Present archived aerosol data in public spectroscopic database catalogs

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Basic physics

**Observed radiance,** \( R \) (watts / cm\(^2\) ster cm\(^{-1}\))

\[
R = \int B \ e^{-\tau} \ d\tau
\]

*assume no scattering*

\( B \), Planck function

**Optical depth,** \( \tau \)

\[
d\tau = d\tau_{\text{gas}} + \beta \ ds
\]

(for path segment ds, in km)

**Aerosol extinction coefficient,** \( \beta \) (km\(^{-1}\))

\[
\beta = \int Q(\lambda, r, m_{\lambda}) \ \pi \ r^2 \ (dn/dr) \ dr
\]

*extinction cross-section*  
*Mic theory*  
*size distribution*

with

\( \lambda \) = wavelength (\( \mu \)m)

\( m_{\lambda} \) = the complex indices of refraction

\( = n_{\text{real}} - i \ n_{\text{imaginary}} \)

\( dn/dr \) = particles cm\(^{-3}\) \( \mu \)m\(^{-1}\)

Also, scattering \( Q_{\text{scatt}}(\lambda, r, m_{\lambda}) \)

The angular distribution of the scattered light is characterized by a phase function \( p(\lambda, r, m_{\lambda}, \theta) \)
#### Aerosol characteristics

<table>
<thead>
<tr>
<th>Microphysical PROPERTIES</th>
<th>OPTICAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size Distribution</td>
<td>Extinction coefficient</td>
</tr>
<tr>
<td>Refractive index</td>
<td>Scattering coefficient</td>
</tr>
<tr>
<td>Shape</td>
<td>Absorption coefficient</td>
</tr>
</tbody>
</table>

Mie theory assumed (particles as spheres) for aerosol particles and cloud droplets and ice crystals (in the terrestrial spectral range).

Geometric optics in the case of ice crystals (hexagonal columns in the solar spectral range).

Different size distribution function (Gamma, lognormal, analytical) depending on the nature of aerosols (water clouds, cirrus clouds, ....)
GEISA-2001/ Aerosols database contains data on microphysical and optical properties of basic aerosol components.

The following 4 sub-databases are included:

A database on refractive indices of basic atmospheric aerosol components
(Massie, 2001):
- Solid Substances
- Acids
- Water ice
- Water droplets
- Water soluble components
- Thin films

A Database on atmospheric aerosols from LITMS
(Laboratory for Information Technologies and Mathematical Simulation) (Rublev, 1994)

The software package and database OPAC
(Optical Properties of Aerosols and Clouds) (Hess et al., 1998)

The Global Aerosol Data Set: GADS
(Global Aerosol Data Set) (Koepke et al., 1997)
### Basic aerosol acid solution components data files complex refraction indices: m=p-iq

<table>
<thead>
<tr>
<th>Component</th>
<th>Conditions: Solution concentration (%)</th>
<th>p</th>
<th>Wavelength (micron)</th>
<th>q</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂SO₄</td>
<td>57%</td>
<td>0.6114</td>
<td>5000</td>
<td>1.9837</td>
<td>23.1492</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>57%, 64%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.3353</td>
<td>23.1492</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>30%, 37%, 64%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.3337</td>
<td>23.1492</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>30%, 45%, 57%, 64%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.3237</td>
<td>23.1492</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>30%, 45%, 57%, 60%, 64%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.3067</td>
<td>23.1492</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>70%, 75%, 80%</td>
<td>0.6114</td>
<td>5000</td>
<td>1.9887</td>
<td>23.1492</td>
</tr>
</tbody>
</table>

