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Aerosol properties and radiative forcing for three air masses transported in summer 2011 to Sopot, Poland

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The aim of this study is to characterize aerosol optical properties measured in summer 2011 in Sopot, the coastal town at Baltic Sea of Poland (54°26′N,18°33′E), and to estimate an aerosol radiative forcing, dependently on histories of air masses advected to this region. An intensive measurement campaign was carried out to obtain information on aerosol optical thickness (using multi-filter rotating shadow-band radiometer MFR-7, YES Inc.), black carbon concentration (aethalometer AE-31, Magee Sci.), scattering properties (integrating nephelometer 3563, TSI), attenuated backscatter in boundary layer (ceilometer CHM15k, Jenoptik; backscatter lidar LB10-D200, Raymetrics) and radiation properties (pyranometer CMP-11, Kipp&Zonen). Three air mass clusters, differing by their transport history, were identified from a set of four-days backward trajectories, which were computed by means of the NOAA HYSPLIT model at the heights of arrival: 500, 1500 and 3000 m. A non-hierarchical clustering algorithm was employed to group the trajectories into prevailing advection directions, which are flows from West (predominant), North and South. The aerosol properties for each flow are given by following examples.

For the North flow on August 3, the trajectories showed an advection of air via Finland and the Baltic Sea (trajectories arriving at 1500 and 3000 m) and via northern Russia, Finland and the coast of the Baltic States (500 m). The observations of low AOT (0.11-0.14 for 500 nm), low scattering coefficient (25-50 Mm-1 for 450 nm), and low black carbon concentration (200-700 ng m-3) suggest that this air can be regerded as a slightly modified Arctic air. However, in the early morning (before 6 UTC) and in the evening (after 20 UTC), black carbon concentration exceeded 1000 ng m-3. Lidar and ceilometer measurements showed low values of attenuated backscatter during the whole day.

For the West flow on August 17, the air masses advected from above Northern Sea, passing Denmark and Baltic Sea (500 m), Northern Tip of Germany (1500 m), and The Netherlands and Northern Germany (3000 m). The aerosol optical thickness varied from 0.12 to 0.24 (for 500 nm) and scattering coefficient from 20 to 50 Mm-1 (for 450 nm). Low black carbon background concentration of ~500 ng m-3 was measured, with a peak of 1700 ng m-3 between 4-6 UTC. Lidar and ceilometer measurements showed turbulent-like filaments above the boundary layer from 0 to 6 UTC, followed by morning boundary layer transition into a decoupled mixed layer and a fair-weather cumulus.

For the South flow on August 27, the trajectories led from the Mediterranean coast (1500 and 3000 m) and from Romania via Ukraine (500 m). For this day the fires in the Ukraine and the Balkan Peninsula were reported and the NAAPS model showed elevated smoke concentration above Sopot (>2000 ng m-3). Our ground based measurements also showed high concentration of black carbon in the range of 1000-3000 ng m-3. The aerosol optical thickness varied from 0.3 to 0.5 (for 500 nm) and the scattering coefficient from 50 to 200 Mm-1 (for 450 nm). Lidar data showed low values of attenuated backscattering at around midday, when the black carbon concentrations were the highest.

A preliminary estimation of aerosol radiative forcing at 12 UCT using the MODTRAN model for the different advection cases results in roughly 10 W m-2 for the Arctic air case and roughly 50 W m-2 for the vegetation fire case.