Application and verification of ECMWF products 2017

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1. Summary of major highlights

2. Use and application of products

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

Statistical adaptation of ECMWF forecasts is made to improve daily minimum and maximum temperatures forecasts in selected locations up to 10 days. The system comprises forecasts from ECMWF and AROME models, whenever available. The application computes linear regression model (MOS) and kalman filter (KALMAN) adjusted temperatures for each model and the final forecast is then computed as the average of all available forecasts. This framework is applied to the 2 m temperature and relative humidity, as well as the 10 m wind speed. Products are available with an hourly frequency up to 3 days and 3/6h frequency up to 10 days on IPMA's website (http://www.ipma.pt/pt/otempo_/prev.localidade.hora/) and on a mobile app (Meteo@IPMA).

2.1.2 Physical adaptation

The spectral density of ECMWF limited area ocean-wave model (WAM) is used together with the 10 m wind of the ALADIN model 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 with an hourly frequency and forecasts are produced until H+72h. Three-hour forecasts are also available on IPMA's portal (http://www.ipma.pt/pt/maritima/cartas/).

Under the scope of the objectives and tasks of the UPCAST project (Unified Platform for CBRN Accident/Attack Scenario Management, https://sites.google.com/a/tekever.com/upcast/home), the HYSPLIT model is used to forecast pollutant concentrations and air parcels trajectories over Portuguese sites. The HYSPLIT model (Hybrid Single-Particle Lagrangian Integrated Trajectory model) was chosen due to its ability to compute air parcels trajectories, dispersion and deposition simulations, based on Eulerian or Lagrangian modeling schemes. Briefly, HYSPLIT model can simulate a pollutant distribution starting with a single particle or puff, or by following the dispersive motion of a large number of particles.

To run the HYSPLIT model, meteorological data is retrieved from atmospheric models, namely ECMWF HRES. An example of HYSPLIT application is presented in Fig. 1, where forward trajectories and related forward dispersions pattern, were computed for a particular day, considering a generic 24h emission source.

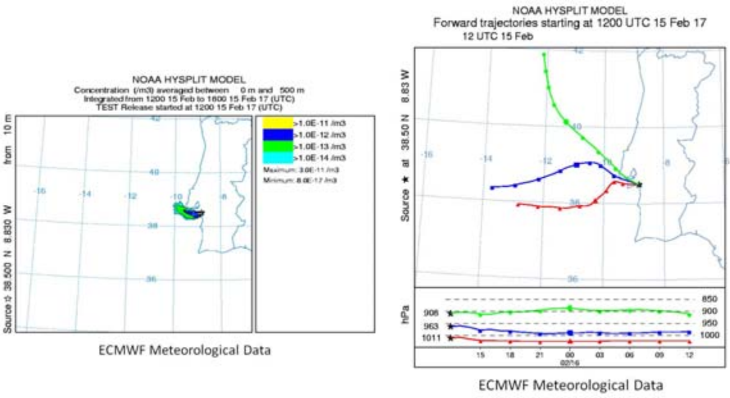

Fig. 1 Hysplit application example: concentration (left) and forward trajectory (right).

2.1.3 Derived fields

ECMWF's HRES data is used to compute several derivedprocessed fields such as:

a) 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;

b) The Fog Stability Index (FSI): this index is based on 2 m air temperature, 2 m dew point temperature, 850 hPa temperature and 850 hPa wind speed;

c) Several parameters commonly used to identify favourable environments for the development of severe convective storms are derived from operational ECMWF deterministic forecasts. These parameters include bulk wind shear in 0-1 km and 0-6 km layers, storm relative helicity in 0-1 km and 0-3 km layers and several instability indexes;

d) Lightning probability, using a logistic regression model with four stability indexes as predictors. The probabilities are computed up to 5 days, with a frequency of 6 hours, with an example being shown in Fig 1. This product provides useful guidance on the areas where convection and lightning will likely occur.

