Two hundred fifty years of aerosols and climate: the end of the age of aerosols

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Spracklen et al. (2011) anthropogenic OC ~ 100 TgC

Mounting evidence that SOA absorbs visible wavelengths

Table 1. Assumed range for radiative forcing. Year 2000 anthropogenic emissions (total emissions – assumed preindustrial baseline) are BC: 5.7 TgC; OC: 17.4 TgC; SO₂: 111 TgSO₂.

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<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
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<tbody>
<tr>
<td>Global 2000 Forcing (W m⁻²)</td>
<td></td>
<td></td>
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<tr>
<td>BC</td>
<td>0.23</td>
<td>0.40</td>
<td>0.57</td>
</tr>
<tr>
<td>OC</td>
<td>-0.11</td>
<td>-0.056</td>
<td>-0.025</td>
</tr>
<tr>
<td>SO₂ Dir</td>
<td>-0.60</td>
<td>-0.40</td>
<td>-0.20</td>
</tr>
<tr>
<td>Cloud Indir</td>
<td>-1.2</td>
<td>-0.70</td>
<td>-0.30</td>
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</table>

Average Unit Forcing (mW m⁻² Tg⁻¹)

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>BC</td>
<td>40</td>
</tr>
<tr>
<td>OC</td>
<td>-6.3</td>
</tr>
<tr>
<td>SO₂ Dir</td>
<td>-5.4</td>
</tr>
</tbody>
</table>
UV-Visible Absorption by Organic Aerosols

soot

Significant absorption at visible wavelengths
Relationship between Oxidation Level and Optical Properties of Secondary Organic Aerosol

Andrew T. Lambe,*†‡ Christopher D. Cappa,§ Paola Massoli,‡ Timothy B. Onasch,†‡ Sara D. Forestieri,§ Alexander T. Martin,† Molly J. Cummings,† David R. Croasdale,† William H. Brune,‖ Douglas R. Worsnop,‡ and Paul Davidovits†

ES&T, 2013

Significant absorption
In visible range
Revised RF of Organic Aerosols
100 Tg/yr (Spracklen et al. 2011)
+ 7 mW m⁻² / Tg (~ 1/10 of soot) + 0.7 W m⁻²

S. J. Smith and T. C. Bond: The end of the age of aerosols

Fig. 3. Radiative forcing ranges for black carbon, organic carbon, sulfate aerosol, and indirect cloud forcing estimated by combining historical emissions estimates plus future emissions under the reference case scenario.
“The Return of the Age of Organic Aerosols”

Graph showing the ratio of annual production of OC/BC, OC/S, OC/NOx, OC/VOC, SO₂, NOx, Org.C., and BC over the years from 2000 to 2100.
The Return of the Age of Organic Aerosols

However, may be different organic composition than pre-industrial:

- Will sulfate (?) decline also cause a decline in BSOA?
  ➢ Recent field campaign data critical to understand this.

- Are we currently underestimating anthropogenic SOA?

Lee-Taylor et al., in internal review, 2014
Chemical Composition of Organics is Key Determinant of Climate-Relevant Aerosol Properties:

Optical Properties, esp. absorption vs. scattering

Particle Mass Growth Rates

Non-precipitation removal:
  dry deposition
  heterogeneous oxidation
  photolysis

Hygroscopicity
Growth Mechanisms with Emphasis on Particle Chemistry
(John Shilling and Sasha Madronich)

Initial survey:
(respondents: Alma, Rahul, Manish, Barbara, Jerome, Alla, Joel – thank you)

1) What particle-phase chemical reactions are included in models at all scales (box, regional, and global)?
   MOSAIC, ADCHAM

2) What kinds of research activities are currently in progress regarding this area, particularly within ASR/DOE funding?
   Evolution of size distribution (PNNL chamber)
   Volatility markers, SVOC uptake (UCI expts, theory)
   FIGAERO, MOVI gas and particle composition, volatility (UW)

3) Any specific activities, such as field campaigns, coordinated lab studies, or model intercomparisons, that we could work toward as a group to improve the representations of SOA growth mechanisms in models?
   Gas phase inputs from GECKO-A
   Aerosol testbed
   Comparisons for CARES, GoAmazon, Thornton’s and Goldstein’s labs,
Fig. 1. Schematic picture of the ADCHAM model structure.