Application and verification of ECMWF products 2009

Hungarian Meteorological Service

1. Summary of major highlights

The objective verification of ECMWF forecasts have been continued on all the time ranges from medium range forecast to seasonal forecast as in the previous years. ALADIN/HU model has been operationally driven by ECMWF lateral boundary conditions since October 2008.

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

2.1.2 Physical adaptation

Dispersion and forward/backward trajectory models based on ECMWF and ALADIN models have been operationally used for more than ten years.

In the middle of 2008 based on the positive experimental results it was considered to use the ECMWF IFS lateral boundary conditions (LBC) for driving the limited area model ALADIN. After having successful real-time double test-suite of the use of IFS boundaries with respect to ARPEGE (French global model) boundary conditions it was operationally introduced in October 2008 (*Bölöni*, 2009). ALADIN/HU model coupled by ECMWF lateral boundary conditions operationally provides short range forecasts four times at day for forecasters. At 00 UTC +54h, at 06 and 12 UTC +48h and at 18 UTC +36 forecasts are made.

The nowcasting system of the Hungarian Meteorological Service uses ECMWF deterministic forecasts as basic background information. The first step of the nowcasting system is making numerical prediction using high resolution LAM models. Nowadays MM5 and WRF models are used. Both models are set with 2.5 km horizontal resolution 32 vertical levels and non-parameterized convection. Using ECMWF data there are 4 daily model runs (00 06 12 18 UTC). Observations are also assimilated (sounding and surface information) using nudging technique at MM5 and 3DVAR technique at WRF. The nowcasting system (MEANDER) uses real time remote sensing and observation and the above LAM information to make 3 hours forecast in every hour.

2.1.3 Derived fields

Clustering for Central European area has been operationally made since 2003. Cluster mean and representative members of the clusters are derived, a wide selection of the meteorological fields is available to the forecasters for both short and medium time range (*Ihász et al*., 2009). Several derived parameters from the deterministic and ensemble models are operationally available too. More details are available in '*Application and verification of ECMWF products, 2004'*. Altogether more than 100 EPS fields are derived.

2.2 Use of products

A wide range of the products are operationally available within the Hungarian Advanced Workstation (HAWK-3) for forecasters. Beside this tool quite a lot of special products, like EPS meteograms, EPS plumes, cluster products are available on intranet for the whole community of the meteorological service. EPS meteograms are available for medium, monthly and seasonal forecast ranges. EPS calibration using VarEPS reforecast dataset was developed in 2008, products (EPS plumes are among them) have been operationally available for forecastters (*Ihász et al.*, 2009, *Üveges*, 2009).

3. Verification of Products

3.1 Objective verification

3.1.1 Direct ECMWF model output

(i) in the free atmosphere
(ii) local weather parameters for locations

The objective verification has been performed by the Objective Verification System (OVISYS) produced by the Hungarian Meteorological Service. More details are available in '*Verification of ECMWF products, 2006*'.

In the recent study the 00 and 12 hours runs of ECMWF model were verified against all the Hungarian SYNOP observations for the whole 2008 year. The input forecast values for ECMWF were taken from a 0.5°x0.5° post-processing grid. The verification was performed for the following variables:

- 2m temperature
- 2m relative humidity
- 10m wind speed
- Total cloudiness
- Daily accumulated amount of precipitation

BIAS and RMSE scores until 168 hours (only for ECMWF) are computed. The computed scores are presented on Time-TS diagrams (with the forecast range on the x-axis) (Fig 1-5).

2m temperature:

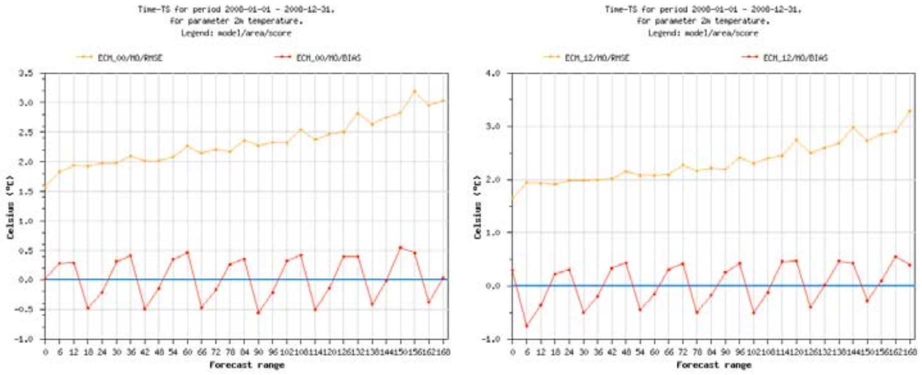

Fig. 1 RMSE and BIAS values for ECMWF 2m temperature forecasts for Hungary. The RMSE values are slightly increasing with the forecast range and the BIAS fluctuates around zero with a strong diurnal cycle.

