The aerosol model OPAC - contents and new software

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Abstract

OPAC (Optical Properties of Aerosols and Clouds) was published in 1998 as an aerosol and cloud model, consisting of a microphysical description of aerosol, as a combination of variable components, and clouds with different types. All relating optical properties, valid for 8 values of relative humidity, can be extracted from a database of Mie calculations covering the wavelength range from 0.2 to 40 micrometers. The extraction software is part of the package. OPAC has meanwhile been downloaded, and probably used, by several hundred researchers all over the world.

Since 1998, new possibilities have been developed to describe the microphysical properties of particles and their corresponding radiative properties. Therefore, we intend to improve OPAC by introducing, for instance, nonspherical particles, an improved description of humidity effects, and additional aerosol components which may be missing.

As a starting point for these improvements, the original OPAC Fortran77 software has been rewritten completely as an object oriented Python program. We will present the current status and planned future additions, as a basis for discussions about possible needs of the OPAC users.

The OPAC aerosol model

The OPAC model (*Hess et al., 1998*) describes an aerosol as external mixture of aerosol components which are representative of aerosol sources. The components themselves may be internally mixed, i.e. they may consist of a mixture of different chemical substances. Components are characterized by size distribution, refractive index, water uptake and density.

From these data, the optical properties are calculated by Mie Theory. Results are stored for 60 wavelengths between 0.2 µm and 40 µm and for 8 values of relative humidity (0%,50%,70%,80%,90%,95%,98%,99%). The database contains extinction, scattering, and absorption coefficients, single scattering albedo, asymmetry parameter, phasefunction, and refractive index.

Several typical mixtures of these aerosol components are also provided. They are characterized by the mixing ratio of the components, the total number density, and a description of a corresponding height profile of the extinction coefficient with up to 4 distinct layers, for optical depth calculations. Optical properties of mixtures are not part of the database but may be calculated using the appendant software.

In addition, the OPAC software allows to define arbitrary mixtures of all available components, and to extract the corresponding optical properties.

Fig. 1 shows the size distributions of all aerosol components in OPAC and Fig. 2 shows the corresponding refractive indices. As an example of the resulting optical properties, the extinction coefficient of all predefined OPAC aerosol mixtures at a relative humidity of 70% is shown in Fig. 3.

Fig. 1: Size distributions of all OPAC aerosol components at a relative humidity of 0%. Water soluble, sea salt, and sulfate grow with increasing rel. humidity. The growth is modelled by a constant shift of the whole distribution.

