Application and verification of ECMWF products – 2008

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1. Summary of major highlights

Since the autumn of 2006, a comprehensive and fully automated system for the operational verification of all the NWP products has been implemented at HNMS. Daily verification is performed for the surface and upper-air fields of the ECMWF products as well as for the three high-resolution limited area models (Skiron/Eta, COSMO and RAMS) that are used by HNMS forecasters. In addition, the relative performance of the three models is subject to intercomparison.

2. Use and application of products

The medium-range weather forecasts at HNMS are primarily based on the deterministic ECMWF forecast. Both the 00 UTC and 12 UTC cycles of the forecasts are received daily in 0.5 deg resolution. For short-range forecasting and for observation of local characteristics of weather patterns in Greece, the output of the limited area models is used in conjunction with the ECMWF products.

The EPS products (plumes, epsgrams, ensemble probability maps) are retrieved daily from the ECMWF web-site and are of particular value for the HNMS forecasters, especially the d+4 to d+7 forecast where the value of the deterministic forecasts is substantially reduced. An increasingly popular ECMWF product at HNMS is the Extreme Forecast Index for temperature and precipitation. As a measure from the distance from the climate (mean), the EFI maps are directly related to the severe weather events. The monthly (weekly anomalies) and seasonal forecasts are not used operationally but only for consultative or research purposes.

2.1 Post-processing of model output

2.1.1 Statistical adaptation

A Kalman-filter procedure is applied operationally to adjust the min and max 2m temperatures and this daily forecast is evaluated using ME, SDE and mean absolute errors. HNMS applies a Kalman filtering technique, based on non-linear polynomials, to the minimum and maximum temperatures of the NWP models, namely COSMO-GR, SKIRON/Eta and ECMWF. The application of the filter helps improve the temperature forecasts by eliminating possible systematic errors. The same technique is also used with the dew point temperature data (minimum and maximum) in order to correct biases related to relative humidity.

2.1.2 Physical adaptation

The ECMWF model output provides the lateral and boundary conditions for the execution of the daily simulations of the HNMS limited area models (Eta/Skiron, COSMO-GR and RAMS). In addition, ECMWF model output provides us with the necessary input for the MOTHY trajectory model. MOTHY is a sea pollution model (e.g. Daniel, 1996), which is applied in cases of oil spills in the eastern Mediterranean Sea. It is based on the numerical weather predictions of the ECMWF model, either the 00:00 UTC cycle or the 12:00 UTC cycle. In particular, the surface wind and the sea surface pressure are used as input data. The location (latitude and longitude) and the time of the incident are specified and the duration of the forecast for the dispersion of the oil is declared. HNMS operates MOTHY as the Marine Pollution Emergency Response Support System (MPERSS) for the Marine Pollution Incident (MPI) Area III East, which includes the eastern Mediterranean Sea.

2.1.3 Derived fields

2.2 Use of products

As mentioned above, the HNMS forecasting centre uses ECMWF products in conjunction with the products of its limited area models for the general 6-day forecast that is provided to the public as well as for the sea state forecast for the Eastern Mediterranean and the forecast for aeronautical purposes.

3. Verification of products

In order to determine the quality of the NWP products of the local models and the ECMWF models and to gain insight into their accuracy and usefulness, a verification process is essential. At HNMS, a versatile, automated verification system was developed and has been in operation since the end of 2006 in order to provide objective statistics regarding the performance of the different models. The verification is divided into two parts: upper-air fields and surface fields. For the upper-air fields, the gridded forecast fields for temperature and geopotential height at different pressure levels are compared with the relative analysis charts from the ECMWF model output.

The forecast values of weather parameters are compared with synoptic meteorological data from the HNMS' operational network of stations and a range of statistical scores is calculated on a daily, monthly and yearly basis.

The surface verification is performed by using the SYNOP data from 30 surface stations every 6 hours (Fig.1). The parameters that are verified are: MSLP, 2m temperature, 2m dew point temperature, 10m wind speed/direction and total precipitation. The choice of the grid point from the model domain to represent the weather station is a very important one. The synoptic value for each parameter at each station is compared with the value derived from the deterministic model at three different points: the closest point of model grid to the station, the interpolated value of the parameter using the nine closest points to the station and with the optimum grid point taking into consideration the proximity of the point to the sea or the elevation of the station. In the case that we need to evaluate the mean performance of a model for all 30 stations for a long period of time, it was found that the interpolated value compares best to the actual values of the weather variables from the meteorological stations. On the other hand, when we need to stratify the stations according to their special characteristics it is best to use the optimum or closest grid point of the model for comparison. The results presented in this report were produced using the interpolated value.

