IMPACT OF HORIZONTAL GRID RESOLUTION ON AIR QUALITY MODELING: A CASE STUDY OVER ITALY

Mihaela Mircea[1], Andrea Cappelletti[2], Gino Briganti[2], Lina Vitali[1], Giandomenico Pace[1], Pietro Marri[2], Camillo Silibello[3], Sandro Finardi[3], Giuseppe Calori[3], Gabriele Zanini[1]

[1]ENEA, National Agency for New Technologies, Energy and Sustainable Economic Development, via Martiri di Monte Sole 4, 40129, Bologna, Italy
[2]ENEA, National Agency for New Technologies, Energy and Sustainable Economic Development, via Vasco Viviani 23, 56124, Pisa, Italy
[3]ARIANET Srl, Via Gilino 9, 20128, Milan, Italy

INTRODUCTION

This study shows the impact of grid resolution on photochemical modeling of tropospheric ozone over Italy. Several yearly simulations were carried out with the atmospheric modeling system (AMS) of MINNI (National Integrated Modelling system for International Negotiation) project (Zanini et al., 2005) for 20kmx20km and 4kmx4km horizontal grid resolutions. More details about AMS components can be found in Briganti et al. (2010, H13-155). The formation and destruction of ozone are described by means of SAPRC90 photochemical mechanism (Carter, 1990). The simulated concentrations of ozone were compared with the measured ones at stations of different types: rural and urban and located in zones with different geographic characteristics (mountain, coast). The results reported here refer to simulations carried out for July, 1999.

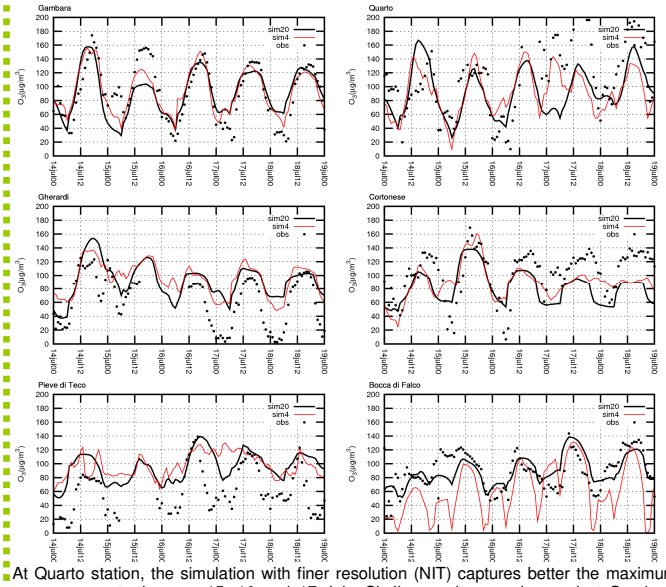
METHODOLOGY

Six yearly simulations were performed: one over the whole Italy with horizontal spatial resolution of 20kmx20km (IT) and five over sub-domains including respectively north of Italy (NIT), centre of Italy (CIT), south of Italy (SIT), Sardinia and Sicily islands with horizontal spatial resolution 4kmx4km. The meteorological fields for IT simulation were produced with the prognostic meteorological model RAMS (Cotton et al., 2003) using the European Centre for Medium Range Weather Forecast (ECMWF) analysis at 0.5 degrees and 6 h resolution for the initial and boundary conditions. The meteorological fields for the simulations on sub-domains (NIT, CIT, etc) were downscaled from the meteorological fields predicted by RAMS at 20kmx20km spatial resolution by means of the diagnostic meteorological model LAPS (Local Analysis and Prediction System) (McGinley et al.,1991). The anthropogenic emission used for the simulation IT was derived from the diffuse emissions inventory at provincial level (APAT, 2000), while the ones for NIT, CIT and SIT simulations are based on a version of the same inventory scaled down to municipalities using a set of proxies.For the other countries included in the IT simulation domain, the emission inventory EMEP 1999 was used.

The EMEP model (Simpson et al., 2003) at 50 km horizontal resolution provided the initial and boundary conditions for IT simulation, while NIT and CIT simulations were nested into IT grid. The same biogenic emissions were used in all simulations (Briganti et al., 2010, H13-155).

The evaluation of hourly ozone concentrations predicted by the AMS was performed at 8 monitoring stations: three rural (1-3) and three urban (4-6), one mountain station– Monte Gazza (7) and one coastal station – Chiaravalle (8).

