Experiences in using ECMWF lateral boundary conditions for the operational ALADIN model in Hungary

Gergely Bölöni, László Kullmann, András Horányi

January 28, 2009

1 Introduction

The operational ALADIN model at the Hungarian Meteorological Service (HMS) has been originally coupled with the ARPEGE model for its lateral boundary conditions (LBC). Several attempts to use LBC data from the ECMWF model have been made in the past 2 years in Hungary in an experimental framework, i.e. in a non-real-time manner (Kertész, 2007). These investigations were done as part of the ECMWF "SPFRCOUP" Special Project led by Meteo-France with the participation of several ALADIN partners. Results suggested a potential improvement of our ALADIN forecasts when using LBC data from the ECMWF model. Following a request from HMS, ECMWF started to provide LBC data for Hungary on a daily basis for pre-operational testing since May 2008. This made possible to run real-time parallel tests at HMS in order to compare the forecast accuracy with ARPEGE and ECMWF LBC data. The parallel test proved a better performance with ECMWF LBC data, which led to an operational use of these data since the 1st of October 2008. On one hand, the article will shortly describe the most important technicalities of preparing LBC data for the ALADIN model from the ECMWF global fields. On the other hand, results of the above mentioned parallel tests will be presented as well as the most recent experiences since the operational use of the ECMWF LBC data.

2 Preparation of the LBC data from ECMWF

The preparation of ALADIN LBC data from ECMWF files consists of running appropriate configurations of the ARPEGE/ALADIN software (see Fig. 1). First, one has to prepare a global ARPEGE file from the global ECMWF file (conf. 901) and then to interpolate it to the LAM LBC geometry (conf. e927). Beside the format change (ECMWF grib –> FA), the first step includes an adjustment of the surface fields in order to convert the ECMWF surface variables into ARPEGE/ALADIN (ISBA) surface variables because the surface schemes in the two global models are rather different (different number of surface layers, etc.). We refer to Saez (2008), Sahdan and Bölöni (2005) and Kertész (2006) for more detailed technical description of the ALADIN LBC data preparation from ECMWF files. ECMWF has started to run the abovementioned applications for HMS in May 2008 and disseminates the LBC files to our service. One can mention here that ECMWF undertook only the regular running of this application, but so far we do not have an agreement about its maintenance (executables, increase of resolution of the LBC files if the ECMWF resolution is increasing, etc.)

3 Use of ECMWF LBC data in an experimental phase

During the summer of 2008 three tests have been run using the regular real-time LBC data from ECMWF. All of them included a local 3DVAR atmospheric data assimilation cycle and 48 hour production forecasts starting from 00 and 12 UTC analyses. Due to the data availability constraints, our ALADIN production runs used

LBC files from the previous ECMWF BC run, that is, with a shift of 6 hours. All the three experiments were compared to our operational run as a control. Verification of the forecasts has been done against SYNOP and TEMP observations over the whole operational model domain (Fig. 2). The experiments and the discussion of the results are detailed below.

3.1 Control run HUN2

The reference is our operational run which includes a 3DVAR atmospheric assimilation cycling with a 6 hour analysis frequency. LBC data are used from ARPEGE both in the assimilation cycle and the production runs. No local surface analysis is included at the moment, which implies that the interpolated ARPEGE analysis is used as surface initial condition (IC) both in the assimilation cycling and the production forecasts. The atmospheric analysis includes the assimilation of the following observation types: SYNOP, SHIP, TEMP, AMDAR, Wind Profilers, MSG2/GEOWIND, NOAA(15/16/17/18)/ATOVS (AMSU-A, AMSU-B and MHS). For more details on the operational ALADIN model of HMS we refer to Randriamampianina (2006) and Bölöni (2006).

3.2 Experiment ECM1

In this experiment all ARPEGE fields have been replaced by ECMWF fields. It means that ECMWF fields have been used both for LBCs and surface ICs. In all other aspects the experiment is the same as HUN2. The parallel test have been run for the period 17/07/2008 - 29/07/2008. Verification results reflect a degradation of the forecast for ECM1 compared to HUN2 near the surface (2m), which can be seen on Fig. 3. The degradation is most pronounced for temperature and humidity. This feature has been found also in our earlier tests (Kertész 2006) and the degradation is, in our understanding, due purely to the surface ICs, and this is consistent with the fact that far from the surface (above 850 hPa) ECM1 over performs HUN2 for most of the variables (Fig. 4). The reason for the inferior results of our surface ICs generated from ECMWF fields most probably originates from the different surface schemes applied in ARPEGE and ECMWF. The applied surface schemes differ in several aspects and it would need a detailed investigation to figure out from where exactly the problem is coming and to improve conf. 901 of the ARPEGE/ALADIN software in this aspect. It is to be mentioned that both Fig. 3 and Fig. 4 are based on the 00 UTC runs but results from the 12 UTC runs are very similar.

3.3 Experiment ECMW

This experiment is the same as ECM1 except that it uses surface ICs from ARPEGE just like in HUN2. In other words, this experiment differs from HUN2 only in the use of the LBCs and not in the use of the ICs. The experiment has been run for the period 01/08/2008 - 14/08/2008. Results at 2m are rather neutral for most of the parameters, however some improvement for temperature bias and sea level pressure rmse can be seen (Fig. 5). One might also notice that a small degradation is visible for the 2m relative humidity bias during daytime (forecast ranges +12h, +36h in the 0 UTC runs). Higher in the atmosphere ECMW has a smaller error than HUN2 for most of the variables. An example for 700 hPa is shown on Fig. 6. Results based on the 12 UTC are again very similar.

3.4 Experiment ECCA

This experiment differs from the previous two again in the treatment of surface ICs, namely by running a local OI assimilation for the surface instead of using interpolated ARPEGE or ECMWF analysis fields. Previously to our LBC tests described here, the local surface assimilation was found to improve the forecast at 2m and a decision has been taken to implement it operationally. However, before this operational implementation, we wanted to repeat the surface assimilation test using LBCs from ECMWF instead of ARPEGE to see the interaction of both modifications compared to our present operational suite. Results from this test show an improvement in the 2m forecast, which is mostly due to the surface assimilation (Fig. 7) and also higher in the atmosphere, which is mostly due to the use of LBCs from ECMWF (Fig. 8). One should notice that the 2m relative humidity bias is degraded further compared to ECMW during the day (forecast ranges +12h, +36h in the 0 UTC runs), which should be a shortcoming of the local surface assimilation.

