Increase of the satellite retrieved aerosol optical depth due to the enhanced illumination of *cloud-free* areas in the vicinity of clouds

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Thanks to:

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How do clouds affect aerosol retrieval?

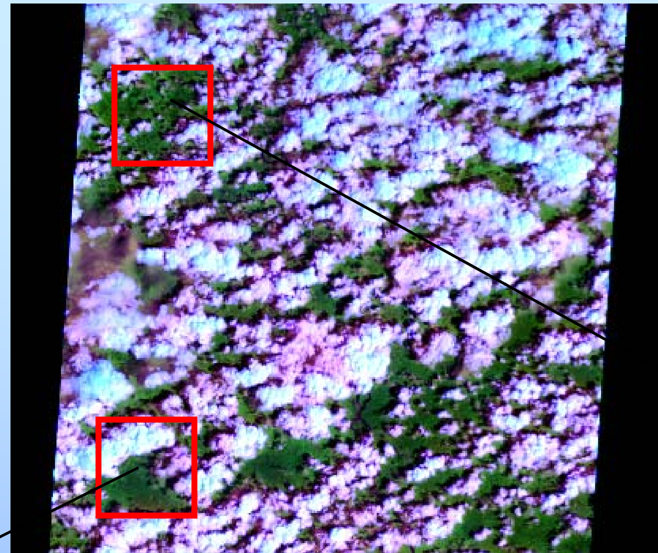
clouds are complex and "satellite analysis may be affected by potential cloud artifacts" (Kaufman and Koren, 2006);

Both
- cloud contamination (sub-pixel clouds)
- cloud adjacency effect (a clear pixel with in the vicinity of clouds)

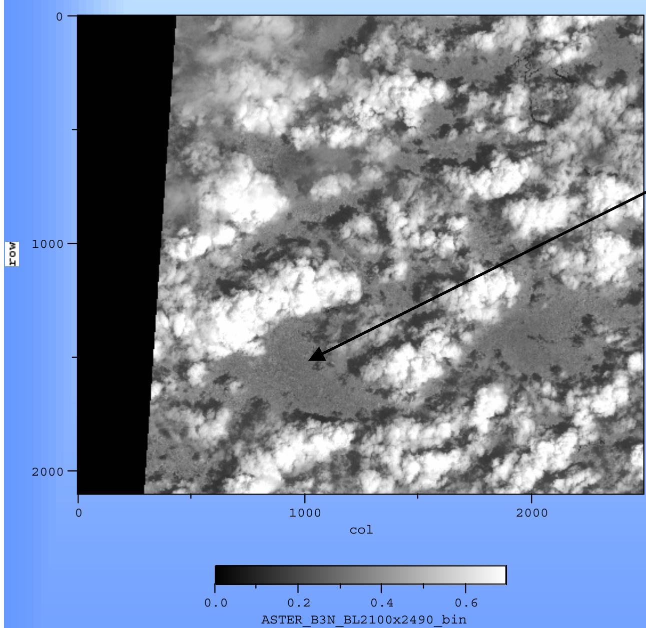
may significantly overestimate AOT.

But they have different effects on the retrieved AOT: while cloud contamination increases "coarse" mode, cloud adjacency effect increases "fine" mode.

