URBAN SCALE MODELING: INVESTIGATION OF A METODOLOGY IN STUDYNG ATMOSPHERIC FLOWS IN URBAN AREAS

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INTRODUCTION

In this paper some results concerning the analysis of the urban scale flow in Naples, Italy, will be discussed. The investigation has been conducted by using a CFD model (MERCURE, EDF) that utilises as input data the results obtained by a mesoscale numerical model (RAMS, Tremback et al, 1995) simulating the flow field related to the Italian peninsula.

The aim of this research is to investigate a methodology in studying atmospheric flows in urban areas. This study is strictly related to air pollution dispersion.

Results will be presented into two stages: first the results of the mesoscale model for two day simulation and later, the results of CFD code for a particular time.

APPLICATION: RAMS

In order to analyse in suitable detail the atmospheric circulations in the Campania region, three nested grids will be activated with different spatial and temporal resolution. The use of the coarser grid will permit the implementation of the Four Dimensional Data Assimilation (FDDA) starting with data acquired from European Centre of Medium range Forecast (ECMWF) located at Reading (UK). This centre provides forecasts obtained by a Global Circulation Model. RAMS utilises these results as boundary conditions for its simulation (Figure 1).

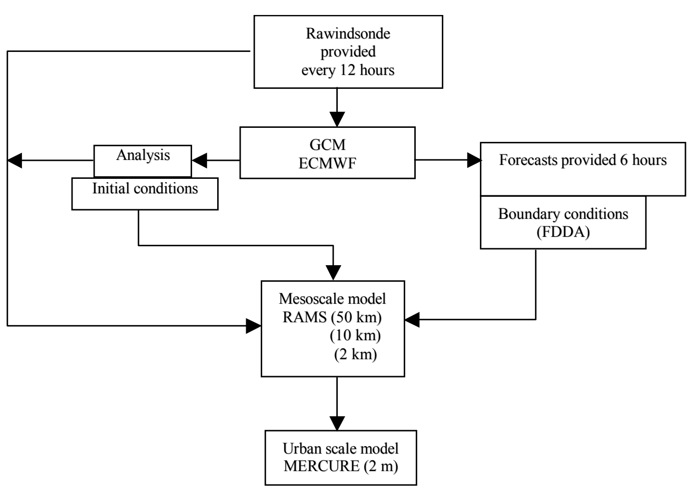


Figure 1. Representation of the methodology applied to the Campania region

The characteristics of the three grids, used for the mesoscale simulation are reported in Table 1.

Table 1. characteristics of the three grids for the mesoscale simulation

	Resolution [Km]	I° Level [m]	Top [m]	nx	ny	nz	Time-step [s]
Grid 1	50	35.0	14562	38	38	26	50
Grid 2	10	11.5	14562	42	42	32	16
Grid 3	2	11.5	14562	42	42	32	5

A good spatial resolution near the ground is vital in order to obtain a suitable simulation of low-level circulations such as land breeze, a typical circulation in this area. Such a restriction highlights a critical aspect of the mesoscale model in evaluating the turbulent diffusion parameters over complex terrain (Serafini et al, 2000). This aspect is also important because MERCURE uses the low-level fields provided by the mesoscale model as boundary conditions.

The topography data for all the grids (Figure. 2), as well as land-use data for the entire world, is provided by the United States Geological Survey (USGS) with 1x1 km resolution.

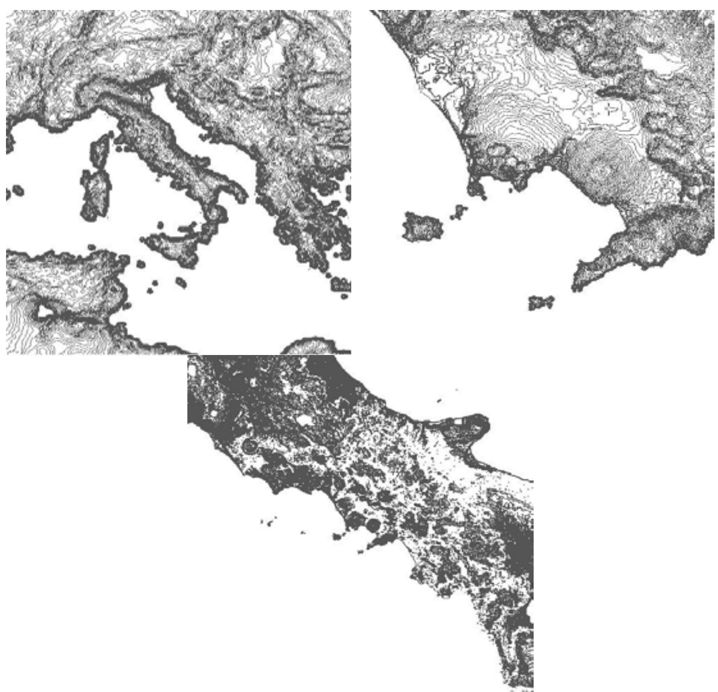


Figure 2. Topography for the three grids.