4 Use of ECMWF LBC data in the operational phase

Based on the parallel tests above, the operational ALADIN model in Hungary is coupled with ECMWF LBC data since the 1st of October 2008. This section summarizes our experiences on the performance of the operational model within the autumn and winter of 2008. It is not easy to choose a good measure of performance now, as we haven't been running a reference model coupled with ARPEGE LBCs since the operational switch in October. However we have tried to find signals of the LBC change in our objective verification scores.

4.1 Time evolution of the bias

One possibility is to plot the time evolution of bias and rmse scores for a long period (01/05/2008 - 07/01/2009) and see if a remarkable change appears by the time of the operational implementation of the ECMWF LBCs. On Fig. 9 2m temperature bias scores are shown for the +24 hour forecast range. This figure reflects a pronounced reduce of the bias around mid-September keeping near zero till mid November and then slightly increasing again with an opposite sign. On these scores, thus, the LBC change does not show up straight. We can also state that the dependence of the bias on the actual weather was stronger then the dependence on the LBC change in this period. This statement is also strengthened by the fact that the bias of the ECMWF model (T799 deterministic) itself changed very similarly as those of the ALADIN model. One might also notice that the ECMWF and ALADIN verification curves run more closely in the second half of the period, i.e. the LBC switch in ALADIN, however this fact does not match neither the exact date of the switch. A last thing to add is that beside the LBC change, the 2m scores shown on Fig. 9 might reflect also another component of the operational switch of October the 1st 2008, namely the implementation of an OI surface assimilation. In order to analyze the impact of the LBC switch more independently from the surface assimilation switch we have plotted bias time evolutions for 700 hPa on Fig. 10 for a somewhat shorter period (September - October 2008). On this figure temperature and humidity curves run a bit closer to zero in the second half of the period, which might be due to the use of new LBC data. However, one should also notice that temperature bias significantly increased by the end of October, and even grew larger than ever in this period. As a consequence, we hardly can state firmly, that the change to ECMWF LBCs is visible on the time evolution of bias scores within this period.

4.2 Seasonal and monthly averages

Another possibility to find a signal of the change in the operational LBC use was to compare three-months (October-December) bias averages for 2007 with those for 2008, assuming that a long period average of the real weather was similar in these two years. Fig 11 shows bias and rmse scores of 2m temperature comparing the two years. One can observe an improvement for the year 2008 for the bias, which may be due to both the OI surface assimilation and the use of ECMWF LBC data. For the rmse, the scores are rather similar for 2007 and 2008, except the analysis, which shows up much better for 2008 very probably due to the OI surface assimilation. A similar comparison has been done for the higher atmosphere as well, namely temperature and humidity scores are shown for the level 850 hPa on Fig. 12 for October 2007 and 2008. These scores reflect an improvement for the year 2008, which is possibly due to the use of the ECMWF LBC data but also can come from the fact that October 2008 was more predictable than October 2007. The unfortunate reason for for plotting the 850 hPa scores only for October is that we have missing data for the upper air verification in November 2007 and December 2008.

5 Conclusions

The parallel tests of the experimental phase reflect that ALADIN forecasts can be improved by using LBC data from the ECMWF model. On the other hand ECMWF data are at the moment not recommended to be used as ICs for surface fields because such data is very model dependent. As a consequence, it is recommended to run a local surface assimilation or to use interpolated ARPEGE surface fields if one would like to run the ALADIN LAM with LBCs from the ECMWF model. Due to the encouraging results obtained with experiment ECCA, the use of ECMWF LBC data was implemented operationally on the 1st of October 2008 at HMS, together with a local OI surface assimilation. In the operational phase we found rather difficult to show straight signals of improvements in the objective scores due to the fact that the reference using ARPEGE LBC data has not been running any more. However we found some improvement of the statistical scores computed for the autumn and winter of 2008 compared to those of computed for 2007. A part of this improvement may possibly come from the change in the LBC use. Last, but not least, we are very grateful to ECMWF for making possible to realize the tests described above and and also for providing the LBC data with a very high reliability in the last 9 months.

6 References

Bölöni G., 2006: Development of a variational data assimilation system for a limited area model at the Hungarian Meteorological Service, Idöjárás, 110, pp 309-329

Kertész S., 2006: Preparing ALADIN BCs on ECMWF HPCF, RC LACE internal report (http://www.rclace.eu/?page=46)

Kertész S., 2007: Using T799 IFS initial and boundary conditions in the ALADIN/HU model, RC LACE internal report (http://www.rclace.eu/?page=11)

Randriamampianina R., 2006: Impact of high resolution satellite observations in the ALADIN/HU model, Idöjárás, 110, pp 329-349

Saez P., 2008: Notice d utilisation de la configuration 901 ISBA, Meteo-France online documentation (http://www.cnrm.meteo.fr/gmapdoc/spip.php?article38)

Sahdan and Bölöni, 2005: How to prepare IC & LBC from ECMWF EPS members, RC LACE internal report (http://www.rclace.eu/?page=35)

