Long-term verification of HIRLAM and ECMWF short-range forecasts over south-western Europe

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1.- Background and methodology

The HIRLAM NWP system is operational at AEMET since early nineties. Two configurations have been run: one synoptic over a wide area at a mid resolution (ONR) and the other at a higher resolution nested into the synoptic one (until 2011) and covering the Iberian Peninsula and surroundings (HNR). Table 1 shows the main changes introduced since 1995. A long-term verification of these two HIRLAM runs over the Iberian Peninsula and Balearic islands has been obtained recently. Besides, the evolution of ECMWF forecast skill has also been assessed. Table 2 presents its changes in horizontal resolution since the same date.

SYNOP observations from a fixed set of EWGLAM stations uniformly spread over the verification area have been used to verify the short-term forecasts of surface parameters (at its original resolution) started from 12UTC analysis. The HARMONIE verification package has been employed to obtain daily and monthly Root Mean Square Error (RMSE), BIAS and Equitable Threat Score (ETS). Then, 12-months running mean has been calculated to obtain long-term trends. In order to obtain a better assessment of Quantitative Precipitation Forecast (QPF) the SAL (Structure-Amplitude-Location) method has been also applied.

2.- Some results

- **2m temperature and relative humidity**

The forecast skill of these two parameters has continuously improved since 1995 in all models, but mainly for ECMWF (influenced by changes in horizontal resolution; see table 2 and arrows in green).

Today, HIRLAM still behaves better than ECMWF (T2m). Notice the positive impact introduced in 2005 by the new HIRLAM surface data assimilation and parameterization, not only in RMSE but also in the BIAS magnitude (see table 1 and arrows 4 and 5 in red in the Figures).

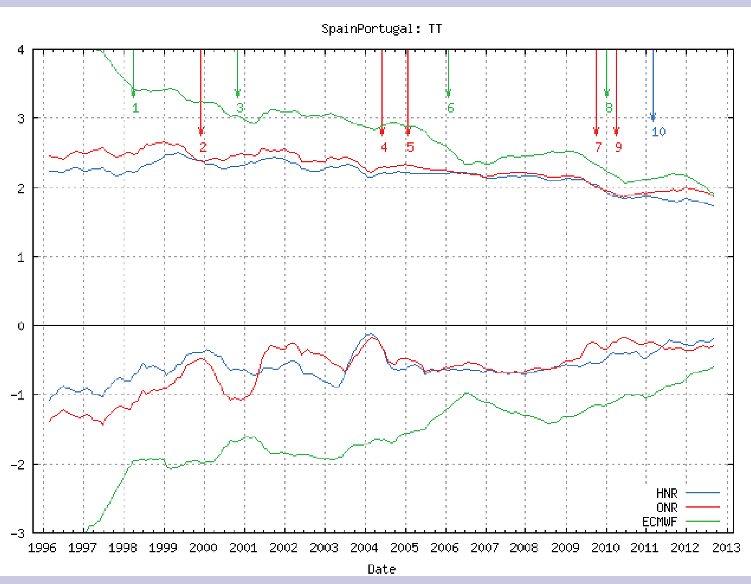

Fig. 1.- Long-term trends of RMSE and BIAS of T2m (12-months running mean) . RMSE and BIAS of t+6, t+12, t+18 and t+24 forecasts have been averaged to remove the diurnal cycle.

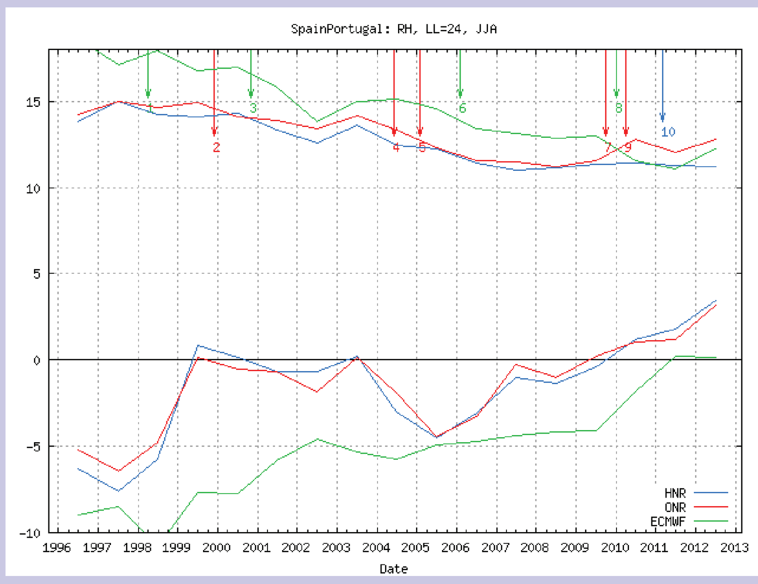

Fig.2.- Time evolution of RMSE and BIAS of t+24 (valid at 12UTC) RH2m forecasts in summer (June, July and August)

- **10m wind speed**

See the continuous improvement since 1995 and the remarkable added value of high resolution. Three milestones can be mentioned in relation to wind forecast improvement: the inclusion of TKE turbulence in 2000, the increase of resolution in 2005 and the change to model version v7.2 in 2009.

