Aerosol and CCN Distributions over Europe

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1) Introduction

- Aerosols indirectly affect the climate through the modification of clouds, therefore an accurate representation of the spatial and temporal variability of aerosols is needed in models.
- The Consortium for Small-scale Modeling (COSMO) Multi-Scale Chemistry Aerosol Transport (MUSCAT) modeling system was used to simulate the emission and transport of anthropogenic and natural aerosols to Europe.
- Table 1 shows the aerosol species and properties simulated with the COSMO-MUSCAT modeling system. Also shown is whether the aerosol species acts as a cloud condensation nuclei (CCN) or an ice nucleus (IN).
- Particle number concentrations were calculated from the particulate masses using the assumed particle properties from Table 1, and assuming external mixing.

<table>
<thead>
<tr>
<th>Species (externally mixed)</th>
<th>Radius (μm)</th>
<th>Density (g/cm³)</th>
<th>Standard Deviation</th>
<th>Hygroscopicity</th>
<th>CCN/IN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium</td>
<td>0.19</td>
<td>1.6</td>
<td>1.6</td>
<td>0.32</td>
<td>CCN</td>
</tr>
<tr>
<td>Sulfate</td>
<td>0.15</td>
<td>1.6</td>
<td>1.6</td>
<td>0.52</td>
<td>CCN</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.19</td>
<td>1.7</td>
<td>1.6</td>
<td>0.57</td>
<td>CCN</td>
</tr>
<tr>
<td>Eum. Carbon</td>
<td>0.09</td>
<td>1.3</td>
<td>1.4</td>
<td>-</td>
<td>IN</td>
</tr>
<tr>
<td>Sea Salt 1</td>
<td>0.1</td>
<td>2.2</td>
<td>1.8</td>
<td>1.16</td>
<td>CCN</td>
</tr>
<tr>
<td>Sea Salt 2</td>
<td>1</td>
<td>2.1</td>
<td>1.3</td>
<td>1.16</td>
<td>CCN</td>
</tr>
</tbody>
</table>

2) Aerosol Distributions

- The total aerosol concentrations (organic carbon, sulfate, nitrate, ammonium) simulated with COSMO-MUSCAT were evaluated against observations from Melpitz, Germany on 18-23 May 2008.

3) Cloud Condensation Nuclei and Ice Nuclei Distributions

- The Abdul-Razzak et al. (1998) parameterization was used to estimate the mean number of activated aerosol particles to form CCN for ammonium, sulfate, nitrate and sea salt aerosols, for May 2008.
- The parameterisation was applied with the mean horizontal temperature field for May 2008, a constant pressure of 800 hPa, and a constant vertical velocity of 1 m/s.
- A parameterisation for deposition freezing on soil particles (Ming et al., 2004) was applied to estimate the deposition of ice nuclei concentrations from the elemental carbon aerosol fields for May 2008.
- For deposition IN, the RH was assumed to be a constant value of 115%, with the mean horizontal temperature field for May 2008. The parameterisation is valid within a temperature range of 285-295 K.
- The number concentration of CCN and IN particles near cloud level are shown in Figure 3.

4) Conclusions and Outlook

- The COSMO-MUSCAT model suggests mean total aerosol concentrations for all species in Table 1 during May 2008 were roughly 10³ m⁻³. The dominant aerosol types are elemental carbon, followed by sulfate, ammonium, nitrate, and sea salt particles having the lowest concentrations. The simulated aerosol concentrations compare well to observations from Melpitz, Germany.
- On average, about 30% of the sulfate aerosols are activated to form CCN, and only a small fraction of elemental carbon aerosols are activated to form IN under the selected pre-stressed conditions. Activated fraction of aerosols to form CCN is slightly enhanced over high terrain regions, due to colder air temperatures. A difference of about 10% increases activation by about 13%. The activated fraction of elemental carbon to form IN increases dramatically in colder regions. A difference of about 10% increases activation by approximately a factor of 4.
- Total CCN and IN concentrations are low for continental conditions, so the method will be refined and also extended to include organic carbon. The estimates of CCN and IN will be used in the COSMO model to simulate how a realistic spatially and temporally varying CCN and IN distribution impacts cloud properties in a meso-scale and an LES scale model. For preliminary results with dust aerosols in a meso-scale model, sea salt. Dust IN concentrations and the impact on clouds in COSMO (Hande et al.).

References