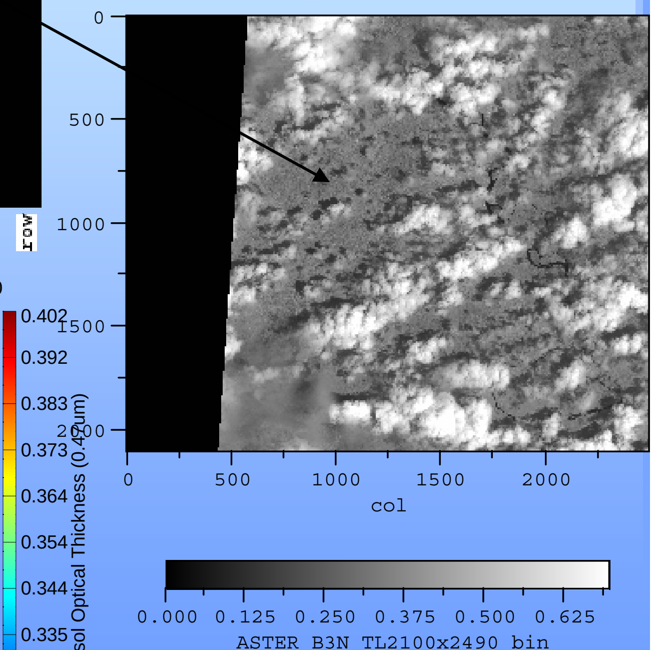
Aerosol-cloud photon interaction

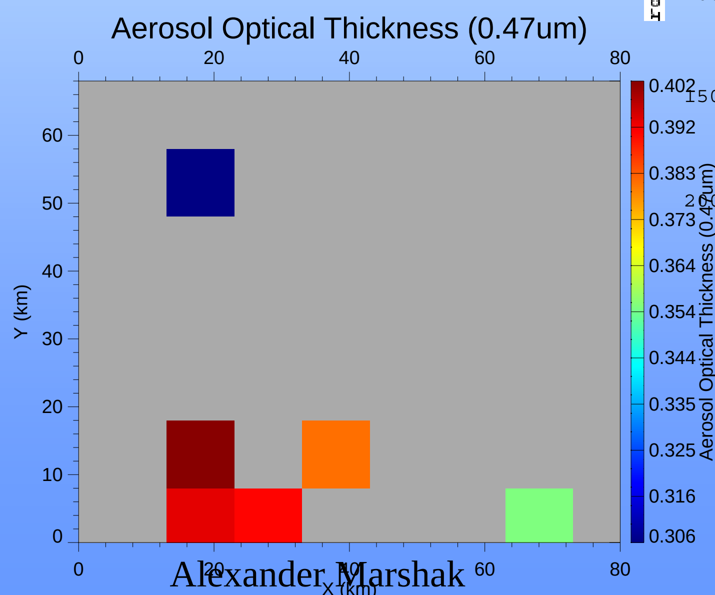


Thick clouds



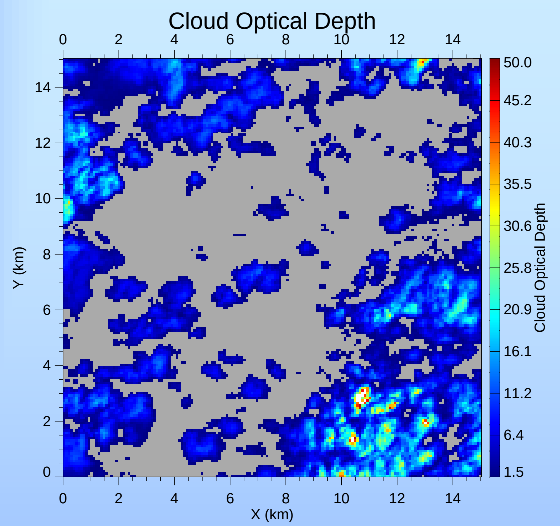
Thin clouds



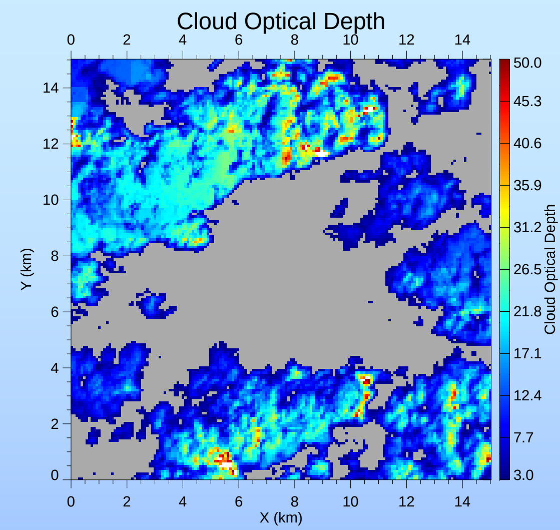


Aerosol-cloud radiative interaction

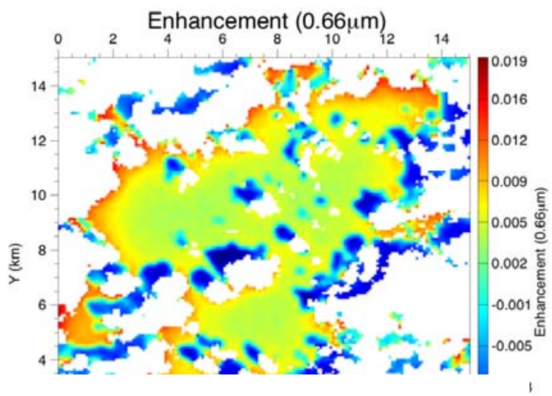
Thin clouds, <τ>=7



Thick clouds, <τ>=15



$AOT_{0.66}$=0.1

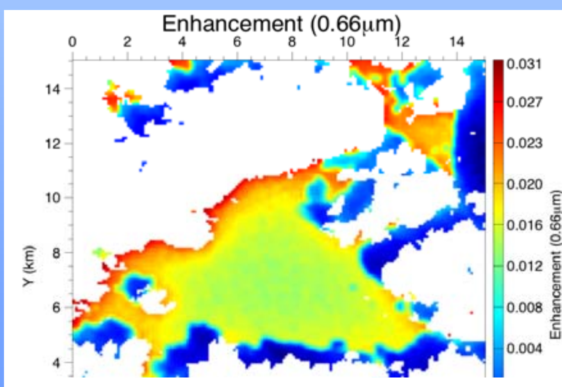


$\Delta\rho$ ~ 0.004

$\Delta\tau$ ~0.04 or ~40%

enhancement:

