Comparison of two Perturbed Initial and Boundary Conditions Ensemble Forecasting Systems applied to Mediterranean cyclones

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Outline

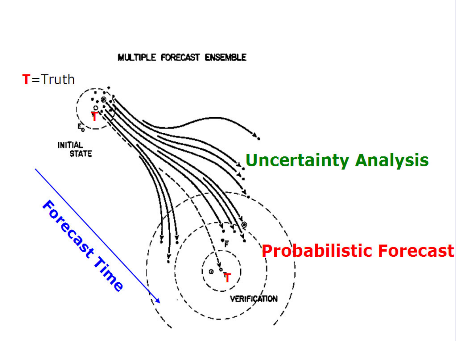
Introduction

The western Mediterranean area

- Very cyclogenetic
- High impact weather phenomena

Introduction

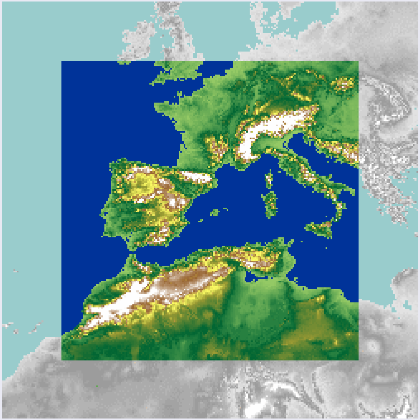
Improve the numerical forecasts of cyclones



- Ensemble prediction system
  - Perturbed initial and boundary conditions
  - Multiphysics
  - Multi-model

Introduction

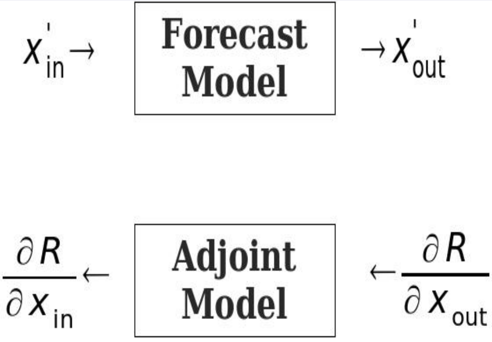
Mesoscale Atmospheric Model: MM5



- Nonhydrostatic dynamics
- High resolution
- Lateral boundary conditions
- Vertical coordinate: σ

Introduction

MM5 adjoint model



- X: meteorological fields
- R: Response function

Introduction

Verification: General framework

		Observed Yes	Observed No
Forecast	Yes	a	b
	No	c	d

Contingency table
(2x2 problem)

Basic Descriptive Statistics

$$\underset{\text{(Base Rate)}}{BR} = \frac{a+c}{a+b+c+d}$$

...

Range: [0,1]

Performance Measures

$$\underset{\text{(Probability of Detection)}}{POD} = \frac{a}{a+c}$$

$$\underset{\text{(Probability of False Detection)}}{POFD} = \frac{b}{b+d}$$

...

Range: [0,1] Perfect Score: 1

Introduction

Objectives

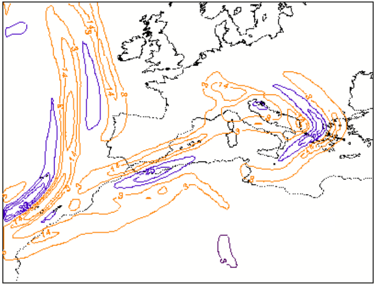
- Develop two EPSs based on pertubing the model initial and boundary conditions through a PV inversion algorithm
- Perturb along the three-dimensional PV structure
  - subjectively:
    with the most intense values and gradients PV zones
  - objectively:
    with the MM5 adjoint model calculated sensitivity zones
- Compare the performance of both EPSs for 24h accumulated precipitation field (30-54 h simulation time)

