Evaluation of a Multiphysics Ensemble Forecasting System applied to Mediterranean cyclones

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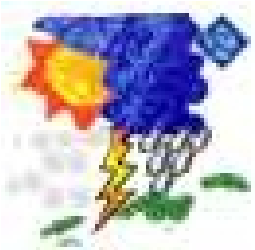
10th Plinius Conference on Mediterranean Storms, 2008



Outline

- Introduction
- Methodology
- Evaluation and Verification
- Conclusions

Outline

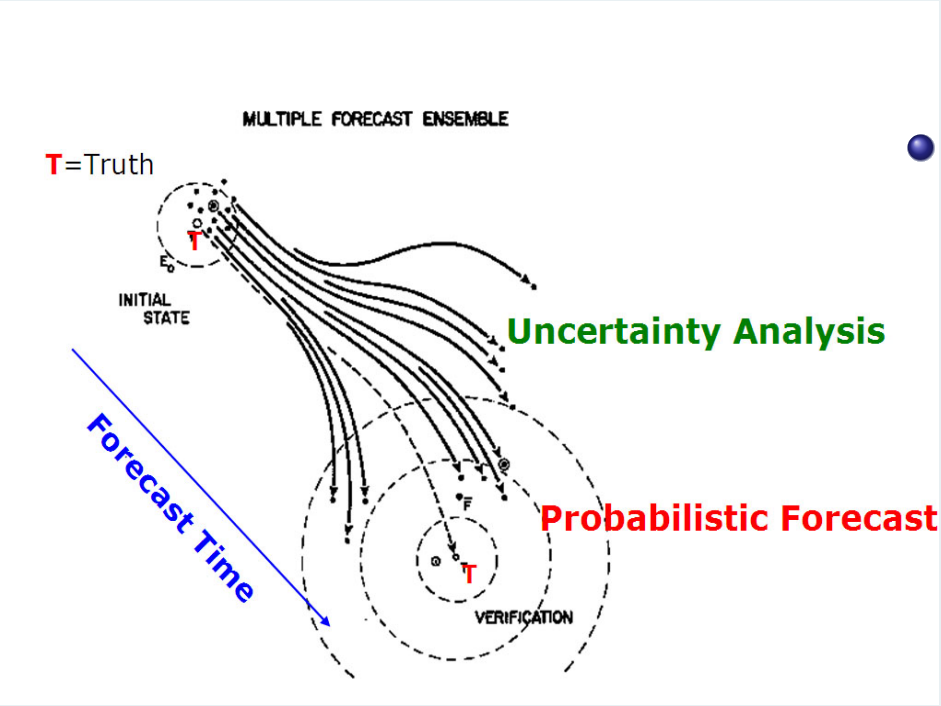
Introduction

The western Mediterranean area

- Very cyclogenetic
- High impact weather phenomena

Introduction

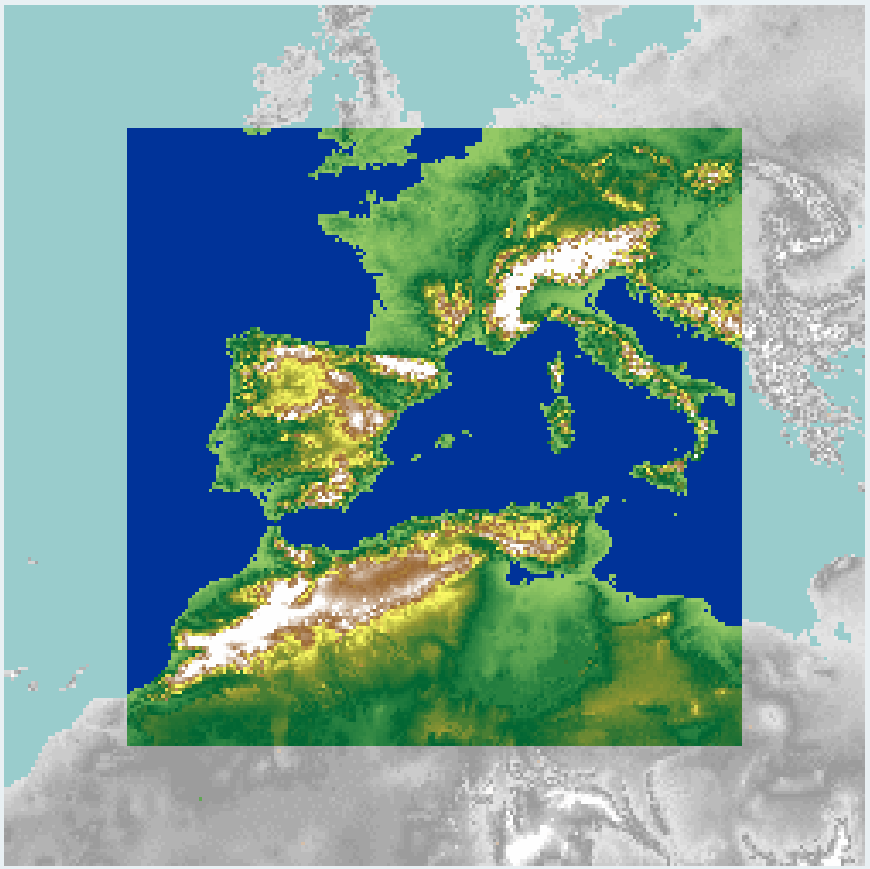
Improve the numerical forecasts of cyclones



- 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
- Land-use categories
- Nesting capability

Introduction

Verification: General framework

		Observed: Yes	Observed: No
Forecast	Yes	a	b
	No	c	d

Contingency table (2x2 problem)

Basic Descriptive Statistics

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

$\dots$

Range: [0,1]

