Application and verification of ECMWF products 2011

Agencia Estatal de Meteorología – AEMET

1. Summary of major highlights

The following major highlights can be mentioned regarding the use of ECMWF models at AEMET.

- Collaboration on research on objective verification methods for NWP. This is kept by Carlos Santos from AEMET, and Anna Ghelli from ECMWF/OD. One paper was published last January (QJRMS) and another one or two are in preparation.

- The global MOCAGE model (2.0 deg horizontal resolution) uses the ECMWF model as meteorological forcing. The MOCAGE 3D multi-scale Chemistry and transport model is used in operational applications in the field of environmental modelling

- From October 2011 and after testing different nesting configurations, HARMONIE 2.5 km runs four times a day in the ECMWF facilities nested directly in the ECMWF model outputs. Currently boundaries are renewed every hour

- Maintenance and improvement of the AEMET Intranet website with products from ECMWF EPS that is used as the main operational tool for medium range forecasters.

- Use of ECMWF products for generation of Digital Forecasting Data Base, DFDB, from H+48 up to 192. Current changes from ECMWF perspective and DFDB: increasing the temporal range, H+48 – H+240, and the inclusion of deterministic Tmax and Tmin, ocean wave outputs as well as precipitation and snow probabilistic products from H+06 - H+240.

- Use of ensemble forecasts and high resolution charts for the Experiment on Nowcasting of Severe Weather Events (NoSWEx) by means of the web-based facility ecCharts

2. Use and applications of products

Use of deterministic, ensemble and monthly forecast models in an operational way:

- Atmospheric models:
  - Comparison of high resolution deterministic model with the EPS control model in Spanish area
  - Clustering of ECMWF EPS for two specific Spanish areas.
  - EPS Probabilities for various meteorological parameters in two specific Spanish areas with normal thresholds and special thresholds for severe weather.
  - EFI for T2m, Tmax, Tmin, PCP, SNOW, V10m, V10m GUSTS.
  - Meteograms
  - PCP and T2m anomalies and probabilities in the upper and lower terciles from monthly forecast for the Monday and Thursday runs.

- Wave models:
  - EPS Probabilities in three specific areas for significant wave height for wind sea, swell and total sea.

2.1 Post-processing of model output

2.1.1 Statistical adaptation

- Application of Analogue Method, AM, to estimate the probability of precipitation from deterministic ECMWF model (12 UTC run), D+1 to D+3 in 24h periods (07-07 UTC).

- Use of Analogue Method from EPS, EPS-AM, to estimate the probability of precipitation from D+1 to D+7 (12 UTC run) in 24h periods (07-07 UTC).

- Adjustment of EPS precipitation probabilities for 6, 12 and 24h periods based on the ratio between the probabilities of EPS and EPS-AM in the common period 06-06 UTC.

- Maximum and Minimum temperatures predictions (D+7) using EPS mean and surface observations of 40 previous days to correct the bias.
- Estimation of the potential snow-rain limit considering 850 hPa temperature and geopotential from ECMWF deterministic model output, up to D+7.
- Estimation of probability of snowfall considering the EPS-AM precipitation probability and the probability of snow-rain limit (D+3).
- Estimation of probability of thunderstorms using deterministic ECMWF model Total of Totals Index, TT, and EPS-AM precipitation data from D+3 to D+7.

2.1.2 Physical adaptation

All the boundary conditions for the LAM short range NWP AEMET operational models (euro Atlantic HIRLAM ONR, 16km; HIRLAM HNR, 5km, over Iberia and surroundings; and HIRLAM CNN, 5km, over Canary Islands) are now directly taken from the ECMWF operational runs.

Experimental HARMONIE runs in AEMET facilities, daily with 11km resolution, and occasionally, with 2.5km resolution. They are also directly nested to the ECMWF outputs. HIRLAM models use their own assimilation, HARMONIE versions run in adaptation mode. This direct nesting performs well even for 2.5 km.

From October 2011 and after testing different nesting configurations, HARMONIE 2.5 km runs 4 times a day at H+30, in the ECMWF facilities nested directly in the ECMWF model outputs. Currently, boundaries are renewed every hour. It runs with surface analysis and blending with ECMWF upper air fields.