2.2 Use of ECMWF products

Apart from the HRES forecasts, in the short and medium range, many of the products derived from the ensemble forecasting are used operationally and considered to be very useful, namely in the case of automatic forecasts at different locations. 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 guidance on the 2 meter air temperature and precipitation for Portuguese mainland for the 3 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.

In the context of scatterometers at IPMA, ECMWF/IFS model has two main applications. First, model fields are used to derive ASCAT high resolution products. Secondly, to perform product comparison in the framework of triple collocation techniques. High resolution scatterometer products, such as ASCAT-6.25, are considered to be of critical importance at IPMA coastal studies. However these products are not distributed operationally as other scatterometer products. IPMA uses ASCAT-6.25 products extensively in process studies and therefore runs AWDP-2.4 in house. In the AWDP-2.4 ASCAT-6.25 wind processing ECMWF's land mask, sea surface temperature and first-guess winds are used. ECMWF/IFS forecasts are also used to assess measurement errors of NWP, scatterometer and buoys on the context of triple collocation method (this work is still in a preliminary phase).

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS)

3.1.2 ECMWF model output compared to other NWP models

Figure 2 shows the RMSE of ECMWF and AROME forecasts of the 2 m temperature, computed from the 00 UTC run, using 100 weather stations in mainland Portugal. Two periods are considered: summer 2016 and the 2016/7 winter. Fig. 3 and Fig. 4 are similar, but valid for the 2 m relative humidity and the 10 m wind speed.

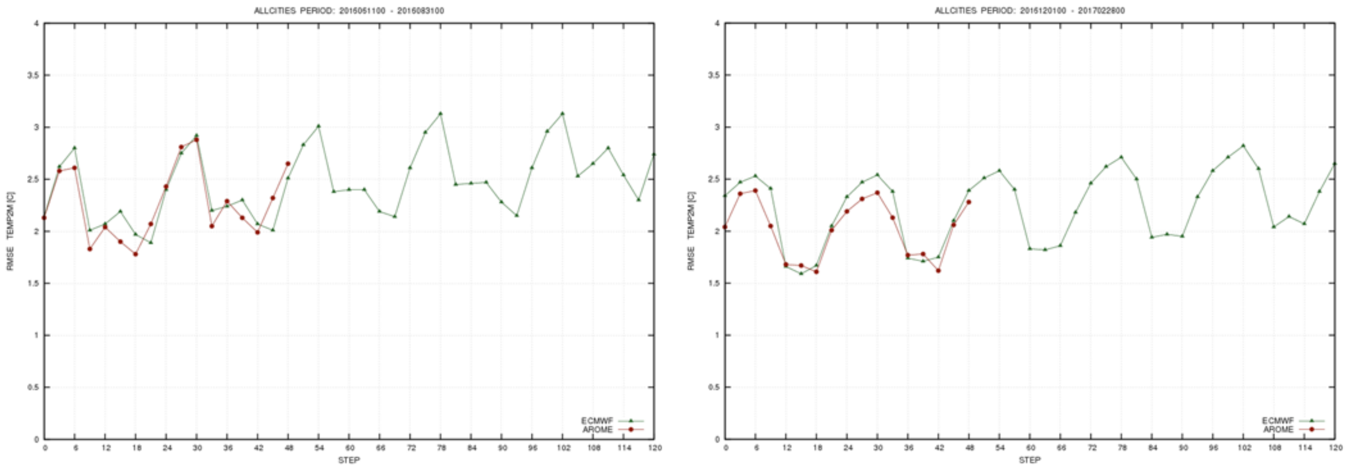

Fig. 2 RMSE of ECMWF and AROME forecasts of the 2 m temperature in the summer of 2016 (left) and in the 2016/7 winter (right). Results were computed for the 00 UTC run, using 100 weather stations in Portugal.

