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Inclusion of Potential Vorticity uncertainties into hydrometeorological chain predictions: Application to a flash-flood event over Catalonia, Spain

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Introduction: the Montserrat flash-flood event

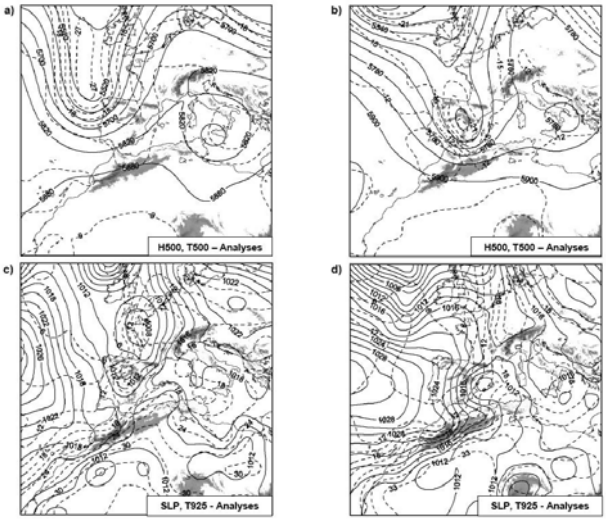
Synoptic situation

1. Entrance of an Atlantic low-level cold front and an upper-level trough
2. Generation of a mesoscale cyclone in the Mediterranean Sea
3. Advection of warm and moist air toward Catalonia from the Mediterranean

Easterly flow + Atlantic front + orographic enhancement

⇩

quasi-stationary convective system

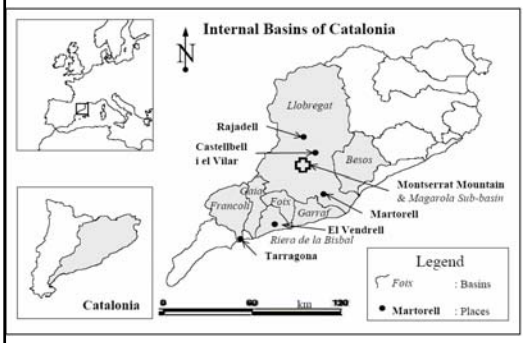


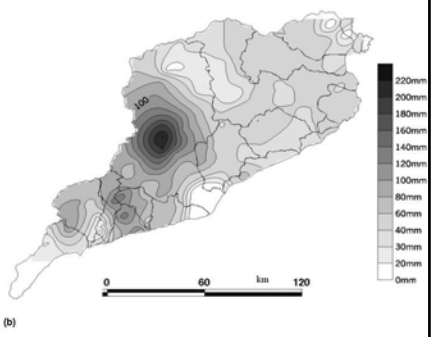
9 June 2000 0000 UTC

10 June 2000 0000 UTC

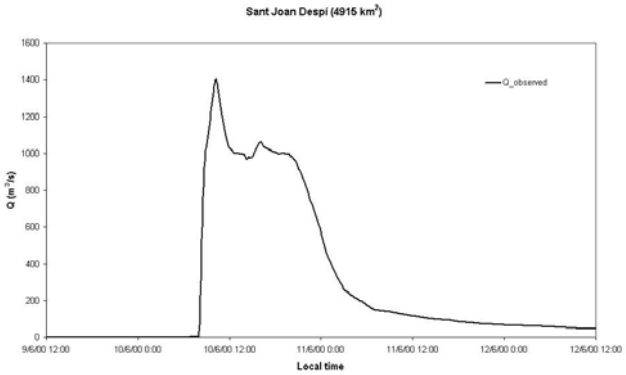
Introduction: the Montserrat flash-flood event

- The Llobregat catchment is a medium-size basin with an area of 5040 km^2 and a length close to 170 km
- Torrential precipitation took place on 10 June 2000 and accumulated rainfall reached over 200 mm inside Llobregat basin





Introduction: the Montserrat flash-flood event



- Huge increase in the river flow, producing 5 fatalities, 500 evacuated people and material damage estimated at over 65 M€
- Return periods:
  Q= 1025 m^3s^{-1} ⟶ 10 yrs
  Q= 1600 m^3s^{-1} ⟶ 20 yrs

