AEMET-SREPS(*): Past, present and future

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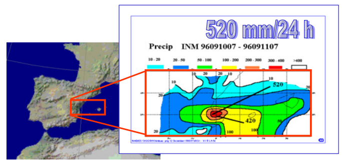
Abstract

Since 2002, the Spanish Meteorological Agency (AEMET) Short-Range Ensemble Prediction System (SREPS), i.e. AEMET-SREPS, pioneer as a LAMEPS multi-model in Europe, provides high performance probabilistic forecasts at synoptic-meso-α scale, giving added value to our deterministic HIRLAM suites by assessing predictability in the Short Range. Current research aims at the transition to meso-gamma scale: a future AEMET-γ-SREPS, but predictability issues at convective scale are not trivial. In this poster its history, applications and current settings are reviewed, as well as an outlook to on-going work and perspectives. Research lines include:

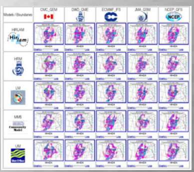
- Close cooperation with GLAMEPS
- Sampling uncertainties: LETKF (ICs), SPPT (model), perturbations LBCs
- DA and verification: High Resolution observations (radar, SEVIRI…)
- Calibration: Extended Logistic Regression (ELR)
- Post-processing: specific SREPS-grams
- Verification: Neighborhood, Feature-based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



Predictability is flow-dependent

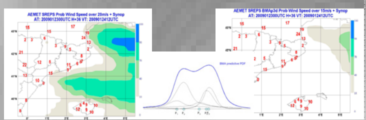
Since the late nineties Ensemble Forecasting has become an essential tool for operational weather forecasting and also for climate projections. Predictability is flow dependent and limited in time, due to the highly non-linearity of the atmosphere as a dynamical system. Different sources of uncertainty must be sampled: initial conditions (ICs), model, and lateral boundary conditions (LBCs). These uncertainties can grow even in the first 24 hours: for instance, Mediterranean deep convective storms often give more than 500 mm in just few hours. In this context, a probabilistic approach is needed and EPS become crucial for the Short Range.

History



Multi-model approach

On an early stage, different methods for assessing uncertainty building probabilistic forecasts were under research in the group: Scaled Lagged Averaged Forecast (SLAF, Ebisuzaki and Kalnay, 1991), Bred Vectors (Toth & Kalnay, 1993), Hybrid Ensemble (Du, 2006), Neighbourhood (Theis et al., 2005), Time Lagged (Hoffman and Kalnay, 1983). Even though it was expensive in terms of computing and human resources, multianalysis-multimodel (Krishnamurti et al, 1999) approach was eventually chosen due to its better performance in our domain and weather regimes (García-Moya et al., 2011),.

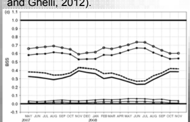


Statistical calibration

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.

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).



CONSORTIUM FOR SMALL SCALE MODELING COSMO

ARPA Agenzia Regionale per la Protezione dell'Ambiente della Lombardia — Servizio Meteorologico Regionale

Users in Europe and Spain

NWP consortia through Europe. COSMO-SREPS (ARPA-SIM Bolonia): 16 members at 10 km (perturbations in the physics and using AEMET-SREPS as BCs), and nested COSMO-DE-SREPS: 16 members at 2.8 km and 24 hours forecast (using COSMO-SREPS as BCs & perturbations in physics).

Operational forecasting and research: ARPA Lombardia, several AEMET forecast offices (especially Mediterranean: Barcelona, Valencia, Málaga), forecast guidance in several AEMET groups.

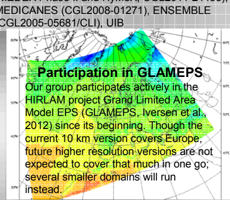
Wind power project SAFEWIND: Multi-scale data assimilation, advanced wind modelling & forecasting with emphasis to extreme weather situations for a safe large-scale wind power integration (Eur Comm).

Projects

Large scale projects TIGGE-LAM: THORPEX Interactive Grand Global Ensemble - Limilted Area Models and GLAMEPS

Wind power HONEYMOON: A High resOlution Numerical wind EnergY Model for On- and Offshore using eNsemble predictions , DMI, Cork Univ., Oldenburg Univ., EED, etc.