Performance Measures

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

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

$\dots$

Range: [0,1] Perfect Score: 1

Introduction

Objectives

- Design a multiphysics ensemble forecast applied to Mediterranean cyclones associated with heavy rain
- Test the performace of the multiphysics ensemble forecasts
- Compare the performance of the ensemble and the control member
- The evaluation and verification will be done for 24h accumulated precipitation field (30-54 h simulation time)

Outline

Methodology

Create a Multiphysics Ensemble Forecasts

Different combinations of MM5 physics parameterization

12 members
+
control member

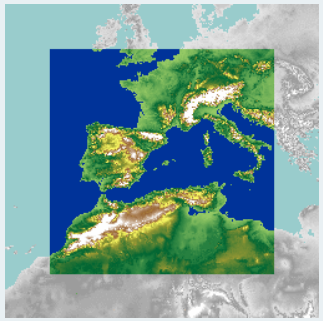
- Explicit Moisture Schemes
  - 6 (Goddard microphysics)
  - 7 (Reisner graupel)
  - 8 (Schultz microphysics)
- Cumulus Parameterizations
  - 3 (Grell)
  - 6 (Kain-Fritsch)
- PBL Schemes
  - 4 (Eta)
  - 5 (MRF)

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

Methodology

Simulations Characteristics

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



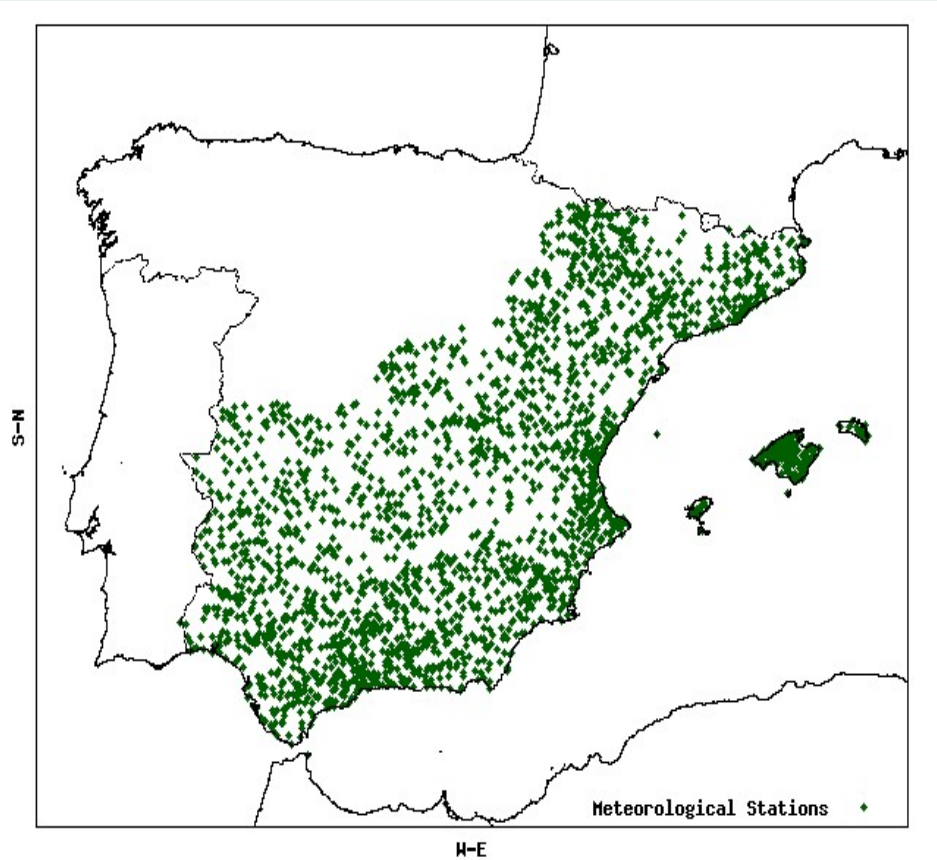
- Forecasting period is 54 h to simplify the posterior verification process (rainfall data is available at 24 h intervals starting each day at 06 UTC).
- The ensemble trial period corresponds to a collection of 19 MEDEX cyclones comprising 56 different simulation periods.

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)