Previous research: the Montserrat flash-flood case study

MM5 model set-up

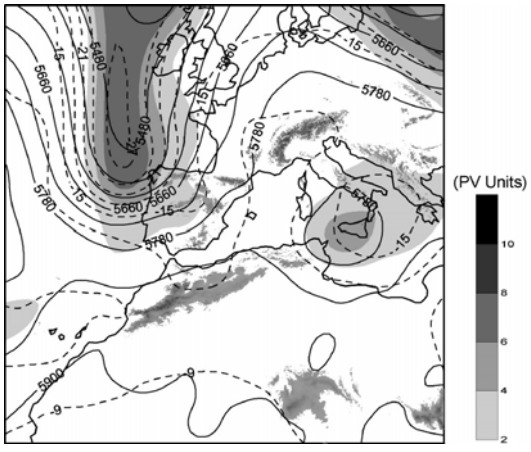
• Control simulation wit (update 12-h, 2.5º)
• Three nesting domain d 24 vertical σ-levels
• Kain-Fritsch scheme i d the second domains,
and no convective sche
• The experiments cons - 10/06/00 at 1200 UTC)

• Loss rate: SCS Curve
• Transform: SCS Unit
• Flow routing: Musking
• The experiments cons TC -13/06/2000 at 00:00
UTC in 10 minutes time-st

Ensemble of MM5-perturbed driven runoff simulations

MM5-NCEP initial conditions of the upper-level precursor trough

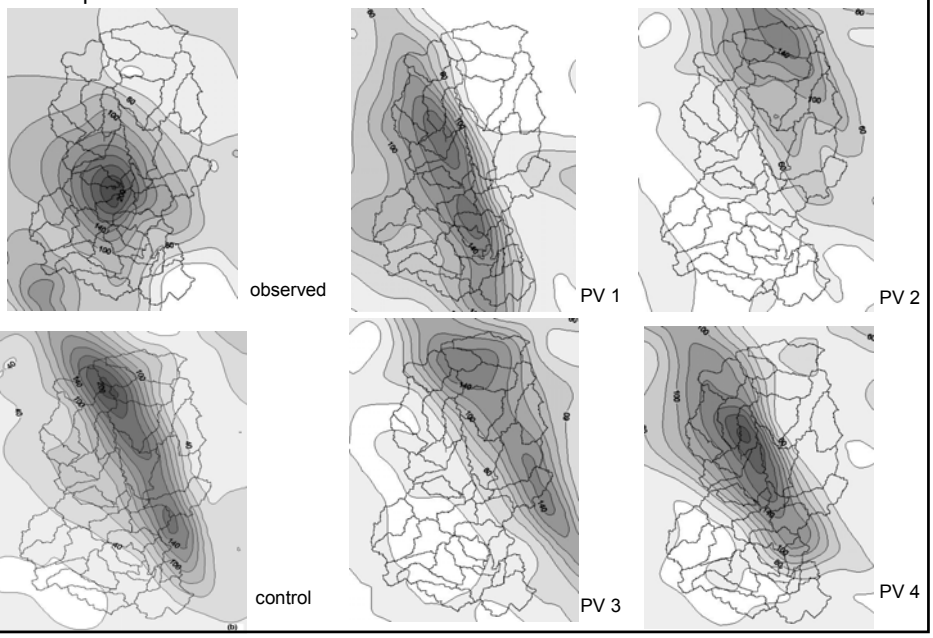
Slight perturbations on the initial state: study of the spatial and temporal uncertainties of the rainfall forecast into the catchment

