Application and verification of ECMWF products 2008

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1. Summary of major highlights

At the Institute of Meteorology (IM I.P.), the ECMWF products are the most important source of numerical data for operational weather watch and forecast. In the short-range, the ECMWF and ALADIN models are used together in operational forecast.

Verification of ECMWF products is briefly shown for a group of selected weather stations, in the period June 2007 to May 2008, as well as a comparison against the ALADIN model.

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Physical adaptation

The ECMWF model is used as the initial conditions for the sea forecast using the named MAR3G model, which is a third generation wind-wave model that solves the transport using a Mercator projection with 1º grid mesh and source and sink terms based on a physical approach to wave growth induced by wind, non-linear wave-wave interaction and dissipation by white capping. MAR3G also includes a parametrisation for the effect of the wind variability on the Miles mechanism for wave generation that improves the model performance. The model is integrated once a day up to H+120h, with a 6 h step.

A Ray Model is then used to transform waves from the open seas to near-shore. Ray model reproduces the effects of shelter by the shore, refraction, shoaling and dissipation by bottom friction. This model, constrained by the bathymetry, computes 25 ray fans (one for each of the frequencies of MAR3G) using 360 rays spaced by 1º at the origin.

MAR3G is also objectively verified. In particular, a validation of model's parameters is made, in order to evaluate the model's performance. Several statistical parameters, such as mean error (ME), mean absolute error (MAE) and root mean square error (RMSE), are calculated for significant wave height, peak period and mean wave direction.

A LAM-EPS has recently been developed, which is presently on a pre-operational mode. The results obtained so far, seemed to have some positive subjective implications in the forecasts, mainly in extreme weather events. A considerable amount of data is being stored and shortly it will be possible to objectively check the performance of the model during the first semester of 2008.

The mesoscale model is ALADIN Cy32T1 forced with LBC and IC given by the ECMWF T399 resolution and 50 EPS members. The outputs to the forecasters are:

- Ensemble mean and standard deviation maps
- EPSgrams for the main Portuguese cities
- Threshold maps

The model's area is centered in portuguese mainland with about 11 km grid resolution. The model runs once a day (12 UTC) in the ECMWF HPC, producing H+3, H+6, …,H+60 forecasts. The data is then downloaded to our local computers. The whole process takes about 3 hours.

2.1.2 Derived fields

The deterministic forecast from ECMWF is used daily to produce the following post-processed fields, which are used operationally at IM:

- Thermal frontal parameter and Q-vector convergence;
- Temperature advection at 850 hPa;
- Vorticity advection at 500 hPa;
- Differential temperature advection in the layers 800-500 hPa and 700-300 hPa;
- Differential vorticity advection in the layers 850-500 hPa and 700-300 hPa;
- Low-level mositure convergence;

- Total-Totals and Jefferson indices.

Additionally, the forecasts are also used in a 2D trajectory model, used operationally for weather forecast and to follow the trajectory of radioactive plumes in case of nuclear emergencies, in cooperation with the Portuguese Environment Agency.

2.2 Use of products

The ECMWF monthly forecast is used to produce a weekly report with forecasts on the 2 meter air temperature and precipitation for 4 weeks of forecast. This weekly report is available for external customers on a regular basis namely for the Portuguese Civil Protection Authority. 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 report with forecasts on the 2 meter air temperature and precipitation for Continental Portugal for the 4 trimesters of forecast. This report is available for external customers if requested, like the weekly report. 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. Both ECMWF monthly and seasonal forecast were evaluated more extensively for the period January 2006- May 2007.

3. Verification of products

Verification of surface parameters from ECMWF forecasts is shown for the period June 2007 until May 2008, for a sample of ten mainland synoptic meteorological stations[1]. The variables under analysis are the 2 meter air temperature, mean sea level pressure, 10 meter wind intensity and the 6 h precipitation. The same variables and scores are then computed for the ALADIN mesoscale model, so that the scores can be compared.

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 Heidke Skill Score (HSS).

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

Figure 1 show the seasonal 2 meter air temperature RMSE of the ECMWF forecasts, up to 168 h, for a sample of ten meteorological stations.