7 Figures

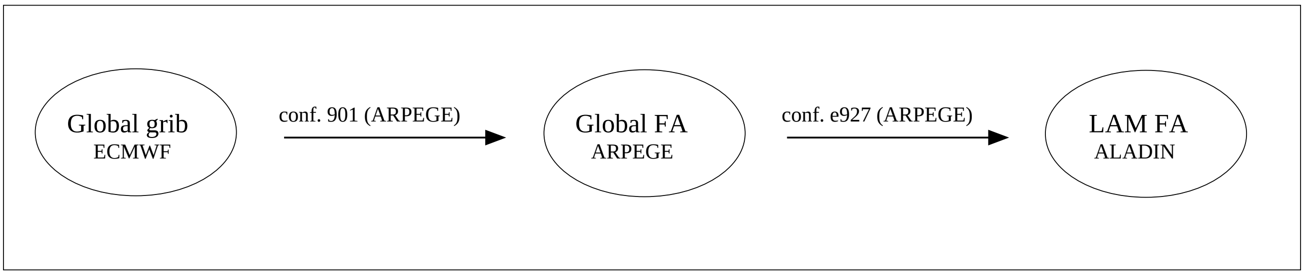

Figure 1: Main steps to prepare ECMWF LBC data for the ALADIN LAM

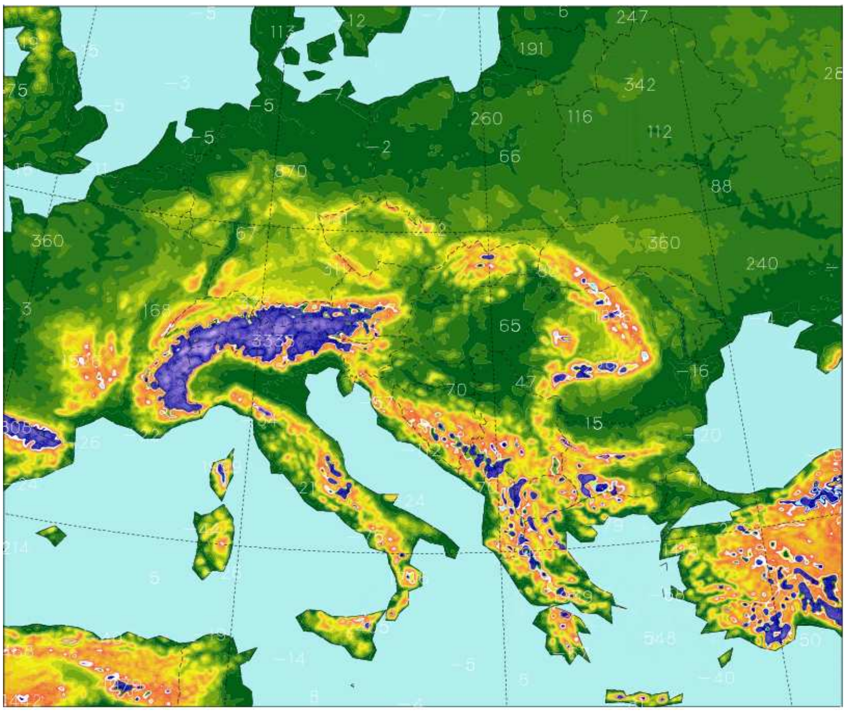

Figure 2: The operational ALADIN domain at HMS