The time period chosen for this study is 0000 LST July 21 2001 to 0000 LST July 23 2001. During this period a wide area of high pressure was present over the Mediterranean basin. Such conditions are favourable to the generation of land-sea breeze circulation along Italian coastlines.

Results of the forecasts provided by RAMS are presented through comparison with observed data, where available, provided by the Agro-Meteorological Centre of the Campania region (Figure 3). The characteristics of the observed data are reported in Table 2.

Table 2. Characteristics of the observed data.

St. ID	Name	LAT	LON	Height s.l.m. [m]	Wind speed	Wind direction	Temperature
501	Acerra	40.58°	14.26°	29	10 m.	10 m.	-
522	Giugliano	40.56°	14.04°	26	10 m.	10 m.	10 m.
527	Villa Literno	40.58°	14.01°	2	10 m.	10 m.	10 m.

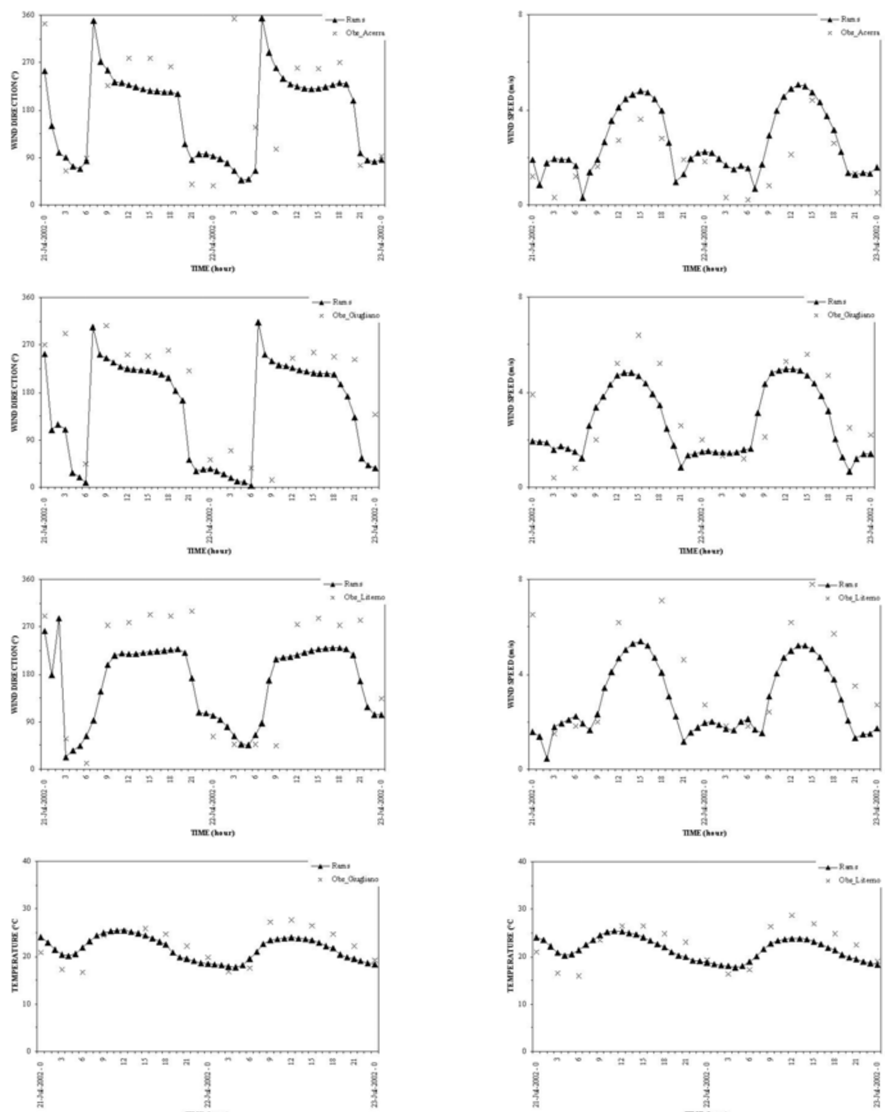


Figure 3. Comparison with observed data.