**Column 1**: component identifications  
**Column 2**: conditions (solution concentration/temperature)  
**Columns 3 to 6**: available wavelength spectral range  
**Column 7**: references
<table>
<thead>
<tr>
<th>Component</th>
<th>Solution</th>
<th>Conditions</th>
<th>Available Wavelength Spectral Range</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂SO₄</td>
<td>40%, 50%, 60%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.3113</td>
</tr>
<tr>
<td></td>
<td>T=223 K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>30%, 40%, 50%, 60%, 70%, 80%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.3144</td>
</tr>
<tr>
<td></td>
<td>T=233 K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>20%, 30%, 40%, 50%, 60%, 70%, 80%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.3683</td>
</tr>
<tr>
<td></td>
<td>T=253 K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>0%, 10%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.3175</td>
</tr>
<tr>
<td></td>
<td>T=263 K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%</td>
<td>0.6114</td>
<td>5000</td>
<td>2.5222</td>
</tr>
<tr>
<td></td>
<td>T=273 K</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Basic aerosol acid solution components data files complex refraction indices: m=p-iq

<table>
<thead>
<tr>
<th>Component</th>
<th>Conditions</th>
<th>Available Wavelength Spectral Range</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂SO₄</td>
<td>0%, 10%, 20%, 30%, 40%, 45%, 50%, 57%, 60%, 64%, 75%, 80% T=293 K</td>
<td>5000</td>
<td>23.191</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>45%, 50% T=200 K</td>
<td>2.1273</td>
<td>12.1126</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>32%, 39%, 61% T=210 K</td>
<td>2.1273</td>
<td>12.1126</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>38%, 43%, 50%, 55%, 66%, 72% T=220 K</td>
<td>2.1273</td>
<td>12.1126</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>75% T=230 K</td>
<td>2.1273</td>
<td>12.1126</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>42%, 50%, 59%, 69%, 80% T=240 K</td>
<td>2.1273</td>
<td>12.1126</td>
</tr>
</tbody>
</table>

**Column 1**: Component identifications  
**Column 2**: Conditions (solution concentration/temperature)  
**Columns 3 to 6**: Available wavelength spectral range  
**Column 7**: References
Basic aerosol acid solution components data files complex refraction indices: $m=p-iq$

<table>
<thead>
<tr>
<th>Component</th>
<th>Conditions</th>
<th>Available Wavelength Spectral Range</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_2SO_4$</td>
<td>42%, 47%, 59%, 72%, 76%, 87% T=260 K</td>
<td>2.1273, 12.1126, 2.1273, 12.1126</td>
<td>Niedziela et al., 1999</td>
</tr>
<tr>
<td>$H_2SO_4$</td>
<td>50%, 63%, 70%, 76%, 89% T=280 K</td>
<td>2.1273, 12.1126, 2.1273, 12.1126</td>
<td>Niedziela et al., 1999</td>
</tr>
<tr>
<td>$H_2SO_4$</td>
<td>72%, 75%, 89% T=300 K</td>
<td>2.1273, 12.1126, 2.1273, 12.1126</td>
<td>Niedziela et al., 1999</td>
</tr>
<tr>
<td>$H_2SO_4$</td>
<td>45.2%, 50%, 55.1%, 61.6%, 65.3%, 70.2%, 71%, 80% T=215 K</td>
<td>1.4293, 20.0200, 2.7415, 20.0200</td>
<td>Taghizadeh et al., 1998</td>
</tr>
<tr>
<td>$H_2SO_4$</td>
<td>75% T=215 K</td>
<td>0.2, 25, 0.2, 25</td>
<td>Hummel et al., 1988</td>
</tr>
<tr>
<td>$H_2SO_4$</td>
<td>79% T=300 K</td>
<td>0.2, 50, 0.2, 50</td>
<td>Hummel et al., 1988</td>
</tr>
</tbody>
</table>

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**Columns 3 to 6**: Available wavelength spectral range  
**Column 7**: References
Basic aerosol acid solution components data files complex refraction indices: $m = p - iq$