2m relative humidity:

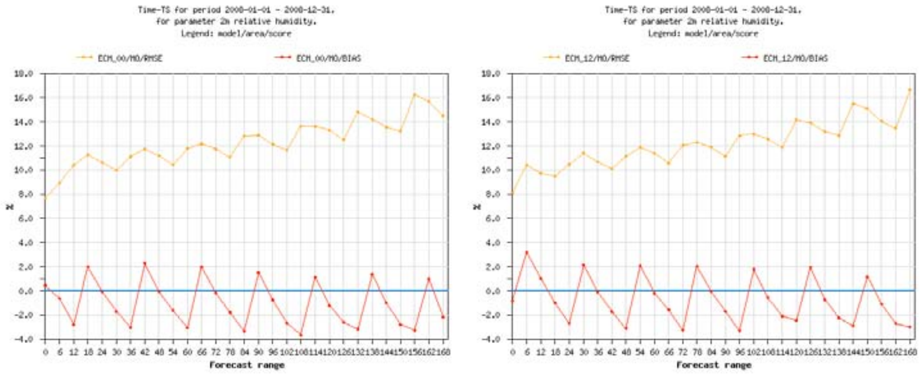

Fig. 2 RMSE and BIAS values for ECMWF 2m relative humidity forecasts for Hungary. The RMSE values are slightly increasing with the forecast range and the BIAS fluctuates between -3 and 3 % with a strong diurnal cycle.

10m wind speed:

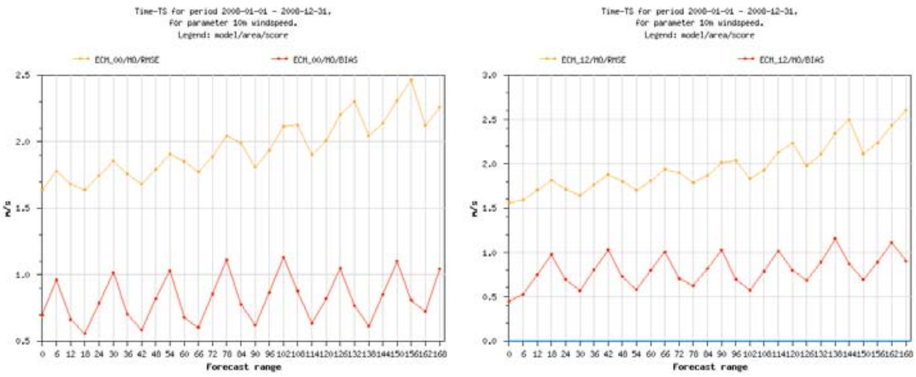

Fig. 3 RMSE and BIAS values for ECMWF 10m wind speed forecasts for Hungary. The RMSE values are rather constant in the first couple days, then there is a slight increase afterwards. The BIAS fluctuates in a diurnal cycle at a range of about 0.3 m/s (first 3 days) and about 0.5m/s (later).

Total cloudiness:

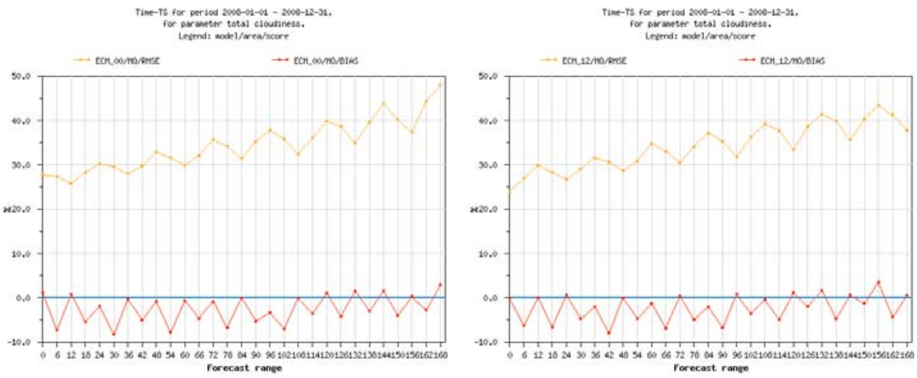

Fig.4 RMSE and BIAS values for ECMWF total cloudiness forecasts for Hungary. There is a cloudiness underestimation at all ranges (around –5 and –10 percent). The RMSE values are strongly increasing along the forecast ranges.

Daily accumulated amount of precipitation:

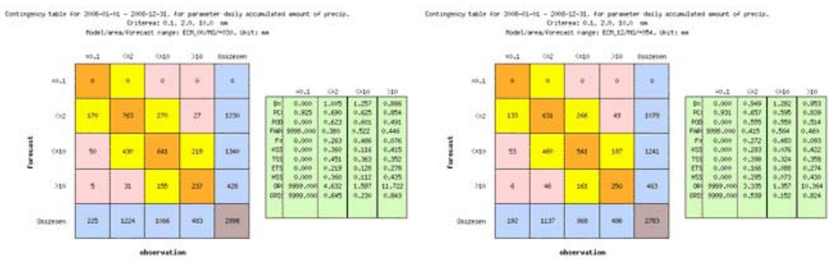

Fig. 5 Contingency table for the 24 h accumulated precipitation for the second forecasted day (between 30 h and 54 h forecast ranges) of the 00 UTC runs. The scores show that the ECMWF model underestimates the large precipitation events and generally overestimate the small precipitation events.

