Particulate matter pollution simulations in complex terrain: a sensitivity analysis

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Introduction

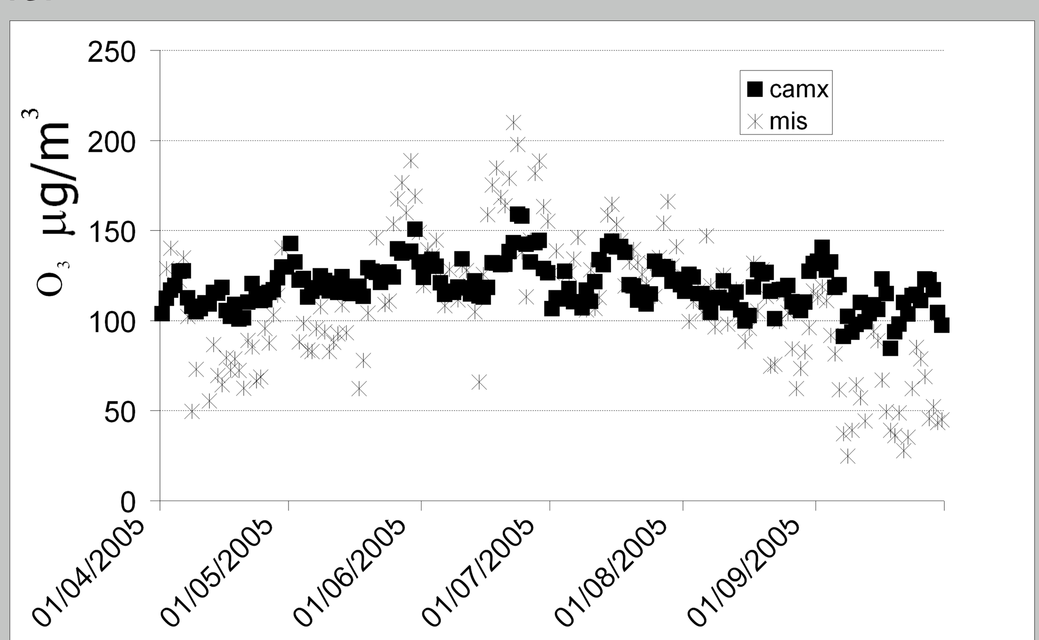
In this work, a chemical transport modelling system is used for simulating airborne dispersion and chemical reaction on a regional scale domain in the North-West of Italy, where the main urban industrial area are located in the Po Valley surrounded by very complex terrain. Indeed the Po river valley is very industrialised and heavily populated and it is characterised by strong urban, industrial and traffic emissions; moreover, the presence of the Alps often gives rise to weak circulation and stagnant conditions. The model resolution is 5 km and the emissions are derived from different regional and national inventories for the year 2005. The project aims at analysing the simulation lasting one year and it is focused on the comparison with measured data. In particular, the influence of the different meteorological and emission parameters is investigated.

THE MODELLING SYSTEM

The modeling system includes the meteorological model (RAMS, Pielke et al., 1992), an emission processor, (Balanzino et al 2007 a,b) and the photochemical model (CAMx, Environ, 2005). Emission input data are prepared starting from different inventories: within the Italian borders, the INEMAR regional emission inventories of Piemonte and Lombardia, the Italian official inventory for European areas and for the portion of Mediterranean Sea emission data have been derived by the EMEP inventory that provides an emission assessment over Europe based on cells of 50X50 km^2. The emission processing system was designed by our group (Balanzino et al. 2007a and b) to produce emission fields needed to the chemical model, based on emission data collected from the different inventories. CAMx (Environ, 2005) is an Eulerian photochemical dispersion model that simulates the emission, dispersion, chemical reaction and removal of pollutants in the troposphere by solving the pollutant continuity equation for each chemical species on a system of nested three-dimensional grids. The domain chosen for the dispersion simulation extends over a 250X250 km^2 area. Two nested grid were used for the meteorological simulation, the larger one covered a 540x540 $\mathbf{km^2}$ domain and the inner grid, having a resolution of 5 km, coincided with that of the dispersion and chemical model.

