EVALUATION OF MEMO USING THE ESCOMPTE PRE-CAMPAIGN DATASET

N. Moussiopoulos[1], *I. Douros*[1], *P. Louka*[1], *C. Simonidis*[2] *and A. Arvanitis*[1]
[1] Laboratory of Heat Transfer and Environmental Engineering, Aristotle University Thessaloniki, Box 483, 54124 Thessaloniki, GREECE
[2] Institute of Technical Thermodynamics, University of Karlsruhe, 76128 Karlsruhe, GERMANY

INTRODUCTION

The non-hydrostatic prognostic mesoscale model MEMO (*Moussiopoulos*, 1995; *Kunz and Moussiopoulos*, 1995) is the core mesoscale meteorological model of the multiscale model ZEUS (Zooming model for European Urban air pollution Studies). Multiscale model systems, capable of prescribing refined boundary conditions to the next smaller scale and incorporating accurate fluxes to the larger scales, are appropriate tools for establishing more accurate source-receptor relationships. ZEUS corresponds to a sequence of scale-interacting three-dimensional prognostic models. The quality assessment of MEMO is therefore crucially important as the wind fields predicted by the model are used as input to subsequent air pollutant dispersion and transformation simulations.

As a step towards the further evaluation of MEMO, the model was applied to the Greater Marseille area (GMA) in order to simulate airflow patterns observed during the ESCOMPTE pre-campaign period. This application is part of the ESCOMPTE_INT model intercomparison exercise which aims at comparing the simulation results of various mesoscale models. The database used for the model evaluation contains a wide and detailed variety of measurements conducted at the surface as well as with airborne instruments.

CASE SPECIFICATION

MEMO is a prognostic mesoscale model that allows describing the dynamics of the atmospheric boundary layer for unsaturated air. Within MEMO the conservation equations for momentum, mass and scalar quantities and, optionally, turbulent kinetic energy are numerically solved on a staggered grid which allows for a terrain influenced vertical coordinate. Initialisation is performed using diagnostic methods, while data needed to apply the diagnostic methods may be derived from observations.

GMA is definitely a challenging area for mesoscale simulations since it includes certain discrete geographical formations (sea, the southern Alps, the Rhone valley) which decisively influence the local circulation. It is the first time that a correlation between modelled and measured variables for the particular area is being examined using MEMO. Besides, within the scope of ESOMPTE_INT, MEMO simulation results are compared with those of other mesoscale models (*URL1*). The selected case-study was the period between June 29 and July 1, 2000, i.e. a summer period for which, depending on the meteorological conditions, the formation of photochemical smog may be favoured. The numerical grids used for the simulations covered an area of $648\times324\ km^2$. In order to assess the sensitivity of the model results to the grid resolution, two different cell sizes were used, namely $4\times4\ km^2$ and $2\times2\ km^2$. In all cases 25 vertical layers were assumed allowing for the finer resolution at lower altitudes. The depth of the lowermost (shallowest) layer was set to 20m, while model top was fixed at 6 km above the sea level. Soundings performed during the pre-campaign period were used for deriving the initial and boundary conditions of MEMO simulations.

The weather situation during the selected period was characterised by relatively light winds. As stability is concerned, the conditions of the atmosphere over the GMA could be characterised as unstable.

PRINCIPAL RESULTS

The map of Figure 1 illustrates the GMA and the location of all stations where measurements were obtained during the ESCOMPTE pre-campaign, together with an additional 15 fictitious stations for which model intercomparison is also performed (*URL1*). Three of the measuring stations were chosen to be considered in the present paper, at locations where differences in local meteorology characteristics can be expected, namely a location by the sea (Marseille), a location further inland (Tarascon) and a location far from the sea (Carpentras).