$\Delta\rho = \rho_{3D} - \rho_{1D}$



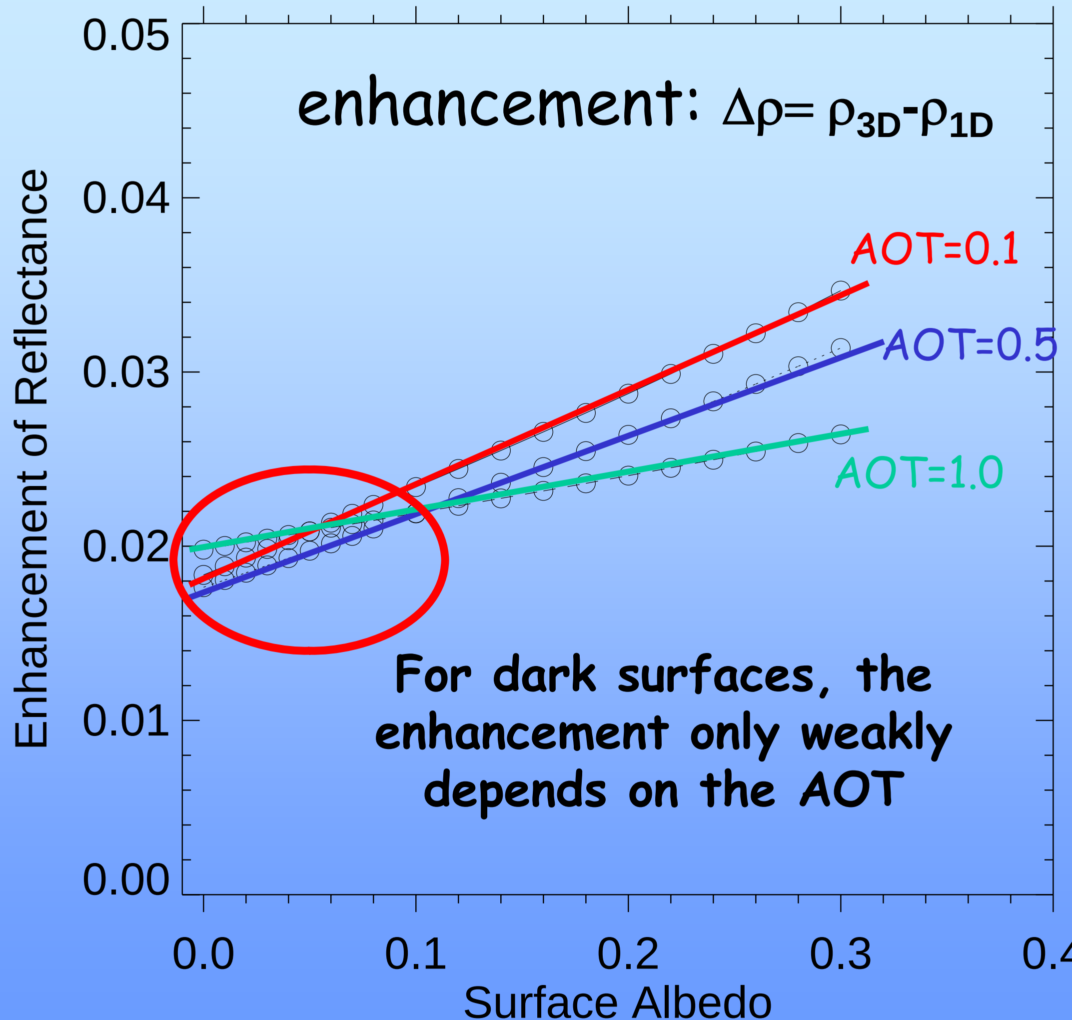
$\Delta\rho$ ~ 0.014

$\Delta\tau$ ~0.14 or ~140%

from Wen et al. 2007

Contributors to the cloud enhancement

- Rayleigh scattering
- Aerosols
- Surface reflectance



If Rayleigh scattering is the main source for the enhancement in the vicinity of clouds then

we retrieve larger AOT
and, namely,
the “fine” mode fraction

However, it is not clear yet how much the observed aerosol grows (in the vicinity of clouds) comes from

- the 3D cloud effects in the retrievals
- real physics (e.g., humidification)

