Application and verification of ECMWF products 2009

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1. Summary of major highlights

ECMWF products are used as the main source of data for operational weather forecasting. In the short-range these forecasts are used along with the ones provided by the ALADIN forecasting system (ALADIN, ALARO and AROME).

Verification of forecasts from ECMWF and the ALADIN system is done operationally, on a seasonal basis. Some results for the summer of 2009 and winter of 2009/10 are shown in Section 3.

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Physical adaptation

The ECMWF model forecasts are used as the input for the sea-wave model MAR3G. The model is run once a day up to H+120h, with a 6h time step. A ray model is then used to transform waves from the open seas to near-shore.

An ALADIN LAM-EPS system is run using LBC and IC provided by the ECMWF's ensemble members. The system runs daily at the ECMWF c1a machine and results are sent to IM-Portugal headquarters. The forecasts have a resolution of 11 km and are run for 60 hours.

Finally, ECMWF forecasts are also used in a trajectory model, in cooperation with the Environment Institute.

2.1.2 Derived fields

The deterministic forecast from ECMWF is used daily to produce the post-processed fields (*e.g.* thermal frontal parameter and Q-vector convergence, temperature advection at 850 hPa, vorticity advection at 500 hPa, Total-Totals and Jefferson indices). Several other indices (*e.g.* Lifted Index) are computed and tephigrams are plotted for selected locations in Portugal.

2.2 Use of products

Apart from the deterministic forecasts, in the short and medium range, many of the products derived from the ensemble forecasting are used daily and considered to be very beneficial.

The ECMWF monthly forecast is used to produce a weekly bulletin with forecasts on the 2 meter air temperature and precipitation for Continental Portugal for the 4 weeks of forecast. The bulletin is made available for external clients on a regular basis, including civil protection authorities. Every week, a draft on the evolution of the anomaly signal of every specific week is performed internally.

The ECMWF seasonal forecast is used to produce a monthly bulletin with forecasts on the 2 meter air temperature and precipitation for Continental Portugal for the 4 trimesters of forecast. This bulletin is made available for external clients if requested, including civil protection authorities. Every month, a draft on the evolution of the anomaly signal of every specific trimester is performed internally. The anomaly signal for the EUROSIP seasonal forecast is also evaluated.

3. Verification of products

Objective verification of near surface variables from ECMWF forecasts is done operationally. The results shown in this section were computed for a sample of 48 mainland synoptic weather stations (figure 1).

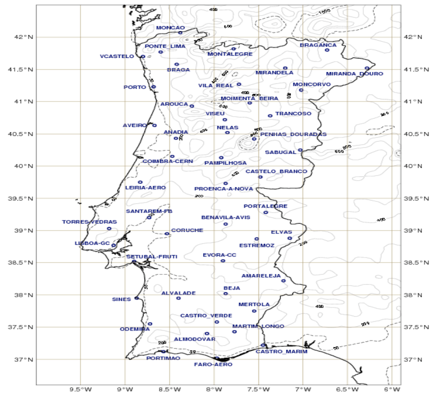


Fig. 1 - Location of the selected 48 weather stations in mainland Portugal.

The variables under analysis are the 2m temperature, mean sea level pressure, 10m wind speed and the 24h precipitation. For continuous variables the computed statistics are the bias (BIAS) and the root mean squared error (RMSE). In the case of precipitation, the forecasts' skill is assessed using the bias, the Equitable Threat Score (ETS) and the Heidke Skill Score (HSS). All scores shown are valid for the 00 UTC run. The same variables and scores are then computed for the ALADIN model, so that the scores can be compared.