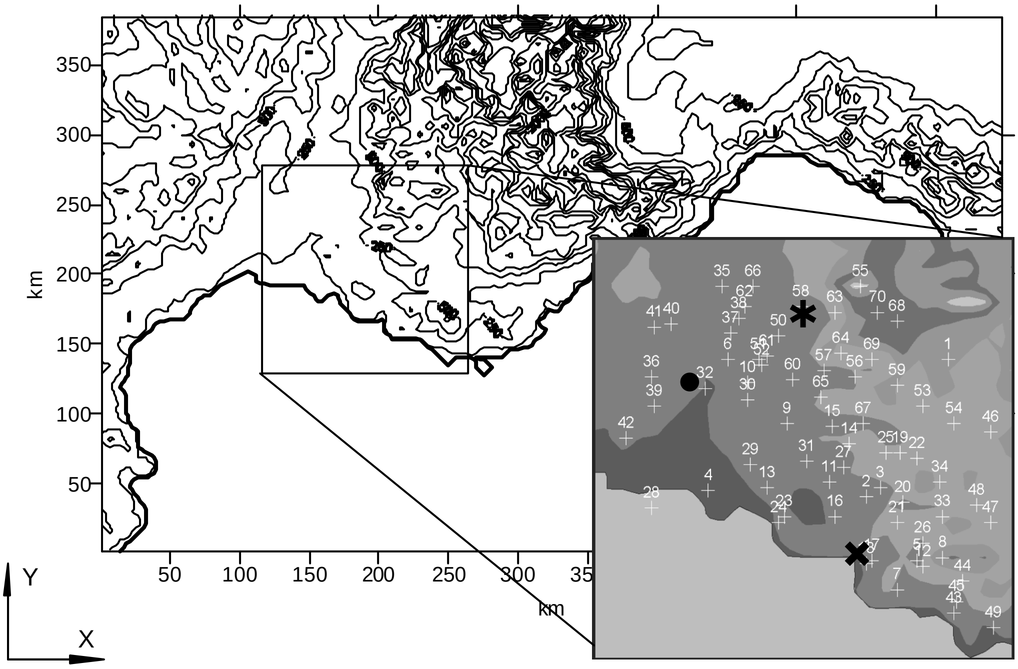

Figure 1. Topography of the model area and locations of the stations Marseille (✖),Tarascon (●) and Carpentras (✱).

Airflow investigation

Figure 2 shows the wind field at four different times of June 30, 2000, resulting from simulations at a resolution of 2×2 km^2. The predicted flow is generally characterised by north winds turning into north-easterlies over the sea at 00:00 and 06:00 LST, while katabatic winds seem also to be present. Additional features are the appearance of local circulations at noon due to convection and the presence of local sea breeze in the afternoon.

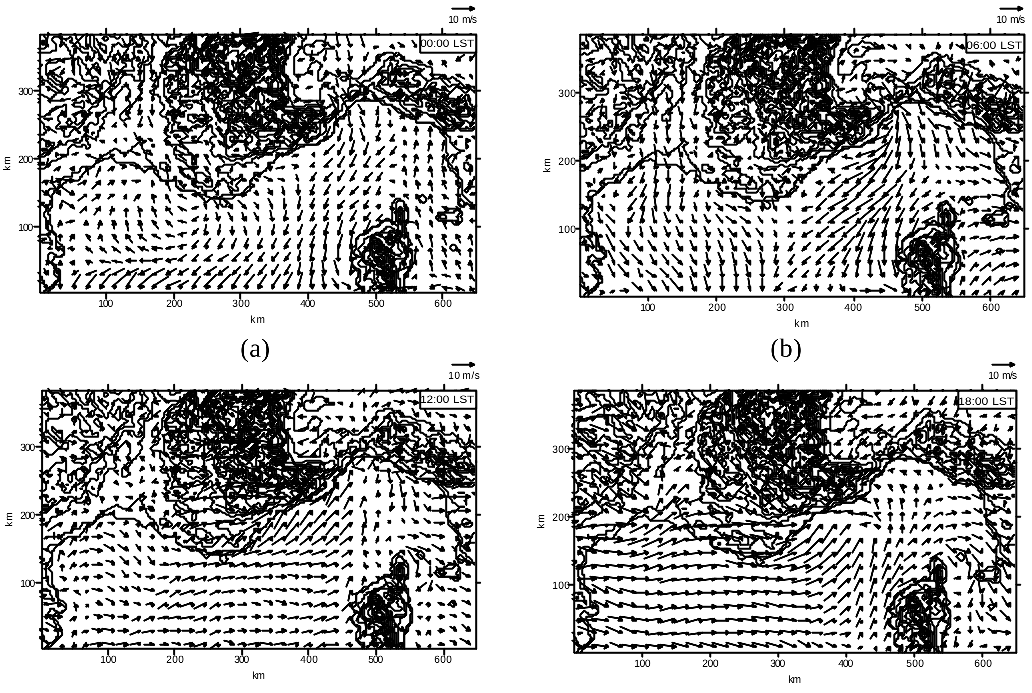

Figure 2. Example of the simulated wind field with resolution 2×2 km^2 on the 30th of June 2000 at (a) 00:00 LST, (b) 06:00 LST, (c) 12:00 LST, and (d) 18:00 LST. The colour scale corresponds to the orography of the region. Sea is drawn white for greater clarity.

