A high resolution hybrid modelling system for the evaluation of urban concentrations

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Urban areas are characterized by high levels of pollution, produced mainly by anthropogenic sources. The urban morphology introduces a strong spatial variability that cannot be captured by an usual operational Air Quality network. To this aim a hybrid modelling system based on CAMx chemistry transport model (www.camx.com) and AUSTAL2000 (www.austal2000.de/en/home.html) lagrangian particle model has been set up and evaluated.

The CAMx model, is used to calculate the background concentration levels due to the emissions surrounding the local scale area, but switching off the local scale emissions, thus avoiding a double counting of their contribution to the final concentration. The local scale concentrations are estimated by AUSTAL and then superimposed to CAMx background concentration in order to build the final concentration field.

This work estimates the spatial variability of concentrations of pollutants over a small area in the centre of Milan for January and June 2010. CAMx is implemented over 3 different grids, with the last one centred on Milan with a 1.7 km horizontal resolution. CAMx accounts for all sources, also including chemical reactions. AUSTAL2000 is implemented over a 20 m resolution domain placed in the centre of Milan and roughly corresponding to one CAMx cell. Within AUSTAL2000 domain, only 2 source categories are included: road transports handled as linear emissions and residential heating simulated as aloft point emissions placed over buildings. Both models are driven by meteorological model WRF.

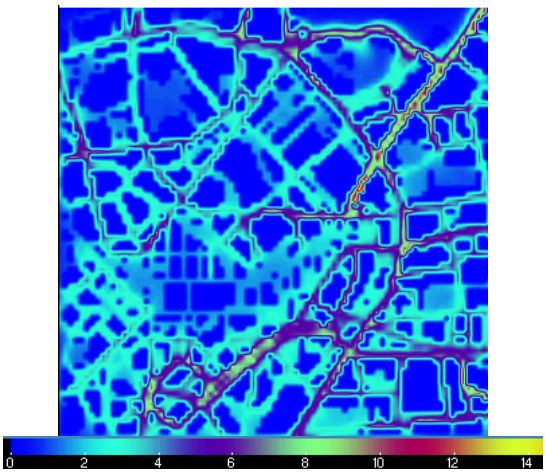

Figure 1. $PM_{2.5}$ [$\mu g/m^3$] – January mean concentration field simulated by AUSTAL at the ground.

As an example, Figure 1 shows the $PM_{2.5}$ monthly mean concentration computed by AUSTAL over the local scale domain. The figure points out the capability of the model to capture the strong spatial gradient of the concentration and the clear pattern of the main roads.

The sum of CAMx background concentration and local contribution, estimated by AUSTAL2000, represents the total concentration. In Figure 2 the sum of blue and green area is the total NO_X concentration estimated at a measuring site, while the red line shows the total concentration computed applying just CAMx.

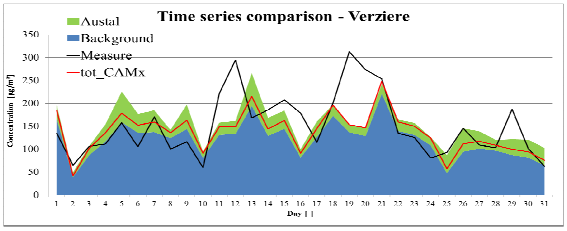

Figure 2. Comparison of measured (black) and estimated NO_X concentrations in January 2010 at Verziere site.

The introduction of the hybrid system generally yields an increase in the total modelled concentrations, in some cases improving the model performance. The background concentration represents the prevailing contribution, with the local scale emissions yielding a greater contribution during more stagnant conditions. The overestimation taking place during the first part of the month seems mostly due to the CAMx background.

Similar analysis have been performed for PM_{10} (Figure 3), but showing a systemic underestimation, not filled by that the introduction of the hybrid modelling.

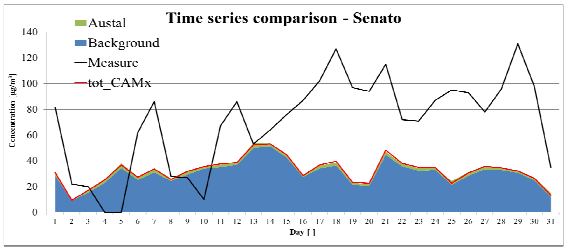

Figure 3. Comparison of measured (black) and estimated PM_{10} concentrations in January 2010 at Senato site.

A sensitivity analysis has been performed too, in order to investigate the influence of some key assumptions of both models such as: the description of the vertical diffusion, the vertical resolution of the AUSTAL model, and the emission gridding.