Aerosol measurements and source apportionment at Birkenes, Norway

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The Birkenes observatory (Fig. 1) is in southern Norway at 58º 23'N, 8º 15'E, 190 m a.s.l. Birkenes is a rural and mostly pollution free site: the vicinity of the site is 65 % forest, 10 % meadow, 15 % freshwater lakes, and 10 % agricultural areas (low intensity). However, the Birkenes Observatory is situated downwind of major anthropogenic emission regions in Europe, and is thus well suited to monitor the outflow of air pollution from continental Europe. Here we present an overview of selected aerosol measurements and preliminary ME2 source apportionment at Birkenes.

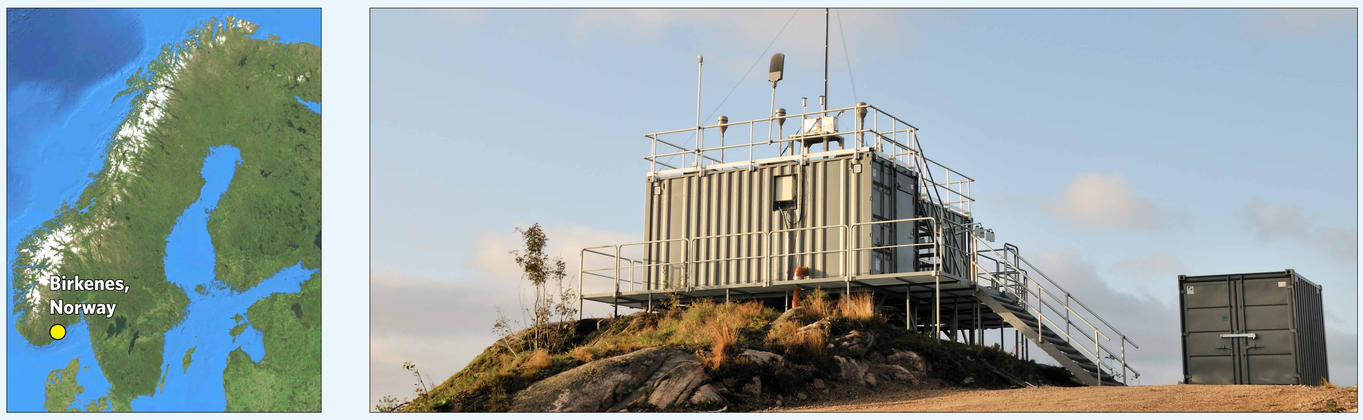

Figure 1: Photograph and location of the Birkenes monitoring site.

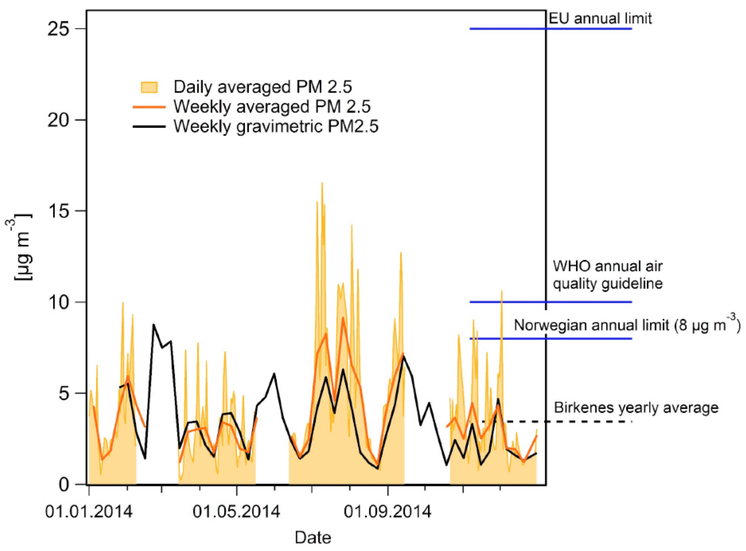

Figure 2: $PM_{2.5}$ measurements at Birkenes. In operation since 1971, Birkenes is one of the longest-running monitoring sites in Europe and an important EMEP station. In keeping with a rural background site, pollution is low. For example, daily and weekly averaged (Optical particle counter, OPC, Grimm 190) as well as gravimetric measurements of $PM_{2.5}$ show concentrations well below national and international guidelines, as indicated.