Outline

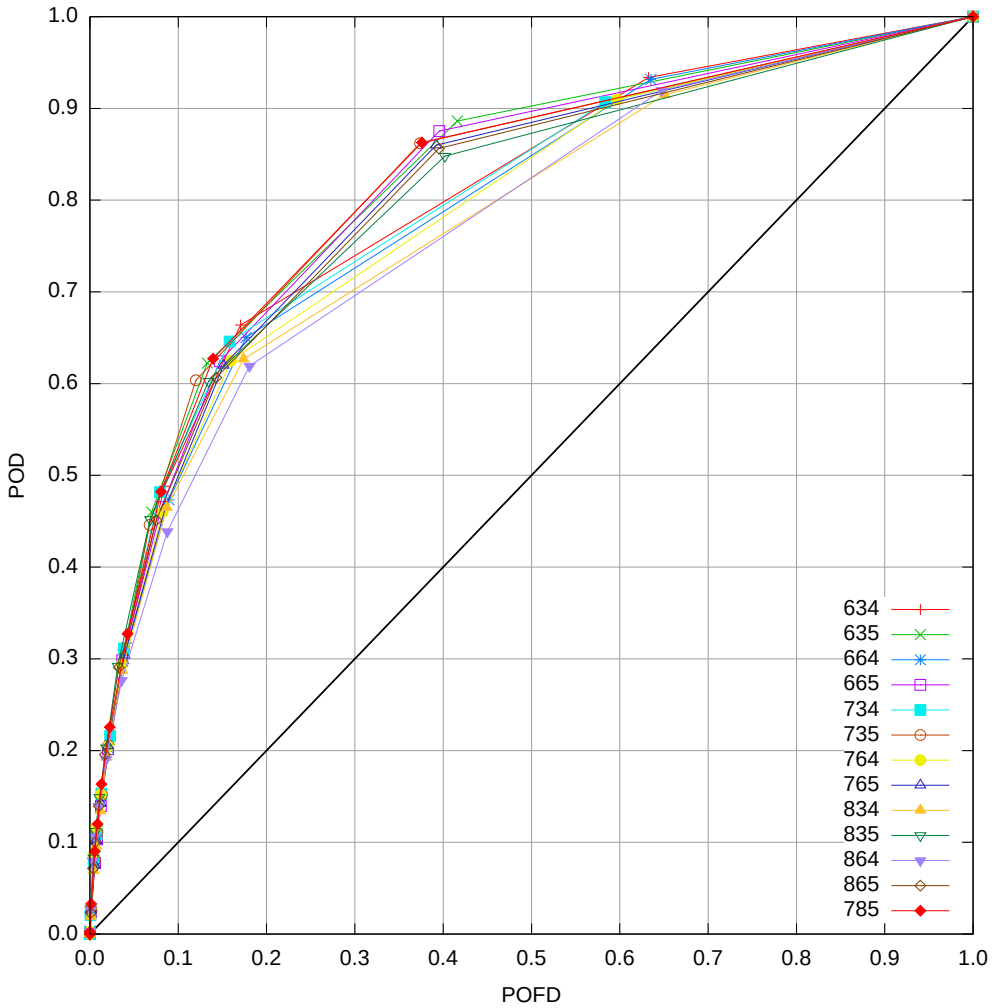
Evaluation and Verification

Deterministic

ROC

(Relative Operative Characteristic)

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



Evaluation and Verification

Deterministic

ROC area

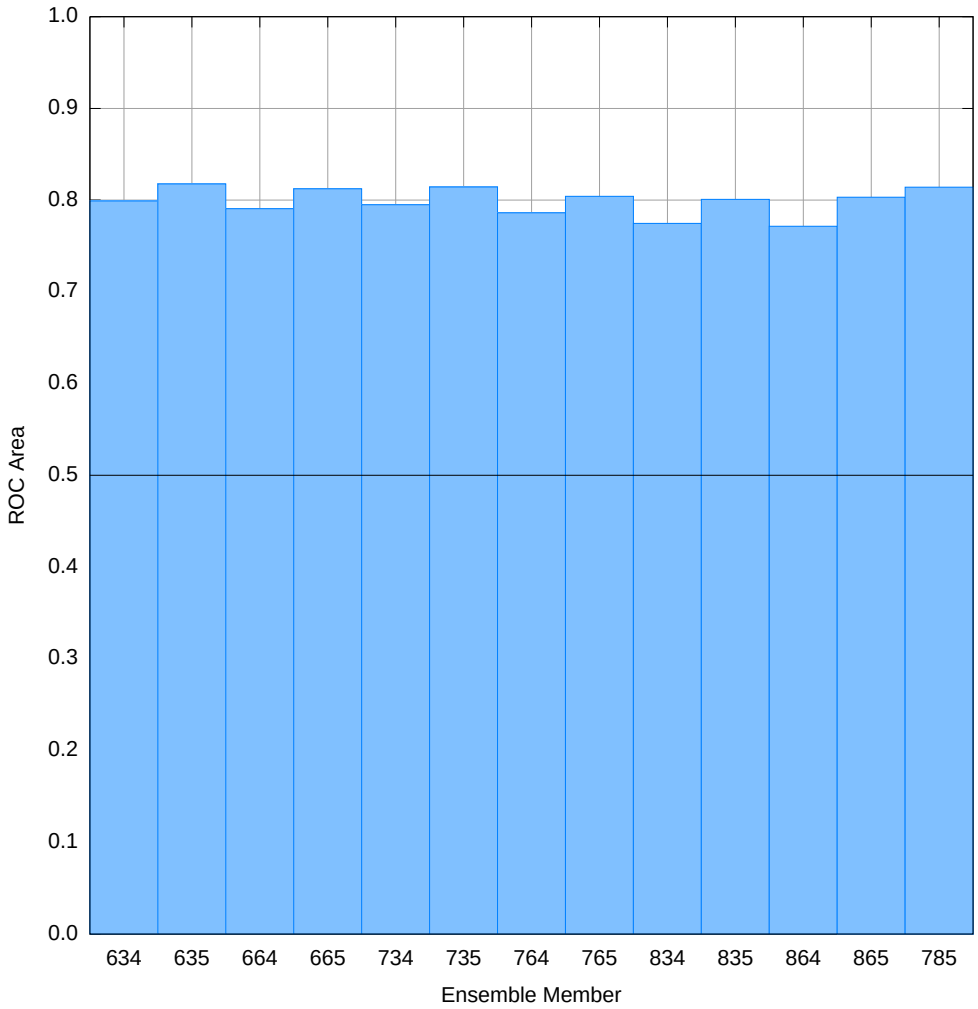
(Area under the ROC curve)

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



Evaluation and Verification

Deterministic

Taylor Diagram

Plot several statistics at one time: correlation coefficient, root-mean-square difference, and standard deviation

