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Effects of transport emissions on reactive nitrogen and ozone during EMeRGe Europe

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The emissions of the transport sector are a major source of nitrogen oxides in Europe. These nitrogen oxide emissions are directly influencing the air quality and serve, among others, as precursors for the formation of tropospheric ozone. Ozone itself also influences the air quality and contributes to global warming as it is a radiatively active gas. To reduce air quality impacts as well as climate effects of the transport sector these nitrogen oxides emissions should be decreased, but the current public debates show that high nitrogen oxide levels are still a problem in many European hot-spot regions.

These European hot-spot regions have been one target of the airborne measurements with the German research aircraft HALO during EMeRGe Europe in July 2017. These measurements therefore build a perfect starting point to analyse the effects of transport emissions on reactive nitrogen and ozone. However, the measurements themselves only provide information of the total abundance of pollutants in the air. Effects of specific emission sources can not be measured directly but require model based source apportionment methods. Especially for effects of emissions on secondary pollutants such as ozone these source apportionment methods need to be rather complex as the ozone chemistry is highly non-linear.

We performed model simulations for the period of EMeRGe Europe using the MECO(n) model system including such a source apportionment method. This model system couples the global chemistry climate model EMAC with the regional scale chemistry climate model COSMO/MESSy online. The model system is equipped with a tagging method for source apportionment of ozone and the most important ozone precursors. The tagging method is applied on the global scale as well as in all regional refinements (50 km, 12 km and 7 km horizontal resolution), which allows us to quantify effects of European emissions as well as of emissions outside Europe (such as biomass burning events). As the source apportionment method heavily relies on the applied emission inventories, which are highly uncertain, we performed several sensitivity studies accounting for two different anthropogenic emission inventories as well as different biomass burning inventories.

We present results of our source apportionment study for July 2017 focussing on the effects of transport emissions. Monthly mean contributions of European land transport emissions to reactive nitrogen of 10 nmol/mol to 20 nmol/mol are simulated near all hot-spot regions in Europe. The largest contributions to ozone, however, are simulated mainly over Southern Europe (Po Basin, Rome, and Barcelona) and Southern Germany. In these regions relative and absolute contributions to ozone of up to 16 % (8 nmol/mol to 11 nmol/mol) are found. Further, we compare the model results with the measurements along the flight trajectories of the HALO aircraft and demonstrate that the additional model diagnostics facilitate the interpretation of the measurements.