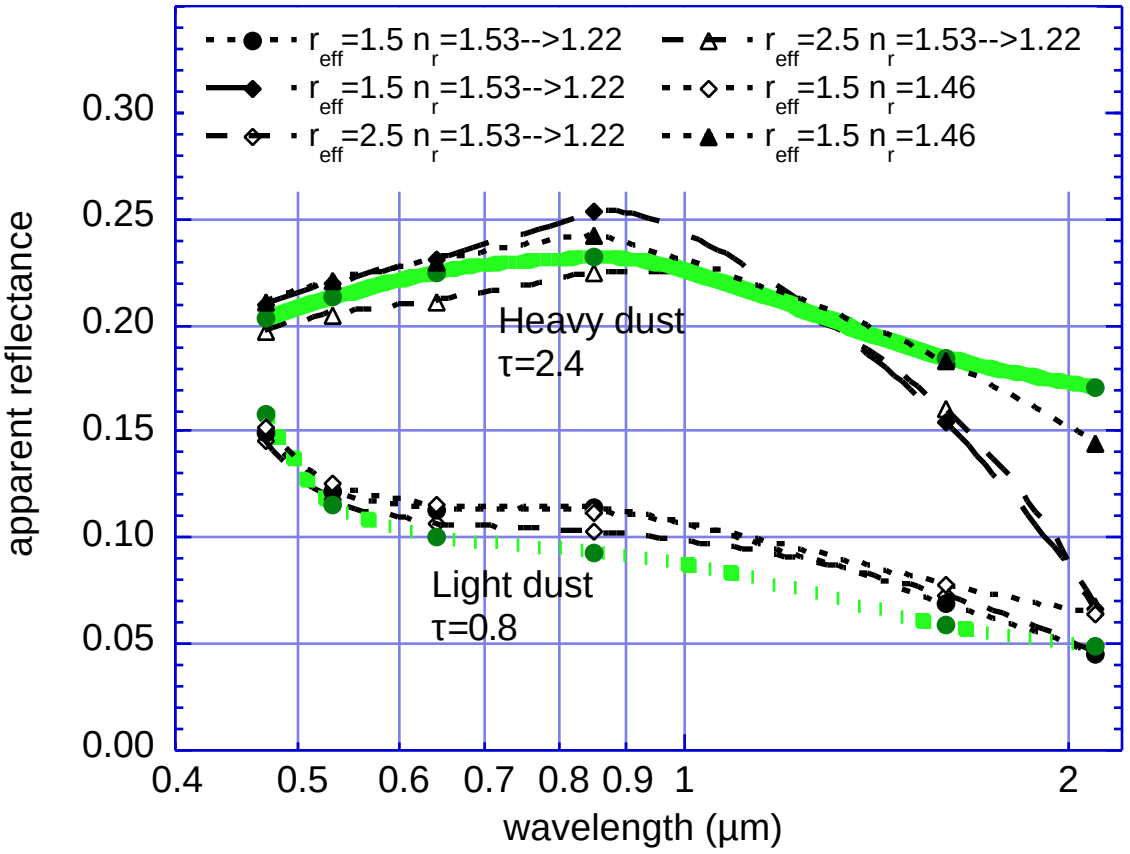

Radiance over desert - influence of dust
Measured from Landsat
heavy dust
τ=2.4
light dust
τ=0.8
apparent reflectance
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.4
0.5
0.6
0.7
0.8
0.9
1
2
Wavelegth (μm)


Radiance over desert - influence of dust
apparent reflectance
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.4
0.5
0.6
0.7
0.8
0.9
1
2
Wavelegth (µm)
heavy dust
τ=2.4
light dust
τ=0.8
Calculations:
τ=2.4, r_eff=2.5 µm, n_i= -0.004
τ=2.4, r_eff=2.5 µm, n_i= -0.001
τ=2.4, r_eff=1.5 µm, n_i= -0.001


Derived single scattering albedo
Single scattering albedo
1
0.9
0.8
0.7
0.6
0.4
0.5
0.6
0.7
0.8
0.9
1
2
wavelength (µm)
San Nicholas
Landsat r eff =1.5 µm
Landsat r eff =2.5 µm


Derived single scattering albedo
Single scattering albedo
wavelength (μm)
1
0.9
0.8
0.7
0.6
0.4
0.5
0.6
0.7
0.8
0.9
1
2
F
S
SG
T(2μm)
T(1μm)
C
W
San Nicholas
Landsat r eff =1.5 μm
Landsat r eff =2.5 μm


Data over ocean - closure
apparent reflectance
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.4
0.5
0.6
0.7
0.8
0.9
1
2
wavelength (μm)
Heavy dust
τ=2.4
Light dust
τ=0.8


r_eff=1.5 n_r=1.53-->1.22
r_eff=2.5 n_r=1.53-->1.22
r_eff=1.5 n_r=1.53-->1.22
r_eff=1.5 n_r=1.46
r_eff=2.5 n_r=1.53-->1.22
r_eff=1.5 n_r=1.46
apparent reflectance
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Heavy dust
τ=2.4
Light dust
τ=0.8
0.4
0.5
0.6
0.7
0.8
0.9
1
2
wavelength (μm)

Conclusions

- **Combination of MODIS spectral remote sensing with AERONET sun/sky radiation is a power tool that can generate new products - to narrow the uncertainty in climate forcing**

- **In some cases we can derive single scattering, ω_o, within $\Delta\omega_o=\pm0.005$. In general $\Delta\omega_o=\pm0.02$**

Plans for the near future

- **Evaluate the possibility of adding direct radiative forcing as a MODIS product - Compare accuracy to that of τ.**
- **Generate a level 3 product of the single scattering albedo for λ and locations with bright surfaces and for τ > 0.4 - How accurately can we derive it ?**
- **Add in level 3 other procedures that may derive more accurately the change in the optical thickness**
- **Use {MODIS/Landsat + AERONET} to derive the effect of particle nonsphericity on remote sensing, atmospheric correction and climate forcing.**