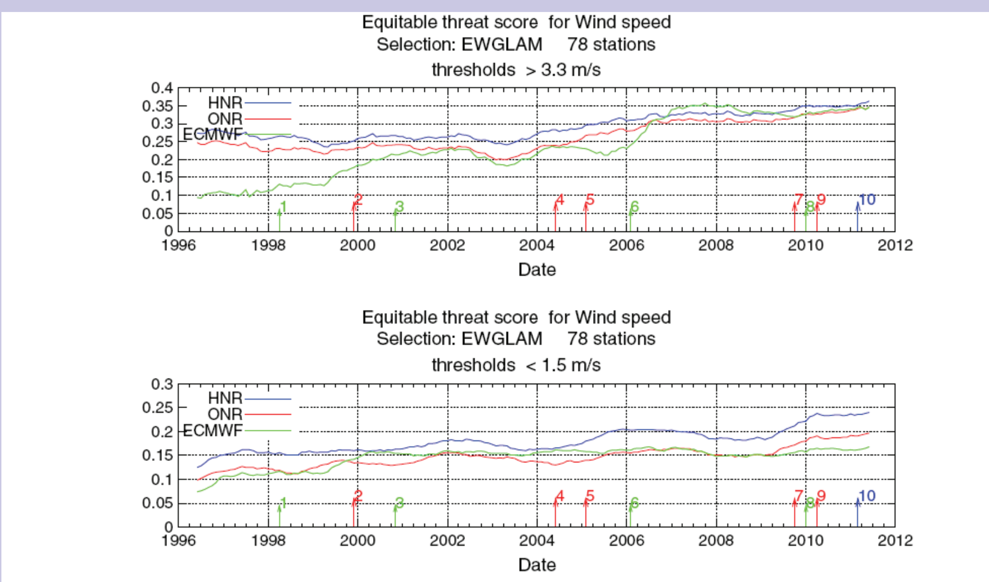

Fig. 3.- Long-term trends of 10m wind speed forecasts skill. As Figure 1 but for ETS with two different thresholds of wind speed.

- **surface pressure**

Initial conditions have played an essential role for the improvements achieved by both ECMWF and HIRLAM. Notice the positive impact produced by the implementation of 3D-Var and the direct assimilation of AMSU-A in the HIRLAM runs (arrows 4 and 5). The introduction of the blending procedure with ECMWF analysis in late 2009 (arrow nr. 7) also clearly improved PS forecasts.

The error growth of HIRLAM forecasts in the first 24h has decreased with time. However, the direct nesting of HNR into ECMWF (and blending with ECMWF analysis) in early 2011 has deteriorated t+6 forecasts. It also happened to ONR run ¿spin-up problems?