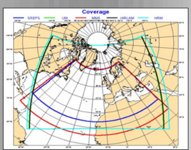
Mediterranean severe weather: PREDIMED (MEDEX Phase II and HyMeX, CGL2011-24458), MEDICANES (CGL2008-01271), ENSEMBLE (CGL2005-05681/CLI), UIB

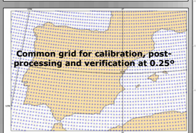


Participation in GLAMEPS

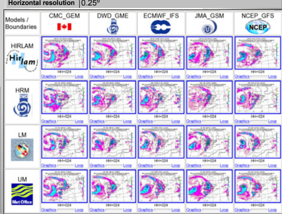
Our group participates actively in the HIRLAM project Grand Limited Area Model EPS (GLAMEPS, Iversen et al., 2012) since its beginning. Though the current 10 km version covers Europe, future higher resolution versions are not expected to cover that much in one go; several smaller domains will run instead.

Current Suite





Multi-model	HIRLAM, HRM (DWD), LM (COSMO), UM (UKMO)
Multi-boundaries	CMC (MSC), GME (DWD), ECMWF, GSM (JMA), GFS
Members	4 LAMs X 5 ICsBCs = 20 members
Daily runs	00, 12 UTC (twice)
Forecast range	72h
Horizontal resolution	0.25º



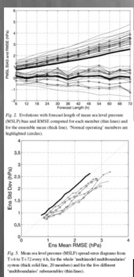


Fig. 2. Evolutions with forecast length of mean sea level pressure (MSLP) bias and RMSE computed for each member (thin lines) and for the ensemble mean (thick line). 'Normal operating' members are highlighted (circles).

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).

Large-scale flow consistency

Individual members MSLP BIAS & RMSE (left), MSLP spread-error (left-down), Z500 rank histograms (down)

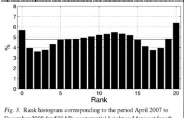
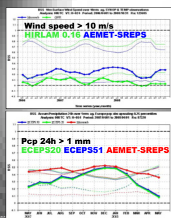
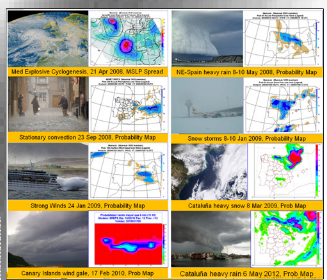


Fig. 3. Rank histogram corresponding to the period April 2007 to December 2008 for 500 hPa geopotential height and forecast length T+24. The analysis of the ECMWF model is taken as observation value.

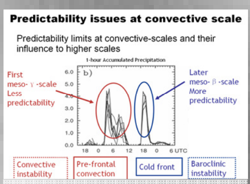


Weather parameters

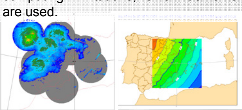
Added value w.r.t. HIRLAM (up), w.r.t. ECMWF-EPS (down), case studies with great value in forecast guidance (right)

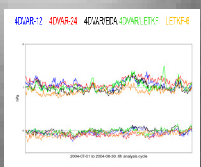


Towards a γ-SREPS



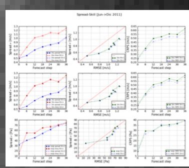
Immediate plans include a critical improvement in resolution, moving straightforward to convection permitting scales. But predictability issues at convective scale are not trivial and a huge effort in research will be necessary. At these scales data assimilation of high resolution observations (e.g. radar) become a crucial requirement, as well as accordingly verification. (figure, Hohenegger & Schär, 2007). Due to computing limitations, small domains are used.





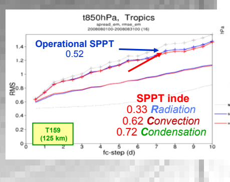
LETKF

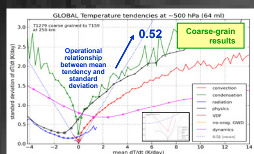
Local Ensemble Transform Kalman Filter (LETKF, Hunt et al., 2007). P. Escribà has been working for 6 months at ECMWF with M. Bonavita, M. Hamrud and L. Isaksen, comparing 4DVAR, LETKF and hybrids, in IFS (ECMWF), for analysis. Comparison has been done assimilating only surface pressure. Next step will be migration of IFS LETKF to Harmonie system to test it as analysis scheme and generator of initial states for EPS. The figure shows 2-months MSLP RMSE and BIAS time series for 5 analysis schemes available in IFS, assimilating only surface pressure. In this case LETKF perfoms the best.



