Methodological aspects of Core-Downstream Service for European Air Quality Forecasts Downscaling from Regional to Street Level

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FP7 EC MACC project — *Monitoring Atmospheric Composition and Climate* (http://www.gmes-atmosphere.eu/) — is the current pre-operational atmospheric service of the European GMES Programme. MACC provides data records on atmospheric composition for recent years, data for monitoring present conditions and forecasts of the distribution of key constituents for a few days ahead. MACC combines state-of-the-art atmospheric modelling with Earth observation data to provide information services covering European Air Quality, Global Atmospheric Composition, Climate, and UV and Solar Energy.

Methodology and Configuration of Downscaling Modelling System

Due to increasing supercomputer power modern nested numerical meteorological and air pollution models realize model nesting/downscaling from the global to the local scale and approach the necessary horizontal and vertical resolutions to provide weather and air quality forecasts for urban and local scales. Most of urban simulations for real conditions consider only a small part of the urban area in a micrometeorological model and urban heterogeneities outside the simulation domain affect the micro-scale processes. Therefore, it is important to build a chain of models of different scales with nesting of high resolution models into larger scale lower resolution models. The methodology for provision of downstream services (downscaling modelling system) is suggested for the city of Copenhagen.

Usually, the up-scaled city-scale (sub-meso) or meso-scale models consider parameterizations of urban effects or statistical descriptions of the urban building geometry, whereas the micro-scale (street canyon) models are obstacle-resolved and consider a detailed geometry of the buildings and the urban canopy.

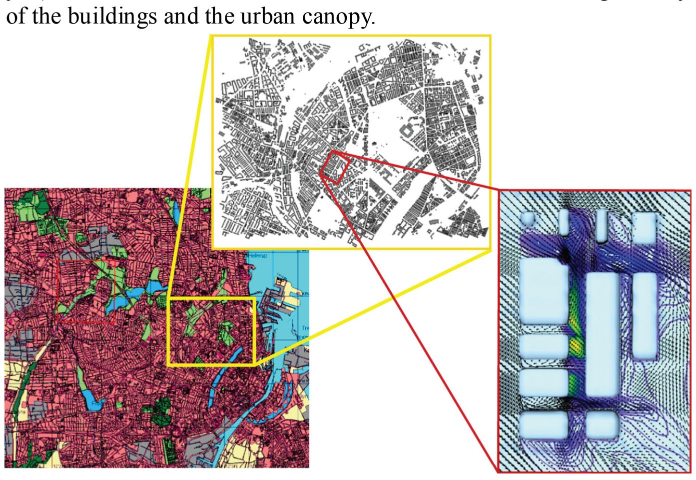

Figure 4. Micro-scale Model for Urban Environment (M2UE) downscaling for the selected Copenhagen area (Jagtvej street).

According to MACC Description of Work (DoW) the first element in the chain should be ensemble forecast from regional/ meso-scale models as input for DMI's downscaling system (Figs.1 and 3). After that two nested domains are used for downscaling from the regional- to meso- and city-scale using

- on-line integrated Numerical Weather Prediction – Atmospheric Chemistry Transport (NWP-ACT) modeling system so-called the Enviro-HIRLAM (Environment - HIgh Resolution Limited Area Model) (*Korsholm et al., 2008; Baklanov et al., 2008; Korsholm, 2009*)

OR

- off-line modeling system consisted of the HIRLAM (http://hirlam.org) and CAMx (http://www.camx.com) models, the so-called CAC (Chemistry-Aerosol-Cloud) originated from a chemistry aerosol model used for stratospheric applications (*Madsen, 2006*) and further adapted for troposphere including chemistry-aerosol-cloud module (*Gross & Baklanov, 2004*).

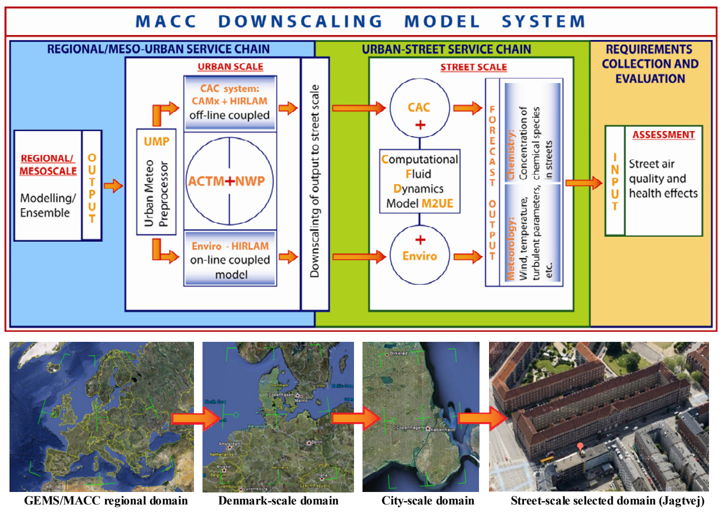

Figure 1. Downscaling of the European-scale forecasts for the city and streets in Copenhagen.

