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NESTED HIGH-RESOLUTION NOx AND PM SIMULATIONS OVER ZÜRICH

Ivo Suter, Lukas Emmenegger, and Dominik Brunner
EMPA, Air Pollution / Environmental Technology, Switzerland (ivo.suter@empa.ch)

Reducing air pollution, which is the world's largest single environmental health risk, demands better-informed air quality policies. Consequently, multi-scale air quality models are being developed with the goal to resolve cities. One of the major challenges in such model systems is to accurately represent all large- and regional-scale processes that may critically determine the background concentration levels over a given city. This is particularly true for longer-lived species such as aerosols, for which background levels often dominate the concentration levels, even within the city. Furthermore, the heterogeneous local emissions, and complex dispersion in the city have to be considered carefully.

In this study, the impact of processes across a wide range of scales on background concentrations over Switzerland and the city of Zurich was modelled by performing one year of nested European and Swiss national COSMO-ART simulations to obtain adequate boundary conditions for gas-phase chemical, aerosol and meteorological conditions for city-resolving simulations. The regional climate chemistry model COSMO-ART (Vogel et al. 2009) was used in a 1-way coupled mode. The outer, European, domain, which was driven by chemical boundary conditions from the global MOZART model, had a 6.6 km horizontal resolution and the inner, Swiss, domain one of 2.2 km. For the city scale, a catalogue of more than 1000 mesoscale flow patterns with 100 m resolution was created with the model GRAMM, based on a discrete set of atmospheric stabilities, wind speeds and directions, accounting for the influence of land-use and topography. Finally, the flow around buildings was solved with the CFD model GRAL forced at the boundaries by GRAMM. Subsequently, Lagrangian dispersion simulations for a set of air pollutants and emission sectors (traffic, industry, ...) based on extremely detailed building and emission data was performed in GRAL. The result of this nested procedure is a library of 3-dimensional air pollution maps representative of hourly situations in Zurich (Berchet et al. 2017). From these pre-computed situations, time-series and concentration maps can be obtained by selecting situations according to observed or modelled meteorological conditions.

The results were compared to measurements from air quality monitoring network stations. Modelled concentrations of NO_x and PM compared well to measurements across multiple locations, provided background conditions were considered carefully. The nested multi-scale modelling system COSMO-ART/GRAMM/GRAL can adequately reproduce local air quality and help understanding the relative contributions of local versus distant emissions, as well as fill the space between precise point measurements from monitoring sites. This information is useful for research, policy-making, and epidemiological studies particularly under the assumption that exceedingly high concentrations become more and more localised phenomenon in the future.