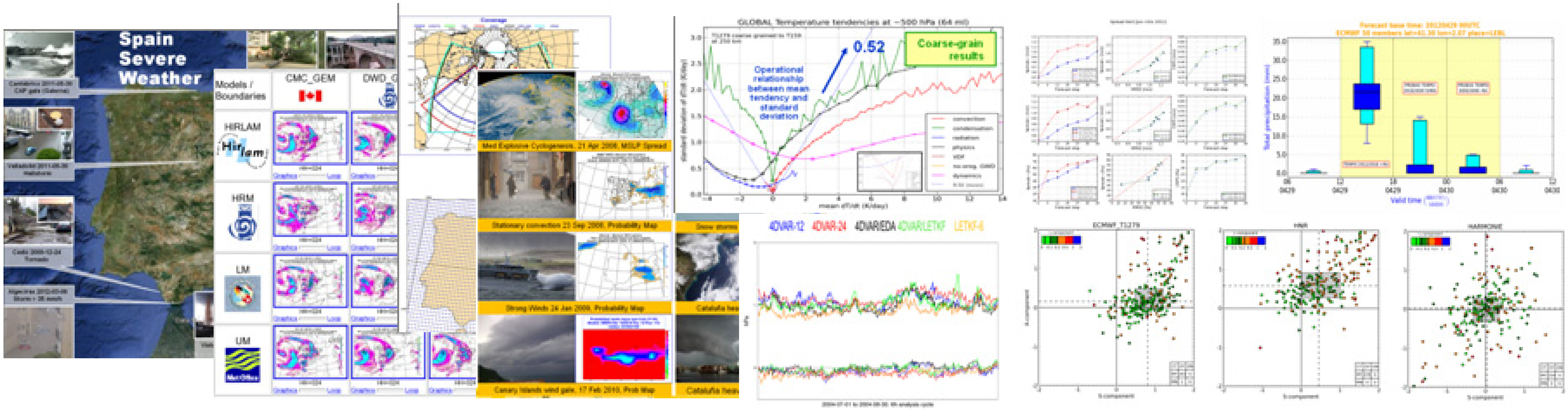
AEMET-SREPS: past, present and future

International Conference on Ensemble Methods in Geophysical Sciences
Toulouse, 12-16 Nov 2012



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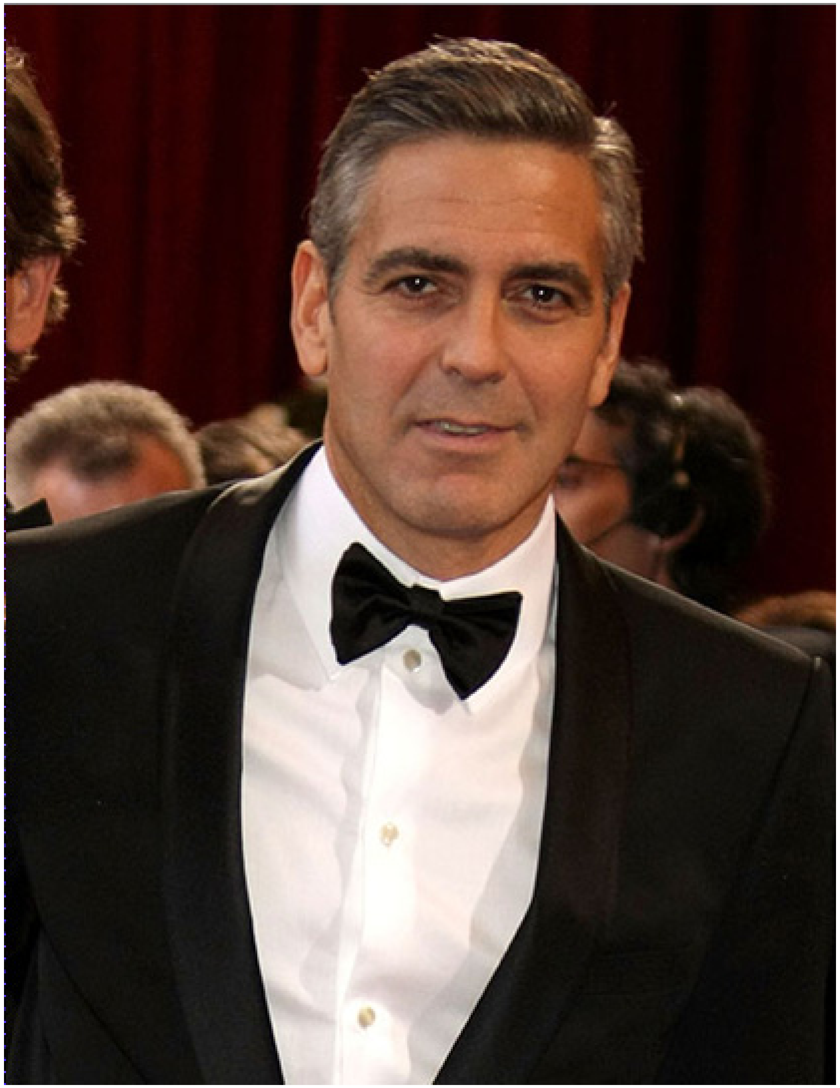
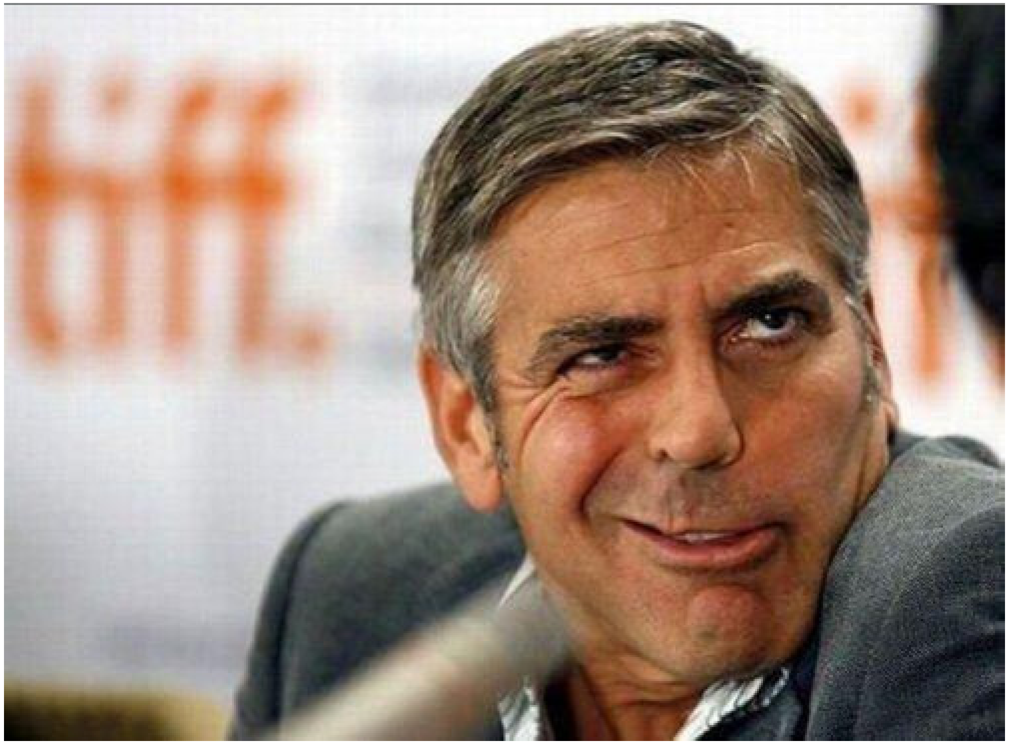
Are models perfect?





“Our models are not perfect”

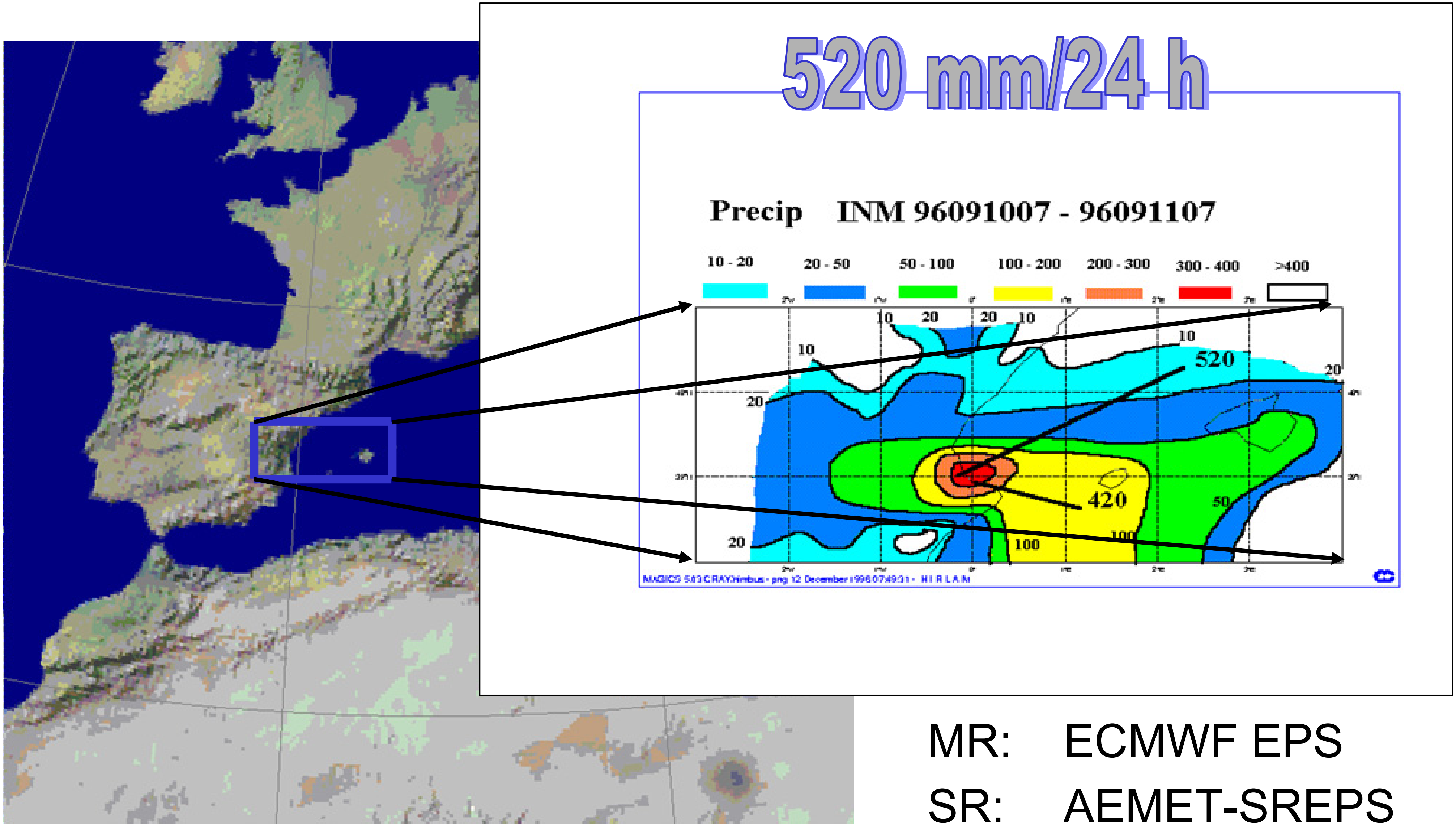
Lenny Smith,

Tuesday talk

That’s why we use ensembles

Spain Severe Weather
Cantábrico 2011-05-30 CAP gale (Galerna)
Huesca 2010-07-21 Tornado
Montserrat 2000-06-09 Flash-floods > 200mm
Oropesa 2009-09-17 Waterspout
Valladolid 2011-05-30 Hailstorm
Tous 1982-10-20 Flash-floods>1000mm
Turia 1957-10-14 Flash flood>350mm/d
Cádiz 2009-12-24 Tornado
Algeciras 2012-03-06 Storm > 35 mm/h
La Safor 2007-- Cut-off low>450mm/d
Vista Alegre 1999-09-07 Tornado
CVal 2009-09-27/29 Cut-off low>300mm/d
GEBCO

Why an EPS for SR?