3.1.2 ECMWF model output compared to other NWP models used by the HMS

Hereafter the ECMWF and ALADIN/HU models will be compared in the first 48 forecast ranges with the help of OVISYS. The forecast values from ECMWF are taken from a 0.5°x0.5°, while for the ALADIN model from a 0.1°x0.1° post-processing grid (the original mesh size of the ALADIN model is 8km on Lambert projection). The scores are computed against SYNOP observation for the Hungarian territory for the year of 2008 (Fig. 6-9).

2m temperature:

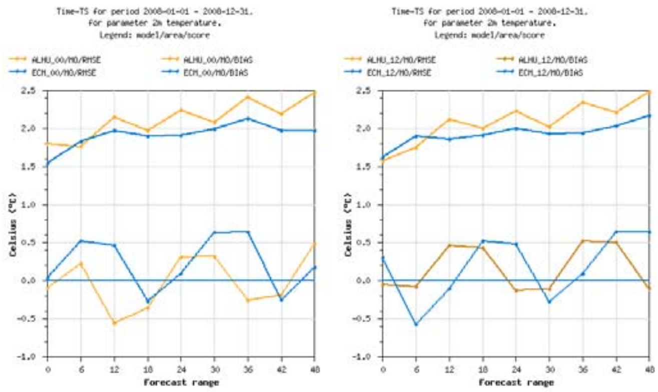

Fig. 6 Comparison of BIAS and RMSE values for ECMWF (blue) and ALADIN (orange) 2m temperature forecasts over Hungary. The scores are similar with some advantage of the ECMWF forecasts from the second day onwards (in terms of RMSE).

2m relative humidity:

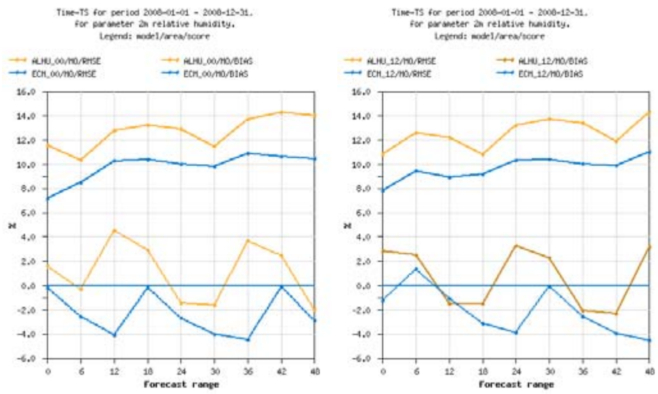

Fig. 7 Comparison of BIAS and RMSE values for ECMWF (blue) and ALADIN (orange) 2m relative humidity forecasts over Hungary. The ECMWF forecast is significantly better in terms of both parameter.

10m wind speed:

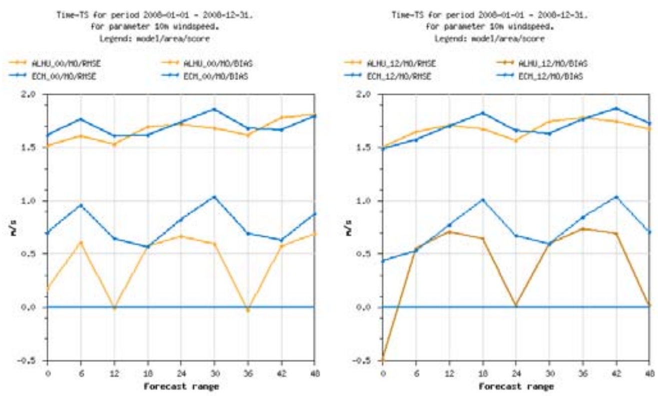

Fig. 8 Comparison of BIAS and RMSE values for ECMWF (blue) and ALADIN (orange) wind speed forecasts over Hungary. In RMSE there is no significant difference between the two model forecasts, in BIAS ALADIN is better than ECMWF.