Model evaluation

Figure 3 illustrates the time series for the measured and simulated (both resolutions are shown) wind speed, wind direction and air temperature for the three selected stations. In general, the simulated values for both resolutions are comparable, with those of highest resolution not surprisingly capturing more details. Taking a closer look at each selected station, it is shown that for the station of Marseille located by the sea, the correlation with measurements is better for the MEMO run with the higher resolution. Especially for wind speed and temperature the simulated values with the higher resolution are very close to the measurements. For the stations of Tarascon and Carpentras located further inland, the performance of the model is also good with both MEMO runs being similar to the measurements. The model performance for temperature is found to be better for Marseille and Tarascon, while the correlation is considerably higher for the daytime values than for night-time values for the station of Carpentras, for which night-time temperature is overpredicted.

The results reflect the fact that physical mechanisms and processes governing the mesoscale wind flow in areas far inland are adequately predicted by the model, with both resolutions used, producing similar results. Closer to the sea where local circulation is expected to be dominant and thus flow is more complex, the highest-resolution simulation performs better as it captures the local flow more accurately. It is suggested that the overprediction of the night-time temperature for the station of Carpentras located at a mountain's slope is possibly due to an underestimation of the radiative heat flux from the ground associated with the land-use categorisation implemented in the model. Overprediction of the night-time temperature is generally observed at mountainous stations of similar positions.

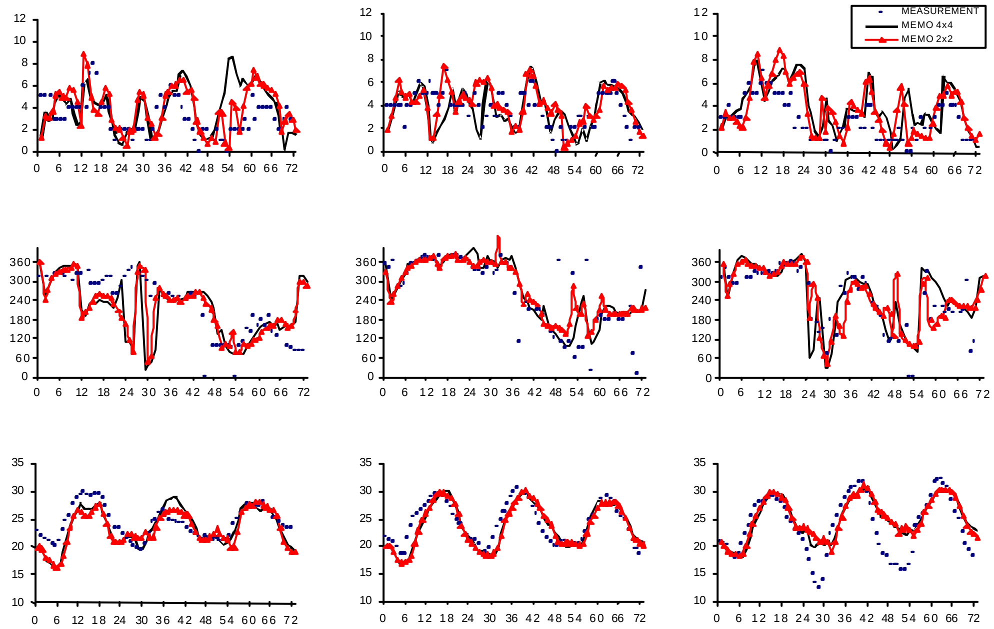

Figure 3. Measured and calculated wind speed (top), wind direction (middle) and air temperature (bottom) at 10m over the ground for Marseille (left), Tarascon (middle) and Carpentras (right).

Statistical analysis of the obtained results provides a clearer view regarding the overall comparison. Statistical *bias* in particular, is a useful tool for the assessment of under- or over-estimation of the values of meteorological variables. *Bias* is calculated using the formula

$$BIAS = \frac{\sum_{i=1}^{N}(p_i - o_i)}{N} \tag{1}$$

where *p* stands for predicted values and *o* for observed ones. N is the number of pairs of values that are being used. The results shown in Figure 4 illustrate the time evolution of *bias* for wind speed, direction and air temperature, calculated taking into account data from all stations from which measurements were available, for the entire simulation period (June 29 – July 1, 2000). The bias was calculated for both resolutions.