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

The monthly RMSE for the 2m temperature and relative humidity, 10m wind speed and mean sea level pressure are shown in figure 2, for the period between January 2008 and May 2010. Results are shown for forecasts valid at 6 UTC and 15 UTC, within the first 48 hours. Notice that the computed score for each month use all forecasts initialized in that month.

a) b)

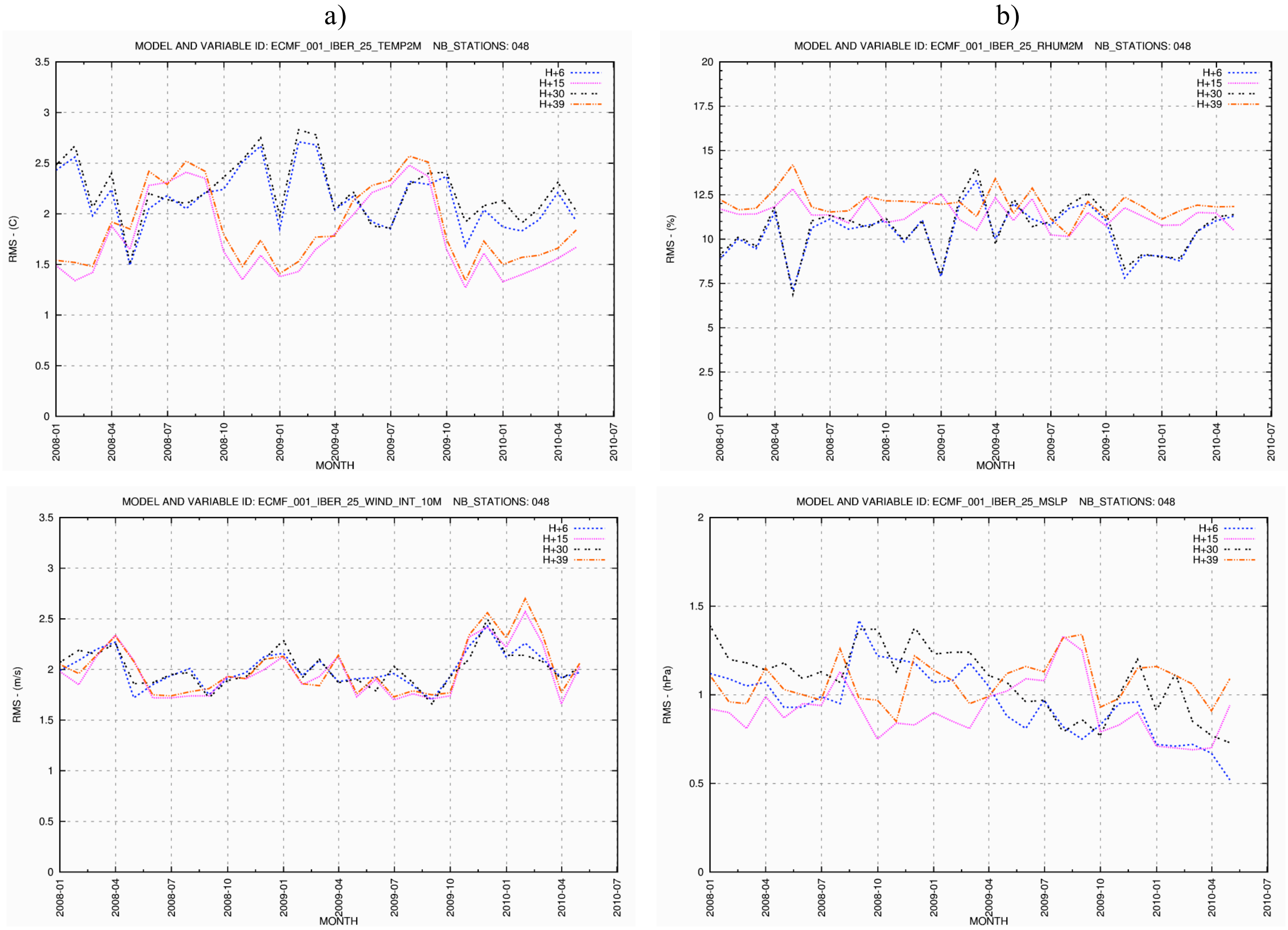


Fig. 2 – Monthly RMSE of the 2m temperature (a) and relative humidity (b)

Figure 2 a) shows that there is a clear trend in the mean sea level pressure, with a continuous decrease in the RMSE. Even though the other variables do not exhibit that trend, the RMSE of the 2m temperature in the last months has been lower than in the last two winters. The only variable in which the RMSE of last months has increased was the 10m wind speed. This result is probably due to an unusually strong westerly flow over Iberia, with a large number of low systems around 40ºN.