Total cloudiness:

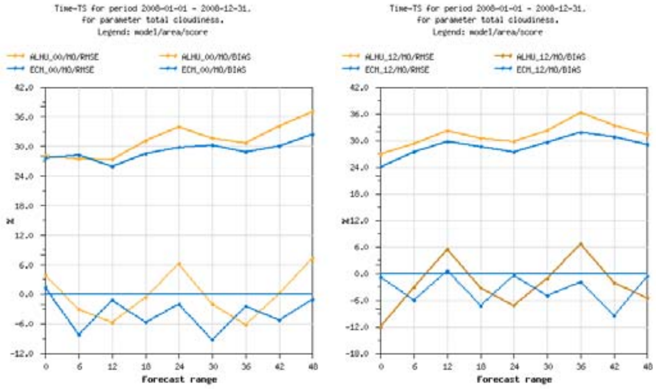

Fig. 9 Comparison of BIAS and RMSE values for ECMWF (blue) and ALADIN (orange) total cloudiness forecasts over Hungary. RMSE values of the ECMWF forecasts are smaller than that of the ALADIN ones during all time range. There is a systematic underestimation in the ECMWF forecasts.

3.1.3 Post processed products

Post processed products are regularly verified in OVISYS. On Fig. 10 RMSE of the raw and post processed 2m temperature and 2m relative humidity forecasts is shown for 2008.

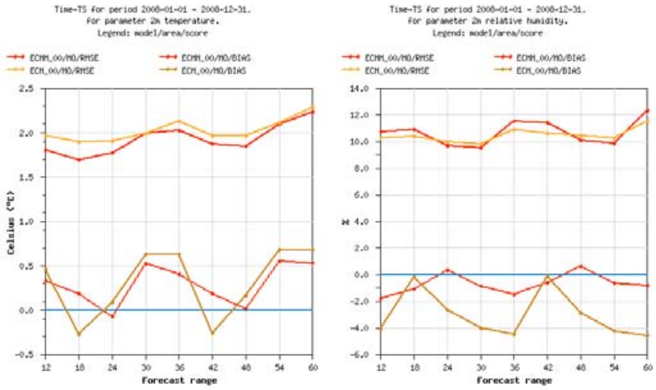

Fig. 10 RMSE of 2m temperature and 2m relative humidity (raw – orange, post processed - red)

3.1.4 End products delivered to users

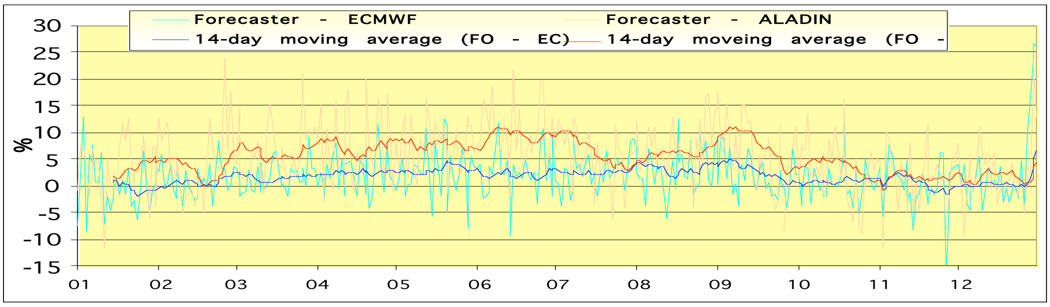

Fig. 11 Difference of the daily Complex Score for *the first day* calculated for the Forecaster and the models in 2008 (difference between the Forecaster and ALADIN as well as the Forecaster and ECMWF). 14-day moving averages are also shown.

Positive values indicate higher overall skill for the Forecaster. The daily improvement of the Forecaster on ECMWF has usually remained under 5 – 10% except for the end of December, when a strong winter inversion situation developed in Central-Europe with overcast sky due to low clouds. The ECMWF model was not capable of describing this situation, which also resulted in wrong temperature forecasts and gave a chance for operational Forecasters to improve up to 25 % on model forecasts in these days as shown in the Fig. 11.

