CASE STUDY OF A SEVERE CONVECTIVE STORM: FLASH FLOOD AND HAIL IN SOFIA ON 23 JUNE 2006

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I. INTRODUCTION

Summer convection often produces severe weather over Bulgaria, even tornado (Georgiev 2003). In the case on 23 June 2006, synoptic methods and NWP tools used in the operational forecasting environment at the National Institute of Meteorology and Hydrology (NIMH) were not efficient to correctly forecast the severity of the convective process.

Different authors have stressed on specific meso- and large-scale features related to the environment of severe convection that are seen on satellite water vapour (WV) imagery in 6.3/6.7 μm channels (Georgiev, 2003; Krennert and Zwatz-Meise, 2003; Santurette and Georgiev, 2005).

This paper shows the usefulness of 6.2 μm channel imagery for indicting upper-level vorticity advection that plays a critical role in conditioning the environment for development of the severe convective storm. The information content of images in other Meteosat channels in helping to assess other features of the convective situation is also discussed.

II. SYNOPTIC SITUATION AND WEATHER PHENOMENA

On 23 June 2006, several convective cells embedded in a Mesoscale Convective System (MCS) developed over western part of Bulgaria (Fig. 1). The Meteosat High Resolution Visible (HRV) channel imagery is a good tool to see a distinct cell just to the north of Sofia, which location is indicated by the cross in Fig. 1 This convective cell produced flash flood in the city (Fig. 2) due to heavy rain and hail about 5 cm in diameter. The case caused significant damages: interruption of electricity in many districts of the capital of Bulgaria because of flooded electricity transfer facilities, car accidents, including a turned over tram.

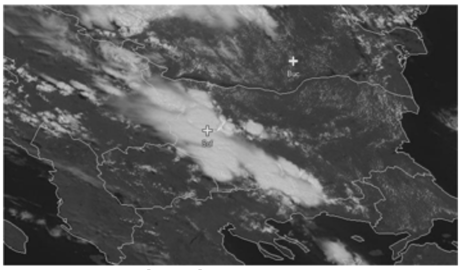


FIG. 1: Meteosat HRV channel image, 23 June 2007 at 11 UTC.

The operational forecast of NIMH underestimated the severity of this convective development. The synoptic analysis performed provides some evidences for the presence of a convective situation on 23 June 2006. On the large scale, the western part of Bulgaria is situated in highly diffluent mid-level flow (at the white arrow in Fig. 3). At low-level, the moist air in a deformation air mass field, diurnal heating, and terrain-induced lifting have been assessed by the forecasters as favourable factors for the initiation of convection over the region of Sofia.

FIG. 2: Flash-flood in the Sofia city on 23 June 2006 afternoon.

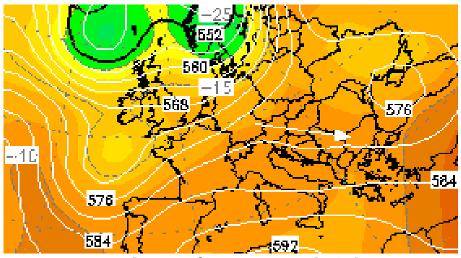


FIG. 3: NCEP reanalysis of geopotential (white contours) and temperature (in colours from –25°green to –5° brown) at 500 hPa isobaric surface for 12 UTC on 23 June 2006.

The operational forecast, however, failed to correctly assess the strong upper-level forcing for vertical motions that was the main reason for underestimating the severe convective development. As a result, only low probability for weak showers and lightening were forecasted in the 24 hours as well as the 12 hours forecasts.

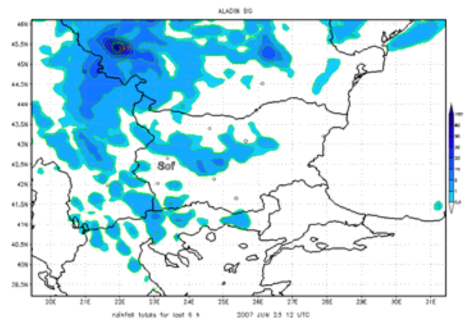


Fig. 4: Total 6-hour rainfall from 06 to 12 UTC on 23 June forecasted from ALADIN model run of 22 June 2007 00 UTC.

The locally run ALADIN operational NWP model did not predict any intensive precipitations over Bulgaria on 23 June. Fig. 4 shows the 36-hours forecast for accumulated rainfall between 06 and 12 UTC on 23 June that is used as a basic reference in issuing the operational forecast. For this as well as for the next 6-hours period (12 – 18 UTC, not presented), areas of heavy precipitation (about 100 mm for 6 hours, dark blue) over Romania and Serbia were predicted. However, only a small zones of less than 10 mm total rain has been forecasted for the western part of Bulgaria where the severe MCS seen in Fig. 1 developed.

