Ensemble prediction systems based on potential vorticity perturbations and multiphysics tested for MEDEX events

A medicane event application

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Why the MEDEX database?

MEDEX

MEDiterranean EXperiment Information Center

MEDEX
Selection of cases

Date	Priority	Country affected	Severe weather: SW = strong wind HP = heavy precipitation SN = heavy snow	Societal impacts	Alerts Warnings	Models Forecast tools Forecast quality	Studies	Access to data
18 Aug. 1995	**Low**	Morocco	HP Orographic thunderstorm (Ourika)	Flood in Ourika valley. Damages. Several casualties	No warning	Precipitation under-estimated by ARPEGE		
21-22 Jan. 1996	**Medium**	Morocco (Tanger to Essaouira)	HP, SW 200 mm /24 h (Chefhaouen), 75 mm/24 h (Casa), 130 mm/ 24 h (El Jadida)	Extended floods. Traffic disruption. Damages in infrastructures	Warning	Quite good precipitation forecasted by Al Bachir, Arpege. Good by ECMWF		
11-12 Sep. 1996	**Medium**	Spain	HP, SW heavy precip. over Valencia (600 mm/24h), and over Bal. Islands (100 mm/24 h in Mallorca, 170 in Ibiza), tornado outbreak (6) in the Balearic and quasi-tropical cyclone crossing Maiorca (wind > 35 m/s)	Flood in Valencia region. Serious damages from winds in Bal. Isl. High risk for navigation	Generic alert 1 day in advance for heavy rain and strong wind, no tornado watches and no warning on sub-synoptic vortex	HIRLAM, MM5, Under-predicted cyclone intensity and wind strength importance of evaporation over the sea and upper level trough	Gili et al (1997), *INM-WMO Int.Symp. on Cyclones and Hazardous Weather in the Mediterranean* Homar et al (2001), *III Plinius Conference* Homar et al (2002), *XXVII EGS GA* Homar et al (in press), *Quart.J.R.Meteorol.Soc.*	
06-09 Oct. 1996	**High**	Italy (Sardinia; Emilia-Romagna) , Spain (Balears)	HP (Sardinia, Em. Rom.) SW Hurricane-like cyclone (Tirrenian). 144 mm/24h (Sardinia), 200 mm/48h.	Widespread floods, affect. 40000 people (Em. Rom.), minor floods (Sardinia)	No warning (Em. Rom.)	ECMWF, LAMBO (precip. in wrong area). BOLAM simulations sensitive to SST		

EPSs generation

To develop several ensemble prediction systems applied to
western Mediterranean heavy precipitation events
related to intense cyclones by

1. combining different sets of model physical parameterizations

2. perturbing initial and boundary conditions through three-dimensional PV structure

EPSs generation

The Multiphysics ensemble:

Different combinations of
MM5 physics parameterization

12 members
+
control member

- Explicit Moisture Schemes
  - Goddard microphysics
  - Reisner graupel
  - Schultz microphysics
- Cumulus Parameterizations
  - Grell
  - Kain-Fritsch
- PBL Schemes
  - Eta
  - MRF

EPSs generation

The PV-perturbed ensemble

To perturb the initial and boundary conditions
by
perturbing the 3-D structure of the PV field

- Why to perturb the PV field?
  1. PV inversion technique $\rightarrow$ perturb the T and Wind fields
  2. precursor upper-level PV structures $\rightarrow$ mid-latitude cyclonic situations
- Perturb: *how much* and *where*?

EPSs generation: The PV-perturbed ensemble

How much?

PV error climatology

Comparing the PV fields of

ECMWF analysis $\longleftrightarrow$ ECMWF 24 h forecast,

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

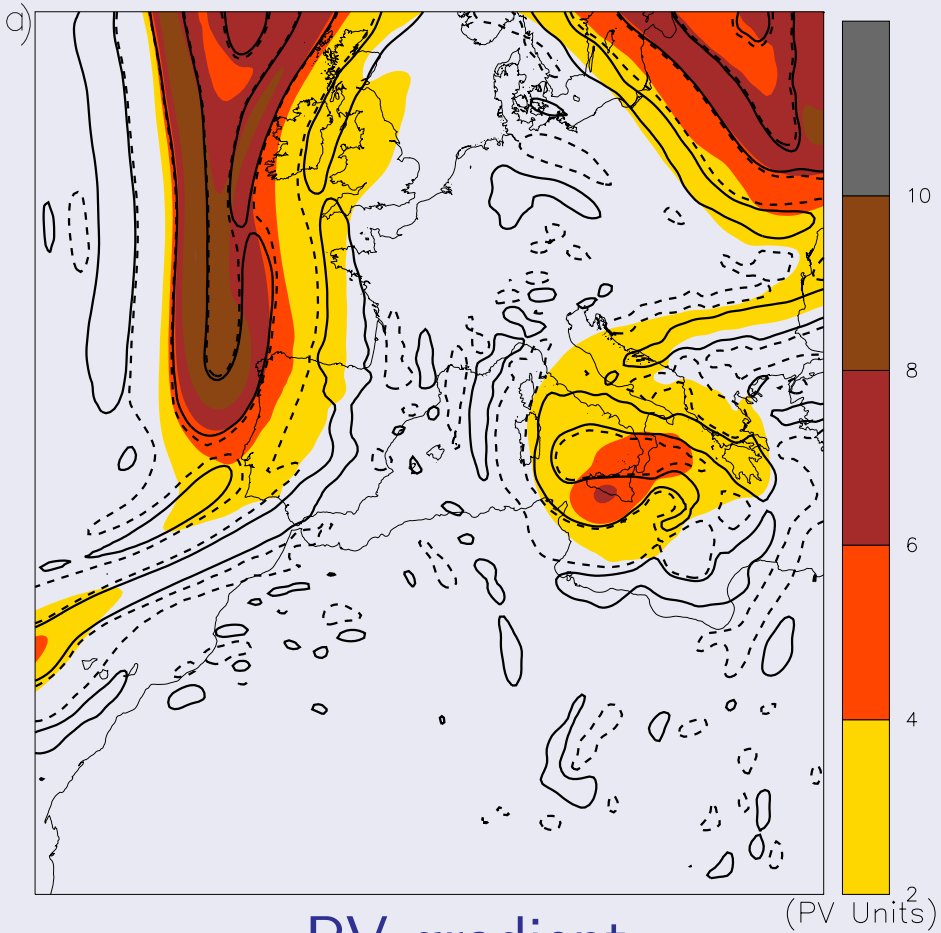
- The displacement error (DE): the minimum displacement of the 24 h forecast PV field showing local maximum correlation with the analysis PV field
- The intensity error (IE): the difference between the displaced 24 h forecast PV field and analysis PV field relative to the analysis PV average