MR: ECMWF EPS

SR: AEMET-SREPS

Outline

AEMET-SREPS so far

- Why an EPS for SR?
- AEMET-SREPS settings
- Tuning
- Added value wrt HIRLAM
- Added value wrt ECMWF EPS
- Case studies
- Use abroad and at home
- Projects

… the future AEMET -γ- SREPS

- Research lines
- Cooperation with GLAMEPS
- Predictability issues at convective scale
- Stochastic Perturbed Parameterization Tendencies (SPPT)
- Local Ensemble Transform Kalman Filter (LETKF)
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- Post-processing: SREPSgrams
- Feature-based verification

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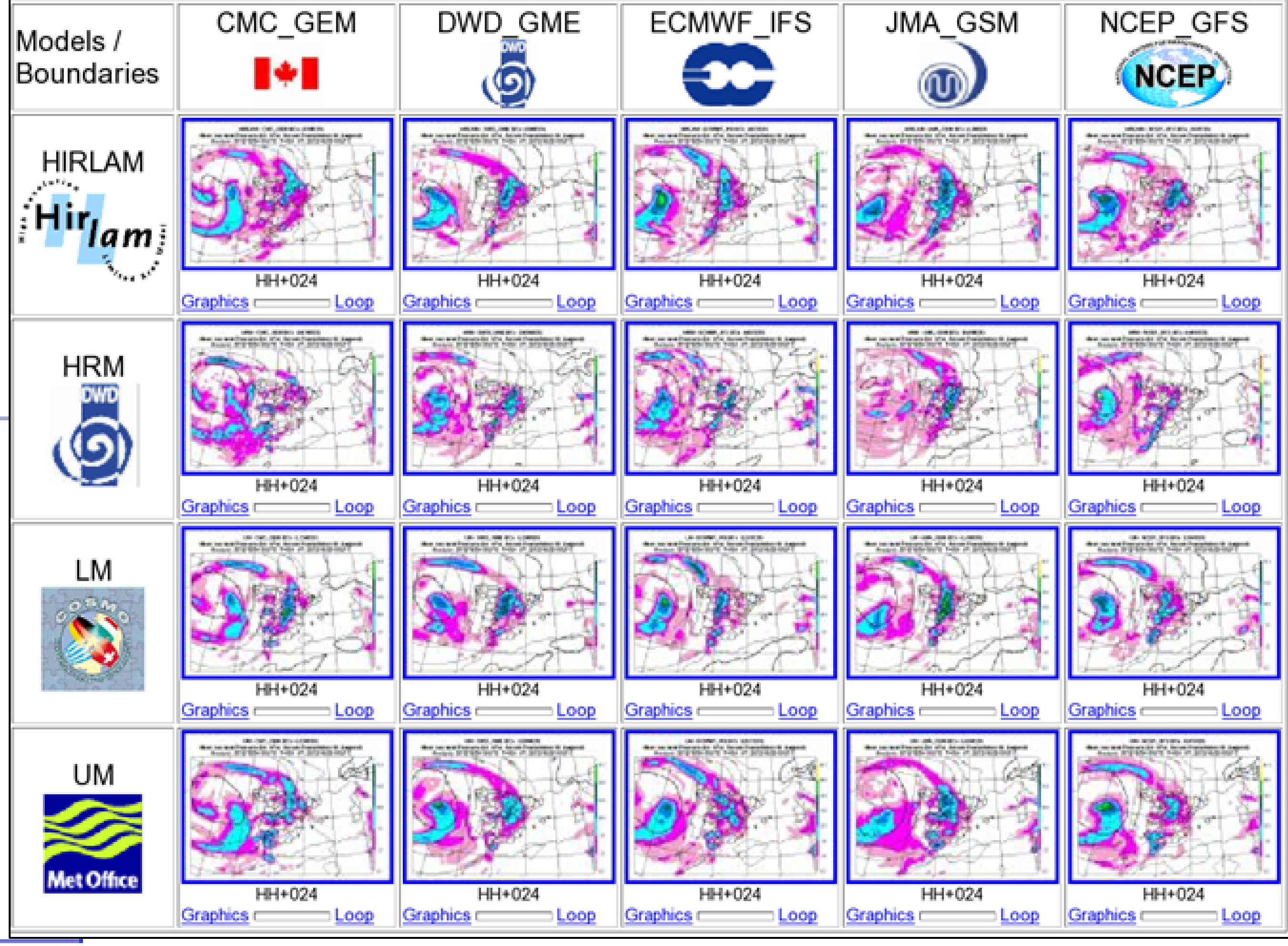
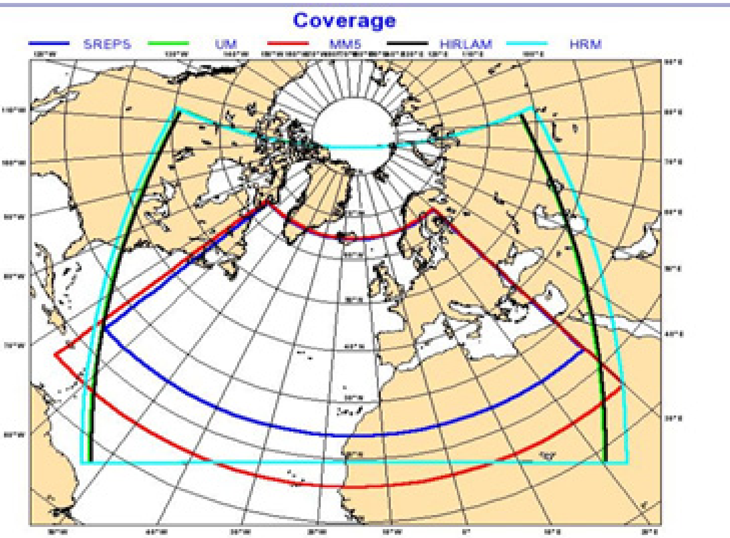
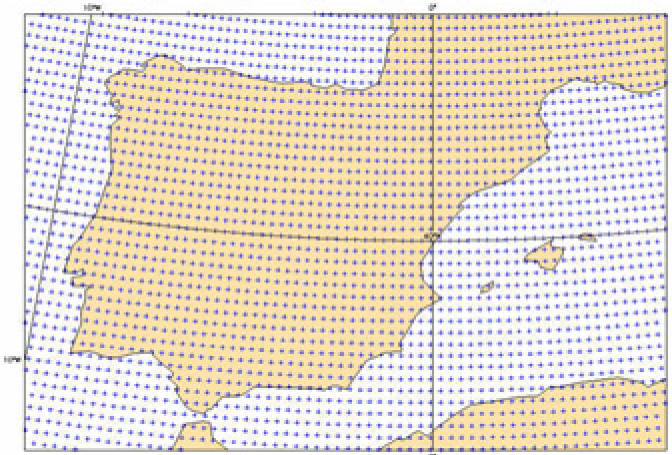
AEMET - SREPS