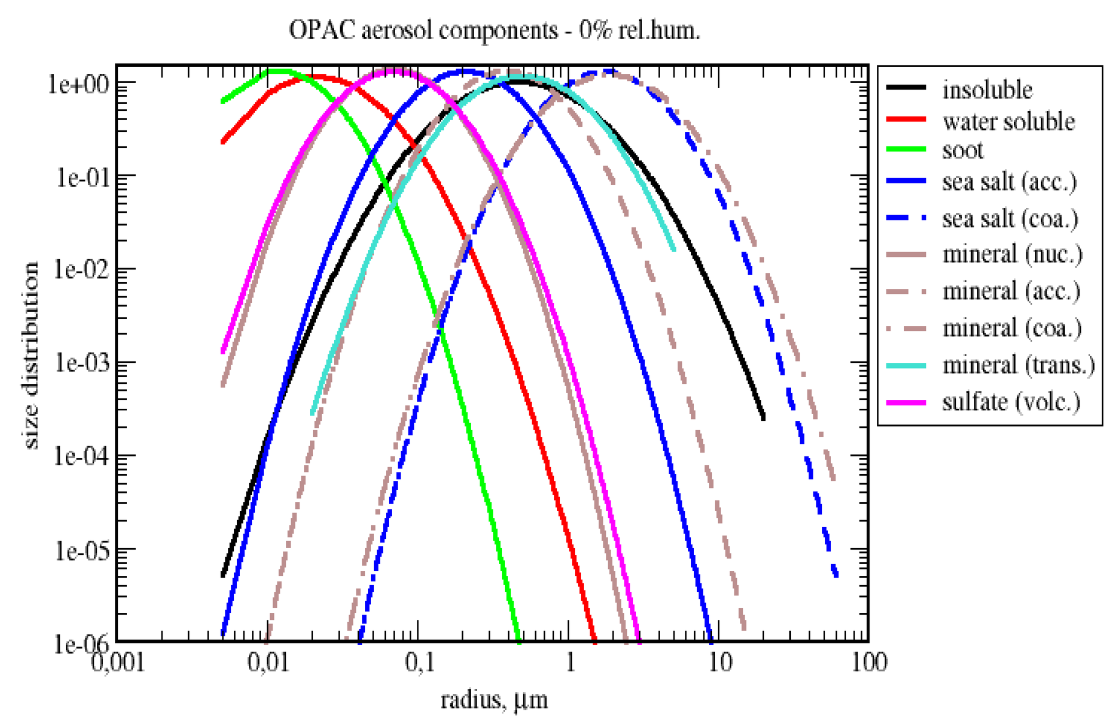


Fig. 2: Refractive indices (imaginary part) of all OPAC aerosol components at a relative humidity of 0%. In case of growth with rel. humidity, the refractive index results from a volume mixing rule with the refractive index of water.

