# Application and verification of ECMWF products 2014

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## 1. Summary of major highlights

At Instituto Português do Mar e da Atmosfera (IPMA) 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 limited area models of ALADIN numerical weather prediction system (ALADIN and AROME).

In 2013/2014 the major highlights were:

- implementation of the Simulating WAves Nearshore (SWAN) third-generation model for Madeira and Azores archipelagos domains
- improvements in the post-processing of NWP products
- hourly forecasts from statistical adaptation available through a mobile app (early summer 2014)

## 2. Use and application of products

### 2.1 Post-processing of model output

#### 2.1.1 Statistical adaptation

Statistical adaptation of ECMWF's forecasts is made to improve daily minimum and maximum temperatures forecasts in selected locations up to 240 hours. This system comprises forecasts from ECMWF as well as from ALADIN and AROME models, whenever available. The application computes MOS and KALMAN adjusted temperatures for each model and the final forecast is then computed as the average of all available forecasts. This framework has been extended to the 2 m temperature and relative humidity, as well as the 10 m wind speed, all available with an hourly frequency up to 3 days and 3/6h frequency up to 10 days, depending on availability. These new products are available through IPMA's website and a mobile app.

#### 2.1.2 Physical adaptation

The spectral density of ECMWF limited area ocean-wave model (WAM) is used together with 10 m wind of ALADIN as the input to the Simulating WAves Nearshore third-generation model, with 0.05º of horizontal resolution, 36 directions and 36 frequencies. Processing of its fields is done for every hour and forecasts are produced until H+72h. The tri-hourly forecasts are also available on IPMA's portal (http://www.ipma.pt/pt/maritima/cartas/).

#### 2.1.3 Derived fields

The deterministic forecast from ECMWF is used on a daily basis to produce some derived-processed fields such as the 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.

The statistical adaptation of surface parameters has also been used to compute a forecast of Universal Thermal Climate Index (UTCI).

## 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 bulletin twice a week with forecasts on the 2 meter air temperature and precipitation for mainland Portugal for the 4 weeks of forecast. This bulletin is made available at IPMA's Web page and for external clients if requested, including civil protection authorities. Every week, a draft on the evolution of the anomaly signal of every specific week is performed internally.

The EUROSIP seasonal forecast is used to produce a monthly bulletin with forecasts on the 2 meter air temperature and precipitation for Portuguese mainland for the 4 trimesters of forecast. This bulletin is also made available at IPMA's Web page and 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 ECMWF alone seasonal forecast is also evaluated.

# 3. Verification of products

## 3.1 Objective verification

### 3.1.1 Direct ECMWF model output (both deterministic and EPS)

### 3.1.2 ECMWF model output compared to other NWP models

ECMWF forecasts are compared with the operational limited area models ALADIN and AROME, respectively, with 9 and 2.5 km horizontal resolution.

Figures 1 to 4 show, respectively, the monthly RMSE of the 2 m temperature, relative humidity, 10 m wind speed and mean sea level pressure, valid at step H+39. RMSE was computed with a sample of 21 weather stations in mainland Portugal. Figure 5 shows the monthly Heidke Skill Score of the 24h precipitation (H+06 to H+30), computed in a sample of 48 stations in mainland Portugal. All scores are shown for the period October 2007 to July 2014.

The RMSE of the 2 m temperature, relative humidity and 10 m wind speed shows a trend towards smaller errors. The RMSE of ECMWF is similar to the ones computed for ALADIN and AROME, except in the 10 m wind speed where there ECMWF has shown a noticeable improvement.

In the mean sea level, there is no clear trend and the RMSE of ECMWF forecasts is usually the lowest. The Heidke Skill Score of 24h precipitation, computed at 48 stations using the single observation-single forecast approach, is similar in all three models and shows a small trend upwards.