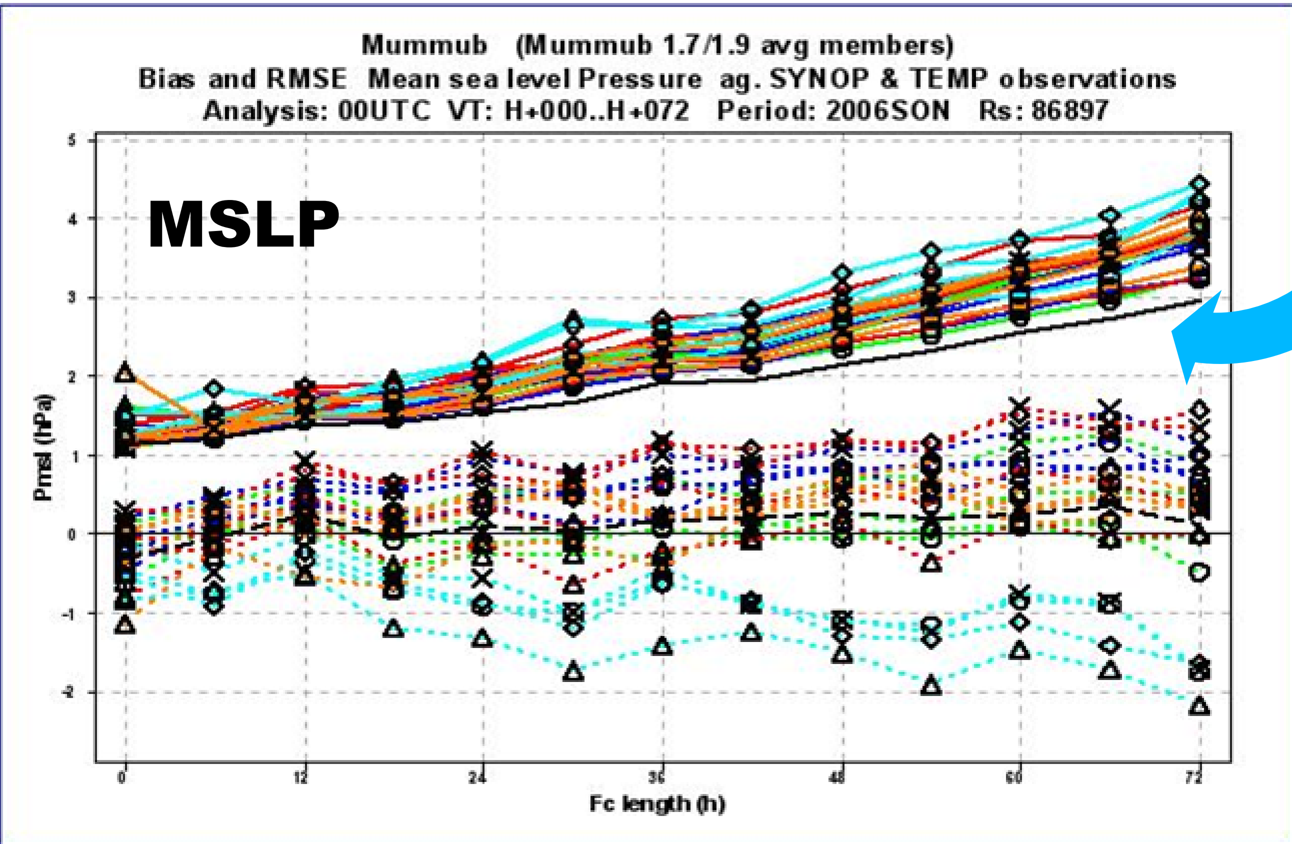


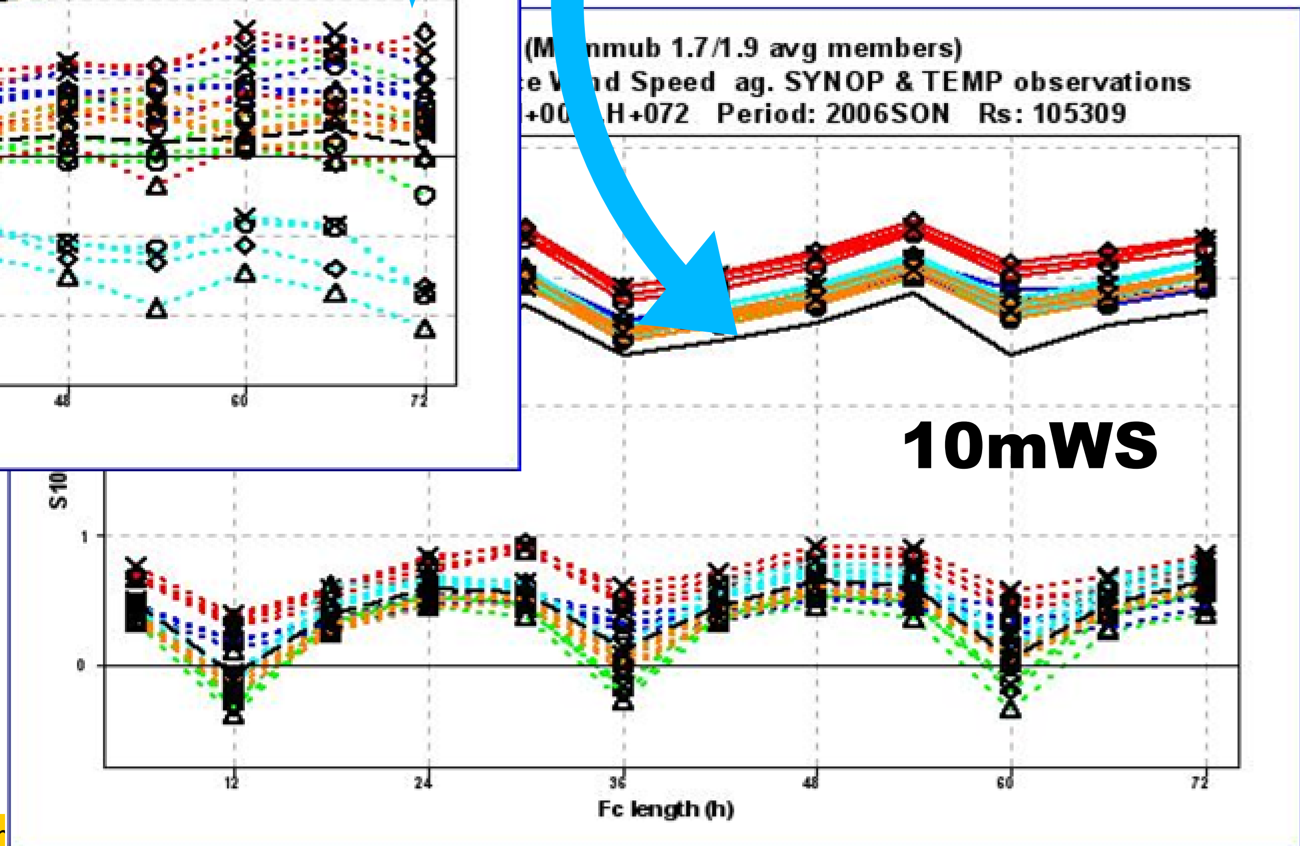




- Multi-model, Multi-ICs, Multi-LBCs
- Twice a day (00,12 UTC) up to T+72
- 4 LAMs x 5 GCMs = 20 members
- 0.25º ~ 25 km

Tuning





- Ensemble mean (black) performs better than any member

Large scale flow consistency

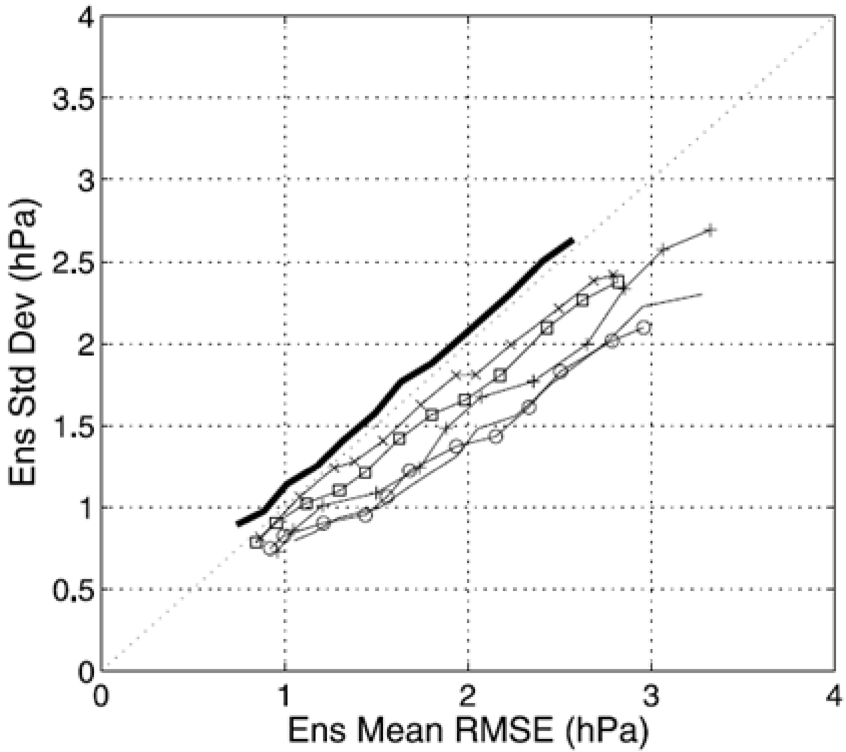


Fig. 5. Mean sea level pressure (MSLP) spread-error diagrams from T+6 to T+72 every 6 h, for the whole 'multimodel multiboundaries' system (thick solid line, 20 members) and for the five different 'multiboundaries' subensembles (thin lines).

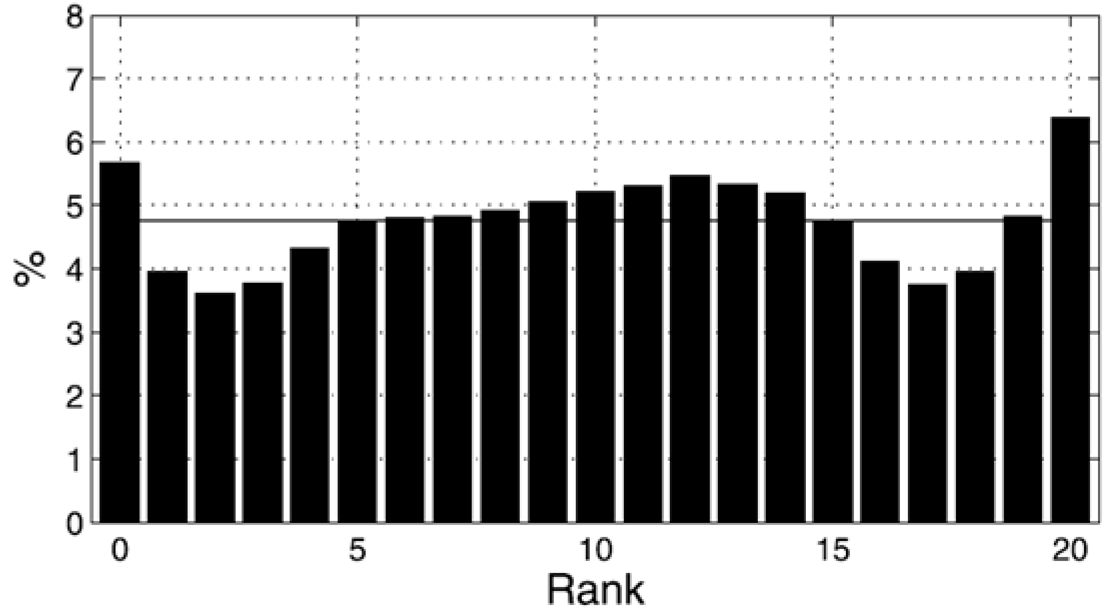
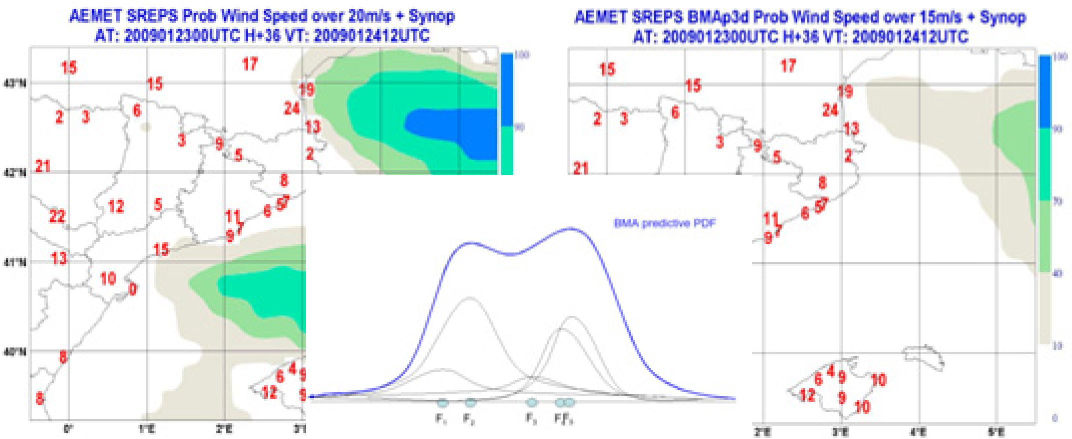


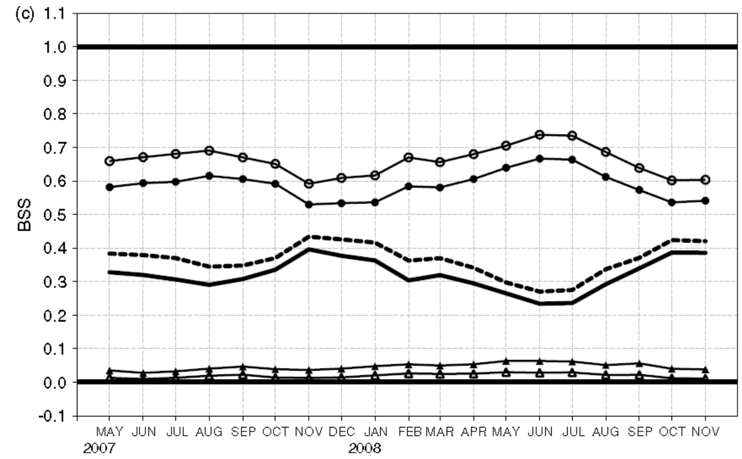
Fig. 3. Rank histogram corresponding to the period April 2007 to December 2008 for 500 hPa geopotential height and forecast length T+24. The analysis of the ECMWF model is taken as observation value.

MSLP

Z500

More research





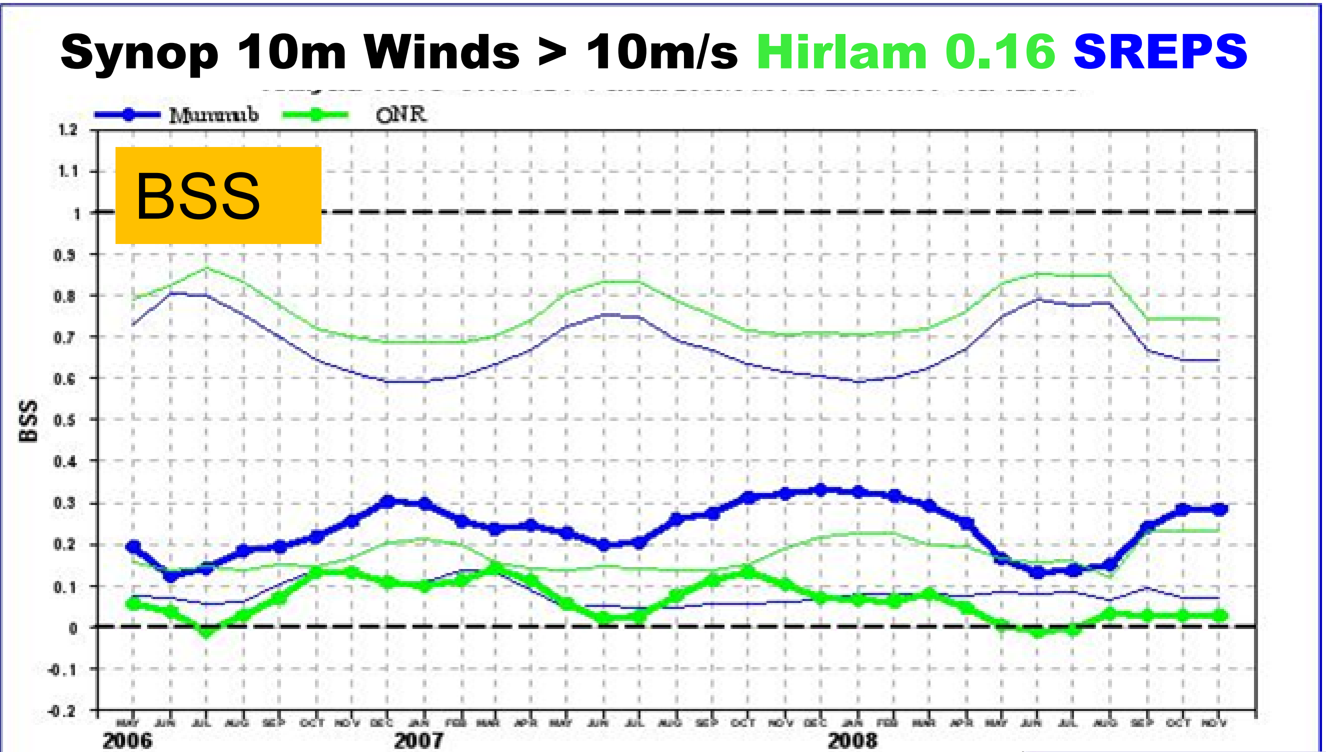
Statistical calibration

Several works were done using Bayesian Model Averaging (BMA, Raftery, 2004) to calibrate the ensemble PDF with the observations. Albeit improving the accumulation scores, **the extreme events are still an issue** (Escribà et al., 2011).

