Linking climate change and air quality over Europe: Effects on aerosol concentrations

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Atmospheric particulate matter, a major constituent of air pollution, in high concentrations could have detrimental effects on human health, as well as on visibility and ecosystems (Seinfeld and Pandis, 2006). Concentrations of PM are strongly influenced by meteorology, but when designing air quality strategies it has been traditionally assumed that climate will remain constant. However, climate change over the next decades is expected to be significant (IPCC, 2007) and may impact local and regional PM levels. Determining how PM concentrations change as climate changes is an important step toward estimating future air quality, as it may allow air quality policy planners to relax the assumption of constant climate and meteorology.

In this study we applied PMCAMx (Fountoukis et al., 2011), a three dimensional chemical transport model, in Europe, in order to quantify the individual effects of various meteorological parameters on particulate matter less than 2.5 μm ($PM_{2.5}$). The modeling domain covers a 5400×5832 km^2 region in Europe with a 36×36 km resolution grid and 14 vertical layers extending up to ~6 km in height.

Our simulations covered 2 periods representative of different seasons to examine also the seasonal dependence of the air quality. In addition to a base case scenario for each simulation period, a suite of perturbations in various meteorological factors, such as temperature, wind speed, were imposed to determine the sensitivities of $PM_{2.5}$ concentrations and composition to these parameters.

Fig. 1 shows the predicted average $PM_{2.5}$ changes to various meteorological perturbations over Europe. $PM_{2.5}$ concentrations have on average a negative response to temperature increase in both periods (-31 ng m^{-3} K^{-1} during summer and -60 ng m^{-3} K^{-1} in the winter). Temperature decreased average nitrate (up to 30%) and organic levels (up to 10%), and increased sulfate (up to 10%), during both periods.

The expected changes on wind speed, precipitation rate and absolute humidity are predicted to be as significant as temperature changes. Decreases of wind speed led to changes in advection and transport resulting in average increases in $PM_{2.5}$ concentrations in both periods of 34 ng m^{-3} %$^{-1}$ during summer and 32 ng m^{-3} %$^{-1}$ in the winter. $PM_{2.5}$ concentrations decreased with increasing precipitation rate in both periods (12 ng m^{-3} %$^{-1}$ during summer and 10.9 ng m^{-3} %$^{-1}$ in the winter), due mainly to changes on $PM_{2.5}$ wet deposition (up to 10%). Increases in absolute humidity led to significant changes on semi-volatile aerosol partitioning (up to 20%) and $PM_{2.5}$ dry deposition (up to 50%), while the predicted $PM_{2.5}$ concentrations changes are driven largely by increases in nitrate (up to 30% during summer) and decreases in sulfate (up to 10% in the winter).

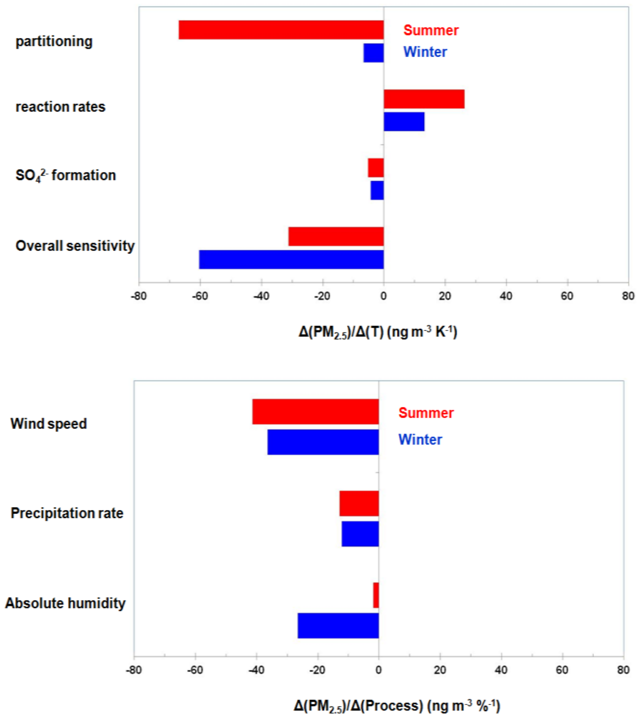

Figure 1. Predicted average $PM_{2.5}$ sensitivities to (a) temperature changes (ng m^{-3} K^{-1}), and (b) other meteorological perturbations (ng m^{-3} %$^{-1}$), during summer and winter.

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Fountoukis, C., et al. (2011) Evaluation of a three-dimensional chemical transport model (PMCAMx) in the European domain during the EUCAARI May 2008 campaign, *Atmos. Chem. Phys*., 11, 10331–10347.

Seinfeld, J. H., and Pandis, S. N. (2006) *Atmospheric chemistry and physics: From air pollution to climate change*, 2nd ed.; John Wiley and Sons, Hoboken, NJ.