Potential vorticity error assessment applied to ensemble forecasts of Mediterranean cyclones

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1 Abstract

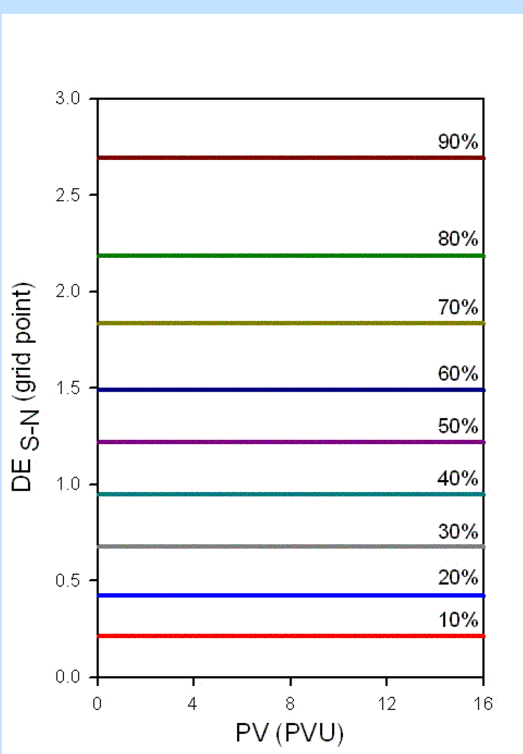
The western Mediterranean is a very cyclogenetic area and many of the cyclones developed over that region are associated with high impact weather phenomena that affect the society of the coastal countries. In the framework of PRECIOSO, a Spanish project devoted to improve the short and mid-range numerical forecasts of cyclones, ensemble prediction systems based on perturbed initial and boundary conditions are being designed. In this study, a Potential Vorticity (PV) Inversion Technique is used to perturb the initial state and boundary forcing of a mesoscale model. These simulations are performed with the MM5 mesoscale model nested in the ECMWF forecast large-scale fields, which provides results at 22.5 km resolution for a two-day period over the western Mediterranean countries (Domain 1 in http://mm5forecasts.uib.es).

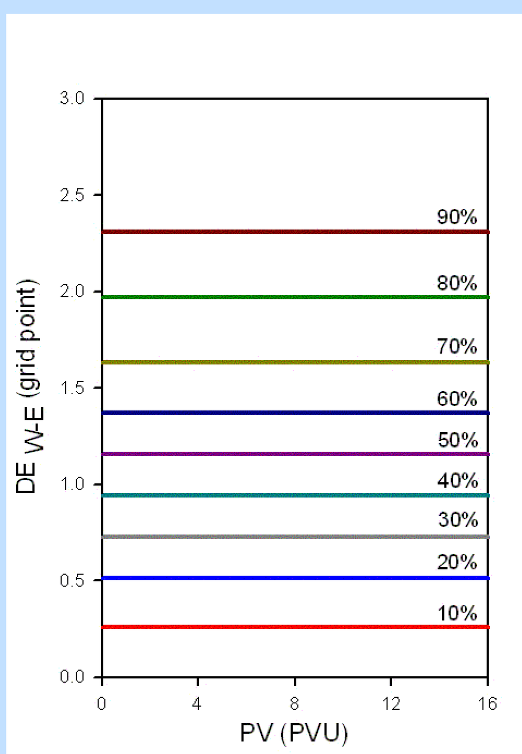
2 Methodology

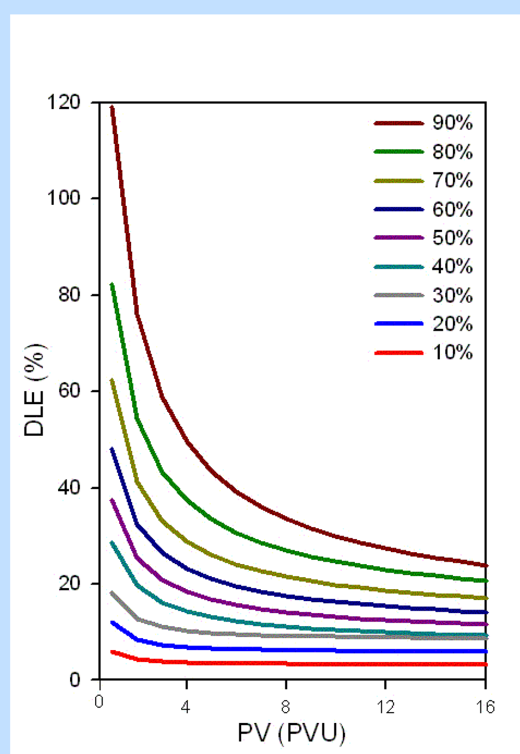
In an attempt to introduce realistic perturbations in the ensemble prediction system, a PV error climatology (PVEC) has to be done. This climatology allows to perturb the ECMWF forecast PV fields using the appropriated error range. The PVEC is calculated using a large collection of MEDEX cyclones, and provides the displacement and intensity error of the PV fields in the study region.