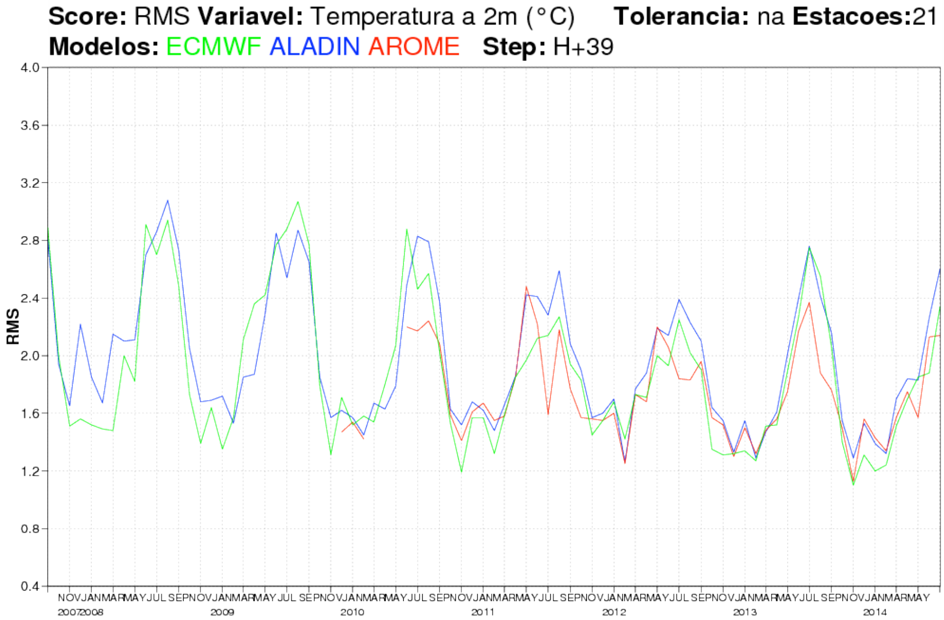



*Figure 1 – Monthly RMSE of the 2 m temperature, at step H+39.*

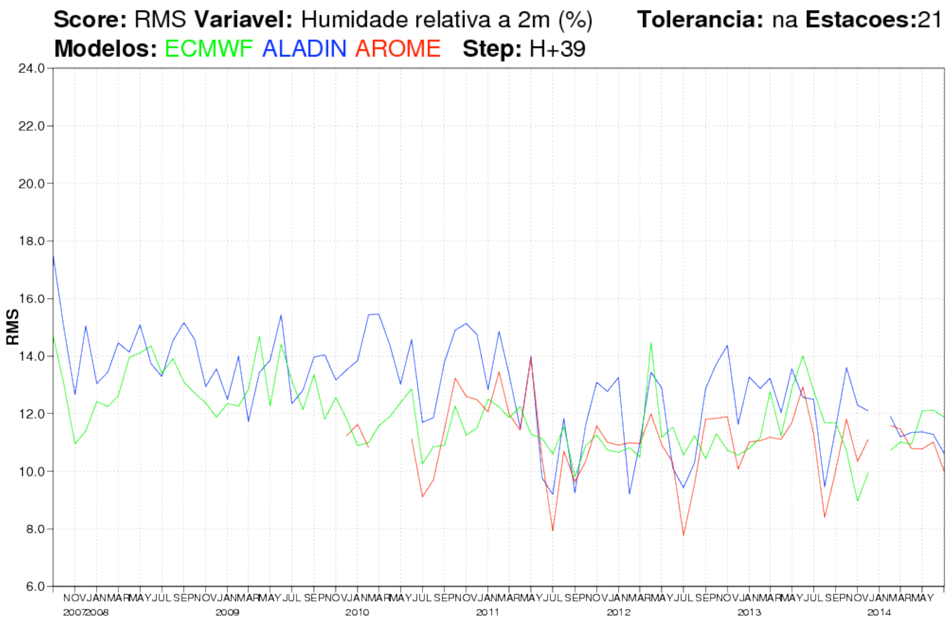



*Figure 2 – Monthly RMSE of the 2 m relative humidity, at step H+39.*

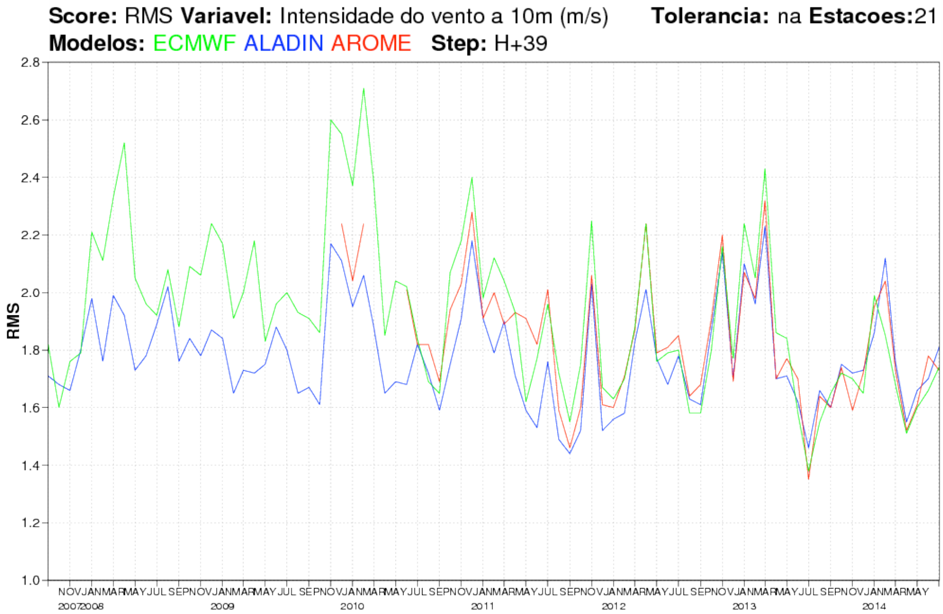



*Figure 3 – Monthly RMSE of the 10 m wind speed, at step H+39.*

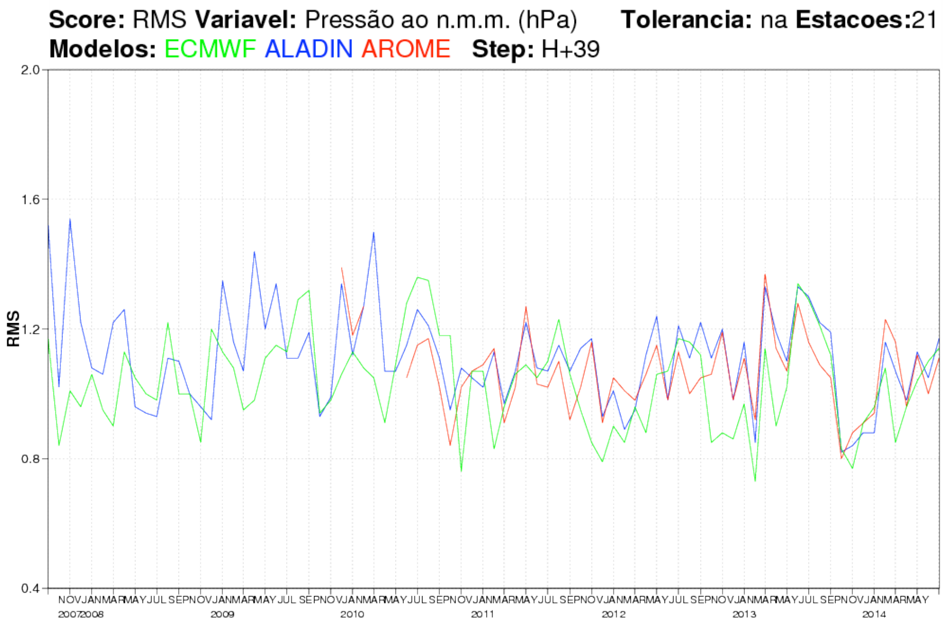



*Figure 4 – Monthly RMSE of the mean sea level pressure, at step H+39.*

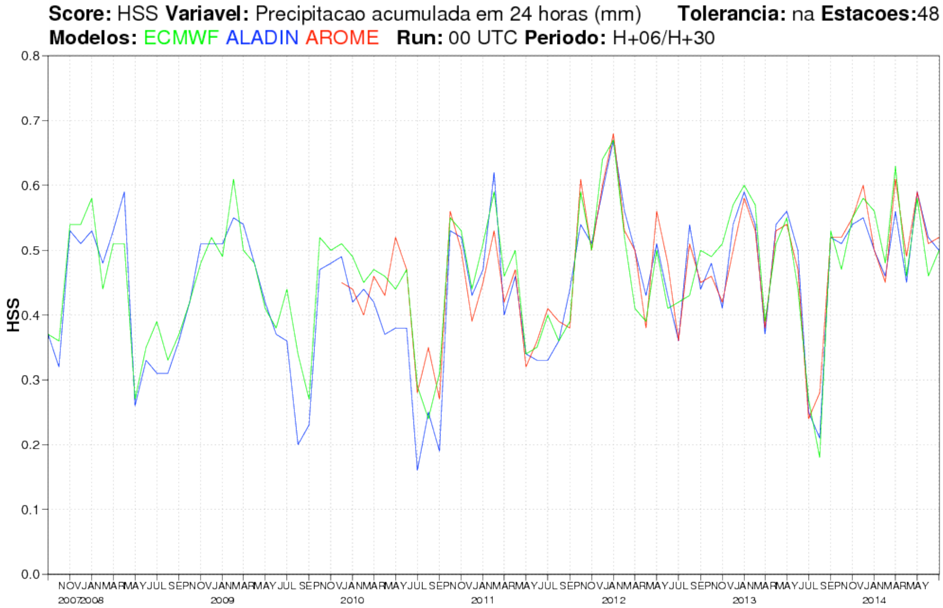