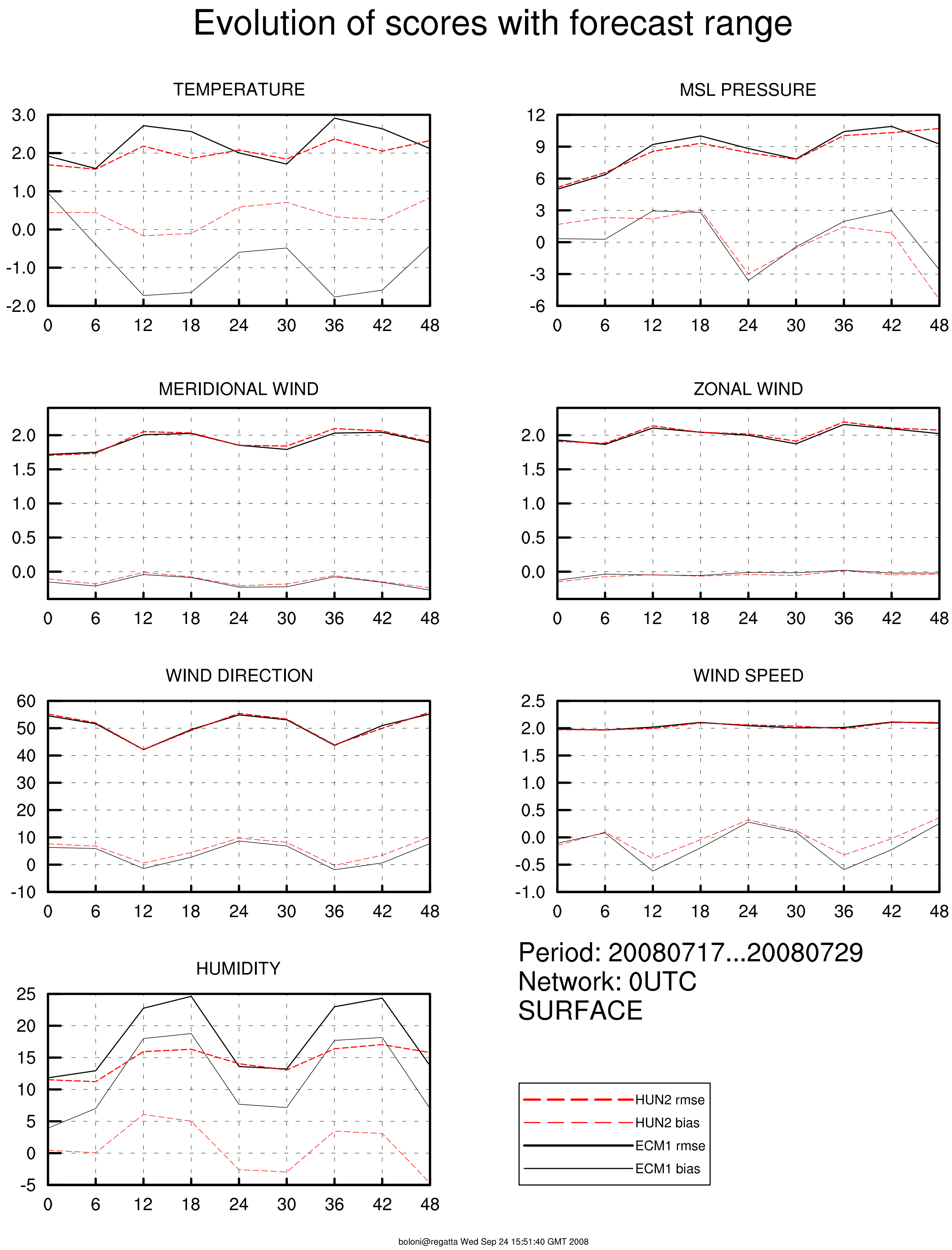

Figure 3: rmse and bias scores at 2m for experiments ECM1 and HUN2

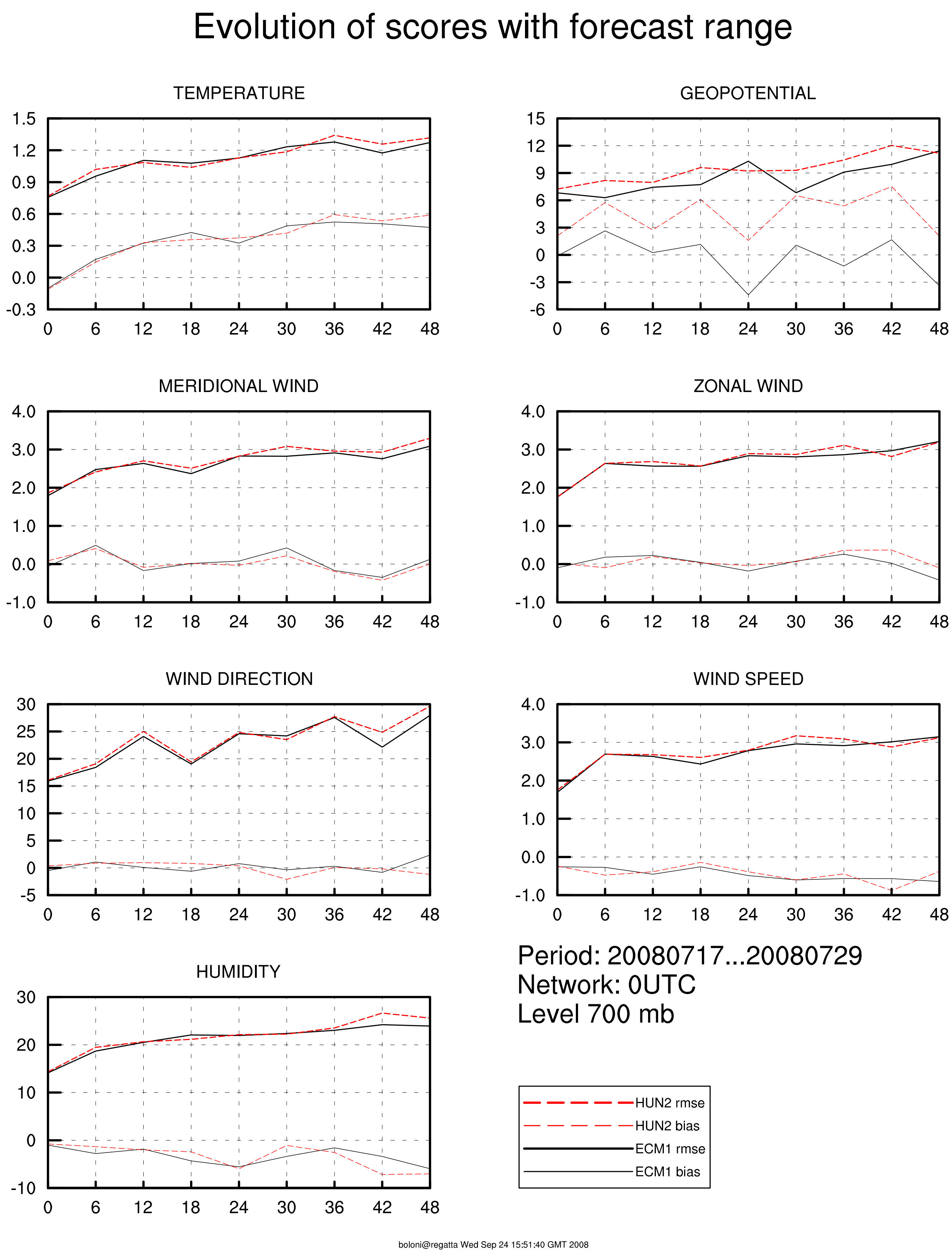

Figure 4: rmse and bias scores on 700 hPa for experiments ECM1 and HUN2