3.1.2 ECMWF model output compared to other NWP models

A. Deterministic Model

Figures 3 and 4 show the seasonal RMSE of the 2m temperature as a function of forecast length. The scores were also computed with the same 48 weather stations shown in figure 1. Figures 5 and 6 are similar but for the 10m wind speed.

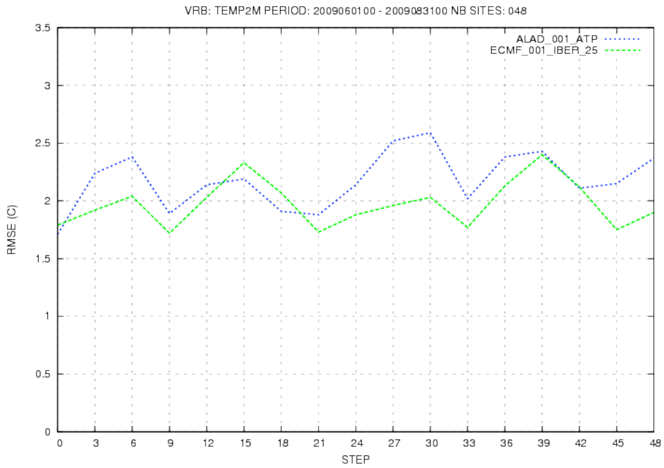


Fig. 3 - RMSE of the 2m temperature, for ECMWF and ALADIN, in summer 2009.

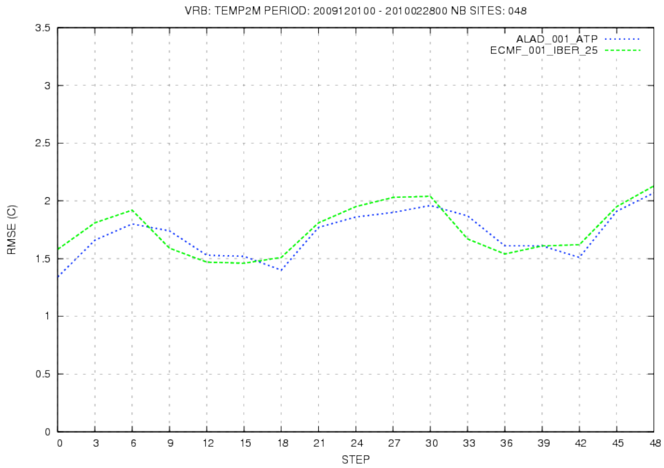


Fig. 4 - RMSE of the 2m temperature for ECMWF and ALADIN, in winter 2009/10.

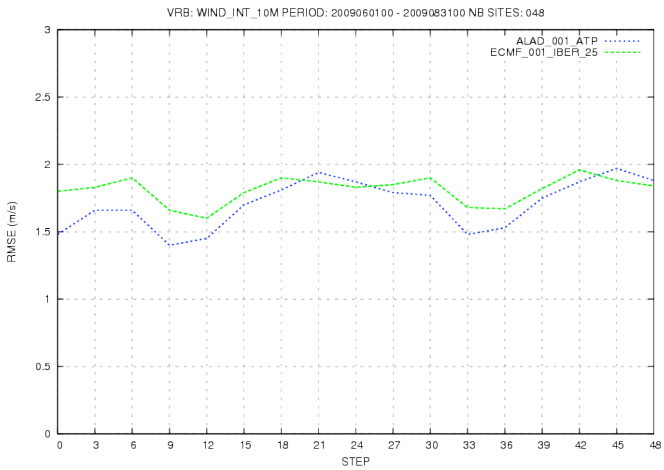


Fig. 5 - RMSE of the 10m wind speed for ECMWF and ALADIN, in summer 2009.

