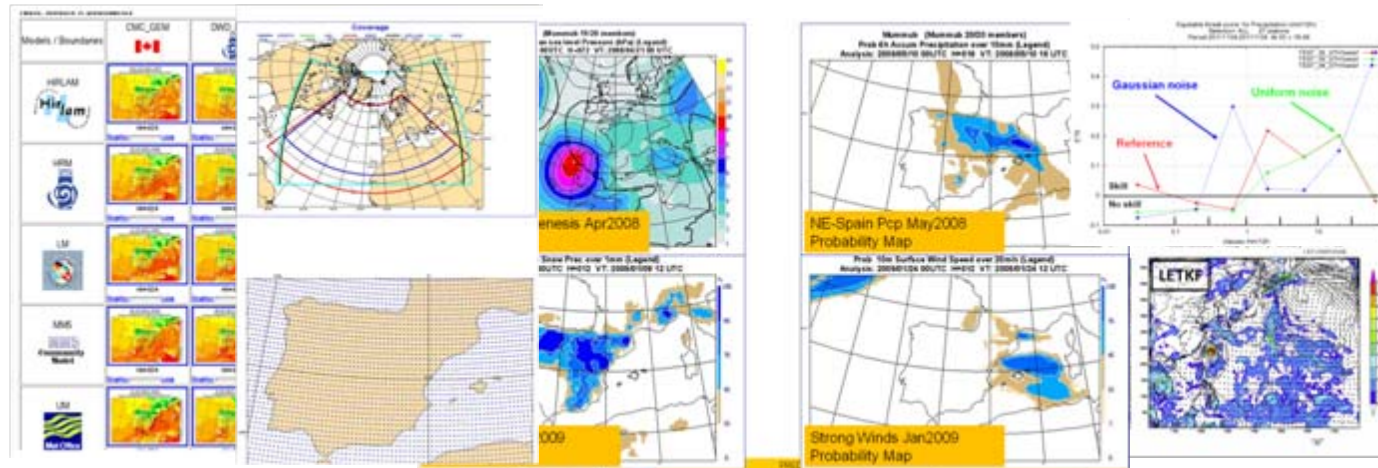


1ª reunión Proyecto PREDIMED, Palma de Mallorca, 19-20 mayo 2012

# AEMET-SREPS status & plans



**Carlos Santos** – AEMET (Spain), Predictability Group, NWP Apps

**AA:** I. Martínez ← J.A. García-Moya

**Predictability Group:** A. Amo, A. Callado, P. Escribà, J. Montero, J. Sancho, D. Santos, J. Simarro

**Acknowledgements:** J. A. López, A. Chazarra, O. García, J. Calvo, B. Navascués, Climatic Database Staff, Computer Systems Staff, member and cooperating states ECMWF

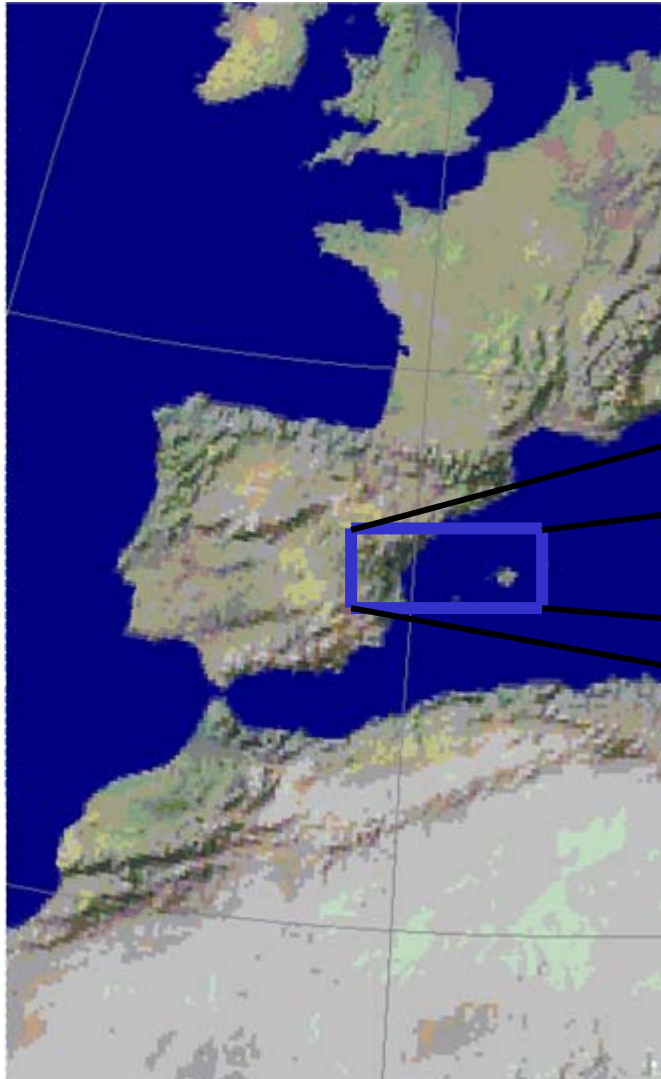
This work is partially funded by project PREDIMED CGL2011-24458 from the Spanish Ministerio de Ciencia en Innovación.



