Predictability of prototype flash flood events in the western Mediterranean under uncertainties of the precursor upper-level disturbance

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The Interreg IIIB-Medocc HYDROPTIMET case studies (9-10/06/2000 Catalogne, 8-9/09/2002 Cévennes and 24-26/11/2002 Piémont) can be considered prototype flash-flood events of the western Mediterranean attending to the relevant synoptic and mesoscale signatures of the flow. In Catalogne, the convective event was driven by a low-pressure system of relatively small dimensions developed over the mediterranean coast of Spain that moved into southern France. For Cévennes, the main circulation pattern was a synoptic-scale Atlantic low which induced a persistent southerly low-level jet (LLJ) over the western Mediterranean, strengthened by the Alps along its western flank, which guaranteed continuous moisture supply towards southern France where the long-lived, quasistationary convective system developed. The long Piémont episode, very representative of the most severe alpine flash flood events, shares some similarities with the Cévennes situation during its first stage in that it was controlled by a southerly moist LLJ associated with a large-scale disturbance located to the west, while during the second half the episode the was dominated by a cyclogenesis process over the Mediterranean which gave place to a mesoscale-size depression at surface (like in Catalogne) that acted to force new heavy rain over the slopes of the Alps and maritime areas. A prominent mid-tropospheric trough or cut-off low can be identified in all events prior and during the period of heavy rain, which clearly served as the precursor agent for the onset of the flash-flood conditions and the cyclogenesis at low-levels. Being aware of the uncertainty in the representation of the upper-level disturbance and the necessity to cope with it within the operational context when attempting to issue short to mid-range numerical weather predictions of these high impact weather events, a systematic exploration of the predictability of the three selected case studies subject to uncertainties in the representation of the upper-level precursor disturbance is carried out in this work.

The study is based on an ensemble of mesoscale numerical simulations of each event with the MM5 non-hydrostatic model after perturbing in a systematic way the upper-level disturbance, in the sense of displacing slightly this disturbance upstream/downstream along the zonal direction and intensifying/weakening its amplitude. These perturbations are guided by a previous application of the MM5-adjoint model, which consistently shows high sensitivities of the dynamical control of the

heavy rain to the flow configuration about the upper-level disturbance on the day before, thus confirming the precursor characteristics of this agent. The perturbations are introduced to the initial conditions by applying a potential vorticity (PV) inversion procedure to the positive PV anomaly associated with the upper-level disturbance, and then using the inverted fields (wind, temperature and geopotential) to modify the model initial fields. The results generally show that the events dominated by mesoscale low-level disturbances (Catalogne and last stage of the Piémont episode) are very sensitive to the initial uncertainties, such that the heavy rain location and magnitude are in some of the experiments strongly changed in response to the 'forecast errors' of the cyclone trajectory, intensity, shape and translational speed. In contrast, the other situations (Cévennes and initial stage of the Piémont episode), dominated by a larger scale system wich basically acts to guarantee the establishment and persistence of the southerly LLJ towards the southern France-north Italy orography, exhibit much higher predictability. That is, the slight modifications in the LLJ direction and intensity encompassed by the ensemble of perturbed forecasts are less critical with respect to the heavy precipitation potential and affected area.