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

EPSs generation: The PV-perturbed ensemble

Where?

The most intense values and gradients PV zones at 300 hPa

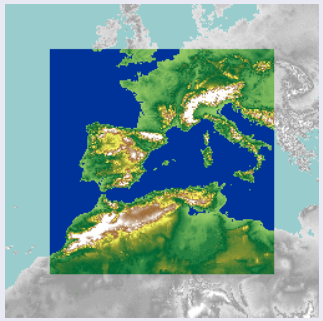


PV-gradient

EPSs generation

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 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.

EPSs results for 19-MEDEX events

ROC area

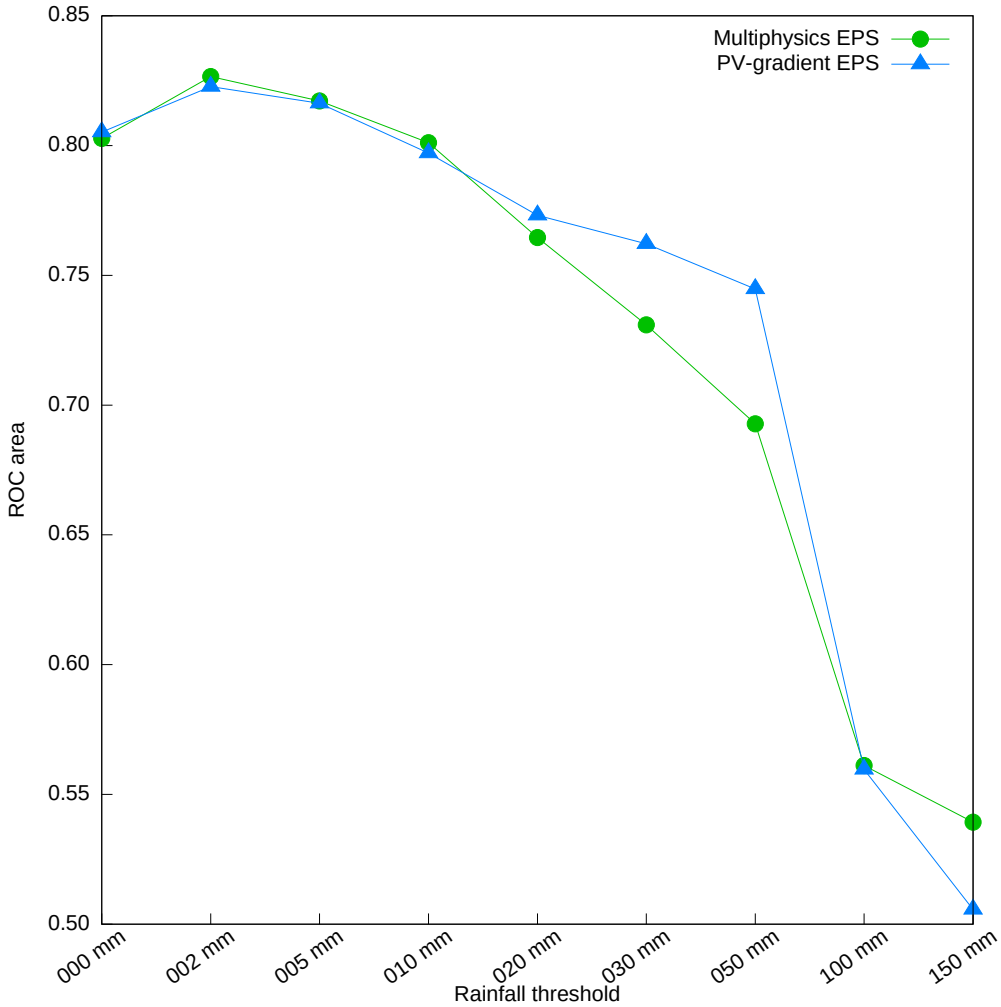
(Area under the ROC curve)