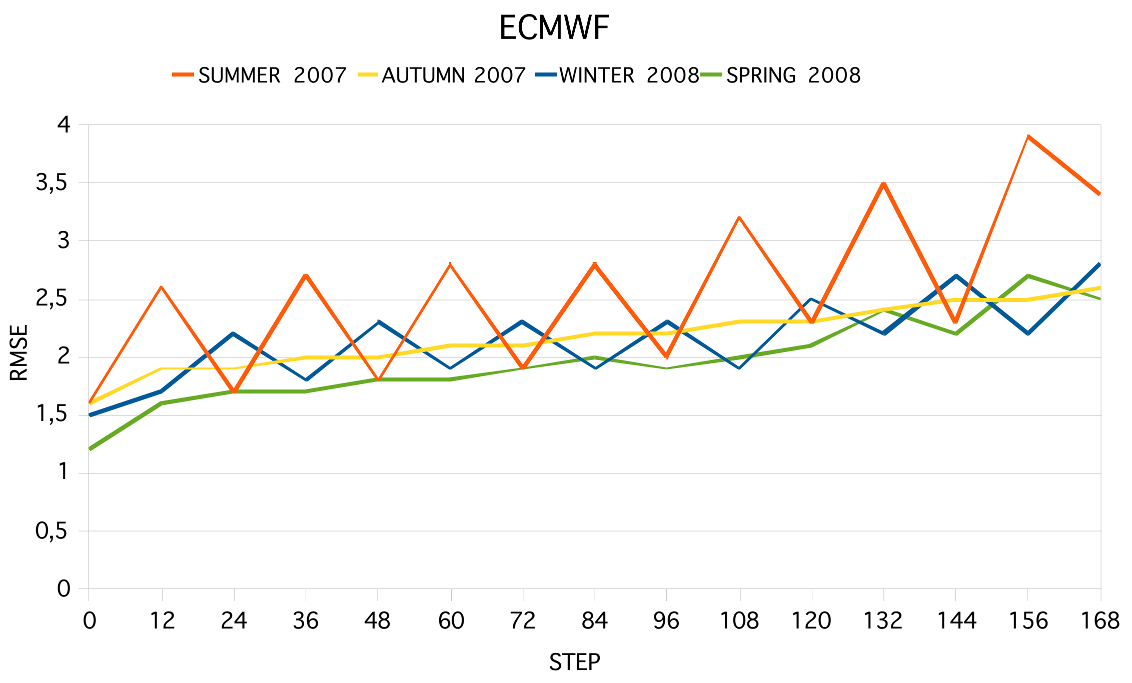

Fig.1 Seasonal RMSE of the 2 meter air temperature, for ten weather stations.

1 (08575) Bragança, (08 567) Vila Real, (08560) Viseu, (08545) Porto, (08548) Coimbra, (08570) Castelo Branco, (08579) Lisboa, (08558) Évora, (08562) Beja, (08554) Faro.

3.1.2 ECMWF model output compared to other NWP models

In figures 2 to 13, the seasonal RMSE of the 2 meter air temperature, mean sea level pressure and 10 meter wind speed are shown for a sample of ten weather stations, for both ECMWF and the operational ALADIN. Figures 14 to 17 show the HSS for the 6 h precipitation for the same locations.

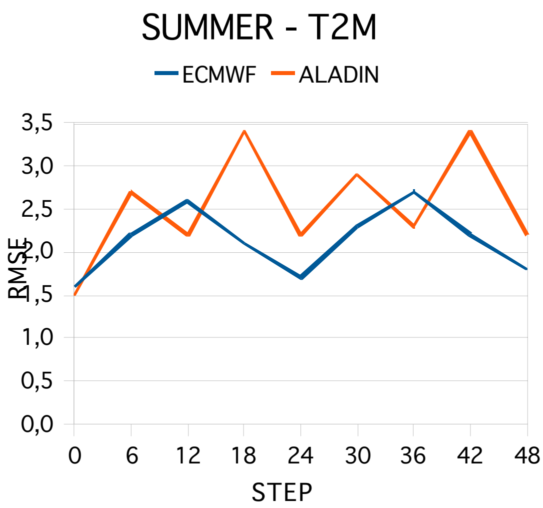

Fig.2 RMSE of the two meter air temperature for ECMWF and ALADIN, in summer 2007.