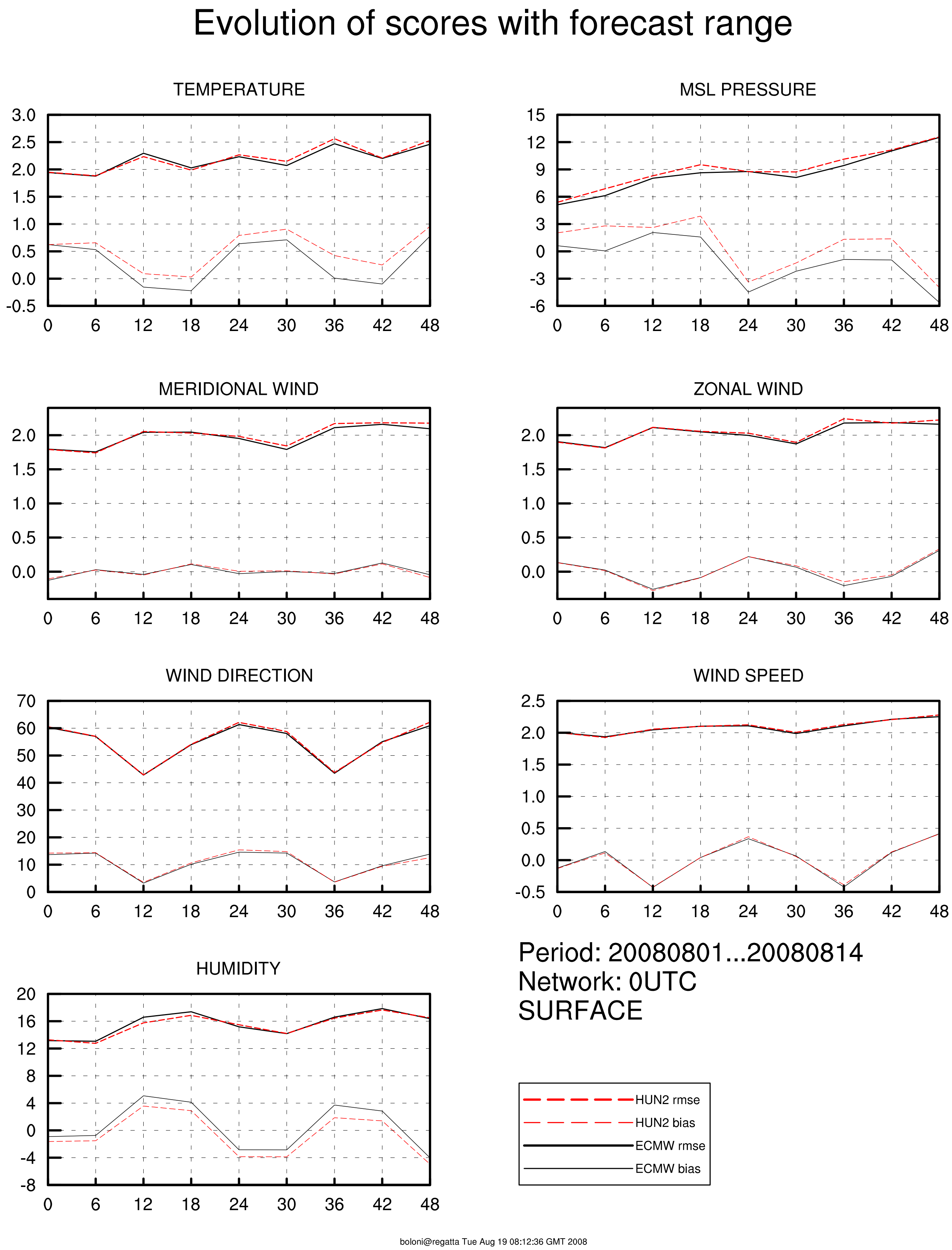

Figure 5: rmse and bias scores at 2m for experiments ECMW and HUN2

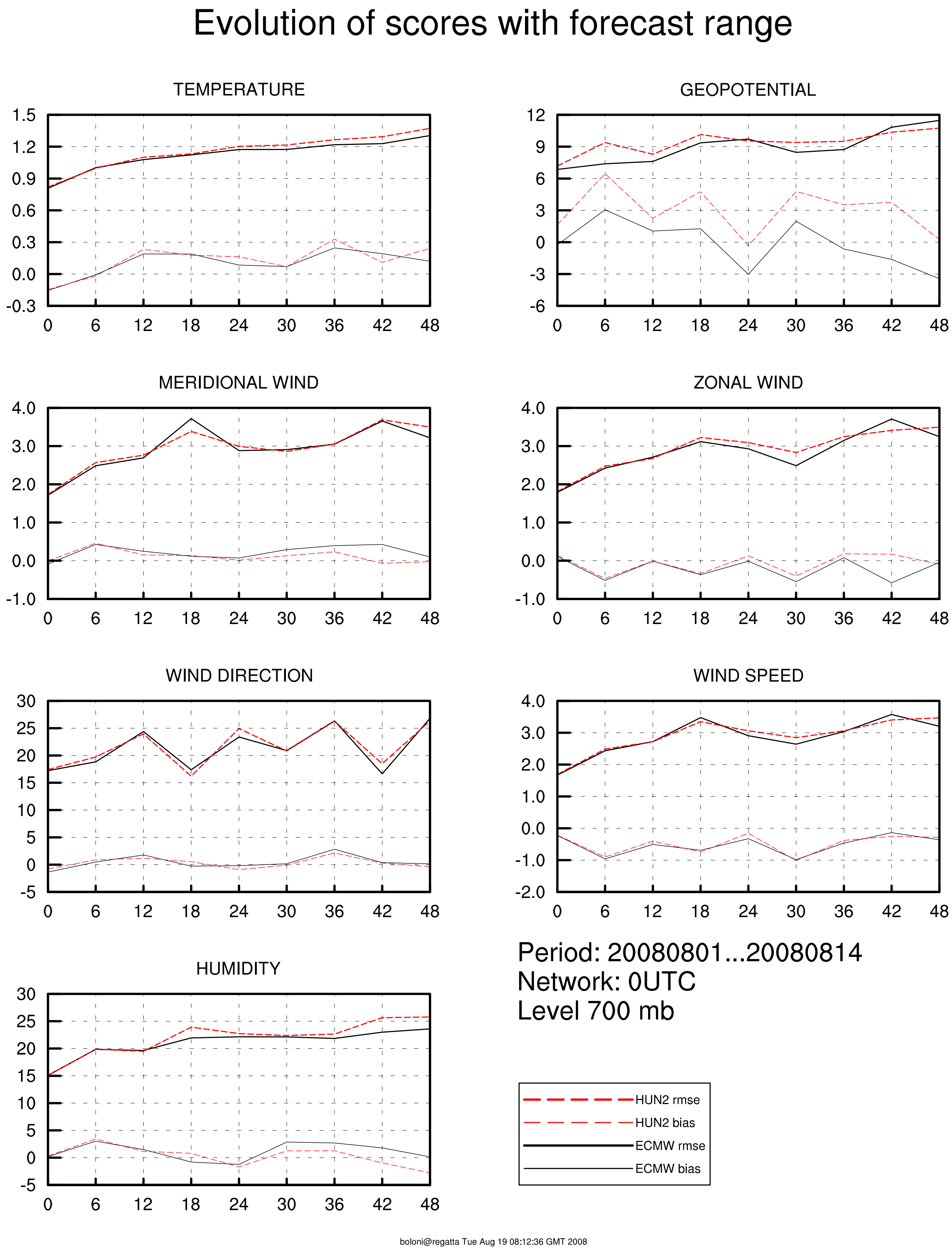

Figure 6: rmse and bias scores on 700 hPa for experiments ECMW and HUN2