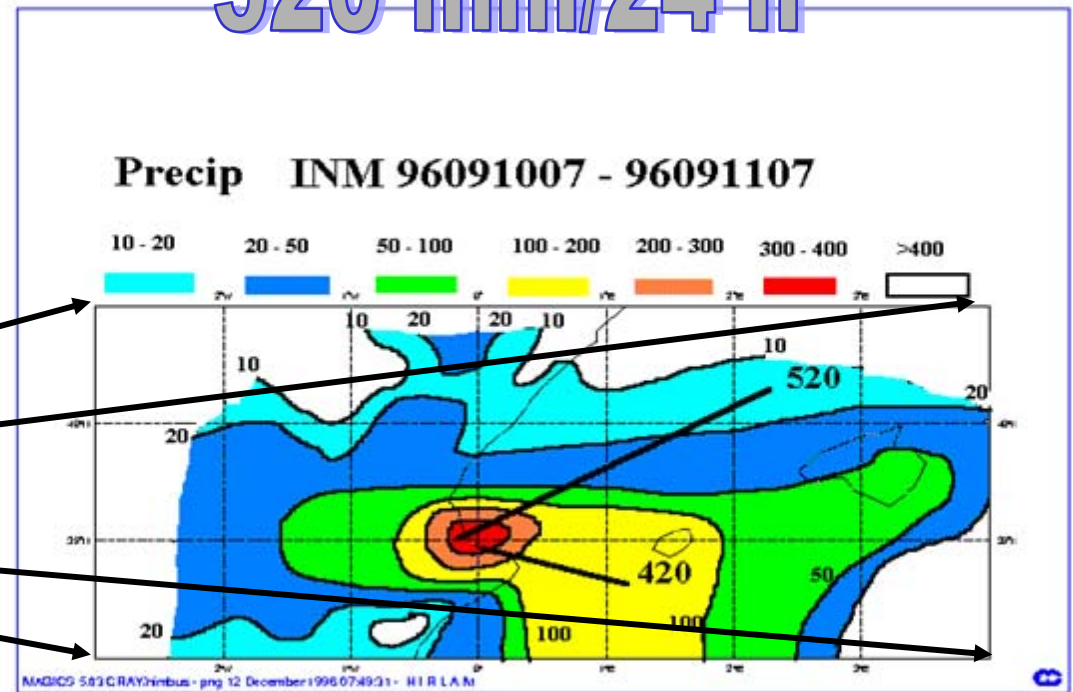
# Outline

- AEMET-SREPS summary
- AEMET- $\gamma$ -SREPS plans

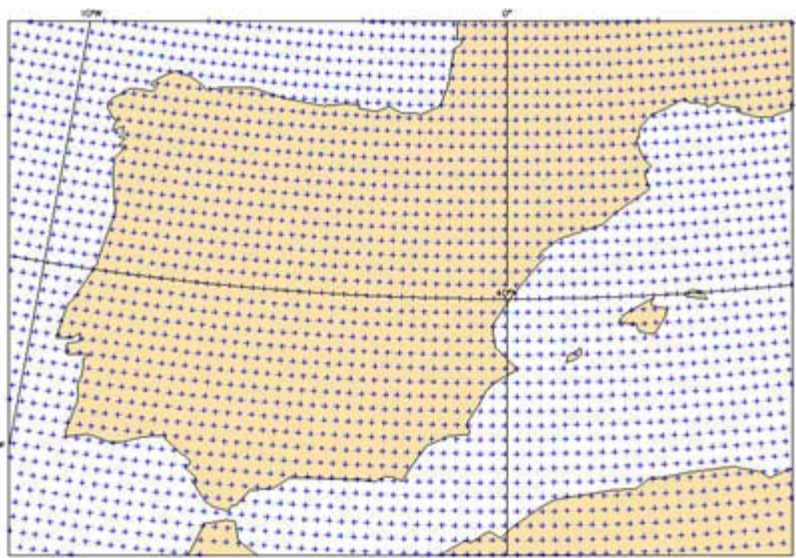
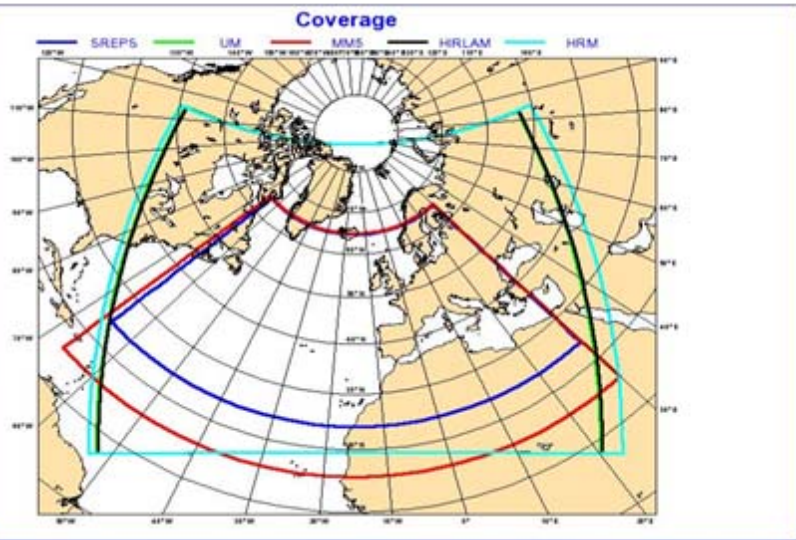
# Why an EPS for SR?



520 mm/24 h



# AEMET Multi-model LAM SREPS

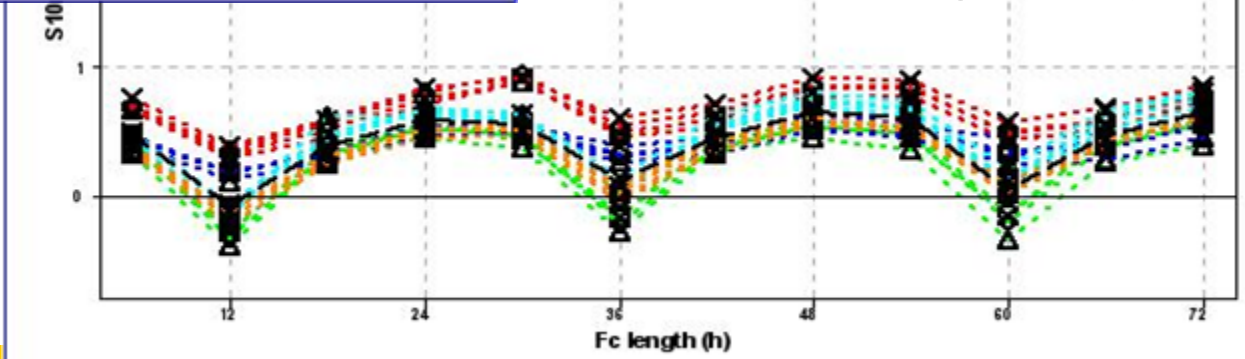
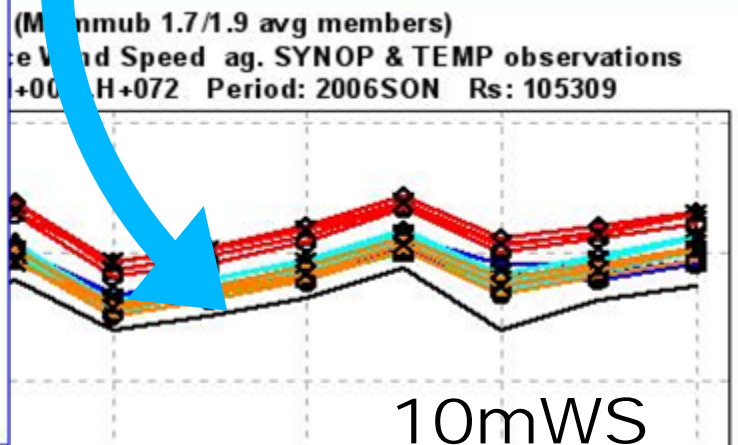
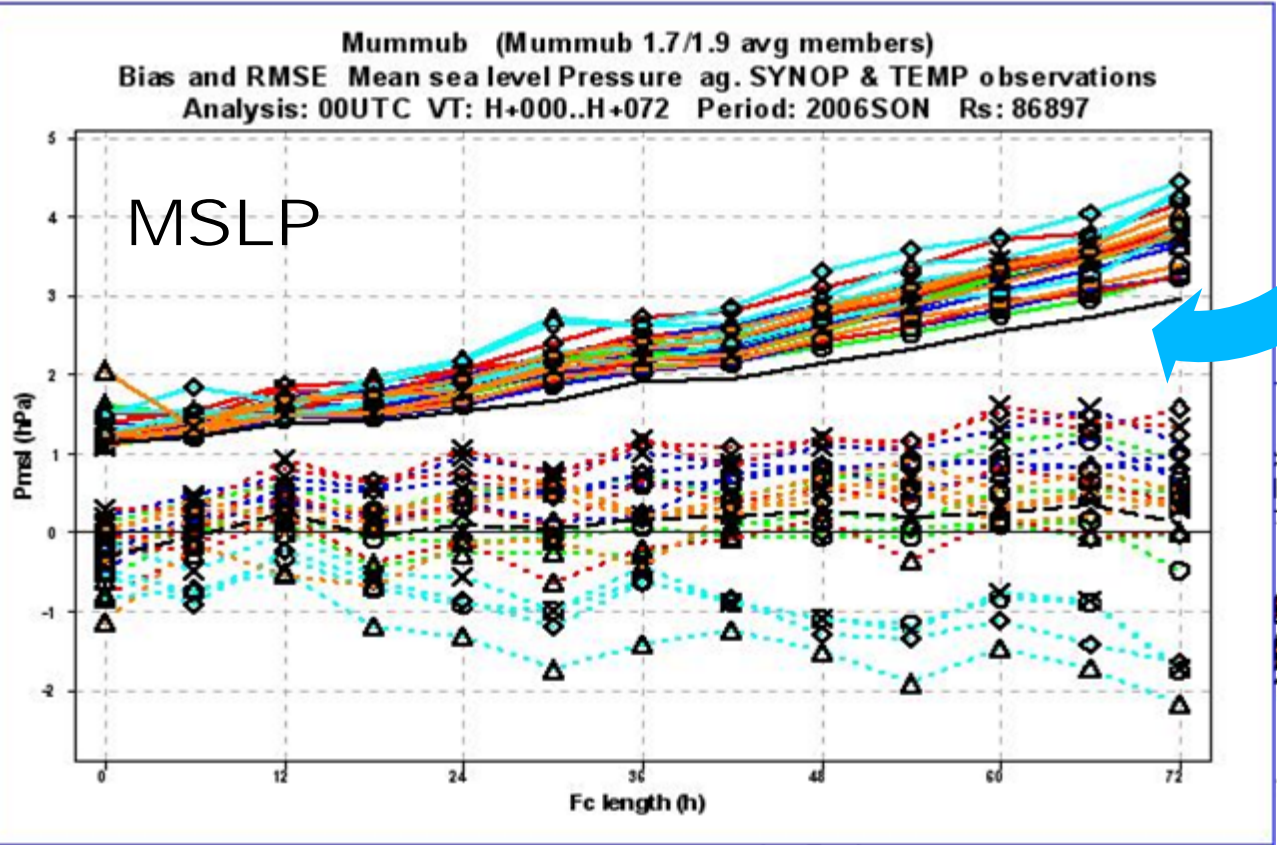


Models / Boundaries	CMC_GEM 	DWD_GME 	ECMWF_JFS 	JMA_GSM 	NCEP_GFS 

- 72 hours forecast range
- Twice a day (00,12 UTC)
- 4LAMs x 5lcBc = 20 members
- 0.25° ~ 25 km