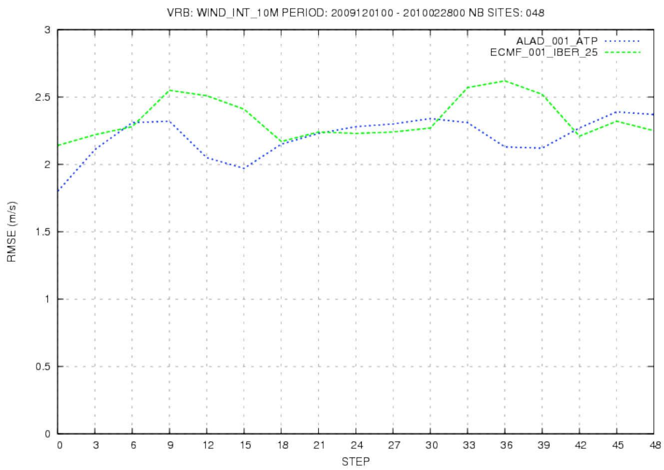


Fig. 6- RMSE of the 10m wind speed for ECMWF and ALADIN, in winter 2009/10.

The RMSE of the 2m temperature is usually similar or smaller in the ECMWF forecasts, when compared with ALADIN. ECMWF's advantage was mainly seen in the summer of 2009. In the case of the 10m wind speed, even though the RMSE for both models is very close, ALADIN performs slightly better, regardless of the time of the year.

Figures 7 to 12 show the BIAS, ETS and HSS for the 24 hour total precipitation, accumulated between H+06 and H+30.

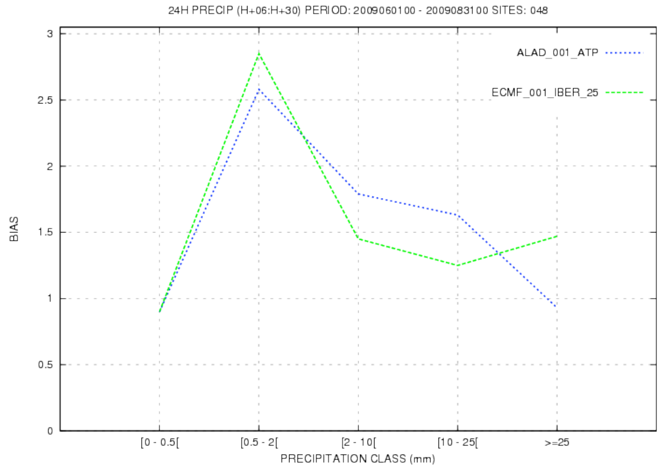


Fig. 7 - BIAS of the 24h total precipitation for ECMWF and ALADIN in summer 2009.

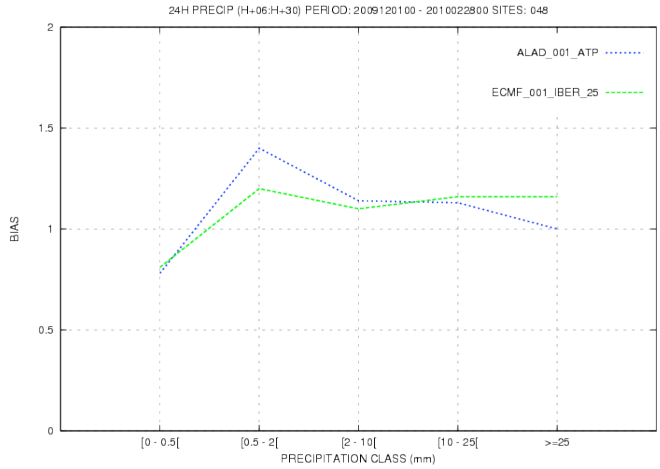


Fig. 8 - BIAS of the 24h total precipitation for ECMWF and ALADIN in winter 2009/10.

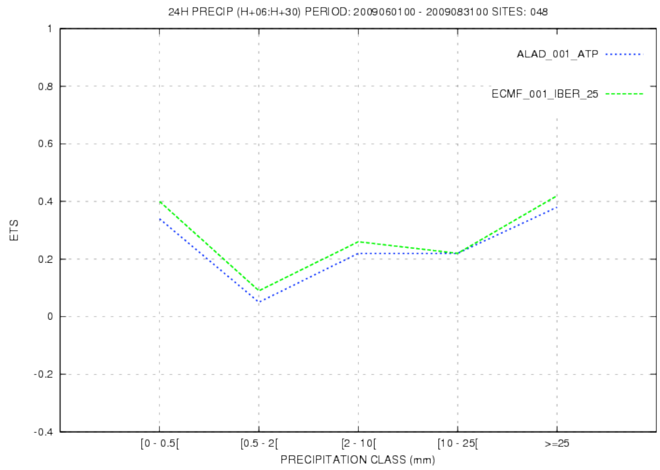


Fig. 9 - ETS of the 24h total precipitation for ECMWF and ALADIN in summer 2009.