Methodology

Build the two Ensemble Forecasts Systems

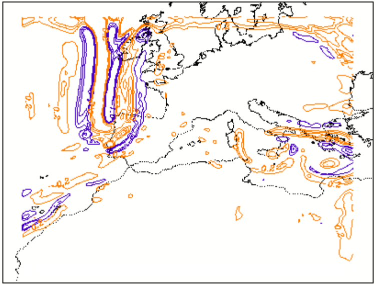
Introduce realistic perturbations randomly to the PV fields through a PV error climatology along the three-dimensional PV structure

- Objectively:



MM5 adjoint model calculated sensitivity zones at 300 hPa

- Subjectively:

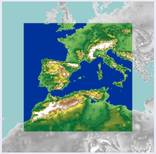


The most intense values and gradients PV zones at 300 hPa

Methodology

Simulations Characteristics

- Domain characteristics:
    - Resolution: 22.5 km
    - Center: 39.8 lat and 2.4 lon
    - Area: 120x120 grid



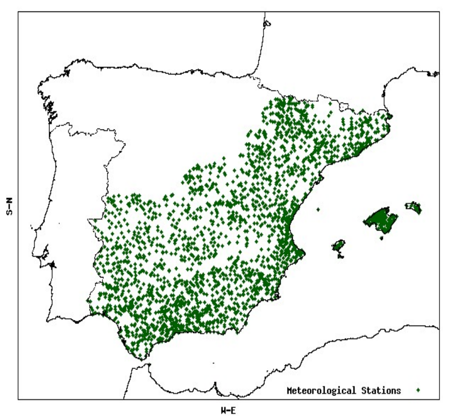
- Forecasting period is 54 h to simplify the posterior verification process (rainfall data is available at 24 h intervals starting each day at 06 UTC).
- The ensemble trial period corresponds to a collection of 19 MEDEX cyclones comprising 56 different simulation periods.

MEDEX: Mediterranean Experiment on Cyclones that produce High Impact Weather in the Mediterranean

Methodology

Field of study: 24h accumulated precipitation

Available Observations



The forecasted gridded field is interpolated over the rain gauges to compare with the observed data

Rain gauge data is provided by AEMET (Spanish MetOffice)

Comparison

Probabilistic forecast

The set of deterministic forecast are assumed as independent realizations of the same underlying random process, so an estimate of the forecast probability of an event is provided by the fraction of the forecasts predicting the event among all forecast considered.

Jolliffe and Stephenson, 2003

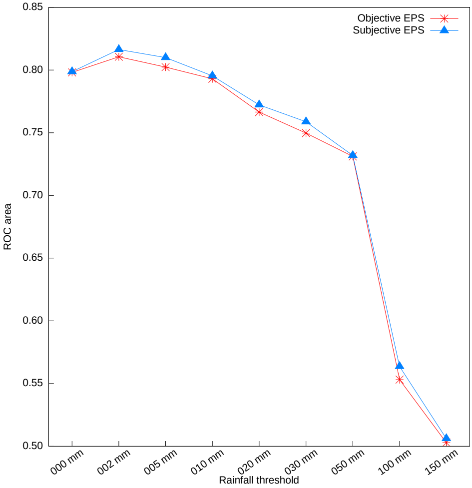
Comparison

ROC area

(Area under the ROC curve)

What is the ability of the forecast to discriminate between events and non-events?

Range: 0 to 1
No skill: 0.5
Perfect score: 1

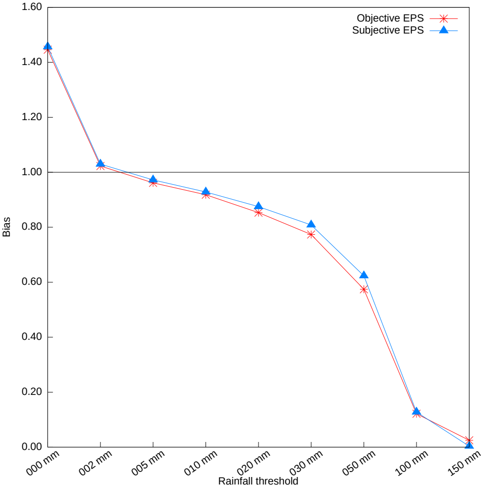


Comparison

Bias Score

How did the forecast frequency of 'yes' events compare to the observed frequency of 'yes' events?