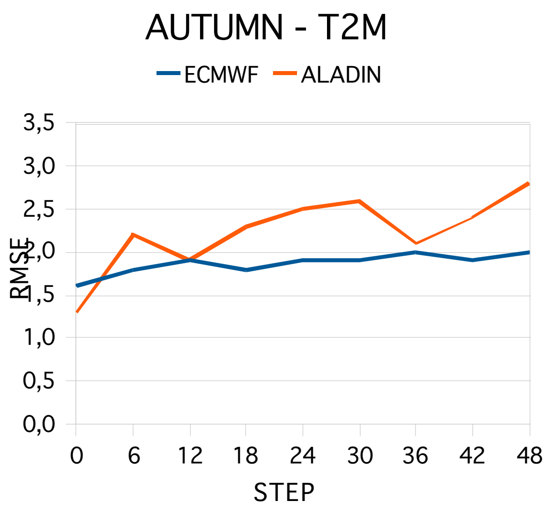

Fig.3 RMSE of the two meter air temperature for ECMWF and ALADIN, in autumn 2007.

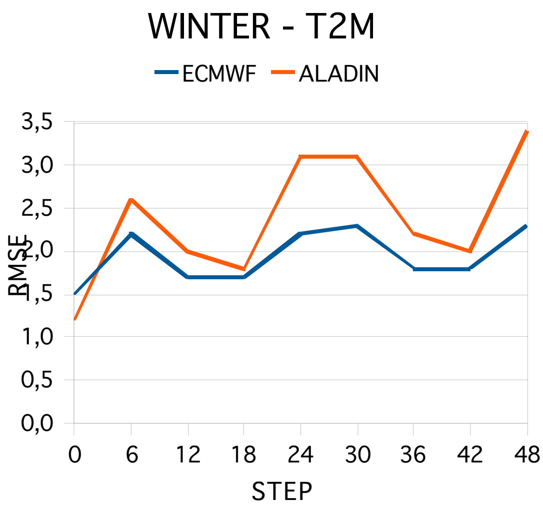

Fig.4 RMSE of the two meter air temperature for ECMWF and ALADIN, in winter 2007/8.

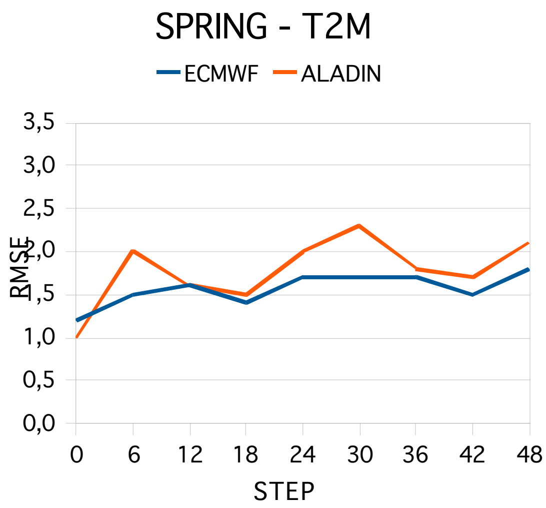

Fig.5 RMSE of the two meter air temperature for ECMWF and ALADIN, in spring 2008.

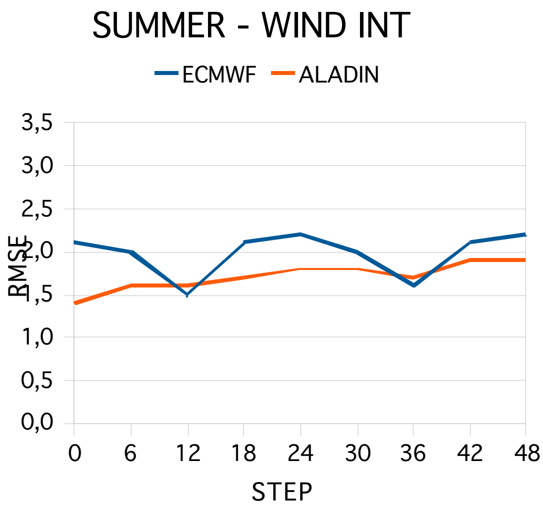

Fig.6 RMSE of the 10 m wind speed for ECMWF and ALADIN, in summer 2007.

