Validation of RCR for spring and summer 2004

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1 Introduction

The duties of FMI as the lead centre for Reference System Runs (RCR) include the development and maintenance of a comprehensive monitoring system, as specified in the agreement between HIRLAM-6 and FMI. The monitoring, still under development, is constructed partly by merging the old DMR monitoring system maintained by KNMI with components already in use at FMI at the start of the activity, but to a large part by designing and implementing new components.

This report describes the current state of the monitoring activity by showing how it is used to assess the quality of the RCR system and forecasts. It should be understood that new components are continuously being developed and incorporated.

We would also like to stress, that the reference system and its performance is the common interest of all the project members and that the monitoring should not be considered solely the responsibility of FMI. For instance, at the moment a large variety of HIRLAM implementations ara being employed in the member institutes, and it would certainly be of great value to the project as well as to members individually, if these were compared to the reference system and to each other in a systematic fashion, sharing experiences. The RCR monitoring facility provides an excellent framework for this kind of activity, for instance by utilizing the online intercomparison with meteorological tower measurements, as is already being done in the case of ARPEGE.

2 Graphical products and monitoring

For monitoring and research purposes as well as for duty meteorologists' aid, a graphical interface for HIRLAM RCR has been developed. The HIRLAM community has also been provided a view to this interface through HeXnet at address http://fminwp.fmi.fi/. The present contents of the interface include:

- Weather maps and hourly animations : temperature, pressure, precipitation, wind speed, pseudo satellite pictures etc.
- Baltic sea wind maps
- Weather meteogramms for various locations, at the moment mainly in Finland
- Mast verification plots : Sodankylä etc. mast measurement vs. forecasts
- Statistical verification plots for various areas and parameters, including log-file statistics

- Monitor window showing observation coverage maps, analysis increments, observation first-guess/analysis statistics, observations and fields for surface analysis, etc.
- Monthly report with statistics etc. plots

The mast verification includes now also comparison with the Arpege model of Meteo France. Cabauw mast from the Netherlands has been added to the mast verification plots and the results will be made available soon. The interface and the plots have been described in more detail by Kangas (2003, 2004) and Eerola (2004). The graphical addendum contains some results and sample plots from the monitoring interface.

An example of graphical output is demonstrated in Fig. 1.

3 Results

3.1 Verification

In this section, essential features of statistical verification from spring 2004 and summer 2004 are shown.

Figure 2 shows the bias and rms error for some near-surface parameters as a function of forecast length and averaged over the three spring months (March, April and May) 2004. Only forecasts from 00 UTC analysis are included so as to see the possible diurnal cycle in the scores. Figure 3 shows the same verification scores for some parameters at 500 hPa level. In both cases the verification is done against observed values at the so-called EWGLAM stations.

The following features can be emphasized concerning the surface variables (Figure 2).

1. In spring there is little bias in surface pressure in contrast to large negative bias in winter and positive bias in summer (compare to Fig. 4 for summer values).

2. 10-metre wind speed show the well-known positive bias of the order 1 m/s, independent of forecast length.

3. 2-metre temperature and relative humidity errors show a diurnal cycle. 2-metre temperature bias is always negative, but is larger in the daytime than in the nighttime. Relative humidity bias is positive in the daytime and almost zero during the night.

4. This figure does not reveal the areal distribution of errors. The 2-metre temperature bias in Scandinavia is about -1.2 K in daytime for this three month period (not shown).

The free atmosphere scores (500 hPa, Figure 3) are worth looking only at the 12, 24, 36 and 48 hour forecasts, because at these times there are enough soundings available to make the verification reasonable. Basically Figure 3 does not show any large problem. In geopotential and relative humidity there seems to be small diurnal cycle, but this may also be due to different observation coverage at different times or diurnal cycle in observations due to radiation..

The summer verification (June, July, August) for surface variables is shown in Fig. 4 and for 850 hPa level in Fig 5. The following comments can be made.

1. In summer surface pressure has a positive bias, which increases with the forecast length.

2. The most important feature is the large negative bias in the 2-mere temperature and related positive bias in relative humidity. The temperature bias is larger in the daytime than in the nighttime. In southern Europe (Spain) the temperature bias is very small, but in Scandinavia it is even lager than for all EWGLAM stations (not shown).