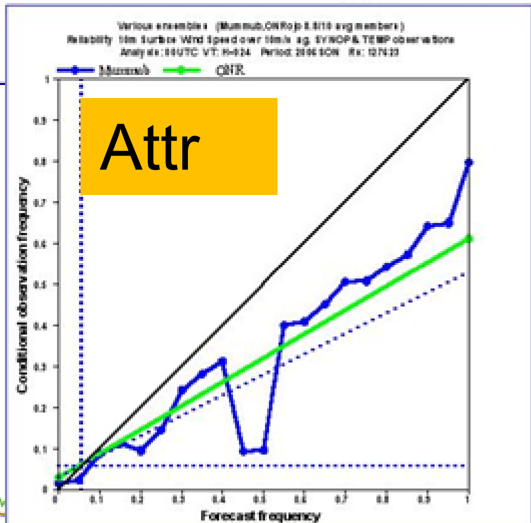
Observational uncertainty

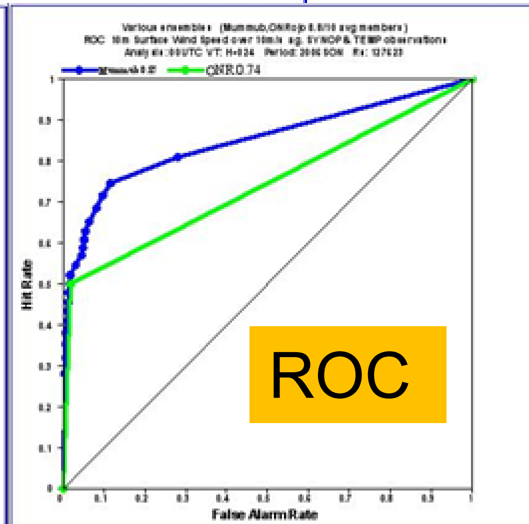
In forecast verification it has been traditionally assumed that the observation error is negligible when compared with the forecast error. Though this assumption can be consistent for long forecast ranges, in a more general framework observations are described together with their uncertainty, **avoiding underestimation of EPS performance**. In this context, *Observational Probability* method (Candille and Talagrand, 2008) was extended for precipitation (Santos and Ghelli, 2012).

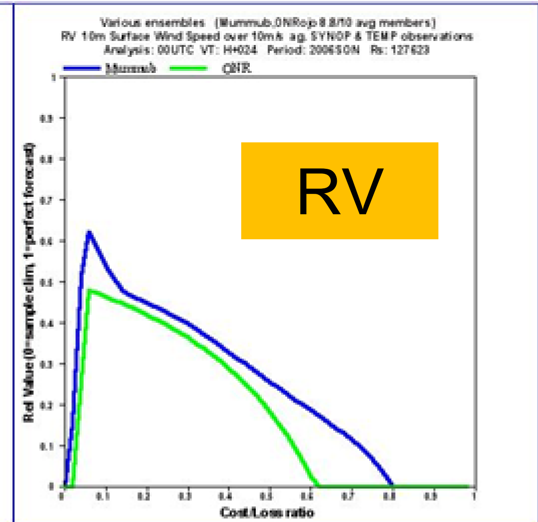
Added value w.r.t deterministic Hirlam



- 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)

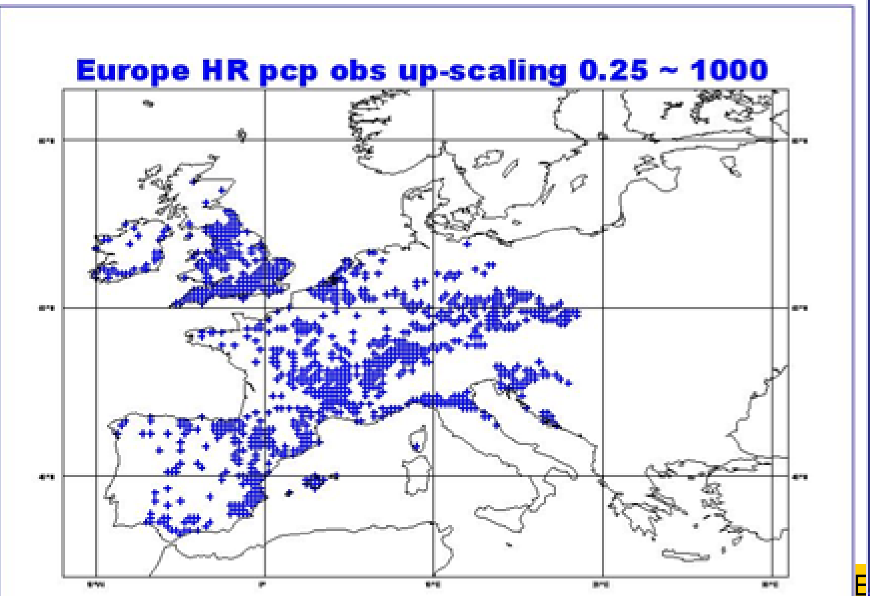


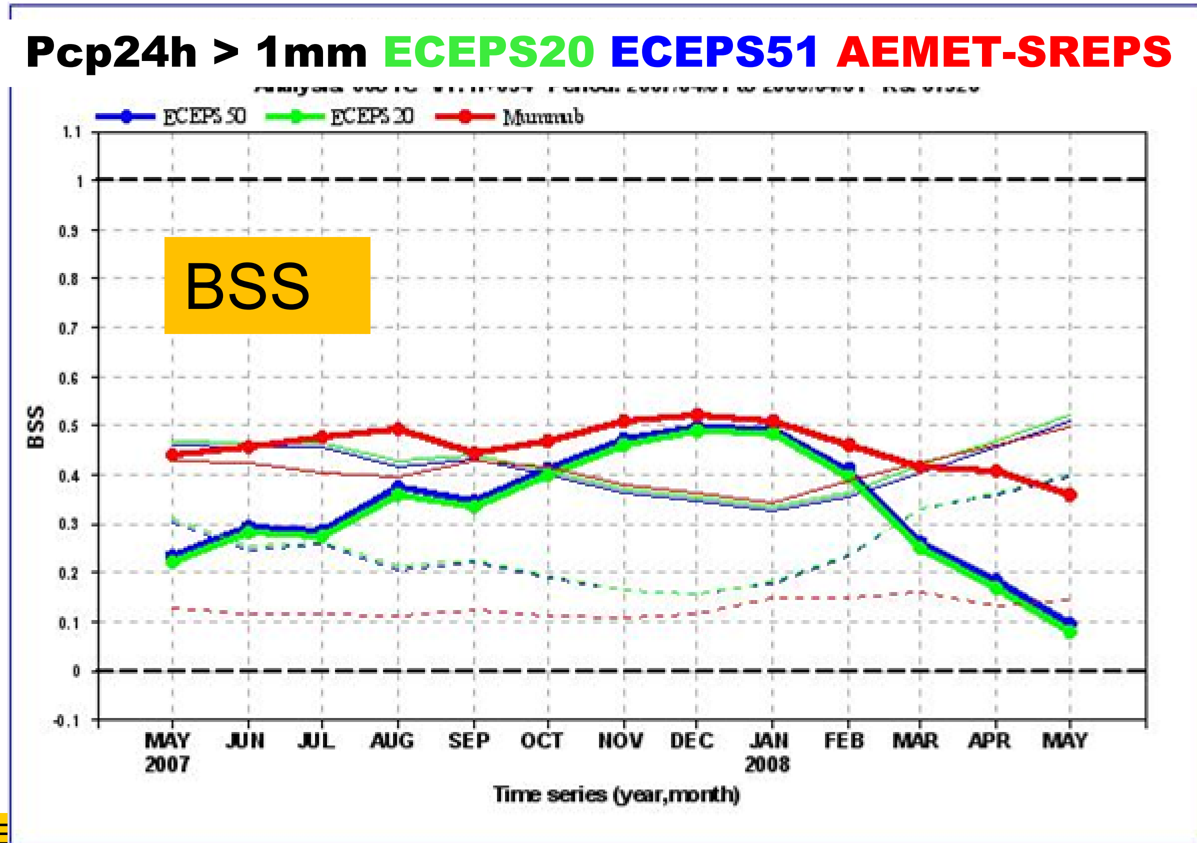




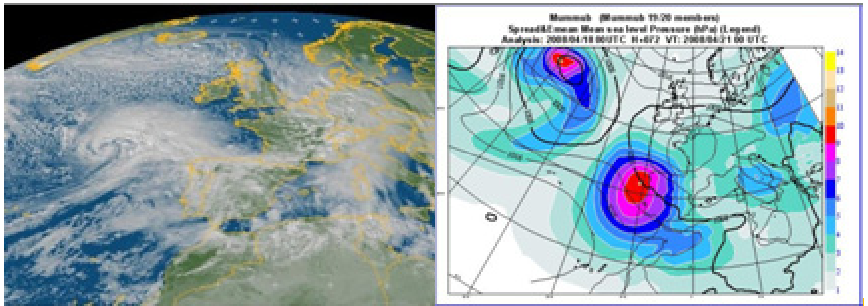
Added value w.r.t. ECMWF EPS

- 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. (2006-2010)

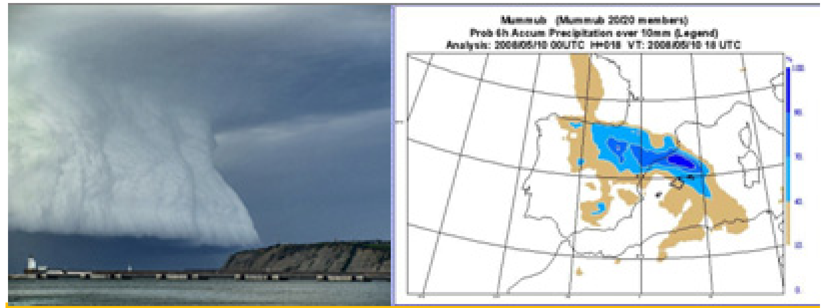




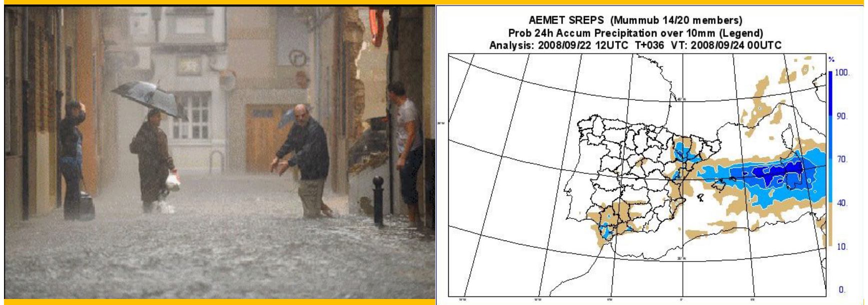
Some Case Studies



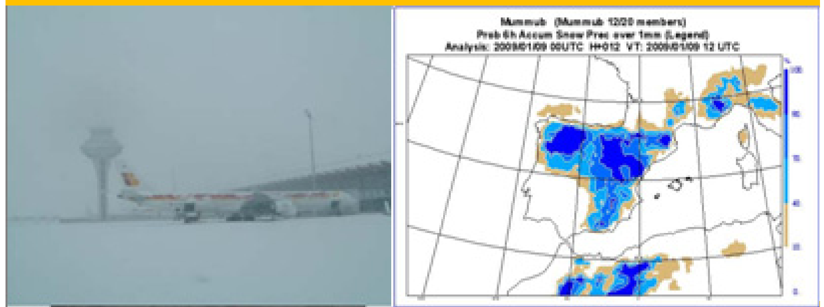
Med Explosive Cyclogenesis, 21 Apr 2008, MSLP Spread



