EGU21-7044, updated on 14 Jun 2021
https://doi.org/10.5194/egusphere-egu21-7044
EGU General Assembly 2021

Turbulence permitting air pollution simulation for the Stuttgart metropolitan area - A winter case study

Thomas Schwitalla, Kirsten Warrach-Sagi, Hans-Stefan Bauer, and Volker Wulfmeyer
University of Hohenheim, Institute of Physics and Meteorology, Stuttgart, Germany (thomas.schwitalla@uni-hohenheim.de)

Currently a strong discussion is ongoing in Germany and Europe whether to ban vehicles from downtown areas in order to lower particle concentrations of e.g. PM_{10} and NO_2. As often only few measurements exist inside city centers, little to nothing is known about the horizontal and vertical distributions of air pollutants. Within the EU demonstration project Open Forecast (https://open-forecast.eu/), we applied the WRF-Chem model system version 4.0.3 in order to close this knowledge gap. We zoom in the urban area of Stuttgart, a hot spot of air pollution in Germany. The outermost domain with convection-permitting resolution of 1.25 km encompasses parts of Central Europe in order to provide boundary conditions for the inner two domains.

The model system was improved in many ways, e.g., with respect to the representation of land cover, urban canopy, and soil properties, which turned out to be key for an acceptable performance. Furthermore, we developed a sophisticated infrastructure to ingest the required high-resolution emission data, which turned out to be very challenging.

We show that this model approach is likely the best means to understand and to predict air pollution, as the distribution of their constituents depends strongly and simultaneously on the vertical mixing by turbulence, the mesoscale circulation in the complex urban environment, and orographic environment.

The model system was operated and investigated for a case study of January 21, 2019 during which an alert with respect to the exceedance of PM_{10} was issued. We present the simulations of meteorological variables as well as PM_{10} and NO_2 and show the complexity of their distribution in the nighttime stable and daytime shallow boundary layer in dependence of the temporal variability of the traffic in the Stuttgart metropolitan area.

To the best of our knowledge, the results reveal for the first time the complex dynamics of air pollution in complex urban space of Stuttgart at a very high spatial and temporal resolution that cannot currently be achieved with measurements.