Sensitivity areas of Mediterranean cyclones derived from the MM5 adjoint model: Application to mesoscale ensemble forecasts

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Outline

Outline

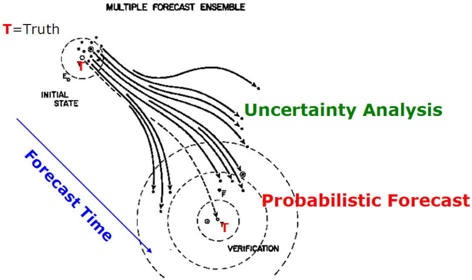
Motivation

The western Mediterranean area

- Very cyclogenetic
- High impact weather phenomena

Motivation

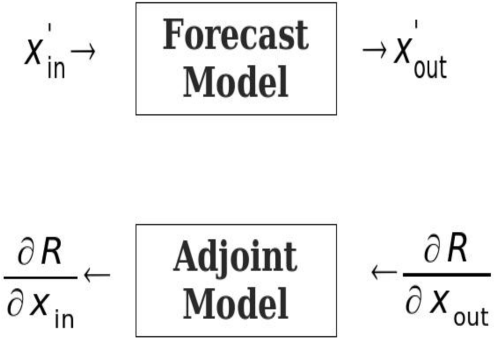
Improve the numerical forecasts of cyclones



- Ensemble prediction system
- Perturbed initial and boundary conditions

Motivation

MM5 adjoint model



- X: meteorological fields
- R: Response function

Outline

Methodology

1. Calculate a PV error climatology (PVEC)
2. Introduce perturbations randomly to the PV fields along the sensitivity areas calculated by the MM5 adjoint model
3. Apply PV Inversion Technique to original and perturbed fields to obtain the balance fields (T, H and Winds)
4. Define the ensemble member by the difference between the original and perturbed balance fields

Methodology

PV error climatology

Comparing

ECMWF analysis PV fields $\longleftrightarrow$ ECMWF 24 h forecast PV fields,

of a large collection of MEDEX cyclones,
one can define:

A displacement error

An intensity error

Methodology

PV error climatology

- The displacement error (DE) corresponds to the minimum displacement of the ECMWF 24 h forecast PV field showing local maximum correlation with the ECMWF analysis PV field

- The intensity error (IE) corresponds to the difference between the displaced ECMWF 24 h forecast PV field and ECMWF analysis PV field

- The %IE is defined by $\frac{\text{intensity error}}{\text{analysis PV}}\%$

Methodology

PV error climatology

Displacement error (DE)

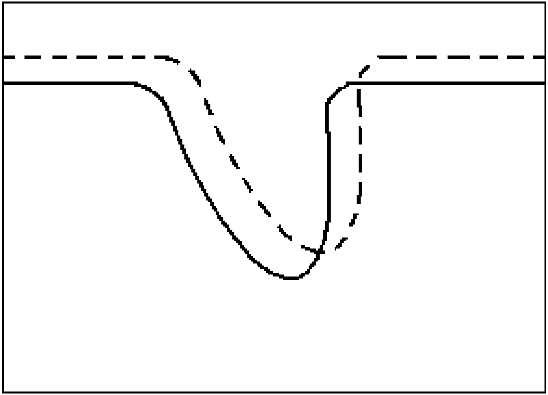


Figure: Analysis (dashed line) and 24 h forecast (solid line) PV fields

Methodology

PV error climatology

Displacement error (DE)

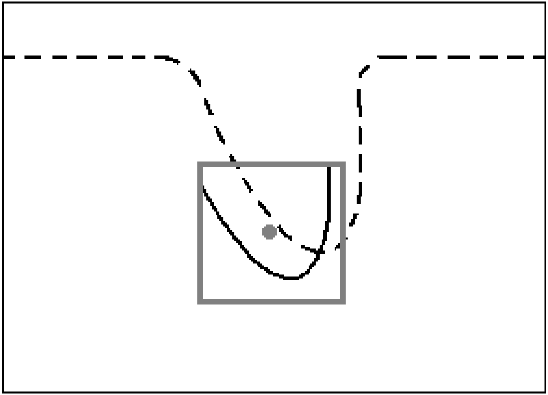


Figure: Analysis (dashed line) and 24 h forecast (solid line) PV fields

Methodology

PV error climatology Displacement error (DE)