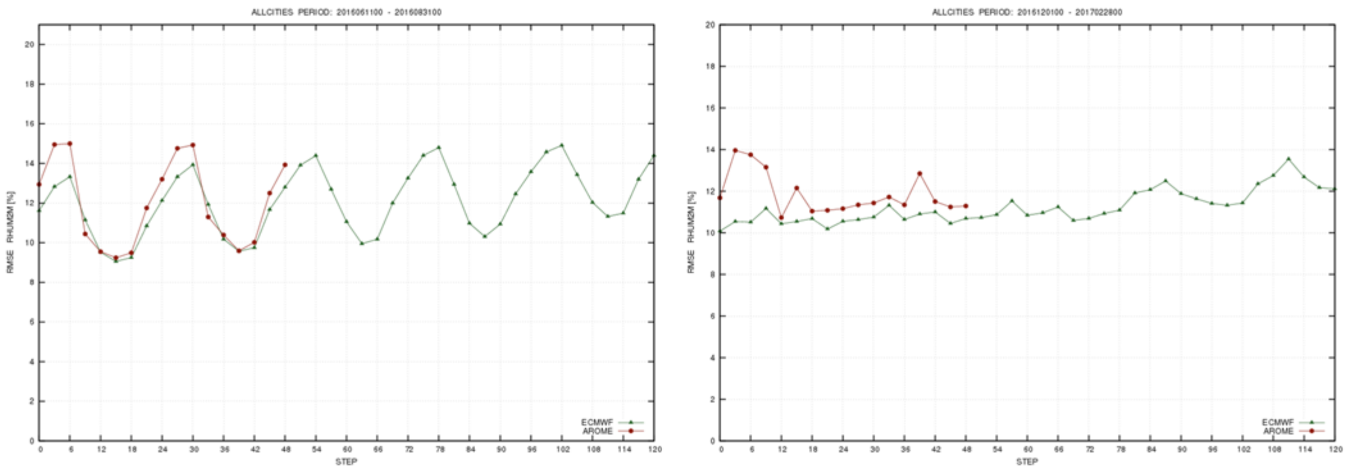

Fig. 3 RMSE of ECMWF and AROME forecasts of the 2 m relative humidity in the summer of 2016 (left) and in the 2016/7 winter (right). Results were computed for the 00 UTC run, using 100 weather stations in Portugal.

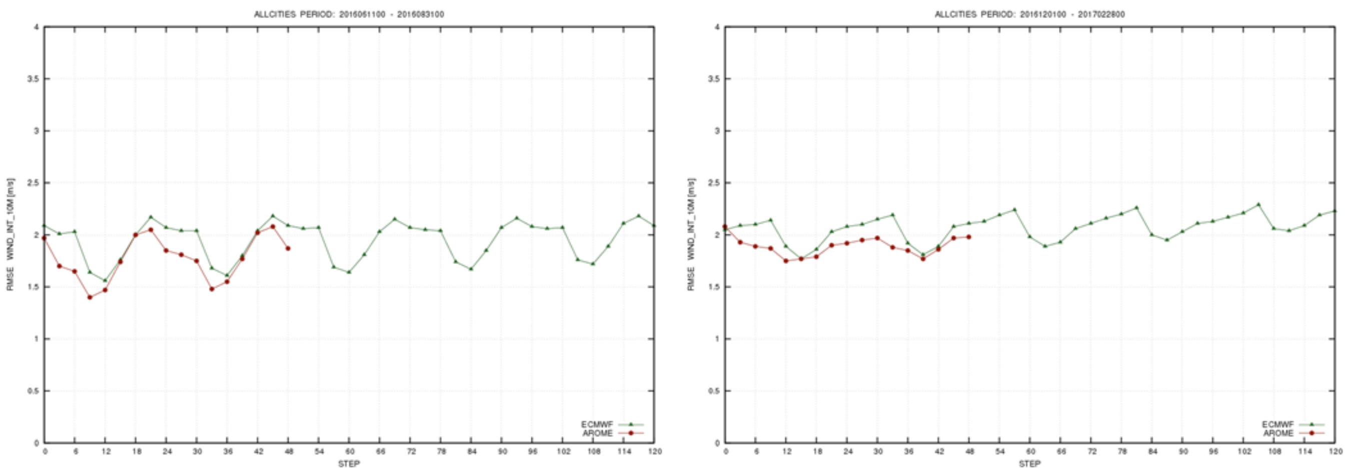

Fig. 4 RMSE of ECMWF and AROME forecasts of the 10 m wind speed in the summer of 2016 (left) and in the 2016/7 winter (right). Results were computed for the 00 UTC run, using 100 weather stations in Portugal.