Enhancement of radiance near clouds

the twilight zone

Cumulus clouds over Atlantics

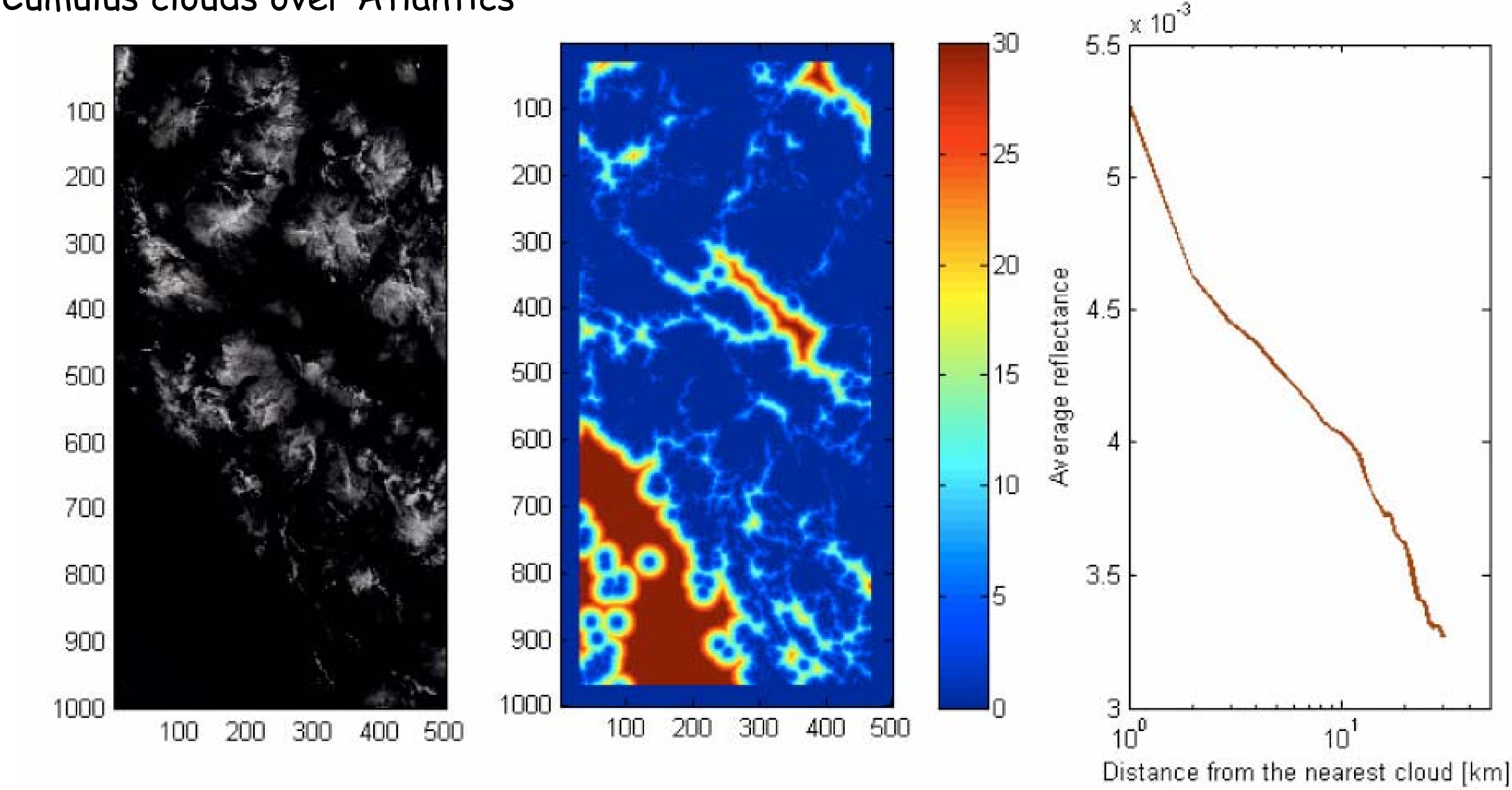
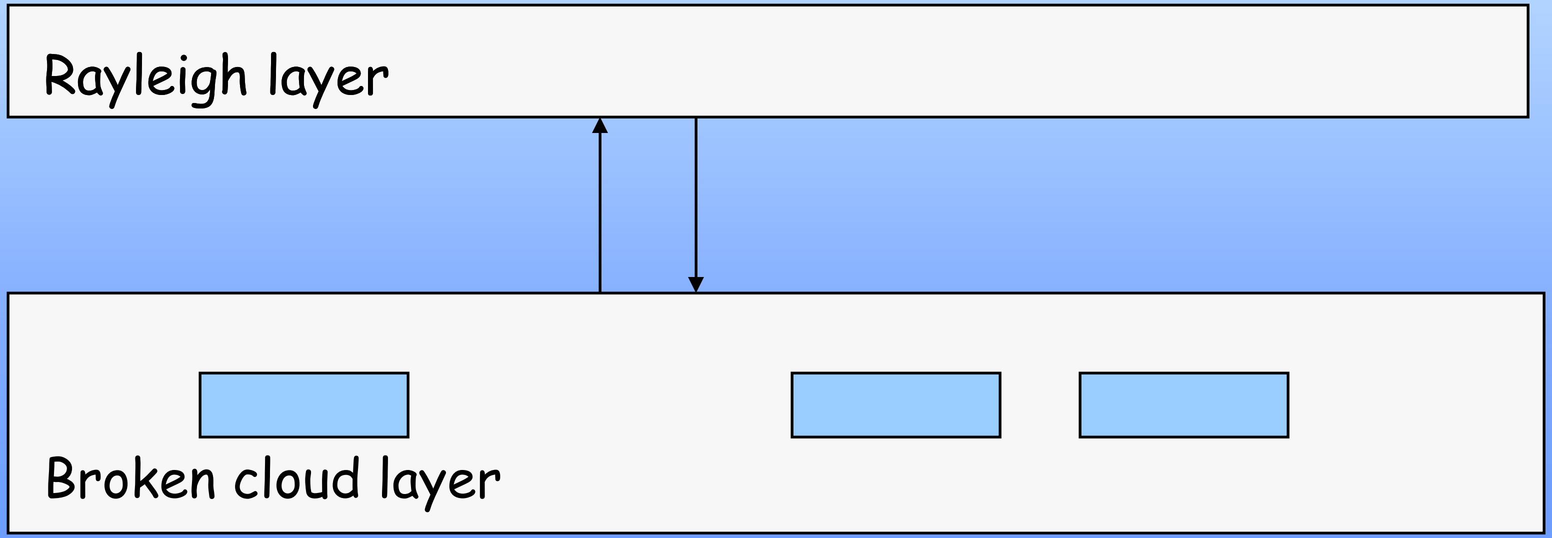


