MODEL BASED YEARLY AIR QUALITY EVALUATION ON A VERY COMPLEX TERRAIN ALPINE REGION (VALLE D'AOSTA)

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INTRODUCTION

European legislation contemplates the combined use of monitoring data, emission inventories and modelling techniques to assess and manage air quality. Aosta valley is one of the deepest and longest valley of the Alps: the strong terrain complexity of the regional territory has induced the Regional Environmental Protection Agency (ARPA-VdA) to employ 3D dispersion models to study air pollution within this valley. The promising results obtained using Lagrangian particle models (Pession et al., 2005) have suggested to test the capability of the Atmospheric Modelling System (AMS) Aria RegionalTM, based on the 3D Flexible Air quality Regional Model (FARM), to reproduce observed concentration levels in such complex situation.

The AMS has been applied to a first reference year (1999) in a nested way (see Figure 1) starting from national-scale fields (meteorology and pollutants concentra-tions) coming from the national MINNI project (Zanini et al., 2004; Silibello et. al, 2005). The AMS includes four subsystems to: reconstruct flows and turbulence parameters; apportion data from emission inventories to grid cells, perform air quality simulations over the selected domain and compute the air quality indicators required by the EC directives (Figure 2).

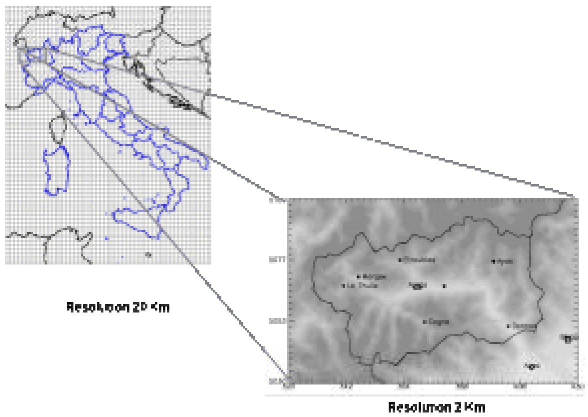

Fig. 1; Nesting from MINNI fields to Valle d'Aosta region.

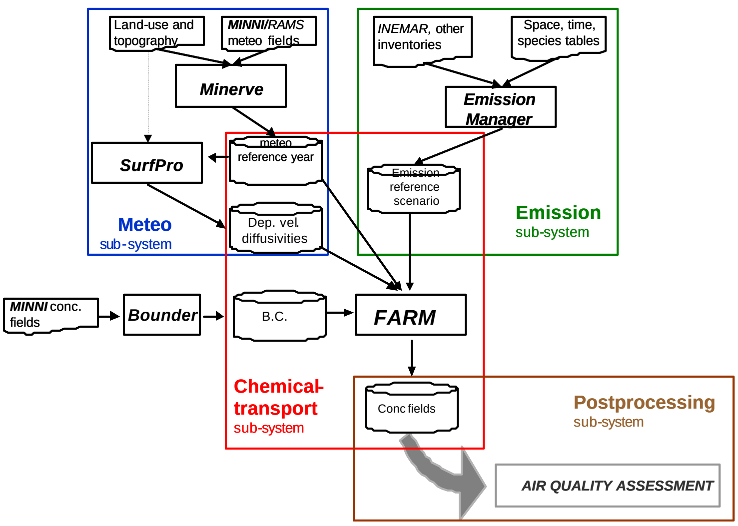

Fig. 2; AMS used to perform air quality evaluation over Valle d'Aosta region from MINNI project.

Emission data coming from the regional inventory have been integrated with data from national and foreign neighbours regions, while meteorological fields have been derived integrating background national scale field, estimated by RAMS model (Cotton et al., 2003), with local surface based observations by means of MINERVE processor (Aria Technologies, 2001). The regional scale meteorological fields together with land cover information (e.g. roughness length) and chemical species characteristics (gas reactivity) have been then used by SURFPRO processor (Arianet, 2004) to produce dry deposition velocities and turbulent diffusivity fields needed by FARM. Boundary conditions for all modelled species on the regional domain have been then derived from the corresponding three-dimensional fields of the national simulation; in such a way the regional-scale simulation takes also into account the influence of sources located outside the selected domain.