III. PRECONVECTION ENVIRONMENT AS SEEN BY METEOSAT IMAGERY

At 06 UTC and 12 UTC, the Showalter index reported by SATREP (2006) near the western part of Bulgaria is under –3° that is the temperature difference of an air parcel lifting from 850 to 500 hPa and comparing with the temperature of its environment. Such a value indicates that thunderstorms are possible. In this case there is also conditions for triggering, coming from both, orographic lifting in the mountains of western part of Bulgaria and from upper-level forcing for vertical motions.

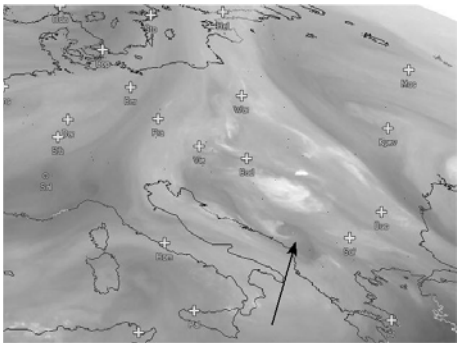
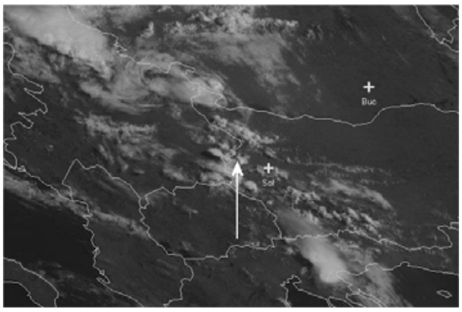


FIG. 5: Meteosat 6.2 μm image, 23 June 2007 at 03 UTC. The black arrow indicates the upper-level vorticity pattern.

(a)



(b)

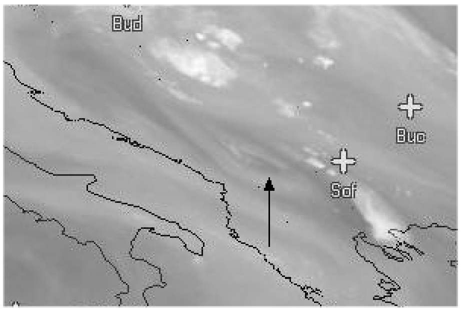


FIG. 6: Meteosat images, 23 June 2007 at 08 UTC. (a) HRV channel (b) 6.2 μm channel. The white and black arrows indicate first initiated convective cells and vorticity pattern respectively.

This study shows that the critical mechanism for strong convective development in a deep layer was the vorticiy advection at mid- and upper-level. The upper-level triggering, produced by vorticity advection, is clearly seen in the 6.2 μm imagery. The vorticity pattern at the position of the black arrow in Fig. 5 was visible on the WV images a day before the severe convective development. Animated WV images could be used to anticipate the upper-level vorticity advection over the area where the low-level conditions were favourable for convection, as they have been assessed by means of synoptic analysis. The presence of low-level moisture over western part of Bulgaria can be also seen in 8.7 μm channel images (not presented).

The first severe convective cells initiated about midday at white arrow in Fig. 6 (a) located at the leading moisture boundary of the dynamic dark zone, seen in 6.2 μm (see Santurette & Georgiev, 2005), associated with upper-level vorticity pattern. Animated images in the previous 24 hours show that this dark zone at the black arrow in Fig. 6(b) is a very conservative feature, which tends to be advected in a favourable pre-convective environment.

IV. CONCLUSION

As suggested by Martín et al. (1997), severe storms are uncommon phenomena and the ability to take into consideration all evidences from synoptic, satellite and sounding data together to explain and evaluate what and why is happening in the atmosphere it is a quite difficult operational task. Significant effort has to be made by the operational forecasters for applying a complex approach in analysing and forecasting hazardous weather, related to heavy rain, flash flood or hail. Following the dynamic upper-level structures (such as this indicated by the black arrow in Fig. 6(b)) in sequences of WV images, the forecasters would be able to assess the upper-level conditioning of the atmosphere for strong convection. In the presence of low-level favourable synoptic factors, the approach of WV imagery analysis could help to correctly assess the severity of the convective situation.

IV. AKNOWLEDGMENTS

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V. REFERENCES

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