Fig. 2 from Koren et al., GRL (in press)

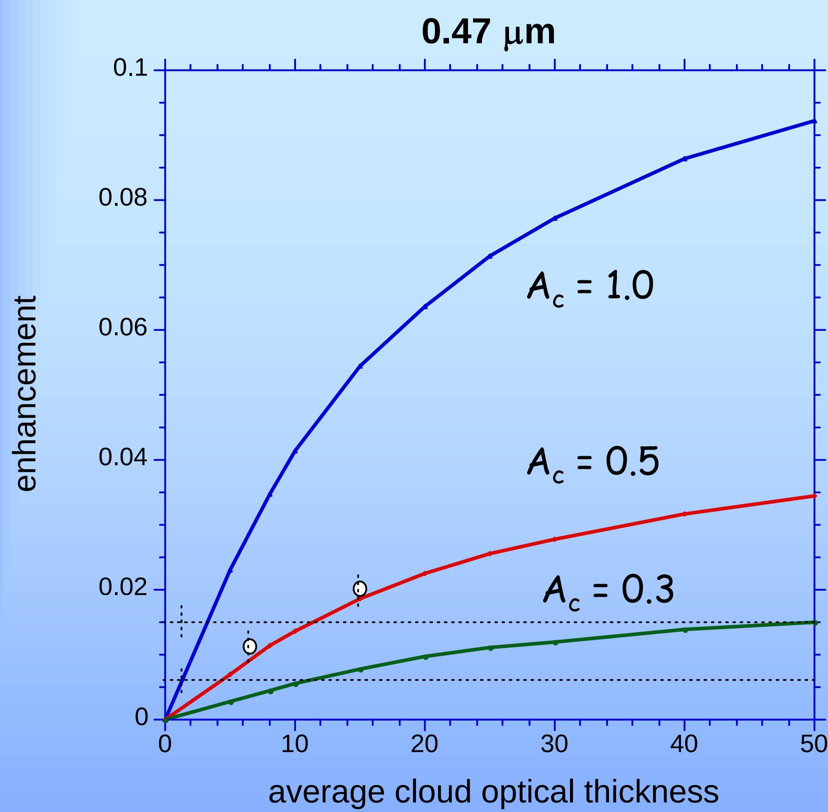
How to (realistically) remove the 3D cloud effect on aerosols?

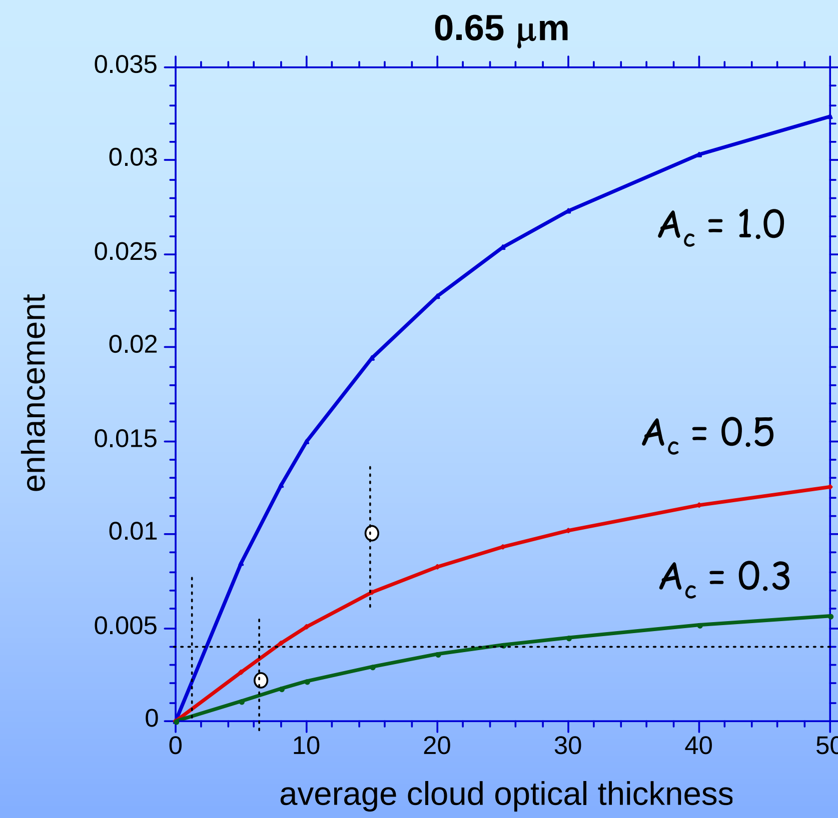
The enhancement is defined as the difference between the two radiances:

- one is reflected from a broken cloud field with the scattering Rayleigh layer above it
- and one is reflected from the same broken cloud field but with the Rayleigh layer having extinction but no scattering



Enhancement (θ_0=60°, θ_v=0°)

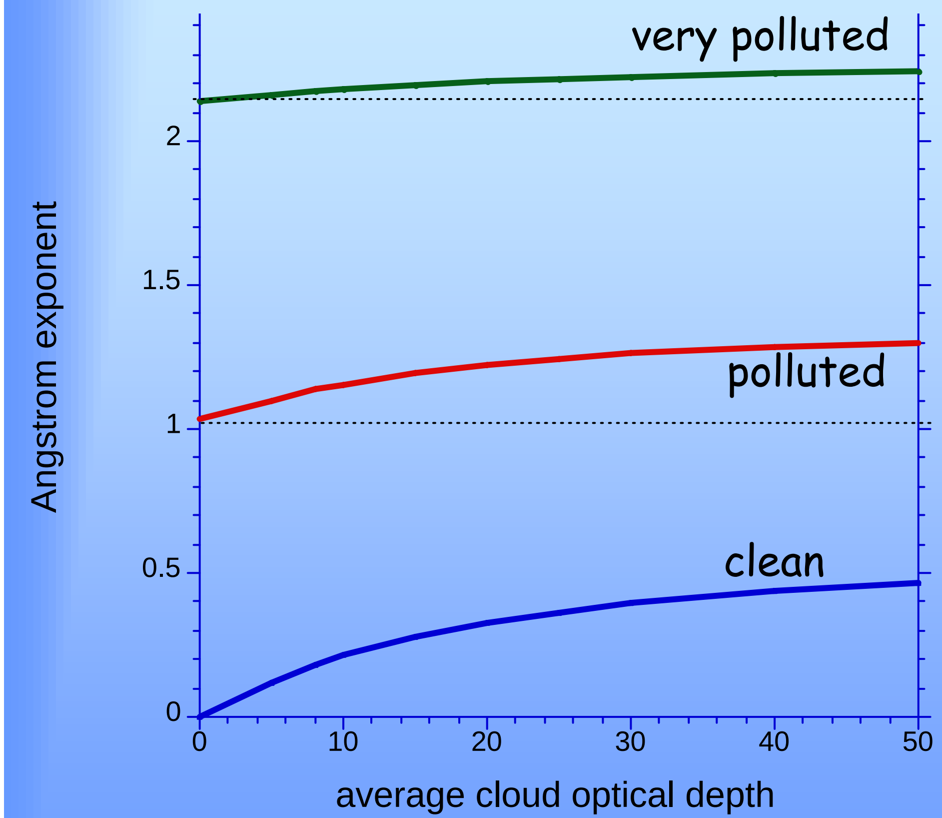




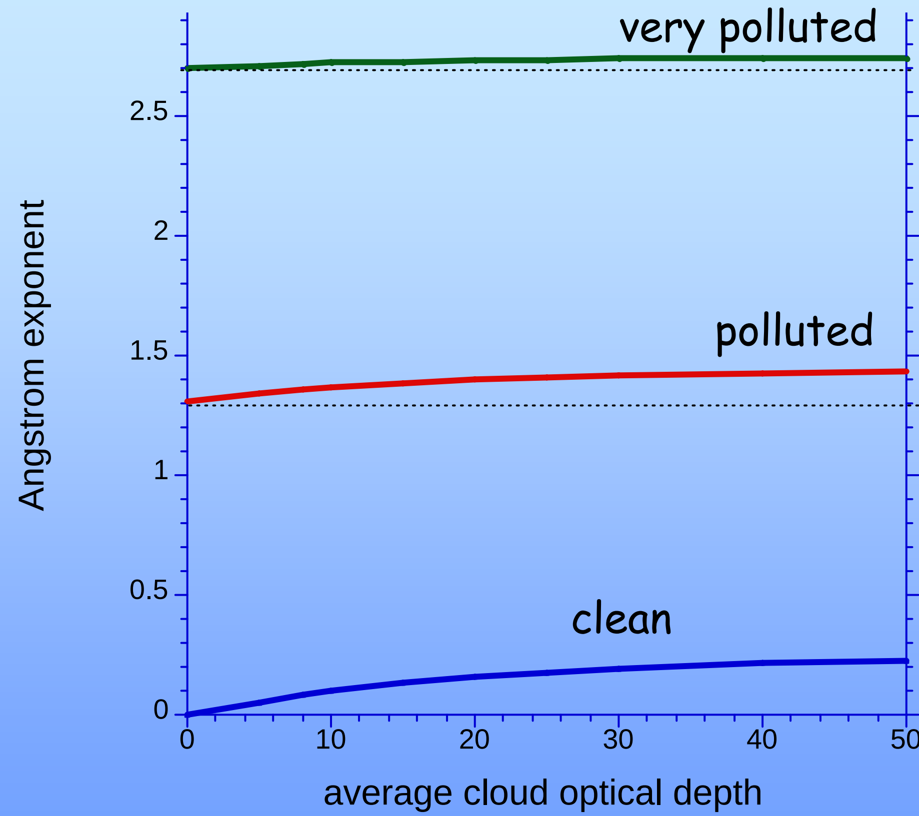
The enhancement vs $\langle\tau\rangle$ for three A_c=1.0, 0.5 and 0.3; A_c=1 corresponds to the pp approximation. Dots (correspond to the thin and thick clouds) and dash lines (correspond to the two Brazilian scenes) are from the Wen et al. (2007) MC calculations.

Angstrom exponent

0.47 μm vs 0.65 μm



0.65 μm vs 0.84 μm



Three cases: clean, polluted and very polluted.