Daily experimental multimodel Short-range Ensemble Prediction System (SREPS) uses ECMWF model as one of the boundary condition of global models to initialize the system. Two runs a day (00 and 12 UTC) uses 12 hours-old ECMWF run.

2.1.3 Direct and derived fields for medium range forecast

In operational duties, a large amount of ECMWF products from medium to monthly range is used. AEMET uses both the deterministic model and EPS system for medium range weather forecast. EFI products are used as well as probability maps to access the warning areas in our early warning system of high impact weather events, called “Meteoalerta“ . Moreover, and special report (not still available at our public web server) based on EPS monthly probabilistic system, is made once a week. Other activities and products are related to:

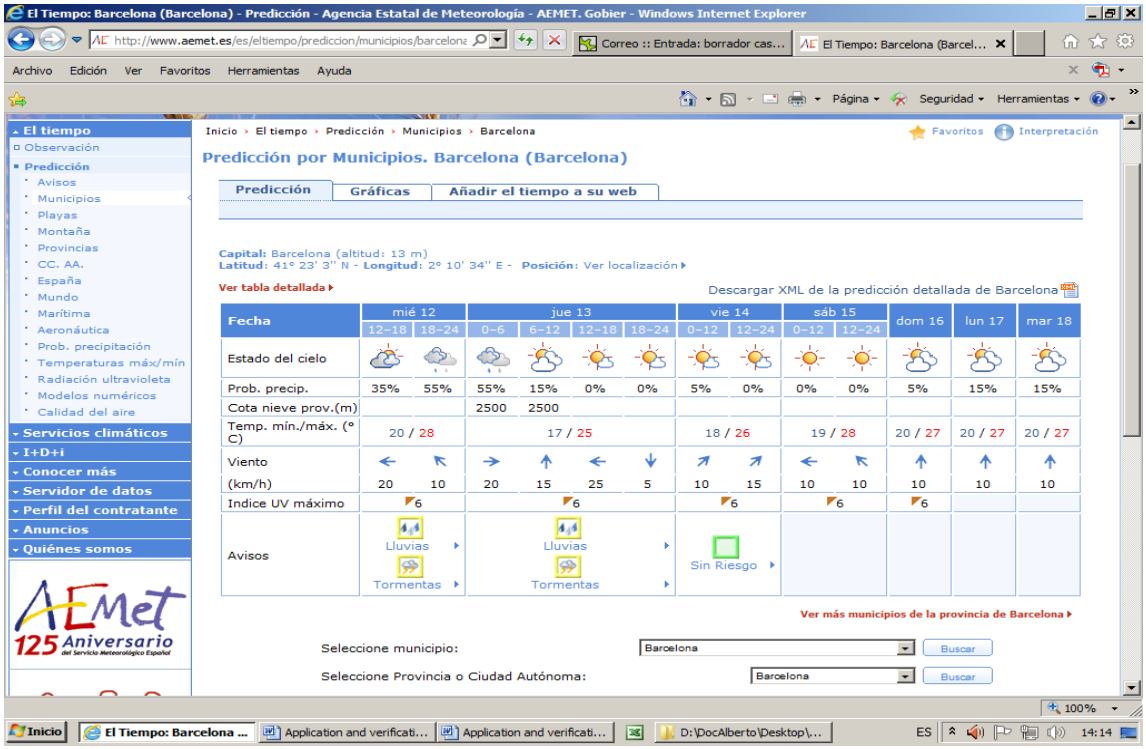
- Comparison of high resolution deterministic model with the EPS Control model in Spanish area.
- Specific Spanish clustering of ECMWF EPS in two specific Spanish areas, the Iberian Peninsula /Balearic Islands and Canary Islands.
- EPS probabilities that various meteorological parameters, from atmospheric EPS, surpass defined thresholds in two specific Spanish areas, from D+1 to D+10 or D+15.
- EPSgrams.
- Wave EPS probabilities that significant height of wind waves and total swell, exceed defined thresholds in specific Spanish areas.
- PCP and T2m anomalies and probabilities in the upper a lower terciles from monthly forecast.