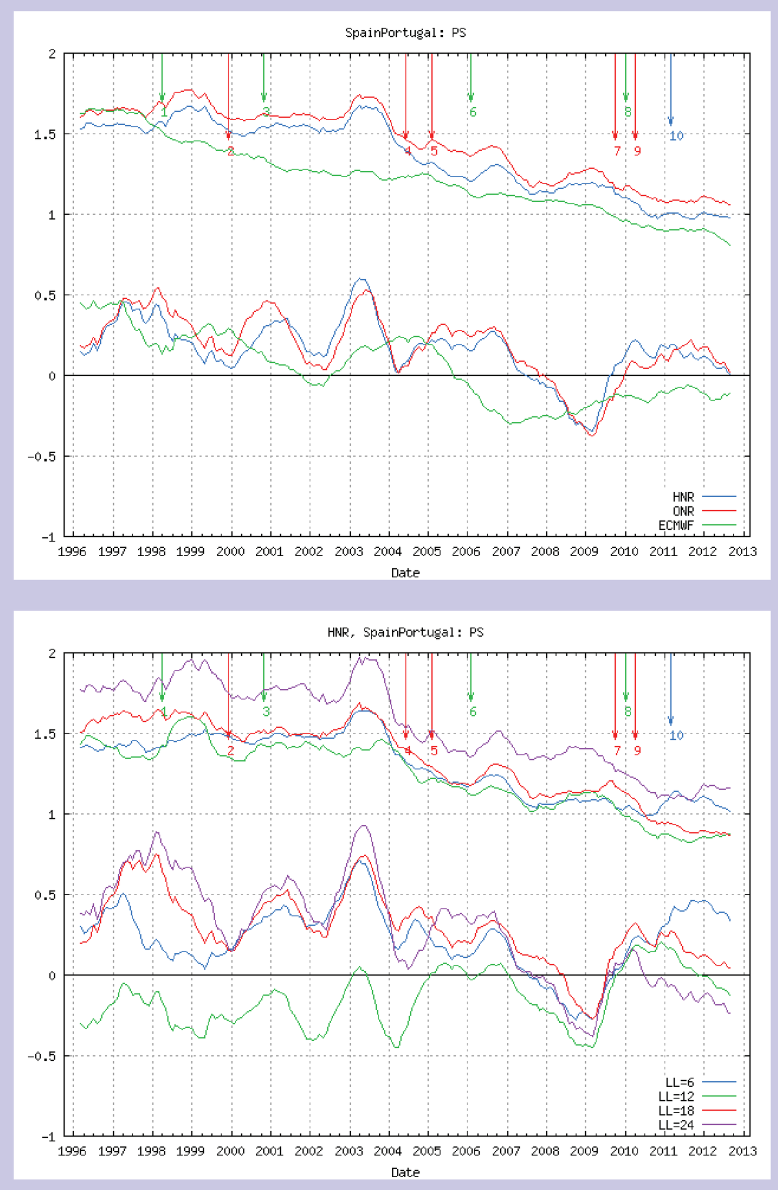

Fig. 4.- Top: same as Fig. 1 but for surface pressure (PS). Bottom: Long-term trends of RMSE and BIAS of the different HNR PS forecast ranges.

- **QPF**

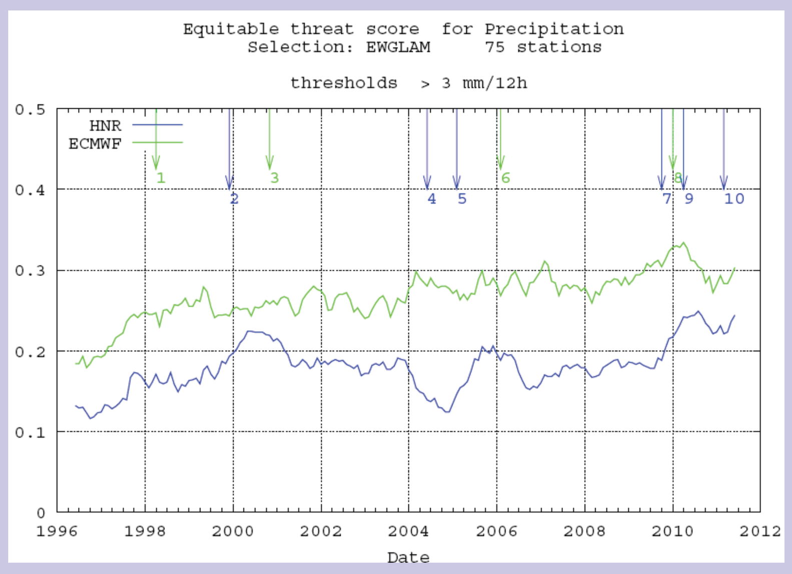

Fig. 5.- Verification against SYNOP observations: Long- term trends of QPF errors of HIRLAM-HNR (blue) and ECMWF (green). 12-monts running mean of ETS for 12h accumulated precipitation with 3mm/12h threshold.

The verification against SYNOP observations of QPF shows that the general trend towards lower forecast errors is probably smoother than for other variables. This might be due to the increase in resolution of all models along the period and the double penalty effects. Part of HIRLAM improvement comes from a better representation of large scale that comes to a great extent from ECMWF boundaries. Nevertheless a clear improvement is seen at the end of 2009 with the inclusion of KFRK treatment for moist processes (arrow nr. 9).

Due to the limitations of point verification, the feature-oriented SAL method (Wernli et al., 2008) has been applied to ECMWF and HNR QPF over north-eastern Spain along the period April 2007 – January 2010 using rain gauge from the Spanish high-resolution climate stations network upscaled to each model resolution. In this period both models kept constant the resolution. See the seasonal performance of QPF of HIRLAM and ECMWF. Notice that HIRLAM presents smaller structure errors in summer and spring, when convective precipitation patterns are very common.