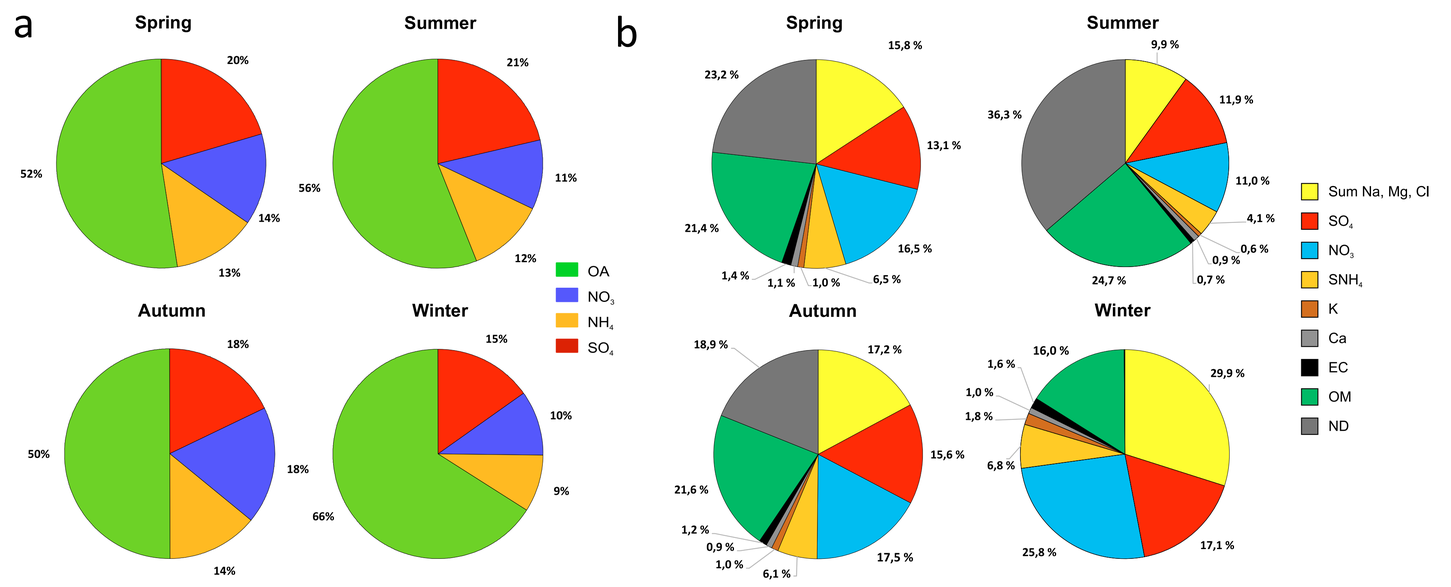

Figure 3: Aerosol composition a) Composition of non refractory PM_1 from the aerosol chemical speciation monitor (ACSM) at Birkenes. Organic aerosol (OA) dominate all year round compared to inorganics nitrate (NO_3), sulfate (SO_4), ammonia (NH_4). The inorganic fraction is higher in winter b) composition of PM10 , by off-line analysis, including organic matter (OM = OC x 1.7), elemental carbon (EC), sea salt [sum of sodium (Na), magnesium (Mg), and chloride (Cl)], calcium (Ca), potassium (K), sulfate (SO_{42-}), nitrate (NO_{3-}), NH_{4+}, and a non defined fraction (ND). A larger inorganic fraction in PM_{10} may be explained by a larger sea salt fraction and the possible inclusion of NO_{3-} following from the reaction between NaCl and HNO_3.