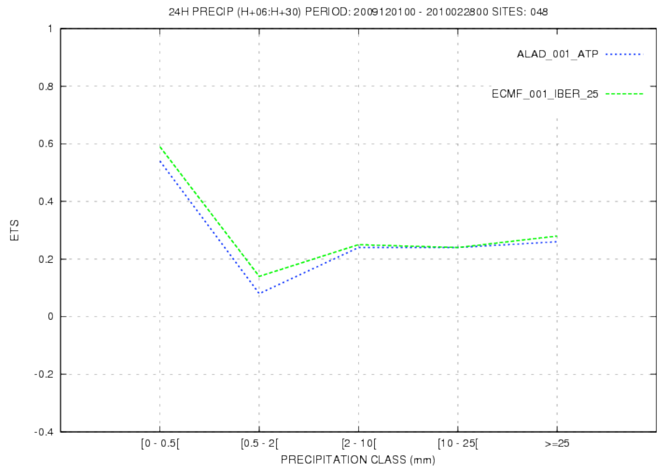


Fig. 10 - ETS of the 24h total precipitation for ECMWF and ALADIN in winter 2009/10.

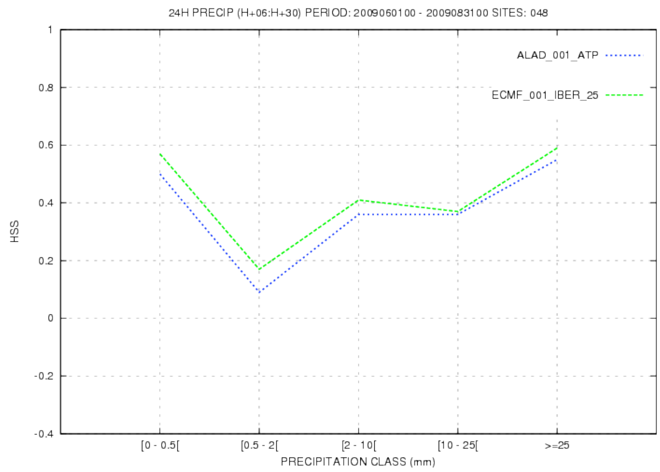


Fig. 11 - HSS of the 24h total precipitation for ECMWF and ALADIN in summer 2009.

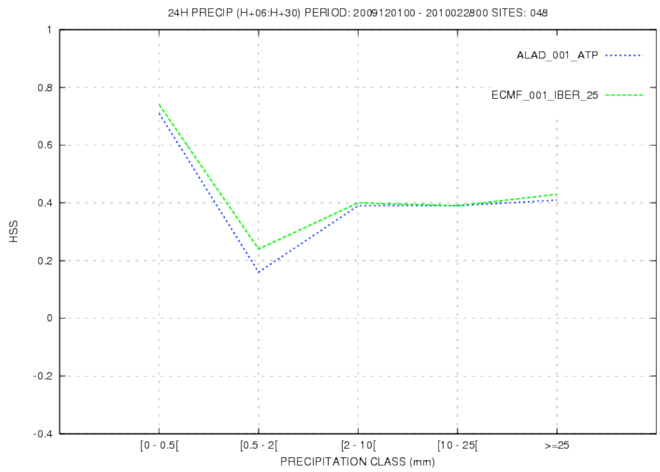
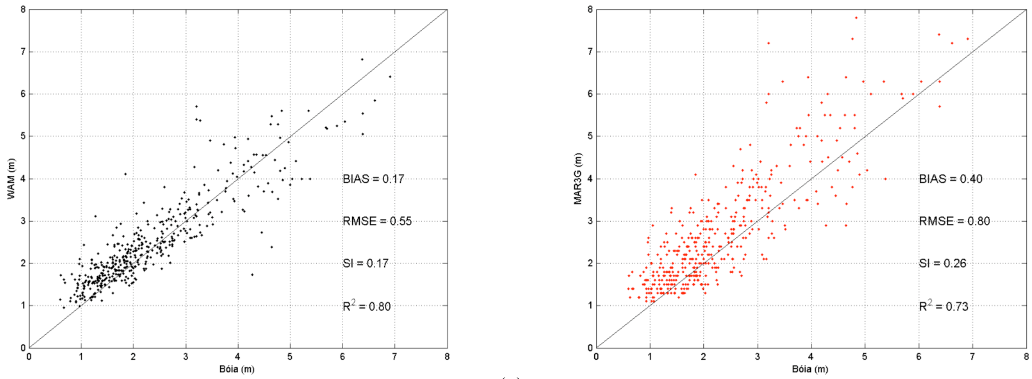


