

LONG-LASTING DEEP CONVECTIVE SYSTEMS IN THE MEDITERRANEAN BASIN: A MODEL STUDY

Pasqui M., S. Melani, B. Gozzini and F. Pasi

Institute of Biometeorology, Via G. Caproni, 8, 50145 Florence, Italy, m.pasqui@ibimet.cnr.it

(Dated: 15 September 2009)

I. INTRODUCTION

Long lasting deep convective storms are of particular interest because of their potential damaging power. Many studies, analyzing the dynamical characteristics of these precipitating systems, highlighted their stationary behaviour as one of the most important dynamical features. It is responsible of large rainfall amount and can produce casualties and hazards over a large area. Such specific dynamical feature is the consequence of interaction between large and local scale atmospheric circulation. Thus it is quite difficult to reproduce with numerical models as both dynamical and thermo – dynamical description must be well simulated (Krichak and Levin, 2000).

4 different storms (see Fig.1 and Fig.2), three over sea: 4th Dec 2004, 4th Nov 2008 and 8th Jan 2009; and one over land (18th Sep 2007), were simulated by means of a non – hydrostatic, high resolution numerical model (the Regional Atmospheric Modelling System – RAMS) and analysed using remote sensed data (see Melani et al., 2009, this Conference).

Among these events, the December 4th, 2004 storm is of particular interest. It developed over the Tyrrhenian Sea, between Corsica Island and Italy as a stationary long live severe convective storm. It lasted over 8 hours, producing heavy rains even far from the convective downdraft areas and intense wind speed. Over the anvil cloud top a so-called V – shape ice plumes was observed. This unusual cloud top feature is composed of very small ice particles with a very high 3.9 μ m reflectivity values, as observed and modelled by Melani et al. (2003a, b).

II. PRESENTATION OF RESEARCH

The Regional Atmospheric Modeling System, RAMS, has been used operationally at Consortium LAMMA (<http://www.lamma.rete.toscana.it>) and National Research Council (<http://www.ibimet.cnr.it>) since 1999. The latest RAMS version, 6.0, has been used for this study as modelling component (Meneguzzo et al. (2004), Soderman et al. (2003), Pasqui et al. (2005)). A general description of the model can be found in Pielke et al. (1992), while a technical description can be found on the ATMET web site (<http://www.atmet.com>).

Today RAMS represents one of the state-of-the-art models in atmospheric science and it is continuously improved on the basis of a multi-disciplinary work. The physical package of the model describes a number of atmospheric effects: a two-way interactive nested grid structure, an atmospheric turbulent diffusion processes according with the Mellor-Yamada scheme, a cloud microphysics parameterization (Walko et al., 1995, Meyers et al., 1997), modified Kain-Fritsch type cumulus parameterization, the Harrington radiative transfer

parameterization short and long wave scheme and the Land Ecosystem Atmosphere Feedback scheme (LEAF-3) for soil – vegetation – atmosphere energy and moisture exchanges, described in Walko et al. (2000).

Using the RAMS model, simulations for these severe convective events were performed at very high horizontal and vertical resolution. Grids specifications following: for each event a nested grid approach with three grids at different horizontal resolution: 32km, 8km and 2km in order to guarantee the proper description of large to local scale dynamics features. The 2km inner grid has a stretched vertical spacing from 22m, near surface, to 800m, in the troposphere. The atmospheric forcing was provided by the NCEP – NCAR Reanalysis 6 – hours dataset for the coarse grid, while the one – way nesting from coarse to medium, and from medium to fine grid is set every 1 hour. Observed sea surface temperature (SST) from MODIS was used in order to provide a good description of vapour exchanges between sea and atmosphere boundary layer. RAMS model provides a full comprehensive simulation system that is able to represent atmospheric evolution of such a severe convective systems.

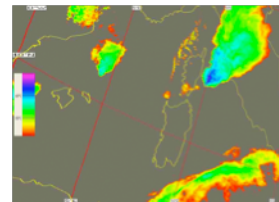


Fig.1: 4th December 2004, 12:41 UTC. NOAA – 16 AVHRR channel 4 image of the cloud top temperature (Event A).

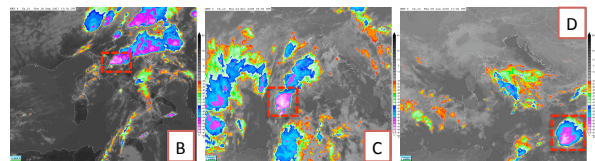


Fig. 2: Thermal infrared satellite images from MSG (Met 9, Ch 10): 18th Sep 2007, 13:30 UTC (event B); 4th Nov 2008, 5:30 UTC (event C); 8th Jan 2009, 17:00 UTC (event D).

