AN AIR QUALITY FORECASTING MODELLING SYSTEM FOR NOVARA PROVINCE, NORTHERN ITALY

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INTRODUCTION

The Italian law 1999/351, implementing the EU Directive 96/62/CE, assigns to the Regions the task of air quality assessment and management. To fulfil its institutional activities concerning the distribution to the population of air quality information, Piemonte Region (NW Italy) has defined an integrated Air Quality Index (AQI), derived from ground level concentration of critical pollutants for the area (NO_2, PM_{10} and O_3), combining both chromatic and numerical information to simplify the air quality classification and provide an easily understandable indicator of population exposure and health risk level. The recent experience of the European project FUMAPEX (Baklanov et al., 2007; Finardi et al., 2007) showed the feasibility of a high-resolution urban air quality forecasting system based on the application of a Chemical Transport Model (CTM). On the basis of the cited experience and to answer the request of Novara Province administration to provide air quality forecast to local population, ARIANET S.r.l. and the Regional Environmental Protection Agency (ARPA-Piemonte), have developed a forecasting modelling system (ARIANOVA) to calculate hourly concentration fields of all the major pollutants, and the resultant AQI, for the next 48 hours, over the whole Province territory.

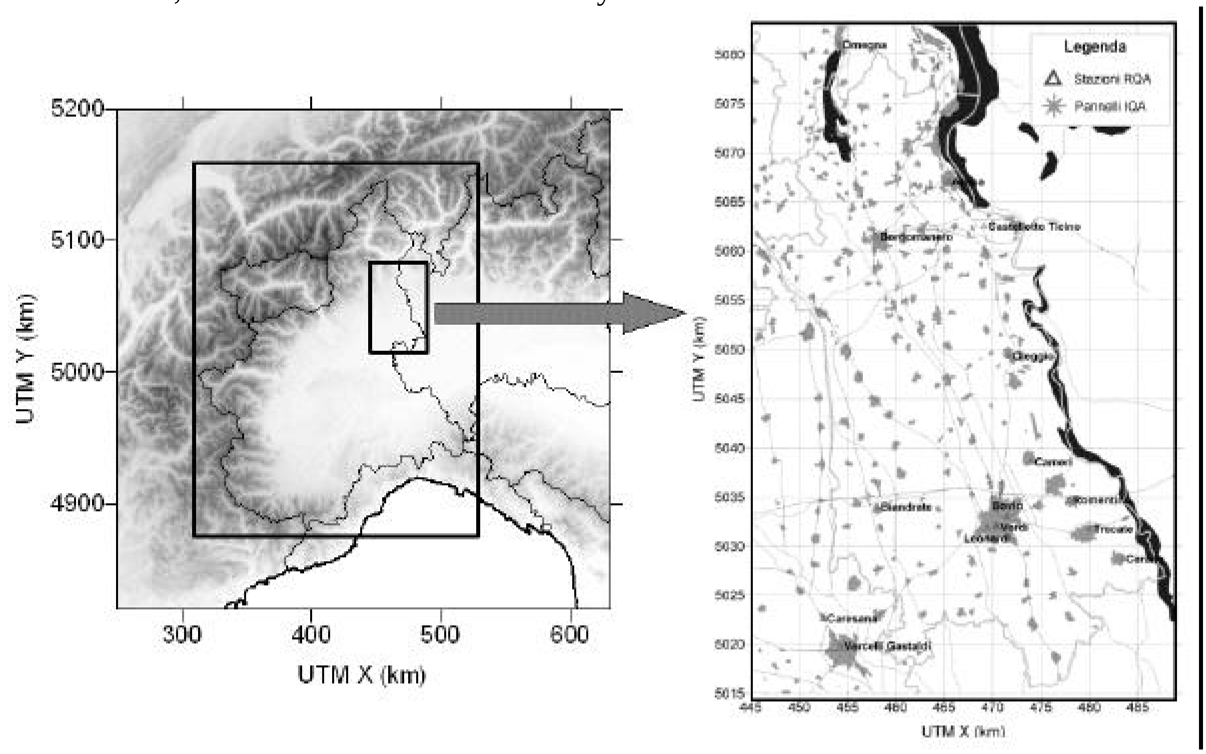


Fig. 1; Outermost and innermost computational domains employed for the forecast modelling system.

The forecasting modelling system employs two nested grids (Figure 1), corresponding respectively to Piemonte Region and Novara Provence, with a space resolution of 4 and 1 km, respectively. This approach allows to take into account the effect of relevant emissions located few kilometers outside of the target Novara domain, such as Milano and Torino urban areas and to better describe phenomena characterized by larger space scales like photochemical smog and PM accumulation processes during unfavorable meteorological conditions.