# Tuning

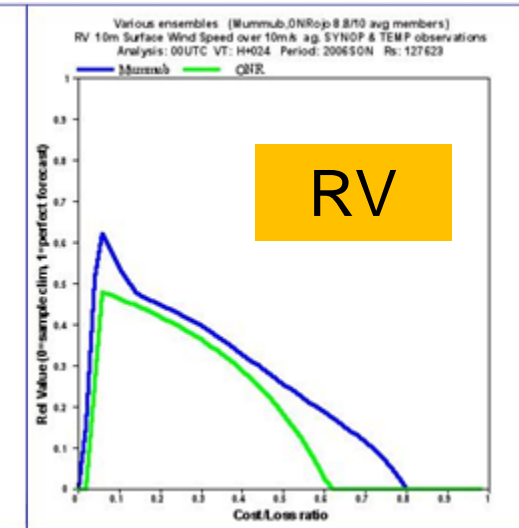
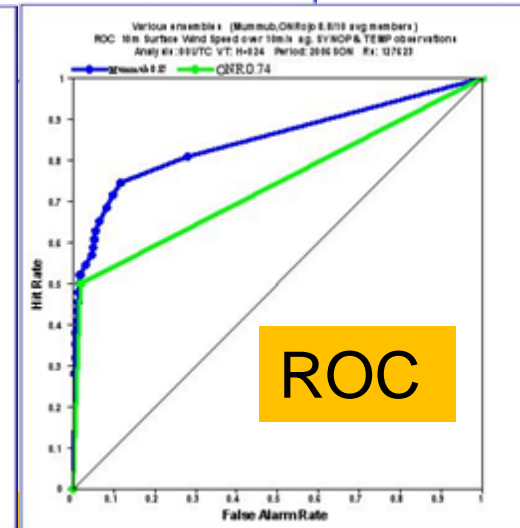
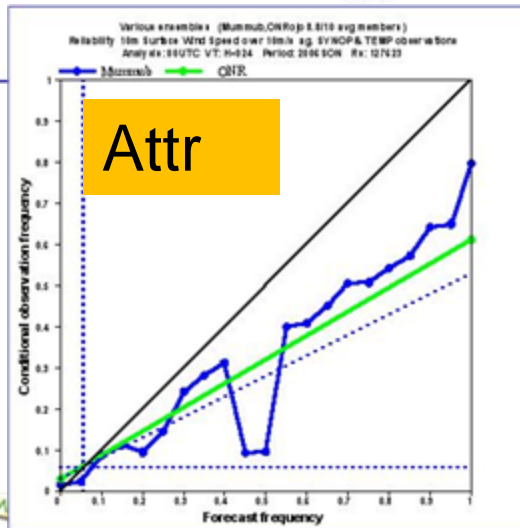
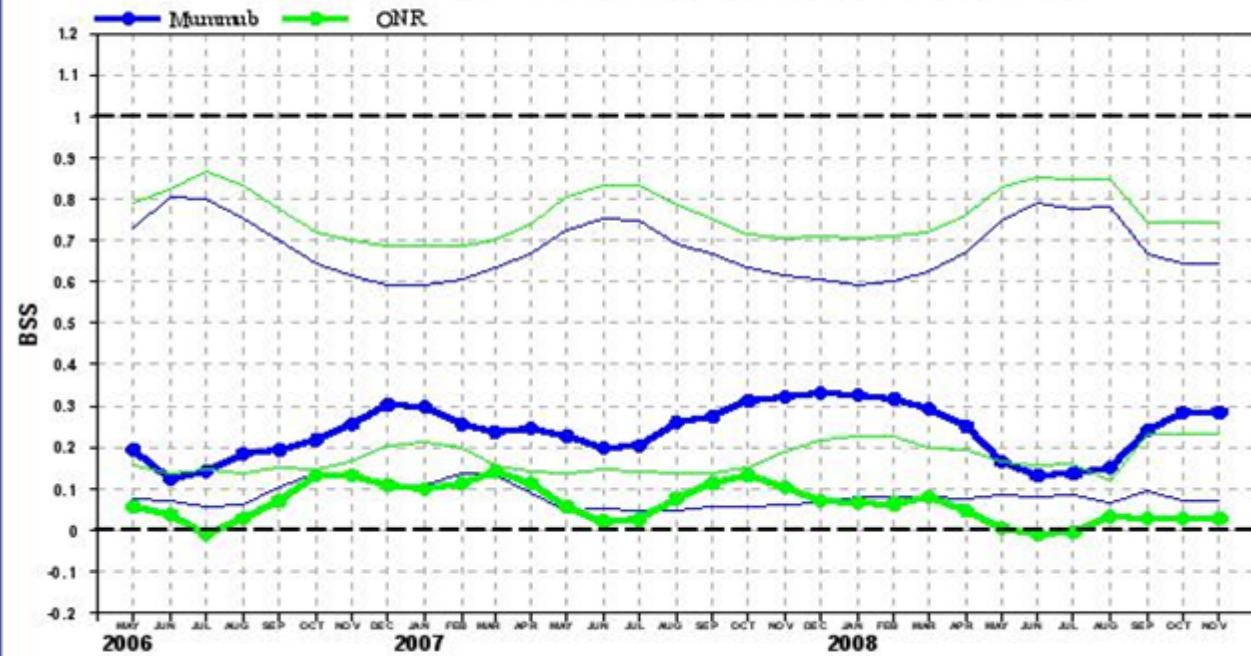
• Ensemble mean (black) performs better than any member



# Added value w.r.t det. Hirlam

Synop 10m Winds > 10m/s Hirlam 0.16 SREPS

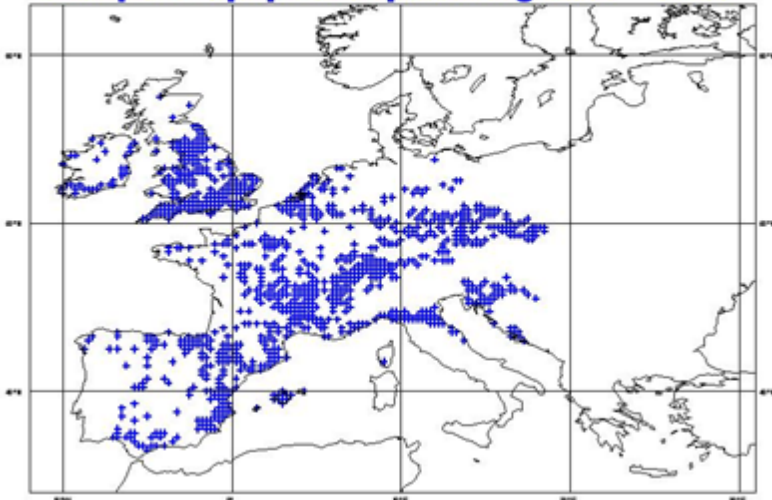
- Added value w.r.t. our deterministic model?
- SREPS purpose: **probabilistic forecasts**
- Better performance measures:
  - Better reliability & Resolution (BSS, Attr)
  - Better discrimination (ROC)
  - Higher relative Value (RV)



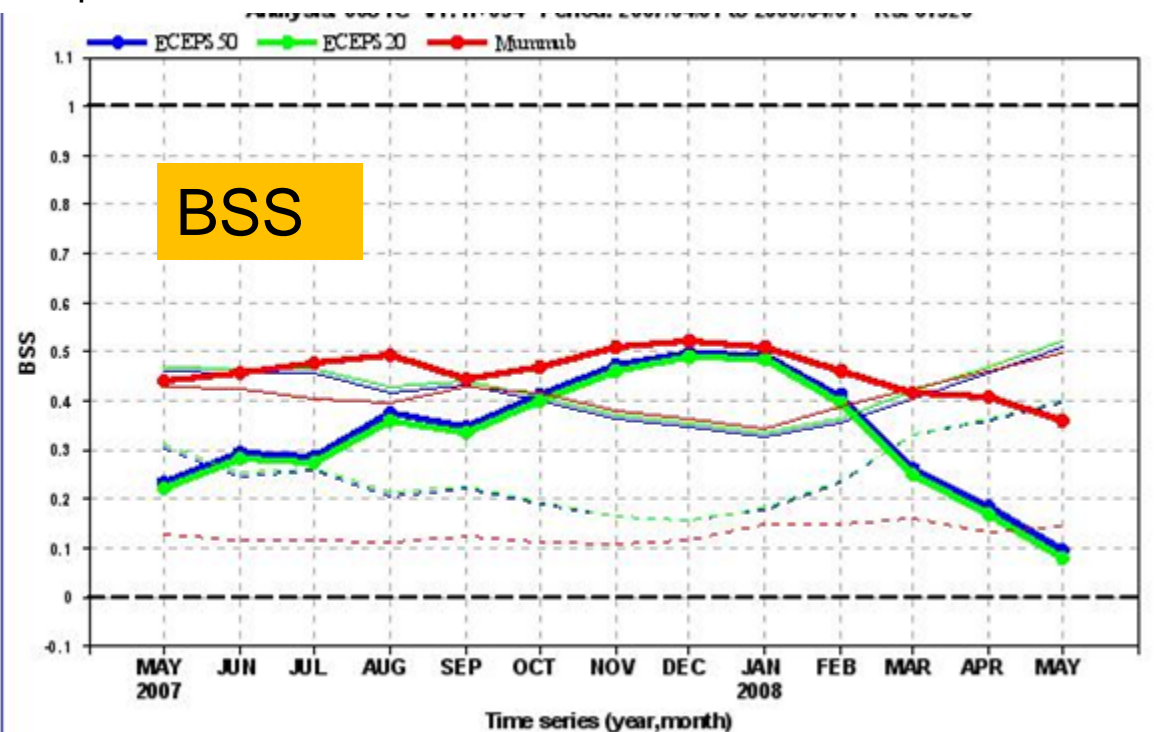
# Added value w.r.t. ECMWF EPS

- Added value w.r.t. ECMWF EPS?
- SREPS covers the **SHORT RANGE**
- **Better performance** due to resolution and ensemble features: using pcp up-scaling over Europe and observational uncertainty method, SREPS shows better reliability, discrimination, etc.

