Observational constraints on the first indirect aerosol effect

Ralf Bennartz
Atmospheric & Oceanic Sciences
University of Wisconsin - Madison
## Acknowledgements

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<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Contribution</th>
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<tr>
<td>Rene Preusker</td>
<td>FU-Berlin</td>
<td>Albedo parameterization</td>
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<td>Lothar Schüller</td>
<td>EUMETSAT</td>
<td>Indirect aerosol effect</td>
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<td>Chris O’Dell</td>
<td>UW-Madison</td>
<td>Diurnal cycle of LWP</td>
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<td>Amato Evan</td>
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<td>Brent Maddux</td>
<td>UW-Madison</td>
<td>Data</td>
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<tr>
<td>Lori Borg</td>
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<td>Data</td>
</tr>
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</table>
Radiative Forcing Components

RF Terms

- Long-lived greenhouse gases
  - CO₂
  - N₂O
  - CH₄
  - Halocarbons

- Ozone
  - Stratospheric
  - Tropospheric

- Stratospheric water vapour from CH₄

- Surface albedo
  - Land use
  - Black carbon on snow

- Direct effect
- Cloud albedo effect

- Total Aerosol

- Linear contrails
- Solar irradiance

- Total net anthropogenic

RF values (W m⁻²) | Spatial scale | LOSU
--- | --- | ---
1.66 [1.49 to 1.83] | Global | High
0.48 [0.43 to 0.53] | Global | High
0.16 [0.14 to 0.18] | Global | High
0.34 [0.31 to 0.37] | Global | High
-0.05 [-0.15 to 0.05] | Continental to global | Med
0.35 [0.25 to 0.65] | Continental to global | Med
0.07 [0.02 to 0.12] | Global | Low
-0.2 [-0.4 to 0.0] | Local to continental | Med - Low
0.1 [0.0 to 0.2] | Continental to global | Med - Low
-0.5 [-1.0 to -0.1] | Continental to global | Med - Low
-0.7 [-1.8 to -0.3] | Continental to global | Med - Low
0.01 [0.003 to 0.03] | Continental | Low
0.12 [0.06 to 0.30] | Global | Low
1.6 [0.6 to 2.4] | Global | Low

Radiative Forcing (W m⁻²)

IPCC 2007
Anthropogenic and natural forcing of the climate for the year 2000, relative to 1750

Global mean radiative forcing (Wm⁻²)

- **Greenhouse gases**
  - Halocarbons
  - N₂O
  - CH₄
  - CO₂

- **Tropospheric ozone**
- **Black carbon**
- **Mineral Dust**
- **Aviation**
  - Contrails
  - Cirrus

- **Aerosols + clouds**
  - Sulphate
  - Organic carbon from fossil fuel burning
  - Biomass burning

- **Solar**
- **Land use** (albedo only)

The height of a bar indicates a best estimate of the forcing, and the accompanying vertical line a likely range of values. Where no bar is present, the vertical line only indicates the range in best estimates with no likelihood.

**LEVEL OF SCIENTIFIC UNDERSTANDING**
- High
- Medium
- Medium
- Low
- Very low

IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

IPCC 2001
Microphysical changes due to pollution

droplet concentration
effective radius

clean

polluted
Data

• Cloud liquid water path diurnal cycle (O’Dell et al., 2007, J Climate, in press)

• Cloud fraction diurnal cycle (ISCCP)

• Cloud droplet number concentration (CDNC) (MODIS, Bennartz, 2007, JGR)

• Aerosol & fine mode fraction (used as proxy for natural background fraction of CDNC)
Cloud droplet number concentration from MODIS
The diurnal cycle of clouds
The diurnal cycle of clouds

Relative Diurnal Amplitude

Liquid Water Path [kg/m²]

Local Time [hours]
The diurnal cycle of clouds

Relative Diurnal Amplitude

Liquid Water Path [kg/m²]

Low Cloud fraction

Local Time [hours]
The diurnal cycle of clouds
How does our albedo compare to observations (CERES)?
Anthropogenic fraction: Note: This is a proxy.
This study

(Chen and Penner, 2005, ACP)
## Conclusions

### Radiative Forcing Components

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<tr>
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<td><strong>Long-lived greenhouse gases</strong></td>
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<td>CO$_2$</td>
<td>1.66 [1.49 to 1.83]</td>
<td>Global</td>
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<td><strong>N$_2$O</strong></td>
<td>0.48 [0.43 to 0.53]</td>
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<td><strong>Stratospheric water vapour from CH$_4$</strong></td>
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<td>Surface albedo</td>
<td>-0.2 [-0.4 to 0.0]</td>
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Land

N to first order a function of anthropogenic aerosol optical thickness

Different behavior for different continents at high anthropogenic fraction
Ocean

\[ N = 20 + 35 \cdot \left[ \left( \log_{10}(c_{\text{chlorophyll}}) + 2 \right) \geq 0 \right] + 104 \cdot \frac{\tau_{\text{anth, proxy}}}{\tau} \]