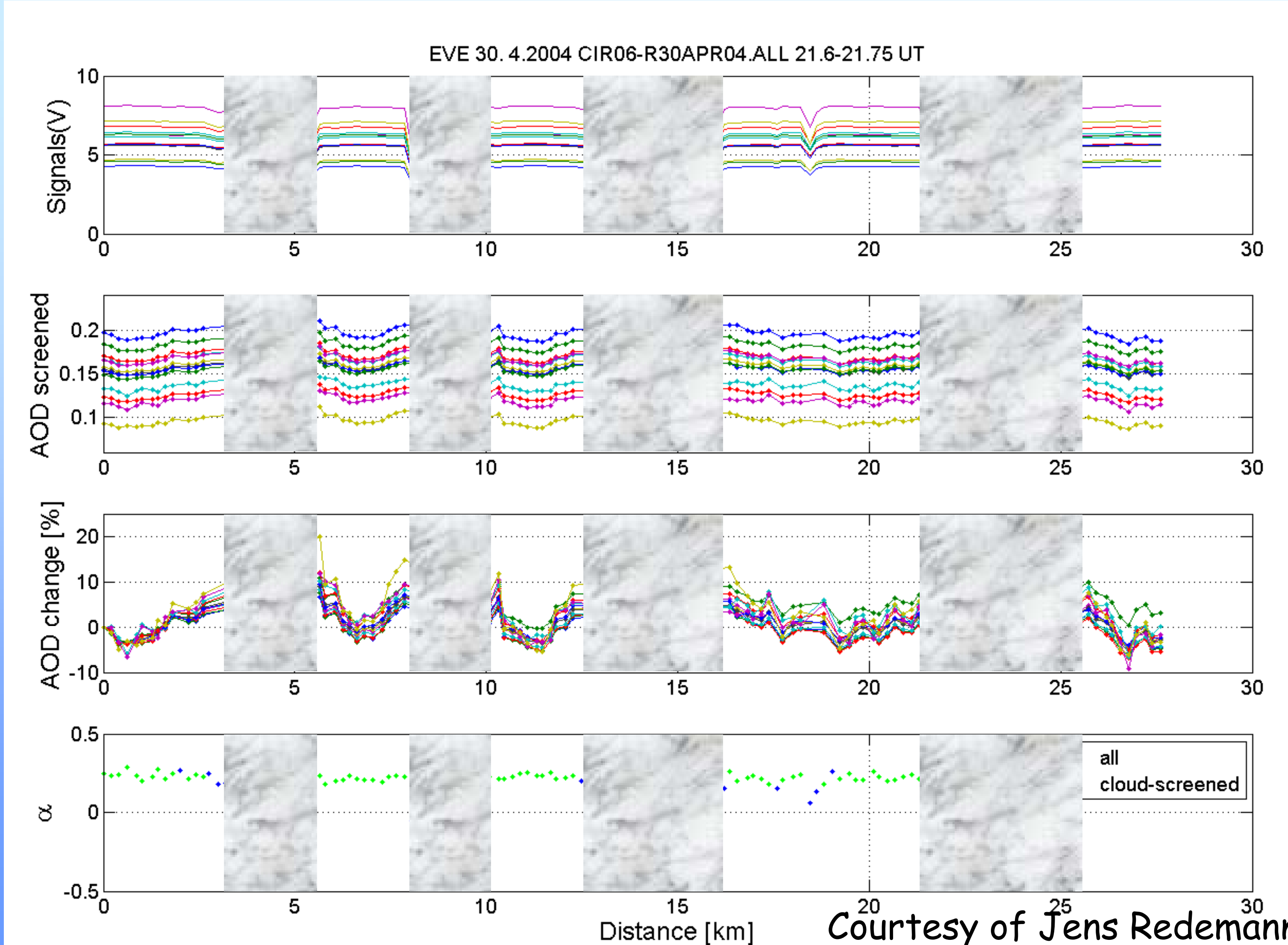
Conclusions

• 3D cloud enhancement only weakly depends on AOT; molecular scatt. is the key source for the enhancement;

• The enhancement increases the fraction of fine aerosol mode;

• Retrieved AOT *can* be corrected for the 3D radiative effects;