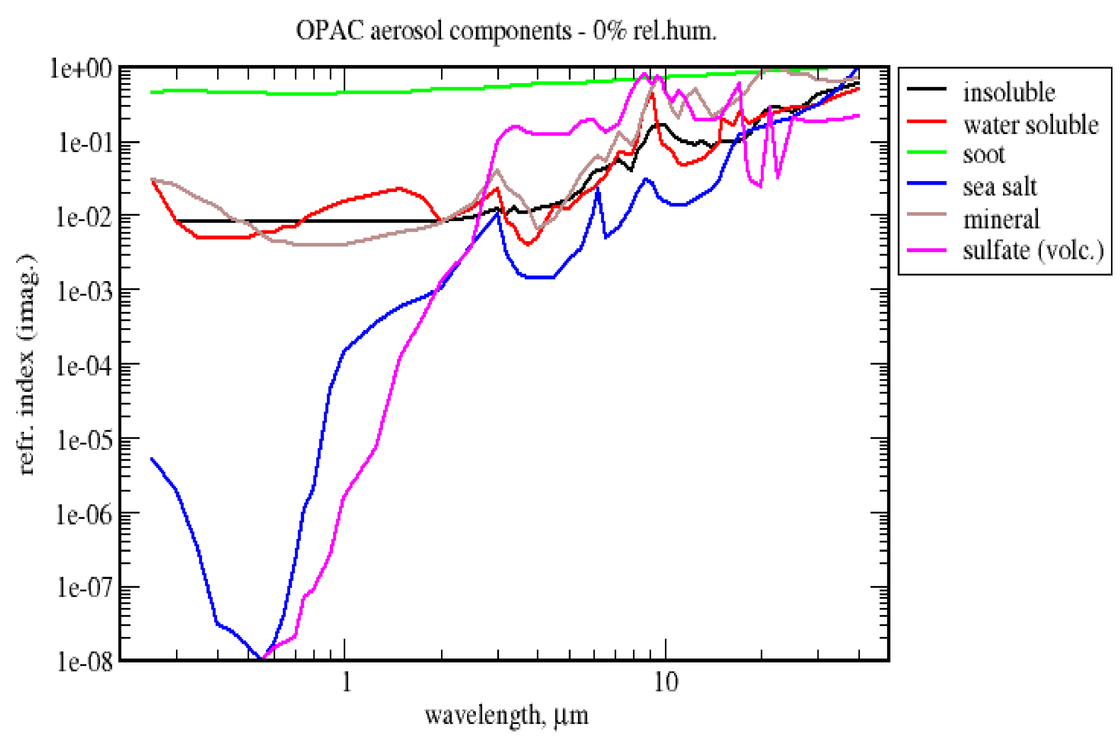
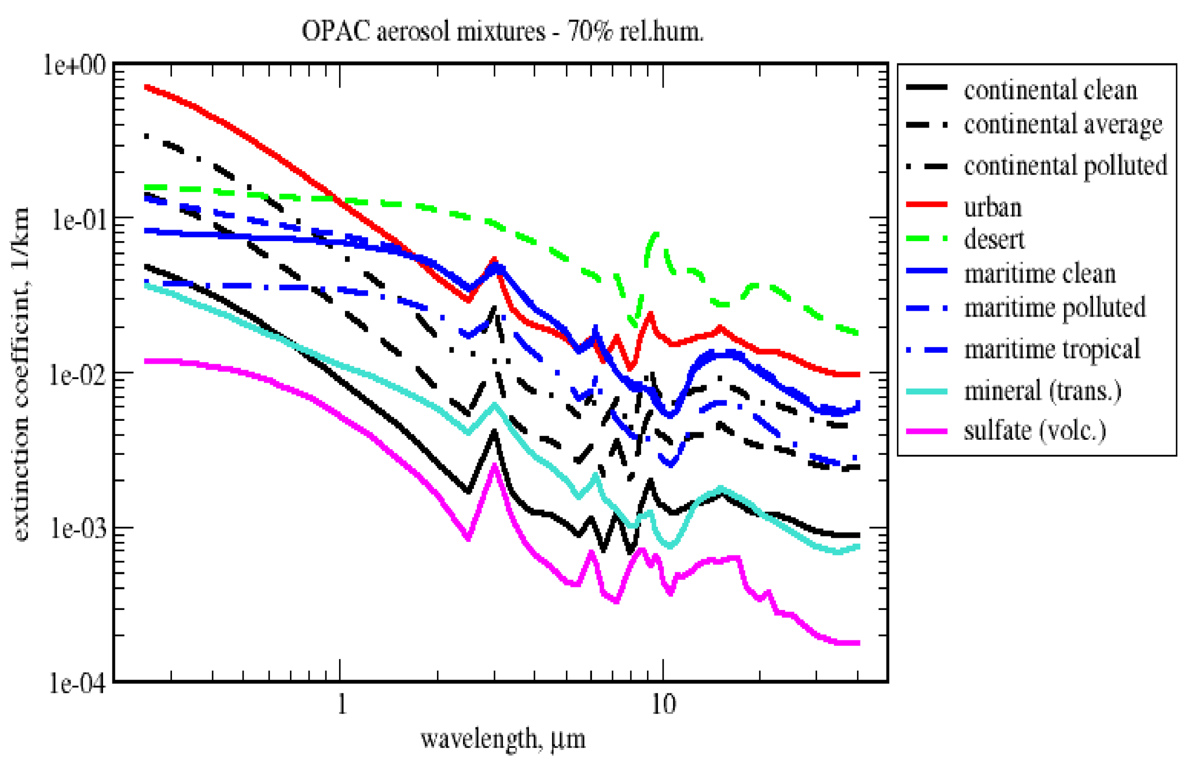