2.2 Use of products

Use of ECMWF products for deriving:

- Frontal diagnosis parameters: TFP, THW, etc.
- Aeronautical and maritime products.
- Seudosounding graphics from deterministic model using pressure levels.
- Wind gust estimation maps.
- Specific parameters for diagnosing thunderstorms potential: CAPE, LI, CIN, convergence zones, SRH, etc.,
- Defence support charts in different international areas (Afghanistan, Lebanon, etc.)
- Use of ERA interim fields (1996-2010), in order to verify the different methods applied in AEMET to estimate the snow-rain limit.
- Use of products for the Experiment on Nowcasting of Severe Weather Events. Special emphasis and use of Ensemble mean and spread charts: 300 hPa geopotential and MSLP. High resolution charts, with emphasis on CAPE and fields related to the forecast of heavy precipitation.
- AEMET have been using the ecCharts suite mainly for meteorological support outside the national territory (international expeditions, military units deployed overseas, etc…).
- The VarEPS/monthly probabilistic system is used at the AEMET every Friday to elaborate a interdepartmental report for the next four weeks for other purposes, such as Hydrological surveys.
- Many ECMWF products, as the “Extreme forecast index” (EFI), are used for public warnings of severe weather for short-range forecasts. ECMWF forecast products are a good guideline for those warnings.
- The ECMWF deterministic and probabilistic model outputs are used extensively by the duty forecasters and are also used to produce a wide range of automatic forecasts as it is shown in the next image from AEMET external web site:

  http://www.aemet.es/es/portada



It would be very useful to have information about the forecast cyclone phase diagrams as much as the structural transition (subtropical/tropical/extratropical).

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

Post-processing of EPS 2m-temperature in Spain.

EPS 51 members forecasted 2m-temperature at 00, 06, 12 and 18 UTC is interpolated at each of the synoptic observatories of Spain. Its mean is calculated and corrected with the mean of the errors (forecasted – observed) from previous days. This procedure is also applied to the daily extreme temperatures as illustrated in the next graphics: monthly percentage of the days with absolute errors less or equal than 2ºC from 2010 applying Tmax and Tmin

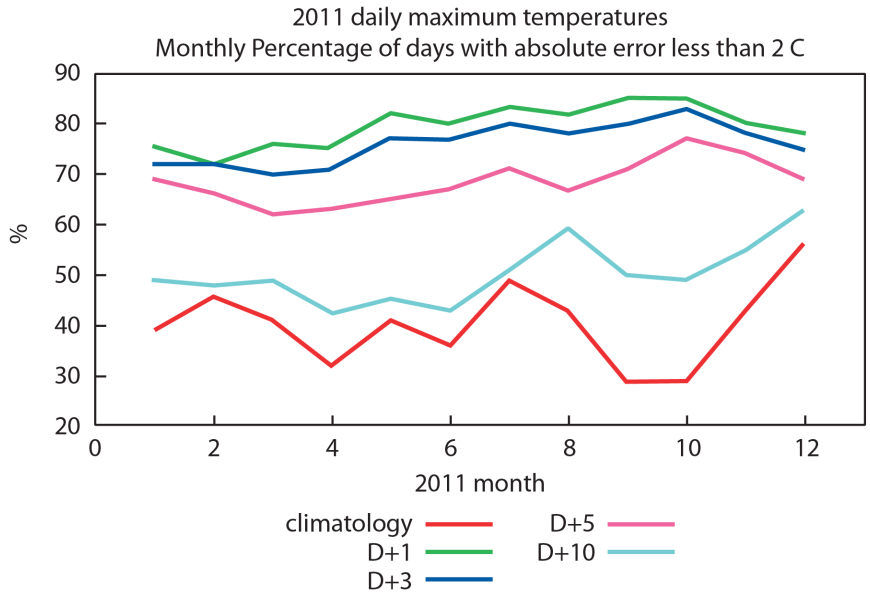


Figure 1. *Time series of percentage of correct maximum temperature forecasts (error less than 2ºC) for different prediction ranges. The verification sample is composed by the forecasts made in 2011 for a set of 50 Spanish synoptic stations.*