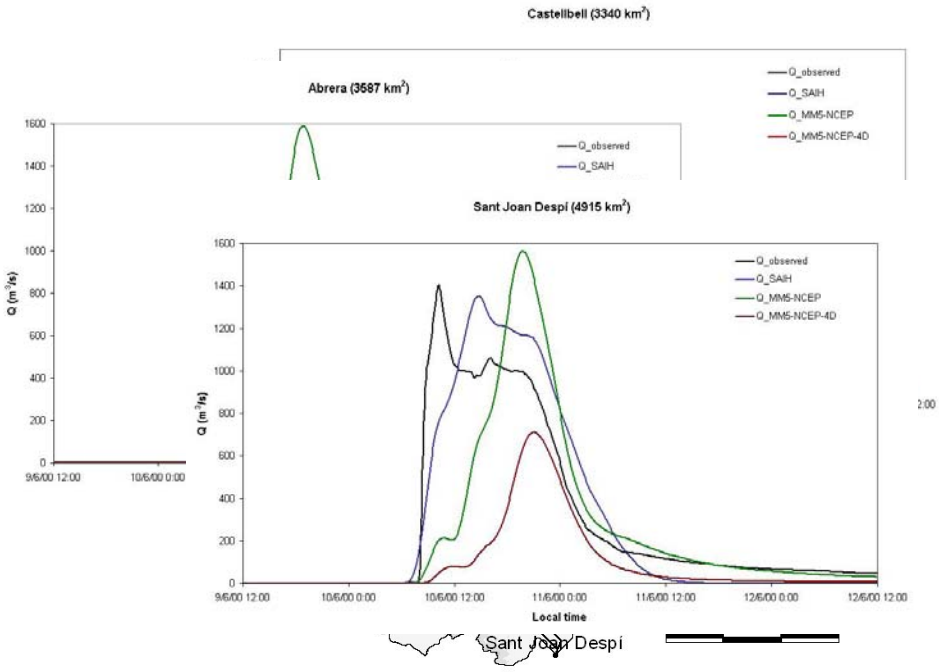


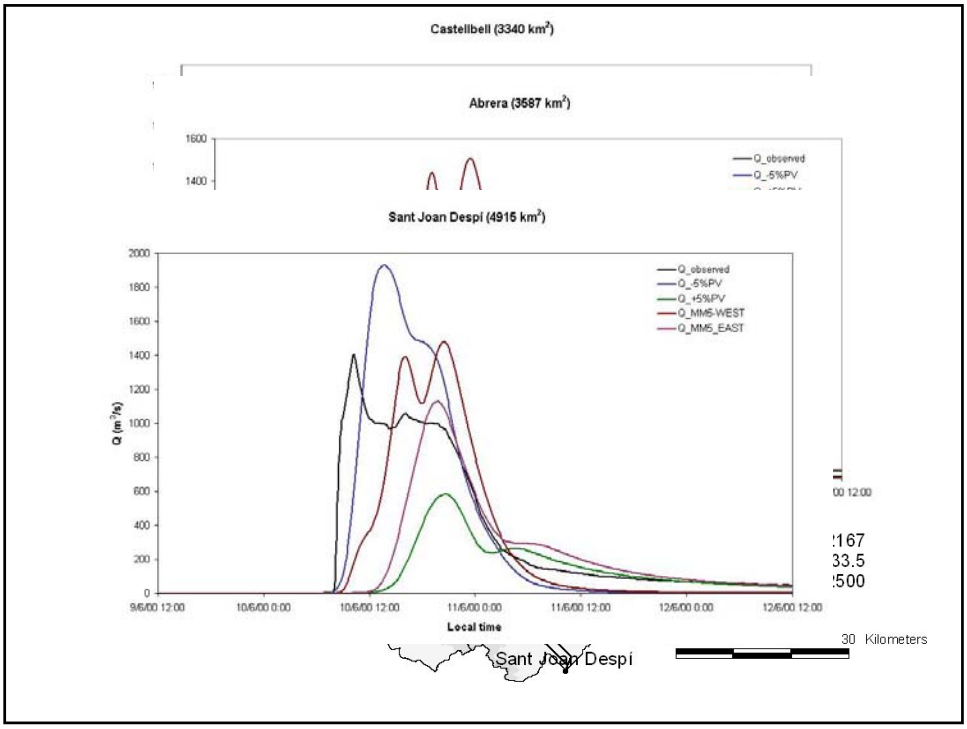
Four perturbed simulations were performed from the MM5-NCEP using PV inversion method guided by sensitivity results

Results: ensemble of MM5 driven runoff simulations

spatial accumulated rainfall distributions for the set of MM5 simulations:







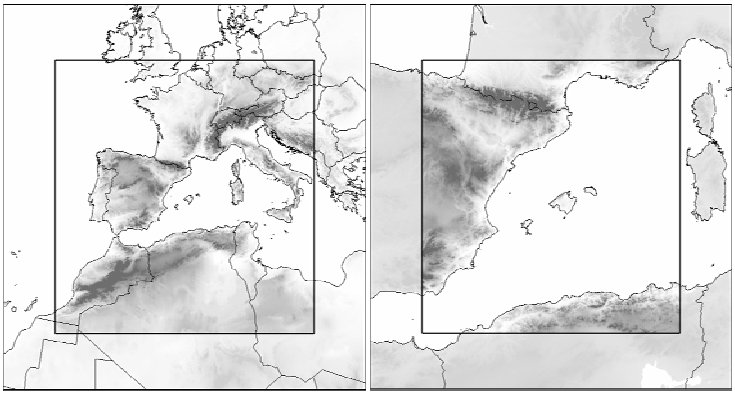
Main conclusions

- Different members of the ensemble outperform the control simulation at different stream-gauges
- The used methodology can be automated to obtain short-range runoff forecasts driven by high resolution mesoscale predictions available in real-time
- This ensemble prediction system (EPS) accounting for the forecast variance associated to the initial conditions uncertainty can avoid poor detection of a flash-flood event from a deterministic hydrometeorological system