Europe HR pcp obs up-scaling 0.25 ~ 1000



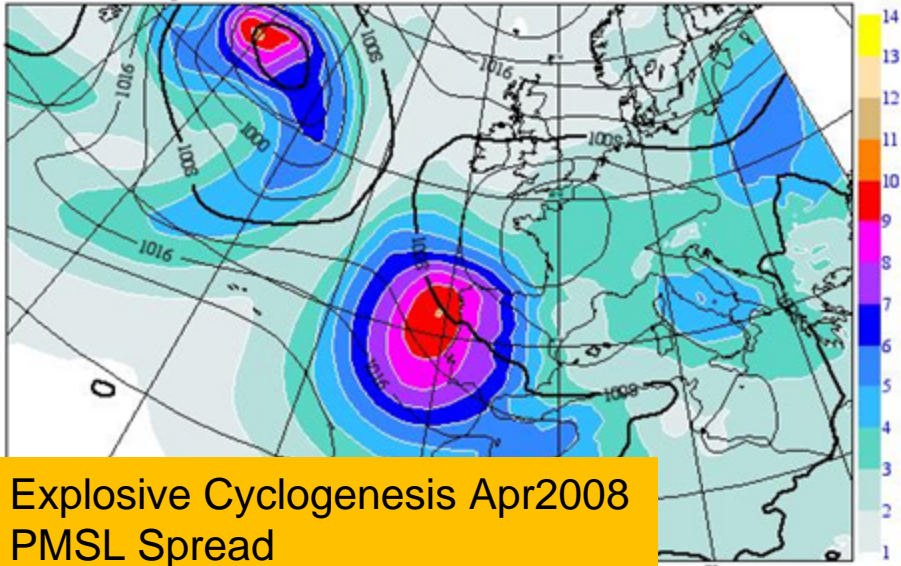
Pcp24h > 1mm ECEPS20 ECEPS51 AEMET-SREPS





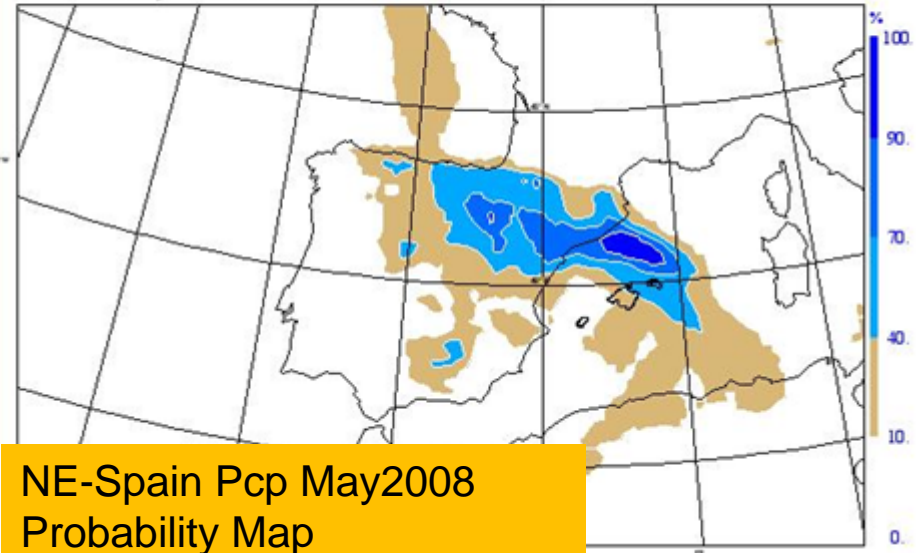
# Case Studies

Mummub (Mummub 19/20 members)  
Spread&E mean Sea level Pressure (hPa) (Legend)  
Analysis: 2008/04/18 00UTC H+072 VT: 2008/04/21 00 UTC



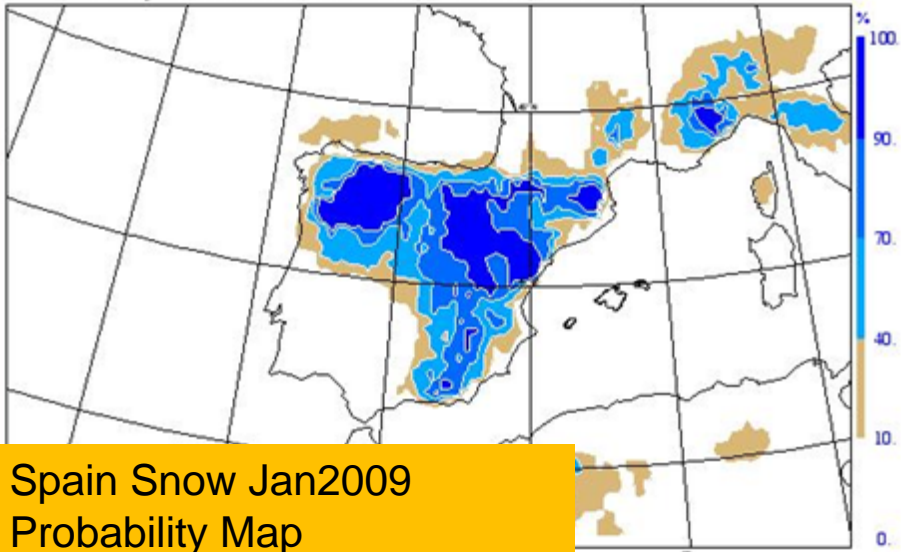
Explosive Cyclogenesis Apr2008  
PMSL Spread

Mummub (Mummub 20/20 members)  
Prob 6h Accum Precipitation over 10mm (Legend)  
Analysis: 2008/05/10 00UTC H+018 VT: 2008/05/10 18 UTC



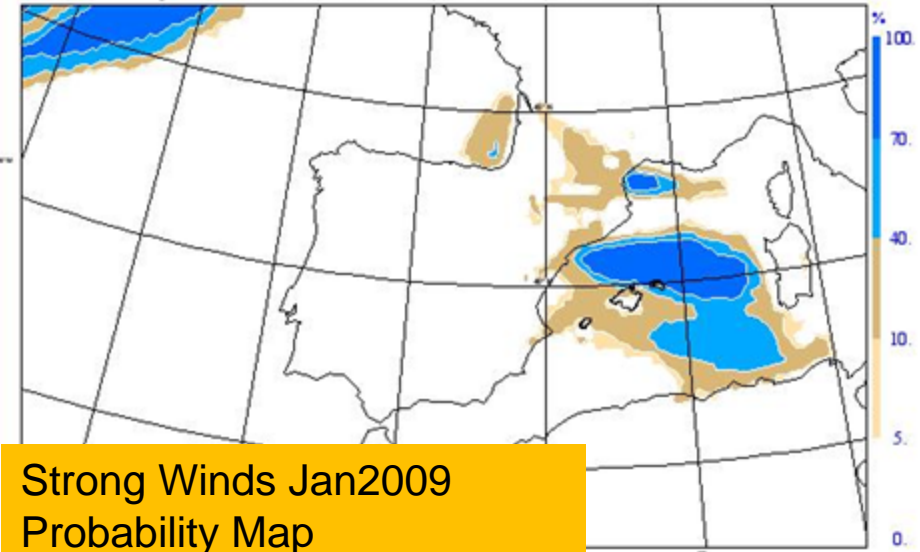
NE-Spain Pcp May2008  
Probability Map

Prob 6h Accum Snow Prec over 1mm (Legend)  
Analysis: 2009/01/09 00UTC H+012 VT: 2009/01/09 12 UTC



Spain Snow Jan2009  
Probability Map

Prob 10m Surface Wind Speed over 20m/s (Legend)  
Analysis: 2009/01/24 00UTC H+012 VT: 2009/01/24 12 UTC



Strong Winds Jan2009  
Probability Map

# Relevant pubs

Ensemble Forecasting, chapter from Weather Forecasting, INTECH

GARCÍA-MOYA, J.-A., CALLADO, A., ESCRIBÀ, P., SANTOS, C., SANTOS-MUÑOZ, D. and SIMARRO, J. (2011), Predictability of short-range forecasting: a multimodel approach. *Tellus A*, 63: 550–563. doi: 10.1111/j.1600-0870.2010.00506.x

IVERSEN, T., DECKMYN, A., SANTOS, C., SATTLER, K., BREMNES, J. B., FEDDERSEN, H. and FROGNER, I.-L. (2011), Evaluation of 'GLAMEPS'—a proposed multimodel EPS for short range forecasting. *Tellus A*, 63: 513–530. doi: 10.1111/j.1600-0870.2010.00507.x

Santos, C. and Ghelli, A., 2011, Observational probability method to assess ensemble precipitation forecasts. *Q.J.R. Meteorol. Soc.*, 138: 209–221. doi: 10.1002/qj.895

Callado, A., Santos, C., Escribà, P., Santos-Muñoz, D., Simarro, J., and García-Moya, J. A., 2011: Performance of multi-model AEMET-SREPS probabilistic forecasts over Mediterranean area, *Adv. Geosci.*, 26, 133-138, doi:10.5194/adgeo-26-133-2011,

