Aerosol optical properties during a 2014 smog period at Uccle, Belgium

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1 INTRODUCTION

The Royal Meteorological Institute of Belgium is located at Uccle (50°48'N, 4°21'E, 100m asl), a residential suburb of Brussels about 100 km from the shore of the North Sea. At this site, several instruments measure aerosol optical properties simultaneously. Aerosol data obtained from March 2014 until May 2015 has been studied. The measurement period covered a smog event on 12-14 March 2014, characterized by high amounts of pollution. Meteorological conditions were responsible for this event: stagnation, inversion and dry air in combination with a lot of sunshine created a situation favouring the formation of secondary aerosol within a stable layer where the aerosol could further accumulate.

2 INSTRUMENTS

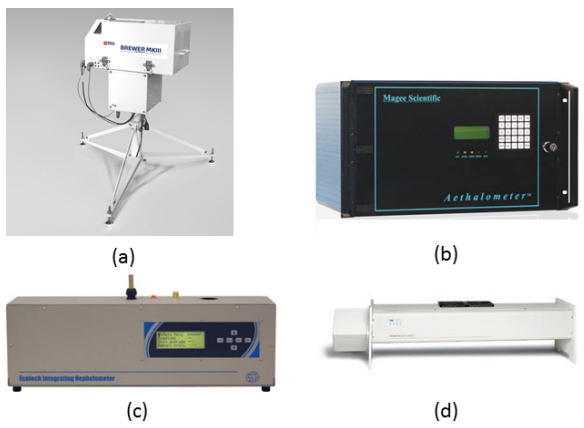

Figure 1. Instruments used in this study.

2.1 Brewer spectrophotometer (#178; Kipp&Zonen; Fig. 1a)

- Measurements: 2001 - present
- Originally designed to measure ozone in the atmosphere from UVB radiation
- Can also be used to retrieve the Aerosol Optical Depth (AOD) in the UVB region from
  1. direct sun measurements $=>$ AOD at 303.3, 310.1, 313.5, 316.8 and 320.1nm (Cheymol and De Backer, 2003)
  2. sun scan measurements $=>$ AOD at 340nm (De Bock et al. 2010)

2.2 Aethalometer (AE31; Magee Sci., 7 wavelengths; Fig. 1b)

- Measurements: May 2013 - present (every 5 min)
- Measures the light absorption of aerosol particles at wavelengths covering the UVA and the Near InfraRed (370, 470, 520, 590, 660, 880 and 950nm)
- The absorption coefficient (σ_a) (in Mm^{-1}) and the mass concentration of light-absorbing particles (in ng/m^3) can be derived from the instrument (Weingartner et al. 2003)

2.3 Nephelometer (Aurora 3000; Ecotech; Fig. 1c)

- Measurements: March 2014 - October 2014 (every 5 min)
- Measures the scattering(σ_s) and backscattering coefficient (σ_{bs}) (in Mm^{-1}) of particles at 450, 525 and 635nm

2.4 Nephelometer (3563; TSI; Fig. 1d)

- Measurements: March 2015 - May 2015 (+ test runs from June 2014 to September 2014) (every min)
- Measures the scattering(σ_s) and backscattering coefficient (σ_{bs}) (in Mm^{-1}) of particles at 450, 550 and 700nm

Combining the absorption measurements of the aethalometer and the scattering measurements of the nephelometer enables us to determine the Single Scattering Albedo (SSA).

3 RESULTS

For 28 days between March 2014 and May 2015, simultaneous measurements (max. time difference of 5 minutes) of aerosol optical properties have been analyzed. During this period, there were three days that could be characterized as smog days: 12/03/2014, 13/03/2014 and 14/03/2014. The following relations have been analyzed for the study period:

- Mass concentration at 370 and 660nm versus AOD
- σ_a at 470, 520 and 660nm versus AOD
- σ_s at 450, 525 and 635nm (Ecotech) and at 450, 550 and 700nm (TSI) versus AOD
- SSA versus AOD
- σ_a versus σ_s

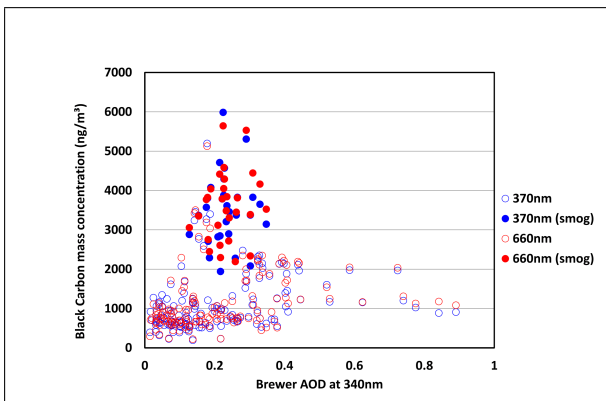

Figure 2. Aethalometer measurements of Black Carbon (BC) mass concentration (in ng/m^3) versus Brewer AOD measurements at 340nm.