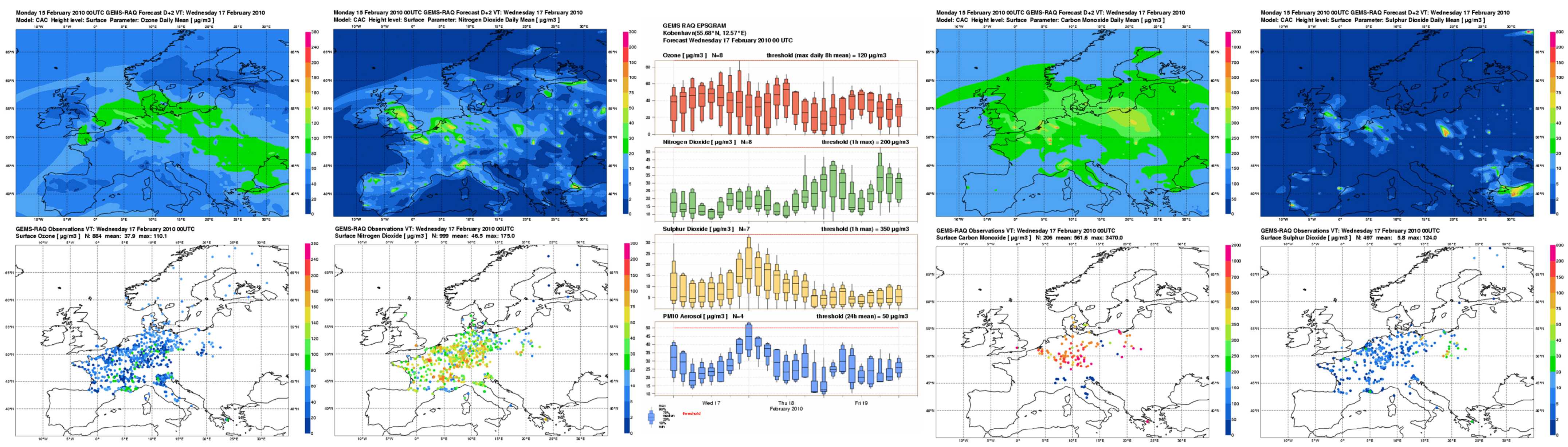

Figure 2. The GEMS-RAQ (by CAC = CAMx+HIRLAM) forecasts (Day+2) for the surface concentrations (in μg/m^3) of chemical species (ozone, nitrogen dioxide, carbon monoxide, and sulphur dioxide) vs. observations on 17 Feb 2010, 00 UTC; and the epsigrams for Copenhagen.