Range: $-\infty$ to ∞
Perfect score: 1

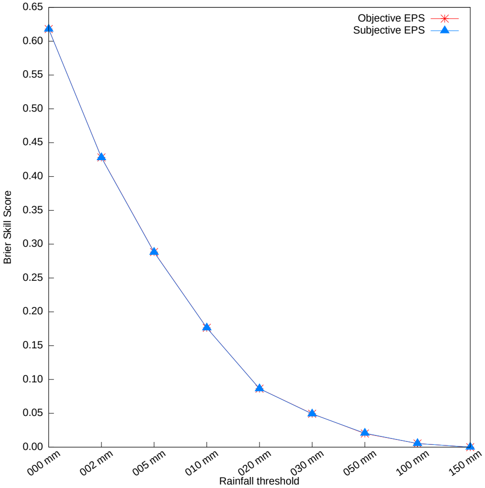


Comparison

Brier Skill Score

What is the relative skill of the probability forecast over that of climatology, in terms of predicting whether or not an event occurred?

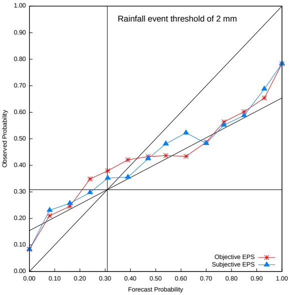
Range: $-\infty$ to 1
Perfect score: 1

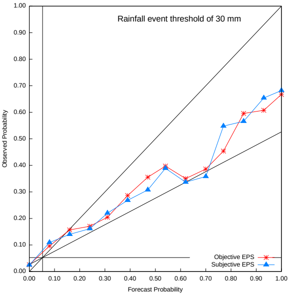


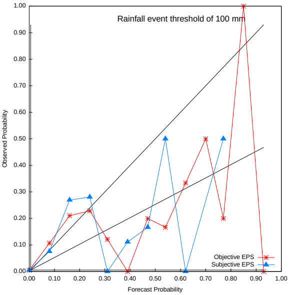
Comparison

Attribute Diagram

How well do the predicted probabilities of an event correspond to their observed frequencies?



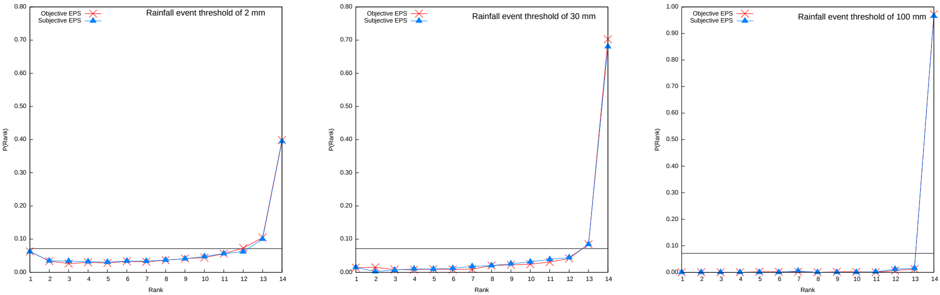




Comparison

Rank Histogram

How well does the ensemble spread of the forecast represent the true variability (uncertainty) of the observations?



Conclusions

It's hard to verify extreme events and precipitation due to the small statistically significance, and the characteristics of the rainfall, like the spatial distribution. In spite of all this:

- Both ensembles have a good performance
- Subjective EPS performes slightly better than the Objective
- More tests will help to reaffirm this conclusion

Conclusions

In the future:

- Further tests to reassure the better performance of the Subjective EPS over the Objective one.
- Design a Multiphysics Superensemble that includes correction of the systematic errors by regression of each Multiphysics ensemble member, developed in a previous study.
- Compare the two Perturbed Initial and Boundary conditions ensembles, the Superensemble and the Multiphysics ensemble