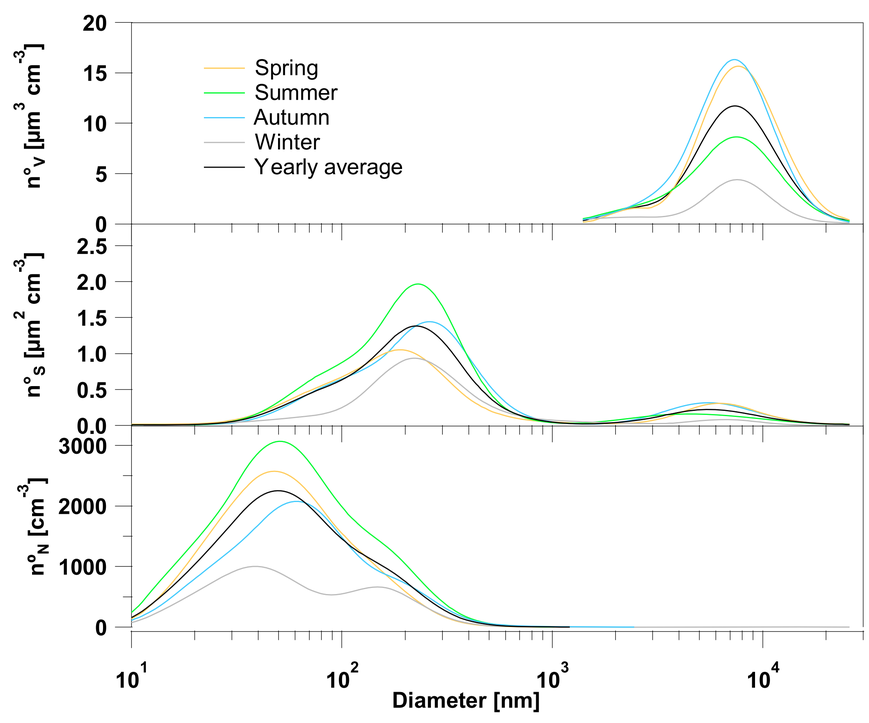

Figure 4: Fitted number (N), surface (S), and volume (V) distributions at Birkenes at different times of year, combined OPC and differential mobility sizer (DMPS) data. The bimodal number distribution is typical of a clean site with some influence of anthropogenic sources. Since the aerosol size distribution is an important parameter in aerosol physics, these data may be used to asses the viability of the size distributions used as inputs in e.g. climate models.