In the two periods under assessment the models have similar values of RMSE, with ECMWF performing somewhat better in the case of the 2 m relative humidity. Taking a single forecast single observation approach, the Heidke Skill Score of the ECMWF and AROME precipitation forecasts is similar for 24h accumulations, with values ranging between 0.4 in summer and 0.6 in the winter period (not shown), in the first 72h. When using a 3h period, ECMWF shows slightly higher values when compared to AROME, which is expected due to the latter's higher resolution.

3.1.3 Post-processed products

3.1.4 End products delivered to users

3.2 Subjective verification

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

Subjective assessment of the forecasts made by the operational centre highlights that the model has been over-estimating light precipitation, both in weather fronts and convective events. In convective events, the model seems to produce precipitation earlier in afternoon than it should.

3.2.2 Case studies

In late April 2017 there was an event where the model showed some issues on identifying the areas where it would rain. Figures 5, 6 and 7 show the probability of 24h precipitation equal or above 1 (left) and 5 mm (right), respectively for the 00 and 12 UTC runs from April 27th and the 00 UTC from April 28th.
Both forecasts from the 27th of April suggested that it would rain in Lisbon as the probability of precipitation equal or above 1 mm/24h was over 0.8 in the 00 UTC run. The 12 UTC run showed a clear shift to the east of the area where the model suggested it would rain and the probability fell below 0.4 (fig. 6). On April 28th there were basically clear skies in Lisbon, with heavy rain affecting the south-east of mainland Portugal and the probability of precipitation in Lisbon was below 0.1 (fig. 7).

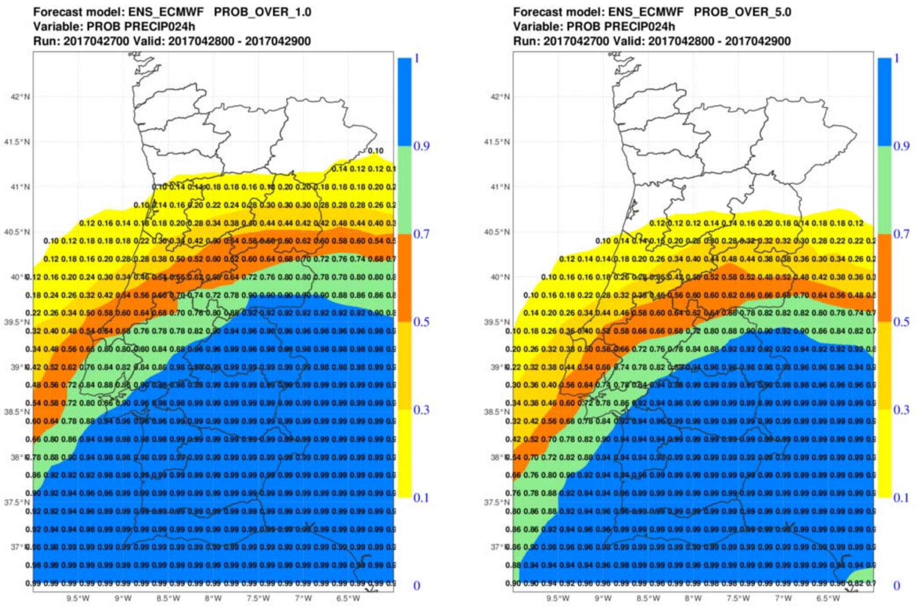

Fig. 5 Probability of 24h precipitation equal or above 1 (left) and 5 mm (right) from the 00 UTC run of 27 April 2017.