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

Range: 0 to 1

No skill threshold: 0.5

Perfect score: 1



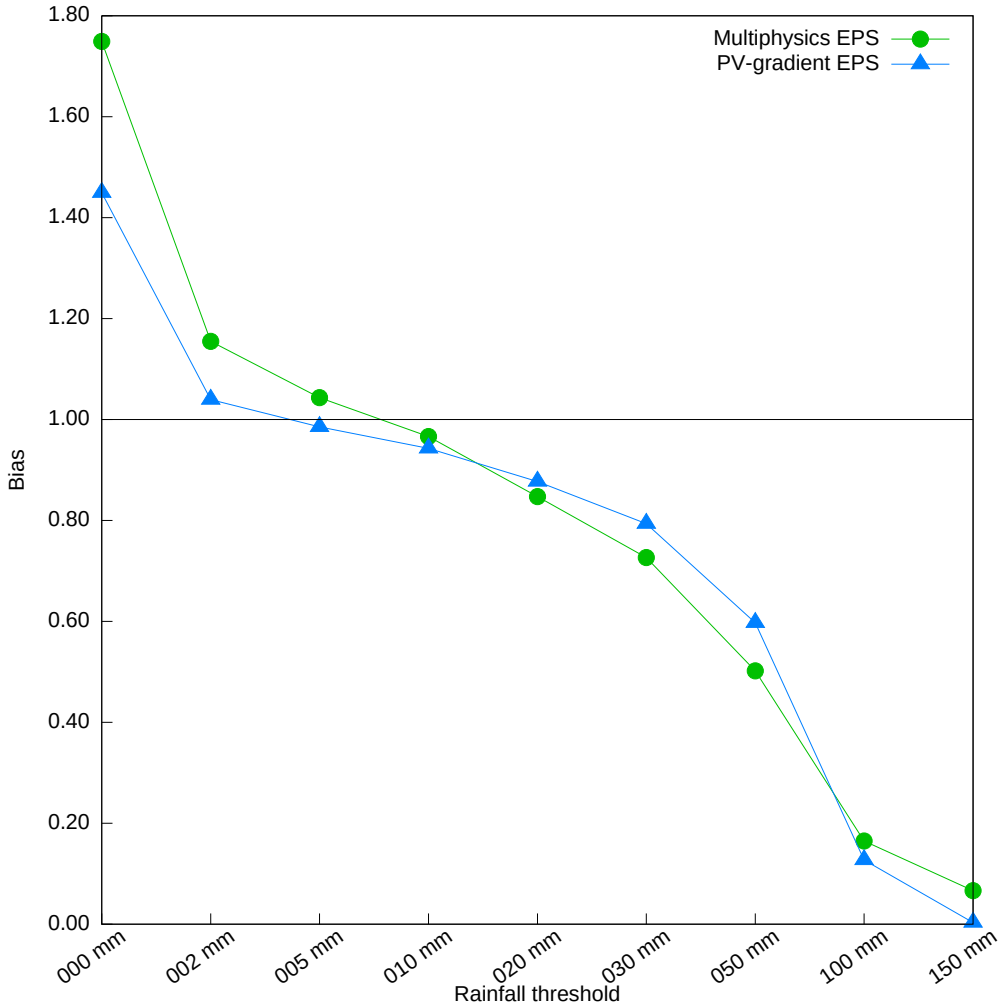
EPSs results for 19-MEDEX events

Bias Score

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

Range: $-\infty$ to ∞

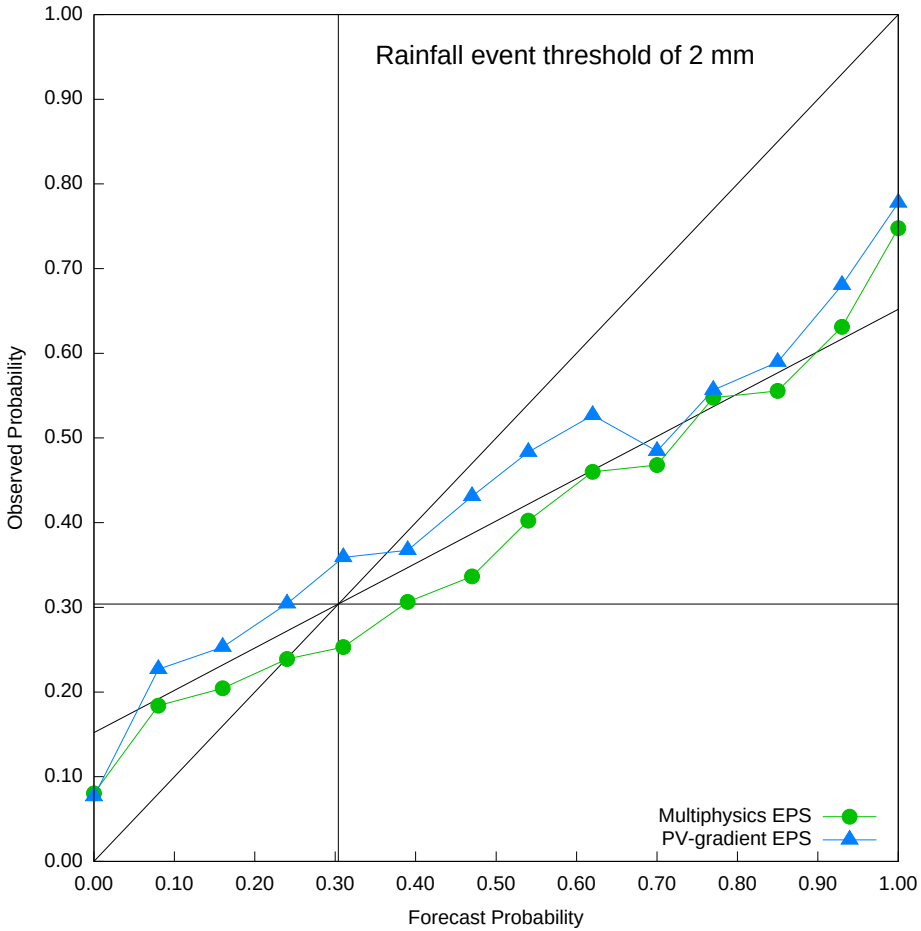
Perfect score: 1

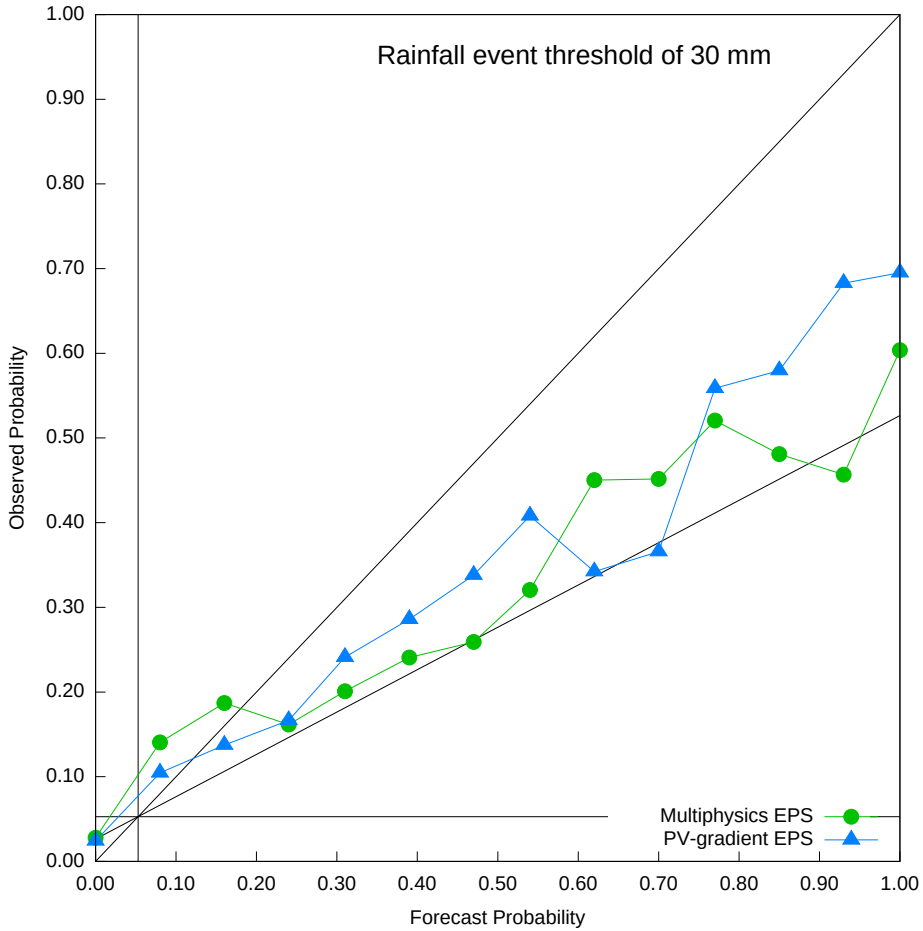


EPSs results for 19-MEDEX events

Attribute Diagram