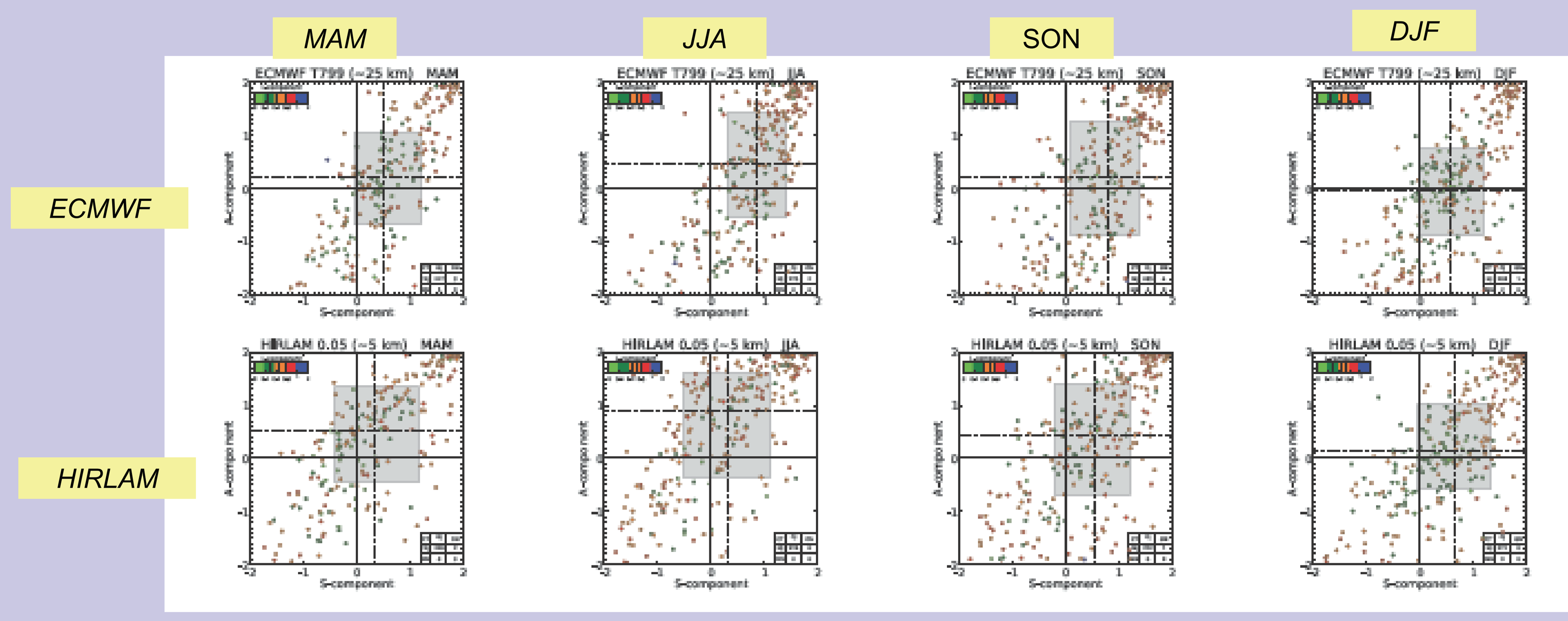

Fig. 6.- Seasonal variations in SAL performance for ECMWF (upper row) and HIRLAM-HNR (lower row) QPF. Columns correspond to spring (MAM), summer(JJA), autumn (SON) and winter (DJF). Shadowed box indicates IQR for A and S components.

Flag	Version	Date	Grid	DA	Dyn	Physics
-	2.4	May 95	0.5°/0.2° 31L	OI NMI	Euler	Louis v.diff. Sunqvist cond.
2	4.6.2	Dec 99				CBR turb.
4	5.1.2	Jun 04		3DVar, DFI New surface analysis	SL	STRACO cond. Tiled surface
5	6.1.2	Feb 05	Rotated 0.16°/0.05° 40L			
7	7.2	Oct 09		Blending with ECMWF analysis (ONR)		
9	7.2	Apr 10				KFRK cond.
10	7.2	Mar 11		Blending with ECMWF analysis (HNR)		

Flag	Date	ECMWF model resolution
1	Apr 98	T319 (62 km) L31
3	Nov 00	T511 (40 km) L60
6	Feb 06	T799 (25 km) L91
8	Jan 10	T1279 (16 km) L91

Table1 (left): main milestones concerning changes in HIRLAM operational runs at AEMET. Table 2 (right): Changes in horizontal resolution of ECMWF model

5.- Conclusions

This poster illustrates the value of the operational HIRLAM system focusing on the historical evolution of short range forecasts errors and their relation with milestones of scientific progress achieved within the Consortium and introduced at AEMET. The evolution of the ECMWF model skill in south-western Europe over the seventeen years long period, 1995-2011 shows the huge and continuous improvement achieved by this global model. However, the higher resolution operational HIRLAM nested into it has continuously improved and has always provided better short range forecasts for some weather parameters having a high social and economic impact, like 2m temperature and 10m wind. Concerning QPF verification, the SAL feature-oriented method provides more complete conclusions about ECMWF and HIRLAM performance.

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Wernli, H., Paulat, M., Hagen, M., and Frei, C.: SAL—A Novel Quality Measure for the Verification of Quantitative Precipitation Forecasts, Mon. Wea. Rev., 136, 4470–4487, doi: 10.1175/2008MWR2415.1, 2008.

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