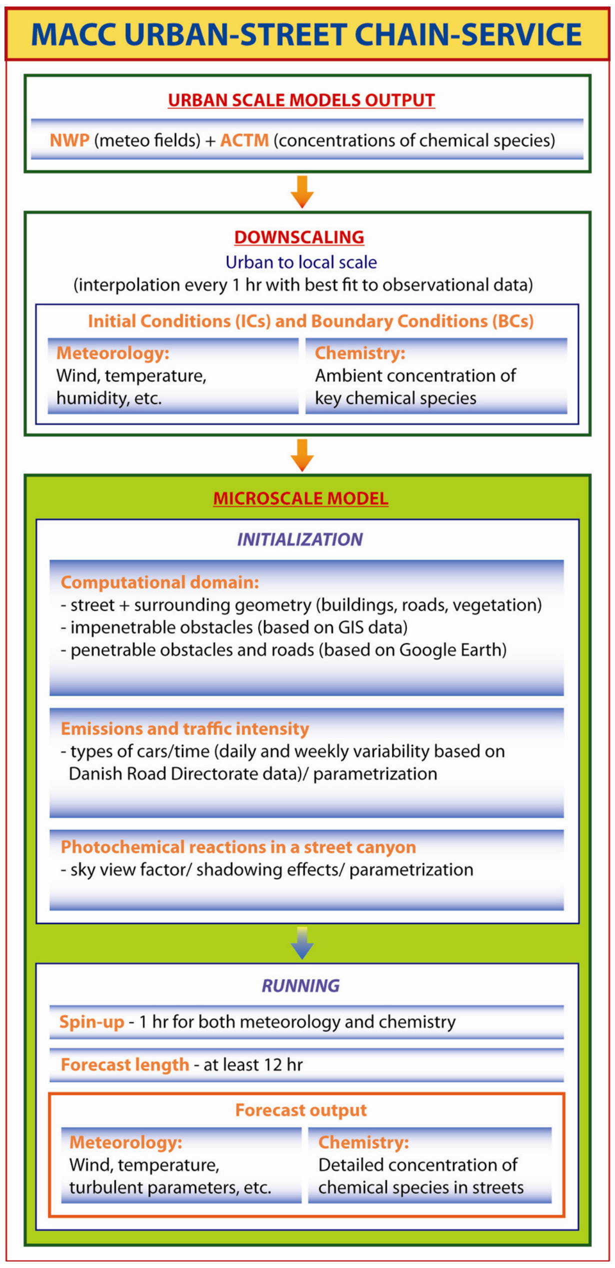

Figure 3. MACC Urban-Street Chain Service for Copenhagen.

Several levels of urban parameterization are planned to use in the chain, they could be chosen depending on considered scales (*Baklanov et al., 2008*). For regional scale the urban modules are based on different approaches such as modifications of anthropogenic heat flux, roughness, albedo, building effects, land-use, etc. For local- and micro-scale nesting the Micro-scale Model for Urban Environment (M2UE) model is used (*Nuterman, 2008; Nuterman et al., 2008; Baklanov & Nuterman, 2009*). It is a comprehensive Computational Fluid Dynamics (CFD) type obstacle-resolved urban wind-flow and dispersion model. It is based on the Reynolds averaged Navier-Stokes approach. Boundary and initial conditions for the nested M2UE model are used from the Enviro-HIRLAM or CAC with corresponding interpolation keeping the mass-consistency. An example of nesting from urban to street scale is shown in Fig. 4, and results of street-scale simulation are shown in Fig. 5. For our simulations the perturbation approach can be recommended, where main meteorological variables (or chemical species) are considered as a sum of two components: background (large-scale) values, described by the coarse-resolution model, and perturbations due to micro-scale features, described by the nested fine resolution model.

Evaluation of Current Regional-Scale Forecast

The finalized FP6 EC GEMS (*Global and regional Earth-system Monitoring using Satellite and in-situ data*; http://gems.ecmwf.int) project developed an operational medium-range forecast / assimilation capability for dynamics and composition, exploiting all available satellite data. The forecasts provide information on long-range transport of air pollutants to the regional forecast models including DMI model. The generated air pollution maps for different chemical species from individual models and ensemble of models can be used for regional air quality applications. Examples of modelled and measured surface concentrations for selected chemical species are shown in Fig. 2 (based on output of DMI modeling system); see details in *Baklanov & Mahura (2010)*.

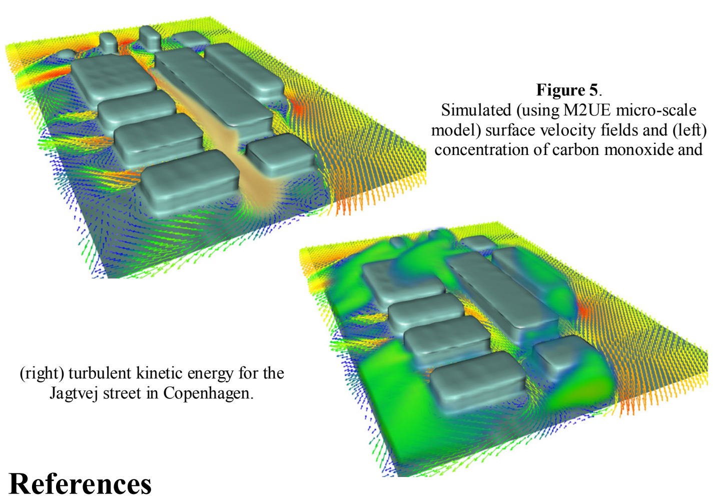

Figure 5. Simulated (using M2UE micro-scale model) surface velocity fields and (left) concentration of carbon monoxide and (right) turbulent kinetic energy for the Jagtvej street in Copenhagen.

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