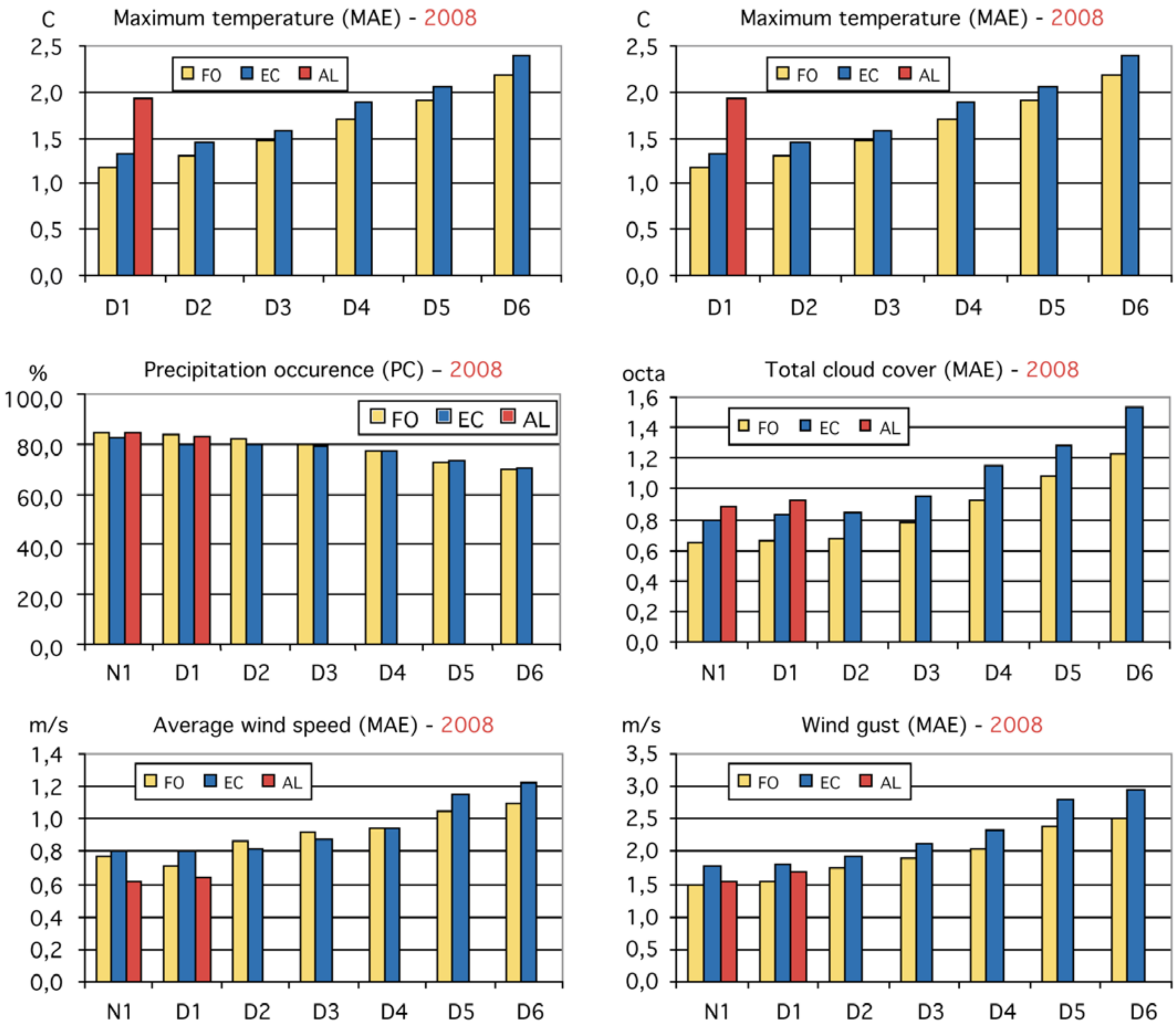

Fig. 12 Mean Absolute Error (MAE) of temperature, total cloud cover, average wind speed and wind gust forecasts and Percent Correct (PC) of precipitation occurrence forecasts for different forecast ranges (D0 stands for the first night where relevant) in case of ALADIN (AL), ECMWF (EC) and the Operational Forecaster (Fo) for 2008.

In case of minimum and maximum temperature, total cloud cover as well as wind gust, the operational forecaster was able to improve on the model forecasts on average for all forecast ranges. For precipitation occurrence, there is no significant difference in skill between automated forecast products and those prepared by the forecasters. In case of the average wind speed, forecasts generated automatically from ALADIN proved to be the best on average for short-range, while operational forecasters were able to improve on ECMWF forecasts except for day 2, 3 and 4 (Fig 12).

3.1.5 Seasonal forecasts

At the Hungarian Meteorological Service (HMS) a statistical technique for long-range forecasting was developed and forecasts based on this method had been issued for more than 20 years. Beside the operational statistical method, in 1998 investigation of the applicability of ECMWF's long-range forecasting system System1 for Hungary was started. In March 2003 the seasonal forecasts based on the ECMWF’s System2 became operational in the HMS. Since May 2007 the operational forecasts are based on System3. Forecasts for the 2 metre, maximum and minimum temperature and the amount of precipitation, for six regions of Hungary are issued in every month.

On Fig. 13 the mean absolute error skill score of the country wide average of the above mentioned parameters is shown for the six forecasted months of the seasonal forecasts. The 12 forecasts issued in 2008 were divided into single months, the one’s with the same lead time were accumulated and the verification was performed on these datasets to see how the forecasts develop in time. It can be seen that the System3 forecasts were outperformed by the climate of the 1971-2000 period which was used as reference forecast while computing the mean absolute error skill score. One reason of this outcome in the case of the temperature forecasts is the strong inversion lasting for more than two weeks in January 2009 resulting in below average temperatures while the model could not handle this situation thus forecasted above average temperatures. The only positive maess value is found for the first month of the 2 metre temperature which is calculated solely against measured values of 2008 so was not effected by this inversion of January 2009.