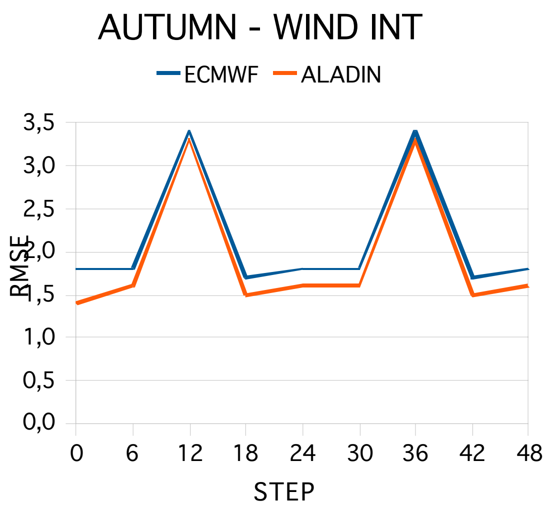

Fig.7 RMSE of the 10 m wind speed for ECMWF and ALADIN, in autumn 2007.

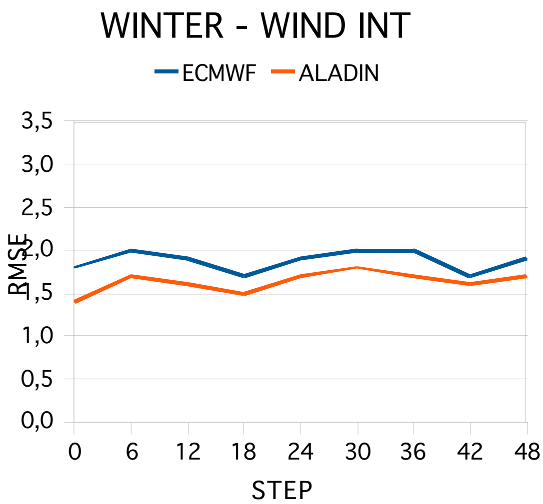

Fig.8 RMSE of the 10 m wind speed for ECMWF and ALADIN, in winter 2007/8.

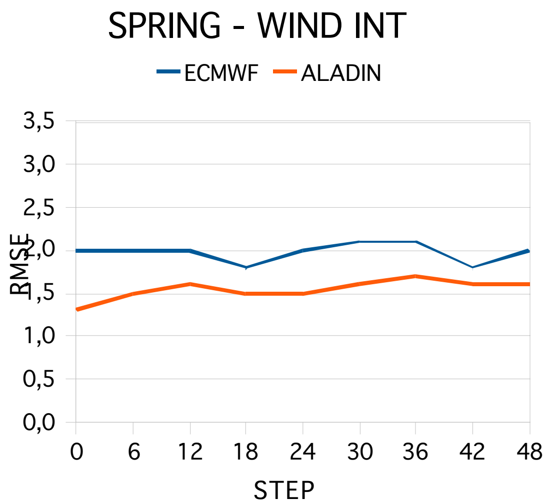

Fig.9 RMSE of the 10 m wind speed for ECMWF and ALADIN, in spring 2008.

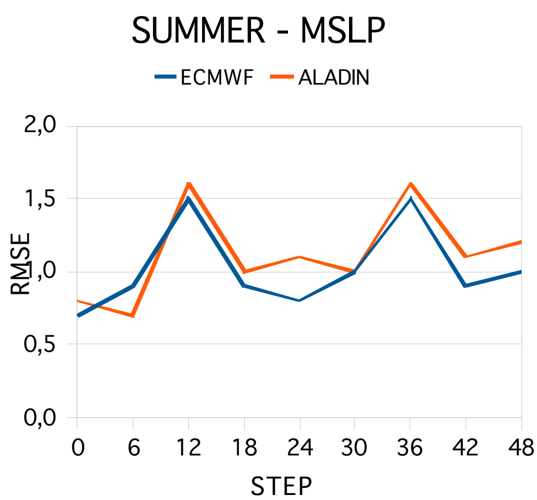

Fig.10 RMSE of the MSLP for ECMWF and ALADIN, in summer 2007.