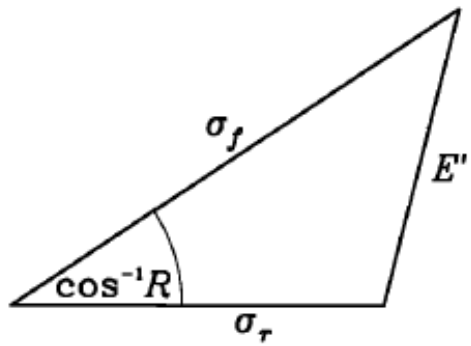
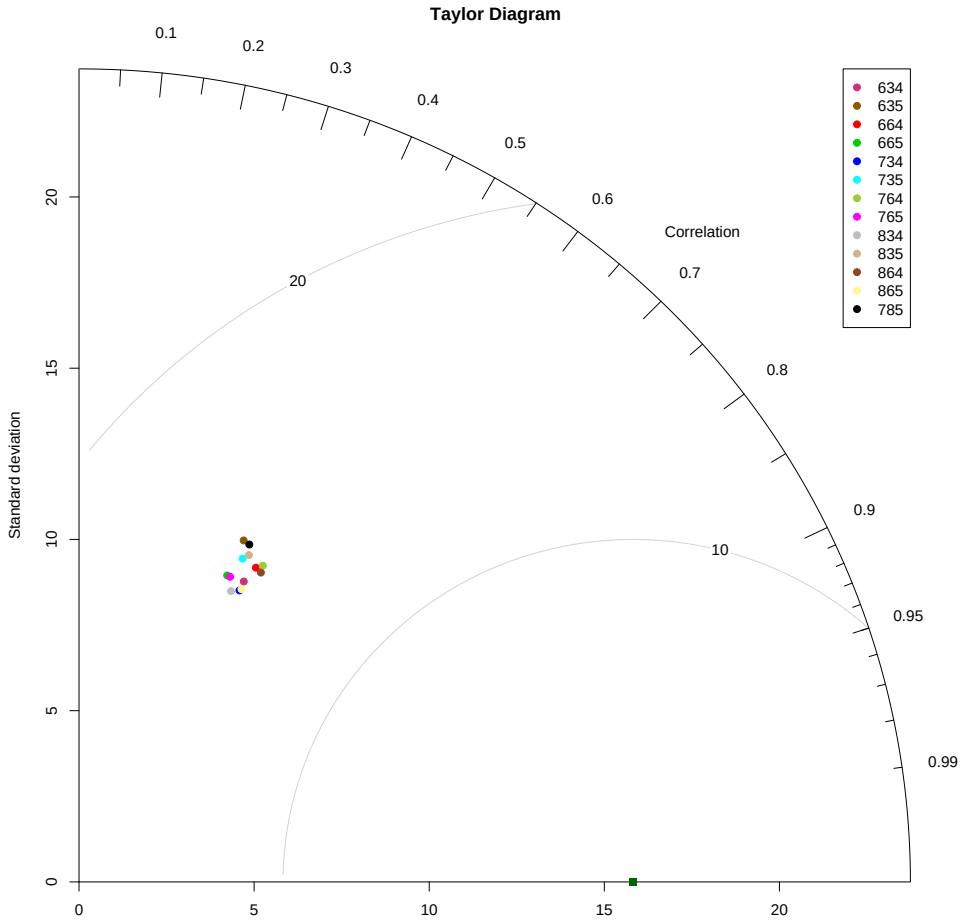


Figure 1. Geometric relationship between the correlation coefficient R, the centered pattern RMS error E', and the standard deviations σ_f and σ_r of the test and reference fields, respectively. (Taylor, 2001)



Evaluation and Verification

Probabilistic

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.

