Aerosol optical properties in the atmospheric surface layer over the Baltic Sea

A. Rozwadowska, P. Makuch, P. Markuszewski, T. Petelski, D. Gutowska and P. Pakszys

Institute of Oceanology, Polish Academy of Sciences, Sopot, 81-712, Poland
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Presenting author email: ania@iopan.gda.pl

The Baltic is surrounded with land. The atmosphere over the sea is influenced by both marine and continental air masses. The inland location of the Baltic affects atmospheric aerosol optical properties, which are shaped by both the advection and local aerosol generation in the Baltic region. Ship-born studies of aerosol optical properties over the Baltic are scarce and they are mainly limited to the measurements of aerosol optical thickness (e.g. Kuśmierczyk-Michulec at al., 2001, Kuśmierczyk-Michulec at al., 2001). In the period from 2011 to 2015, measurements of aerosol scattering coefficients (total and backward) and absorption coefficient were performed during research cruises of r/v Oceania to the Baltic sea. The aim of this paper is to distinguish classes of aerosols optical properties observed over the Baltic Sea and to characterize these classes with respect to the season, predominating advection direction (air mass trajectory), near surface sulfate concentration and wind velocity which is a proxy of local aerosol generation.

During the cruises to the Baltic sea the scattering coefficients were measured with the integrating nephelometer model 3563 (TSI). The absorption coefficient was retrieved from simultaneous measurements of the scattering coefficients and transmittance of aerosol accumulated on a filter (aethalometer AE31, Magee Scientific Company). The aerosol measurements were accompanied with the standard meteorological observations. Six-day backward trajectories of the air inflowing at 500 m over the stations during optical measurements were computed by means of the HYSPLIT model (Draxler *et al*., 2003). The surface concentrations of smoke, sulfates and desert dust from the NAAPS model were also used in this study (http://www.nrlmry.navy.mil/aerosol-bin/aerosol/display_directory_all_t.cgi?DIR=/web/aerosol/public_html/globaer/ops_01/europe/).

Based on the measured scattering and absorption coefficients we calculated backward to total scattering coefficient ratio and single scattering albedo for wavelength λ=550 nm and Ångström exponent of the extinction coefficient for wavelengths λ=450 nm and λ=700 nm. An application of non-hierarchical cluster analysis (k-mean method, e.g. Friedman et al., 2009) to these aerosol optical properties allowed us to distinguish six classes of atmospheric aerosol over the Baltic. We did not uses extinction coefficient in this classification, because it characterizes aerosol concentration rather than an aerosol type.

Our study shows that differences in the aerosol optical properties among the clusters relate to the dominating directions of air mass advection (HYSPLIT) as well as differences in the wind velocity at the measuring stations and the near surface sulfate concentration (NAAPS), which is an indicator of anthropogenic influences. For example, for the cases belonging to the cluster with low values of back-to-total scattering ratio and Ångström exponent and high single scattering albedo, the advections from the NW-N_NE sector predominated. This cluster is also characterized by low mean extinction coefficient (0.02 Mm^{-1}), low sulfate concentration (the mean concentration <0.05 $\mu m\ m^{-1}$) and the mean wind velocity of 6 $m\ s^{-1}$. In the cluster with low values of back-to-total scattering ratio and large values of Ångström exponent, high sulfate concentration (2.4 $\mu m\ m^{-1}$) with relatively high mean wind velocity (7 $m\ s^{-1}$) and high mean extinction coefficient (0.08 Mm^{-1}) were observed. In the cluster with the highest Ångström exponent the air advections from the SE-S-SW sector dominated. This cluster was also characterized with high mean extinction coefficient (0.09 Mm^{-1}) and high mean sulfate concentration (3 $\mu m\ m^{-1}$).

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