<table>
<thead>
<tr>
<th>Component</th>
<th>75% Solution, $T=293$ K, 3 relative humidities</th>
<th>0.25</th>
<th>40</th>
<th>0.25</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_2SO_4$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_2SO_4$</td>
<td>solution</td>
<td>0.36</td>
<td>25</td>
<td>0.702</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_2SO_4$</td>
<td>75%, 90%, $T=293$ K</td>
<td>6.365</td>
<td>13.382</td>
<td>6.365</td>
<td>13.382</td>
</tr>
<tr>
<td></td>
<td>solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_2SO_4$</td>
<td>75%, $T=293$ K (assumed)</td>
<td>0.2</td>
<td>40</td>
<td>0.2</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$HNO_3$</td>
<td>48%, 45%, $T=213$ K</td>
<td>0.6104</td>
<td>5000</td>
<td>2.1912</td>
<td>23.1492</td>
</tr>
<tr>
<td></td>
<td>solution</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$HNO_3$</td>
<td>30%, 45%, 50%, $T=223$ K</td>
<td>0.6104</td>
<td>5000</td>
<td>1.9955</td>
<td>23.1492</td>
</tr>
<tr>
<td></td>
<td>solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$HNO_3$</td>
<td>30%, 40%, 43%, 50%, $T=233$ K</td>
<td>0.6104</td>
<td>5000</td>
<td>1.9955</td>
<td>23.1492</td>
</tr>
<tr>
<td></td>
<td>solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<th>Conditions</th>
<th>Available Wavelength Spectral Range</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>HNO₃</td>
<td>0%, 30%, 40%, 45%, 50%; T=353 K</td>
<td>0.6104</td>
<td>3000</td>
</tr>
<tr>
<td>HNO₃</td>
<td>0%, 20%; T=263 K</td>
<td>0.6104</td>
<td>3000</td>
</tr>
<tr>
<td>HNO₃</td>
<td>0%, 10%, 20%, 30%, 40%, 45%, 50%; T=273 K</td>
<td>0.6104</td>
<td>3000</td>
</tr>
<tr>
<td>HNO₃</td>
<td>0%, 10%, 20%, 30%, 40%, 45%, 50%; T=293 K</td>
<td>0.6104</td>
<td>3000</td>
</tr>
<tr>
<td>HNO₃</td>
<td>35%, 45%, 54%, 63%, 70%; T=220 K</td>
<td>2.127</td>
<td>13.239</td>
</tr>
</tbody>
</table>

**Column 1**: Component identifications  
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**Columns 3 to 6**: Available wavelength spectral range  
**Column 7**: References
**Basic aerosol acid solution components data files complex refraction indices: m=p-iq**

<table>
<thead>
<tr>
<th>Column 1: Component identifications</th>
<th>Column 2: Conditions (solution concentration/temperature)</th>
<th>Column 3: Available wavelength spectral range</th>
<th>Column 7: References</th>
</tr>
</thead>
</table>
| **HNO₃**                            | 3.1%, 6.1%, 11.8%, 22.3%, 40.3%, 70%  
  Solution: T=293 K                 | 2.0050                                             | 39.9500                                           | Query and Tyler, 1980 |
| **HNO₃**                            | 68%  
  Solution: T=293 K (assumed)     | 9.193                                              | 11.761                                             | Remsberg et al., 1974 |
Aerosol optical data from LITMS (Laboratory for Information Technologies and Mathematical Simulation of the Institute of Molecular Physics at the Russian Research Center "Kurchatov Institute"), such as: integrated optical properties (e.g. extinction coefficient, asymmetry factor, etc...) as well as refractive indices of the basic aerosol constituents (e.g. Dust-Like, Water-Soluble, Soot, Volcanic Ash, etc...), have been archived in the GEISA aerosols databank.

Detailed description of these data are given in a paper by Rublev, 1994.
Complex indices of refraction $m = p - iq$ of basic aerosol components

($H_2O$ complex indices of refraction from Zolatarev et al., 1984; other complex indices of refraction are from WMO, 1986)

<table>
<thead>
<tr>
<th>Basic aerosol constituent</th>
<th>FILE$^{(*)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (liquid)</td>
<td>h2o.ref</td>
</tr>
<tr>
<td>Dust</td>
<td>dust_ref</td>
</tr>
<tr>
<td>75% $H_2SO_4$</td>
<td>h2so4.ref</td>
</tr>
<tr>
<td>Sea salt</td>
<td>ocean_ref</td>
</tr>
<tr>
<td>Soot</td>
<td>soot_ref</td>
</tr>
<tr>
<td>Volcanic ash</td>
<td>volc_ash_ref</td>
</tr>
<tr>
<td>Water-soluble particles</td>
<td>w_s_ref</td>
</tr>
</tbody>
</table>