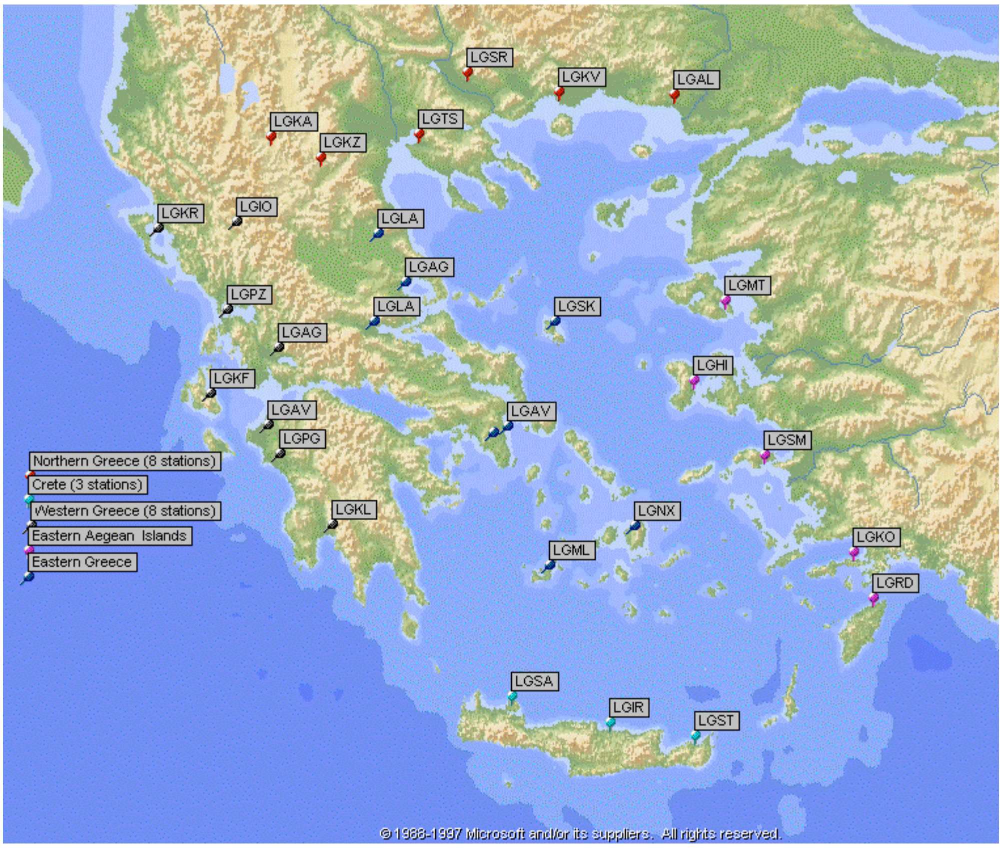


Fig.1 The 30 surface stations that are used for the verification of surface parameters in Greece.The pins indicate the number of stations in the different regions.