III. RESULTS AND CONCLUSIONS

In RAMS model, providing a full comprehensive simulation system, was able to represent atmospheric evolution of such a severe convective systems. Using the detailed parameterisation scheme for cloud microphysics dynamics, it reproduces quite accurately the main feature of convective storms (see Fig.3). In particular location, cloud top properties (skin temperature and shape) and rainfall amount of active cells were represented. In general the stationary phase was reproduced, even if duration was in

general shorter than the observed one. Topography plays a key role for the studied events since the triggering mechanism is due to the instabilities generated by the interaction between large scale flow and mountain chain respectively over Corsica, Sardinia, Appennini and Etna mountain. The stationary phase was always guaranteed by the evaporation from the positive sea surface temperature anomaly for cases A, C and D, and from the positive soil moisture anomaly present for case B.

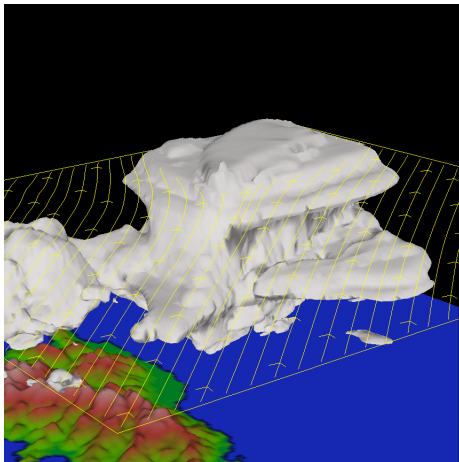


Fig.3: Event A modelled by RAMS. Total condensate concentration: in white it is shown the isosurface at 0.1 g/kg along with horizontal wind streamlines at 14km above ground level.

IV. ACKNOWLEDGMENTS

The authors would like to thank Francesca Guarnieri, Graziano Giuliani for their support and the LAMMA Consortium for availability of satellite data used in such research.

V. REFERENCES

- Krichak, S.O. Levin, Z., 2000: Mesoscale Simulation of Life Cycle of Cloud Microphysics During Hazardous Weather Conditions in the Southeastern Mediterranean *Atmos. Res.*, 53, 63-89.
- Meyers, M. P., R. L. Walko, J. Y. Harrington, W. R. Cotton, 1997: New RAMS cloud microphysics parameterization. Part II: The two-moment scheme. *Atmos. Res.*, 45, 3-39.
- Melani, S., E. Cattani, V. Levizzani, M. Cervino, F. Torricella, and M.J. Costa, 2003a: Radiative effects of simulated cirrus clouds on top of a deep convective storm in METEOSAT Second Generation SEVIRI channels. *Meteor. Atmos. Phys.*, 83, 109-122.
- Melani, S., E. Cattani, F. Torricella, and V. Levizzani, 2003b: Characterization of plumes on top of deep convective storm using AVHRR imagery and radiative transfer simulations. *Atmos. Res.*, 67-68, 485-499.
- Melani, S, M. Pasqui, A. Antonini, A. Ortolani and V. Levizzani: The synergy of GEO-LEO satellite observations in analysing enhanced-V features on top of severe storms. ECSS, 2009
- Meneguzzo F., M. Pasqui, G. Menduni, G. Messeri, B. Gozzini, D. Grifoni, M. Rossi and G. Maracchi, "Sensitivity of meteorological high-resolution numerical simulations of the biggest floods occurred over the arno river basin, Italy, in the 20th century.", *Journal of*

Hydrology, 288, 37-56, 2004.

Pasqui M., Baldi M, Giuliani G., Gozzini B., Maracchi G. and Montagnani S., 2005. Operational Numerical Weather Prediction systems based on Linux cluster architectures, *Nuovo Cimento*, 28 C, N.2, DOI 10.1393/ncc/i2005-10183-4.

Pielke, R. A. & Coauthors, 1992: A comprehensive meteorological modelling system-RAMS. *Meteor. Atmos. Phys.*, 49, 69-91.

Walko, R. L., W. R. Cotton, M. P. Meyers, and J.Y. Harrington, 1995: New RAMS cloud microphysics parameterization. Part I: The single-moment scheme. *Atmos. Res.*, 38, 29-62.

Walko, R.L., L.E. Band, J. Baron, T.G.F. Kittel, R. Lammers, T.J. Lee, D. Ojima, R.A. Pielke, C. Taylor, C. Tague, C.J. Treback, and P.L. Vidale, 2000: Coupled atmosphere-biophysics-hydrology models for environmental modeling. *J. Appl. Meteor.*, 39, 931-944.