

The effect of sulfur and nitrogen emission reductions on PM concentration in various smog regimes

Rita Van Dingenen, Jean-Philippe Putaud, Alessandro dell'Acqua, Sebastiao Martins-Dos Santos, Luca Pozzoli, Maria Grazia Perrone, Frank Raes

Exceedance of limit values of fine particulate matter (PM₁₀) is still commonly occurring in large parts of Europe, not only in urban agglomerations but also on regional scale. The same particles that cause adverse health effects, often lead to acidification and may play a role in global climate change. Chemical mass closure experiments have shown that most of the PM₁₀ mass is made of secondary aerosol components (sulfate, nitrate, ammonium, carbonaceous matter). Efficient and cost-effective abatement strategies thus require an understanding of how and how much secondary aerosol is formed from emitted precursors. Nitrate, ammonium and probably many organic species occur in fact as semi-volatile compounds showing a complex gas-aerosol phase partitioning, depending on temperature, humidity and relative concentrations. Therefore, reduction measures will not necessarily lead to a linear response in PM loadings.

Here we explore the link between emissions and ambient concentrations of the major ionic components of sub-micrometer particles for 3 real-world cases. We conducted 3 field campaigns where both aerosol and gas phase of sulfate and semi-volatile nitrogen compounds (nitrate, ammonia) were measured simultaneously, with a high time resolution, and in an artifact-free set-up. The measurements were made in the following conditions: (urban background, winter, high nitrate/sulfate), (regional polluted, summer, high nitrate/sulfate) and (rural, summer, low nitrate/sulfate). The measured partitioning between aerosol and gas phase is reproduced by the aerosol thermodynamics equilibrium model ISORROPIA. The same model is then used to simulate the effect of reductions in total sulfate, nitrate and ammonia on PM. We find that the different smog regimes show very different responses to a given reduction scenario. We also explore how such reductions may affect the atmosphere's radiative properties.