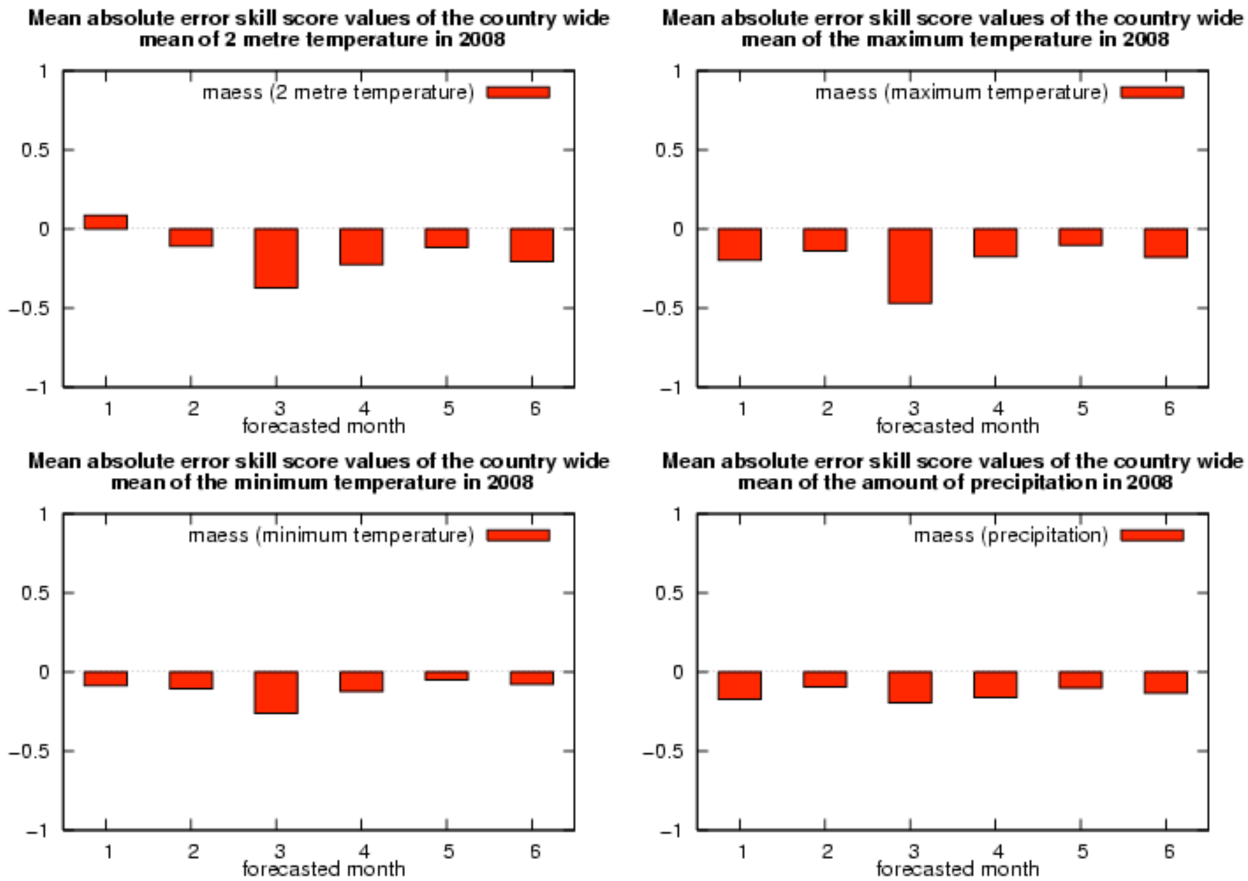

Fig. 13 Mean Absolute Error Skill Score of ensemble means of 2 meter, maximum, minimum temperature and precipitation for the 6 forecasted months in a forecast for 2008. Reference forecast was the 30-year climatological mean.

To assess the performance of System3 for the area covering Hungary in more detail a verification based on the hindcasts of the 1987-1999 period was performed along with the other two seasonal forecast models, UK Met. Office and Météo France, of the EUROSIP project. Bias correction was applied to the ensemble mean of the discrete models as well as to the multimodel forecast and the calibration of the ensembles was performed also. The bias correction improved the performance of all the models. On Fig. 14 the comparision of the mean square skill score (msss) obtained by the bias corrected models is shown for the mean temperature (left) and the preciptation (right). In the case of the temperature among the discrete models ECMWF's System3 has the best result while the multimodel has very similar values. The precipitation shows different features, System3 is outdone by the other models and the multimodel is clearly more effective than the discrete models however the msss values are still below zero. Fig. 15 shows the ROC area values of the calibrated (left) and uncalibrated (right) forecasts of the mean temperature. The values are above 0.5 which indicates better performance than climate and among the models System3 has the best result but the calibration had no positive effect on the prognoses.

The analysis of the long term performance of System3 and the other models in the EUROSIP project was the subject of the master thesis of Mihály Szűcs and the detailed results of this work was published there (*Szűcs*, 2009).