The following sections briefly describe the forecasting system architecture and structure, present and discuss the preliminary results obtained during the first six months of the system operational life.

ARIANOVA AIR QUALITY MODELLING SYSTEM

The forecasting modelling system ARIANOVA employs state-of-the-art techniques for the emission treatment, pollutants dispersion and chemical transformation modelling in the atmosphere. The ambitious aim of the System is to evaluate ground level concentrations for major pollutants (SO_2, NO_2, CO, PM_{10}, O_3 and C_6H_6) at local scale (1 km) for the current day and the following one. A reliable air quality simulation on such an extent and complex domain (because of the closeness to the Alps, the presence of lakes, the high percentage of urban areas) requires detailed description of the whole investigated area and of major sources located in the surrounding region (e.g. Milan city). This task has been realized by means of nested grids, allowing to downscale background pollution effects to the target domain. The air quality forecast is released every day before 12:00 a.m.

The main components of the forecasting modelling system are briefly resumed in Figure 2.

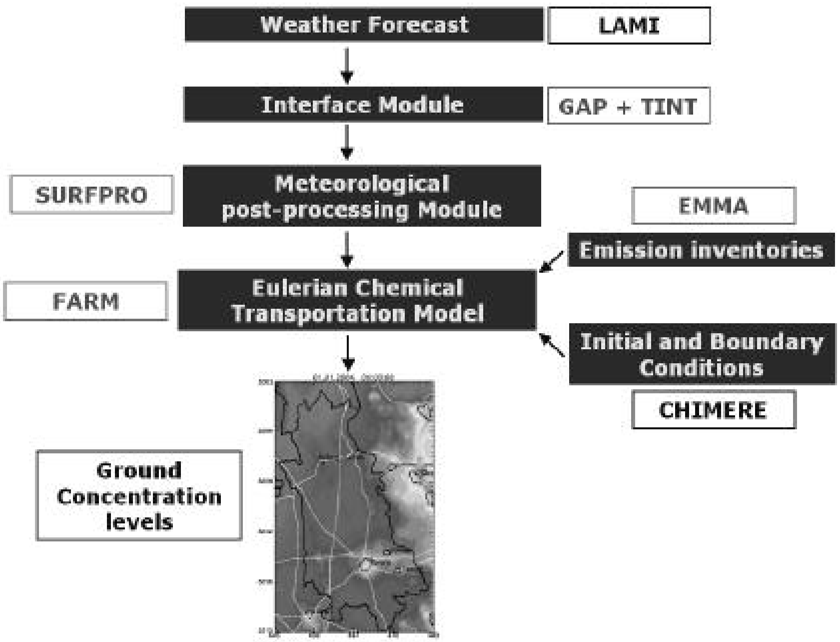
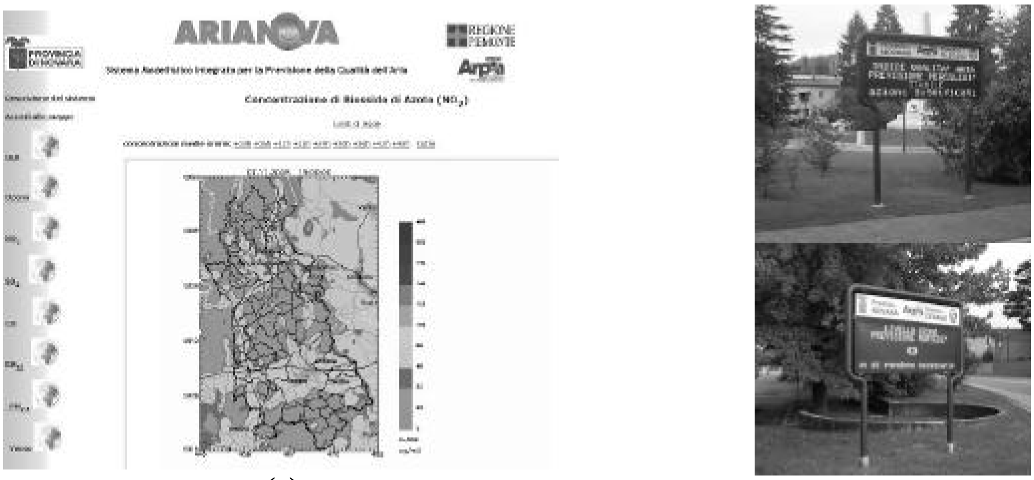


Fig. 2; Interconnection between modules that constitute the ARIANOVA system.

