MODEL INTER-COMPARISON FOR RESEARCH AND OPERATIONAL USE: A CASE STUDY IN THE ALPINE REGION

R. Salerno[1]

[1] Raffaele Salerno, Epson Meteo Centre (CEM), Milan, Italy
E-mail: *raffaele.salerno@epson-meteo.org*

Abstract: In the framework of an integrated modeling approach at regional and local scale, some models have been implemented and run in our institution: the SISL-MSM by us, the MESO-NH by the Laboratoire de Aerologie and Meteo-France, the ETA Model by NCEP, the MC2 model by CMC-Environment Canada and the WRF model (by many agencies). Boundary conditions are provided by our ESM (European Spectral Model) which is nested in our GSS (Global Simulation System), a global model and an ensemble prediction system. A case study of a summer thunderstorm in the south-alpine region is presented, with simulation made by different models and grid mesh sizes in the same area. Observational data have been compared to the model simulations. The comparison shows the differences among the models and simulation designs in the complex topography of the Alps, the characteristics of the atmosphere behaviour in mountain regions and the importance of non-hydrostatic effects to correctly reproduce the overall physics and dynamics at the mesoscale .

Keywords *– Numerical simulation, model inter-comparison, thunderstorm*

1. INTRODUCTION

Many projects of model inter-comparison are currently operational throughout the world, depending on aims, space and time scales, domains. However, in the last years, only a few projects concerned the comparison of meteorological atmospheric models at the mesoscale. For example, in the Map project comparisons have been performed to evaluate precipitation amounts, thermodynamics, orography-generated gravity waves and their turbulent break down, interaction of large-scale dynamics on locally-driven fluxes and so on. From the operational point of view, the availability of different numerical weather prediction models (NWPM) may help the forecasters to better infer the weather from NWPM results. In our institution, forecasters operate every day in an area where the complexity of the domain plays a major role and this motivates the request to compare results of different models with the aim to operationally use them to improve the forecast itself. Usually there is also a strong orientation toward direct model inter-comparison, which requires a common simulation protocol and specific validation procedures. This is (and, more extensively, will be) done in our project, but an important focus will be given to the forecaster direct use of NWPM results. Another aim will be the evaluation of numerical errors of high-resolution simulations in mountain areas and the assessment of the presence of spurious effects near such a steep topography. Among others, some considered aspects are also the sensitivity of the models to the range of flows, the propagation of mountain waves and their interaction with the mixed layer, and the orography-enhanced storms.

In this preliminary work some results concerning a summer thunderstorm case study is presented. This event occurred on July 24th, 2004. The choice was due to the fact that some models represented the event with a fair accuracy and some others failed. The used models are our Semi-Lagrangian Semi-Implicit Mesoscale Spectral Model (SISL-MSM), the ETA model and the MESO-NH. Since, at this time, MC2 and WRF cannot use yet our European Spectral Model (ESM) data as boundary conditions, simulations have not been performed by these two models, but it will be done in the next future. This case-study example has been also used to assess and test the implementation of different models in the present state of developing.

2. CONSIDERED MODELS

The SISL-MSM is a fully-compressible model with a semi-implicit (e.g. Tapp and White, 1976; Juang, 1992) semi-lagrangian time integration and spectral perturbation nesting. Lateral boundary relaxation is considered; it may be either explicit or implicit, time-splitting. A lateral boundary blending may be also considered and 4th order horizontal diffusion is applied. The model uses a type of dynamical initialization which can be considered whenever there is a doubt about the balance state of the initial conditions or when a field such as vertical motion is not given in the initial analysis, but the inizialization on the finer meshes is omitted when these are driven by coarser runs. Flux computation in the surface layer follows the Monin-Obukhov similarity profile (Arya, 1988) with a multi-layer soil model in which different classes of vegetation and soil types are considered. Vertical turbulent eddy diffusion of momentum, heat and vapour is computed in this study via a non-local approach in the boundary layer. Deep convection has been treated with a relaxed Arakawa-Schubert scheme (Moorthi and Suarez, 1992-1999; a modified Grell scheme and Kain-Fritsch (1993) parameterization are available). The microphysics treatment employs five prognostic species including water vapour, cloud water, cloud ice, snow and rain (Rutledge and Hobbs, 1983).

MESO-NH is a mesoscale time-explicit non-hydrostatic model developed by the Centre National de Recherches Meterologiques (Meteo-France) and the Laboratoire d'Aerologie (CNRS). It makes use of the anelastic approximation in the resolution of the equations of motion. The lateral boundary conditions are variable: cyclic, or rigid wall, or open or a combination of these different types of conditions can be chosen. For the microphysics, up to eight water species can be chosen (vapour water, cloud water, rain, ice, snow, graupel, hail and pristine ice), or a combination of these species, and several cloud schemes can be used. For deep convection the Kain-Fritsch scheme is used. Also several options for the radiation scheme can be chosen, but for a complete treatment of radiation the ECMWF radiation scheme is implemented.