Escribà, P., Callado, A., Santos, D., Santos, C., García-Moya, J. A., and Simarro, J., 2011: Probabilistic prediction of raw and BMA calibrated AEMET-SREPS: the 24 of January 2009 extreme wind event in Catalunya, *Adv. Geosci.*, 26, 119-124, doi:10.5194/adgeo-26-119-2010,

# Outline

- AEMET-SREPS summary
- AEMET- $\gamma$ -SREPS plans

# AEMET $\gamma$ -SREPS

## Research phase

- SREPS (25 km)  $\rightarrow$   $\gamma$ -SREPS (4-7 km)
- **Convergence with GLAMEPS:** staff and efforts, but an independent suite
- Road map: 2012-2013 research phase

## Research lines

- **Predictability issues** at convective scale are different than at synoptic/mesoscale
- Starting point: HARMONIE as base model
- Sampling uncertainties: SPPT (model), ETKF/EDA (ICs), LBCs
- Case studies: according to scale
- Feature-based verification: MODE
- Python wrapping

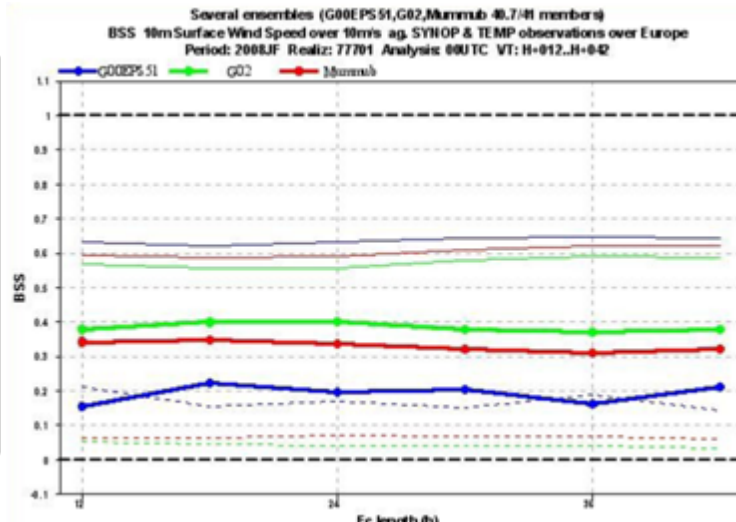
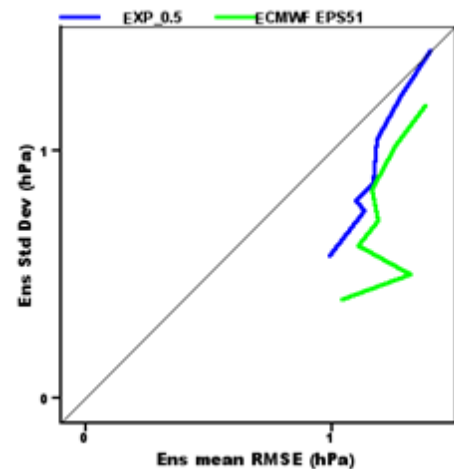
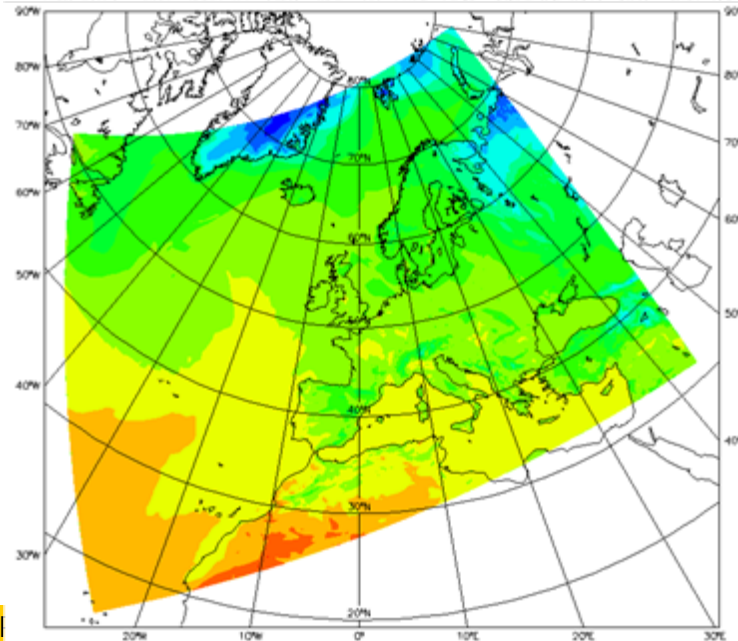
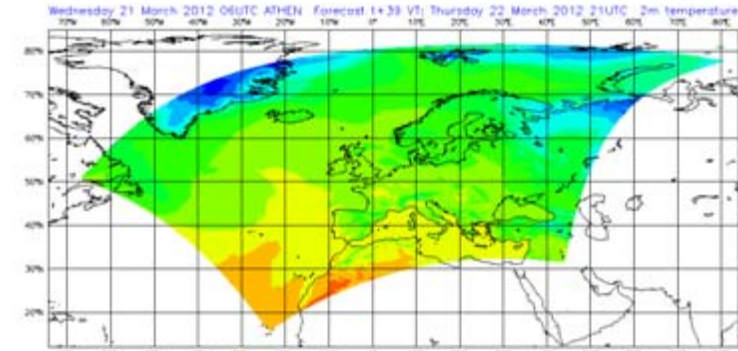
# About GLAMEPS

## Grand Limited Area Model Ensemble Prediction System

- HIRLAM – ALADIN pan-european ensemble, since 2006
- **Norway**, Sweden, Finland, **Denmark**, **Belgium**, Netherlands, Hungary, **Spain**, Ireland

## Current settings

- Multi-model: Hir\_Straco, Hir\_K.Fritz, Aladin, ECEPS\_subset
- ICs: downscaling ECMWF EPS (i.e. SVs + EDA)
- 10 km (GLAMEPS) → 2-4 km (Harmon-EPS)
- Short range: 06 & 18 UTC, T+54
- Better performance than ECMWF & AEMET-SREPS



# Predictability issues at convective scale

## Grand Limited Area Model Ensemble Prediction System

- HIRLAM – ALADIN pan-european ensemble, since 2006
- **Norway**, Sweden, Finland, **Denmark**, **Belgium**, Netherlands, Hungary, **Spain**, Ireland

## Current settings

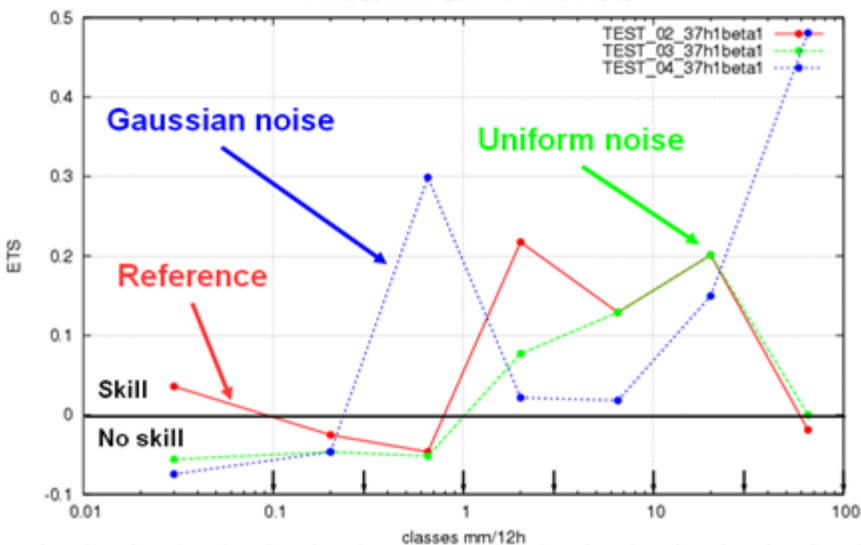
- Multi-model: Hir\_Straco, Hir\_K.Fritz, Aladin, ECEPS\_subset
- ICs: downscaling ECMWF EPS (i.e. SVs + EDA)
- 10 km (GLAMEPS) → 2-4 km (Harmon-EPS)
- Short range: 06 & 18 UTC, T+54
- Better performance than ECMWF & AEMET-SREPS

# SPPT

## A Callado: stochastic parameterization to take into account uncertainties of NWP HARMONIE in an EPS

- **6 months visit ECMWF:** Glenn Shutts, Roberto Buizza
- **SPPT:** Stochastic Perturbed Parameterization Tendencies (Buizza et al., 1999)
  - Multiplicative noise applied to each physics variable tendency
  - Spectral spatial and time correlations (at ECMWF)
- **Harmon-EPS** experiment: to apply multiplicative noise (~SPPT) to physics temperature tendency independently to each grid point, i.e. without spatial and temporal correlations