Airborne aerosol observations in the vicinity of clouds

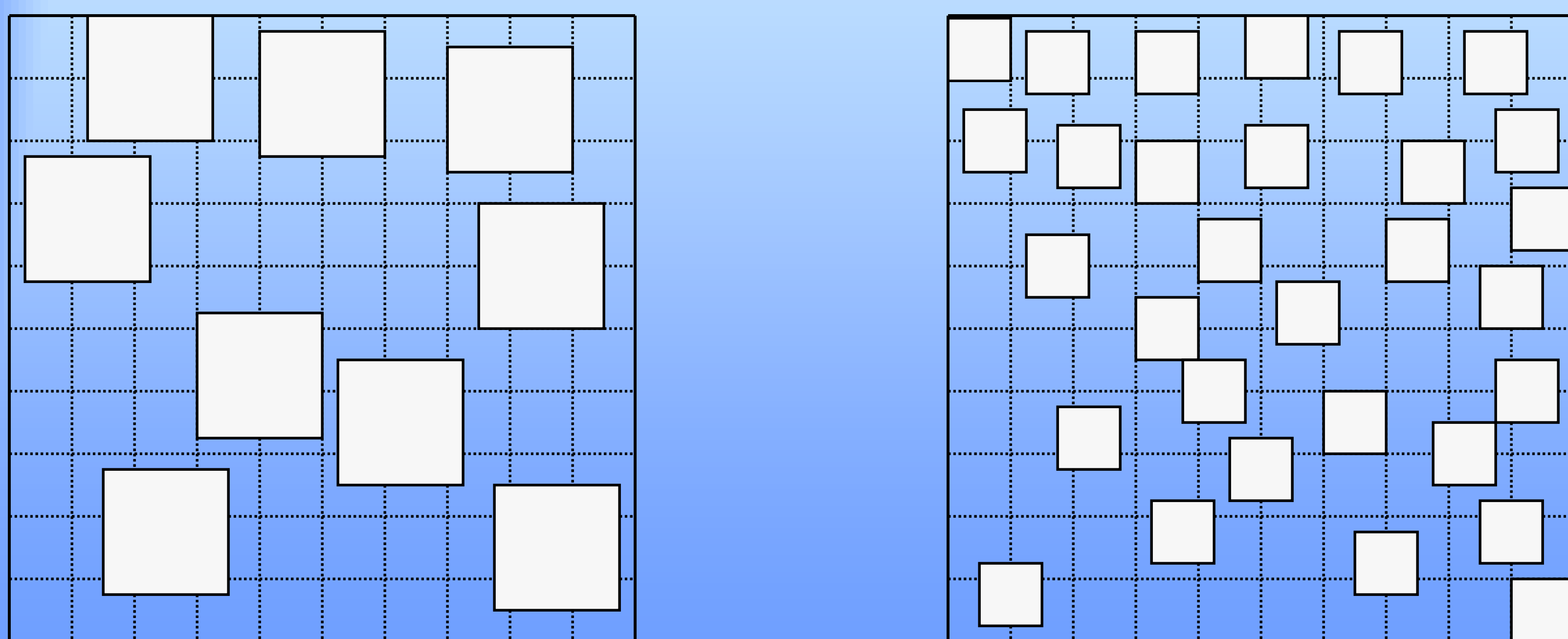


Courtesy of Jens Redemann

Stochastic model of a broken cloud field

Clouds follow the Poisson distr. and are defined by

- average optical depth, $\langle\tau\rangle$
- cloud fraction, A_c
- aspect ratio, AR = hor./vert.



AR = 2 A_c = 0.3 AR = 1