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





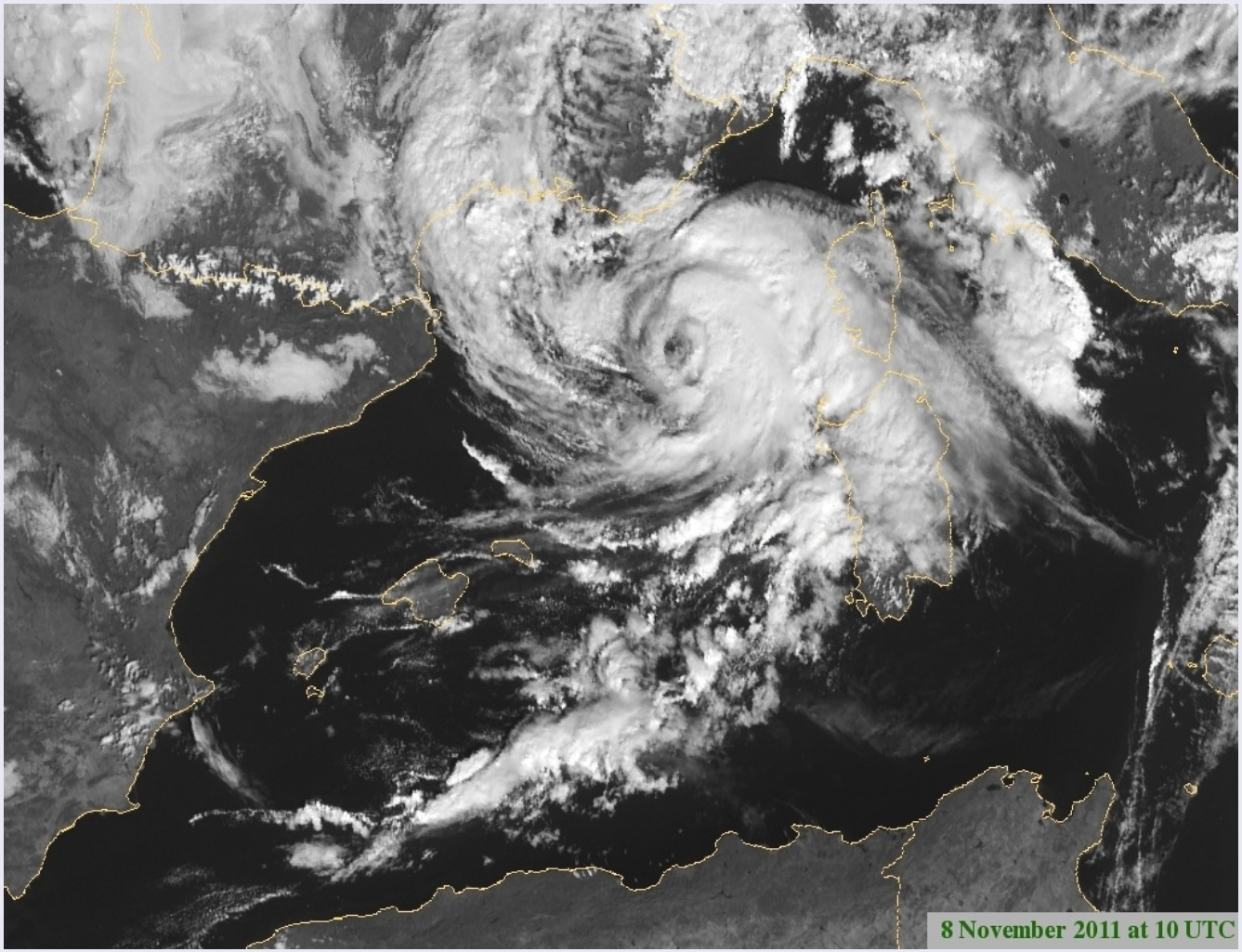
EPSs results discussion

It is hard to verify extreme events and precipitation due to the small statistically significance, and the characteristics of the rainfall, like strong gradients in space and rapid variations in time. In spite of all this:

- The ensembles perform well.
- The PV-gradient perform better than Multiphysics.

