EULERIAN MODELLING APPLICATION FOR A HIGHWAY AIR QUALITY IMPACT ASSESSMENT

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1 – A NEW HIGHWAY IN THE VENETO REGION

The ‘Passante di Mestre’, the blue line in Figure 1, is a new highway, part of the A4 Italian motorway, in the Eastern area of the Veneto Region, opened to traffic at the beginning of 2009. About 33 km long, it allows the West-East long distance traffic between Turin and Trieste and toward Eastern Europe to by-pass the ‘Tangenziale di Mestre’ (green line), the local beltway of the Venice mainland. In this way, the Mestre ring road, formerly driven by 150,000-170,000 vehicles per day, is now used by local traffic among the three towns of Padua, Treviso and Venice.

The atmospheric modeling system described in this study allowed to conduct a scenario analysis of the air quality state based on hypotheses about the traffic fluxes induced by the new route on the whole road network around Mestre.

2 – MODEL AND SIMULATIONS FOR THE AIR QUALITY ASSESSMENT

The atmospheric modeling system (AMS) consists of four subsystems used respectively to reconstruct flows and related turbulence parameters, apportion data from the emission inventories to grid cells, perform air quality simulations over the selected domain and compute air quality indicators required by the EC directives. The AMS is based on FARM model that has been applied with the SAPRC-90 chemical mechanism and the aero chemical model scheme implemented in CMAQ framework. Time varying boundary conditions for all modelled species on the regional domain have been derived from the corresponding three-dimensional fields coming from PREVAIR system based on CHIMERE chemistry-transport model. Meteorological fields needed by FARM model have been provided by means of the diagnostic model SWIFT/MINERVE using local data coming from the regional meteorological network. The meteorological fields together with land cover information (e.g. roughness length) and chemical species characteristics (gas reactivity), have been then used by interface module GAP/SURFPRO to produce dry deposition velocities and turbulent diffusivity fields needed by FARM.

Domain

The modeling system has been applied on a 60 x 50 km² domain (map in Figure 2), with a 1-km horizontal resolution, including, besides the Mestre-Venice urban system, also the larger Padua – Treviso – Venice urban area, involved in the road network reorganization. The horizontal resolution choice is the result of a balance between a quite detailed description of the emission line sources and the computational time.

Emission scenarios analysis

The emissions coming from diffuse sources over the considered domain were derived from the national emission inventory for the year 2000 (APAT, 2004) that was projected to the simulated year using national trends differentiated for sector and activity. A more detailed approach has been adopted to estimate emissions coming from major industrial facilities and traffic over the investigated area. The former have been estimated on the basis of an exhaustive inventory that includes major facilities present in the area: thermal power plants, refineries, cement factories, chemical plants and glass factories. As for traffic emissions, the availability of detailed data (flows and velocities for different kind of vehicles: motorcycles, cars, light and heavy duty vehicles, trucks and buses), coming from a traffic assignment model applied on a road network, made up of more than 6000 links, that covers a large part of the investigated area (Venice and adjacent provincies). TRECFC model, that implements COPERF III approach and includes ISAIA emission factors for the treatment of PM, has been used to estimate such emissions.

3 – MODEL PERFORMANCE EVALUATION

In this study the discussion is focused on two pollutants that are critical for the air quality in the Veneto Region namely nitrogen dioxide and particulate matter. For both of them, the current European legislation mirrored in the Italian legislation prescribes that the annual mean concentration should not exceed the value of 40 µg/m².

The model performance is evaluated by comparing the monitoring stations data available for the year 2005 [7 stations for NO2 and 5 stations for PM10 inside the model domain, see station location in Figure 2] and the model results for the base case.

The comparison between computed and measured annual mean concentrations at the monitoring stations both for NO2 and PM10 is represented by the scatter plots in Figure 3. The dotted lines correspond to a difference of ±30% between model and measured data for NO2 and ±50% for PM10, as EU legislation requires for model estimates.

The annual mean concentration of NO2 exceeds the limit value of 40 µg/m² at the sites of Mandria, along the Padua ring road, Mira, along the A4 motorway, and at the industrial site of Malcontenta. At the other sites, the NO2 levels are a little lower than the law limit. At all monitoring stations the PM10 annual mean concentration is above the law limit of 40 µg/m². The model presents a generalized light tendency to underestimate the measured values, however the uncertainty is well between the prescribed value of ±30% for NO2 and ±50% for PM10.

4 – IMPACT ANALYSIS

Figure 4 shows annual mean concentration maps for NO2 (left panel) and PM10 (right panel); at the top panels the base scenario, in the middle the future ones and at the bottom the difference between the future and the base scenario. The difference maps, positive values mean an increase in concentrations for the future scenario. In all the maps the road system and the shoreline are represented as well. In the base scenario map, NO2 records the highest concentrations along the Mestre ring road. High concentrations, exceeding the annual limit value, are calculated along the Padua ring road and at the Venice airport as well. In the difference map the increase in concentration values along the new highway is stronger than the increase along the Mestre ring road.

PM10 highest concentrations, exceeding the annual limit value, are calculated at South of Padua and in the urban area of Mestre. As previously commented for NO2, the PM10 difference map records a stronger increase along the new highway than the decrease along the Mestre ring road.

5 – CONCLUSIONS

This work confirms the capability of modelling techniques to reconstruct a base case scenario (year 2005, assessment) and to evaluate the impact of important infrastructures on air quality levels (future scenario, management). The comparison between observed and estimated NO2 and PM10 concentrations for the base case scenario evidences a good agreement confirming the use of the adopted modeling system to estimate the impact of ‘Passante di Mestre’ on surrounding areas.