O_3 Results

We compare the results obtained for two measurement location, the first one refers to **urban environment**, while the second one to **rural environment**.



In the figure it can be observed the comparison between simulated and measured daily maximum 8-h average $\mathbf{O_3}$ concentrations at the **urban station**. In this case the mean values seem to be better predicted than the trend during the period. The predicted ozone concentration does not show seasonal variation, while the measurements exhibits largest values in the hottest months. Overestimation is related to the excess of dilution, limiting the effect of $\mathbf{NO_X}$ titration. Summer underestimation is probably related to the dispersion which can give rise to an underestimation of precursors.

References

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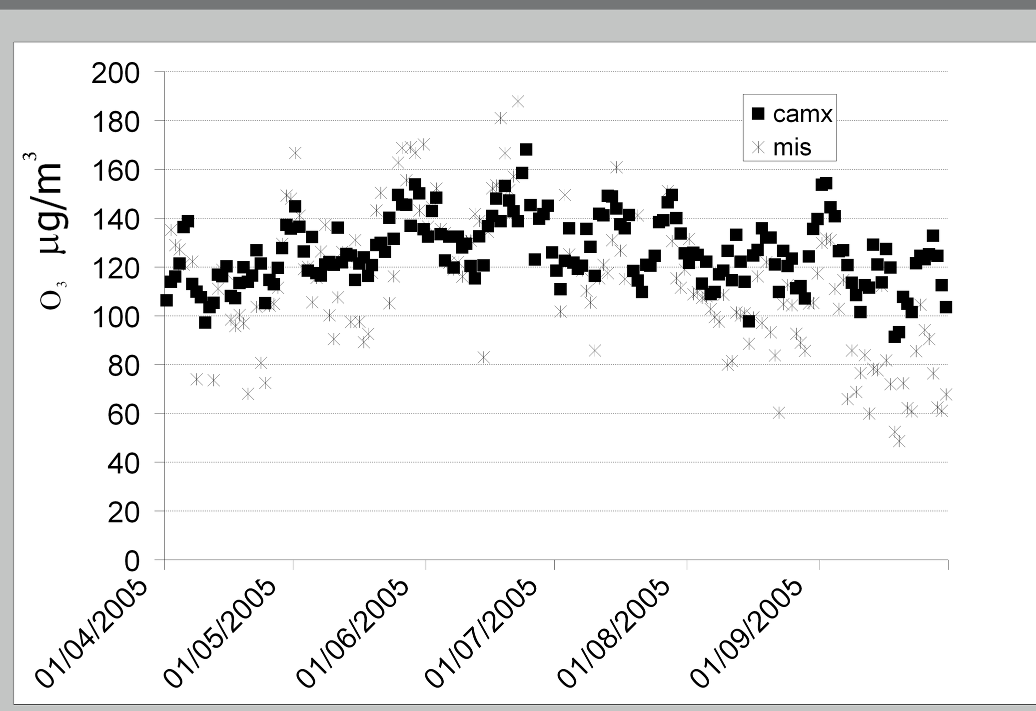
O_3 Results