Application: The 8 November 2011 medicane event

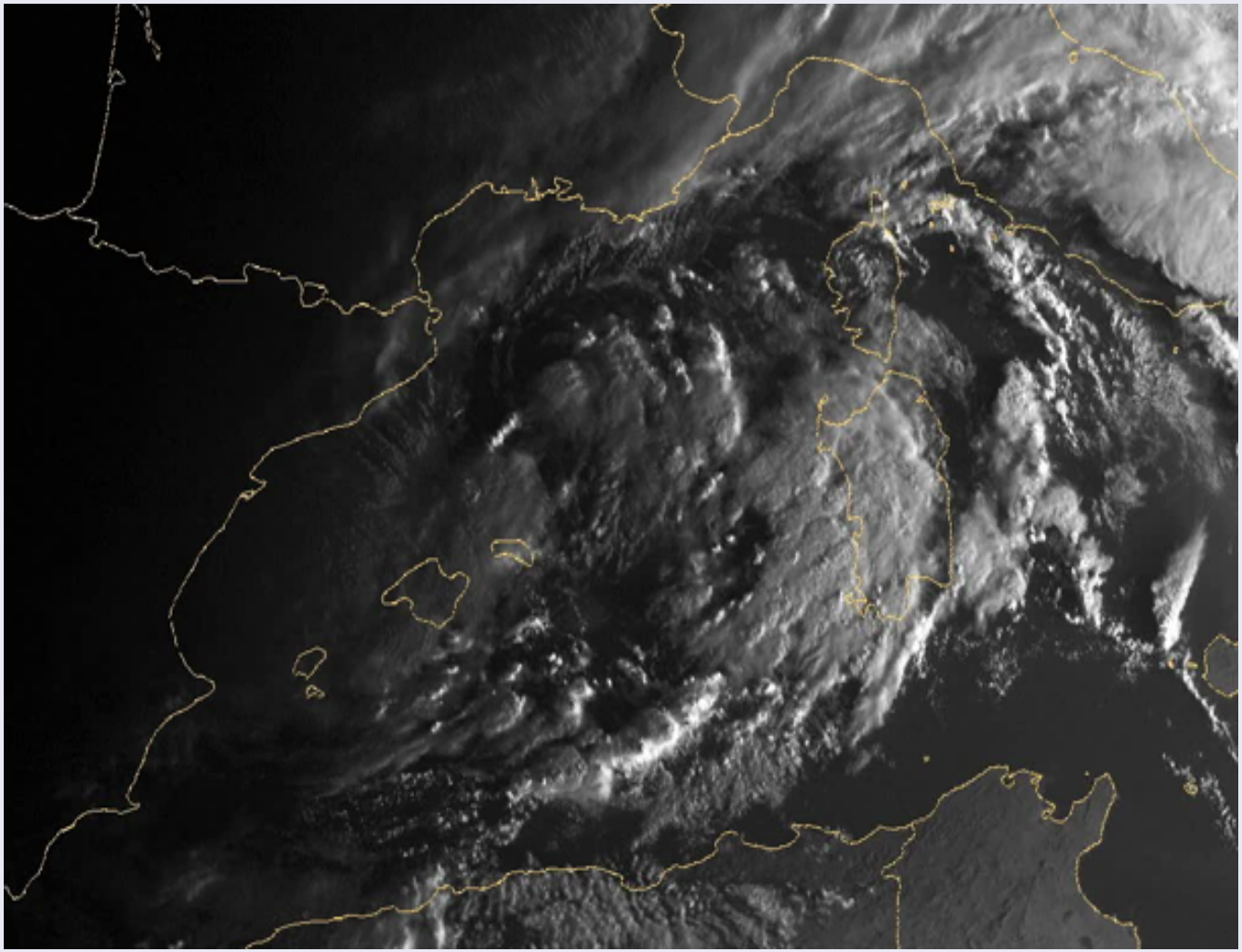
EUTMETSAT Met-8, High-resolution visible band