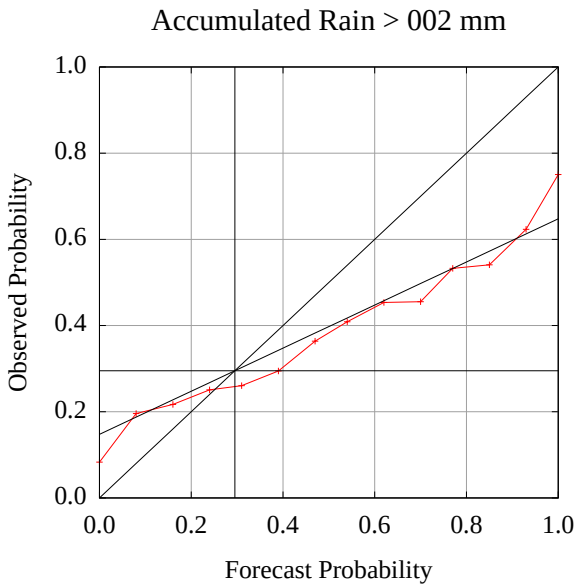
Jolliffe and Stephenson, 2003

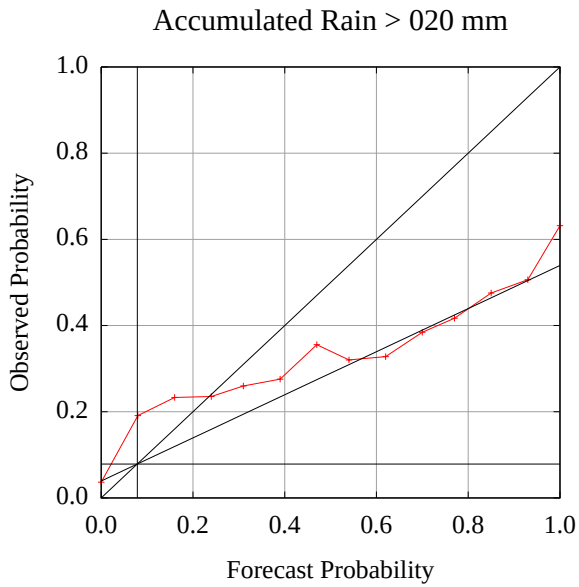
Evaluation and Verification

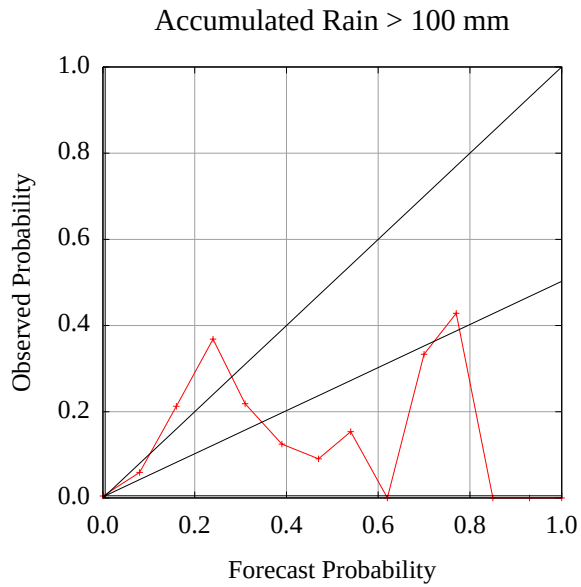
Probabilistic

Attribute Diagram

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





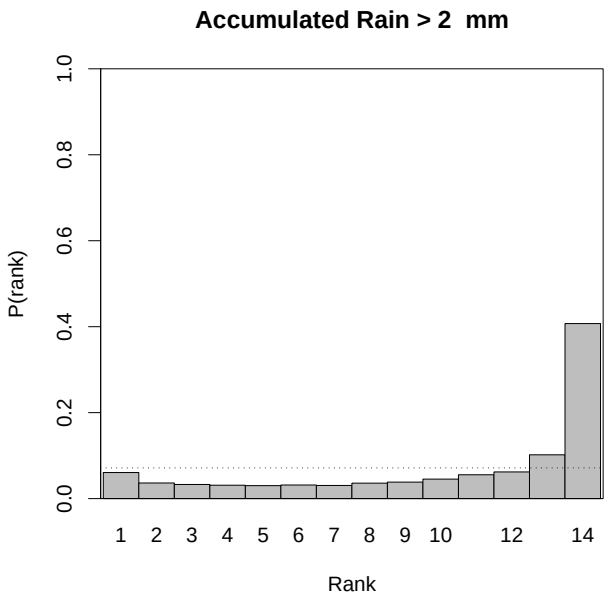


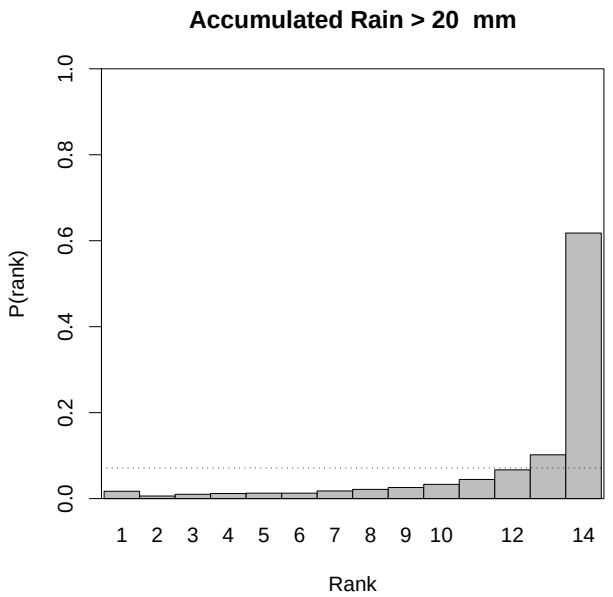
Evaluation and Verification

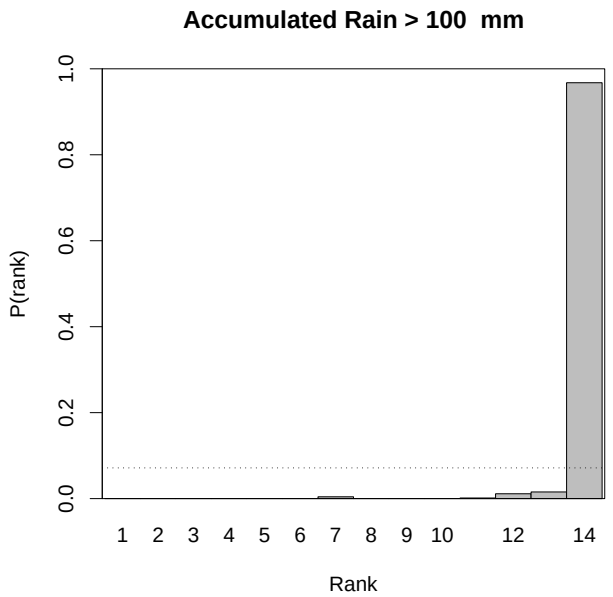