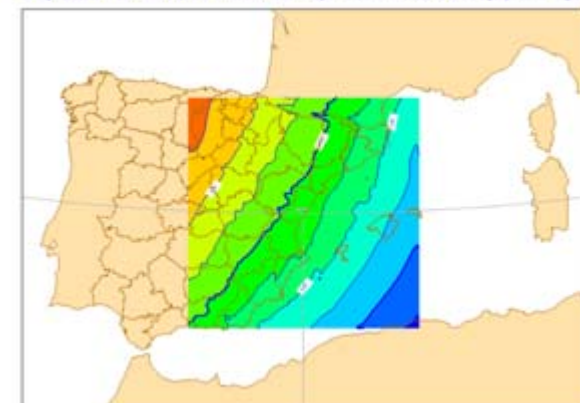
Equitable threat score for Precipitation (mm/12h)  
Selection: ALL 27 stations  
Period: 20111104-20111104 At 00 + 18-06



$$\frac{\partial X}{\partial t} = D_X + K_X + P_X + \delta P_X$$



Friday 4 November 2011 00:15 C ATHEN Forecast 1-6 V1: Friday 4 November 2011 00:15 C 500hPa geopotential height

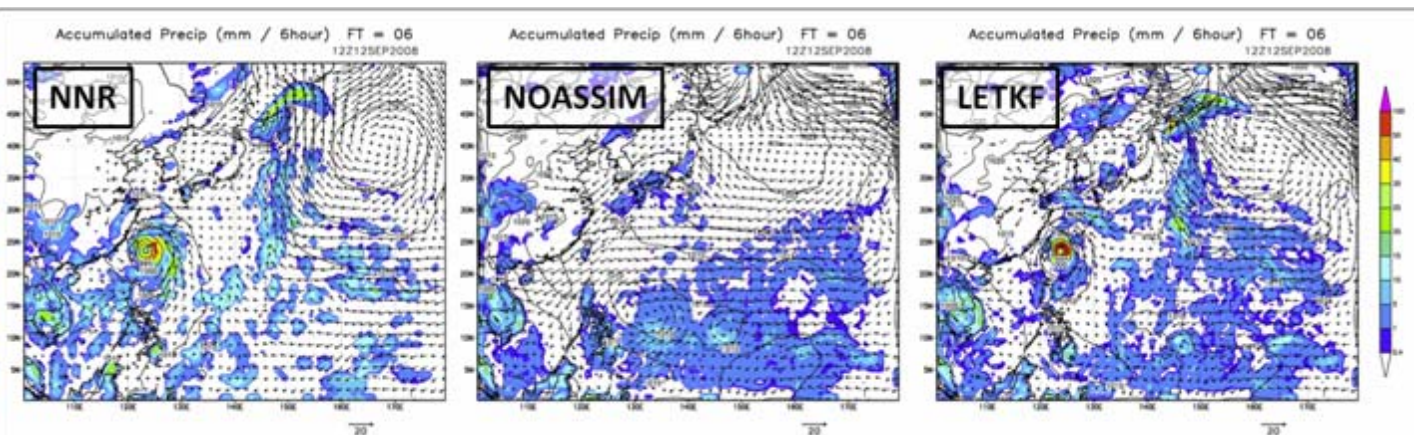


# ETKF & EDA

## P Escribà: ETKF in Harmon-EPS

- 6 months visit **ECMWF**: Massimo Bonavita, Lars Isaksen
- EDA, hybrid 4D-Var/EDA and the EnKF implemented at ECMWF

