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High resolution climatology
- towards climate change services

Downscaling modelling system for multi-scale air quality forecasting

R. Nuterman (1,2), A. Baklanov (1), A. Mahura (1), B. Amstrup (1), and J. Weismann (1)

(1) Research Department, Danish Meteorological Institute, DMI, Lyngbyvej 100, DK-2100 Copenhagen Ǿ, Denmark (ron@dmi.dk; phone: +45-3915-7416; Fax +45-3915-7400), (2) Tomsk State University, TSU, Lenin Ave., 36, 634050, Tomsk, Russia

Urban modelling for real meteorological situations, in general, considers only a small part of the urban area in a micro-meteorological model, and urban heterogeneities outside a modelling domain affect micro-scale processes. Therefore, it is important to build a chain of models of different scales with nesting of higher resolution models into larger scale lower resolution models. Usually, the up-scaled city- or meso-scale models consider parameterisations of urban effects or statistical descriptions of the urban morphology, whereas the micro-scale (street canyon) models are obstacle-resolved and they consider a detailed geometry of the buildings and the urban canopy.

The developed system consists of the meso-, urban- and street-scale models. First, it is the Numerical Weather Prediction (HIgh Resolution Limited Area Model) model combined with Atmospheric Chemistry Transport (the Comprehensive Air quality Model with extensions) model. Several levels of urban parameterisation are considered. They are chosen depending on selected scales and resolutions. For regional scale, the urban parameterisation is based on the roughness and flux corrections approach; for urban scale - building effects parameterisation.

Modern methods of computational fluid dynamics allow solving environmental problems connected with atmospheric transport of pollutants within urban canopy in a presence of penetrable (vegetation) and impenetrable (buildings) obstacles. For local- and micro-scales nesting the Micro-scale Model for Urban Environment is applied. This is a comprehensive obstacle-resolved urban wind-flow and dispersion model based on the Reynolds averaged Navier-Stokes approach and several turbulent closures, i.e. $k-\varepsilon$ linear eddy-viscosity model, $k-\varepsilon$ nonlinear eddy-viscosity model and Reynolds stress model. Boundary and initial conditions for the micro-scale model are used from the up-scaled models with corresponding interpolation conserving the mass. For the boundaries a kind of Dirichlet condition is chosen to provide the values based on interpolation from the coarse to the fine grid.

When the roughness approach is changed to the obstacle-resolved one in the nested model, the interpolation procedure will increase the computational time (due to additional iterations) for meteorological/ chemical fields inside the urban sub-layer. In such situations, as a possible alternative, the perturbation approach can be applied. Here, the effects of main meteorological variables and chemical species are considered as a sum of two components: background (large-scale) values, described by the coarse-resolution model, and perturbations (micro-scale) features, obtained from the nested fine resolution model.