*Figure 5 – Monthly Heidke Skill Score of the 24h precipitation (H+06 to H+30).*

### 3.1.3 Post-processed products

Figures 6 and 7 show the RMSE of the minimum and maximum temperatures, for the summer of 2014 (1st of June until 10th of August). The scores are valid for the 00 UTC run and computed at 105 weather stations. The plots allow the comparison of the statistical post-processing (STA) and the direct model output (DMO) of ECMWF, ALADIN and AROME forecasts.

When assessing DMO forecasts, ECMWF has the lowest RMSE for the 2 m minimum temperature, but it is the opposite in case of the maximum temperature. The statistical post-processing has the lowest values of RMSE, regardless of the variable and forecast length.

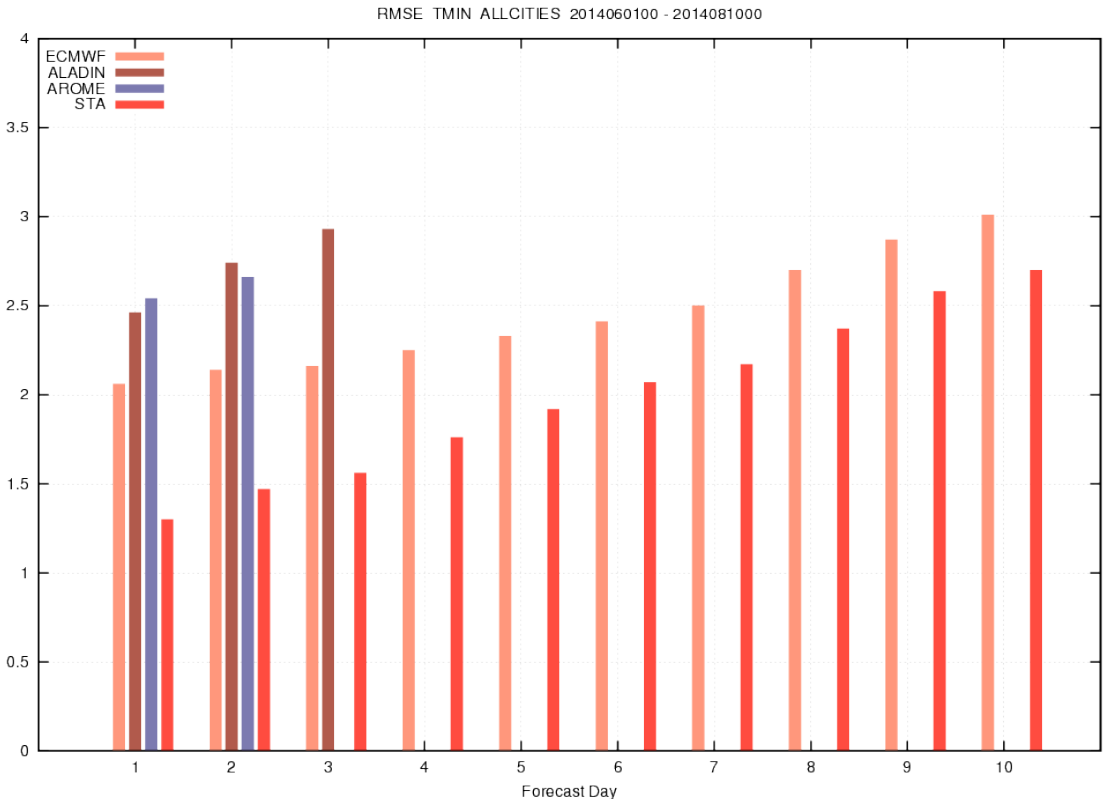



*Figure 6 – RMSE (ºC) of the 2 m minimum temperature, in the summer of 2014. Scores were computed for DMO and statistical post-processing of ECMWF, ALADIN and AROME forecasts.*