The displacement error (DE) corresponds to the displacement of the ECMWF 24 h forectast PV field showing local maximum correlation with the ECMWF analysis PV field. The DE presents a clear symmetry along South-North and West-East directions. The intensity error corresponds to the diference between the displaced ECMWF 24 h forecast PV field and ECMWF analysis PV field. This error presents a high symmetry, so the absolute value is used. The %DLE is defined as intensity_error/analysis_PV %.

Analytical functions have been fitted to model the error statistics (percentile levels of displacement and intensity errors) as function of pressure level and PV value. An example, at 300 hPa, is shown in the following figures.





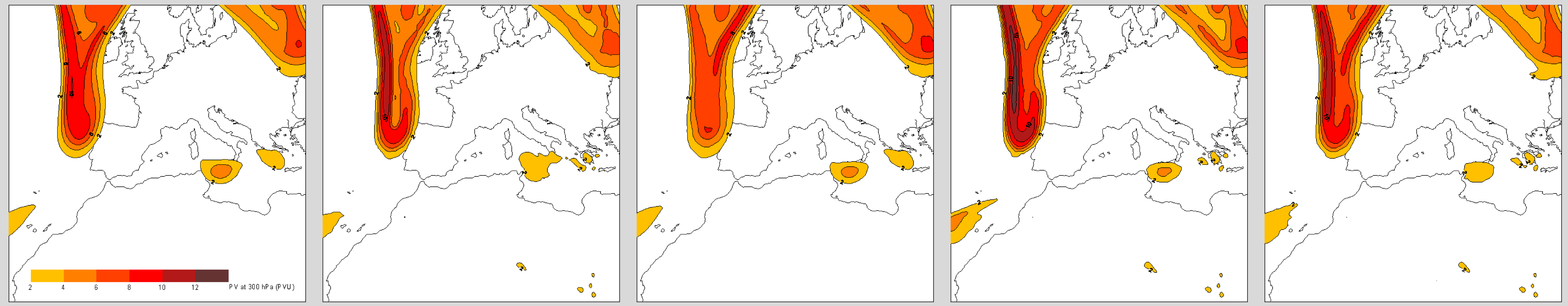


This PVEC is used to implement the above mentioned ensemble system by randomly perturbing the fields. These perturbations are aplied along the zones with the most intense PV values and gradients.

3 Application to a Mediterranean cyclogenesis event

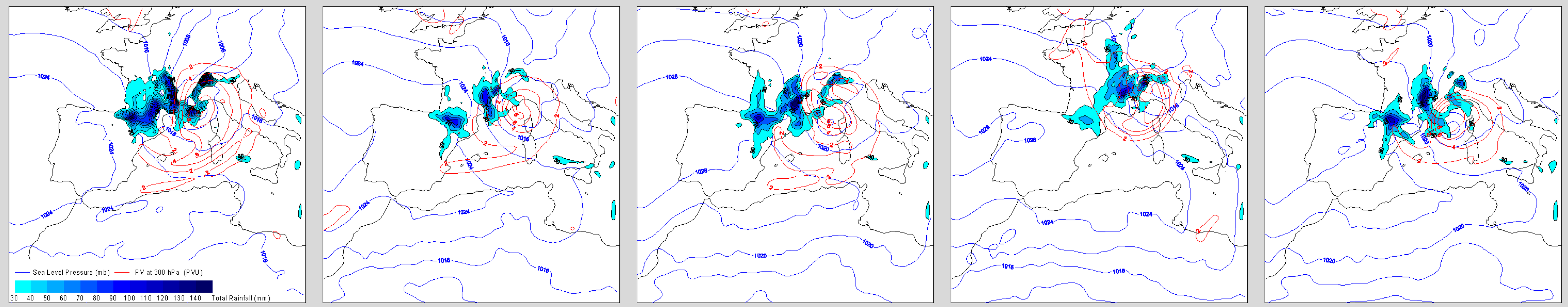
Original and perturbed PV fields in the three dimensional domain through the forecasting period are defined, and with the PV Inversion Technique the balance fields (temperature, geopotential and horizontal wind) are calculated. Then, the difference between the original and perturbed balance fields provides the initial and boundary perturbations for each member of an ensemble of simulations.

Preliminary results showing the potential of this methodology are presented for the flash-flood producing MEDEX cyclone of 9th June 2000. The following figures show the original initial state and four perturbed ensemble members. (9 th June 2000 at 00 UTC)



Control member | 1st memeber | 2nd memeber | 3th memeber | 4th memeber

The following figures show the MM5 54 h forecasts from the above initial states. (11th June 2000 at 06 UTC)



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4 Conclusions and Further Work

The designed methodology appears to be a promising tool for building ensemble forecasts of extreme weather events such as high impact Mediterranean cyclones. The use of a single variable (PV) on which to define perturbations, combined with the PV Inversion Technique, keeps the method simple while ensures modifications of all the meteorological fields without compromising the mass-wind balance. The resulting forecasts are consistent with the real uncertainties of the PV field and produce precipitation fields of realistic variability. In the next future, this method will be applied systematically, using 20 ensemble members, to a collection of 19 MEDEX cyclones comprising 56 different simulation periods.

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