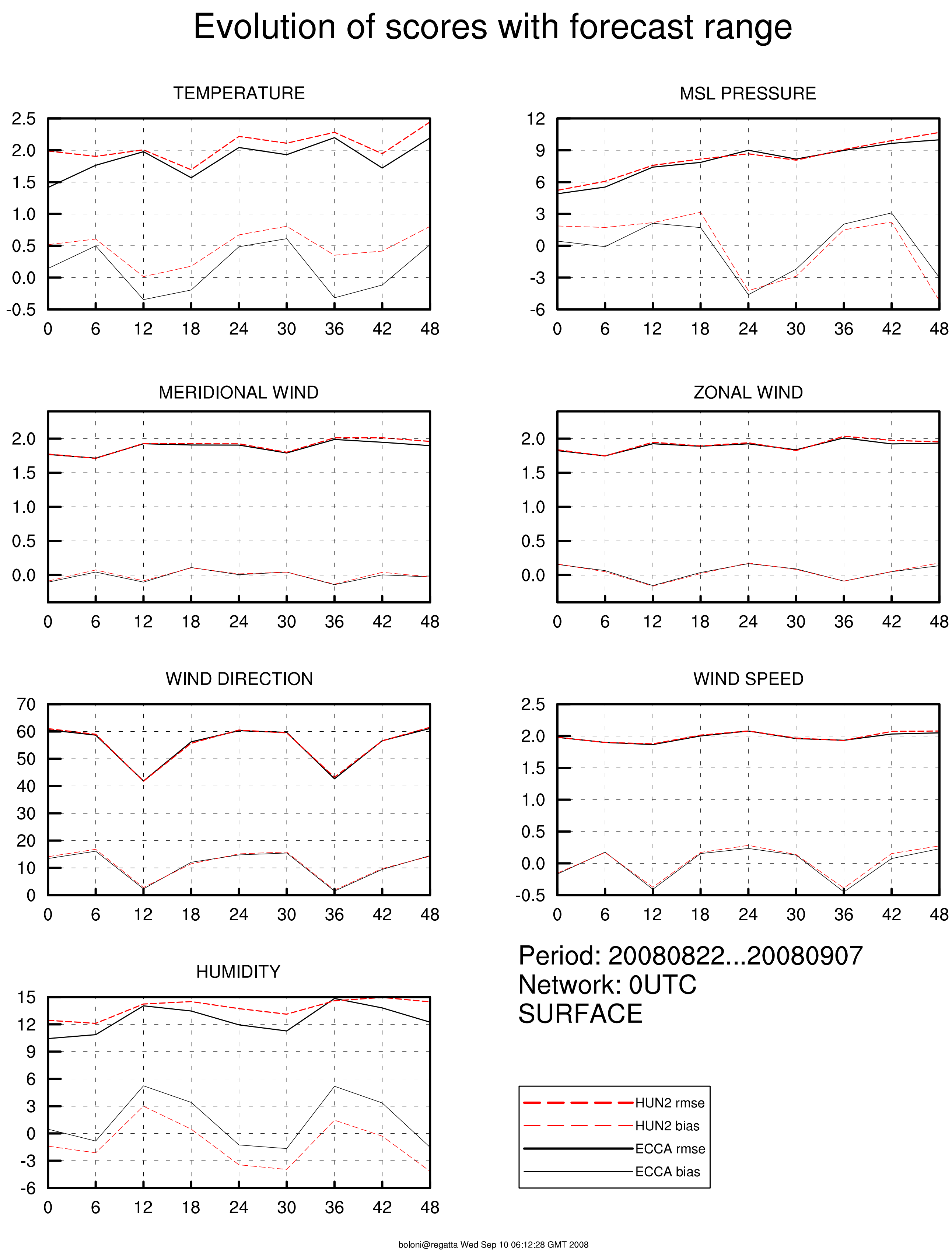

Figure 7: rmse and bias scores at 2m for experiments ECCA and HUN2

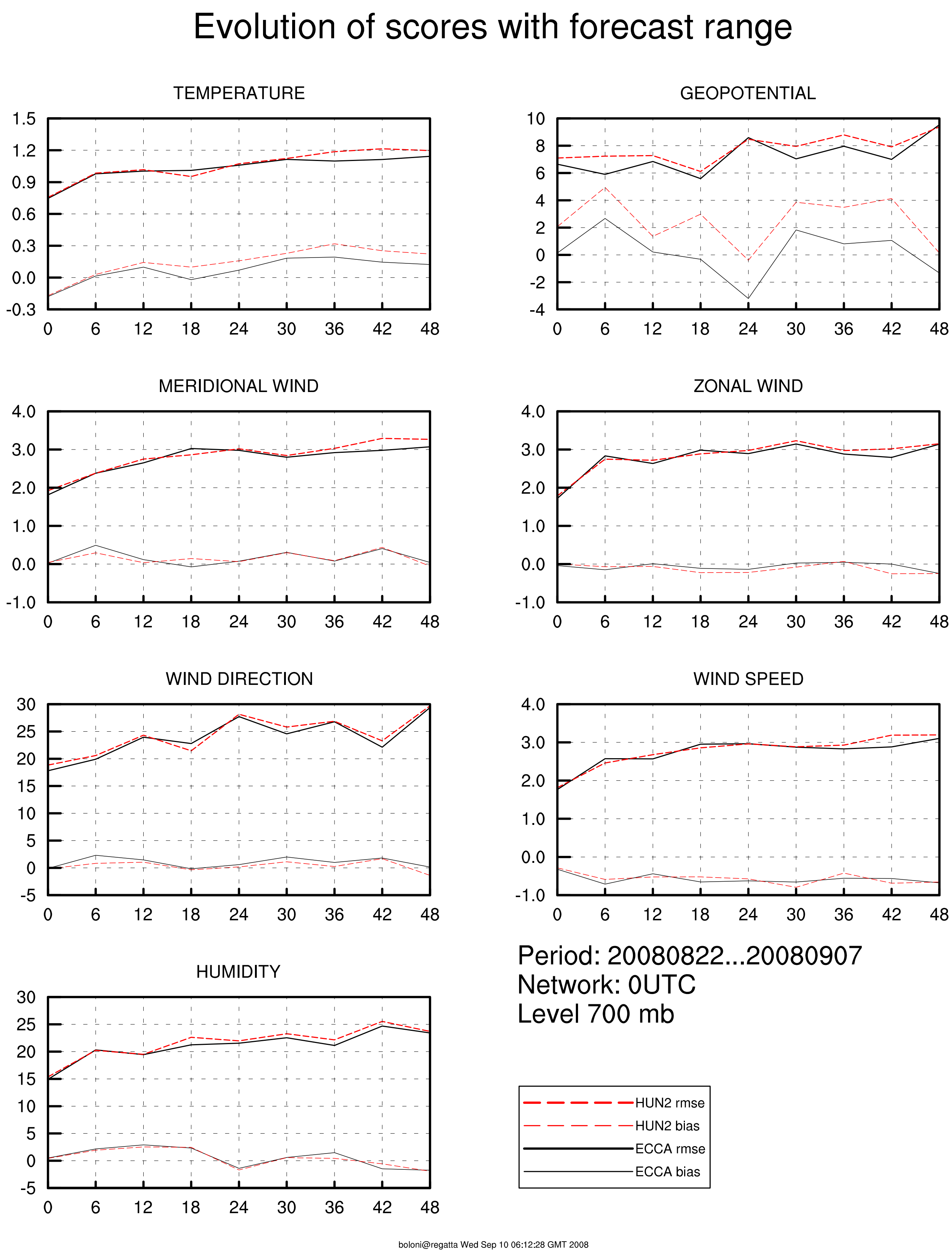

Figure 8: rmse and bias scores on 700 hPa for experiments ECCA and HUN2

