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Model study on effect of hematite and goethite on optical properties of inhomogeneous desert dust aerosols

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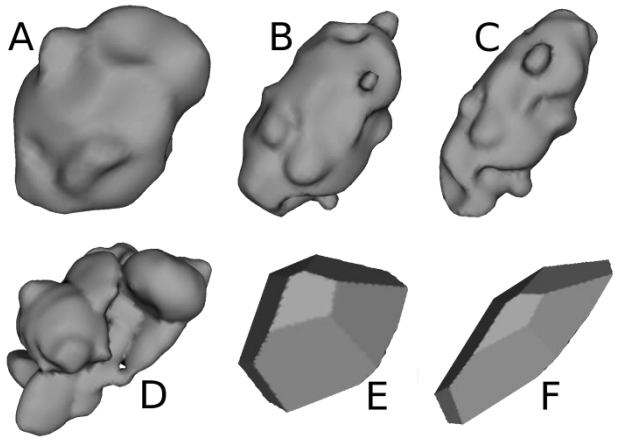
Overview

- **Optical models** usually **assume homogeneous** desert dust particles [1].
- However: **Real dust** particles are **inhomogeneous** consisting of different minerals and **light scattering and absorption** is affected by the inhomogeneity.
- **Hematite and goethite** content controls **light scattering and absorption by desert dust**.

This model-based sensitivity study investigates **effects of the inhomogenous distribution** of hematite and goethite within dust particles **on light scattering and absorption**. First results are shown here.

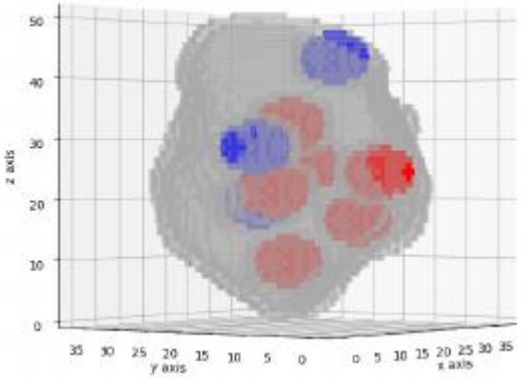
[1] Exception, e.g., https://doi.org/10.5194/acp-15-12011-2015 (Kemppinen et al., 2015)

The model simulations of this study are part of the master thesis of Andreas Gattringer.