Probabilistic

Rank Histogram

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







Evaluation and Verification

Comparison

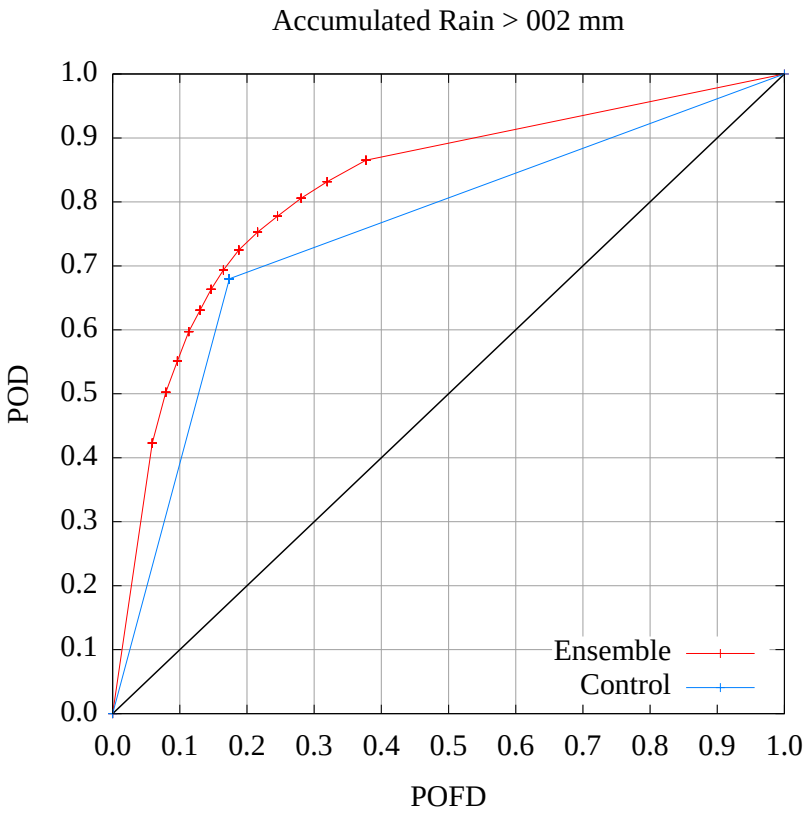
Comparison

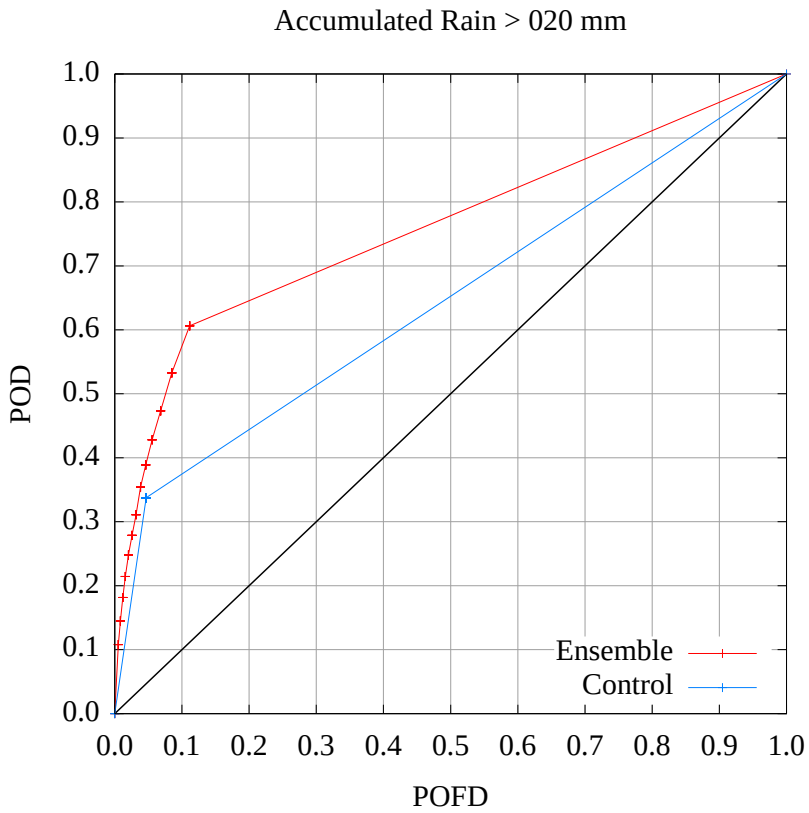
To compare the control ensemble member and the ensemble itself, the control member is considered an ensemble of one member, so the forecast probability can only be 0 or 100%

