Comparison of several Ensemble Prediction Systems applied to Mediterranean high impact cyclones associated with heavy rainfall and strong winds

Maria-del-Mar Vich[1]*
Romualdo Romero[1] Victor Homar[1] Harold Brooks[2]

[1]Meteorology Group, Universitat de les Illes Balears, Palma de Mallorca, Spain

[2]NOAA - National Severe Storm Laboratory, Norman, Oklahoma, United States

*(mar.vich@uib.es)

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Outline

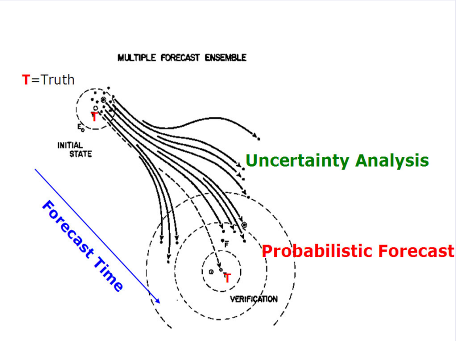
Introduction

The western Mediterranean area

- Very cyclogenetic
- High impact weather phenomena

Introduction

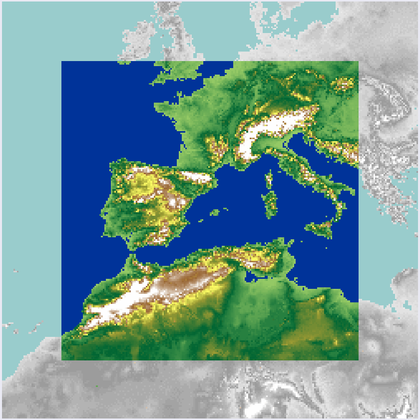
Improve the numerical forecasts of cyclones



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

Introduction

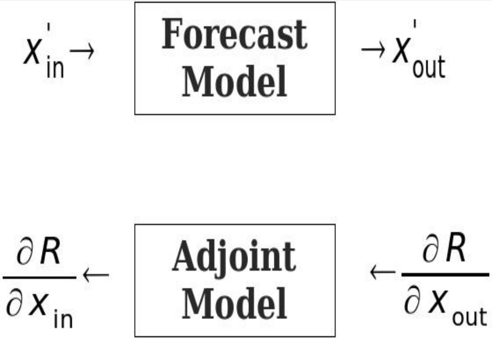
Mesoscale Atmospheric Model: MM5



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

Introduction

MM5 adjoint model



- X: meteorological fields
- R: Response function

Introduction

Verification: General framework

Contingency table (2x2 problem)

		Observed	
		Yes	No
Forecast	Yes	a	b
	No	c	d

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 several ensemble prediction systems applied to Mediterranean high impact cyclones associated with heavy rain
  - Multiphysics
    (different combinations of model physical parameterizations)
  - PV-perturbed
    (initial and boundary conditions through 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 the EPSs for the 24h accumulated precipitation field (30-54 h simulation time)

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Methodology

Build the Multiphysics Ensemble Forecasts

Different combinations of MM5 physics parameterization

12 members
+
control member

- Explicit Moisture Schemes
  - 6 (Goddard microphysics)
  - 7 (Reisner graupel)
  - 8 (Schultz microphysics)
- Cumulus Parameterizations
  - 3 (Grell)
  - 6 (Kain-Fritsch)
- PBL Schemes
  - 4 (Eta)
  - 5 (MRF)

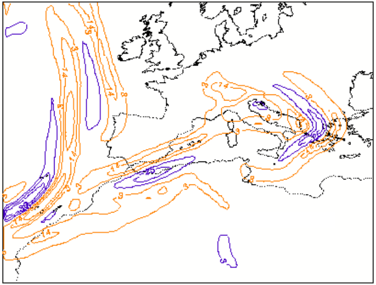
634, 635, 664, 665, 734, 735, 764, 765, 834, 835, 864, 865, 785 (control)