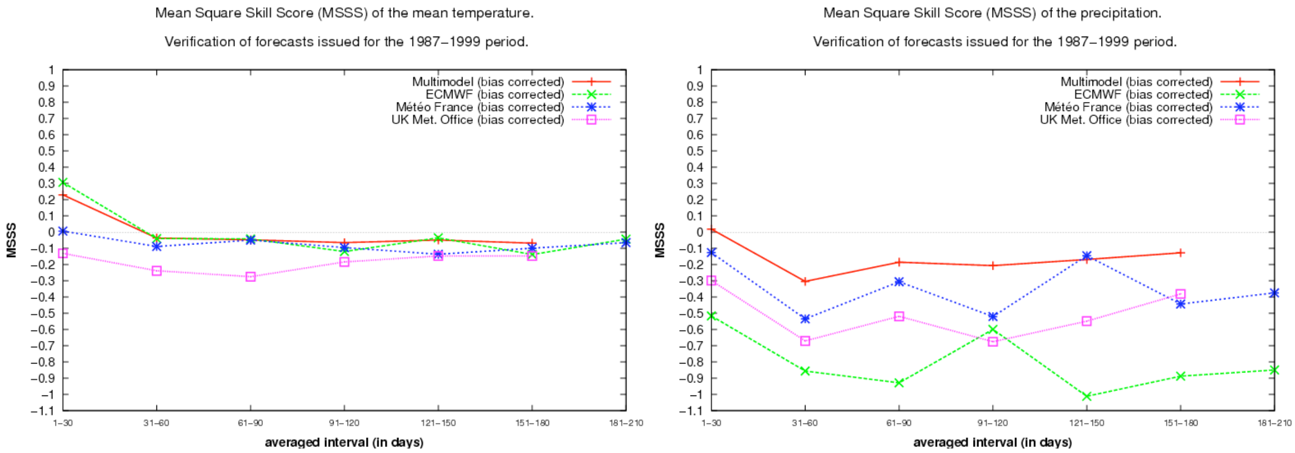

Fig. 14 The mean square skill score of the mean temperature (left) and precipitation (right) forecasts issued for the 1987-1999 period for the area covering Hungary. 30 day averaged values were verified, the reference forecast is the climatological mean of the same period.

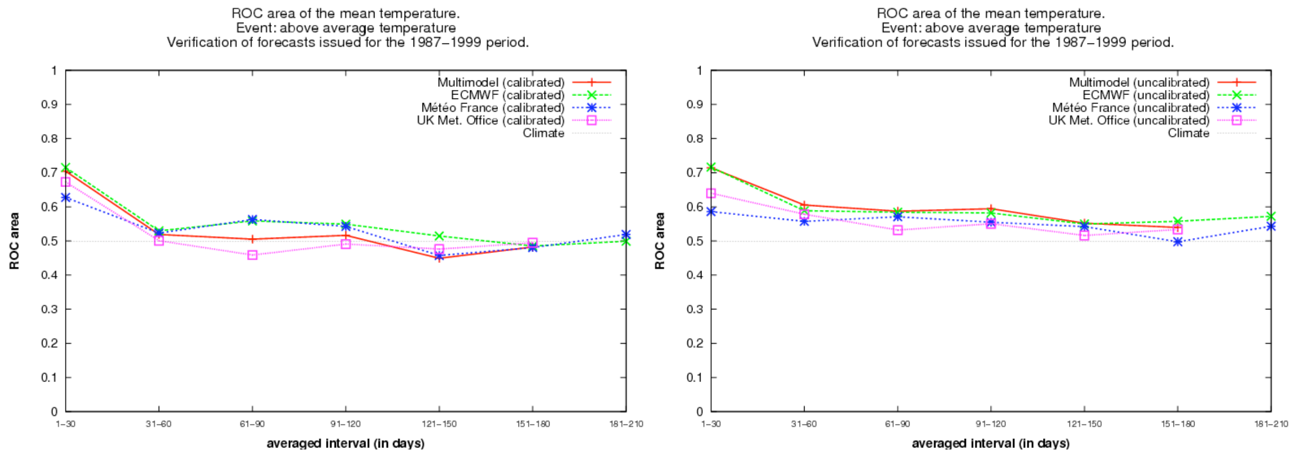

Fig. 15 ROC area values of the calibrated (left) and uncalibrated (right) forecast of the mean temperature issued for the 1987-1999 period for the area covering Hungary. 30 day averaged values were verified

3.1.6 Monthly forecasts

Monthly forecasts have been operationally used at the HMS since the beginning of its experimental run, March 2002. Once a week ensemble means for weekly mean, minimum and maximum 2m temperature and accumulated precipitation amounts are calculated. The verification has been realized for 6 regions of Hungary and also for the entire country. The calculated statistics are the daily mean error (ME), mean absolute error (MAE) and root mean square error (RMSE) (Fig. 16). Weekly Skill Scores based on the mean absolute error are also calculated. In that case the reference dataset was the climate mean, which was expressed by the measured values averaged between 1961and 1990 (Fig. 17).