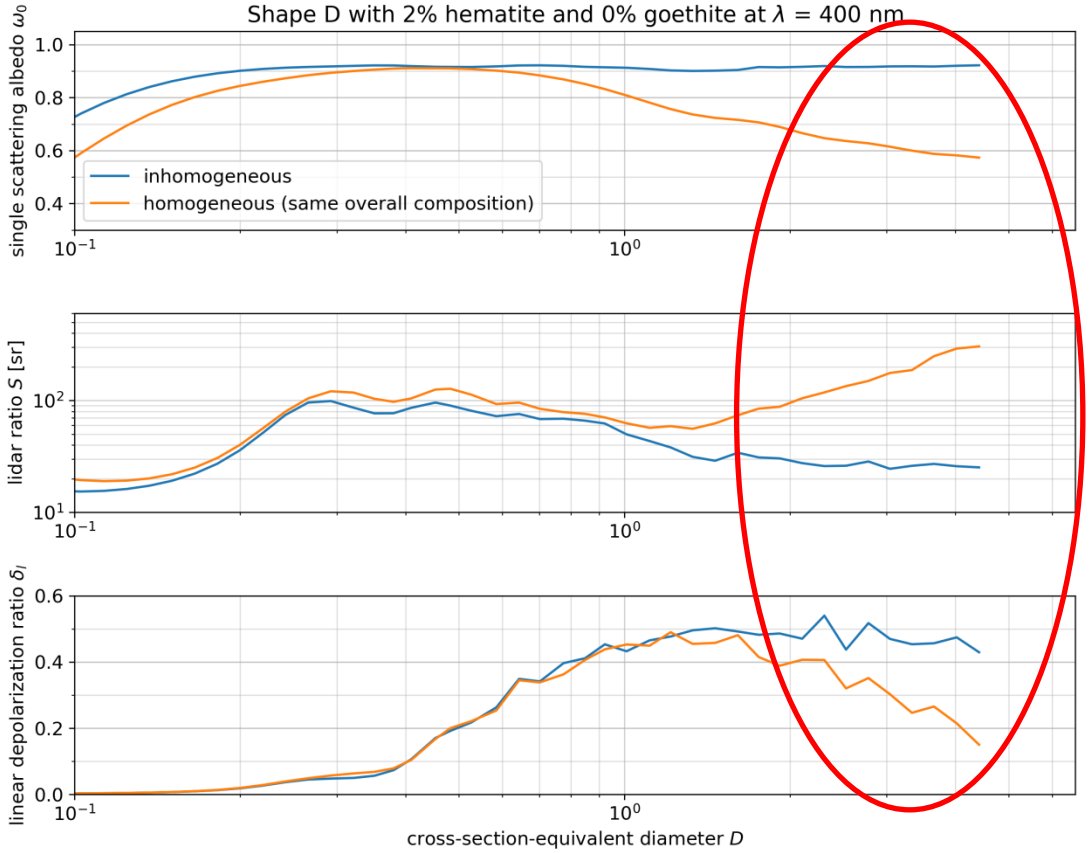
Model simulations

- Discrete dipole approximation code **ADDA** [1]
- **Six irregular dust-like** model shapes from MOPSMAP data set [2]
- **Size parameter range** from 0.001 to 30.2
- Inhomogeneity considered with varying number of **goethite and hematite inclusions** within irregular shapes
- **Non-absorbing base material**
- **Goethite and hematite refractive index representative for visible wavelengths**
- For comparison: Homogeneous particles



[1] https://github.com/adda-team/adda ; [2] https://mopsmap.net

Results: example at short wavelength (2% hematite)



Significant effect of (in)homogeneity for coarse mode dust

Single scattering albedo
(= scattering/extinction)

Lidar ratio
(= extinction/backscattering)

Linear depolarization ratio
(≈ how much backscattered light looses original polarization)

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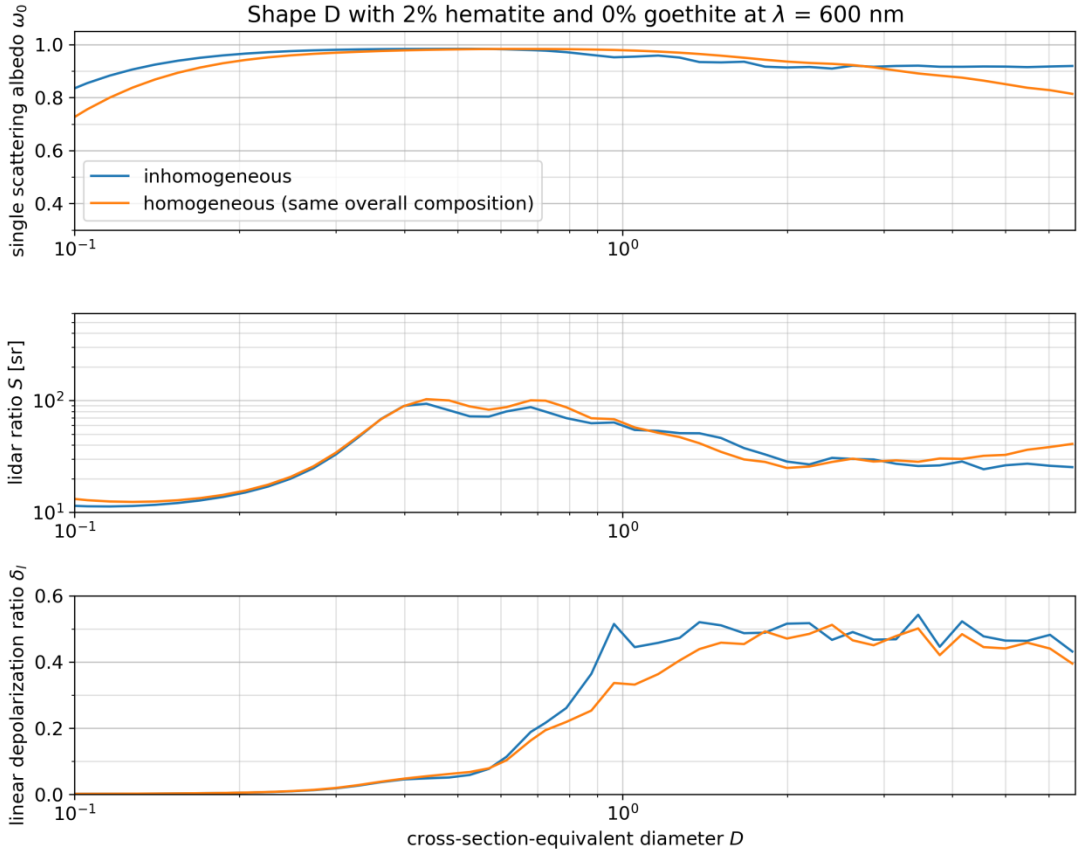
Results: example at short wavelength (2% hematite)

Log-normal distribution with D_{mod} = 1.0 µm, σ = 2.0, D_{max} = 4.0 µm, D_{eff} = 2.13 µm, shape D, and wavelength 400 nm

Optical parameter	Inhomogeneous dust	Homogeneous dust	Δ
Extinction [arb. unit]	352	350	- 0.6%
Single scattering albedo	0.922	0.696	**- 0.226**
Asymmetry parameter	0.670	0.800	**+ 0.130**
Lidar ratio [sr]	30.2	96.1	**x 3,18**
Linear depolarization	0.483	0.397	- 0.086

Almost four times more absorption!