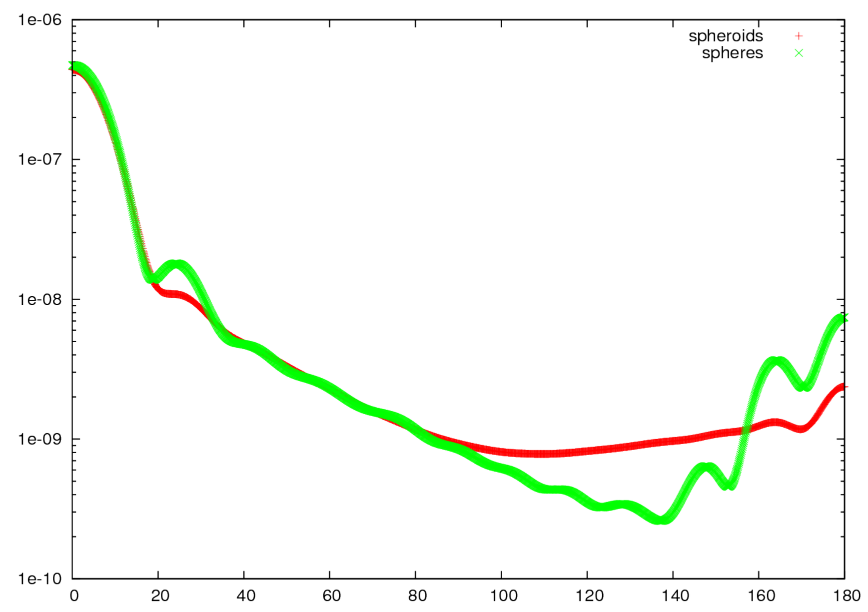
Fig. 3: Extinction coefficients of all predefined OPAC aerosol mixtures at a relative humidity of 70%



Planned improvements of the OPAC aerosol model

Work for the implementation of nonspherical particles for desert aerosol is already in progress: Especially for remote sensing of desert dust, the use of optical properties considering the non-sphericity of particles is essential to consider in the side- and backward scattering direction (*Koepke and Hess, 1988*).

Fig. 4: Differences of the (1,1)-element of the scattering matrix (phase function) between spherical and non-spherical particles (*Wiegner et al., 2009*). Refractive index and aspect ratio distribution (spheroids) are from SAMUM measurements. Main differences occur in the side- and backscatter regions, which are relevant for remote sensing.



The following is a **list of possible improvements**. They are sorted roughly according to importance and feasibility, where feasibility is to a certain degree restricted by available time and funding:

- **non spherical particles:**
  - mineral particles (desert dust)
  - sea salt (dry conditions)
  - volcanic ash
- **additional components:**
  - strongly absorbing mineral
  - organic carbon
  - volcanic ash
- **improved components:**
  - mineral transported
  - sulfate
- **improved optical and microphysical properties:**
  - polarization
  - PM10 and PM2.5
- **improved description of humidity effects**
- **improved spectral refractive indices (e.g. absorption of desert aerosol)**
- **wind speed dependent aerosol amount** (*Koepke et al., 1997*)
  - Desert dust
  - sea salt
- **additional predefined aerosol types:**
  - biomass burning
  - desert dust plus biomass burning
  - coastal city
  - Smog

We appreciate any proposals or hints from the previous and possible future OPAC users for corrections and improvements of the OPAC package.

The new OPAC software

OPAC is completed by software which allows to extract data from the database. Extraction includes calculation of additional optical properties, not stored in the database, or optical properties of predefined or user-defined mixtures.

The additional optical properties are *spectral turbidity factor, lidar ratio, phase function, mass extinction cross section, mass absorption cross section, normalized extinction coefficient, spectrally weighted coefficients, Angstrom coefficients, and visibility.*

The original FORTRAN code is not able to deal with additional components. Neither is the simple exchange of a component easily possible.

Therefore, a new program was written in Python which is able to handle additional aerosol component data, which are not part of the original OPAC model and database, but are stored in an additional data base.

Future extensions to the OPAC software will make OPAC a complete **Tool Package** for the investigation of aerosol radiative properties. The main new features will be:

- Implementation of a Mie code.
  This allows the generation of additional component data, and to compare them directly with the original OPAC.
- Output of a complete set of height dependent optical parameters for use in radiative transfer codes.
  The current version only gives ground based values and calculates the optical depth of mixtures from the included height profiles. The new version will provide a set of the most important optical properties at each desired altitude, if an appropriate aerosol height profile is given.
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References

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Wiegner, M., et al. (2009): *Numerical simulations of optical properties of Saharan dust aerosols with emphasis on lidar applications*, Tellus B, 61, 180-194.

Weblink

OPAC download and description → http://www.rascin.net/en/forum

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