The ETA model characteristics are well-known. From the physical point of view, vertical turbulent mixing between levels in the free atmosphere is performed by using mixing coefficients of the Mellor-Yamada 2.5 level turbulence, while in the surface layer is performed by the Monin-Obukhov similarity model. Nonlinear fourth-order lateral diffusion scheme with the diffusion coefficient depending on the deformation and the turbulent kinetic energy is considered in order to control the level of small-scale noise. For simulation of the radiative atmospheric effects, the GFDL radiation scheme is considered and the Kain-Fritch deep cumulus convection scheme is used. Finally, the LAPS scheme for prediction of the surface processes is employed in the model.

3. CASE-STUDY SIMULATIONS

3.1. Meteorological description

The situation of July 24th in the Po Valley was characterized by a cold air mass coming from the north. A few days before, due to an high pressure field centred on northern Africa, an heatwave hit Italy and the 23rd of July the hottest day was registered, with maximum temperatures of 32-35 °C almost everywhere. During the day of 24, thunderstorms were registered in northern Italy, with heavy rain, hails and more than 2000 strikes in Lombardia. Rain occurred in the morning and the afternoon in the central and eastern part of the Po Valley, and, more limited, in the afternoon in the Piedmont plain.

3.2. Short Discussion

Precipitation occurred in the morning (Fig. 1) and in the afternoon in Lombardia; some other precipitation occurred during the day in many areas of northern Italy. The three models (Figs. 2 and 3, MESO-NH not shown here) have fairly well detected the major precipitation areas even if the maxima locations are not precisely detected as well as the amounts. All simulations are referred to a grid mesh size of about 15 km. Simulations at higher resolution than 15 km (not shown) present the same characteristics, but maximum values are slightly more correct both in location and amounts. Also the distribution of rain with time was in reasonable agreement with the observed precipitation.

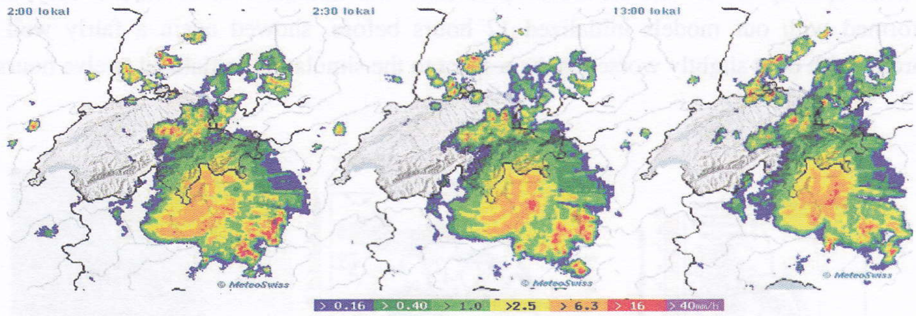

Figure 1. Radar images from 12.00 to 13.00 CET (from MeteoSwiss).

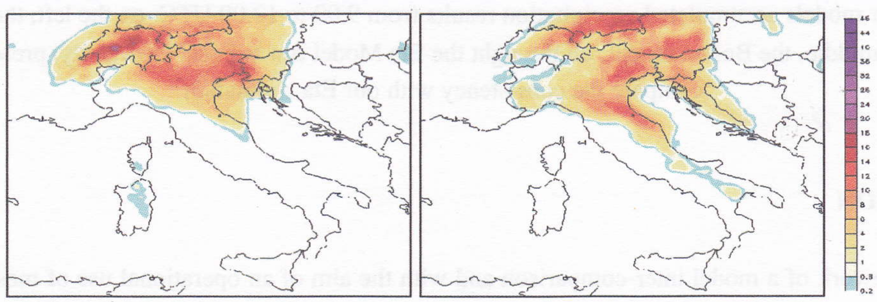

Figure 2. Eta model precipitation results: on the left from 9.00 to 12.00 UTC, on the right from 12.00 to 15.00 UTC.

