The synergy of GEO-LEO satellite observations in analysing enhanced-V features on top of severe storms

S. Melani [1,2], M. Pasqui[1,2], A. Antonini[1,3], A. Ortolani[1,2] and V. Levizzani[4]

[1]*Instiute of Biometeorology, National Council of Research (IBIMET-CNR), via G. Caproni 8, Florence, I-50145. Email: s.melani@ibimet.cnr.it*
[2]*Consorzio LAMMA, Laboratory of Monitoring and Environmental Modelling for the sustainable development, via Madonna del Piano 10, Sesto Fiorentino (FI), I-50019. Email: melani@lamma.rete.toscana.it*
[3]*Hydrological Service of Tuscany Region, via S. Gallo 34a, Florence I-50129. Email: andrea.antonini@regione.toscana.it*
[4]*Institute of Atmospheric Sciences and Climate, National Council of Research (ISAC-CNR), via Gobetti 101, Bologna, I-40129. Email: v.levizzani@isac.cnr.it*

I. INTRODUCTION

The presence of enhanced-V features is a good marker of severe weather conditions (Adler et al., 1985; Heysmfield and Blackmer, 1988), making their characterization interesting for possible severe weather early warnings systems. Significant cloud top features, as plumes of small ice crystals, have been observed (Levizzani and Setvak, 1996; Setvak et al., 2003) and modelled (Melani et al., 2003a,b; Wang, 2003; 2007; Pasqui et al., 2009, this issue) through polar-orbiting (NOAA-AVHRR, MODIS) instruments, taking advantage of their high spatial resolution. Against the poor refresh time of polar satellite, the enhanced high temporal sampling Rapid Scan Service (RSS) of MSG1 (i.e., one image every 5 minutes) opens up unprecedent opportunities to follow the dynamical evolution of such cloudy features (e.g., water vapour transport in stratosphere) with greater detail, having sometimes very short lifetime. Four selected case studies were chosen for their marked presence of enhanced-V features, producing heavy precipitation and presenting intense updrafts and strong tropospheric shear. The heterogeneous sources of generation of these storm events, localised on land and sea, have allowed to better characterise possible mechanisms of generation as well as favourable thermodynamical conditions for their developing.

II. PRESENTATION OF RESEARCH

Severe storms top properties have been investigated for the selected case studies, through their scattering properties by means of bidirectional reflectance factor in the visible (VIS) channels and their emission properties through brightness temperatures in the water vapour (WV) and infrared (IR) channels. Also, regional model simulations (Pasqui et al. 2009, this issue) have been performed for the same case studies to comprehend the dynamical mechanisms responsible for the convection generation, its maintenance and decay. A set of polar (AVHRR and MODIS), and GEO images (MSG-SEVIRI) was chosen to analyse such features and extract some cloud microphysics characteristics. The analysis of the different stages of the severe storm systems has also been addressed, supported by lightning data and precipitation patterns through rainfall classes provided by ground radar measurements and rainfall estimates via a satellite-based precipitation algorithm.

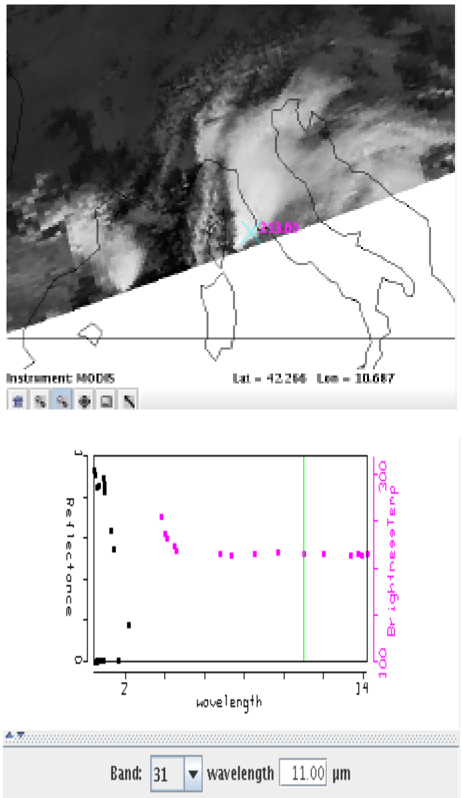

FIG. 1: 04 December 2004, 12:20 UTC. MODIS AQUA. Spectral signature of a pixel located in the right branch of the storm, showing high reflectance values and exhibiting a blackbody behaviour.

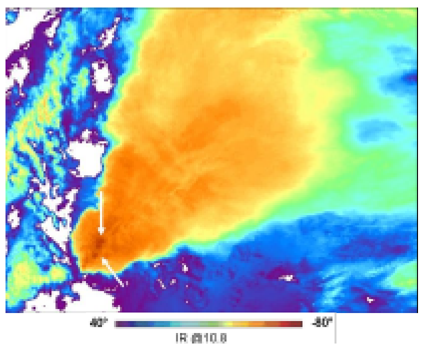

FIG. 2: 04 December 2004, 12:42 UTC. NOAA-16 AVHRR channel4 Tb image, showing the location of the overshooting tops of the multicell storm, injecting in the stratosphere.