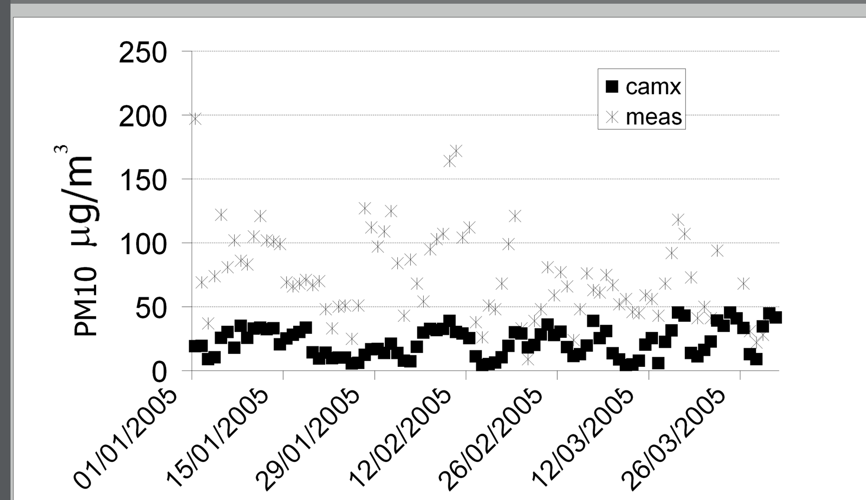


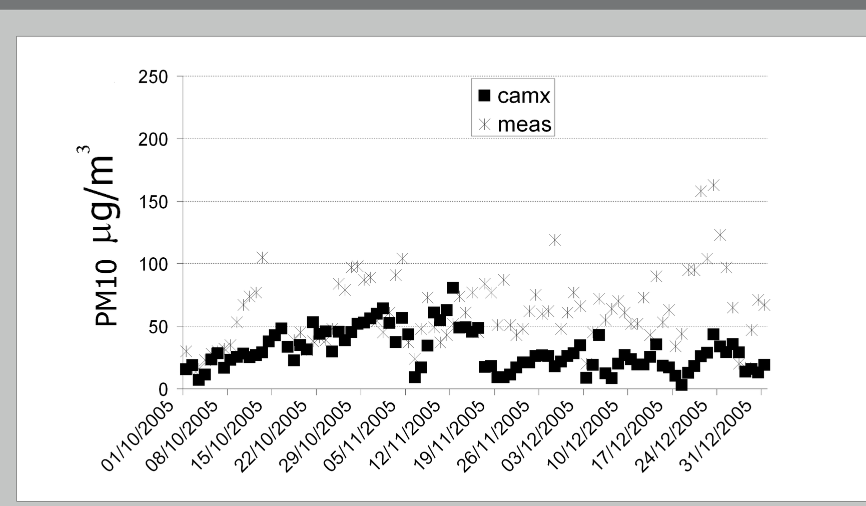
The daily maximum 8-h average $\mathbf{O_3}$ concentrations at the rural station, shows a rather good agreement between measurements and simulation. However the model seems to be not able to follow the extreme variations (maxima and minima) of the date gathered at station.

Statistical analysis for NO_2 and O_3

Station	Pollutant	Model mean	Meas. mean	NMSE	R	FB
urban	$\mathbf{NO_2}$	21.0 (μg/m^3)	36.9 (μg/m^3)	0.55	0.5	0.14
urban	$\mathbf{O_3}$	119.5 (μg/m^3)	108.6 (μg/m^3)	0.08	0.7	-0.02
rural	$\mathbf{NO_2}$	6.2 (μg/m^3)	20.6 (μg/m^3)	2.14	0.4	0.27
rural	$\mathbf{O_3}$	125.8 (μg/m^3)	112.5 (μg/m^3)	0.04	0.7	-0.03

PM10 Results





Concerning the winter semester (dived in two trimesters) we consider the comparison of the simulated daily mean PM10 concentration with the measurements. It can be observed that the model always largely underpredicts the measured concentrations. These last are higher than the level of 50 μg/m^3 during almost all the periods considered, while the model predictions are below this value, except for some episodes in October and November.

Statistical analysis for PM10

Station	Model mean	Meas. mean	NMSE	R	FB
FIRST TRIM.	22 (μg/m^3)	74 (μg/m^3)	2.2	0.4	0.3
SECOND TRIM	30 (μg/m^3)	62 (μg/m^3)	1.0	0.2	0.2

Conclusions

The simulation has also put in evidence some relevant nitrogen dioxide underestimations, mainly in the rural area, but the seasonal trend seems to be captured. This result could be linked to the meteorology (overestimation of the wind velocity and vertical dispersion). As a matter of fact, the model does not correctly reproduce the urban effect. Regarding the ozone, the mean values seem to be better reproduced than the seasonal variability. In general, the analysis of statistical indices demonstrates that the performances of the model are satisfactory for $\mathbf{O_3}$ and that unsatisfactory results for $\mathbf{NO_2}$ seem to be related to local scale processes as the poor emission accuracy or vertical dispersion reconstruction. As far as the PM10 mean daily concentration is considered, for the winter semester, the model results show a large underestimation of the measured data at the urban station.

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