$^{(*)}$ See headers of data files for format and content description
Integrated optical properties (*) of principal aerosol models

(extinction coefficient, single scattering albedo, asymmetry factor)

<table>
<thead>
<tr>
<th>AEROSOL MODEL</th>
<th>BASIC AEROSOL CONSTITUENT</th>
<th>VOLUME RELATIVE CONCENTRATION (%)</th>
<th>PARTICLE NUMBER RELATIVE CONCENTRATION (***)</th>
<th>FILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continental</td>
<td>Dust-Like</td>
<td>70</td>
<td>2.26278 x 10^{-6}</td>
<td>s_cont.dat</td>
</tr>
<tr>
<td></td>
<td>Water-Soluble</td>
<td>29</td>
<td>9.37437 x 10^{-1}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soot</td>
<td>1</td>
<td>6.25607 x 10^{4}</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>Water-Soluble</td>
<td>61</td>
<td>5.85931 x 10^{-1}</td>
<td>s_urb.dat</td>
</tr>
<tr>
<td></td>
<td>Soot</td>
<td>22</td>
<td>4.11069 x 10^{-1}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dust-Like</td>
<td>17</td>
<td>1.64128 x 10^{-7}</td>
<td></td>
</tr>
<tr>
<td>Maritime</td>
<td>Ocean</td>
<td>65</td>
<td>4.29942 x 10^{4}</td>
<td>s_mar.dat</td>
</tr>
<tr>
<td></td>
<td>Water-Soluble</td>
<td>5</td>
<td>9.99573 x 10^{1}</td>
<td></td>
</tr>
<tr>
<td>Stratospheric</td>
<td>75% H₂SO₄</td>
<td>100</td>
<td>1.0</td>
<td>s_h2so4.dat</td>
</tr>
<tr>
<td>Volcanic</td>
<td>Volcanic Ash</td>
<td>100</td>
<td>1.0</td>
<td>s_volc.dat</td>
</tr>
<tr>
<td>Cloudy</td>
<td>Water</td>
<td>100</td>
<td>1.0</td>
<td>s_cloud.dat</td>
</tr>
</tbody>
</table>

(*) See headers of data files for format and content description
(**) For each aerosol model, the total sum of basic aerosol constituent concentrations has to be equal to 1 (dimensionless)
Integrated optical properties computed for basic aerosol constituents

(extinction coefficient, single scattering albedo, asymmetry factor)
by Rublev, 1994

<table>
<thead>
<tr>
<th>Basic aerosol constituent</th>
<th>FILE(*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust-like particles</td>
<td>s_dust.dat</td>
</tr>
<tr>
<td>water-soluble particles</td>
<td>s_w_s.dat</td>
</tr>
<tr>
<td>Soot</td>
<td>s_soot.dat</td>
</tr>
<tr>
<td>Oceanic</td>
<td>s_oc.dat</td>
</tr>
</tbody>
</table>

(*) See headers of data files for format and content description
The software package OPAC: Optical Properties of Aerosols and Clouds

The software package OPAC has been developed by Hess and Köpke (Meteorologisches Institut der Universität München, Germany) and Schult (Max-Plank-Institut für Meteorologie, Hamburg, Germany).