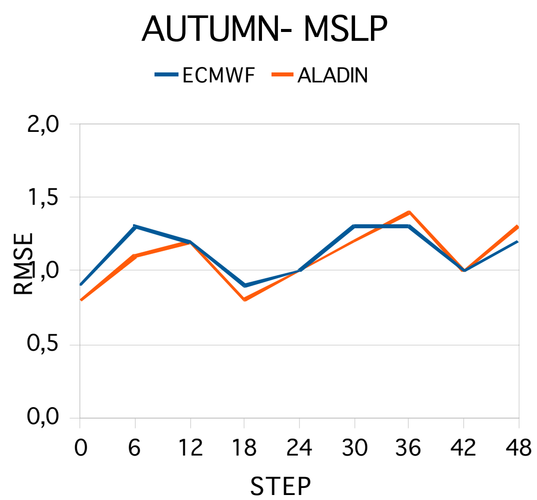

Fig.11 RMSE of the MSLP for ECMWF and ALADIN, in autumn 2007.

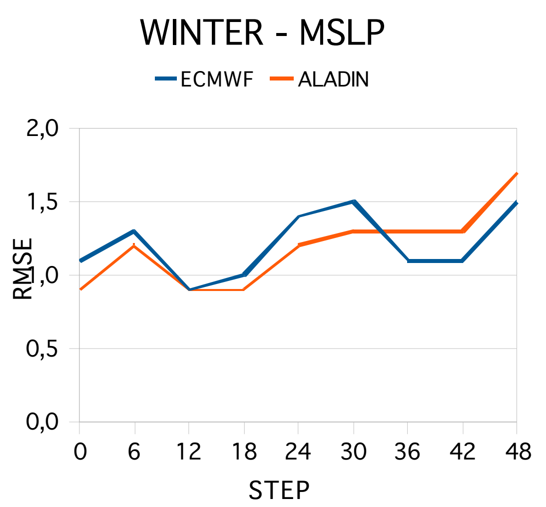

Fig.12 RMSE of the MSLP for ECMWF and ALADIN, in winter 2007/8.

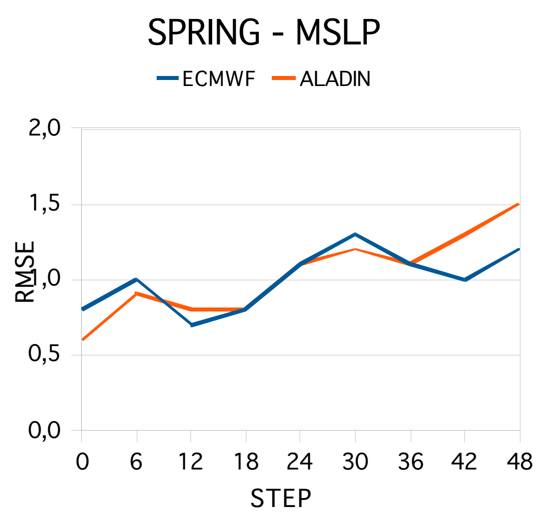

Fig.13 RMSE of the MSLP for ECMWF and ALADIN, in spring 2008.

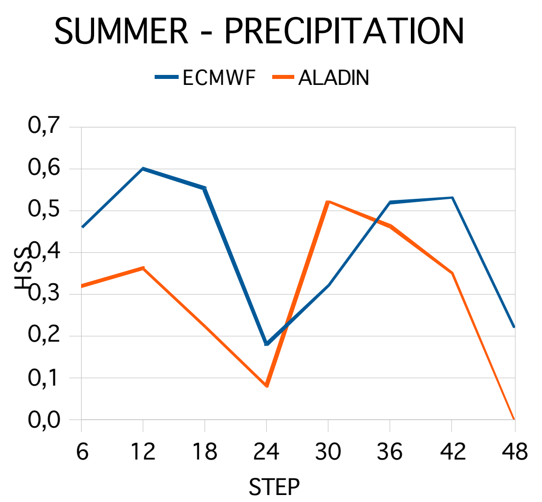

Fig.14 HSS of 6 h precipitation for ECMWF and ALADIN, in summer 2007.