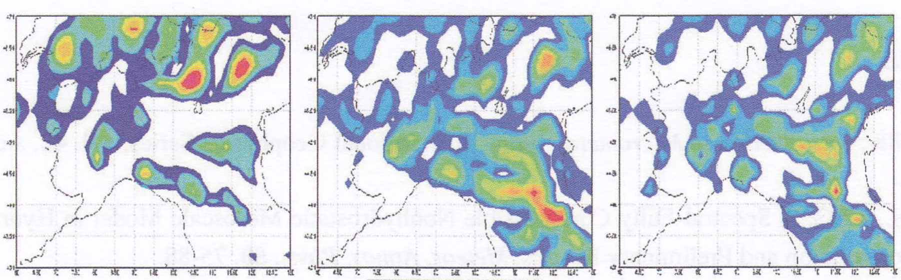

Figure 3. SISL-MSM precipitation results: on the left, 9-12 UTC, in the middle 12-15 UTC, on the right 15-18 UTC.

Some other verifications have been performed, comparing simulated data with those available from radiosoundings at 12 UTC. Again, the profiles of modelled temperature and humidity agreed fairly well with the observed data. In particular, the location and the dynamics of the cold air mass was quite well simulated. In the simulations started at 12 UTC of the day before, results were similar to those obtained by the computations made with 00 UTC initialization.

Differences with other models are inferable looking at Fig. 4 (left and middle pictures), where the results of the two models qualitatively failed both in locations of precipitation areas and amounts. Of course, these results cannot be directly compared to ours and it should be also evidenced that the LM forecast could be in somewhat influenced by some spin-up effects and the Bolam prediction was initialized at 12 UTC of July, 23rd. However, the tests, performed with our models initialized 12 hours before, showed again a fairly well detection of precipitation areas, with only slightly worse results respect to the simulation initialized twelve hours later.

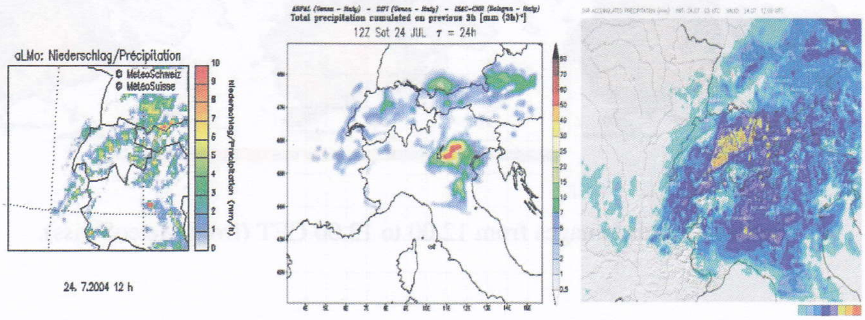

Figure 4. Other models accumulated precipitation results from 9.00 to 12.00 UTC: on the left, the Local Modell (LM); in the middle, the Bolam model; on the right the Eta Model run at Basel University, presented only to compare the consistency with our Eta simulation.

4. CONCLUSION

In the framework of a model inter-comparison and with the aim of an operational use of mesoscale models, preliminary results have been briefly presented about simulation performed with SISL-MSM, ETA and Meso-NH models in a case-study of a summer thunderstorm in northern Italy. Results of precipitation forecast agreed fairly well with observations. The use of an higher resolution in the grid size improved the location and the values of the precipitation. As soon as the boundary conditions of our ESM model will be available to MC2 and WRF models, the same test will be also performed with this two ones.

REFERENCES

Arya, S. P., 1988 : *Introduction to Micrometeorology*. International Geophysics Series, **vol. 42**, Academic Press inc.

Juang, H.-M. H., 1992: A Spectral Fully Compressible Nonhydrostatic Mesoscale Model in Hydrostatic Sigma Coordinates: Formulation and Preliminary Results. *Meteor. Atmos. Phys.*, **50**, 75-88.

Kain, J. S., and J. M. Fritsch, 1993: Convective parameterization for mesoscale models: The Kain-Fritsch scheme. *The representation of cumulus convection in numerical models*. K. A. Emanuel and D. A. Raymond, Eds., Amer. Met. Soc., 246 pp.

Moorthi, S., and M.J. Suarez, 1992: Relaxed Arakawa-Schubert: A parameterization of moist convection for general circulation models. *Mon. Wea. Rev.*, **120**, 978-1002.

Moorthi, S., and M.J. Suarez, 1999: *Documentation of version 2 of Relaxed Arakawa-Schubert cumulus parameterization with moist downdrafts*. NOAA Technical report NWS/NCEP 99-01. 44pp.

Rutledge, S. A. and P. V. Hobbs, 1983 : The mesoscale and microscale structure and organization of clouds and precipitation in midlatitude cyclones. Part VIII: A model for the "seeder-feeder" process in warm-frontal rainbands. *J. Atmos. Sci.*, **40**, 1185-1206.

Tapp, M.C. and P.W. White, 1976: A Nonhydrostatic Mesoscale Model. *Quart. J. Roy. Meteor. Soc.*, **102**, 277-296.