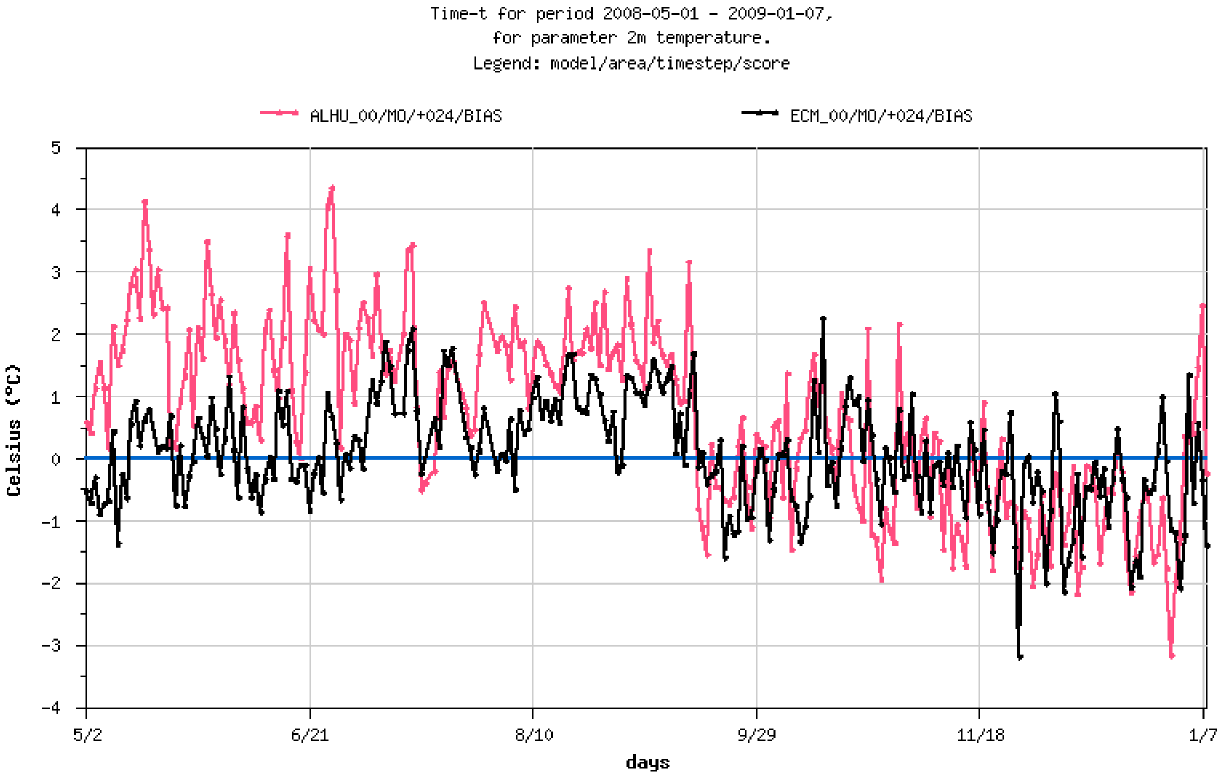

Figure 9: Time evolution of T2m bias scores of the operational ALADIN model in Hungary for the +24 hour forecast range. Red: operational ALADIN model, Black: ECMWF deterministic (T799)

