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North Atlantic Oscillation affecting aerosols ground levels over Europe through local processes: asymmetries in time and space

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Air pollution is a major environmental and health problem. Hence, understanding when and why episodes of air pollution arise becomes essential. Besides emissions, air pollution levels depend on the atmospheric conditions handling and transforming them through processes related to chemistry, transport and removal. In this sense, this contribution assesses the variation in ground-level aerosols concentrations over Europe associated to changes in the phase of the North Atlantic Oscillation (NAO) motivated by the well-known strong impact of the NAO on the European climate variability. For that we used a high-resolution (25 km) air quality simulation spanning the period 1970-1999 and covering western Europe and most of the Mediterranean basin. Additionally, we used observed aerosol data from the EMEP database whose observational periods range between 1993 and 2010. The simulation was performed by using climatological boundary conditions for the aerosols concentrations, hence allowing to isolate the influence of the local atmospheric processes, as they are governed by the NAO, on the levels of the various aerosol species analyzed (namely sea salt, wind-blown and resuspended dust, secondary inorganic aerosols, organic matter and elemental carbon) from the influence of large-scale mechanisms. The results highlight that positive NAO phases favor increased aerosols levels in southern (northern) regions in winter (summer), while negative NAO phases enhance them in northern (southern) regions in winter (summer), being generally in good agreement with the analysis based on the observational database. Variations are up to and over 100% for most aerosols, being clearly related to the NAO-impact on local precipitation and wind, as they act to clean the atmosphere through removal and dispersion processes, but equally resulting from the NAO-impact on the radiation balance (i.e. cloudiness) as it rebounds on the biogenic emitting activity and on the oxidative capacity of the atmosphere. Beyond deepening the knowledge of fundamental relationships between climate and air quality, this study provides a basis for (1) improving the potential short-to-medium range predictability of air pollution episodes, since much work is being done in order to gain accuracy in the NAO predictions, and (2) interpreting long-term future projections of the NAO evolution in terms of air quality.