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Impacts on Cloud Formation and Radiative Forcing of Co-Condensation of Organic Vapours

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Clouds have a profound influence on weather and climate, dependent on the optical thickness ("brightness") and lifetime of the clouds. These properties are determined by cloud droplet concentrations, which are, in turn, dependent on the composition and number of available seed particles within that particular environment. While the formation of cloud droplets on non-volatile atmospheric compounds is well understood, most particulate matter in the atmosphere is composed of compounds (both inorganic, such as ammonium-nitrate, and organic) with a wide range of volatilities. While the co-condensation of semi-volatile inorganic compounds with water is routinely included in regional atmospheric modelling, the co-condensation of semi-volatile organic compounds is not. Parcel-model studies have, however, shown that this could be a major oversight, potentially leading to significant underestimates (<40%) in cloud droplet number where organic aerosols dominate (Topping et al, 2013). This work will investigate the impacts of the co-condensation of organic vapours within a 3-D regional atmospheric model, to see if these predicted impacts hold true.

For this study we used a modified copy of WRF-Chem v3.8.1. Gas-phase chemistry is represented using CBM-Z whilst aerosol thermodynamics are simulated using the 8-section MOSAIC scheme, including a 9-bin VBS treatment of organic aerosol (after Shrivastava et al, 2011). The MOSAIC-VBS aerosol has been modified to include a water content associated with organic aerosol (calculated using ZSR), and linked to the cloud-phase. Two model versions are used: "base", in which there is no water contribution to the organic aerosol absorptive mass; and "co-cond", in which the water associated with the organic aerosol contributes to this absorptive mass.

We have run the model for a period of 3 days (in mid-summer) over a domain centred on the English Channel and North Sea. This is an anthropogenic-emission dominated region, but contains an extensive maritime boundary layer capped with strato-cumulus clouds (ideal conditions for exploring co-condensation processes). The domain grid spacing is 3km, allowing the effects of co-condensation to be explored without parameterised cloud processes. From these results we will show the impact that co-condensation of organic vapours has on cloud droplet number concentrations. We will also explore the changes in precipitation, and direct, indirect, and semidirect radiative forcings over this domain, and illustrate what the impact of including this process more widely in regional, and global, modelling studies could be.

Shrivastava, et al.: Modeling organic aerosols in a megacity: comparison of simple and complex representations of the volatility basis set approach, Atmos. Chem. Phys., 11(13), 6639–6662, doi:10.5194/acp-11-6639-2011, 2011.

Topping, D., Connolly, P. and Mcfiggans, G.: Cloud droplet number enhanced by co-condensation of organic vapours, Nat. Geosci., 6(6), 443–446, doi:10.1038/ngeo1809, 2013.

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