The meteorological fields provided by the Numerical Weather Prediction model LAMI, at 7 km space resolution and 3 hours time frequency, are adapted to the two nested computational domains trough the interface module GAP/TINT (Finardi et al., 2005). The meteorological processor SURFPRO (Arianet, 2004) is then applied to compute dispersion parameters and deposition velocities. The different resolution emissions inventories available over the area (EMEP, national and regional inventories) are treated by the emission processor EMMA, performing spatial disaggregation, time modulation and VOC speciation, to produce gridded hourly emission data. The CTM FARM (Arianet, 2006; Silibello *et al.*, 2005, 2007) is adopted to perform air quality simulations over the selected domains using 2-way nesting technique. FARM, originally derived from STEM II (Carmichael *et al.*, 1991). implements two aerosol modules: the *aero3* modal aerosol module used in CMAQ (Binkowski *et al.*, 1999) and a simplified bulk aerosol module (*aero0*) based on the EMEP Eulerian Unified model (EMEP, 2003) approach. The simplified aerosol scheme is employed in the forecasting system to limit computational time. The air quality boundary conditions for the external domain are built from CHIMERE forecast provided by the *Prev'air* system (http://prevair.ineris.fr). A postprocessing module is finally applied to calculate the air quality indicators required by the EC directives and Piemonte Region AQI and to distribute results to the end users.

The forecasting system is physically composed by two different interconnected units:

1) ARIANOVA Server, running at ARPA Piemonte (Torino): the central air quality modelling applications including all the precedures and tasks previously described and resumed in Figure 2.
2) ARIANOVA Client, running at Provincia di Novara (Novara): a peripheral application automatically accessing the output of ARIANOVA Server, and realising post-processing to distribute air quality forecast to stakeholders and general public. It provides visualisation of hourly concentration fields, generates AQI for current and following day, distributes results in graphic form through web pages, sends local air quality forecast to 16 road informative panels located in different towns of the Novara Province.

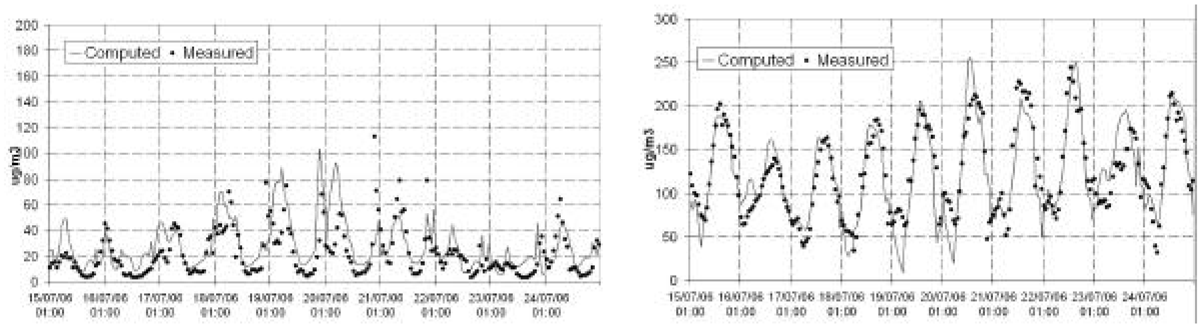


(a) (b)

Fig. 3; ARIANOVA forecasting modelling system provides information easily accessible by population through: (a) web pages, (b) road information panels in 16 sites within Novara Province.