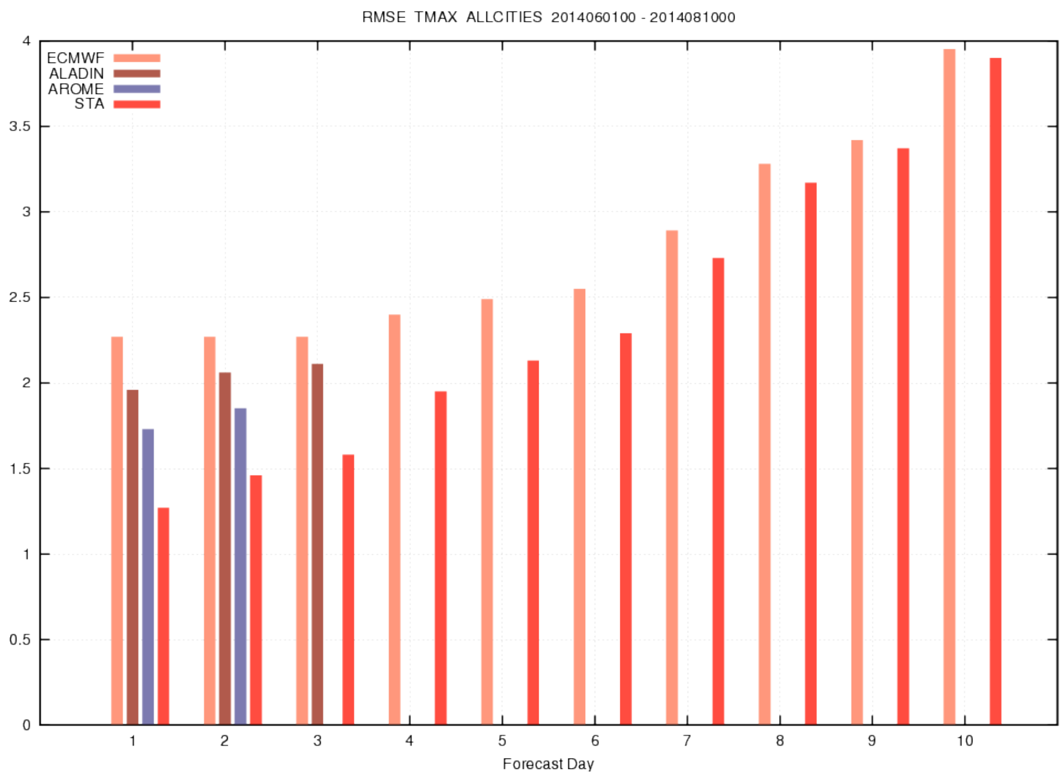



*Figure 7 – RMSE (ºC) of the 2 m maximum temperature, in the summer of 2014. Scores were computed for DMO and statistical post-processing of ECMWF, ALADIN and AROME forecasts.*

### 3.1.4 End products delivered to users

### 3.2 Subjective verification

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

### 3.2.2 Synoptic studies

ECMWF model outputs along with ALADIN and AROME model outputs have been used to evaluate some case studies during the 2013/2014 winter season, especially for wind events:

i) Frontal Christmas wind storm on 24/25th December 2013 (Figure 8)
ii) Post-frontal instability with tornado on 4th January 2014 (Figure 9)
iii) Stephanie storm / Rapid Cyclogenesis on 9th February 2014 (Figure 10)

