Modelling and forecasting of regional and urban microclimate and air quality

Alexander Baklanov, Allan Gross and Jens Havskov Sørensen
Danish Meteorological Institute, Lyngbyvej 100, DK-2100 Copenhagen, Denmark

In urban and regional air quality studies address the questions:

- How does a contribution of a source influence the concentration of pollutants at a given site?
- What is the most cost-effective strategy for reducing pollutant concentration below an air quality standard?
- How will reduction or addition of a specific air pollutant emission effect the air quality?
- Where should future industrial complexes, freeways etc. be situated in order to minimised its environmental impacts?
- What will the air quality be tomorrow or the day after?

The above questions critically depends on: (i) the mapping of emissions, (ii) the Regional (RAP) and Urban Air Pollution (UAP) models, and (iii) the meteorological data.

Meteorological data from regional scale NWP models have been used to off-line RAP modelling over many decades. Classical examples are ground-level ozone, dispersion and source appointment modelling. However, the feedback from RAP models to the NWP models are not included in these model systems (on-line).

UAP models in operational Urban Air Quality Information and Forecasting Systems (UAQIFSs), as a rule, use simple in-situ meteorological measurements which are fed into meteorological pre-processors. Lacking an adequate description of physical phenomena and the complex data assimilation and parameterisations of numerical weather prediction (NWP) models, these pre-processors do not achieve the potential of NWP models in providing all the meteorological fields needed by modern UAP models to improve the urban air quality forecasts. However, during the last decade substantial progress in NWP modelling and in the description of urban atmospheric processes was achieved. Modern nested NWP models are utilising land-use databases down to 1 km resolution or finer, and are approaching the necessary horizontal and vertical resolution to provide weather forecasts for the urban scale. In combination with the recent scientific developments in the field of urban atmospheric physics and the enhanced availability of high-resolution urban surface characteristics, the capability of the NWP models to provide high quality urban meteorological data will therefore increase.

Despite the increased resolution of existing operational NWP models, urban and non-urban areas mostly contain similar sub-surface, surface, and boundary layer formulation. These do not account for specifically urban dynamics and energetics and their impact on the numerical simulation of the atmospheric boundary layer and its various characteristics.

The presentation will outline the common status of European and DMI activities in the field of urban and regional scale air pollution modelling, with examples from UAP to RAP modelling. These examples are, a description of:

- the new European FUMAPEX (Integrated systems for Forecasting Urban Meteorology, Air pollution and Population EXposure) project. The purpose of the project is to improve meteorological forecasts for urban areas, the connection of NWP models to UAP and exposure models, build improved UAQIFS, and demonstrate their application in cities subject to various European climates. An example of simulation of a hypothetical accident at the nuclear power plant Barsebaek (in Sweden close the the Danish capital) will be shown.
- regional scale ozone forecasts produced at DMI. The purpose of the activity is to inform and warn the public in cases of exceedances of critical limit values.
- an aerosol model recently developed at DMI. The simplicity of the model makes the possible to implement this physics in RAP and UAP models. The aerosol model has been implemented in the chemistry transport model and applied to the problem: DiMethyl Sulphid's influence on aerosol formation in the marine boundary layer and the free troposphere.
- nuclear emergency preparedness at DMI based on the DERMA long-range transport model.

In the examples the NWP model DMI-HIRLAM (HIgh Resolution Limited Area Model) used as meteorological driver.