RESULTS AND DISCUSSION

FARM (Silibello et. al, 2007) has been originally derived from STEM-II code (Carmichael et al., 1991) and implements different gas-phase chemical mechanisms and two aerosol modules: the aero3 modal aerosol module (Binkowski et al., 1999) and a simplified bulk aerosol module (aero0) based on the approach adopted by the EMEP Eulerian Unified model (EMEP, 2003). For this application FARM model has been applied, coherently with MINNI project, with the SAPRC-90 (Carter, 1990) gas-phase chemical mechanism and the aero0 aerosol module. The extension of the target domain is 110 x 70 km2 (Figure 1), with an horizontal resolution of 2 km, represents a good compromise between representation of terrain and emission inhomogeneities and computational time needed to perform yearly simulations. An evidence of the influence of higher resolution emission and meteorological fields on concentration values and space distribution is given in Figure 3 in which the comparison between NO_2 concentration fields at national (MINNI project) and regional (computed by the AMS) scales is given.

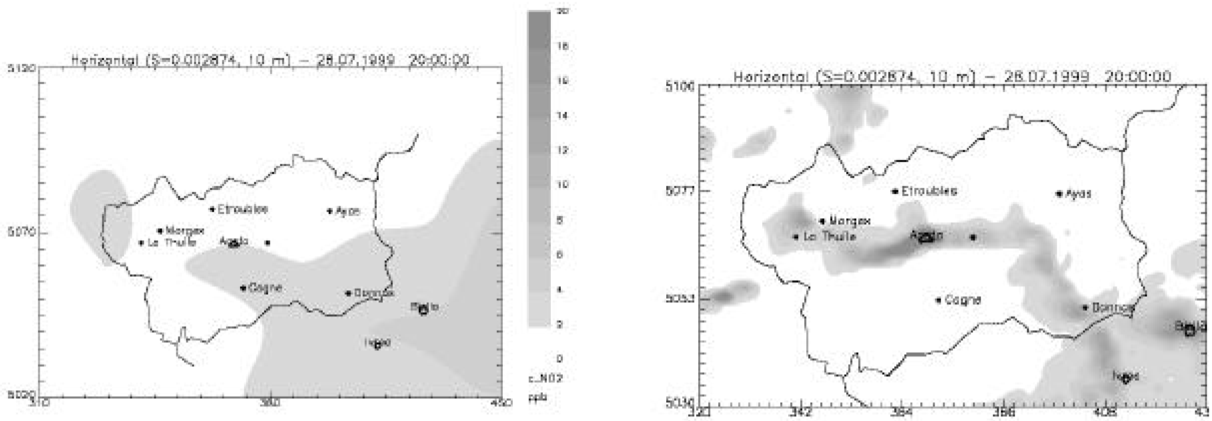

Fig. 3; Examples of NO_2 concentration fields input on 28 july 1999 at hr. 20: MINNI national scale (left) and regional local scale (right).

To check the accuracy of concentration fields at the regional scale, the whole year 1999 has been simulated over the selected domain and simulated concentrations have then been compared with the operational monitoring network data. Examples are given in the following figures that show the comparison between O_3 yearly averages (Figure 4) and measured and computed NO_X and O_3 hourly average concentrations at Aosta during January and July (Figure 5). The analysis of such figures evidences the capability of the AMS to reproduce measured values.

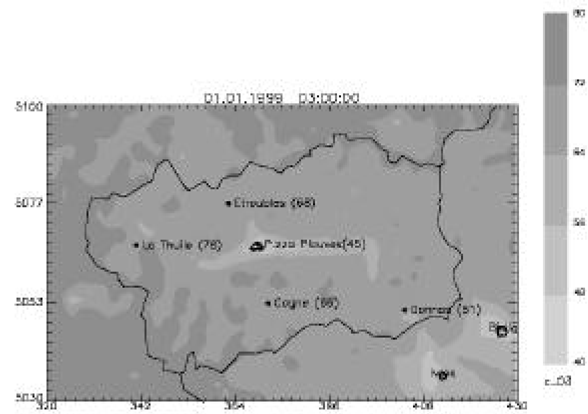

Fig. 4; O_3 yearly average [mg m^{-3}].

In a further phase, spatial distribution maps of air quality target values for the protection of human health and the environment have been produced from hourly computed concentrations fields. Figure 6 shows NO_2 yearly average concentration (limit value: 40 µg m-3) and number of days for which maximum ozone 8-hours mean exceeds the 120 µg m-3 threshold (limit value: 25 days per calendar year).