Potential Vorticity uncertainties into hydrometeorological chain predictions

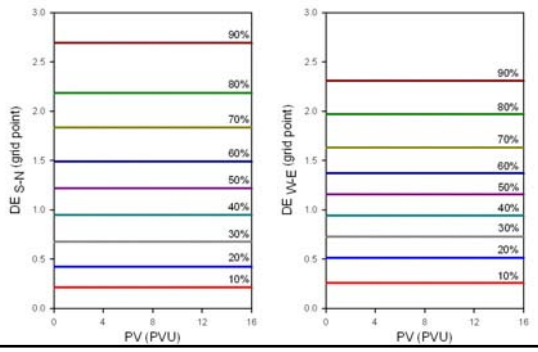
MM5 model set-up

• Meteorological simulations have used the same model configuration as in the real-time operational version at UIB (http://mm5forecasts.uib.es)
• Initial and boundary conditions: ECMWF forecasts (update 6h, 0.3º)
• Two domains: 22.5 and 7.5 km, interacting with each other and 30 vertical σ-levels
• Kain-Fritsch scheme is used to parameterise convection for both domains
• The experiments consider a 54-h period simulation (09/06/00 at 0000 UTC - 11/06/00 at 0600 UTC)



Potential Vorticity uncertainties into hydrometeorological chain predictions

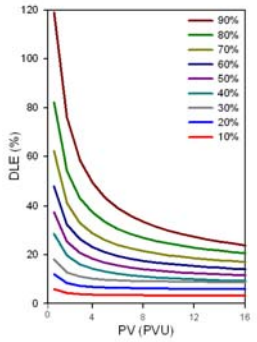
- A PV error climatology (PVEC) has been carried out to introduce realistic perturbations in the EPS. This allows to perturb the PV fields using the appropriated error range
- The PVEC is calculated using a large collection of MEDEX cyclones (19 cases, 56 days of simulation; further information available at: http://medex.inm.uib.es/), and provides the displacement and intensity error of the PV fields in the study region
- The displacement error corresponds to the displacement of the ECMWF 24 h forecast PV field showing local maximum correlation with the ECMWF analyses PV field



Percentile levels of displacement errors at 300 hPa

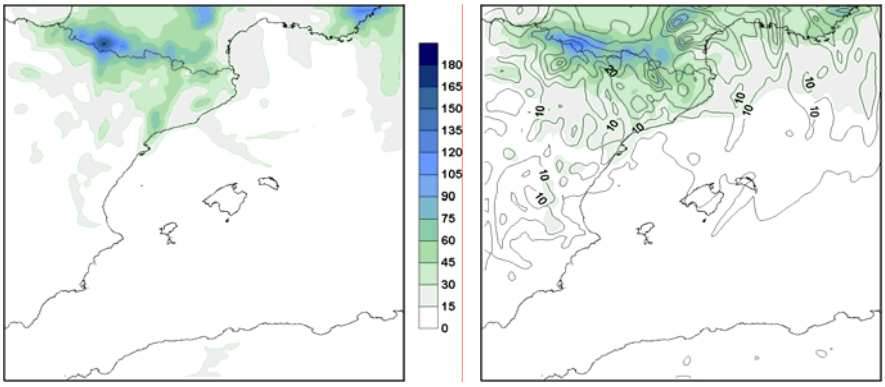
Potential Vorticity uncertainties into hydrometeorological chain predictions

- The intensity error corresponds to the difference between the displaced ECMWF 24 h forecast PV field and ECMWF analyses PV field
- This PVEC is used to implement the EPS by randomly perturbing the PV field. The perturbations are applied along the areas with the most intense PV values and gradients
- The PV Inversion Technique and the random PV field allow to perturb consistently the mass and wind fields conserving the energetic balance