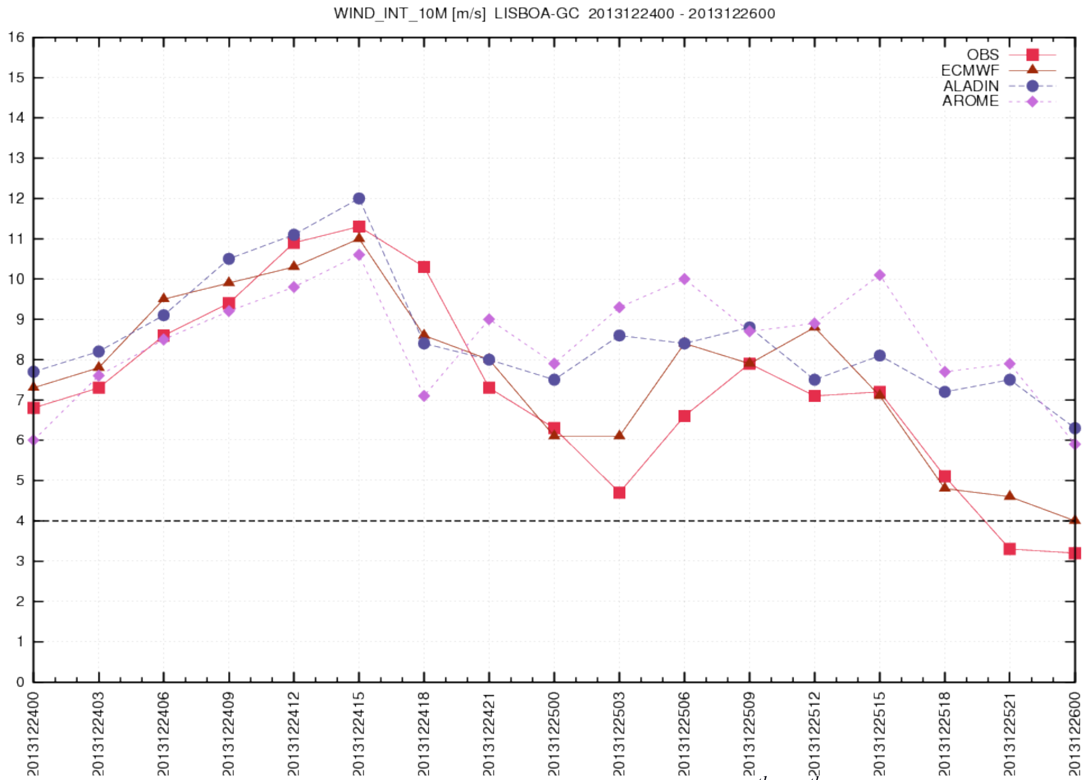



*Figure 8 – Mean wind (m/s) for Lisboa/Gago Coutinho on 24th/25th December 2013: Observations (in red) and forecasts (brown for ECMWF, blue for ALADIN and purple for AROME).*

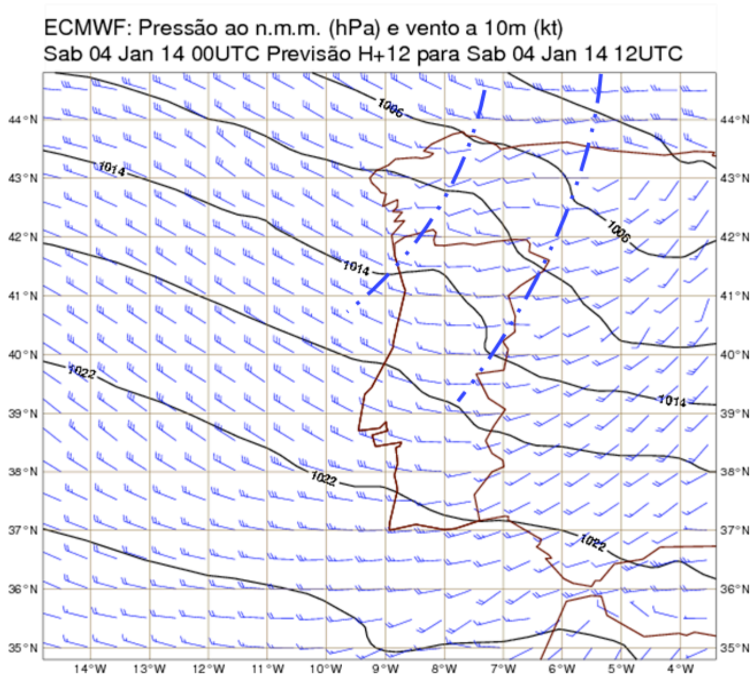



*Figure 9 (a) – ECMWF 12h forecast for 4th January 2014 at12UTC of mean sea level pressure (black line every 4 hPa), 10 m wind (blue wind barbs) and instability line (blue dash line).*

