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Aerosol Optical Properties over Northwestern European Seas

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Atmospheric aerosols, both natural and anthropogenic, can affect the regional and global climate through their direct, indirect, and semi-direct effects on the radiative energy budget of the Earth-atmosphere system. In order to quantify these effects it is necessary to determine the aerosol load. An effective way to do this is by measuring the aerosol optical depth (AOD). Besides AOD, the Fine mode Fraction (AOD of particles smaller than 1 μm / total AOD, FF) is a useful parameter for the characterization of the aerosol and provides a good proxy for particle size.

In this study, we investigate the spatial and temporal variability of the AOD and FF over the Western and Northwestern European Seas (43° N – 67° N, 10° W – 31° E), where significant sources of both natural and anthropogenic particles are located. Anthropogenic particles (mostly fine mode) originate from ship activity, or from urban-industrial and biomass-burning processes in the European countries. The natural, coarse mode particles are primarily sea salt. The study is performed using Collection 006 Level-3 mean daily aerosol data from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on board Aqua satellite, available in 1° $\times$ 1° resolution (ca. 100 km $\times$ 100 km) over the period 2002- 2014.

Our results indicate significant spatial variability of the aerosol load over the study region. The highest AOD values (up to 0.32 on annual level) are observed over the English Channel and the coasts of the Netherlands and Germany. In these regions the highest FF values are also observed (up to 0.77), indicating a relatively large contribution of anthropogenic particles to the aerosol load. Offshore, both AOD and FF are lower compared to coastal regions, indicating the predominance of maritime aerosols (sea salt). The data also show a clear seasonal cycle, with larger aerosol load during spring and summer (AOD up to 0.60), and lower during autumn and winter (AOD up to 0.30). A similar pattern is observed for FF indicating a larger contribution of anthropogenic particles during spring and summer compared to autumn and winter. The highest FF values (up to 0.80- 0.85) are observed over the Baltic Sea during summer while year-round the lowest values are observed in remote maritime areas, mostly in the northern part of our study region, highlighting the predominance of sea salt particles.

The AOD exhibits a generally decreasing trend (slope between -0.18 to 0.05 per decade). Positive values are observed over the northwestern ocean areas (sea salt dominated), while over most of our study region the slope is of the order of -0.02 to -0.05 per decade. These trends are possibly associated with a reduction of the anthropogenic emissions.