6 November 06:30 - 9 November 16:30 UTC

Application: The 8 November 2011 medicane event

EUTMETSAT Met-8, High-resolution visible band

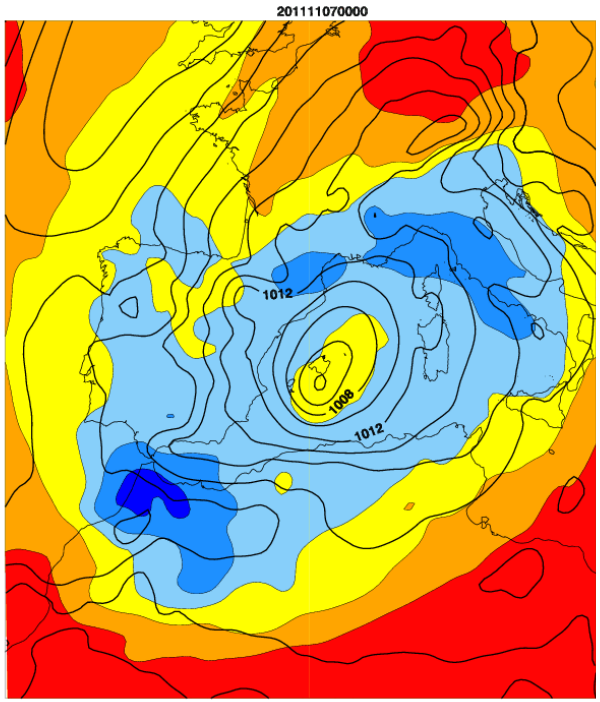


6 November 06:30 - 9 November 16:30 UTC

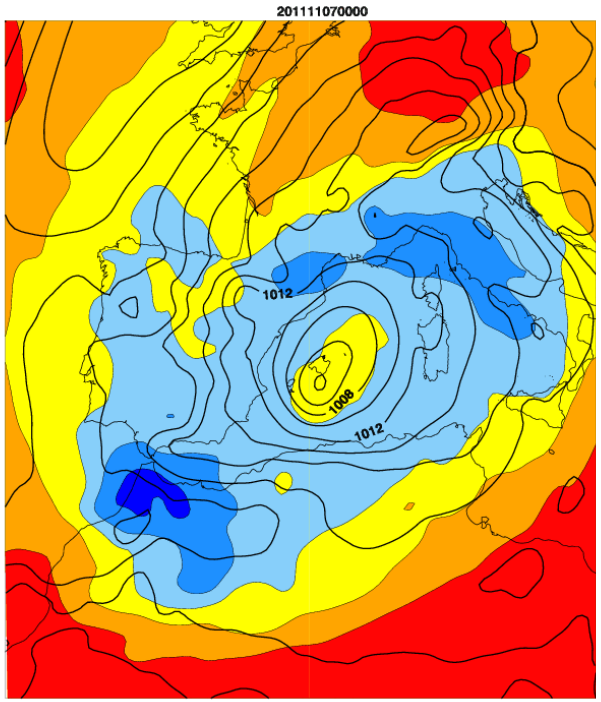
Application: The 8 November 2011 medicane event