RESULTS AND DISCUSSION

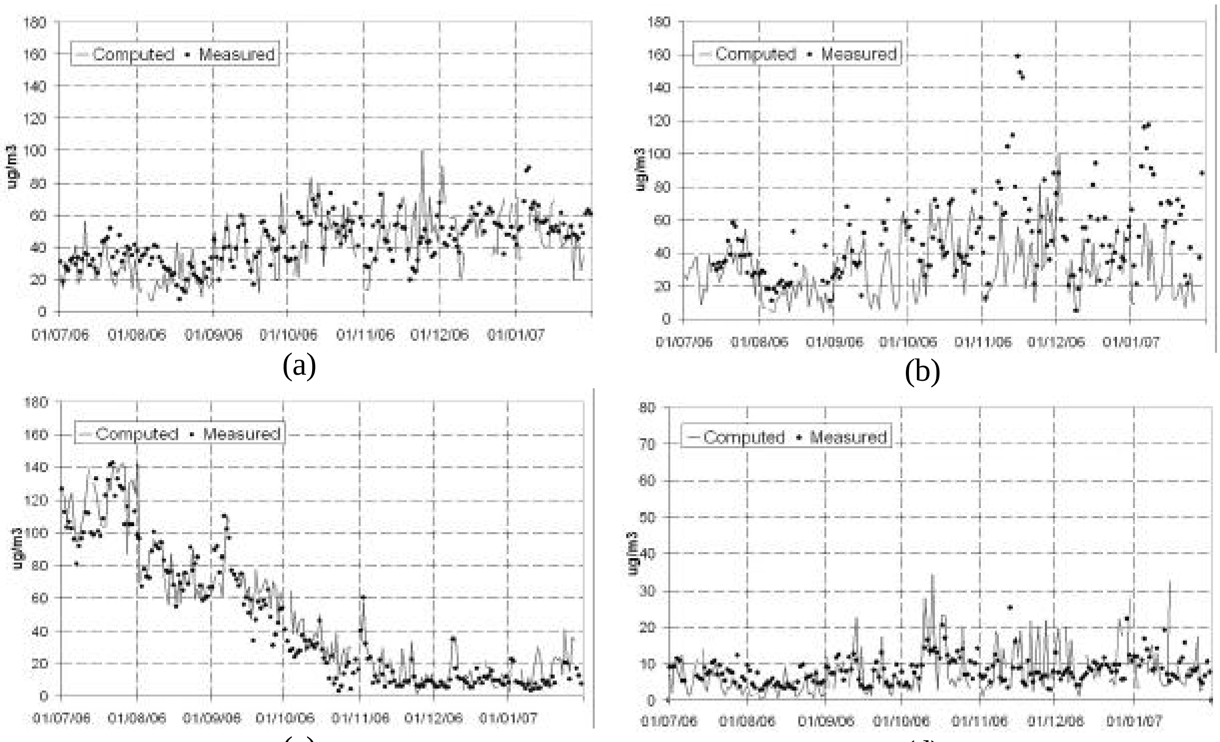
ARIANOVA system started working experimentally at the end of November 2005 and can be considered completely operative from July 2006. The modelling system performances have been preliminary evaluated for the 7 months period July 2006-January 2007 to verify its reliability and individuate weak points for futher improvement. An example of the forecasting modelling system results over a summer period characterised by elevated ozone concentrations is given in Figure 4, where measured and computed NO_2 and O_3 hourly average concentrations are compared during a ten days period. The model is able to forecast O_3 and NO_2 observed values with an appreciable precision.



(a) (b)

Fig. 4; Novara – Via Verdi monitoring site: Comparison between measured and computed hourly ground concentration levels from 15th to 25th July 2006. (a) NO, concentrations b) O3 concentrations.

Figure 5 shows the comparison of measured and computed concentrations for the main pollutants during the whole considered period. Plots refer to daily average concentrations. The comparison over a long period, including summer and winter months, evidences the capability of the modelling system to reproduce seasonal and daily trends.



(a) (b) (c) (d)

Fig. 5; Comparison between measured and computed daily average ground concentration levels. (a) NO_2 concentrations, Novara – Via Leonardi monitoring site (b) PM_{10} concentrations , Novara – Via Verdi (c) O_3 concentrations , Novara – Via Verdi (d) SO_2 concentrations , Novara – Via Bovio.

Very good results have been obtained for O_3, peak values are detected during both summer and winter. Reasonably good results are shown for NO_2 and SO_2. Some overestimation of

NO_2 values is observed between the end of November and the beginning of December, while underestimation is observed at the beginning of January. SO_2 observed discrepancies are considered acceptable due to the low concentration values and to the possible effects of industrial sources whose actual emission are unknown and modelled emissions are estimated from yearly values. PM10 concentration forecast is rather good for summer and autumn, while underestimation can be noticed during wintertime, when the modelling system has difficulties to forecast very high concentrations affecting the Po valley, e.g. around mid November and beginning of January.

CONCLUSIONS

The preliminary analysis of results obtained by ARIANOVA air quality forecasting modelling system confirmed its capability to describe air pollutant concentration trends during most observed conditions. Very good results have been obtained for ozone, while underestimation of PM10 concentration during winter peak episodes has been detected. The reproduction of PM winter concentrations within the Po valley is still a challenge for air quality modelling. Further investigation is ongoing to improve PM emissions, the definition of initial and boundary conditions and parameterisation of dispersion parameters during unfavourable meteorological conditions.

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