Solar radiative effects of non-spherical mineral dust particles during SAMUM 2006

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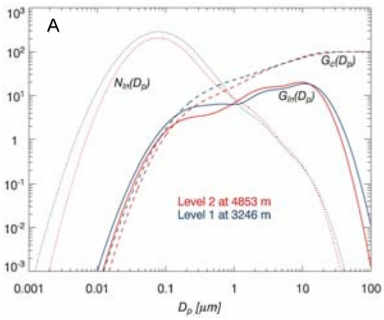
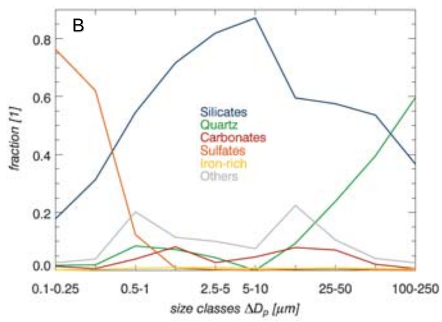
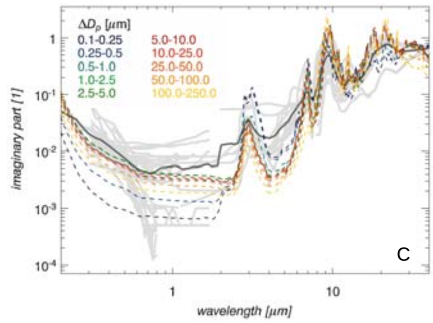
Measurements within Saharan mineral dust plumes during SAMUM-1 in Morocco 2006

- Environmental conditions: temperature, pressure, relative humidity profiles
- Number size distribution $N_{ln}(D_p)$ of the Saharan mineral dust (Weinzierl et al., 2009; A) to calculate the cross section size distribution $G_{ln}(D_p)$ and the cumulative cross section distribution $G_c(D_p)$: high fraction of coarse particles which have a large optical impact (e.g. Otto et al., 2007)
- Chemical composition of the airborne dust particle ensemble (Kandler et al., 2009; B) to derive the size-resolved complex refractive index (C, colored) using literature data for the individual component classes of mineral dust silicates, quartz, carbonates, sulfates, iron rich material:

  λ = 550 nm: real part 1.51-1.55, imaginary part 0.0008-0.006 depending of particle size
- Extinction coefficient at 532 nm applying the air-based lidar HSRL (Esselborn et al., 2009) and the ground-based BERTHA (Tesche et al., 2009)
- Spectral surface albedo and upwelling as well as downwelling irradiances (Bierwirth et al., 2009)

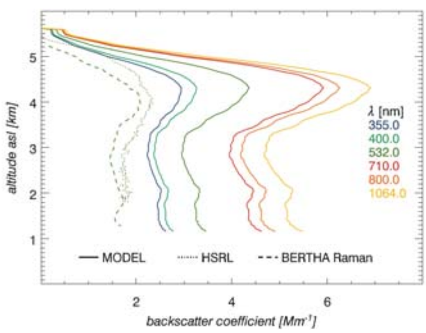


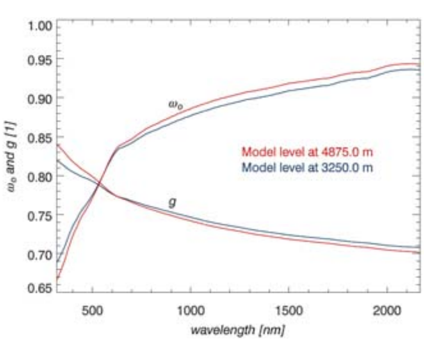




Optical properties of spherical dust particles

- Assumed spherical particles (MODEL) cannot explain the measured lidar backscatter coefficient (HSRL, BERTHA)
- Dust particles were of non-spherical shape resulting in enhanced backscattering



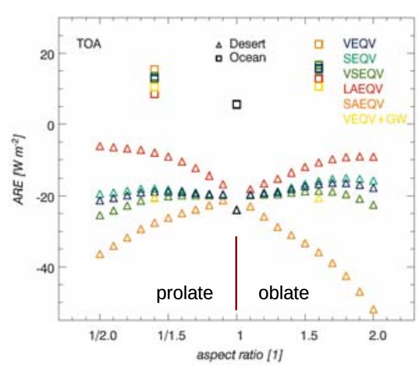


- Single scattering albedo of 0.8 at 550 nm due to the presence of coarse particles which have a relatively high imaginary part compared with smaller particles
- Asymmetry parameter of 0.8 at 550 nm is increased by the large particles, too

Radiative effects of spheriodal dust particles

- Spheroidal model particles assuming various cases of interpreting „size" D_p in the measured size distributions: volume, surface, volume-to-surface, longest axis and shortest axis equivalence; considering fixed particle aspect ratios
- Non-spherical particle effects on ω_o and g with up to ± 1 % and 4 % for realistic cases of VEQV, SEQV and VSEQV; non-sphericity effects on the optical depths up to 40 % depending on size eqivalence (SE) and aspect ratio (AR)
- Lidar and sun photometer measurements were used to estimate the most representative SE and particle shape: volume equivalent oblate spheroids with an AR of 1.6 which was also found by single particle analyses using a scanning electron microscope (Kandler et al., 2009)

- Simulation of the atmospheric radiative effect (ARE) at TOA within the solar spectral range as a function of AR
- ARE strongly dependent on SE
- Dust leads to *cooling over ocean* or *warming over desert*
- Non-sphericity causes always cooling due to backscattering: ARE increases by ~ 30 % over desert and ~ 170 % over ocean
- Details: see Otto et al. (2009)



References:

Bierwirth et al., Spectral surface albedo over Morocco and its impact on the radiative forcing of Saharan dust, Tellus, 61B, 2009, accepted.
Esselborn et al., Spatial distribution and optical properties of Saharan dust observed by airborne high spectral resolution lidar during SAMUM 2006, Tellus, 61B, 2009, accepted.
Kandler et al., Size distribution, mass concentration, chemical and mineralogical composition, and derived optical parameters of the boundary layer aerosol at Tinfou, Morocco, during SAMUM 2006, Tellus, 61B, 2009, accepted.
Otto et al., Atmospheric radiative effects of an in situ measured Saharan dust plume and the role of large particles, Atmos. Chem. Phys., 7, 4887-4903, 2007.
Otto et al., Solar radiative effects of a Saharan dust plume observed during SAMUM assuming spheroidal model particlesTellus, 61B, 2009, accepted.
Tesche et al., Vertical profiling of Saharan dust with Raman lidars and airborne HSRL in southern Morocco during SAMUM, Tellus, 61B, 2009, accepted.
Weinzierl et al., Airborne measurements of dust layer properties, particle size distribution and mixing state of Saharan dust during SAMUM 2006, Tellus, 61B, 2009, accepted.