Simulations initialized on 7 Nov 2011 at 00UTC

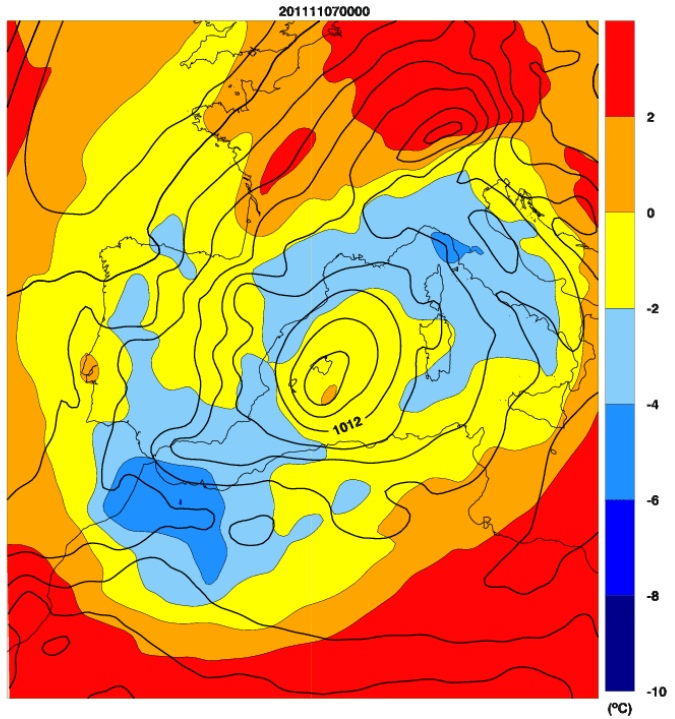
Control



Multiphysics

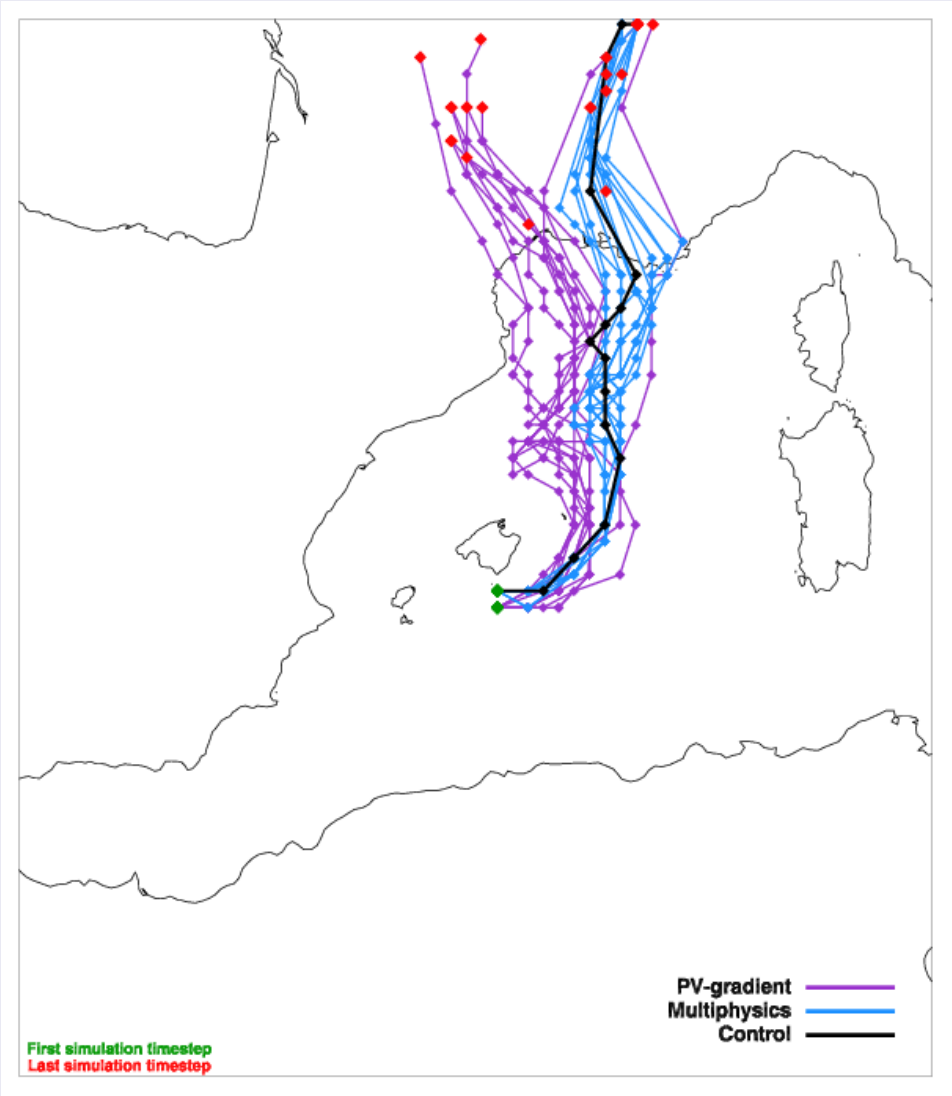


PV-gradient

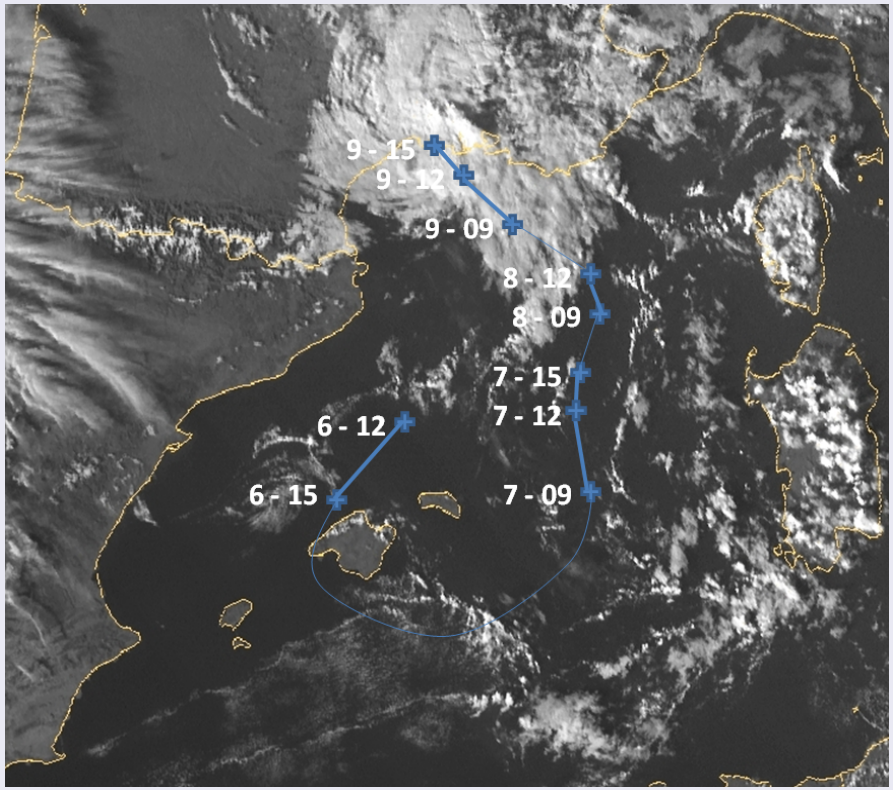


Application: The 8 November 2011 medicane event

Medicane track



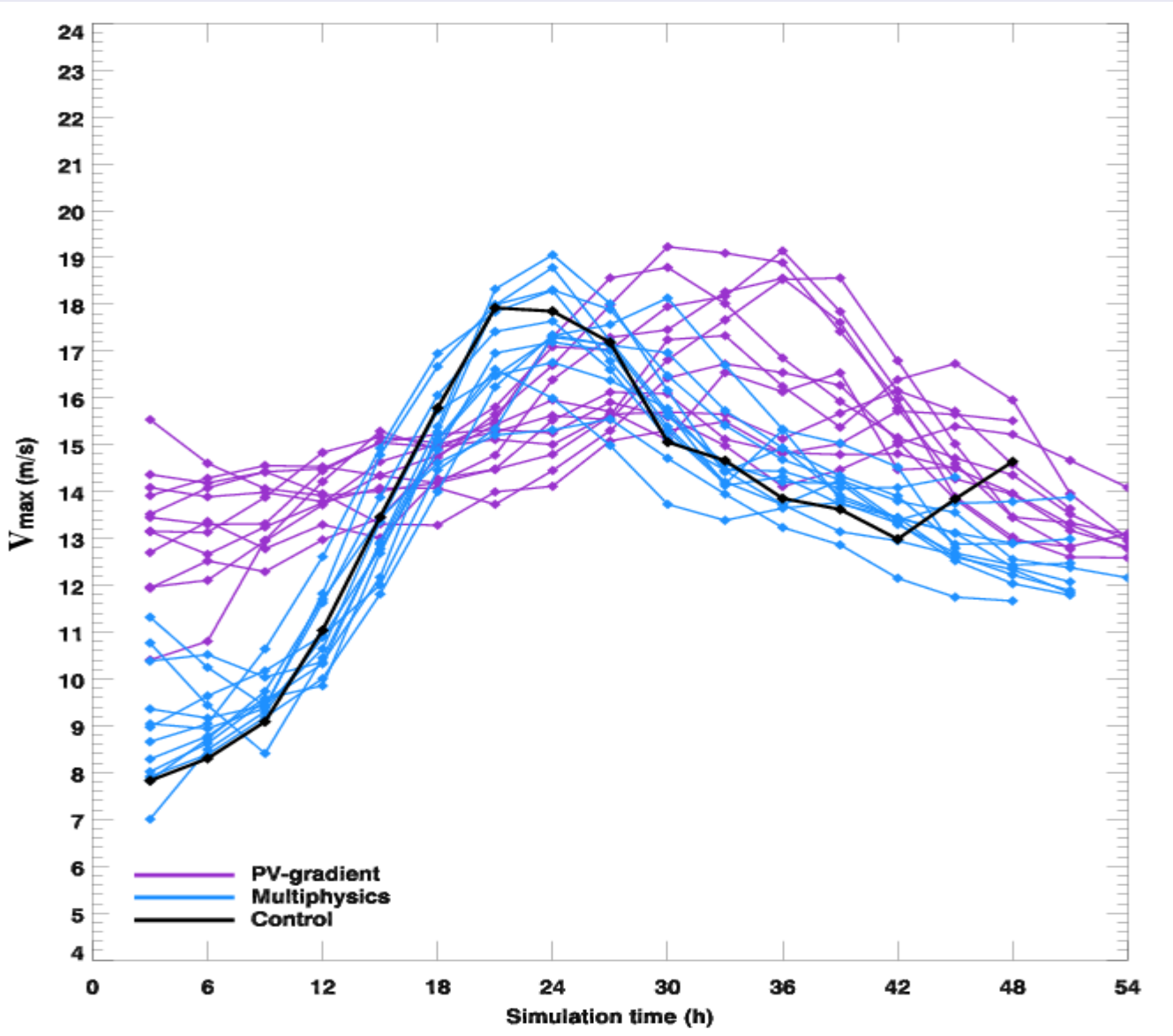
EPSs results



EUMETSAT

Application: The 8 November 2011 medicane event

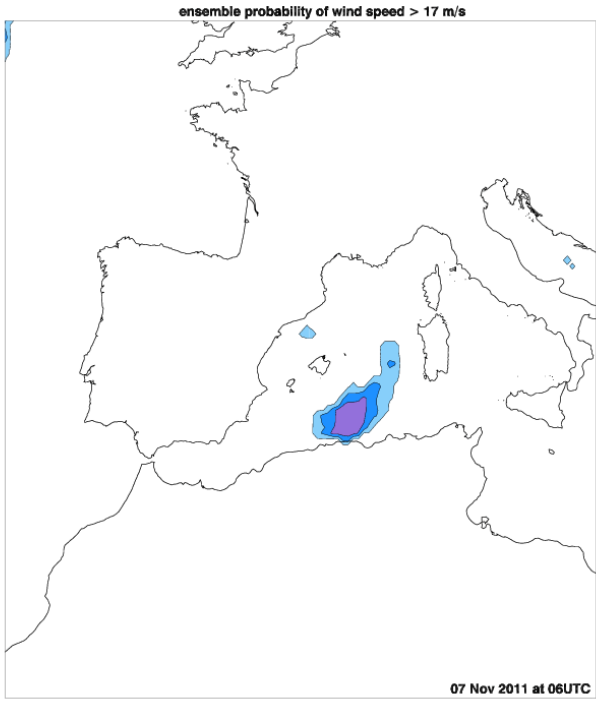
Medicane maximum wind speed

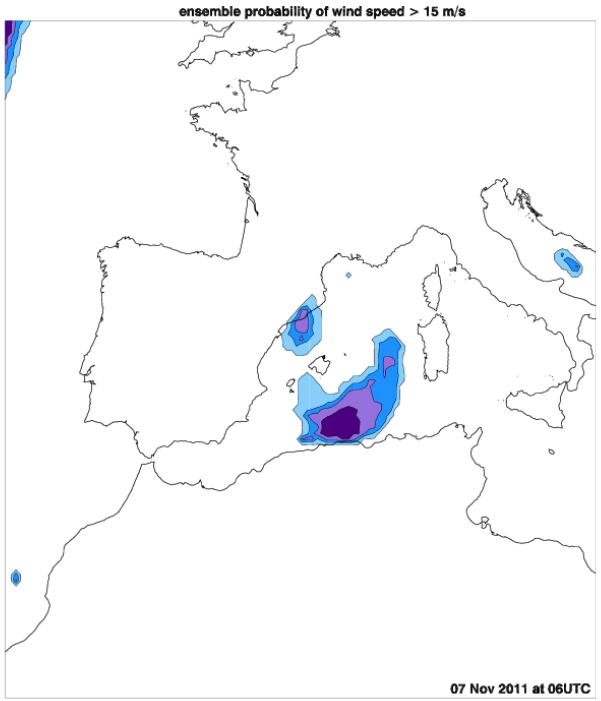