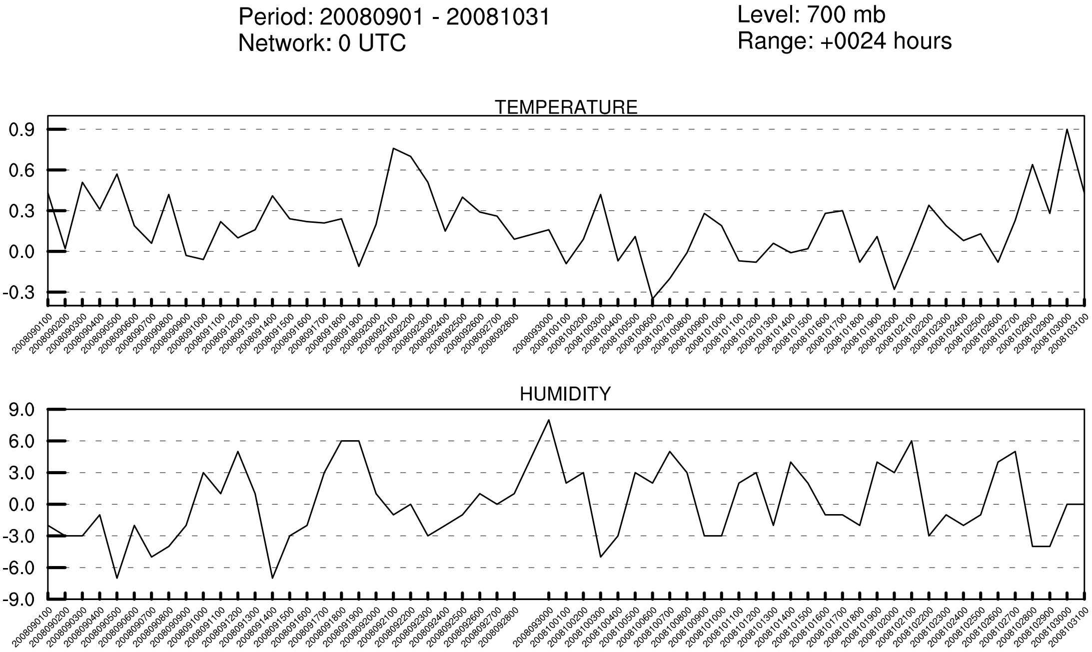

Figure 10: Time evolution of 700 hPa bias scores of the operational ALADIN model in Hungary for the +24 hour forecast range

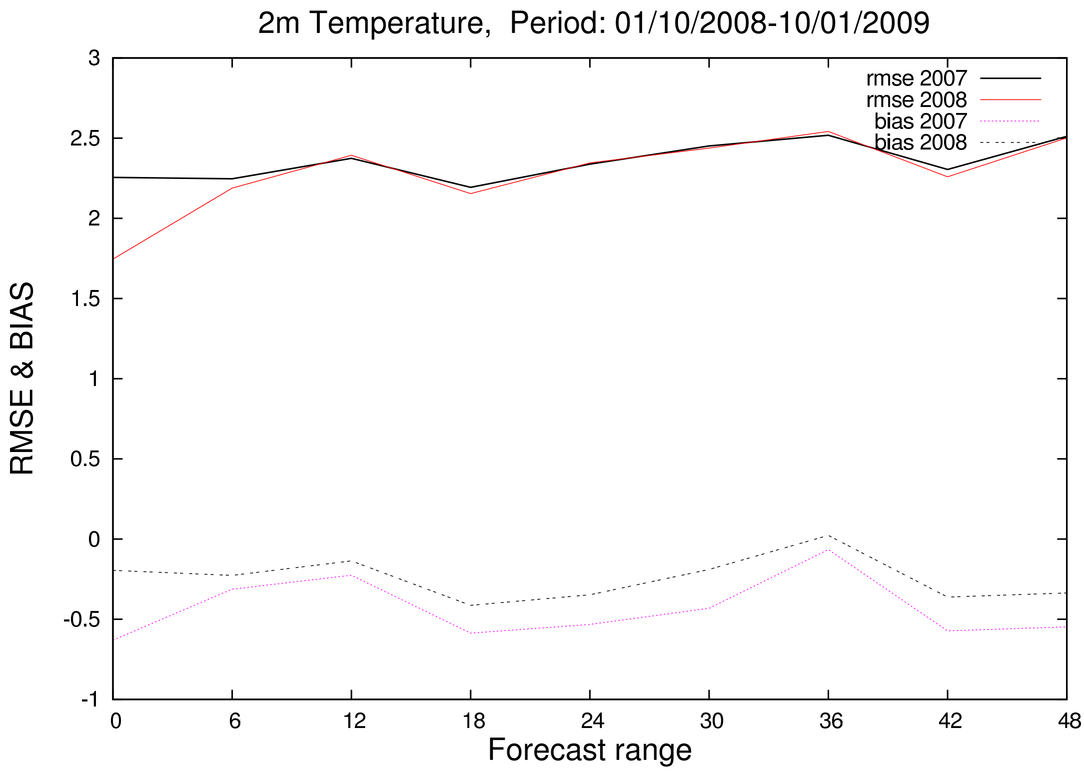

Figure 11: T 2m rmse and bias scores of the operational ALADIN model in Hungary.

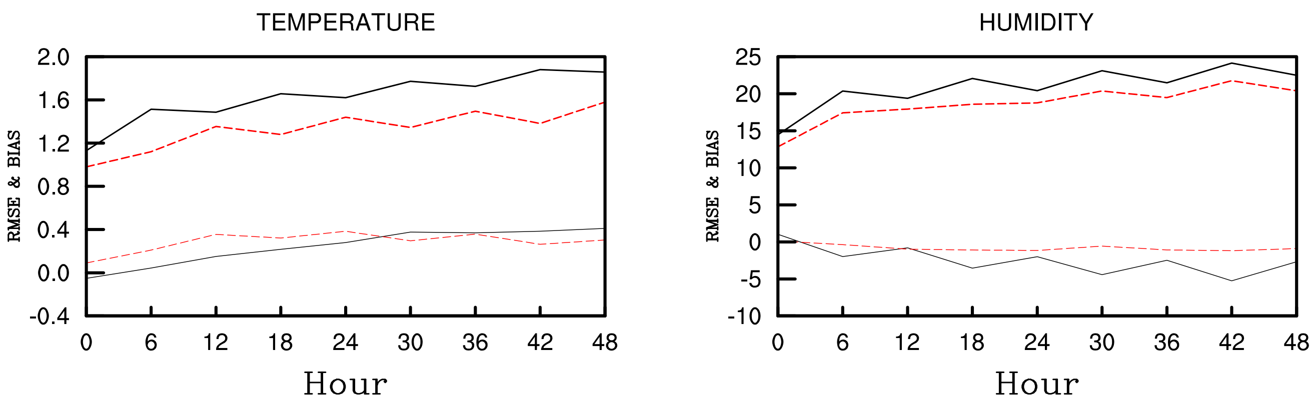

Figure 12: 850 hPa rmse and bias scores of the operational ALADIN model in Hungary. Red-dashed: scores for October 2007, Black-solid: scores for October 2008