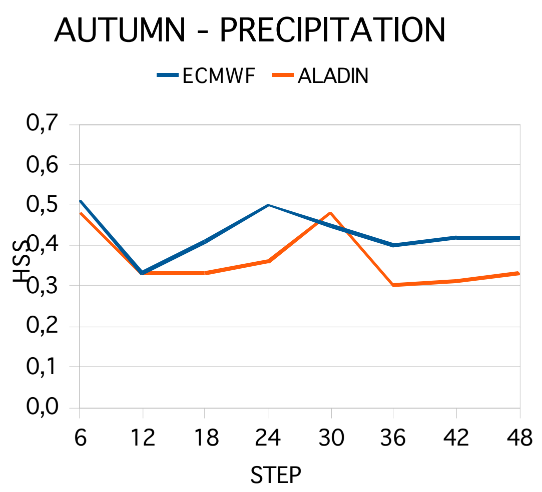

Fig.15 HSS of 6 h precipitation for ECMWF and ALADIN, in autumn 2007.

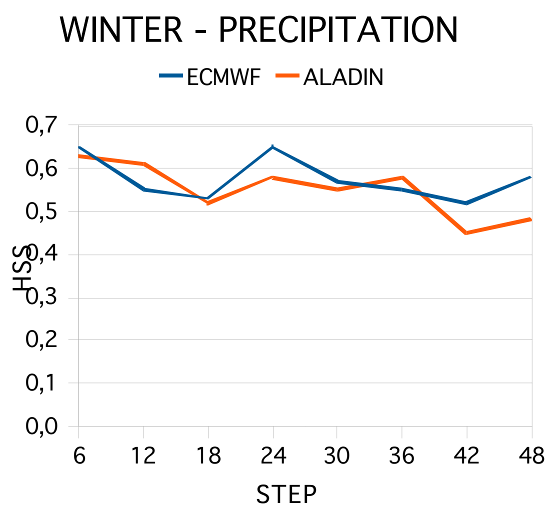

Fig.16 HSS of 6 h precipitation for ECMWF and ALADIN, in winter 2007/8.

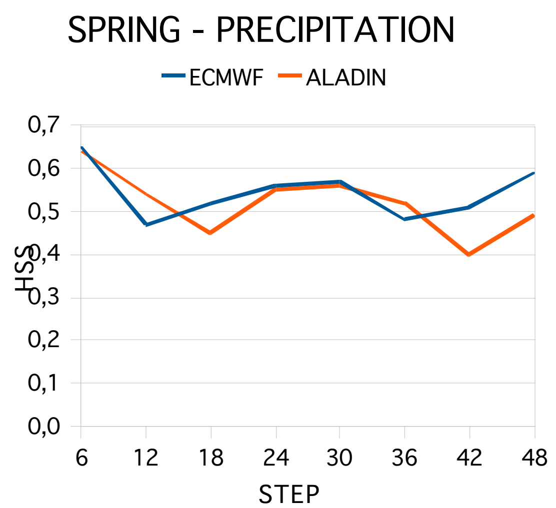

Fig.17 HSS of 6 h precipitation for ECMWF and ALADIN, in spring 2008.

The forecast skill of ECMWF for 2 meter air temperature is clearly better than ALADIN, because the latter has a clear negative bias, which can be noticeable during the night. In the AL32T3 ALADIN cycle, which will become operational very soon at IM, the feature is much reduced so that the skill becomes comparable.

When one compares the forecasts for the surface wind speed, ALADIN performs slightly better than ECMWF. For the remaining variables, scores are comparable.

3.2 Subjective verification

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

A subjective analysis of the mean sea level pressure field is done for the 12 UTC chart and is compared against the analysis of the model, in order to assess its behaviour.

Subjective verification of ECMWF forecasts products from the operational forecasters suggests that the forecasts provide are very good in the short term and provide useful guidance in the outlooks for days 5 to 7. Ocasionally, 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 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 February 18th 2008, an extreme event of precipitation occurred in the southern part of Portuguese mainland, affecting mainly the metropolitan areas of Lisboa and Setúbal. For example, in the 24 hours period between 9 UTC of February 17th and the 18th, several locations recorded over 100 mm, with some areas showing 40-65 mm in just three hours. The maximum amount recorded in 24 hours was 150,6 mm.

A study comparing the forecasts of several models was made. In this extreme event ECMWF forecasts underestimated considerably the total amount of precipitation, but did provide some reasonable guidance on its spatial distribution.