Methodology

Build the two PV-perturbed Ensemble Forecasts

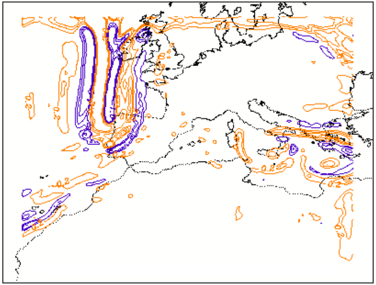
Introduce realistic perturbations randomly to the PV fields through a PV error climatology along the three-dimensional PV structure

- Objectively:



MM5 adjoint model calculated sensitivity zones at 300 hPa

- Subjectively:

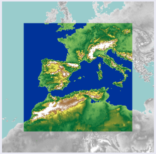


The most intense values and gradients PV zones at 300 hPa

Methodology

Simulations Characteristics

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



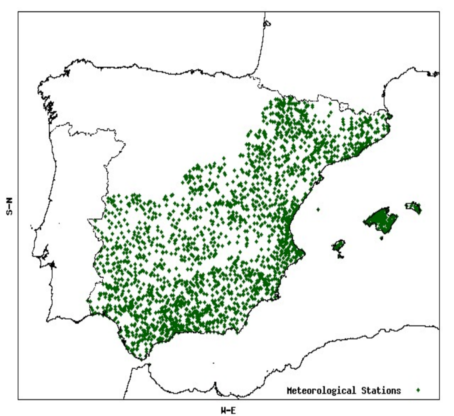
- Forecasting period is 54 h to simplify the posterior verification process (rainfall data is available at 24 h intervals starting each day at 06 UTC).
- The ensemble trial period corresponds to a collection of 19 MEDEX cyclones comprising 56 different simulation periods.

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)

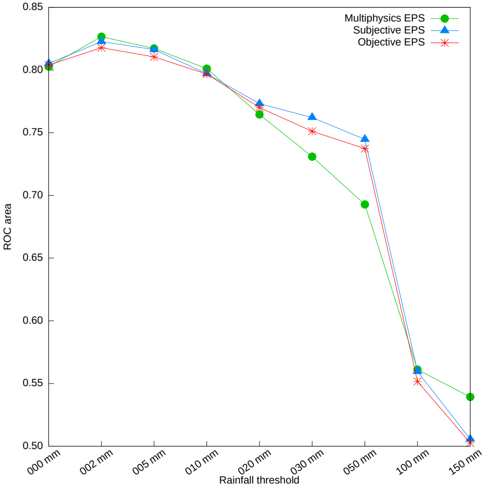
Comparison

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

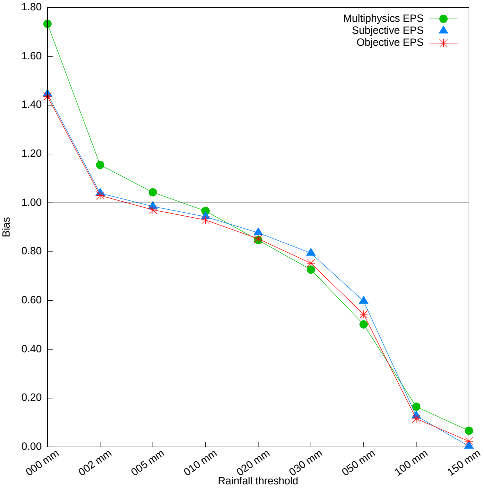


Comparison

Bias Score

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

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

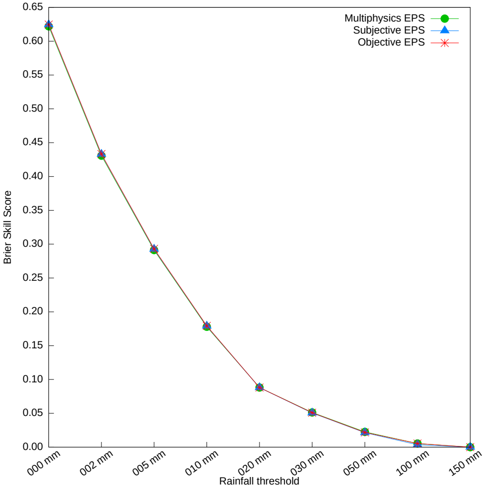


Comparison

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?