LBCs

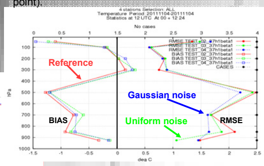
To assess the impact of **LBCs** selection, spread-error balance for different global EPS or GCM combinations is computed, e.g. EPS ECMWF (as well as some subsets and tubing), GCMs from TIGGE and AEMET-SREPS. The figure shows an example with spread evolution, spread-error, and CRPS evolution. Though this spread is already known to be low, some combinations can be better.



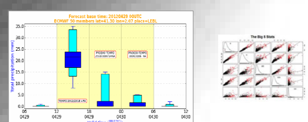


SPPT

Stochastic Perturbed Parameterization Tendencies (**SPPT**, Buizza et al. 1999). A. Callado: 6 months visit at ECMWF with G. Shutts 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).



SPPT applied independently to several physical parameterizations.

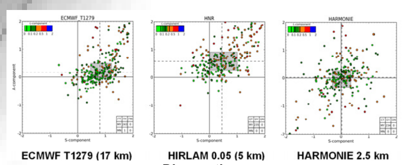


Statistical calibration

For calibration, Extended Logistic Regression (ELR, Wilks, 2009) is tested.

Post-processing

Specific SREPS-grams including TAF reports can help in SR local forecast guidance.



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

Diagnostics

Meso-gamma scales need new spatial verification methods, e.g feature-based that deal with patterns, to avoid problems like double penalty. Structure-Amplitude-Location method (SAL, Wernli et al., 2008) has been successfully tested to assess ECMWF T1279 (~0.125º), HIRLAM HNR (0.05º), and HARMONIE (2.5 km) QPFs in the Iberian Peninsula domain. This verification method qualifies model performance according to three parameters that provide information on the shape and/or size of pcp objects (Structure), their distribution (Location), and the accuracy in the total pcp quantity, i.e. bias (Amplitude) relative to observation fields.

Upper figure shows SAL plots from the verification of daily pcp for the three mesoscale models in the period Oct. 2011-May 2012, using AEMET high resolution observation network. The non-hydrostatic model HARMONIE presents the best performance (SAL=0.025, 0.022, 0.13), being the one that best reproduces the structure of objects (S) and shows less bias (A), with the S and A values closest to zero. In contrast, ECMWF and HNR models overestimate the shape and/or size of objects (S>0), and the total pcp quantity (A>0). Differences for location component are not that significant. Other verification methods that also deal with patterns (MODE; Davis et al., 2009) will be tested for ensemble forecasts.

Conclusions & on-going work

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-α 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.

Current plans to improve resolution moving to mesoscale-gamma have to deal with predictability issues at convective scales. Research lines include LETKF (ICs uncertainties), SPPT (model unc), perturbations on the LBCs, DA and verification of High Resolution observations (radar, SEVIRI…), statistical calibration metods (ELR), specific SREPS-grams for airports, new verification methods (SAL, MODE…).

Acknowledgements

Developing a multimodel-multianalysis ensemble prediction system is a difficult issue to address. The authors are very grateful to many people. J.A. García-Moya was the *alma mater* for many years and had to leave the group due to *external* non-linear forcing dynamics. We would like to acknowledge E. Kalnay from the University of Maryland for her grip at the beginning of the project. For their support on LAMs, ICs or BCs we give specific mention to J. Bornemann and K. Mylne from UKMO, D. Majewski, M. Gertz and M. Denhard from DWD, Chiara Marsigli and Ulrich Schättler from the COSMO Consortium. Metview Team (ECMWF) support was essential. Precious discussions were held with A. Ghelli, M. Leutbecher, R. Buizza (ECMWF), M. Göeber (DWD), P. Nurmi (FMI), P. Doblas-Reyes (IC3), V. Homar, R. Romero (UIB), O. García, B. Navascués, J. A. López, A. Chazarra, J. Calvo and I.Martínez (AEMET). People that worked formerly in the group were D. Santos, J. Montero, while I. Guerrero (AEMET) was involved in SAL soft, original version kindly provided by M. Paulat (DWD) and M. Zimmer (Univ. Mainz). B. Orfila posed the first proposal of a multimodel in AEMET. In GLAMEPS project, K. Satler (DMI) help with technical issues has been always critical. We would also like to acknowledge ECMWF member and cooperating states (and also to A. Ghelli, ECMWF) for providing their climate network precipitation data. Any development wouldn't have been possible without the help from AEMET Climate Database Staff and Computer Systems Staff. This work is partially funded by project PREDIMED CGL2011-24458 from the former Spanish Ministry of Science and Innovation.

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