Aerosol introduces one of the largest uncertainties in climate research. Aerosol originates from different sources and has short life-times on the order of a few days. Thus, aerosol properties (amount, size and absorption) and aerosol altitude vary strongly in space and time. Any estimates for the associated impact on the Earth’s climate are further complicated, because underlying surface (solar albedo), co-located clouds and available sun-light also influence the eventual radiative forcing (which captures imposed changes to the radiative energy balance). As radiative forcing continuously changes not only in magnitude but also in sign, the overall impact (daily average, regional average or even global average) is made up by differences of larger numbers. Moreover, aerosol and environmental properties are usually poorly defined. Thus, the aerosol radiative forcing attributed to aerosol is highly uncertain – even when integrating over time. Here results from radiative transfer simulations are presented. These calculations only address the impact due to the presence of aerosol in the atmosphere (direct effect – no feedbacks). Monthly statistics of data for aerosol properties and for environmental properties were assembled. Based on these data-sets aerosol forcings are determined separately for solar and infra-red spectral regions, for total aerosol and its anthropogenic fraction and for clear-sky (no clouds) and all-sky (cloudy) conditions.

The following table provides an overview of the aerosol forcing results for the year 2000.

### Aerosol Input Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerosol Optical Depth</td>
<td>resents the optical thickness of the aerosol layer</td>
</tr>
<tr>
<td>Aerosol Absorption</td>
<td>Absorption coefficient of the aerosol layer</td>
</tr>
<tr>
<td>Aerosol Size</td>
<td>Size distribution of the aerosol layer</td>
</tr>
<tr>
<td>Albedo Below</td>
<td>Reflectance of the underlying surface</td>
</tr>
<tr>
<td>Cloud Presence</td>
<td>Presence and properties of clouds</td>
</tr>
</tbody>
</table>

### Aerosol Forcing Results

The following table provides an overview of the aerosol forcing results for the year 2000.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear-sky ToA Forcing</td>
<td>Forcing at the Top of the Atmosphere (ToA)</td>
</tr>
<tr>
<td>Annual Aerosol Forcing</td>
<td>Forcing over the year 2000</td>
</tr>
<tr>
<td>Annual Aerosol Efficiency</td>
<td>Efficiency of the aerosol forcing</td>
</tr>
</tbody>
</table>

### Critical Parameters

- **Aerosol Size**
- ** Aerosol Absorption**
- **Albedo Below**
- **Cloud Presence**

### Forcing Approach

- 'climate' forcing
- Top of Atmosphere
- Cooling: more energy to space
- Warming: less energy to space

- Aerosol is complex!

S. Kinne (1) the AERONET-group (2)

- AeroCom (3) modeling community

(1) Max-Planck Institute for Meteorology, Hamburg
(2) NASA Goddard Space Flight Center, Greenbelt
(3) European Commission, Joint Research Center, Ispra

### Forcing Results

- Label – explanation
  - t0a – ToA / all / total
  - s0a – surf / all / total
  - t0a – ToA / cir / anthr
  - s0a – surf / cir / anthr
  - t1a – ToA / all / anthr
  - s1a – surf / all / anthr

- Comparison at all sites
  - Anat climatology:
    - t0a - 8.7 - 4.5 Wm2
    - s0a - -11.5 - 9.5 Wm2
    - t1a - -4.1 - 2.7 Wm2
    - s1a - -5.1 - 7.8 Wm2

- AERONET data suggest: climatology underpredicts direct forcing by ca 20%.

- Clear-sky ToA Forcing (based on simulated efficiencies, + satellite aot)
  - Sample corrected ToA Forcing:
    - MIX: 7.1 Wm2
    - MODIS: 7.2 Wm2
    - MISR: 6.3 Wm2
    - TOMS: 7.8 Wm2
  - MODIS: PO-DEER: 8.7 Wm2
  - AVHRR: 4.6 Wm2
  - ABI: AVHRR: 4.6 Wm2
  - ABI: AVHRR: 4.6 Wm2
  - ABI: AVHRR: 4.6 Wm2

- F’-efficiency of climatology:
  - Climatology: 4.8

- AERONET data sets: direct forcing by ca 20%.