HEAVY RAINFALL AND FLASH FLOOD IN DUBROVNIK ON 22ND NOVEMBER 2010

M. Tudor, A. Stanešić, D. Mazzocco Drvar, D. Plačko Vršnak, S. Ivatek-Šahdan

1Croatian Meteorological and Hydrological Service, Grič 3, Zagreb, Croatia, tudor@cirus.dhz.hr
(Dated: 26 August 2011)

I. INTRODUCTION

The flash flood event on 22nd November 2010 in Dubrovnik, Croatia, is analyzed using available in situ measurements, satellite data and NWP model runs with various configurations. The rainfall in Dubrovnik was the highest ever measured. The flood water level reached 1.5 m caused damage and endangered lives.

II. THE SYNOPTIC SITUATION

The synoptic situation was characterized by a huge low moving over the Alps (Fig 1a) with the frontal system covering most of Central Europe and Mid-Mediterranean. Jet streak at the rear side of the cold front was crossing the frontal cloud band at a large acute angle causing the intensification of the process over the Mid-Mediterranean (Fig 1b). PV anomaly developed with the intrusion of the dry stratospheric air reaching below 450hPa (Fig 1c). Intensive Positive Vorticity Advection (PVA) as a consequence of the deepening trough in the neighbourhood of the left exit region of the jet streak contributed to the strong upward motion in the area (Fig 1d). Over the southern Italy and Adriatic Sea, a secondary cyclone developed and the meso-scale convective system grew within.
The rain gauge measurements exceeded 100 mm/24hr in the area and the one in Dubrovnik measured 161.4 mm/24hr, with a peak intensity of 71.5 mm/h. The satellite derived precipitating clouds, convective rainfall rate and severe storm figures show high intensity (Fig 2).

III. RESULTS AND CONCLUSIONS

The operational ALADIN forecast (Fig 4a) uses ARPEGE initial and boundary conditions and digital filter initialization (DFI). The parallel suite (Fig 4b) uses 3Dvar data assimilation. The operational and parallel suite model results forecast large 24 hour accumulated rainfall amounts in the area around Dubrovnik, with the maxima over 100 mm situated above the surrounding areas of Montenegro and Bosnia and Herzegovina. The peak intensity of precipitation in all model runs is late. The peak in runs coupled to IFS is several hours later than in runs coupled to ARPEGE (Fig 5).
FIG. 5: Hourly or 3 hourly measured and 8 km model precipitation.

Several experiments using high-resolution (2 km) non-hydrostatic ALADIN and WRF model runs have been performed. The 8 km resolution ALADIN run coupled to IFS with 3Dvar initialization (Fig 4d) was used for initial and boundary conditions of the 2 km ALADIN NH experiments. The results of these runs show dependency on the model, input data from initial and lateral boundaries. The position (Fig 6) and time (Fig 7) of the precipitation maxima in the high resolution ALADIN output fields is similar to the lower resolution (8 km) run used for initial and lateral boundary conditions.

There are options in ALADIN model that control the advection and horizontal diffusion of the prognostic variables that describe microphysics (cloud liquid water and ice, rain and snow) and deep (rain producing) convection (updraft and downdraft vertical velocities and mesh fractions). Several experiments have been performed that assess the impact of these options. The accumulated 24 hr precipitation field shown in Fig 6 is from the experiment with the advection and no horizontal diffusion of microphysics variables and "static" prognostic convection scheme (the prognostic convection variables were neither advected nor diffused horizontally).

In the high-resolution experiments of the ALADIN model, significant part of the precipitation was given by the convection scheme, when it was switched on. This result suggests the importance of using the convective parameterization in the ALADIN model even for resolutions in which it is assumed that the convection is resolved.

WRF simulations were initialized on 12 UTC 21 Nov 2010 for 42 hr forecast range with ECMWF LBC using the following parameters: 41 sigma levels, 2 domains, outer at 8 km (d01), inner at 2 km (d02), Betts-Miller_Janjic cumulus (only in d01), Morrison 2-moment microphysics, Noah land-surface model, Monin-Obhukov-Janjic (eta) surface scheme, Mellor-Yamada-Janjic TKE scheme for PBL parametrization with 1.5 order TKE closure, 2nd order diffusion on coordinate surfaces, 3rd order Runge-Kutta time-integration scheme, 5th order momentum advection and no assimilation. The WRF simulation gives a rainfall over 100 mm in the Dubrovnik area (Fig 8).

FIG. 8: WRF simulation of 24 hr precipitation.

IV. ACKNOWLEDGMENTS

The authors would like to thank the Meteorological and Hydrological Service of Montenegro for providing the meteorological and water level measurements. The authors also thank the Croatian Ministry of Science who supported this research through Grant 004-1193086-3036 to the Croatian Meteorological and Hydrological Service.

V. REFERENCES