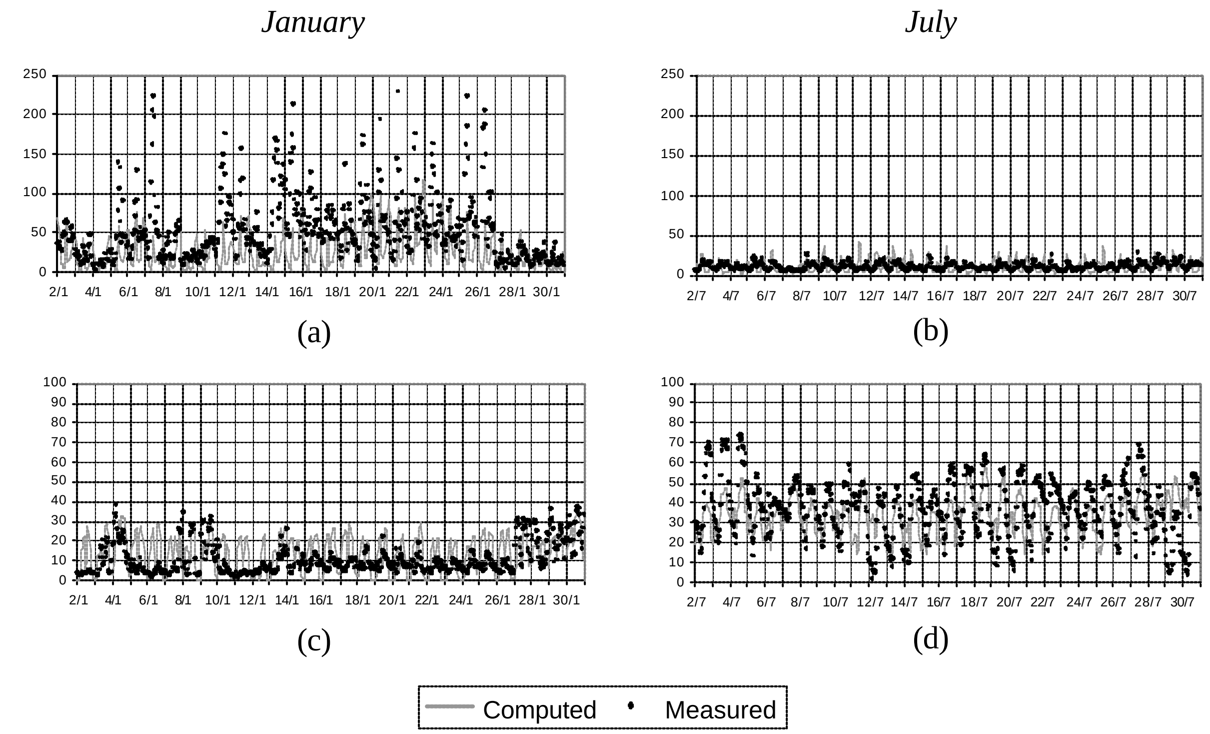

Fig. 5. Aosta – P.zza Plouves monitoring site: comparison between measured and computed NOX (a, b) and O3 concentrations (c, d)[ppb] during January (left) and July (right) 1999.