$$K = CH^T (HCH^T + R)^{-1}$$

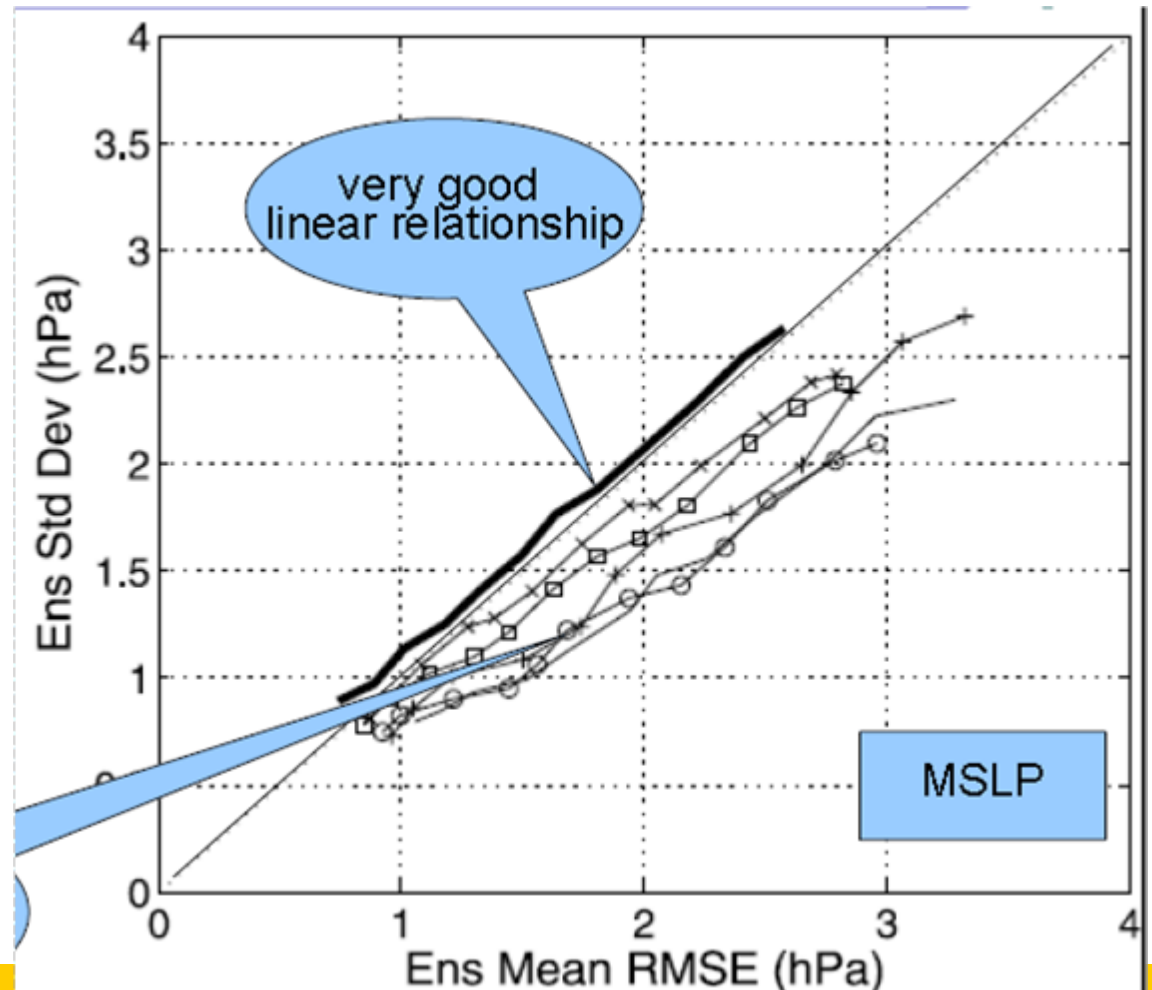




# Perturbations LBCs

## J Montero → J Sancho: perturbations LBCs

- **TIGGE** AGCMs
- Spread comparison



# HR observations

## A Amo / C Santos

- SEVIRI (Roebeling et al 2011)
- RADAR

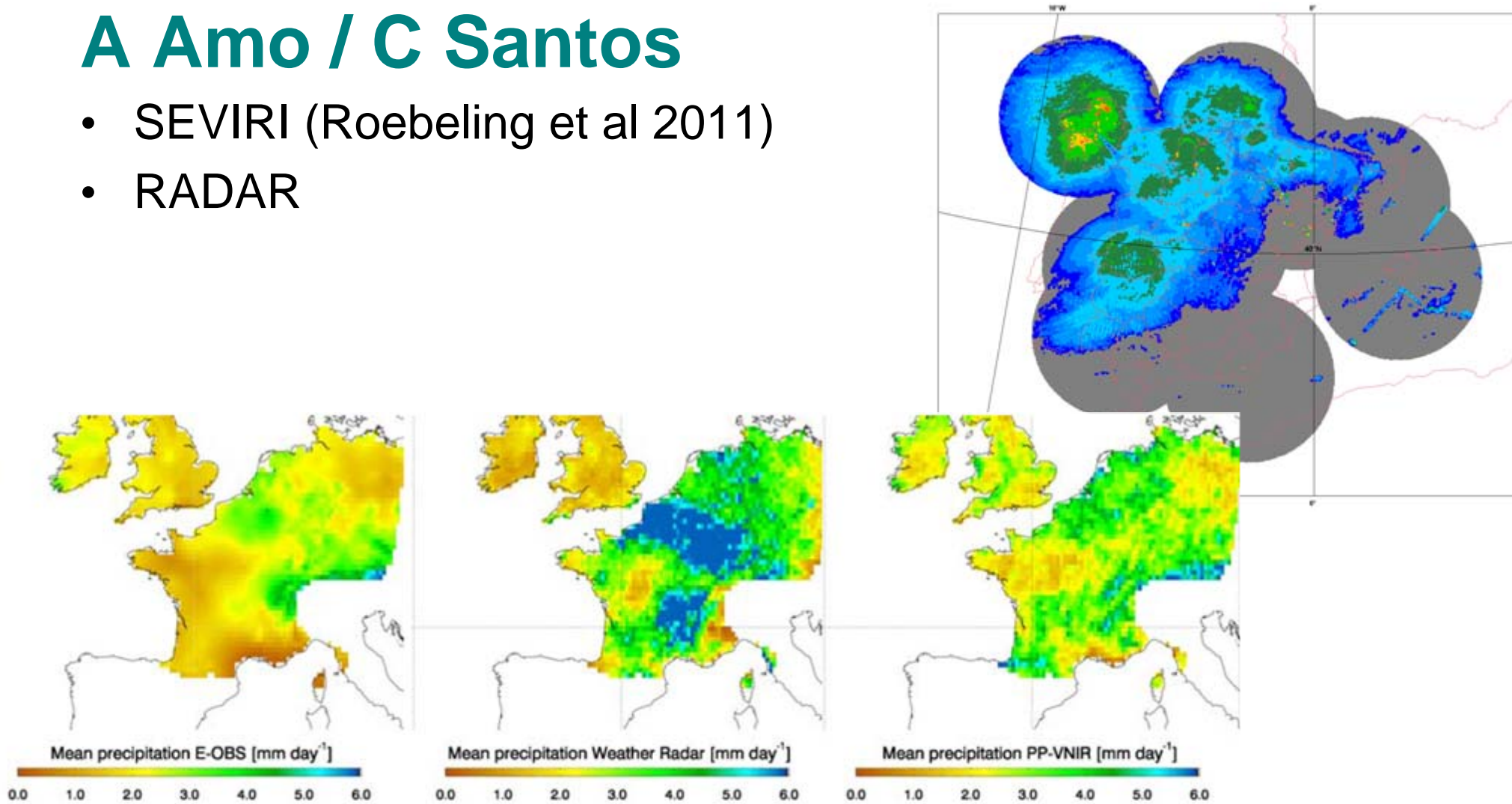
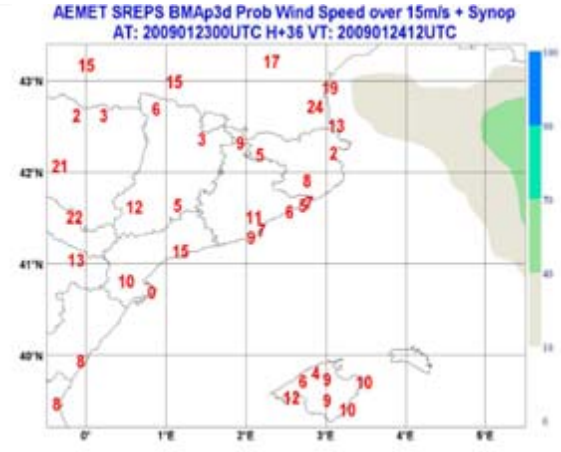
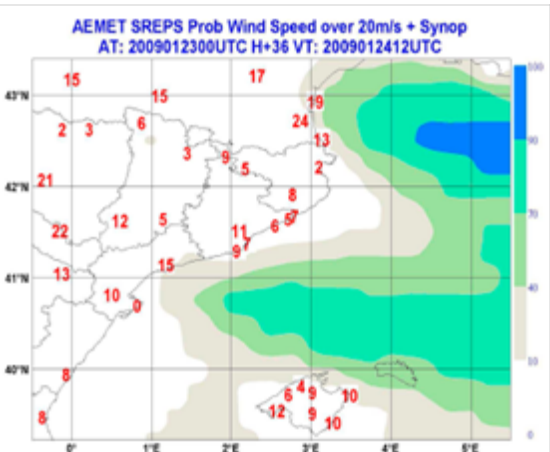
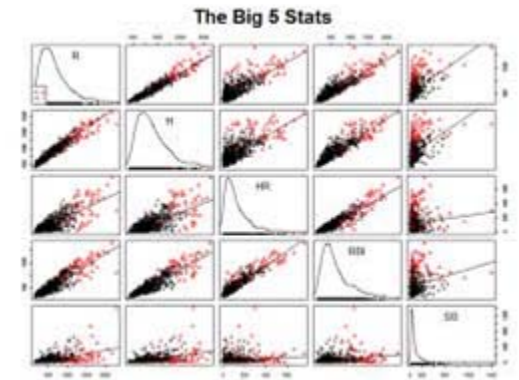
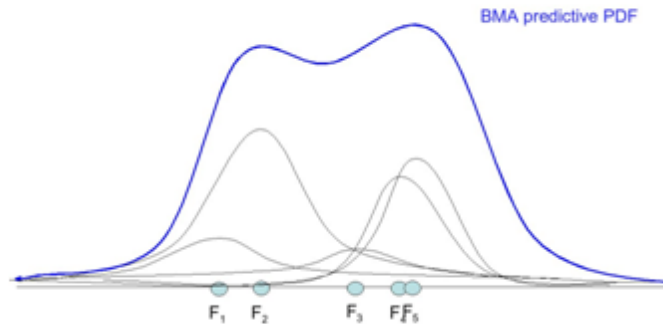


FIG. 1. Example of the mean daily precipitation amounts from E-OBS (left panel), Weather

# Calibration

## Research lines

- Experience with BMA
- Issue of extreme events
- Bayesian Model Averaging → Extended Logistic Regression



# Aplicaciones a la Meteo Aeronáutica

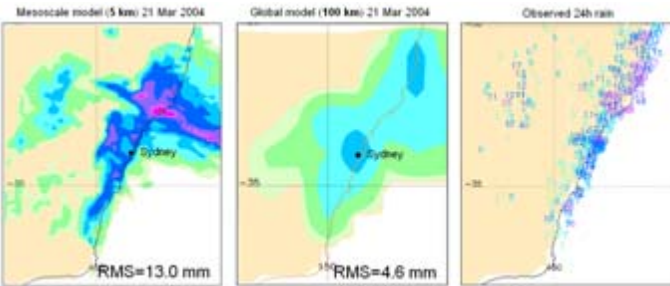
## E Abellán / Callado and Escribà

- Basado en una comunicación dinámica con los Grupos de Predicción y Vigilancia (GPV) para evaluar sus necesidades, van a generarse EPS-gramas, predefinidos y dinámicos, específicos en aeropuertos.

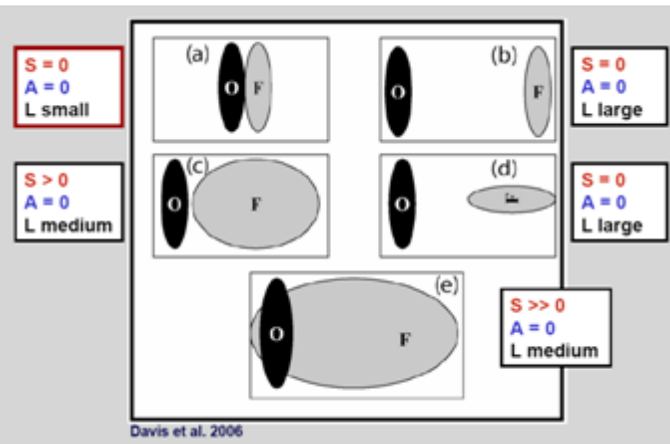
# Feature-based verification

## A Amo / C Santos

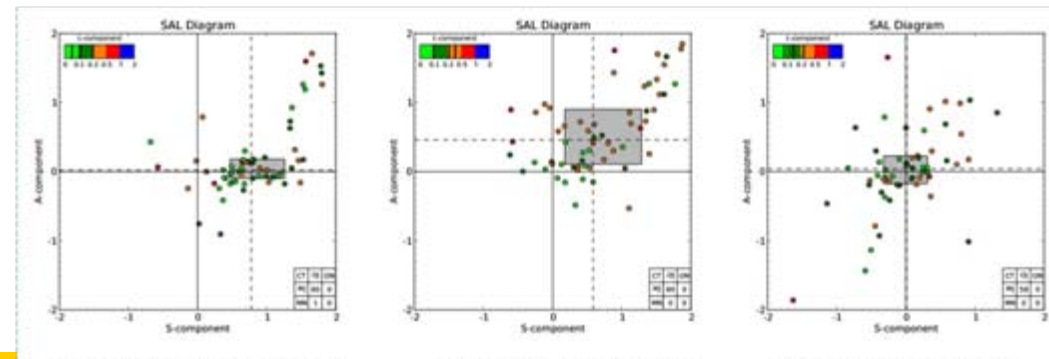
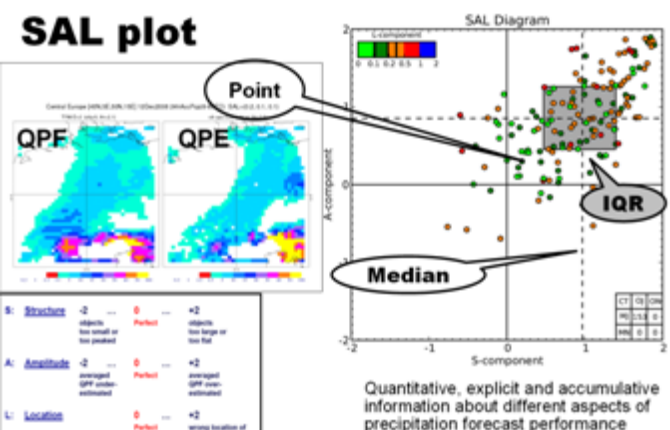
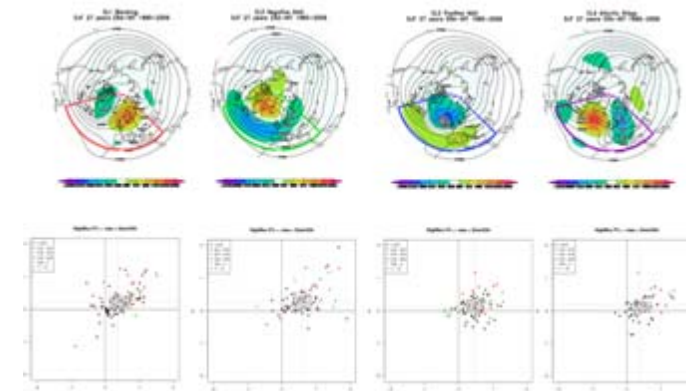
- Scale issues → feature-based methods
- SAL: valid for deterministic models
- MODE: possible for ensembles
- Flow dependent verification