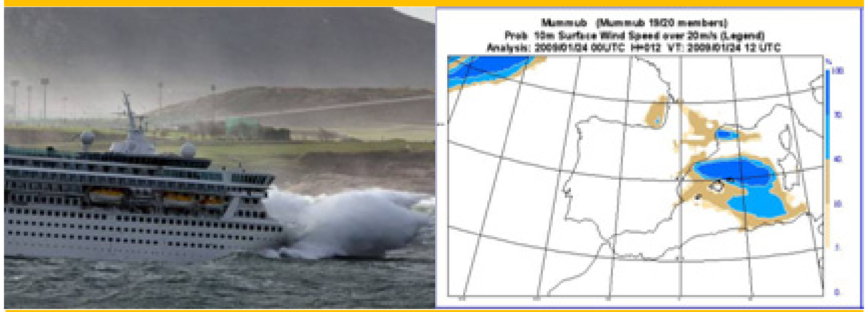
NE-Spain heavy rain 8-10 May 2008, Probability Map



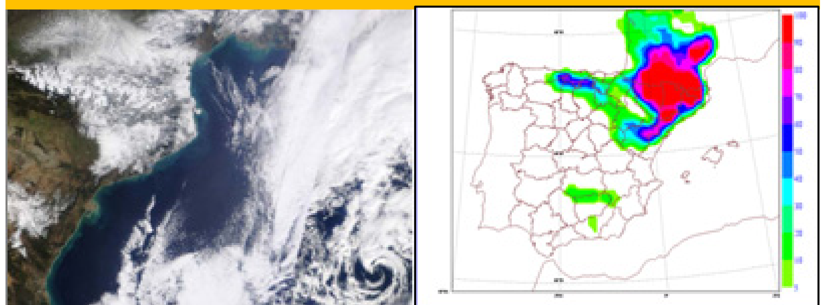
Stationary convection 23 Sep 2008, Probability Map



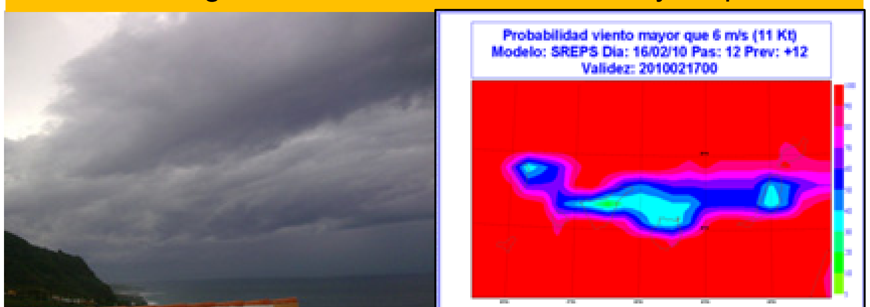
Snow storms 8-10 Jan 2009, Probability Map



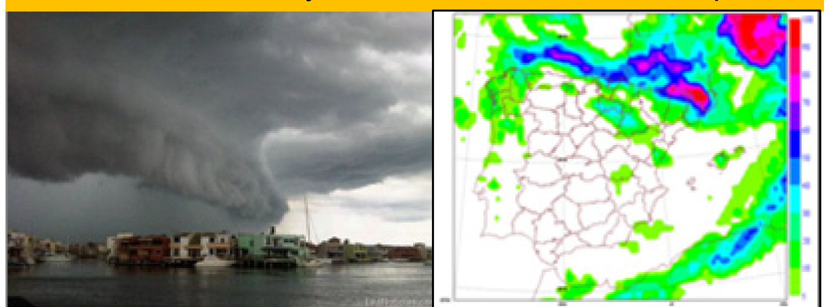
Strong Winds 24 Jan 2009, Probability Map



Cataluña heavy snow 8 Mar 2009, Prob Map



Canary Islands wind gale, 17 Feb 2010, Prob Map



Cataluña heavy rain 6 May 2012, Prob Map

Use abroad and at home

NWP consortia through Europe

- COSMO: members of SREPS (4) at 25 km
- Nested COSMO-SREPS (ARPA-SIM Bolonia): 16 members at 10 km (perturbations in some parameters of the model physics and using SREPS as BCs).
- And nested COSMO-DE-SREPS: 16 members at 2.8 km and 24 hours forecast (using COSMO-SREPS as BCs and perturbations in the physics).

Operational forecasting and research

- ARPA Lombardia
- Several AEMET forecast offices (especially Med: Barcelona, Valencia, Málaga).
- Forecast guidance in several AEMET groups (ATAP, several EyD)

Projects

Large scale projects

- 2008-2012 **TIGGE-LAM**: THORPEX Interactive Grand Global Ensemble - Limilted Area Models
- 2006-2012 **GLAMEPS**: Grand Limited Area Model Ensemble Prediction System, Consorcio HIRLAM

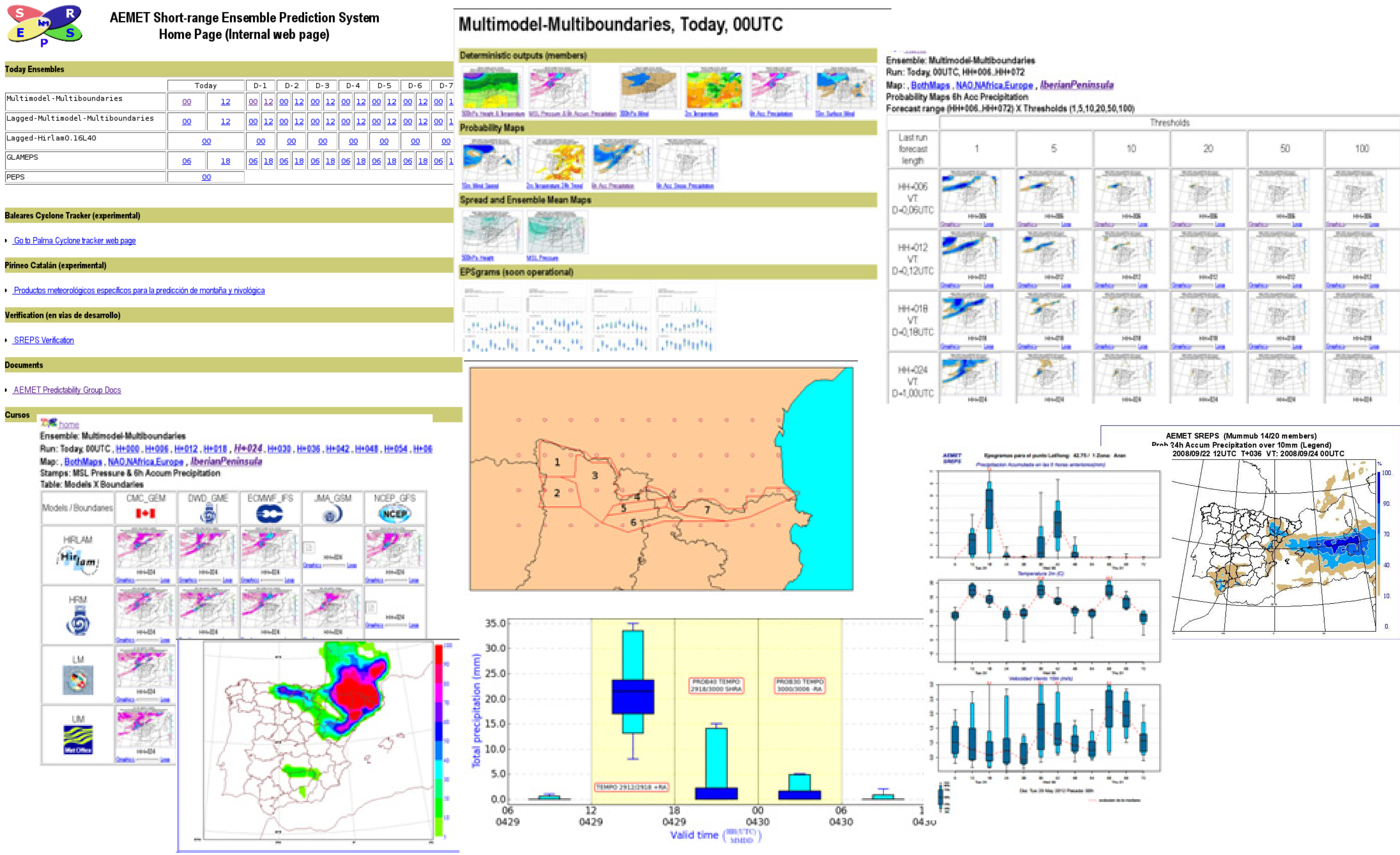
Wind power

- 2009-2010 **SAFEWIND**: Multi-scale data assimilation, advanced wind modelling & forecasting with emphasis to extreme weather situations for a safe large-scale wind power integration. Collaborative project funded by the European Commission under the 7th Framework Program, Theme 2007-2.3.2: Energy
- 2003-2005 **HONEYMOON**: A High resOlution Numerical wind EnergY Model for On- and Offshore using eNsemble predictions , DMI,INM, Cork Univ., Oldenburg Univ., EED, etc.

Mediterranean severe weather

- 2011-2014 **PREDIMED**: Mejora de las predicciones de tiempo severo Mediterráneo por medio de observaciones adaptativas y métodos avanzados de predicción por conjuntos en el marco de los proyectos MEDEX Fase II y HyMeX (CGL2011-24458), CICYT, UIB
- 2008-2011 **MEDICANES**: Ambientes Meteorológicos, Predecibilidad Numérica y Evaluación del Riesgo en el Clima Presente y Futuro (CGL2008-01271), CICYT, UIB
- 2005-2008 **ENSEMBLE**: Aplicación de Técnicas de Predicción por Conjuntos a episodios meteorológicos de gran impacto en el Mediterráneo Occidental (CGL2005-05681/CLI), CICYT, UIB

Forecast guidance: Internal web site



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AEMET-γ-SREPS

Research phase

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

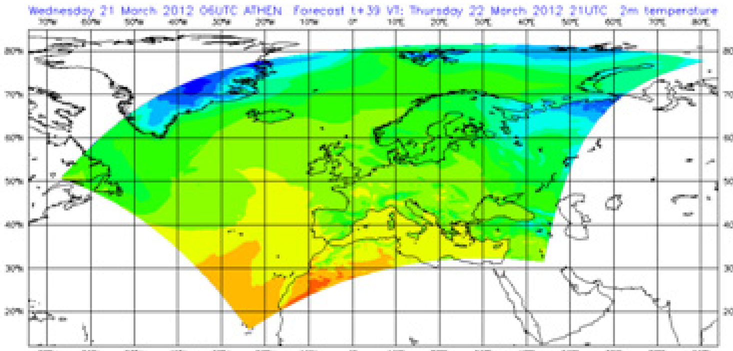
Research lines

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

Cooperation with GLAMEPS

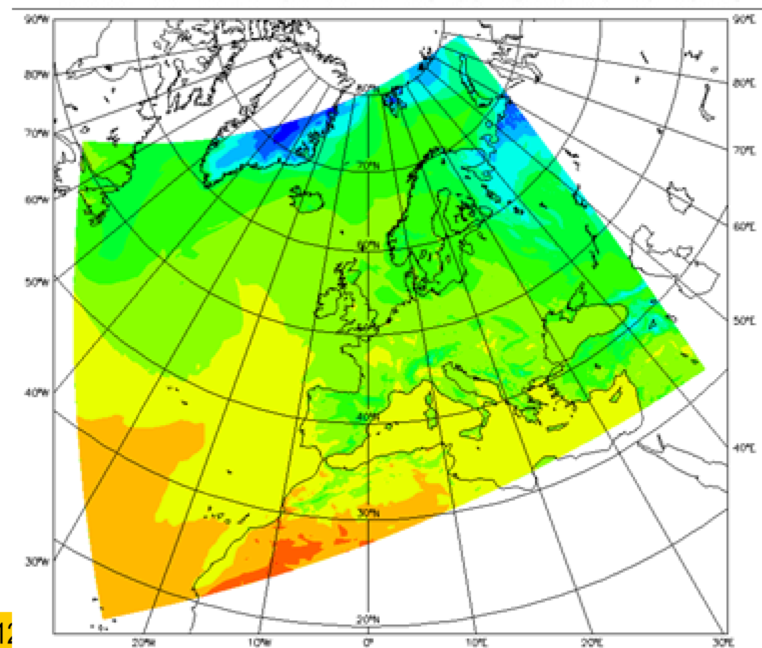
Grand Limited Area Model Ensemble Prediction System