APPLICATION: MERCURE

At 0600 LST July 22 2001 MERCURE was implemented in Via Foria, a zone in the centre of Naples (Figure 5a). The domain covers an area of 204x208 meters in the horizontal direction with 2x2 meter resolution. The height of the domain is 150 meters. Meteorological input data came from RAMS forecasts at this time and was rotated, as was the computational mesh, in order to represent more accurately the actual building characteristics, and therefore improve the accuracy of the simulation (Figure 5). Figure 4 shows the magnitude and direction of the incoming wind. The CFD results are reported in Figures 5 and 6. In particular, Figure 5b displays the streamlines and the dispersion of pollutants produced by traffic.

Figure 6 shows a cross section (AA) of the flow vectors and streamlines in Via Foria, a contour plot of the pollutant.

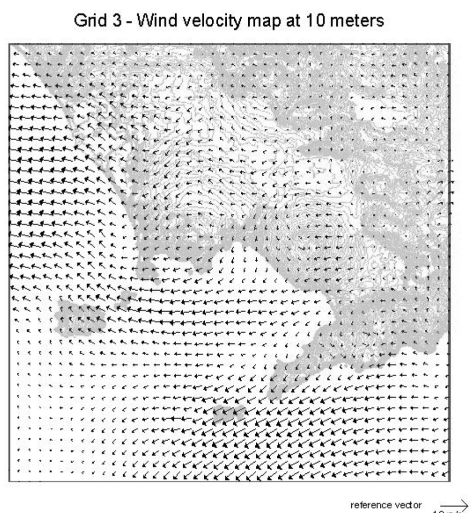
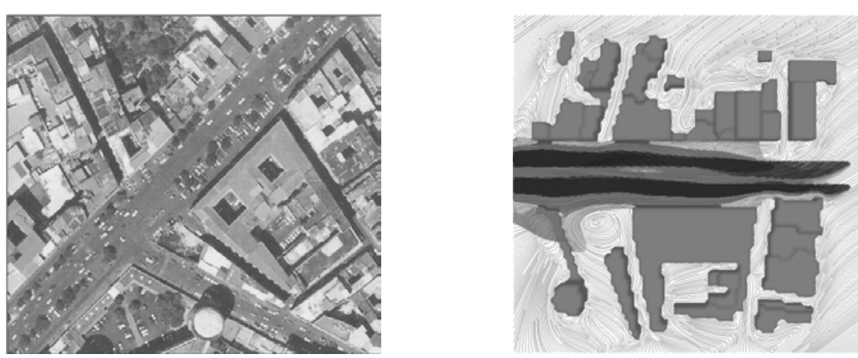


Figure 4. Wind velocity map provided by RAMS. 0600 LST of July 22 2001.



(a) (b)

Figure 5. Area of interest in the centre of Naples (a). Streamlines and dispersion of passive track(concentration of pollutant represented by shading),over the rotated mesh (b).

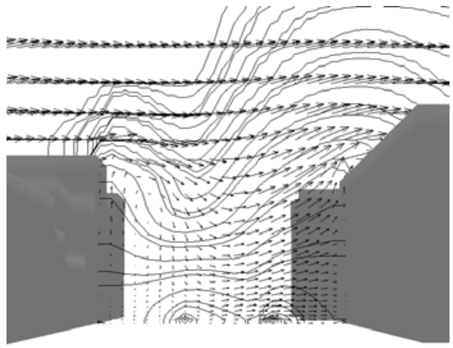


Figure 6. Cross section (AA) of CFD results in Via Foria

CONCLUSION

The investigation of a methodology in studying the dispersion of pollutants over an urban area in the center of Naples (Italy) has been conducted using a CFD model (MERCURE). Results from the mesoscale numerical model (RAMS), simulating the flow field in the Gulf of Naples, are utilised as input data. In evaluating the turbulent diffusion parameters over complex terrain, a high resolution of grid points at low levels of the atmosphere is required in order to generate accurate simulations. Results provided by the mesoscale model are in good agreement with available observational data in the Campania region (Figure 3). Qualitative results of the simulation of the CFD code are also reported for 0600 LST July 22 2001 (Figures 5b and 6). An important issue in applying such methodology is the high computational resources involved. The CFD code, in fact, requires several hours to reach the steady state due to the high resolution of the computational grid required in order to simulate the flow structure in areas with many narrow streets, such as the centre of Naples. The simulation of the flow field over urban areas and hence the dispersion of pollutants within a complex topology, remains an important issue and requires further investigation. Modifications to the current model may include thermal effects due to solar insolation on buildings, which is understood to be an important factor affecting dispersion of pollutants in low wind speed conditions.

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