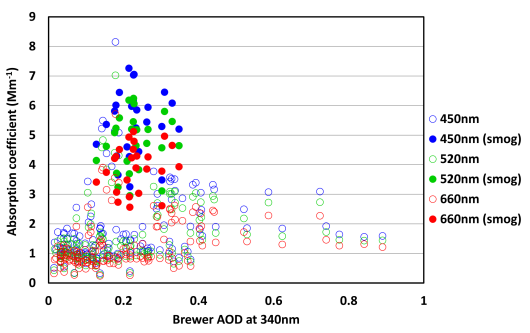

Figure 3. Aethalometer measurements of the absorption coefficient (in Mm^{-1}) versus Brewer AOD measurements at 340nm.

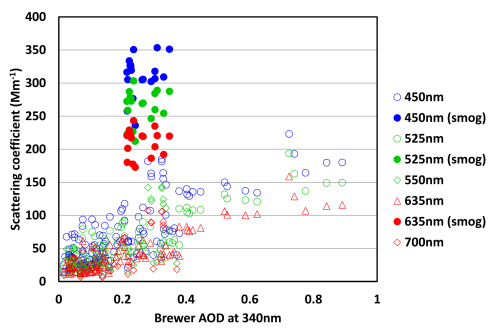

Figure 4. Nephelometer measurements of the scattering coefficient (in Mm^{-1}) versus Brewer AOD measurements at 340nm.

The smog period clearly distinguishes itself from the other days:

- The mass concentration of BC particles is much higher during the smog period
- The absorption coefficients (at all wavelengths) are higher during the smog period
- The scattering coefficients (at all wavelengths) are higher during the smog period
- Whereas there seems to be a correlation between AOD and the scattering coefficient for most of the days, during the smog period no such correlation was seen
- For AOD and SSA, we found no clear distinction between 'smog' days and 'normal' days. The smog days are characterized by rather low AOD values (0.2 to 0.4) and SSA values are around 0.98.

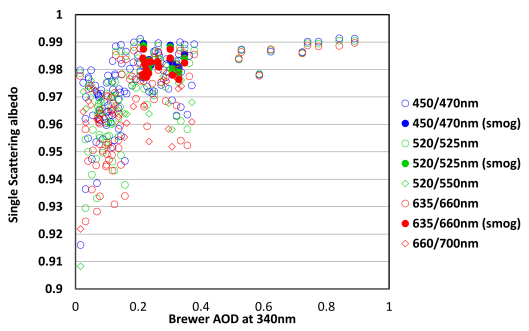

Figure 5. SSA values (derived from the absorption and scattering coefficient from the Aethalometer and Nephelometer) versus Brewer AOD measurements at 340nm.

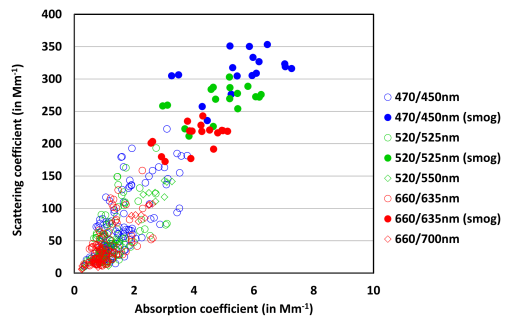

Figure 6. Aethalometer scattering coefficient versus Nephelometer absorption coefficient.

4 CONCLUSIONS

Aerosol optical properties for 28 days between March 2014 and May 2015 have been studied. During this period, three days could be characterized as smog days.

The smog days clearly distinguish themselves from the normal days: higher BC mass concentration + higher absorption coefficients + higher scattering coefficients.

There is a linear relation between AOD at 340nm and the scattering coefficient. However, this relation did not hold during the smog event. AOD at 340nm does not seem to be the best parameter to characterize such a smog period.

References

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