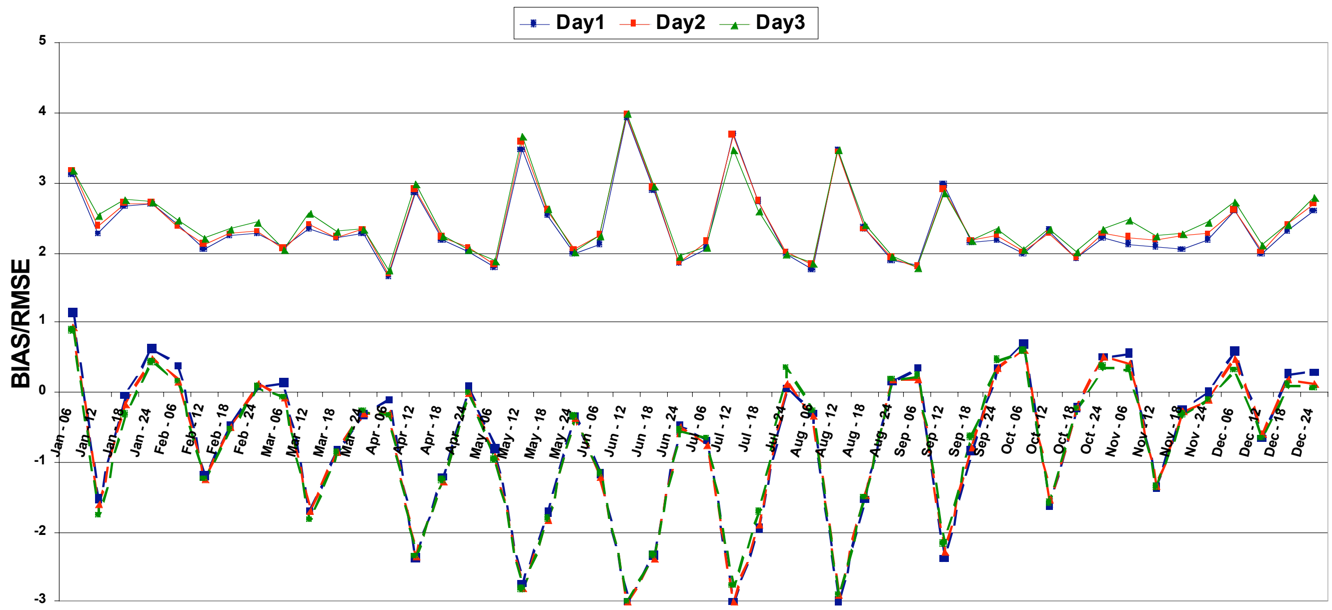
3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

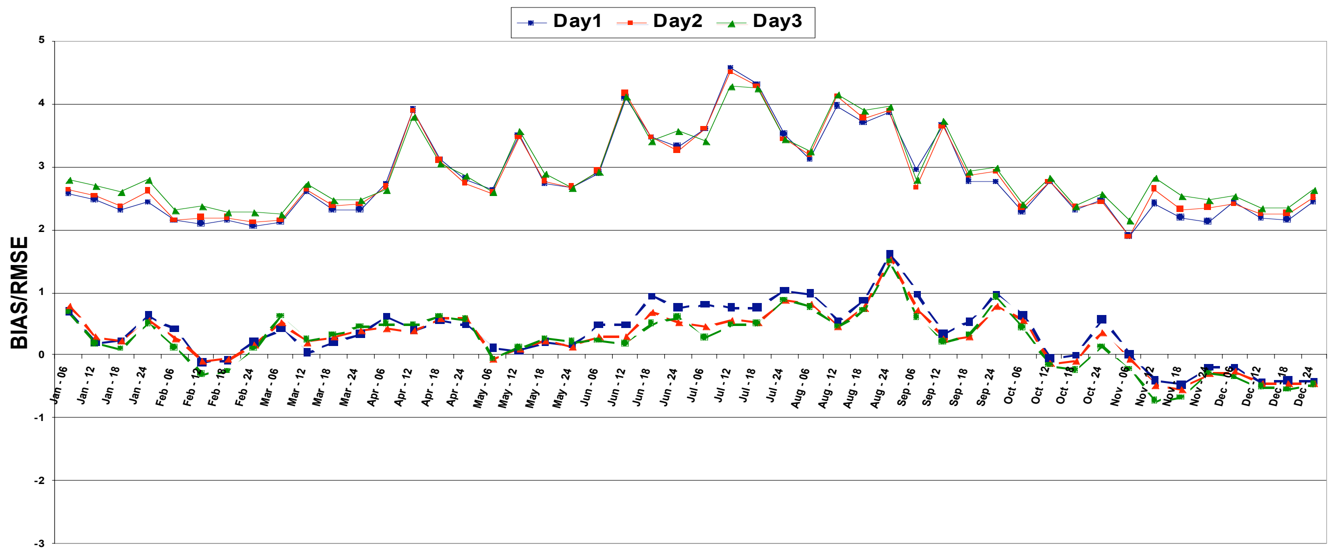
In order to introduce greater temporal resolution to the analysis, the BIAS and RMSE were calculated for each 6-hour period for each forecast day and averaged for each month for temperature at 2m (T2m), dew point temperature at 2m (Td2m) and wind speed (Figs. 2,3 and 4 respectively). The results are presented for the whole year of 2007 and with the different colored lined one can see the results of the first, the second and the third forecast day. This yearly approach allows us to determine the possible impact of changes made to the model configurations in 2007. With respect to the monthly results for T2m and Td2m (Fig. 2 and Fig. 3), the ECMWF model in general underpredicts T2m and overpredicts Td2m and produces a larger RMSE during the spring and summer months. Moreover, a very small deterioration of the forecast skill is observed over time. This is almost negligible in the ECMWF model during the warm period.