The statistical analysis performed generally suggests that there is an overestimation of wind speed early in the morning of the last day of the simulation, which however does not correspond to a bad prognosis of the wind direction during the same time period. Temperature on the other hand, reveals the night - overestimation trend, which was already evident from the diurnal profiles at the selected stations. Generally, the bias at a grid spacing of 2 km is comparable to that at 4 km, a fact not justifying the much higher computational effort associated with the higher resolution.

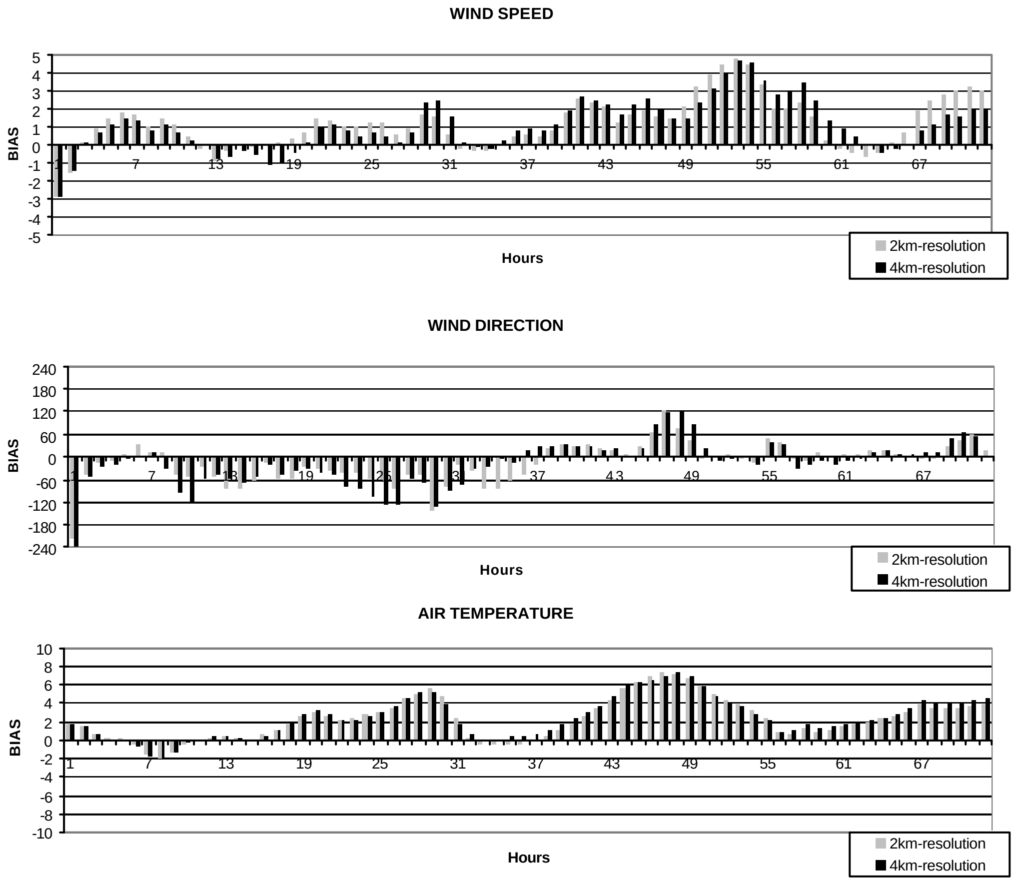

Figure 4. Bias for wind speed, direction and air temperature during the simulation period (June 29 to July 1, 2000)

CONCLUSIONS

The non-hydrostatic mesoscale model MEMO has been successfully applied to the Greater Marseille area in Southern France, a region with a rather complex topography and local meteorology. Comparison with available measurements revealed that the model is capable of reproducing observed wind flow patterns with the performance being slightly better for the highest resolution simulations especially for areas close to the sea.

REFERENCES

Kunz, R. and N. Moussiopoulos, 1995: Simulation of the wind field in Athens using refined boundary conditions. *Atmos. Environ*. **29**, 3575-3591.

Moussiopoulos, N., 1995: The EUMAC Zooming model, a tool for local-to-regional air quality studies. *Meteorol. Atmos.Phys***.** **57**, 115-133.

URL1 : http://rem.jrc.cec.eu.int/escompte_int/RESULTS/main.html