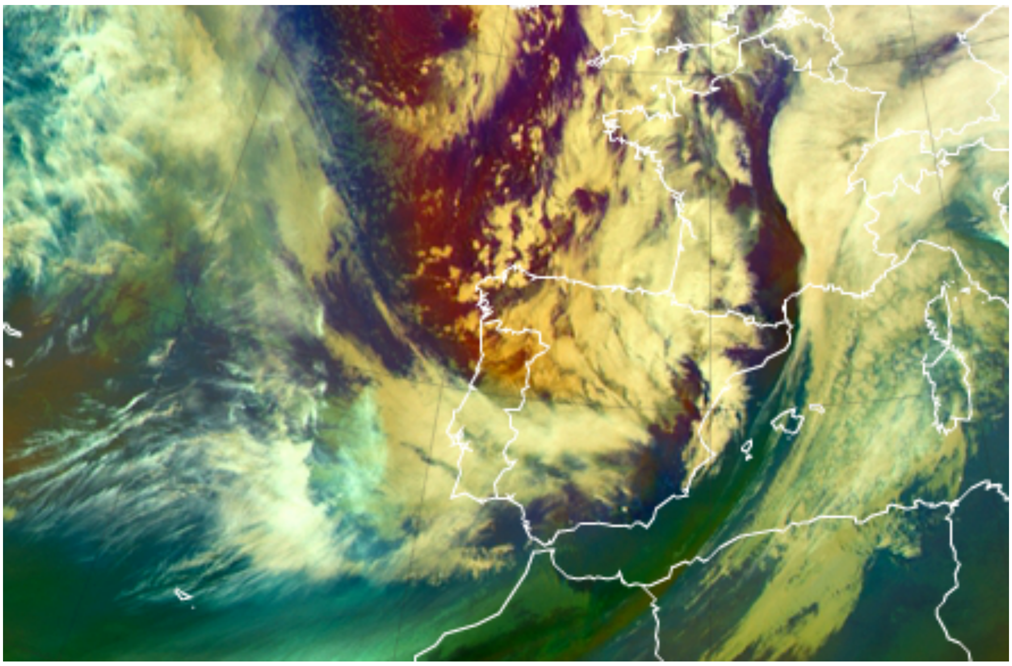
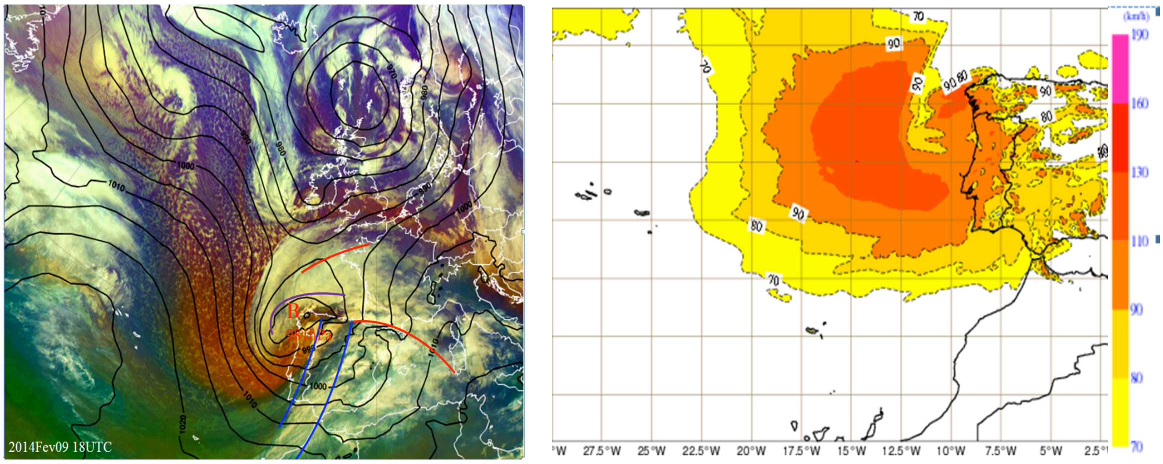


*Figure 9 (b) - Air Mass RGB from MSG at 12UTC on 4th January 2014.*




(a) (b)

*Figure 10 – (a) Air Mass RGB from MSG at 18 UTC on 9th February 2014 with H+18 forecast of ECMWF mean sea level pressure and synoptical analysis: cold fronts (blue line), warm fronts (red line) and occluded front (purple line). (b) Wind gust ECMWF H+6 forecast for 9th February 2014 at 18 UTC.*

## 4. References to relevant publications