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Inclusion of potential vorticity uncertainties into a hydrometeorological forecasting chain: application to a medium size basin of Mediterranean Spain

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Abstract. The improvement of the short- and mid-range numerical runoff forecasts over the flood-prone Spanish Mediterranean area is a challenging issue. This work analyses four intense precipitation events which produced floods of different magnitude over the Llobregat river basin, a medium size catchment located in Catalonia, north-eastern Spain. One of them was a devasting flash flood – known as the "Montserrat" event – which produced 5 fatalities and material losses estimated at about 65 million euros. The characterization of the Llobregat basin's hydrological response to these floods is first assessed by using rain-gauge data and the Hydrologic Engineering Center's Hydrological Modeling System (HEC-HMS) runoff model. In second place, the non-hydrostatic fifth-generation Pennsylvania State University/NCAR mesoscale model (MM5) is nested within the ECMWF large-scale forecast fields in a set of 54 h period simulations to provide quantitative precipitation forecasts (QPFs) for each hydrometeorological episode. The hydrological model is forced with these QPFs to evaluate the reliability of the resulting discharge forecasts, while an ensemble prediction system (EPS) based on perturbed atmospheric initial and boundary conditions has been designed to test the value of a probabilistic strategy versus the previous deterministic approach. Specifically, a Potential Vorticity (PV) Inversion technique has been used to perturb the MM5 model initial and boundary states (i.e. ECMWF forecast fields). For that purpose, a PV error climatology has been previously derived in order to introduce realistic PV perturbations in the EPS. Results show the benefits of using a probabilistic approach in those cases where the deterministic QPF presents significant deficiencies over the Llobregat river basin in terms of the rainfall amounts, timing and localization. These deficiences in precipitation fields have a major impact on flood forecasts. Our ensemble strategy has been found useful to reduce the biases at different hydrometric sections along the watershed. Therefore, in an operational context, the devised methodology could be useful to expand the lead times associated with the prediction of similar future floods, helping to alleviate their possible hazardous consequences.

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