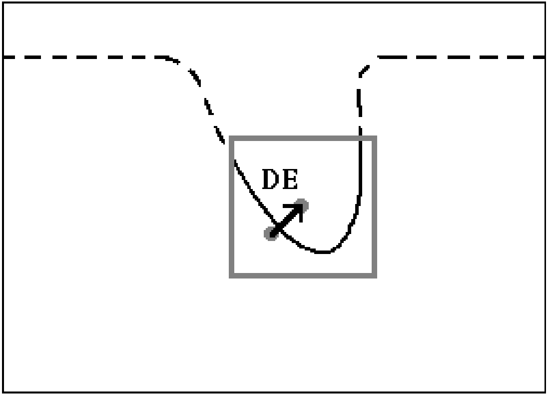
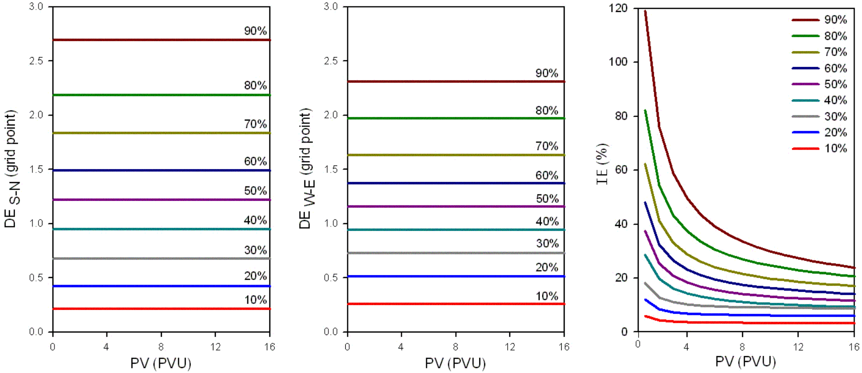


Figure: Analysis (dashed line) and 24 h forecast (solid line) PV fields

Methodology

PV error climatology

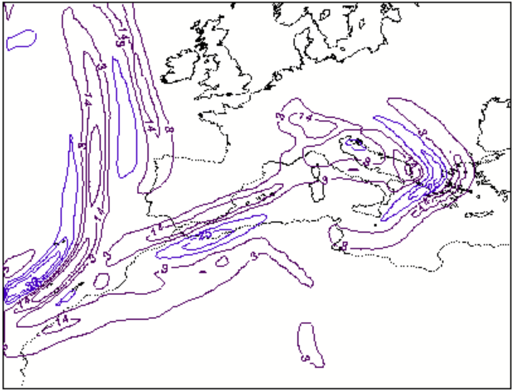
DE and %IE percentile levels at 300 hPa



Methodology

Zones of perturbation

Sensitivity areas calculated by the MM5 adjoint model



PV Sensitivity at 300 hPa

Response function: Vorticity

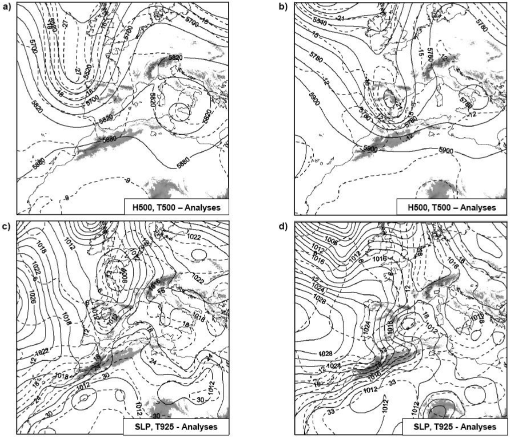
Outline

1. Motivation
2. Methodology
3. Application to mesoscale ensemble forecasts
4. Conclusions and further work

Application to mesoscale ensemble forecasts

MEDEX cyclone of 9th June 2000 (9th June 2000 at 00 UTC)