This page provides a description of the OPAC-related topics, i.e.:

• General description of the OPAC software package
• Online access to the OPAC data set.
• OPAC FORTRAN program
• Mixing of atmospheric particles.
• Download the OPAC software package
### Aerosol components

<table>
<thead>
<tr>
<th>Aerosol components</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insoluble (soil particles with a certain amount of organic material)</td>
<td></td>
</tr>
<tr>
<td>Soot (absorbing black carbon)</td>
<td></td>
</tr>
<tr>
<td>Water-soluble (sulfates, nitrates &amp; other water-soluble substances)</td>
<td></td>
</tr>
<tr>
<td>Sea salt -acc. mode(*) (various kinds of salt contained in seawater)</td>
<td></td>
</tr>
<tr>
<td>Sea salt -coa. mode(*) (various kinds of salt contained in seawater)</td>
<td></td>
</tr>
<tr>
<td>Mineral -acc. mode(**) (a mixture of quartz and clay minerals)</td>
<td>Deepak and Gerber, 1983; Shettle and Fenn, 1979;</td>
</tr>
<tr>
<td>Mineral -coa. mode(**) (a mixture of quartz and clay minerals)</td>
<td>d'Almeida et al., 1991; Köpke et al., 1997</td>
</tr>
<tr>
<td>Mineral-transported (desert dust transported over long distances with a reduced amount of large particles)</td>
<td></td>
</tr>
<tr>
<td>Sulfate droplets (75% solution of H₂SO₄)</td>
<td></td>
</tr>
</tbody>
</table>

(*) Two sea-salt modes are given to allow for a different wind-speed-dependent increase of particle number for particles of different size (Köpke et al., 1997).

(**) Three mineral modes are given to allow to consider increasing of relative amount of large particles for increasing turbidity (BAMS98).
Water clouds used in the OPAC software package (BAMS98)

<table>
<thead>
<tr>
<th>Clouds</th>
<th>REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratus (continental) (water clouds)</td>
<td>Tampier and Tomasi 1976; Diem, 1948; Hofmann and Roth, 1989</td>
</tr>
<tr>
<td>Cumulus (continental, clean) (water clouds)</td>
<td>Tampier and Tomasi 1976; Squires 1958; Leitch et al., 1992</td>
</tr>
<tr>
<td>Cumulus (maritime) (water clouds)</td>
<td>Tampier and Tomasi 1976.</td>
</tr>
<tr>
<td>Fog</td>
<td>Tampier and Tomasi 1976.</td>
</tr>
</tbody>
</table>
## Ice clouds used in the OPAC software package (BAMS98)

<table>
<thead>
<tr>
<th>Clouds</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cirrus 2 (T=-50° C) (ice clouds)</td>
<td></td>
</tr>
<tr>
<td>Cirrus 3 (T=-50° C) + small particles (ice clouds)</td>
<td></td>
</tr>
</tbody>
</table>
The following optical properties of aerosols and clouds have been archived (see, e.g. Van de Hulst, 1981, BAMS98 for explicit formulas and definitions):

1. extinction coefficient (km$^{-1}$)
2. scattering coefficient (km$^{-1}$)
3. absorption coefficient (km$^{-1}$)
4. single scattering albedo
5. asymmetry parameter
6. volume phase function (km$^{-1}$ sr$^{-1}$)
The OPAC FORTRAN program allows the user to extract data from the dataset and to calculate additional optical properties of mixtures of the stored clouds and aerosol components.

The following optical properties can be computed:

- the extinction coefficient (km⁻¹),
- the scattering coefficient (km⁻¹),
- the absorption coefficient (km⁻¹),
- the volume phase function (km⁻¹ sr⁻¹),
- the single scattering albedo,
- the asymmetry parameter,
- the aerosol optical depth
- spectral turbidity factor
- lidar ratio
- mass extinction cross section
- mass absorption cross section
- normalized extinction coefficient
- spectrally weighted coefficients
- Angstrom coefficients
- visibility
- refractive index
Global Aerosol Data Set (GADS)

- Global distribution of basic aerosol microphysical properties and online access to data files
- Reprint of the related paper by Hess et al.
- Computations of aerosol microphysical properties at each grid point
- Download the complete version of GADS
- GADS programs on line
- References

This data set consists of aerosol properties averaged in space and time and therefore is mainly determined for use in climate modelling.
ACCESS TO The GEISA/IASI aerosols Sub-Database

http://ara.lmd.polytechnique.fr/registration

**registerme** as name

*No password required*

More information is available from jacquinet@lmd.polytechnique.fr