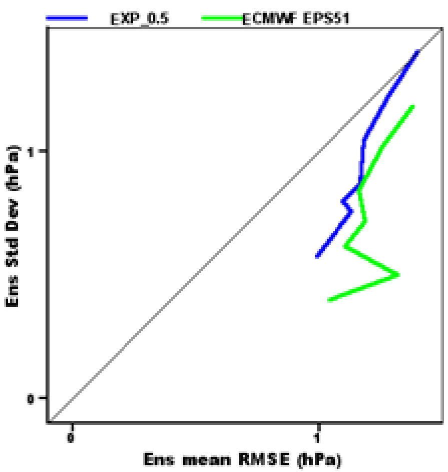
- HIRLAM – ALADIN pan-european ensemble, since 2006
- Norway, Sweden, Finland, Denmark, Belgium, Netherlands, Hungary, Spain, Ireland

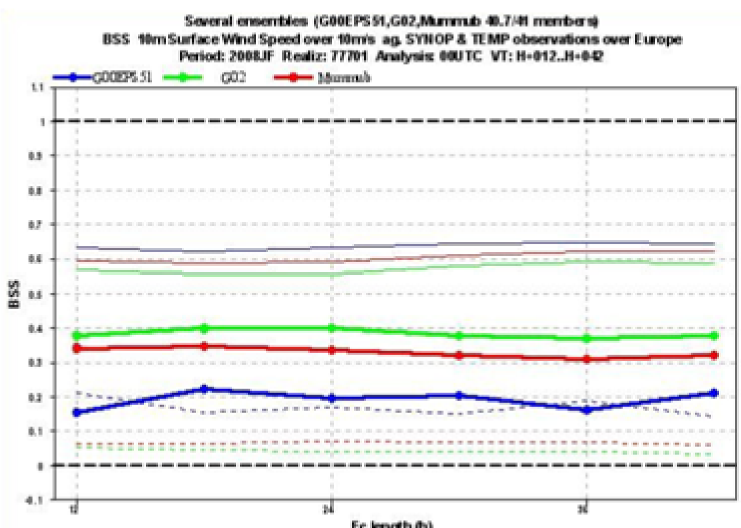


Current GLAMEPS settings

- 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



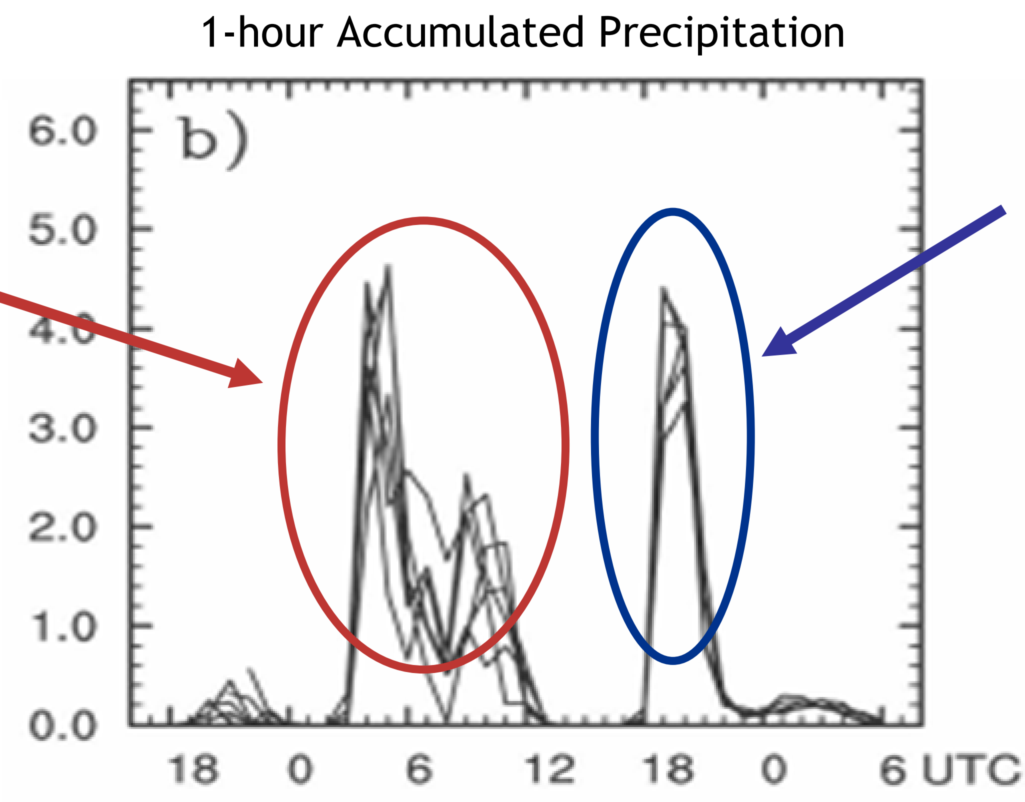




Predictability issues at convective scale

Predictability limits at convective-scales and their influence to higher scales (Hohenegger & Schär, 2007)

First meso- γ -scale
Less predictability



Later meso- β -scale
More predictability

Convective instability

Pre-frontal convection

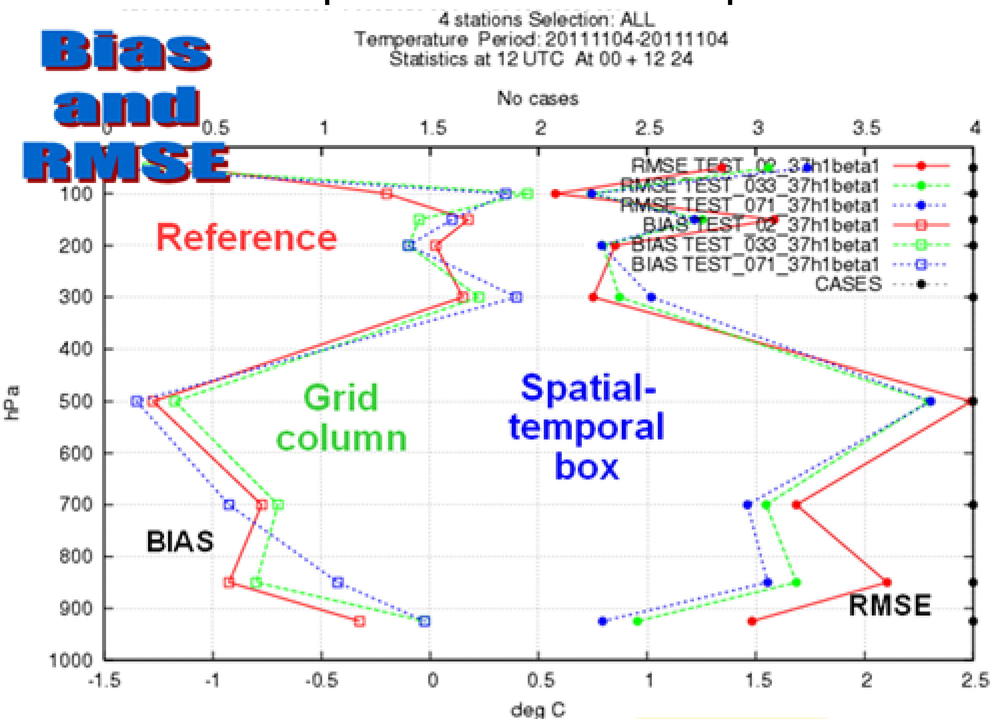
Cold front

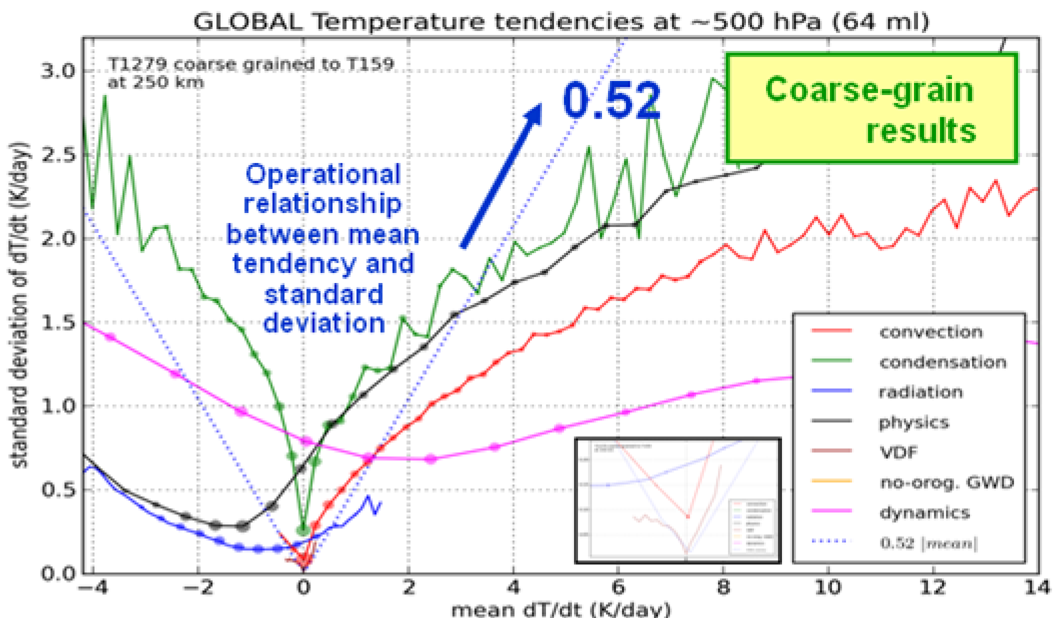
Baroclinic instability

SPPT

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

- **SPPT:** Stochastic Perturbed Parameterization Tendencies (Buizza et al., 1999)
- **6 months visit ECMWF**: G Shutts, R Buizza, TN Palmer, M Leutbecher, developing new approaches to SPPT, coarse-graining studies evaluating parameterizations uncertainties (figure), and later
- First HarmonEPS experiments (multiplicative noise (~SPPT) to physics temperature tendency independently to each grid point)
- Next experiment: include spatial and temporal correlations