Regarding the 10m wind speed (Fig. 4), the ECMWF model consistently overpredicts wind speed through all four seasons. A very distinct daily cycle is evident in the BIAS results for the ECMWF model, particularly during the spring and summer months, with the greatest overestimation occurring during midday. With respect to RMSE, as for T2m, there is little month-to-month variation for all three models. As with T2m, there is little variation between the three forecast days for the ECMWF model.

2m TEMP - ECMWF



2m Dew TEMP - ECMWF



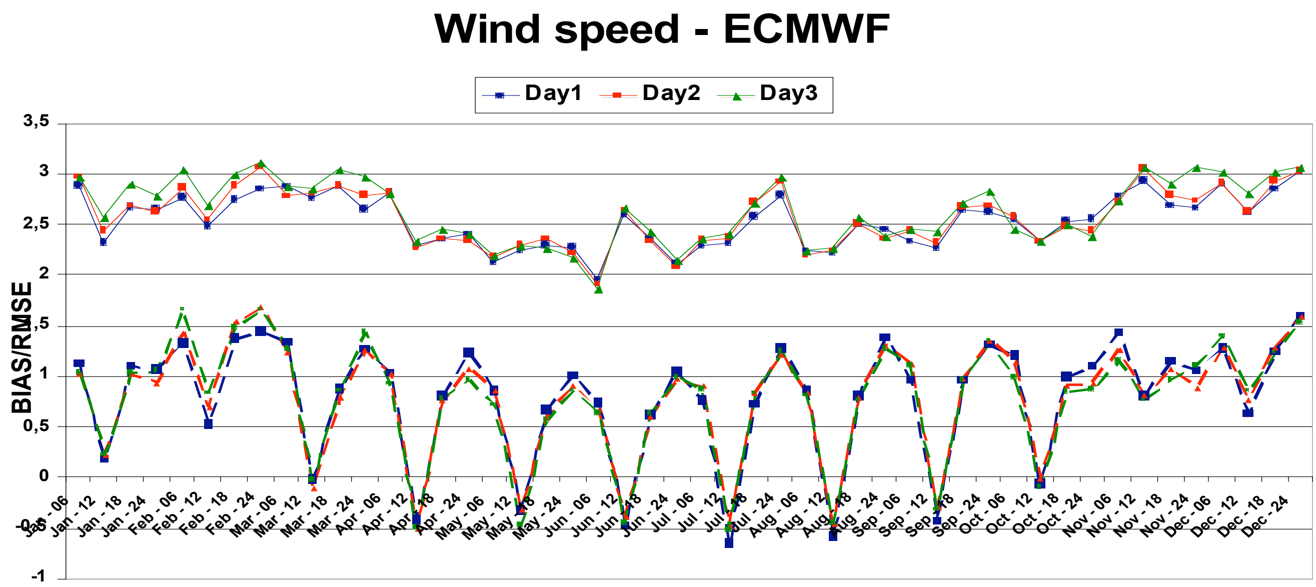


Fig.5 Month by month evolution of BIAS/RMSE for T2m, Td2m and Wind Speed.

Verification of the 6h total precipitation is performed using the rain gauge data from the 30 synoptic stations with three different points (previously described in section 3) for each station. Categorical verification of the forecasts is carried out based on the following categories: 0-0.1mm, greater than 0.5mm, greater than 1mm, greater than 3mm , greater than 5mm and greater than 10mm of precipitation. Contingency tables and various statistical scores are calculated for the twelve month period (Jan-Dec 2007) and for the t+24 to t+30 forecast interval (Table 1).