III. RESULTS AND CONCLUSIONS

The chosen convective systems presents some common features, as they seem to be triggered by an advancing tropopause height anomaly (or potential vorticity maxima) coupled with a strong upper level jetstream. All these features are coherent with the long lasting and regenerating character of the analysed systems.

For example, MSG1-based RSS sequences of images of HRV and BTD (WV@6.2 – IR@10.8) show the evolution of the multicell storm for the 8th of January 2009 in its mature stage, with a 5 minutes sampling. A relevant water vapour flux exchange between the troposphere and the stratosphere is evident during all the sequence, as documented by the positive values of BTD.

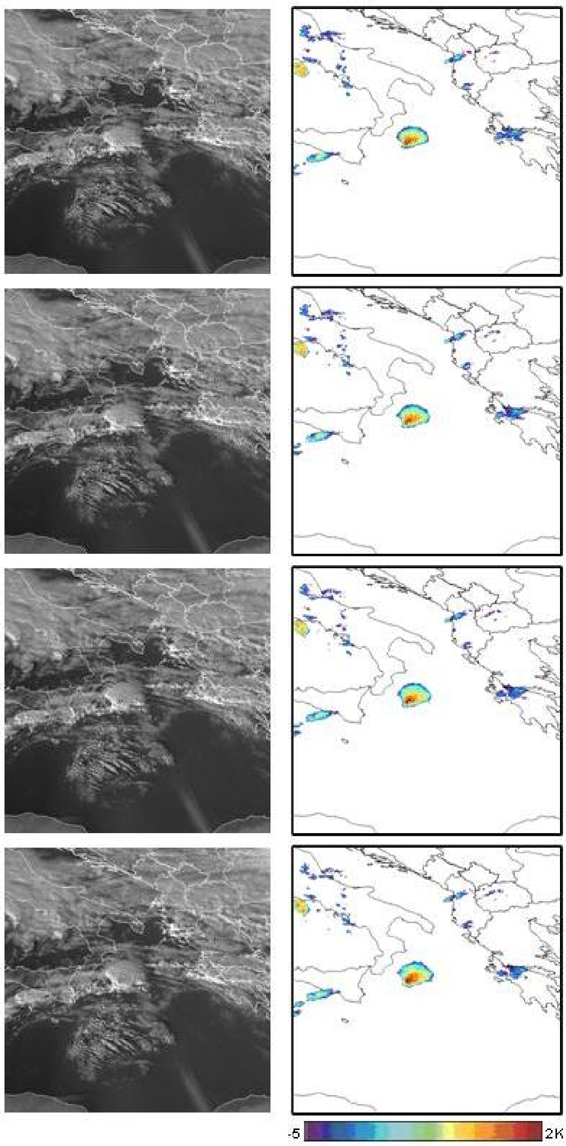

FIG. 3: RSS MSG1 sequences of images of HRV and BTD (WV@6.2-IR@10.8) for 8th January 2009. Images are every 5 minutes, from 1430 to 1445 UTC.

This study has shown the potential of the synergic use of very high temporal resolution, multichannel instrument like RSS service from MSG1 and high spatial resolution, multichannel instrument like MODIS and AVHRR for characterising severe storm V-features and highlighting mass exchange between tropospheric and stratospheric layers. Such analysis supported by model simulations of the dynamics of the severe weather storms (Pasqui et al., 2009) may reveal crucial in explaining some mechanisms not yet fully understood.

IV. AKNOWLEDGMENTS

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V. REFERENCES

Adler, R.F., M.J. Markus, and D.D. Fenn, 1985: Detection of severe Midwest thunderstorms using geosynchronous satellite data. *Mon. Wea. Rev*., 113, 769-781.

Heymsfield, G.M., and R.H. Blackmer, Jr., 1988: Satellite-observed characteristics of Midwest severe thunderstorm anvils. *Mon. Wea. Rev*., 116, 2200-2224.

Levizzani, V., and M. Setvàk, 1996: Multispectral, high resolution satellite observations of plumes on top of convective storms*. J. Atmos. Sci*., 53, 361-369.

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.

Pasqui, M., S. Melani, B. Gozzini, and F. Pasi, 2009: Long-lasting deep convective systems in the Mediterranean basin: a model study, *this issue.*

Setvàk, M., R.M. Rabin, C.A. Doswell III, and V. Levizzani, 2003: Satellite observations of convective storm tops in the 1.6, 3.7 and 3.9 um spectral bands. *Atmos. Res*., 67-68, 607-627.

Wang, P.K., 2003: Moisture plumes above thunderstorm anvils and their contributions to cross tropopause transport of water vapour in midlatitudes. *J. Geophys. Res.*, 108 (D6) , 4194, doi:10.1029/2003JD002581.

Wang, P.K., 2007: The thermodynamic structure atop a penetrating convective thunderstorm. *Atmos. Res*., 83, 254-262.