Percentile levels of intensity errors at 300 hPa

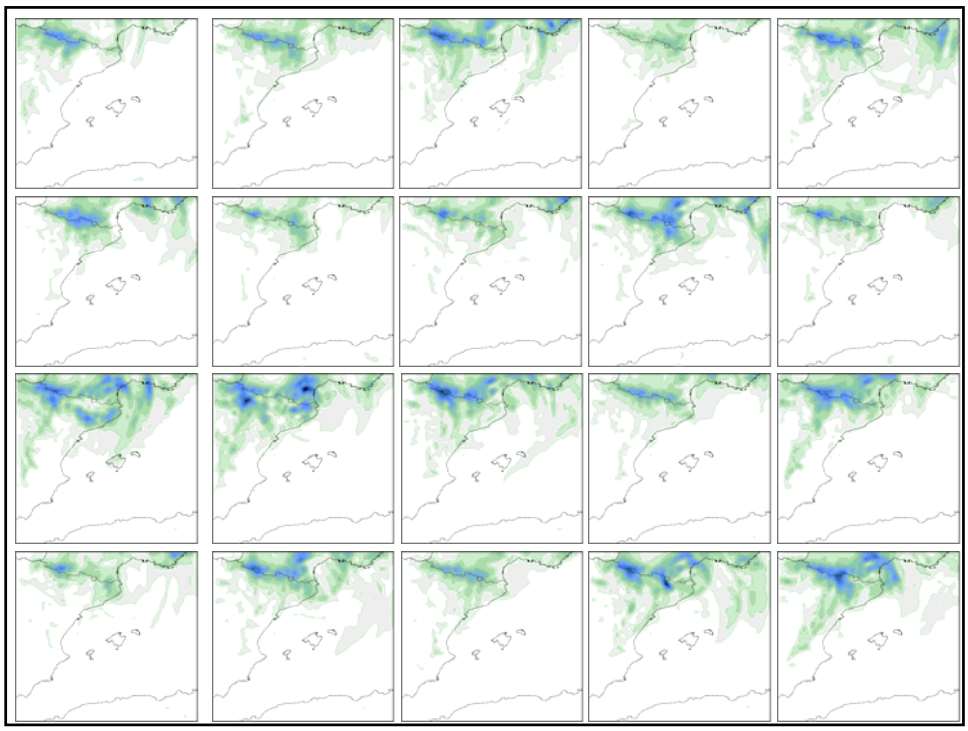
Results: Ensemble of MM5-PV perturbed simulations



Spatial distribution of accumulated precipitation for the control simulation

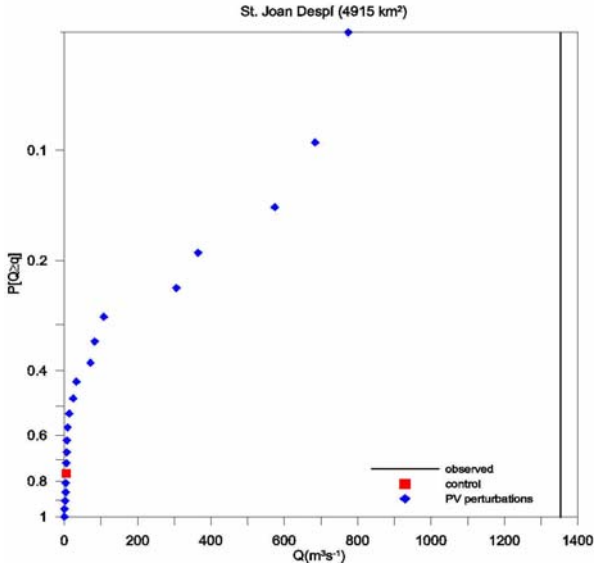
Ensemble mean (in mm, shaded) and ensemble standard deviation (in mm, continuous line at 5 mm interval

- MM5 ensemble comprises 21 elements (control + 20 PV-perturbed)



Results: Ensemble of MM5-PV perturbed driven runoff simulations

The elements of the MM5 driven runoff ensemble are considered to be equally-likely and are represented as cumulative distribution functions (CDFs) for the peak flows, plotted on a Gumbel chart



First considerations and future work

- MM5 control simulation is very deficient for the Montserrat event since the maximum amounts of precipitation are obtained over the north-western part of the meteorological domain, quite far away from the Llobregat basin

- The ensemble strategy slightly reduces the biases obtained for the control simulation, but a poor detection of the Montserrat event has arisen with this methodology

- The performance of the hydrometeorological simulations for the case strongly depends on the initial and boundary conditions of the databases

- Ongoing work: Application of this technique to other flood events affecting the Llobregat river basin

- Further information:

Amengual et al. (2007): A hydrometeorological modeling study of a flash-flood event over Catalonia, Spain. *J. Hydrometeor*., 8, 282-303

Romero et al. (2006): Predictability of prototype flash-floods events in the Western Mediterranean under uncertainties of the precursor upper-level disturbance. Adv. Geosciencies, 7, 55-6

Romero R. (2001): Sensitivity of a heavy rain producing Western Mediterranean cyclone embedded potential vorticity anomalies. Quart. J. Roy. Meteor. Soc., 127, 2559-2597