	>0.5 mm	>1 mm	>3 mm	>3 mm	>10 mm
FBI	2.593	2.410	1.524	1.023	0.468
PC	0.883	0.918	0.961	0.978	0.992
POD	0.842	0.771	0.496	0.322	0.106
FAR	0.575	0.680	0.674	0.686	0.773
POFD	0.114	0.075	0.027	0.012	0.002
KSS	0.728	0.696	0.470	0.310	0.104
ORSS	0.953	0.950	0.946	0.952	0.960
ETS	0.264	0.263	0.230	0.181	0.076

Table 1. Statistical scores for the 6h precipitation for t+36 forecast of the 00UTC run for Jan-Dec 2007.

The scores indicate an over-forecasting of the precipitation events for the lower thresholds while the opposite is evident for higher precipitation amounts. The POD values are quite satisfactory for very small amount or rain (mainly indicating successfully if it rained or not) but it deteriorates quickly over forecast time (Fig.5) and for higher threshold values. The same characteristics can also be extracted from the skill score (KSS), with values very low (no skill forecast) for precipitation higher than 10mm (Fig.5).

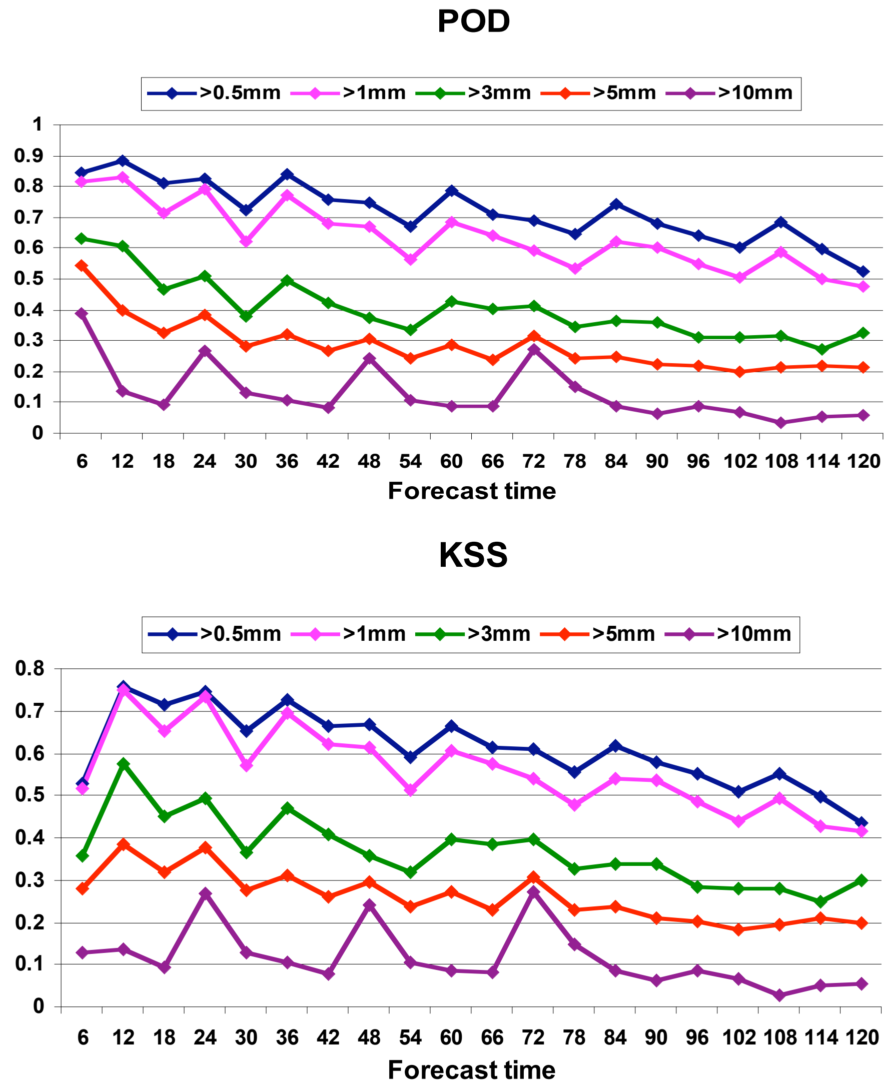


Fig.5 Probability of Detection (POD) and Hansen-Kuipers Skill Score (KSS) for different thresholds per 6h