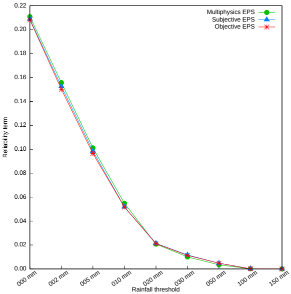
Range: $-\infty$ to 1
Perfect score: 1



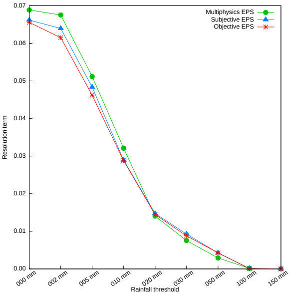
Comparison

Brier Score components

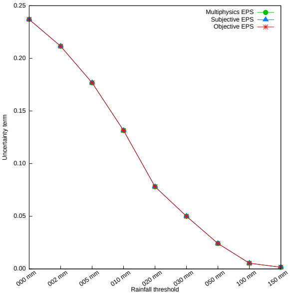
Reliability



Resolution



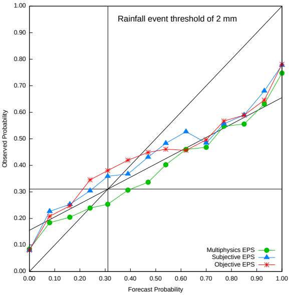
Uncertainty

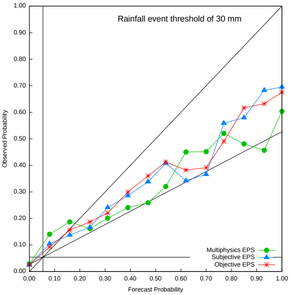


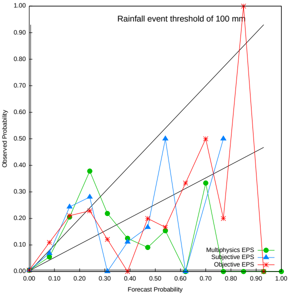
Comparison

Attribute Diagram

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



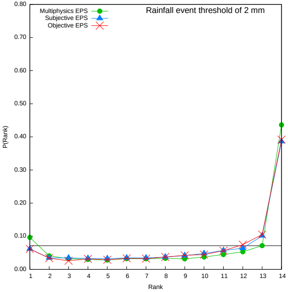


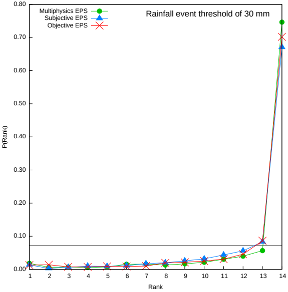


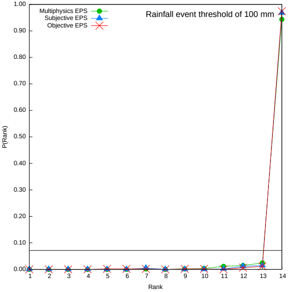
Comparison

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:

- The three ensembles have a good performance
- PV-perturbed performes better than Multiphysics
- Subjective PV-perturbed performes better than Objective

Conclusions

In the future:

- Design a new set of PV-perturbed ensembles based on
  - PV modification technique guided by satelite water vapor observations (Dermitas and Thorpe, 1999)
  - MIMOSA a high resolution advection model of PV developed at Service d'Aeronomie, France
- Compare this new set with the current Objective and Subjective ensembles

Thank you for your attention!