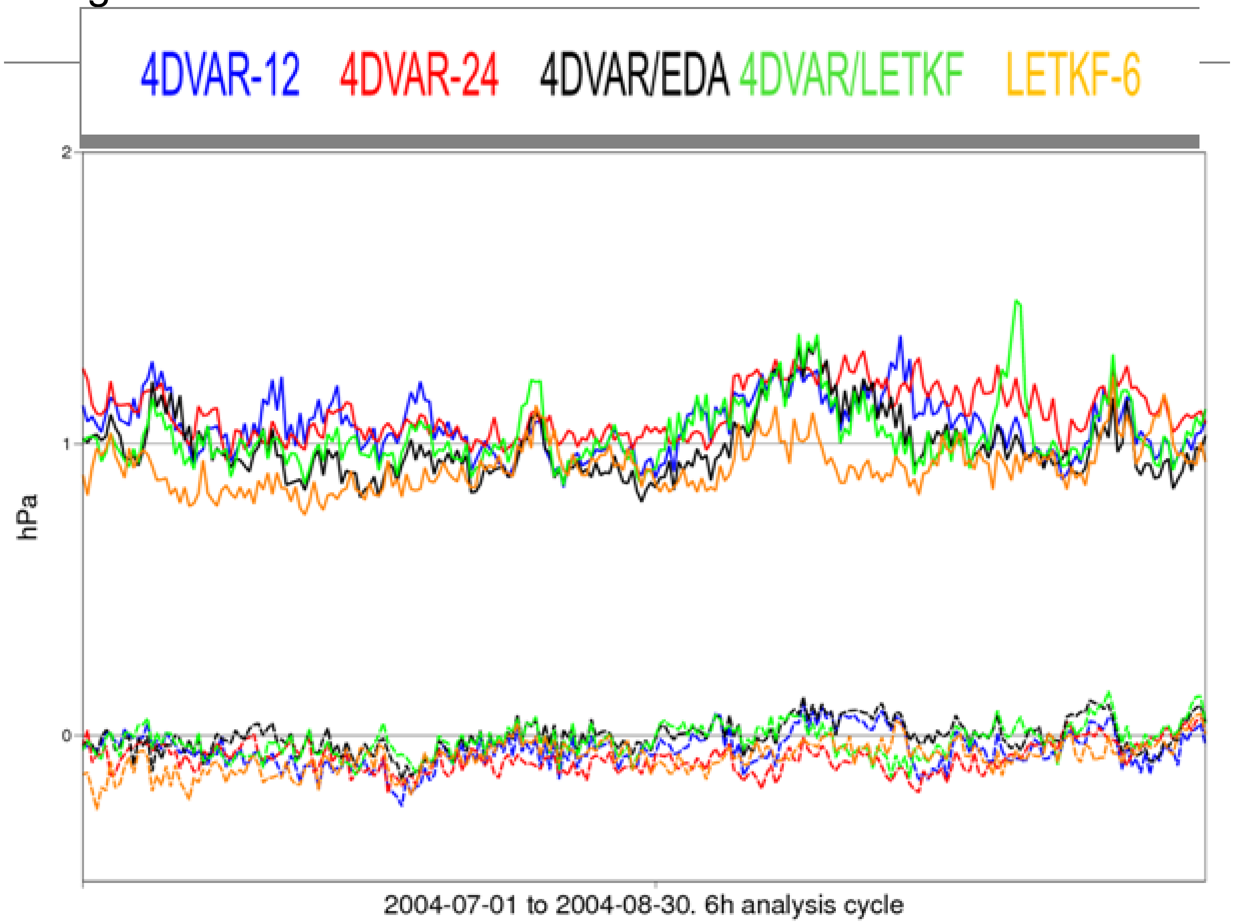




LETKF

P Escribà talk: LETKF in Harmon-EPS

- Local Ensemble Transform Kalman Filter (LETKF, Hunt et al., 2007).
- **6 months visit ECMWF**: M. Bonavita, M. Hamrud, L. Isaksen, comparing 4DVAR, LETKF and hybrids (EDA), in IFS (ECMWF) for analysis, assimilating only surface pressure
- Next step will be migration of IFS LETKF to Harmonie system to test it as analysis scheme and generator of initial states for EPS

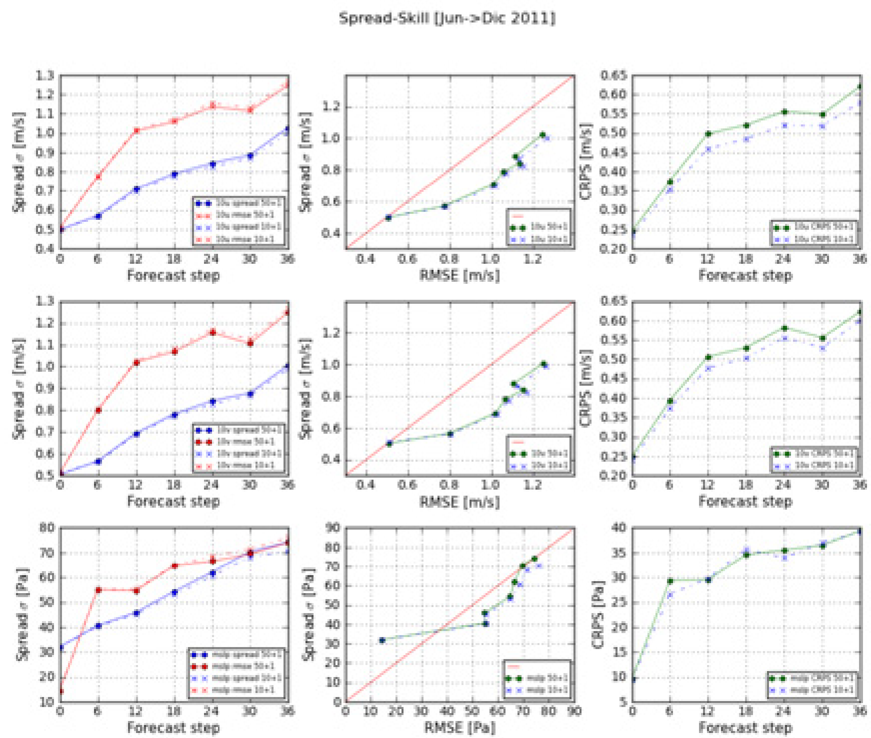


2-months MSLP RMSE and BIAS time series for 5 analysis schemes available in IFS, assimilating only surface pressure. In this case LETKF performs the best

Perturbations LBCs

J Sancho: perturbations LBCs

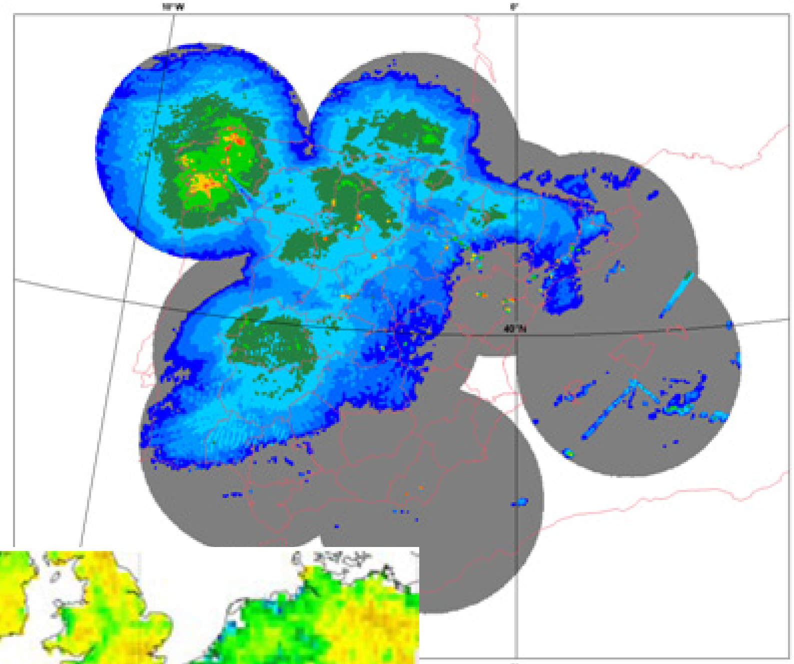
- **ECEPS_raw**: 51 members ECMWF EPS
- **ECEPS_rnd10**: 10 members rnd selected
- **ECEPS_DA10**: 10 members from EDA
- **ECEPS_tub10**: 10 tubing clusters
- **TIGGE_4**: 4 TIGGE from TIGGE: ECMWF, CMC, UKMO, GFS
- **EC_SLAF**: 9 members using SLAF applied to ECMWF deterministic T1279
- **AEMET_4**: 4 GCMs from AEMET_SREPS
- **Spread-error assessment**



HR observations

A Amo / C Santos

- SEVIRI (Roebeling et al 2011)
- RADAR



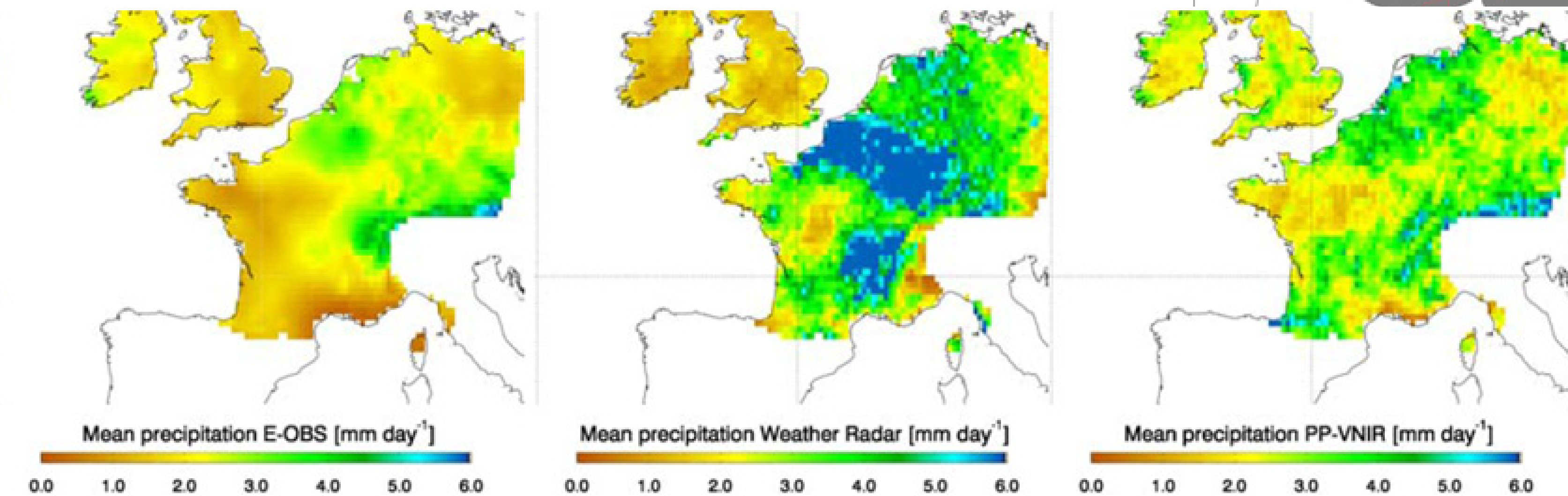
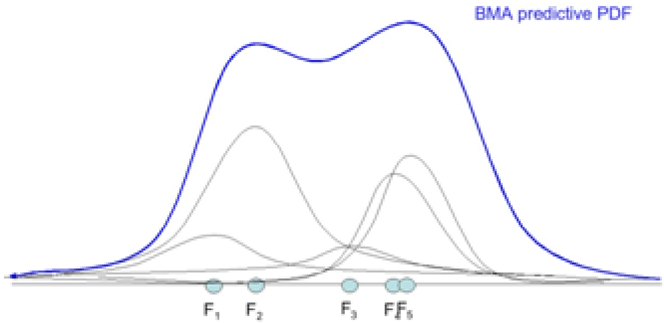


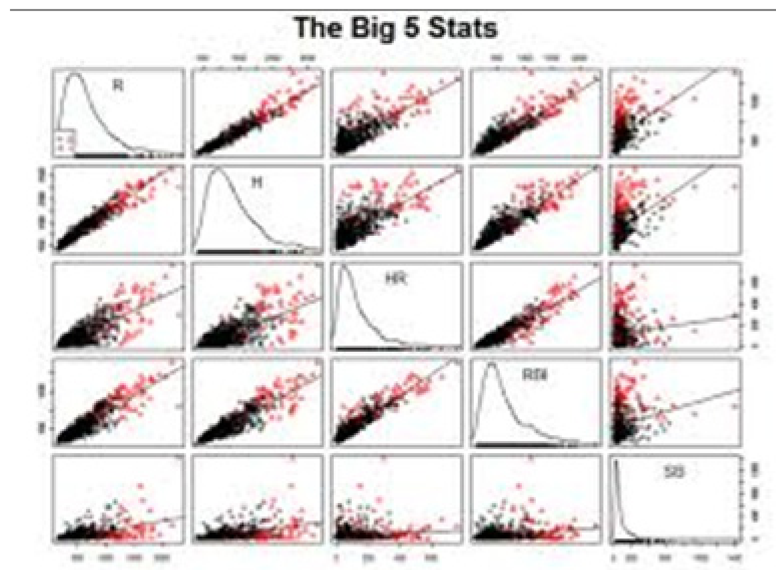
FIG. 1. Example of the mean daily precipitation amounts from E-OBS (left panel), Weather radar (middle panel), and PP-VNIR (right panel) in mm day^{-1} over the period May-August 2006.