Results: example at longer wavelength (2% hematite)



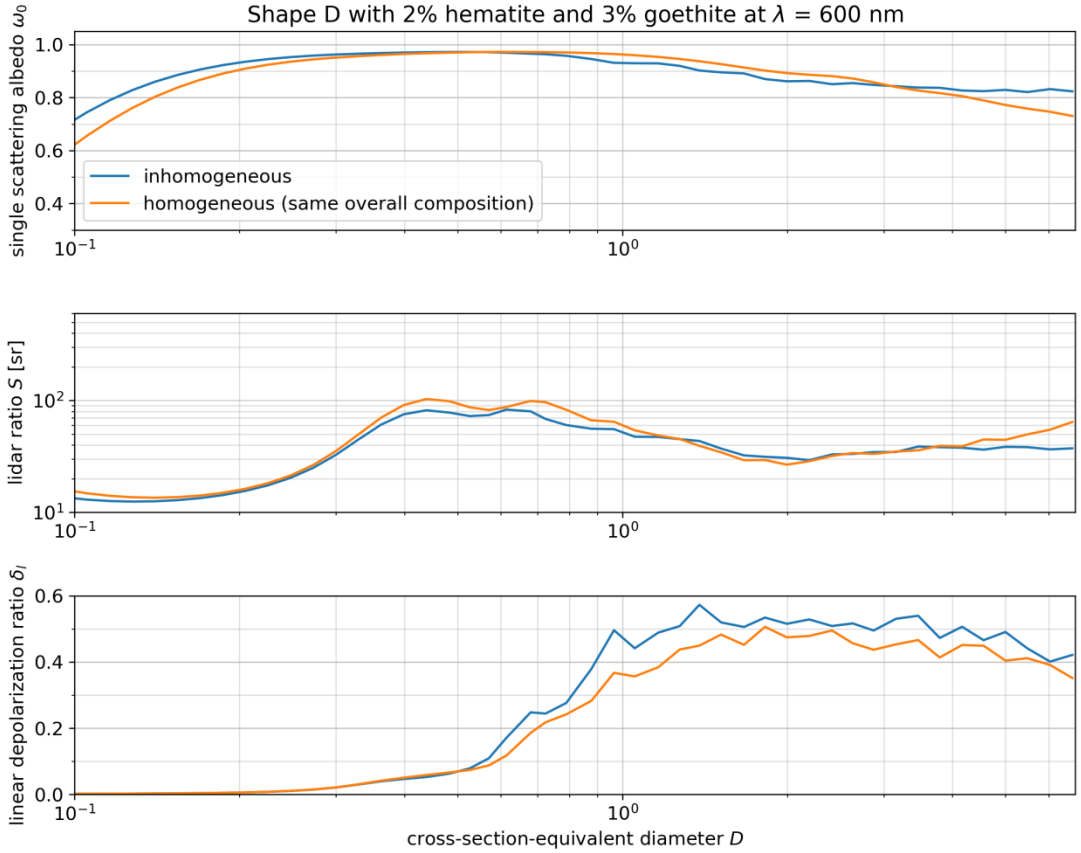
At λ = 600nm much weaker effect of (in)homogeneity for coarse mode dust

Single scattering albedo
(= scattering/extinction)

Lidar ratio
(= extinction/backscattering)

Linear depolarization ratio
(≈ how much backscattered light looses original polarization)

Results: example at longer wavelength (2% hematite and additional 3% goethite)



Again weaker effect of (in)homogeneity for coarse mode dust

Single scattering albedo
(= scattering/extinction)

Lidar ratio
(= extinction/backscattering)

Linear depolarization ratio
(≈ how much backscattered light looses original polarization)

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Summary / outlook

- Ongoing sensitivity study investigating effect of dust inhomogeneity on optical dust properties
- **Inhomogeneity effect seems particularly strong for absorption and lidar-relevant properties of coarse dust particles at short visible and UV wavelengths.** *At these wavelengths hematite has a very high imaginary part of the refractive index.*
- Extension of MOPSMAP with inhomogeneous dust envisaged

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Acknowledgements

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