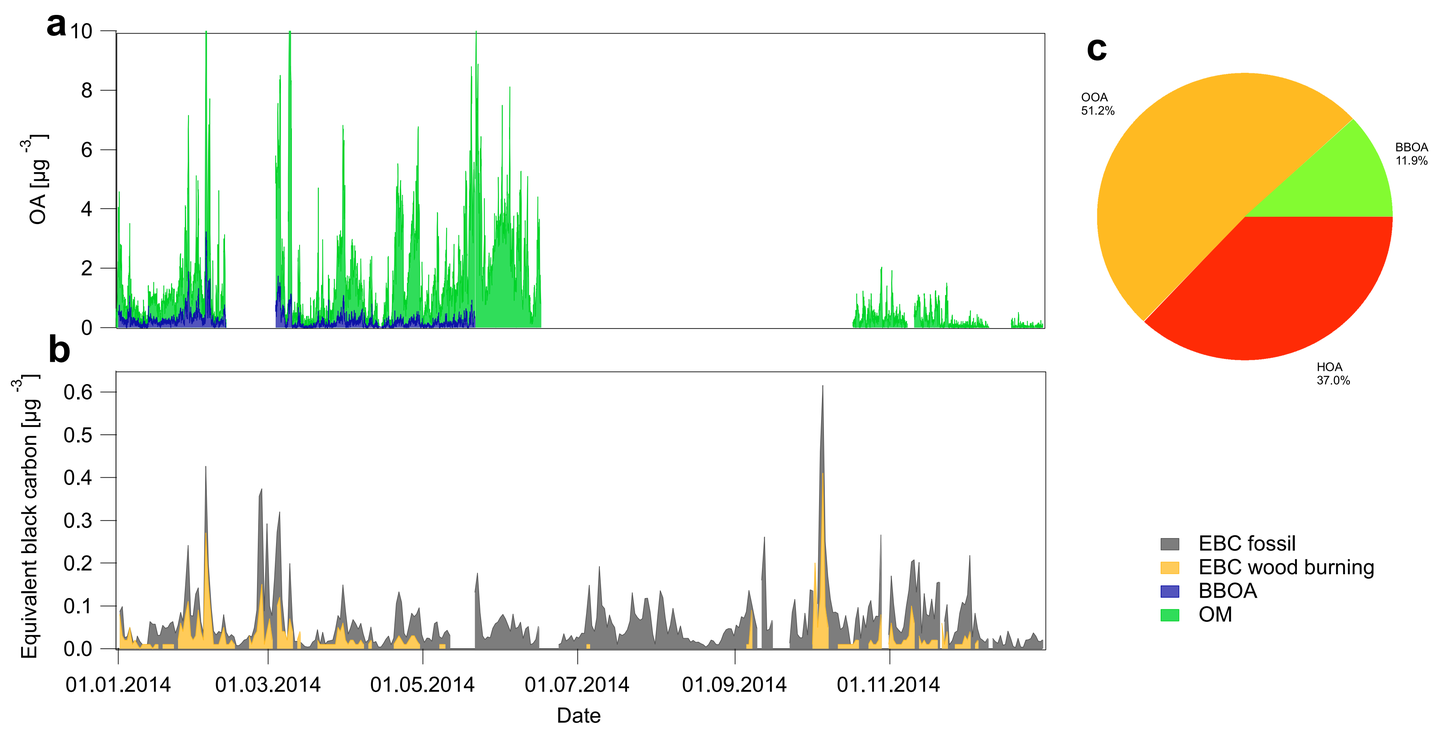

Figure 5: Source apportionment a) Organic time trace (aerosol chemical speciation monitor (ACSM), data, OA, green) and biomass burning organic aerosol (BBOA, blue). The BBOA fraction was retrieved using ME2 REF with an alpha value of 0.5 as part of a three factor solution b) Equivalent black carbon (EBC) measured using a three channel (470/522/620 nm) particle soot absorption photometer (PSAP) with the mass absorption coefficient determined via comparison to filter measurements of elemental carbon. The wood burning and fossil fractions were derived from the attenuation in absorption between 470 and 620 nm REF. Using this model wood burning is a large, sometimes the largest source of EBC in colder months, but is absent in summer. Due to the narrow wavelength range this fraction may be underestimated d) Composition of OA according to ME2 model outputs. OA at Birkenes in the first part of 2014 consisted mainly of oxygenated organic aerosol (OOA) with smaller fractions of hydrocarbon like organic aerosol (HOA) and BBOA.

Conclusions

Birkenes is a relatively clean site as shown by e.g. $PM_{2.5}$ mass well below international and national guidelines and typical aerosol number, surface and volume distributions show typical properties for a clean, rural continental site. Source apportionment via the ME2 model can be successfully applied to the Birkenes ACSM data, and indicates the presence of a small BBOA contribution

Acknowledgements

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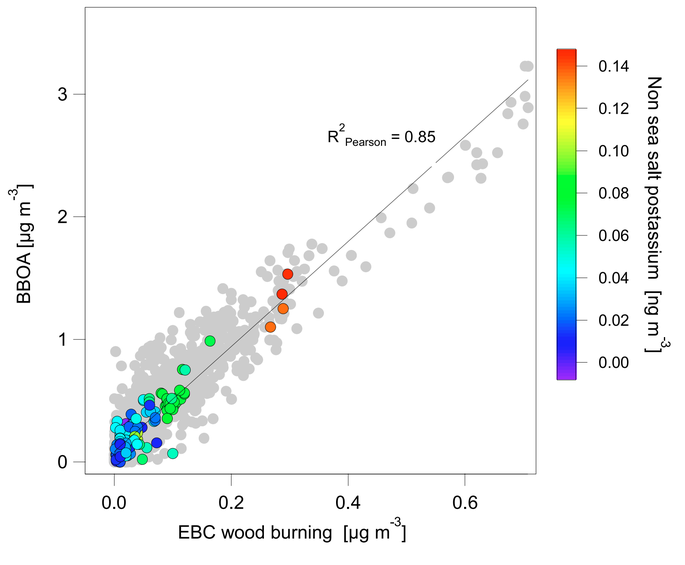
Figure 6: Evaluation of PMF output. The BBOA factor correlates well with wood burning EBC from the attenuation model. Correlation between HOA/ OOA factors and wood burning EBC is poor with R2 < 0.4, indicating good separation of BBOA form these factors. Higher concentrations of wood burning EBC and BBOA are associated with higher concentrations of non-sea salt potassium ([K+]nss = [K+]ws - ([Na+]ws x 0.038)) as indicated by the colour scale (where available; data are daily averaged, with the mid point of a daily sample chosen for evaluation).



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