Evaluation and Verification

Comparison

ROC Curve

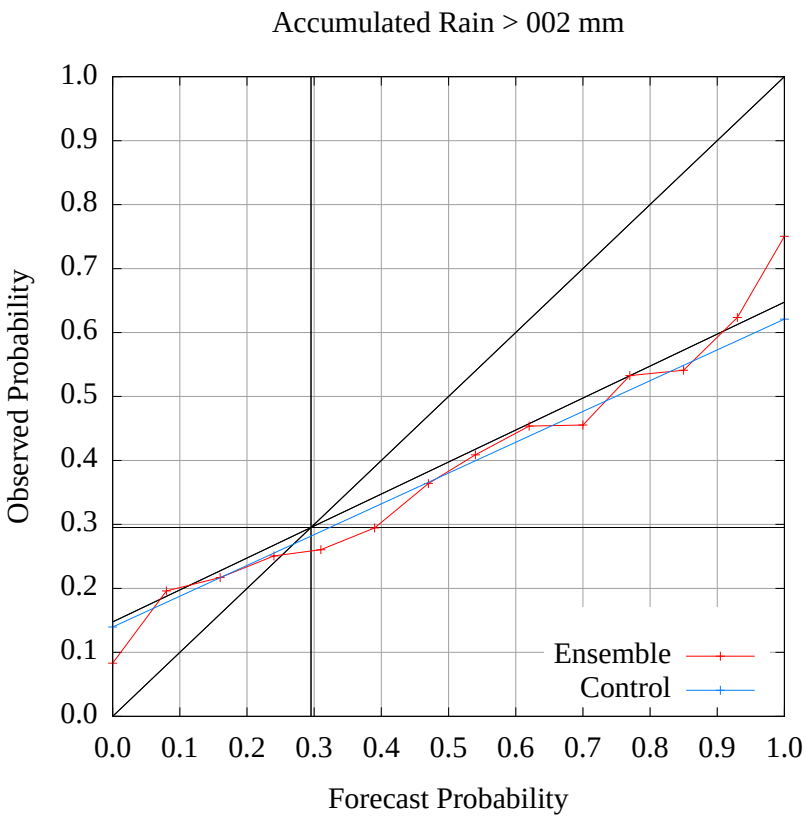


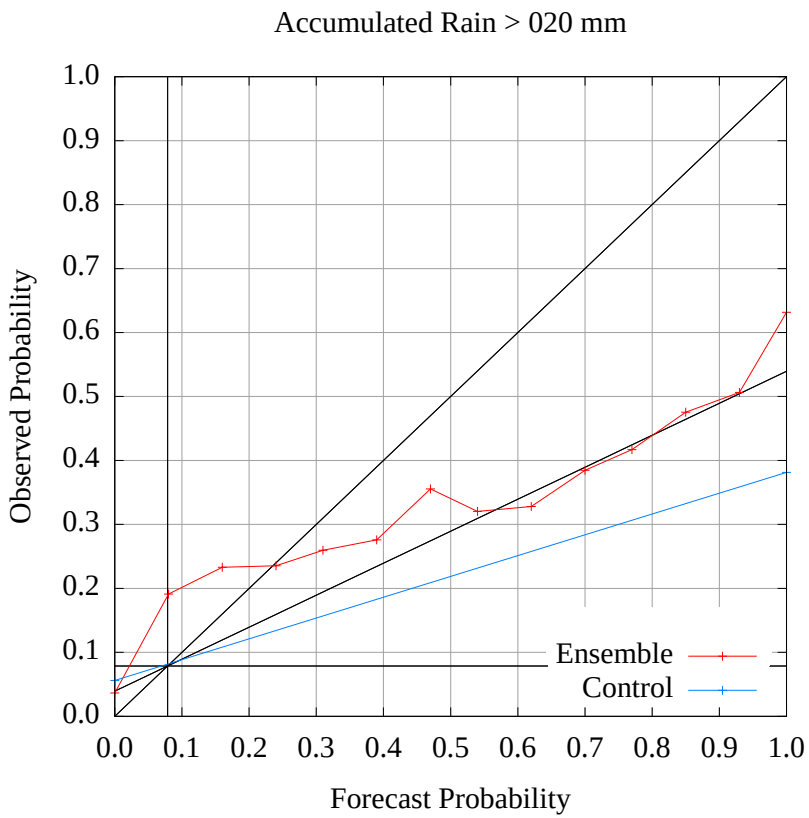


Evaluation and Verification

Comparison

Attribute Diagram





Outline

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 ensemble members have a good performance
- The ensemble has a better performance that each member separately
- A multiphysics ensemble prediction system seems to be very usefull to predict cyclones associated with heavy rain in the western Mediterranean

Conclusions

In the future:

- Design a Multiphysics Superensemble that includes correction of the systematic errors by regression of each Multiphysics ensemble member
- Design an ensemble forecasting system perturbing the initial and boundary conditions
- Compare the Multiphysics ensemble, the Superensemble and the Perturbed Initial and Boundary conditions ensemble