3.1.2 ECMWF model output compared to other NWP models

HNMS operates two high-resolution Numerical Weather Prediction (NWP) systems (COSMO-GR and SKIRON/Eta that provide detailed deterministic forecasts for an extended area around Greece on a daily basis. The operational domain of COSMO-GR covers an area with a longitude range of 45^o and a latitude range of 24.5^o, with 35 vertical levels and a horizontal resolution of 0.0625^o (~7km). The operational domain of SKIRON/Eta at HNMS is: 26N-56N, 20W-40E and it has spatial resolution of 0.06^o (~6-7km).

Comparison of the performance of ECMWF model with the limited area models is performed on a regular basis. As indicated in the plots of the RMSE for the 2m temperature and the 10m wind speed, the models give similar results for the 72 hour forecast with slightly increased errors for the ECMWF model for the wind speed (Fig. 6).

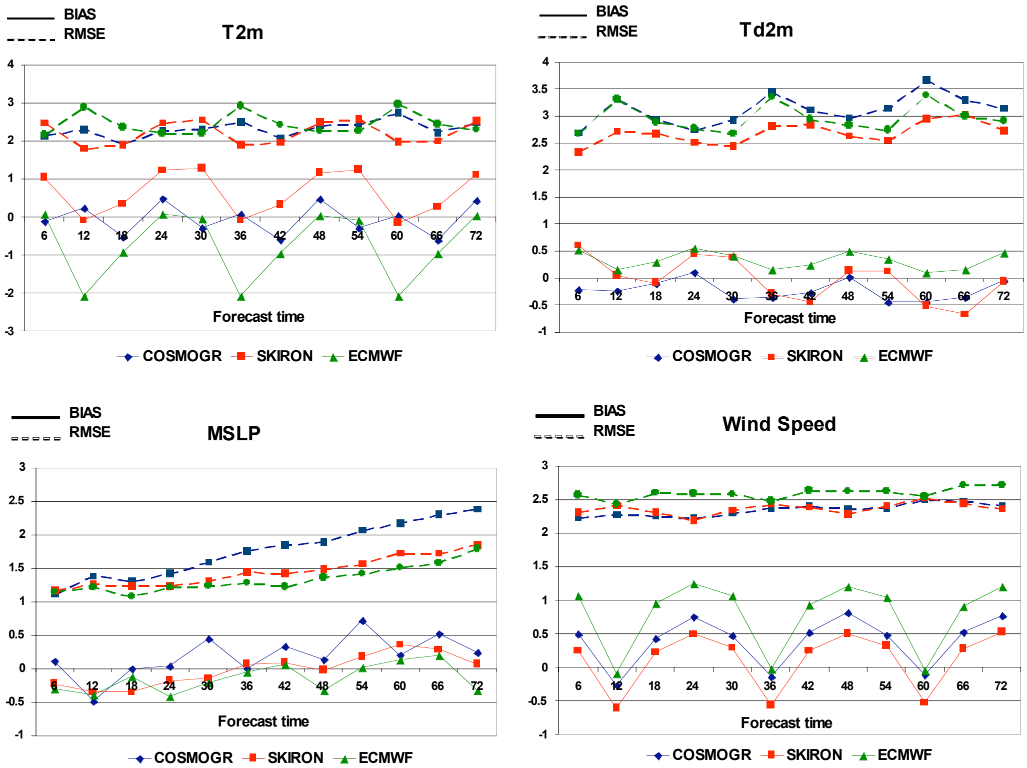


Fig.6 BIAS /RMSE results for the four weather parameters averaged over the year 2007 over all stations

3.2 Subjective verification

4. References to relevant publications

Galanis, G., P. Louka, P. Katsafados, G. Kallos, I. Pytharoulis (2006), Application of non-linear Kalman filters to numerical weather predictions. *Annales Geophysicae,* **24**, 2451–2460.

Daniel, P. (1996), Operational forecasting of oil spill drift at MeteoFrance, *Spill Science and Technology Bulletin*, Vol. 3, No. 1/2, pp. 53-64.