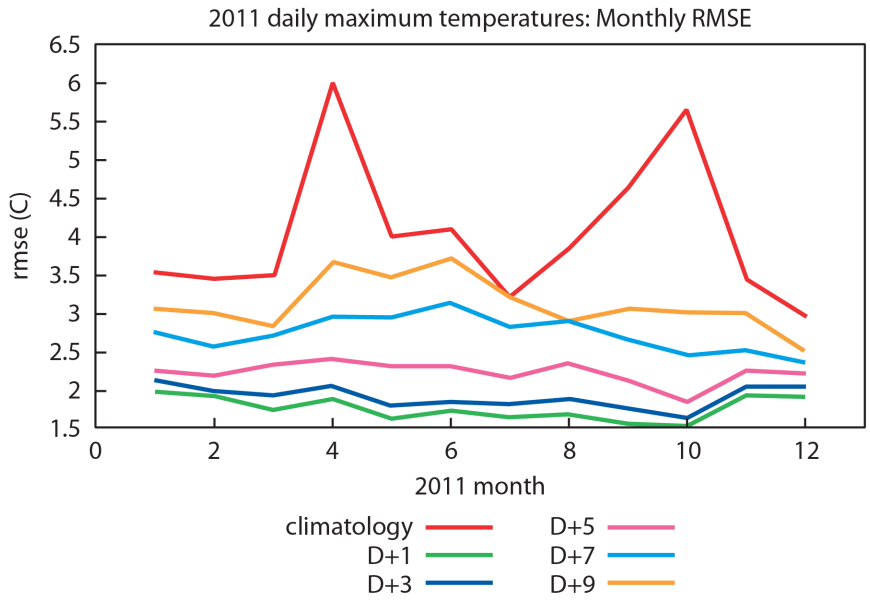


Figure 2. *Time series of monthly mean values of RMSE for objective maximum temperature forecasts for different prediction ranges during 2011. Local forecasts are obtained from the filtering of the 2m-Temp EPS mean. The verification sample is composed by the forecasts for a set of 50 Spanish synoptic stations.*

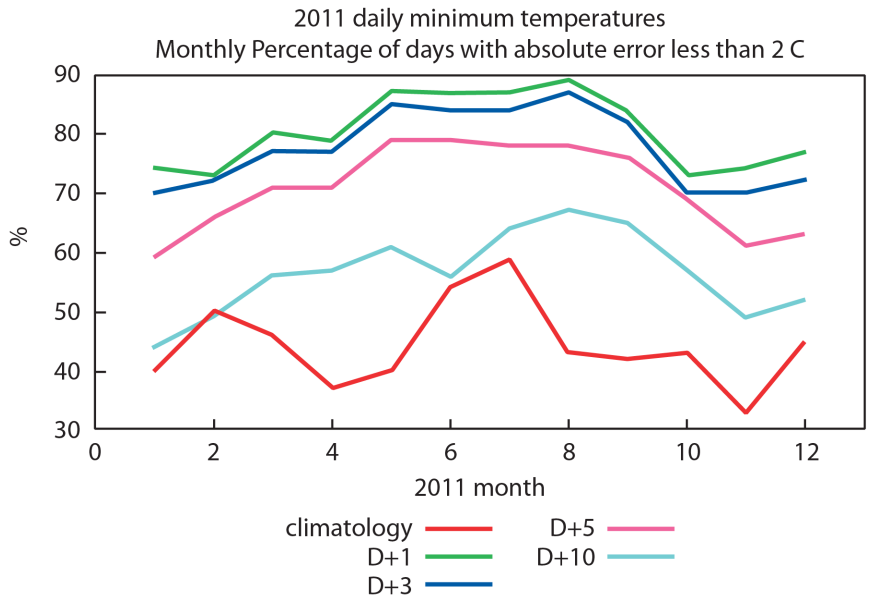


Figure 3. *Time series of percentage of correct minimum temperature forecasts (error less than 2ºC) for different prediction ranges. The verification sample is composed by the forecasts made in 2011 for a set of 50 Spanish synoptic stations.*