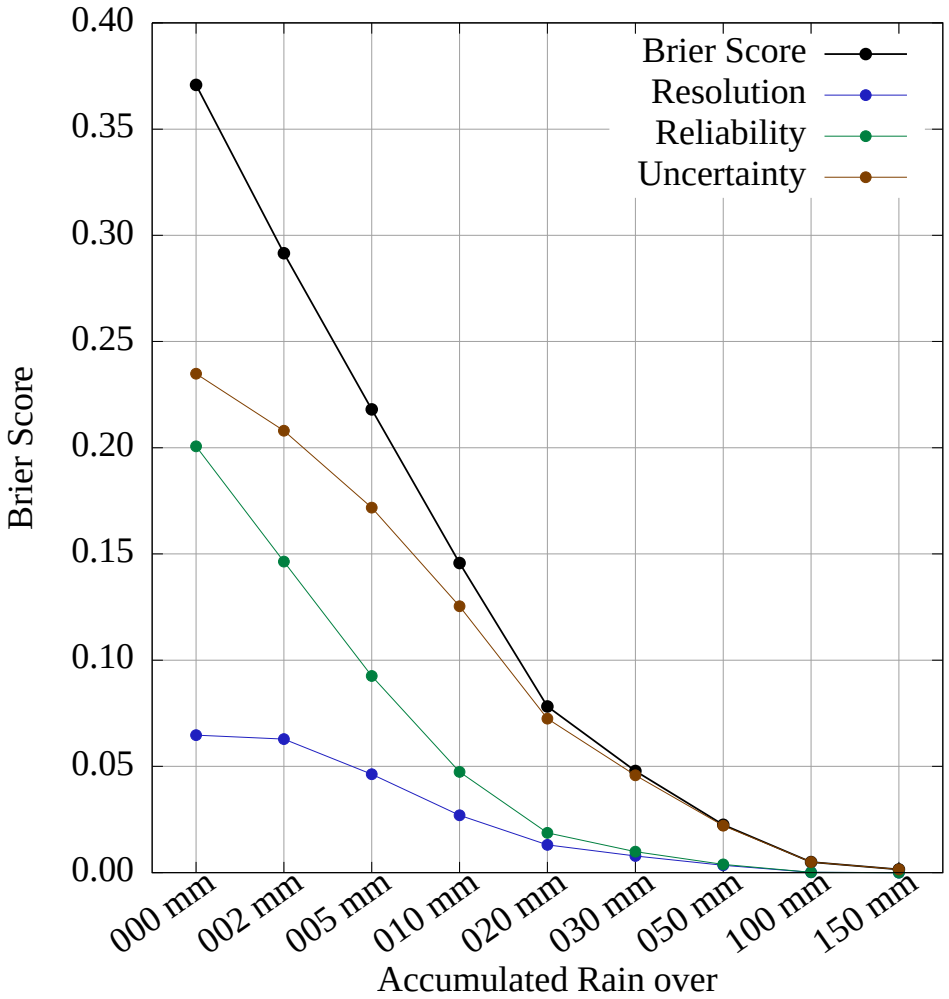
Evaluation and Verification

Probabilistic

Brier Score

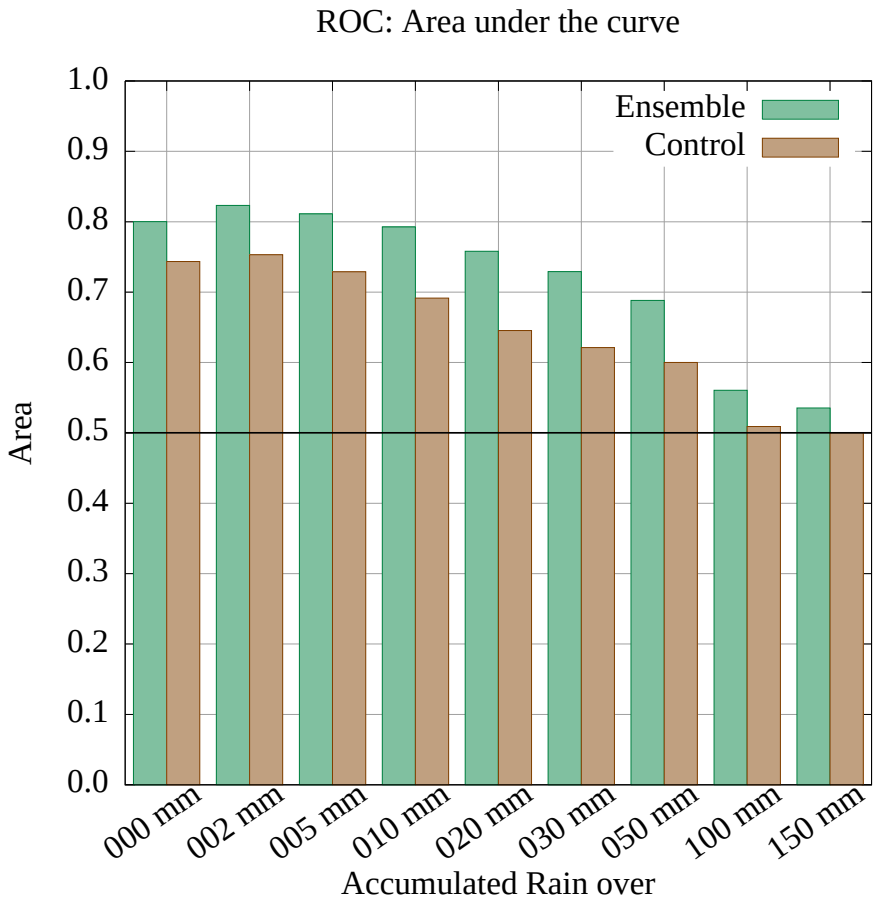
What is the magnitude of the probability forecast errors?

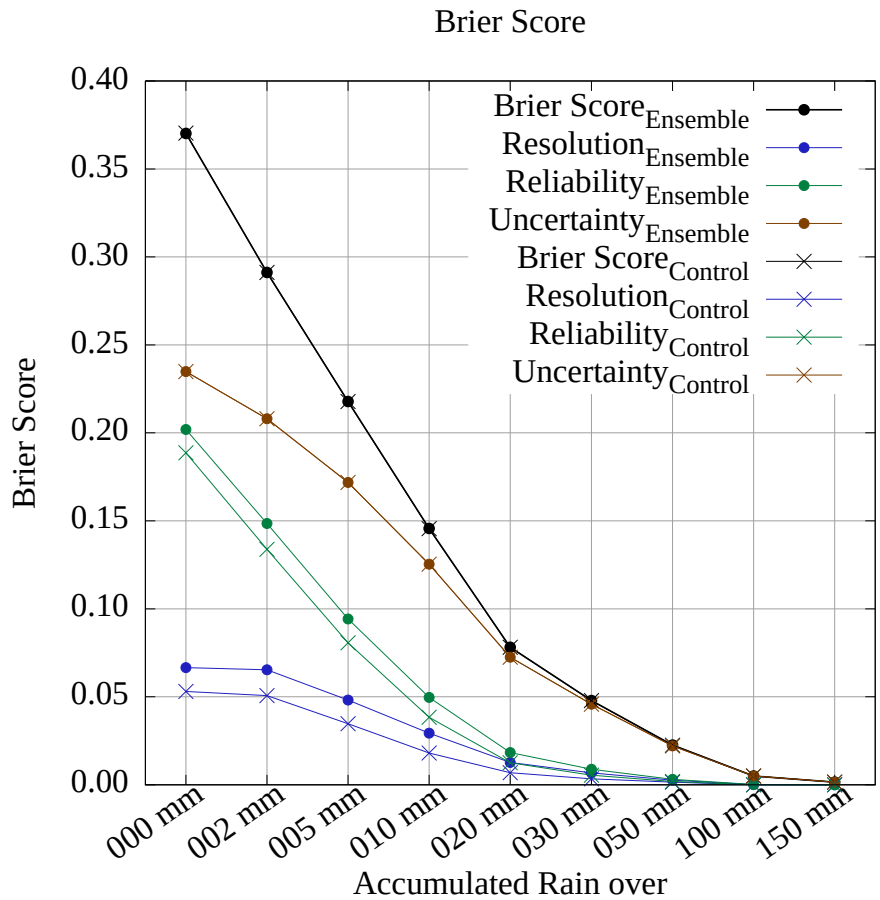
Range: 0 to 1
Perfect score: 0



Evaluation and Verification

Comparison





Evaluation and Verification

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