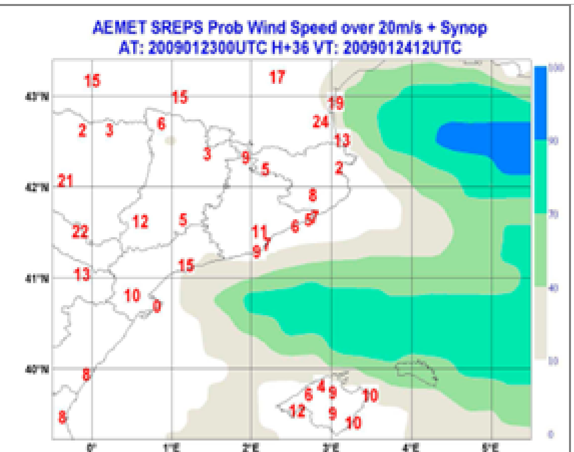
Calibration

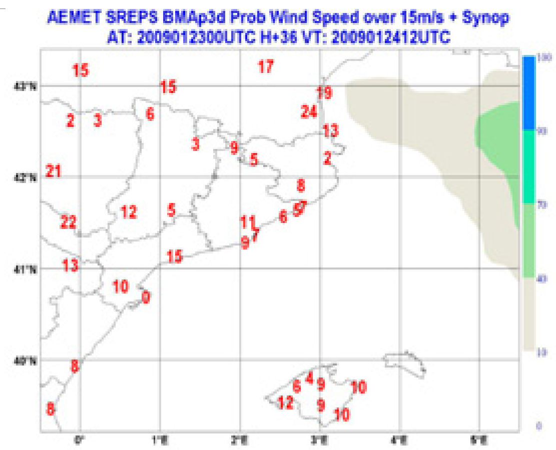
P Escribà / C Santos

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









Post-processing: e.g. SREPSgrams

E Abellán / Callado and Escribà

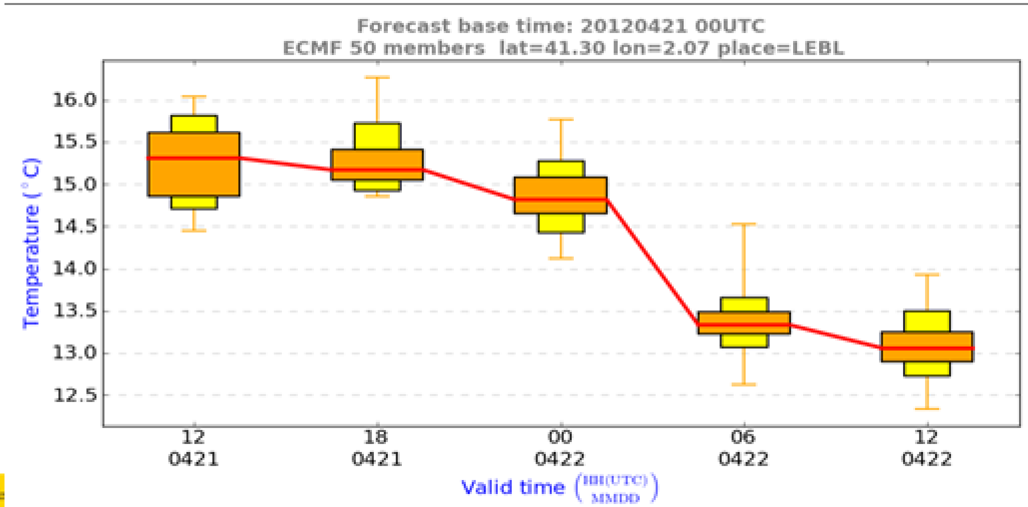
Site-specific probabilistic interpretation of EPS forecasts (EPS meteogram)

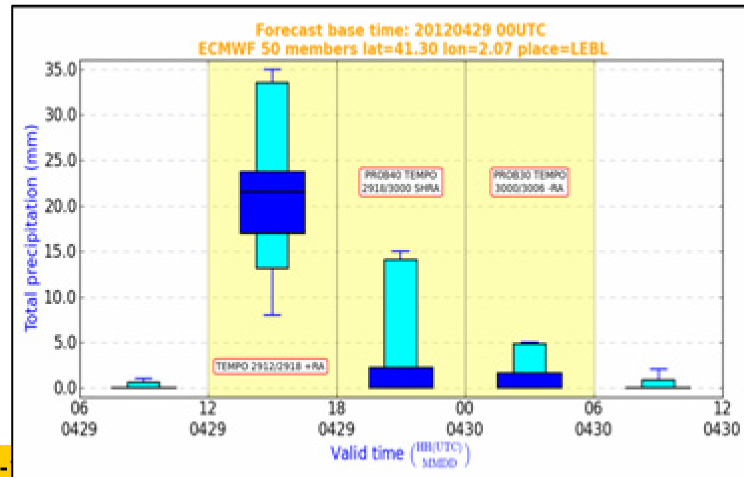
Python-based application to generate EPSgrams

- Adaptable to any EPS (GRIB format)
- On-the-fly generation (on user request)

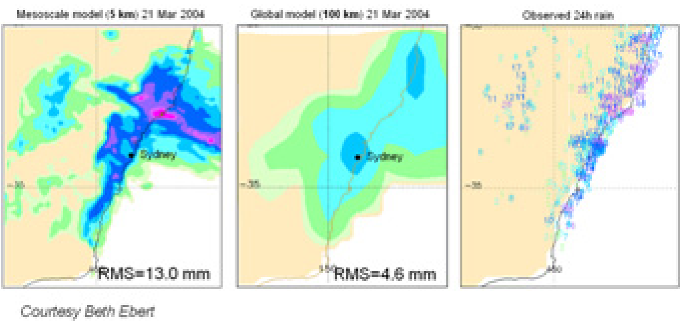
For instance: very short range airport forecasts (**TAF**)

Based on forecasting centres and air traffic control needs to forecast weather parameters such as temperature, gust, turbulence, visibility, mountain waves…



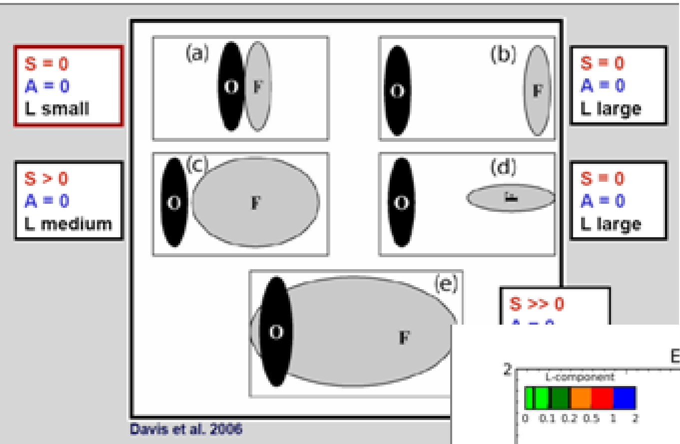


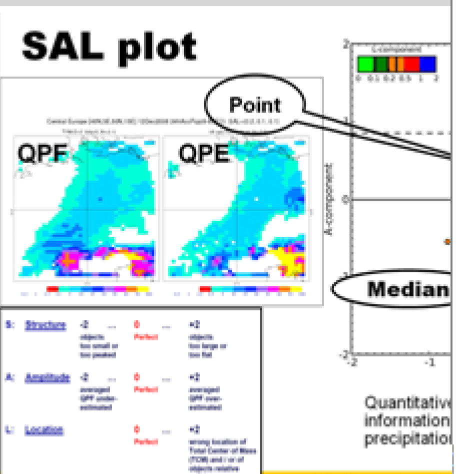
Feature-based verification

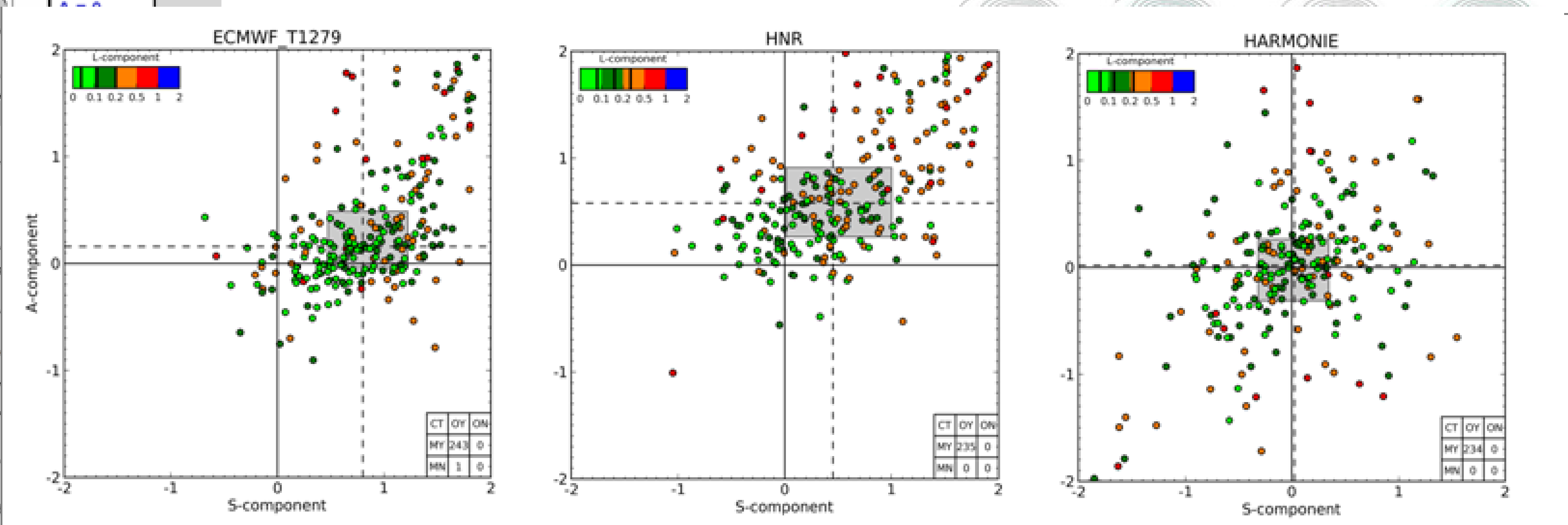


A Amo / C Santos

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







ECMWF T1279 (17 km) **HIRLAM 0.05 (5 km)** **HARMONIE 2.5 km**

Conclusions & on-going work

AEMET-SREPS history

The Spanish Meteorological Agency (AEMET) Predictability Group developed a multimodel-multianalysis Short-Range EPS. For one decade this AEMET-SREPS has been issuing high performance probabilistic forecasts at synoptic-meso-alpha scale, providing predictability assessment in the Short Range for Mediterranean forecasters (Spain & Italy) and (for a time) ICs and LBCs for COSMO-SREPS. The group has been involved in large scale projects (e.g. TIGGE-LAM) and collaborates actively in GLAMEPS.

AEMET-γ-SREPS current plans to improve resolution moving to mesoscale-gamma have to deal with predictability issues at convective scales. Research lines include:

- Close cooperation with GLAMEPS
- Sampling uncertainties: LETKF (ICs), SPPT (model), perturbations LBCs
- DA and verification: High Resolution observations (radar, SEVIRI…)
- Calibration: Extended Logistic Regression (ELR)
- Post-processing: specific SREPS-grams
- Verification: Neighborhood, Feature-based (SAL, MODE…)

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