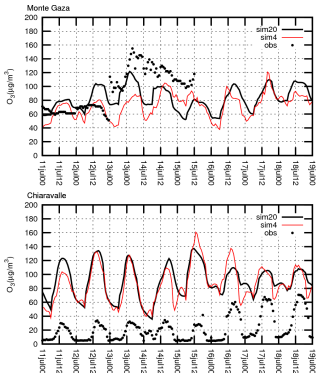
RESOLUTION EFFECTS AT URBAN AND RURAL STATIONS



At Quarto station, the simulation with finer resolution (NIT) captures better the maximum ozone concentrations on 15, 16 and 17 July. Similar results are observed at Gambara station, while for the other stations no particular improvement is visible. On the contrary, at Pieve di Teco, the ozone concentrations predicted by the finer resolution simulation (NIT) are much worse than those predicted by IT simulation: the daily ozone cycle is not reproduced by the model from 16 to 18 July . The results of finer simulations are also worst at Bocca di Falco, especially in the morning and in the evening.

RESOLUTION EFFECTS AT MOUNTAIN AND COASTAL STATIONS

A slight improvement in simulated ozone concentrations can be observed at Monte Gaza on 12 and 14, 15 July , while at Chiaravalle all the simulations highly overestimate the observed concentrations. The relative good model results at Monte Gaza station (1601m a.s.l.) can be due to the fact that it is far from anthropogenic emission sources (it is classified as a rural site) and, thus, less affected by errors in emissions inventory. Chiaravalle station (15m a.s.l) is located in the vicinity of an urban area, the systematic overestimation of ozone concentrations by all simulations suggests that some emissions are misplaced in anthropogenic inventories of ozone precursors.

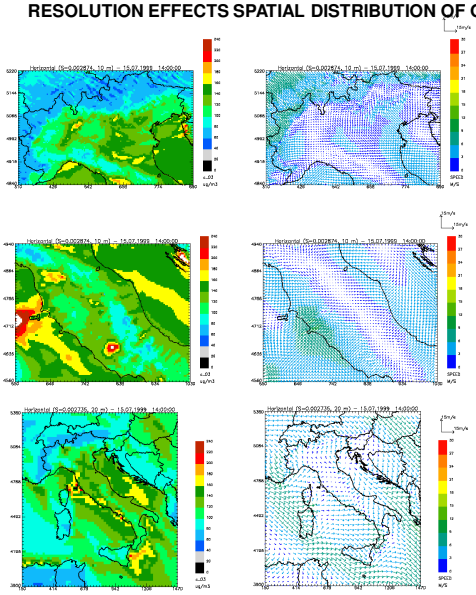


STATISTICAL EVALUATION OF MODEL PERFORMANCES

	Station name	Station type	20kmx20km		4kmx4km	
			MNBE	MANGE	MNBE	MANGE
1	Gambara	rural	-6.99	18.01	-9.29	19.03
2	Gherardi	rural	10.41	13.88	10.41	14.02
3	Pieve di Teco	rural	7.66	14.02	-4.46	18.41
4	Quarto	urban	-25.18	28.93	-29.68	32.32
5	Cortonese	urban	-19.96	22.45	-14.92	23.3
6	Bocca di Falco	suburban	-18.05	21.81	-38.05	39.24

The statistical indicators do not show substantial variation at rural stations, but they have substantially increase at urban stations for fine grid simulations. This indicates that the derivation of municipal emission inventories from the provincial one using proxy should be improved.

RESOLUTION EFFECTS SPATIAL DISTRIBUTION OF OZONE AT SURFACE



NIT and CIT simulations (upper and middle graphs) shows more areas with high ozone concentrations with respect to IT simulation (lower graphs). The increase in concentration for the simulations with finer resolution is from 20 to 40 µg/m3 for NIT simulation with respect to IT, and higher in the case of CIT simulation. However, none of the monitoring stations were located in these areas and this explain the little difference between the ozone concentrations simulated with coarse and fine grids.

CONCLUSIONS

The finer grid resolutions are able to better resolve inhomogeneities in emission rates, land cover and dispersion, but no systematic improvement of calculated statistical scores at monitoring stations used in this study is observed. On the contrary, at the urban stations, the MNBE and MANGE are worse for finer grid resolution than for the coarse one. However, the direct comparison of model results with observations shows that finer resolution grids improve model predictions for some particular days, at same sites (see 17 July at Quarto).

ACKNOWLEDGEMENTS

This work is part of the MINNI (Integrated National Model in support to the International Negotiation on Air Pollution) project, funded by the Italian Ministry for Environment and Territory and Sea and carried out by ENEA.

REFERENCES

APAT, 2000: APAT- Agency for Environmental Protection and Technical Services
Briganti et al., 2010: this Conference – H13-155
Carter, 1990: Atmospheric Environment, 24A, 481-518.
Cotton et al., 2003:Meteorology and Atmospheric Physics, 82, 5-29.
McGinley et al., 1991: Weather Forecasting, 6, 337– 356.
Simpson et al., 2003: EMEP Status Report 1/2003 Part I, EMEP/MSC-W Report.
Zanini et al., 2005: MODSIM 2005 International Congress on Modelling and Simulation, Melbourne, Australia, 12-15 December 2005, pp. 2005-2011. ISBN: 0-9758400-2-9.