Fig. 12 - HSS of the 24h total precipitation for ECMWF and ALADIN in winter 2009/10.

The results show that both models overestimate small amounts of precipitation, mainly in the summer season. Additionally, even though there are no relevant differences in the scores in both periods, the forecasts of total precipitation over 25mm/24h performed slightly better in the summer of 2009.

B. Wave Model

Wave model predictions of significant wave height (Hs) are routinely verified against buoys observations in the Portuguese coast. Figure 13 shows the results from winter periods of 2007/08 and 2008/09 for the Portuguese West coast computed from WAM and MAR3G.



(a) (b)

Fig. 13 – Forecast (T+48h) scatter diagrams of WAM (a) and MAR3G (b) for the Portuguese West coast.

Results show that WAM produce more accurate forecasts for that period of time (less BIAS, RMSE, SI and higher correlation coefficient). In the future we will also seek the performance of LAM in our coastal region, covering a longer period of time.

3.2 Subjective verification

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

Subjective verification of ECMWF forecasts products from the operational forecasters suggests that the forecasts provided are very good in the short term and provide useful guidance in the outlooks for days 5 to 7. Occasionally, reasonable guidance can extend up to ten days. Nevertheless, whenever convection is the main feature the model's performance is much lower, as expected.

Products derived from the ensemble forecasting system such as the EFI and probability maps for variables like the gust of at least 15 m/s, mean wind speed of at least 10 m/s, precipitation and temperature are found to be very useful in the operational forecasting, particularly for weather advisories.

3.2.2 Synoptic studies

In the period under analysis, four main severe weather events struck Portugal. Full reports (in portuguese) are ongoing so only a brief reference is given here.

In late December, a small low system touched mainland Portugal, just 100 km north of Lisbon, causing widespread damage in agriculture and property. No lifes were lost. Estimate from radar measurements suggest that in a limited area gusts may have reached 220-230 km/h. Maximum measured gust speed at an IM site was around 150 km/h, but there were unofficial values of 170 km/h. The performance of the models was somewhat limited, because even though the location was well forecasted, the suggested wind intensity was too low.

In this winter snowfall was far more frequent than usual. For example, in January 10th 2010, ahead of a warm front, widespread snowfall hit the north and centre of Portugal. The snow fell in locations as low as 250/300m in the centre of Portugal mainland and briefly touched coastal cities in the north (*e.g.* Porto). Overall, the model's guidance was useful.

In February 20th 2010, severe flash floods hit the Madeira Island, mainly in the south coast. In the city of Funchal 123mm were recorded between 09-18UTC and in the mountains (around 1800m) the amounts reached 340mm in the same time frame. This event caused widespread damage, lost of 42 lives and was widely reported in the news. In this event the ECMWF forecast provided some guidance, but as the precipitation was reinforced by orographic effects, the totals amounts were much smaller that those observed.

In February 27th 2010, a storm system swept the west coast of Portugal, with a south-southwest to north-northeast trajectory. In this case, both the trajectory and development of the low were rather well forecasted. However, in this event the model overestimated the 10m wind speed and gusts.

4. References