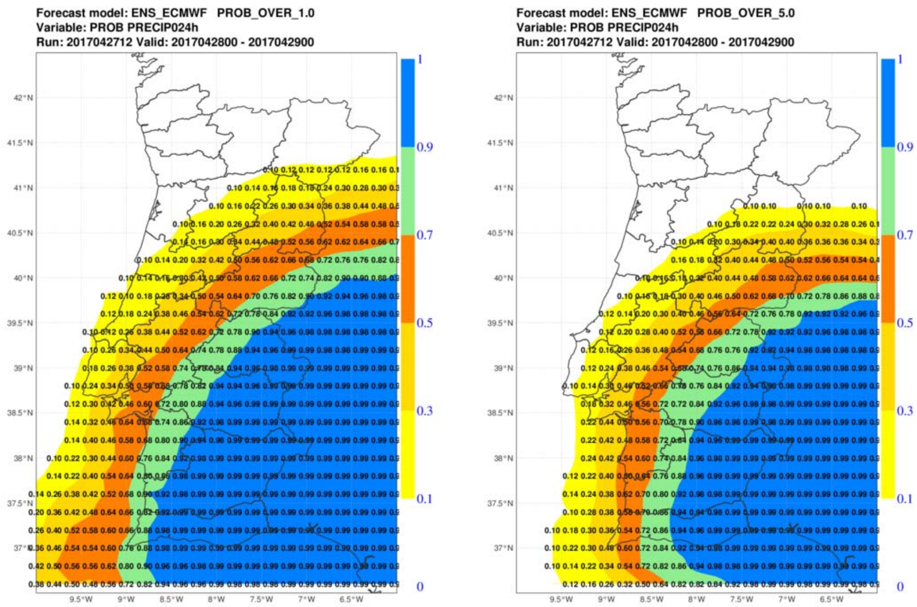

Fig. 6 Probability of 24h precipitation equal or above 1 (left) and 5 mm (right) from the 12 UTC run of April 27th 2017.

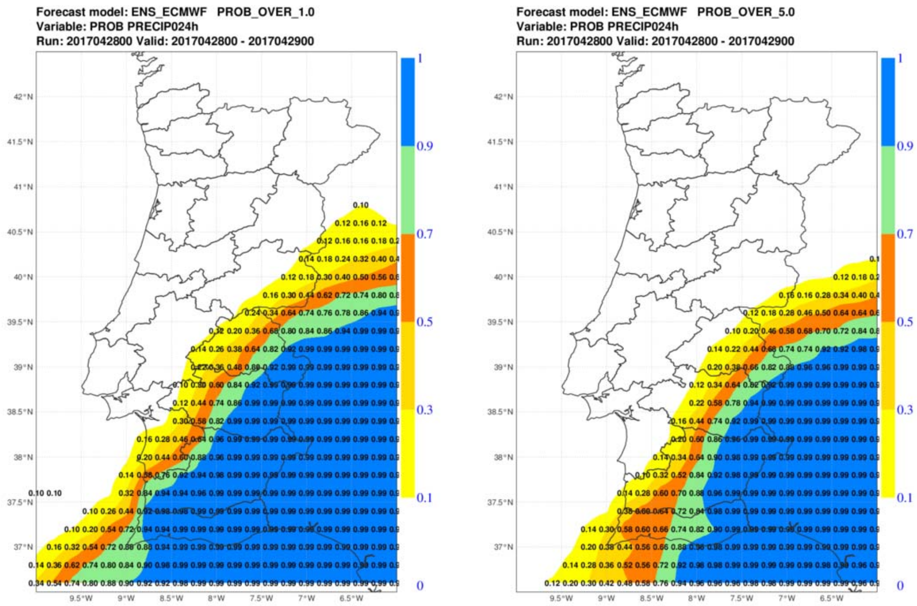

Fig. 7 Probability of 24h precipitation equal or above 1 (left) and 5 mm (right) from the 00 UTC run of April 28th 2017.

4. Feedback on ECMWF "forecast user" initiatives

5. References to relevant publications