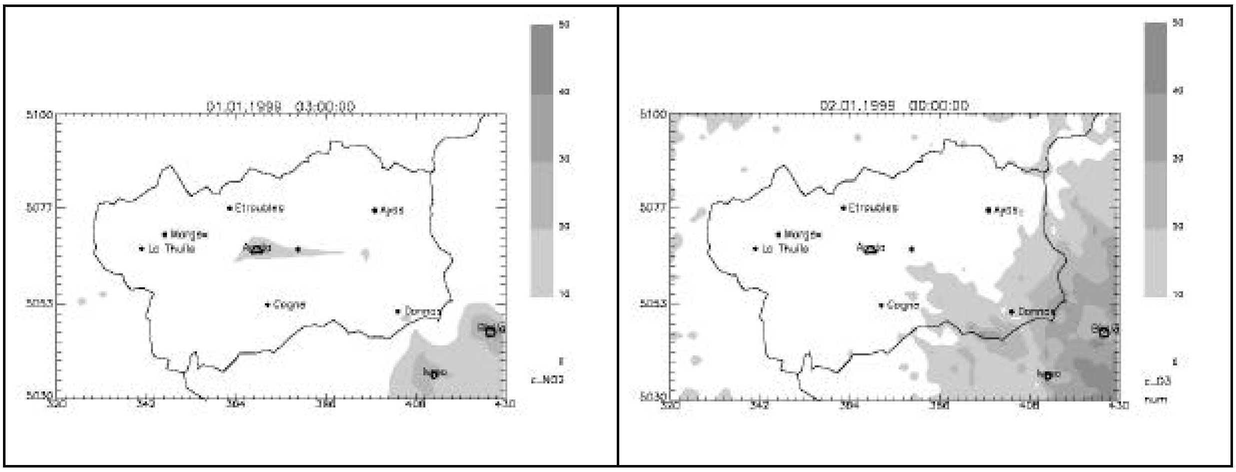

Fig. 6; NO_2 yearly averages (left) and the number of days for which maximum ozone daily 8-hour means exceed the value of 120 mg m^{-3} (right).

Such maps allow to identify zones with pollutant concentrations exceeding limit values and on which, according to 96/62/EC Directive, action plans have to be developed. The analysis of model results evidences non-attainment areas within Aosta city and neighbouring Piemonte urban cores (Ivrea and Biella) for nitrogen dioxide and in south-eastern part of the domain for ozone.

As for PM_{10}, the limited number of experimental sites available during 1999 (one) makes even more significant the information provided by the AMS since this pollutant represents the most relevant environmental concern in Northern Italy, especially during wintertime, when thermal inversion and frequent calm conditions generally lead to elevated particulate levels. Figure 7 shows PM_{10} yearly average concentrations everywhere below the limit value within the Valley. The comparison with experimental data at the Aosta (P.zza Plouves) monitoring site evidences an underestimation for this pollutant (an yearly average of 39 µg m^{-3} was observed) that may be attributed to a number of factors: the uncertainties in the emission inventory, the spatial resolution considered in the study (the horizontal resolution of 2 km may be to low for small size urban sites) and to the adopted aerosol modelling approach not including condensation of organic gases on the atmospheric particulate and resuspension processes.

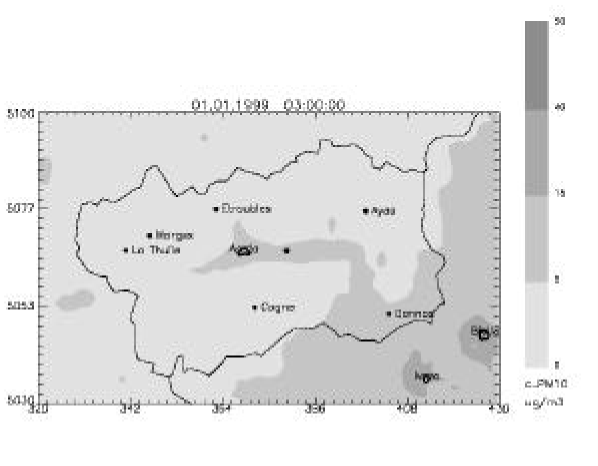

Fig. 7; PM_{10} yearly average [mg m^{-3}].

CONCLUSIONS

The results obtained in this study confirm the importance of air pollution modelling in assessment and management of regional air quality. The complementary use of state-of-the-art photochemical models (adequately fed by meteorological drivers and detailed regional emission inventories) and measurements provided by the air quality networks allows to obtain an adequate description of the spatial distribution of atmospheric pollutants and to identify, according to EU Directives, non-attainment areas for which action plans have to be developed. This study has evidenced a good reproduction of observed levels of NO_X and ozone and allowed to identify non-attainment areas within Aosta city for NO_2 and in south-eastern part of the region for ozone.

These preliminary results encourage the application of the AMS to more recent years and its use to further investigate the impact of future emission control strategies on air quality, both on valley floor and on high mountain. In this perspective a cooperation with Piemonte region, that surround Valle d'Aosta on Southern and Eastern sides, will be pursued integrating emission inventories and air quality data. Results of model simulations over Piemonte region, available at four km horizontal resolution, will be used to provide background meteorological fields and air quality boundary conditions to Valle d'Aosta domain and some subdomains (e.g. Aosta urban area) that will be simulated with a higher horizontal resolution (500 m – 1 km).

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