Synoptic situation



9th June 2000 at 00 UTC

10th June 2000 at 00 UTC

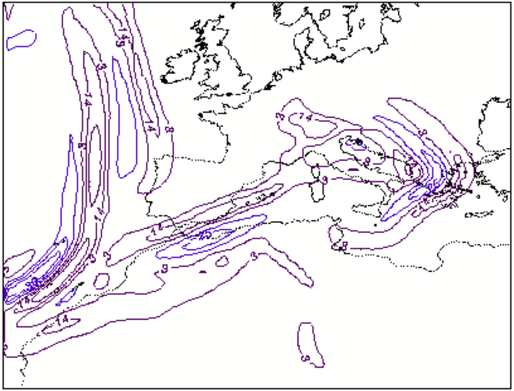
Quasi-stationary convective system

- Atlantic upper-level trough and low-level cold front
- Generation of a mesoscale cyclone
- Advection of warm and moist air toward Catalonia from the Mediterranean Sea

Application to mesoscale ensemble forecasts

MEDEX cyclone of 9th June 2000 (9th June 2000 at 00 UTC)

Sensitivity areas calculated by the MM5 adjoint model



FV Sensitivity at 300 hPa

Response function: Vorticity

Application to mesoscale ensemble forecasts

MEDEX cyclone of 9th June 2000 (9th June 2000 at 00 UTC)

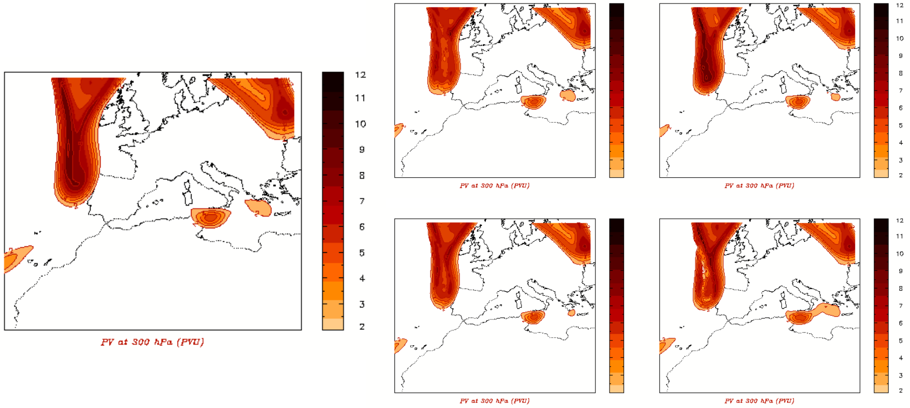


Figure: Original initial state and four perturbed ensemble members

Application to mesoscale ensemble forecasts

MEDEX cyclone of 9th June 2000 (11th June 2000 at 06 UTC)

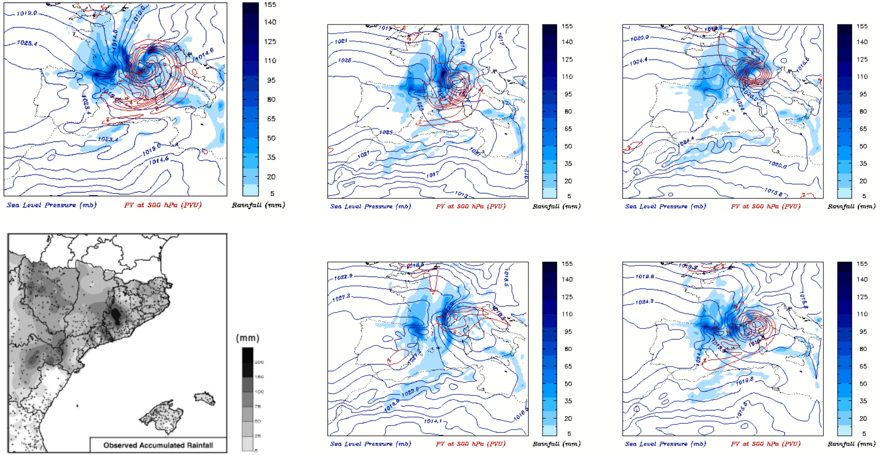


Figure: MM5 54 h forecast from above initial states

Outline

Conclusions and further work

- Simple method: only one variable, PV, is used to define perturbations
- PV Inversion Technique ensures modifications of all the meteorological fields without compromising the mass-wind balance
- The sensitivity fields calculated by the MM5 adjoint model are expected to display the most effective area to be pertubed
- The preliminary results seem to produce a high spread and precipitation fields of 'realistic' variability

Conclusions and further work

In the future:

- The method will be applied systematically, using 20 ensemble members
- Comparison between the presented method and the previous developed method that applies the PV perturbation along the zones with the most intense values and gradient