Courtesy Beth Ebert



Davis et al. 2006



# Verification Software

- No hay paquetes de verificación completos ni estandarizados (de hecho no hay un sistema abstracto estándar de verificación)
  - Inmensos volumen y diversidad de datos: GRIB, netCDF, BUFR, etc
  - Volumen / complejidad colosales de metadatos: SQL o similar
  - Entorno de desarrollo
  - Lenguaje de programación OO
  - Soporte array, estadístico, geográfico, gráfico, plug-in de C++/Fortran
- Algunas opciones
  - Model Evaluation Toolkit (MET, NCAR)
  - Paquete de verificación R (CRAN)
  - **MetPy+Verify** (ECMWF pero no liberado)
- Python
  - Ofrece ventajas descritas arriba
  - Niveles scripting / alto / medio / bajo
  - Utilizado en NCEP / NCAR / NSSL (Wicker 2005: Improving Scientific Productivity using Python: An Example from an Ensemble Data Assimilation System in Meteorology)

# References

## Predictability of short-range forecasting: a multimodel approach

By JOSE-ANTONIO GARCÍA-MOYA<sup>1</sup>, ALFONSO CALLADO<sup>2</sup>, PAU ESCRIBÀ<sup>3</sup>,  
CARLOS SANTOS<sup>1</sup>, DANIEL SANTO-S-MUÑOZ<sup>1</sup> and JUAN SIMARRO<sup>3\*</sup> *AEMET, C/ Leonardo  
Prieto, C/ Castro 8, Ciudad Universitaria, 28071 Madrid, Spain; <sup>2</sup>AEMET, Delegación Territorial en Cataluña,  
C/ Aragües de Sert 1, 08071 Barcelona, Spain; <sup>3</sup>AEMET, Delegación Territorial en la Comunidad Valenciana,  
C/ Benlloch Casanilles 3, 46110 Valencia, Spain*

Online receipt received 11 April 2010; in final form 19 February 2011

### ABSTRACT

Numerical weather prediction (NWP) models (including mesoscale) have limitations when it comes to dealing with severe weather events because extreme weather is highly unpredictable, even in the short range. A probabilistic forecast based on an ensemble of slightly different models may help to solve this issue. Among other ensemble techniques, multimodel ensemble prediction systems (EPS) are proving to be useful for adding probabilistic value to mesoscale deterministic models. A multimodel Short Range Ensemble Prediction System (SREPS) focused on forecasting the weather up to 72 h has been developed at the Spanish Meteorological Service (AEMET). The system uses the different limited area models (LAMs), namely HIRLAM (HIRLAM Core system), IRLM (IRLM), the UM (UM-NC), IRLM (PSURVOR) and COSMO (COSMO Core system). These models run with initial and boundary conditions provided by the different global deterministic models, namely IFS (ECMWF), UM (UM-NC), GME (DWD), GFS (NCEP) and CHOROCC. AEMET SREPS (AEMET) validation on the large-scale flow, using ECMWF analysis, shows consistent and slightly underdispersive system. For surface parameters, the system shows high skill forecasting binary events (4-h precipitation probabilistic forecasts verified using an up-casting grid of observations from European high-resolution precipitation networks, and compared with ECMWF SREPS (ECMWF).

### 1. Introduction

From the dynamical point of view the atmosphere is a chaotic non-linear system. This fact implies that, even if a quasi-perfect numerical weather prediction (NWP) model were initialized with quasi-perfect initial conditions, the forecast would cease to be valid within a finite time interval (Lorenz, 1963). The lack of atmospheric predictability is due to the non-linear amplification, as the forecast period lengthens, of small errors in both the initial conditions and in the NWP model formulation. This intrinsic deficiency in the atmospheric predictability can be found at a wide range of time and space scales, including the mesoscale. A single NWP model being initialized with a single initial condition only provides one forecast of the future atmospheric state, and it has been largely proved that generating several predictions based on slightly different initial conditions and model configurations can improve the forecast (e.g. Hou

et al., 2001). The improvement comes with a probabilistic representation of the atmospheric forecasts, which in turn comes usually from an equally likely set of deterministic forecasts or ensembles of forecasts.

A variety of approaches are used to generate an ensemble prediction system (EPS) from deterministic numerical models, most of them sample both initial state and model uncertainties. One of the first proposed techniques to sample initial state uncertainty consists in the use of Monte Carlo methods to construct multiple random initial conditions for feeding models. This technique was proposed by Leith (1974), Hollingsworth (1980) and Molteni and Baumhauer (1989) among others. Hoffman and Kalnay (1983) proposed a time-lagged averaged forecast using forecasts from lagged starting times or members, as an alternative technique, which has led to some expertise (Ebersoldt and Kalnay, 1991). More recent approaches are based on generating dynamically constrained perturbations. Random vectors (e.g. Toth and Kalnay, 1993, 1997) and singular vectors (e.g. Buizza and Palmer, 1995, 1997; Hamill et al., 2000) are two of the main methods of introducing perturbations into the subspace of fastest growing errors. Hou et al. (1996) developed the idea of obtaining a better

\*Corresponding author.  
e-mail: jsimarro@aemet.es  
DOI: 10.1111/j.1600-0870.2010.00506.x

**García-Moya et al (2011):  
Predictability of short-range  
forecasting: a multimodel approach.  
Tellus A, 63: 550–563.  
doi: 10.1111/j.1600-0870.2010.00506.x**

# Bonus slides



# Plans

## ECMWF Operational Model Resolution (< 26 Jan 2010)

- Det: T799L91 25 km GG 0.25° en MARS
- Eps: T399L62 50 km GG 0.5° en MARS

## ECMWF Operational Model Resolution (> 26 Jan 2010)

- Det: T1279L91 16 km GG 0.125° en MARS
- Eps: T639L62 31 km GG 0.25° en MARS

# GLAMEPS verification numbers

## How many files?

- 4 sub-ensembles, 12+1[+1+1] each ~ 54 members
- 00 and 12 UTC = 2 run times
- 3/TO/42/BY/3 = 13 forecast steps
- $54 \cdot 2 \cdot 13 = 1378$  **daily files**

## How many parameters inside?

- Intermediate output set: z500, t500, t850, mslp, 10mW, gusts, 2mT, AccPcp, etc = 18 params
- Minimum verif set: z500, t850, mslp, 10mW, gusts, 2mT, AccPcp = 8 params

## Data volume to process daily?

- Intermediate set: 11 Mb/file ~ **30 Gb**
- Minimum verif set: 5 Mb/file ~ 18 Gb

## Data volume to process?

- ~ 540 Gb monthly,
- ~ 1500 Gb seasonally
- ~ **10 Tb yearly**

## Who to compare with?

- ECMW EPS = 1 set of graphs
- Deterministic HARMONIE (not here) = x2

## Deterministic verification (a minimum)

- Bias & RMSE for any member + ensemble mean = 2 daily (or season) graphs

## Probabilistic verification: large scale flow

- Dynamical fields typically z500, t500, t850, mslp: spread-skill + talagrand = 8

## Probabilistic verification: weather parameters

- 2mT, wind, AccPcp: here come the thresholds!!!
- E.g. prob (pcp $\geq$ 0.3,1,5,10...) = x5, x10
- Reliability, Sharpness, ROC, RV = x3
- BS, BSrel, BSres, BSS, BSSrel, BSSres[and decompositions?] = x3
- DRPS, CRPS, DRPSS, CRPSS [and decompositions?] = x2

The number of possible verification graphs grows up to **10 000** → we need to select a summary of information to show