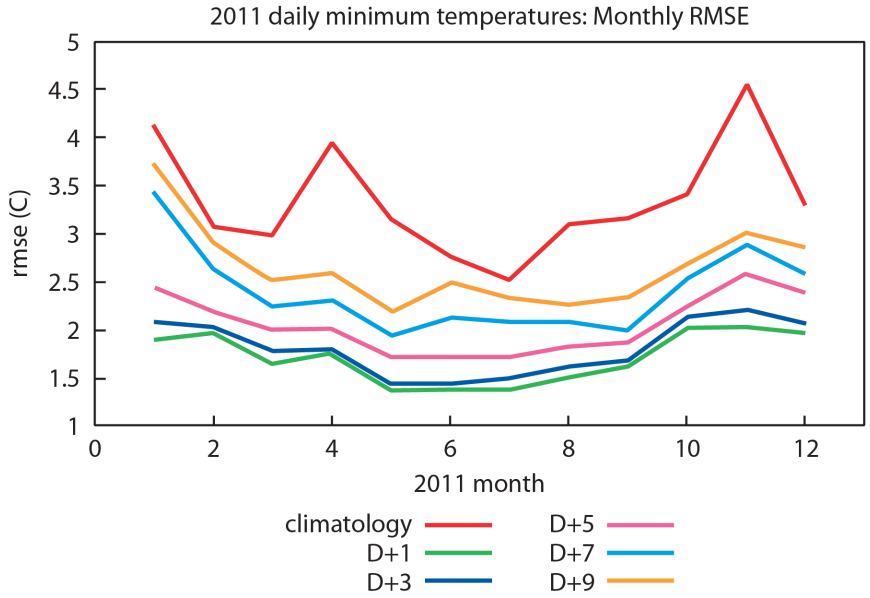


Figure 4. *Time series of monthly mean values of RMSE for objective minimum temperature forecasts for different prediction ranges during 2011. Local forecasts are obtained from the filtering of the 2m-Temp EPS mean. The verification sample is composed by the forecasts for a set of 50 Spanish synoptic stations.*

3.1.2 ECMWF model output compared to other NWP models

The most relevant differences among the three models ECMWF,HIRLAM ONR and HIRLAM HNR are found for precipitation forecasts, mainly the convective one. ECMWF model forecasts precipitation over more extended areas but with smaller amounts than the higher resolution models.

There are two projects AEMET is doing in collaboration with ECMWF. In particular Carlos Santos and Anna Ghelli are working together in two items:

One of them is an assessment of the impact of observational uncertainty in verification results for ensemble precipitation forecasts. This study compares performance of ECMWF EPS and AEMET-SREPS. The resulting paper has been recently published in QJRMS: Santos, C. and Ghelli, A., 2012, Observational probability method to assess ensemble precipitation forecasts. Q.J.R. Meteorol. Soc., 138:209–221. doi:10.1002/qj.895.

Another one is the application of new feature oriented techniques for verification of QPF using a method called Structure Amplitude Location (SAL). First tests (2010) showed interesting results comparing T799, T399, HIRLAM 0.16 and HIRLAM 0.05 in Central Europe and Spain during 2009. Laura Ferranti collaborates as well, introducing a clustering technique to stratify results. A couple of publications might come up from this.

3.1.3 Post-processed products

See point 3.1.1.

3.1.4 End products delivered to users

No end products different from Direct Model Output are delivered to users.

3.2 Subjective verification

3.2.1 Subjective scores (including evaluation of confidence indices when available)

From the daily technical discussions at the National Prediction Centre (CNP) we can conclude that high resolution deterministic model underestimates the CAPE index when compared with observed lighting and with respect to the limited area Hirlam model also. This happens especially in Spring, and also for the convective precipitation in situations of light dynamic forcing.

On the other hand, and related to the EPS, we have observed that the model consistency has improved a lot and the model dispersion is less that it used to be in the past.

3.2.2 Synoptic studies

Evaluation of the behaviour of the deterministic and EPS forecasts in severe weather situations:

- Spanish case studies during 2012

- *Freezing rain*. 9 febrero 2012. Posible 'lluvia/llovizna engelante en carreteras de País Vasco-Navarra'. Working Group ATAP-DTARA-DTCAN. Internal Document.
- *Hazardous wind gust event at Malaga coastline*. 4 febrero 2012. 'Rachas en la costa malagueña con situación de nortes'. Working group DTAND Málaga- ATAP. Internal Document.

- Short Range Convection Workshop with the operational forecasters from the National Weather Center in Madrid.
- Brief summary about the large-scale episodes occurred during the NoSWEX 2011 campaign. The Spanish report of the experiment is already available in Spanish (in preparation, in English). A convective event has been compared with the high-resolution forecasts.

4. Reference to relevant publications

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.,** 2012, Observational probability method to assess ensemble precipitation forecasts. *Q.J.R. Meteorol. Soc.,* **138**: 209–221. doi: 10.1002/qj.895