Aerosol direct radiative forcing on Djougou (Benin) during the AMMA dry season experiment

What do we measure during SOP_0 / aerosol microphysical properties

- aerosol number size distribution (0.05 – 0.5 µm) from SMPS
- aerosol number size distribution (0.5 – 10 µm) from GRIMM
- total particle number concentration
- aerosol mass size distribution for major ions, BC and OC from impactor Dekati (13 stages)
- aerosol radiative properties (SSA & g at ≠ λ) from the Mie theory

derived properties
What do we measure during SOP_0 / aerosol radiative properties

- light absorption coefficient ($\sigma_{abs}$) from MAGEE aethalometer (at 7\(\lambda\)) at the surface
- aerosol optical depth (440, 670, 870 and 1020nm)
- aerosol volume size distribution (0.05 < \(r\) < 10 \(\mu\)m) for the total atmospheric column (Dubovik et al., 2002)
- aerosol single scattering albedo and asymmetry parameter (at 4 \(\lambda\)) for the total atmospheric column (Dubovik et al., 2002)
- light scattering coefficient ($\sigma_{scat}$) from ECOTECH nephelometer (at 520nm) at the surface

PHOTON / LOA

- aerosol optical depth (440, 670, 870 and 1020nm)
- aerosol volume size distribution (0.05 < \(r\) < 10 \(\mu\)m) for the total atmospheric column (Dubovik et al., 2002)
- aerosol single scattering albedo and asymmetry parameter (at 4 \(\lambda\)) for the total atmospheric column (Dubovik et al., 2002)

derived properties

- vertical profiles of aerosol backscattering coefficients (coll. SA)
- vertical profiles of aerosol extinction coefficients (coll. SA)
- aerosol single scattering albedo (at 520nm) at the surface
Aerosol optical depth on Djougou

- The region was rather turbid → $\text{AOD}_{440} \geq 0.5$ for major days
- Mean $\text{AOD}_{440}$ during January 2006 is equals to $0.90 \pm 0.01$ (coll. LOA)
Aerosol single scattering albedo on Djougou

\[ 2 \leq \sigma_{\text{abs}} \leq 90 \ \text{Mm}^{-1} \ (520\text{nm}) \]
\[ \text{mean } \sigma_{\text{abs}} = 19.2 \ \text{Mm}^{-1} \]

Very good comparisons with aircraft measurements over Djougou (alt. \(\sim 500\) m)
BAe-146 \(\rightarrow\) SSA\(_{520}\) \(\sim 0.90\) (S. Osborne, Met Office)

\[ 50 \leq \sigma_{\text{scat}} \leq 400 \ \text{Mm}^{-1} \]
\[ \text{mean } \sigma_{\text{scat}} = 160 \ \text{Mm}^{-1} \]

0.75 \(\leq\) SSA\(_{520}\) \(\leq\) 0.99
\[ \text{mean SSA}_{520} = 0.90 \]
Aerosol number size distributions on Djougou

- aerosol number size distributions are monomodal at the surface → Aitken mode.
- very good comparisons with aircraft BAe-146 measurements (S. Osborne)

Adjusted with optical measurements

<table>
<thead>
<tr>
<th>Date</th>
<th>Number conc. (#.cm⁻³)</th>
<th>GMD (nm)</th>
<th>GSD</th>
<th>RI₅₅₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 / 01</td>
<td>5604</td>
<td>115.11</td>
<td>1.83</td>
<td>1.54 ± 0.025</td>
</tr>
<tr>
<td>18 / 01</td>
<td>6391</td>
<td>112.13</td>
<td>1.81</td>
<td>1.54 ± 0.035</td>
</tr>
<tr>
<td>19 / 01</td>
<td>5089</td>
<td>85.94</td>
<td>1.95</td>
<td>1.54 ± 0.018</td>
</tr>
<tr>
<td>21 / 01</td>
<td>8486</td>
<td>99.39</td>
<td>1.86</td>
<td>1.54 ± 0.014</td>
</tr>
<tr>
<td>22 / 01</td>
<td>3927</td>
<td>74.71</td>
<td>1.95</td>
<td>1.54 ± 0.005</td>
</tr>
<tr>
<td>23 / 01</td>
<td>6085</td>
<td>87.99</td>
<td>1.85</td>
<td>1.54 ± 0.008</td>
</tr>
<tr>
<td>24 / 01</td>
<td>7120</td>
<td>100.17</td>
<td>1.86</td>
<td>1.54 ± 0.013</td>
</tr>
<tr>
<td>mean</td>
<td>6100</td>
<td>96.49</td>
<td>1.87</td>
<td>1.54 ± 0.017</td>
</tr>
</tbody>
</table>

Mie Computations
Aerosol vertical profiles over Djougou

used to improve aerosol vertical profiles in RTM!

21 / 01 / 06 (14 UTC)

AOD_{TOT, 550} \sim 0.75

AOD_{550} (1 – 4km) \sim 0.22

AOD_{550} (0-1km) \sim 0.49

\omega_{o,\lambda} & g_{\lambda} for FT and ST models (Hess et al., 1998)

- 330 nm (AOD = 1.36)
- 440 nm (AOD = 1.06)
- 550 nm (AOD = 0.91)
- 670 nm (AOD = 0.75)

\omega_{o,\lambda} & g_{\lambda} for « aged BB » model

\omega_{o,\lambda} & g_{\lambda} estimated at the ground level

thermodynamic parameters profiles (T° and RH) (coll. B. Pospichal & S. Crewell)
surface albedo → Modis sensor (http://delenn.gsfc.nasa.gov) (coll. J.C. Roger) → R_s \sim 0.20 at 555nm
Aerosol local direct radiative forcing on Djougou

- significant aerosol atmospheric forcing!
  + 20 W.m\(^{-2}\) ≤ \(\Delta F_{\text{ATM}}\) ≤ + 70 W.m\(^{-2}\)!

what is the possible impact on the atmospheric dynamic and on the cloud formation?

- significant aerosol surface forcing!
  - 45 W.m\(^{-2}\) ≤ \(\Delta F_{\text{BOA}}\) ≤ - 100 W.m\(^{-2}\) → 17\(^{th}\) Jan. due to SSA ~ 0.85 & AOD ~ 1.5!

what is the possible impact on the surface energy budget, such as latent or sensible heat fluxes?