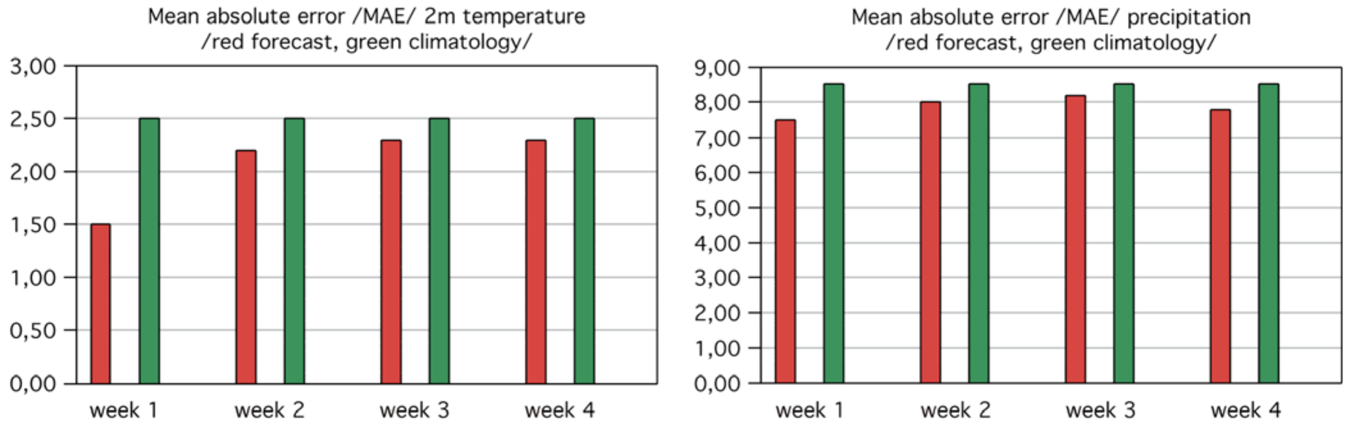

Fig. 16 Mean absolute error of weekly mean 2m temperature and precipitation /red is ECMWF forecast, green is climatology/.

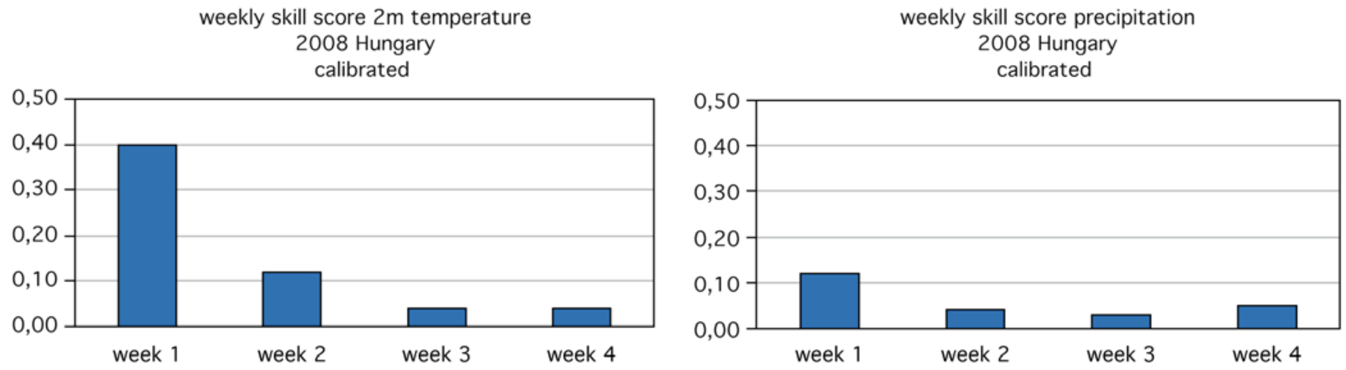

Fig. 17 Weekly Skill Scores based on the mean absolute error for 2m temperature /left/ and precipitation /right/.

3.2 Subjective verification

3.2.1 Subjective scores

none

3.2.2 Synoptic studies

none

4. References

Bölöni, G., Kullmann, L. and Horányi, A. 2009: Use of ECMWF lateral boundary conditions and surface assimilation for the operational ALADIN model in Hungary. *ECMWF Newsletter 119*, 29-35.

Ihász I., Mile., M, Üveges, Z and Szintai, B. 2009: Clustering and calibration of ECMWF's medium range forecasts. *Submitted to Időjárás*

Szücs, M, 2009: Calibration and verification of seasonal forecasts. *Master Thesis*, Budapest Eötvös Loránd University

Üveges, Z., 2009: Calibration of ECMWF monthly forecasts. *Master Thesis*, Budapest Eötvös Loránd University