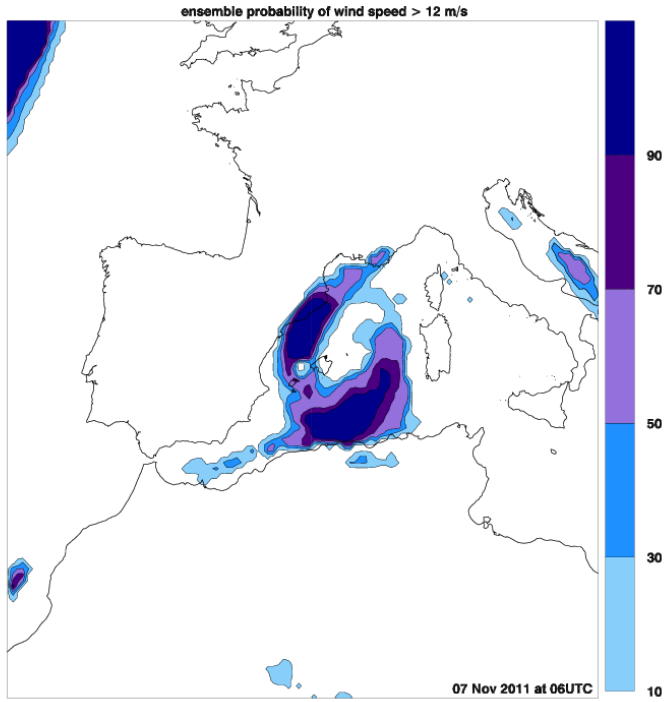
Application: The 8 November 2011 medicane event

ensemble probability of wind speed over

17 m/s | 15 m/s | 12 m/s







surface wind speed > 17 m/s

tropical storm

Conclusions

- The ensembles capture the medicane track.
- The PV-gradient ensemble has more spread, both in medicane intensity and track, than the multiphysics EPS.
- Ensemble probability of wind speed could become a powerful tool to issue high wind condition warnings.

Thank you very much!