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Trends of inorganic and organic aerosols in Europe: insights from the EURODELTA multi-model experiment over the 1990 – 2010 period

Giancarlo Ciarelli and the EURODELTA team

Laboratoire Inter-Universitaire des Systèmes Atmosphériques (LISA), UMR CNRS 7583, Université Paris Est Créteil et Université Paris Diderot, Institut Pierre Simon Laplace, Créteil, France

Several studies have shown a significant reduction in particulate matter (PM) concentrations over the past decades in Europe. However, only a few have investigated the evolution of the single PM components, i.e. inorganic and organic phases, after the enforcement of emission reduction strategies took place. The trends in PM components might be different because of the different chemical regimes in different European regions and the non-linear response of PM to emission precursors changes. Thus, knowing how the chemical composition of PM has evolved during the last decades could provide more insight for future air quality legislation.
In the framework of the Eurodelta-Trends (EDT) modeling initiative, several Chemical Transport Models (CTMs) were applied for the 1990 – 2010 period in order to investigate air quality changes in Europe due to enforced emission reduction strategies. Common anthopogenic emissions were used by the modeling teams based on the estimates retrieved from the Greenhouse gases and Air pollution Interactions and Synergies (GAINS) model. Model simulations were conducted at 0.25° and 0.4° resolution in latitude and longitude, respectively, with a domain extent from 17° W to 39.8° E and from 32° S to 70° N. Up to five CTMs have provided air quality model data for 21 continuous years (i.e. CHIMERE, EMEP, MATCH, LOTO and MINNI).
For this study, we combined consolidated long-term air quality measurements of sulfate, total nitrate, total ammonium as well as sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) available at different sites in Europe for the 1990 – 2010 period with CTMs output data as available in the Eurodelta-Trends exercise.
Comparisons between modeled and measurements data showed a relatively good agreement between the models ensemble and the measurements data. In particular, the faster decline in SO_2 and sulfate concentrations in the first analyzed decade (1990 – 2000) compared to the second one (2000 – 2010) was well captured by the models ensemble. For the total nitrate and total ammonium concentrations, both the measurements and the models ensemble showed a rather flat trends for both periods, with larger differences in trends significance occurring at single stations level. Trends in secondary organic aerosol (SOA) were also investigated together with the trends in biogenic volatile organic compounds (VOCs) emissions. For the models that provided biogenic emission data, a statistically significant increase in biogenic emission (i.e. isoprene and monoterpene) was found along with an increase in the relative contribution of biogenic SOA (B-SOA) to the total SOA.
Finally, an evaluation against positive matrix factorization (PMF) data, available during the second decade, revealed a systematic under-estimation of the modeled SOA fraction with large differences among the models, likely because of the different levels of complexity of the SOA schemes.