Looking at 850 hPa level scores (Fig 5) we can see that the negative temperature bias is in a deep layer: bias is negative also at 850 hPa. Otherwise the free atmosphere seems sound.

3.2 Time series of skill scores

Next, some daily verification scores as a time series are presented. In each case the forecast length is 24 hours.

Figure 6 shows the individual bias values of the 2-metre temperature forecasts as a time series from 24 April to 24 May 2004 for Scandinavia. We see that the negative bias (too low predicted temperatures) is very large, of the order -3 ... -4 K, during 6-9 May. Especially the daytime temperatures are very much underestimated. This period was very warm in Scandinavia: the maximum daily temperatures in Finland were of the order 25°C. After this period the weather became cool or even cold very quickly because of a cold outbreak from north. During this cold period the temperatures are very well predicted, as can be seen also in the rms values in Fig. 7.

Figure 8 shows the bias of wind direction for the same period. Here we see (and also the same feature is seen in summer results, not shown) that the 10-metre wind is biased about 10 deg. towards clockwise direction. This means that there is not enough cross-isobaric flow towards lower pressure. Because the 10-metre wind is sensitive to local effects, only a more careful study would reveal if this is really the case.

Figure 9, showing the bias of the 10-metre wind speed suggests that in spring the nighttime wind speed is normally overestimated, while in daytime the wind speed is better predicted and even underestimated. So, the diurnal cycle is underestimated. The same feature can be seen when looking at the summer verifications scores of the wind speed (not shown).

Figure 10 shows the bias of the 2-metre temperature forecasts for the period 28 July to 28 August. We see a large negative bias, of the order -1.5 K during the first ten days. In addition, we see a clear diurnal cycle: nighttime temperatures are less biased than daily temperatures. So, the diurnal cycle of the 2-metre temperature is underestimated.

3.3 Examination of extreme weather events

Southern and central Finland received very large precipitation amounts during the final week of July 2004. This rain event created severe floods over large areas. The cause for this was a slow moving low pressure system, which was in the vicinity of southern Finland during 27-29 July. Radar retrieved 12 h accumulated precipitation on 29 July at 12 UTC is shown in Fig. 11. At that time the maximum rainfall was 30-50 mm/12h. Overall, the record breaking diurnal precipitation amount, 122 mm/24h, was observed at Vesanto in central Finland (black dot in Figs. 12 and 13) on 29 July 2004 06 UTC.

Figures 12 and 13 show the predicted 12 h accumulated precipitation for 48 and 24 h forecasts, respectively. The cycle starting from 27 July 12 UTC clearly misplaces the low pressure center about 300 km to south-west from the observed location. Therefore, the areas with heaviest precipitation are also predicted in a wrong place. Moreover, the maximum precipitation rates are underestimated by 10-20 mm/12h. However, the shape of the predicted precipitation area resembles the observed structure.

The later forecast cycle (28 July 12 UTC) predicts the locations of low pressure center and rain coverage remarkably well. Furthermore, the maximum precipitation rates are now much closer to the observed values. However, this cycle still underestimated the record breaking diurnal precipitation amount by about 40 mm/24h.

3.4 Comparison with other models

A regular routine comparison of precipitation forecasts from European limited area models using the UK radar composites is now in operation at the UKMO. A model from each of the four consortia is included. The models (with horizontal resolution indicated) are : the UK mesoscale (12 km), the DWD Lokal Model (7 km), the HIRLAM reference as run at FMI (22 km) and Aladin France (10 km). All models are averaged to the common grid of the Hirlam model for comparison. An example of precipitation scores is shown in Fig. 14.

3.5 Feedback from duty meteorologists

Duty forecasters are requested to fill in a questionnaire every day, explaining what models they have used in their work, and why. The software to analyse the material and generate periodical reports is still under development. An example of the information gained by this process is given below:

Mon, 13 Sep 2004 15:07:59 +0300:

-Forecaster: Asko

-Latest HIRLAM available: 06 UTC

-Selected models: Day 1: HIRLAM, Day 2: ECMWF, Days 2+: ECMWF

-Arguments (Day 1): HIR and Poland bring rain from west a bit faster than EC.

-Arguments (Day 2): No major differences.

-Arguments (Days 2+): EC and UK have a deeper low on Thursday than USA and DWD.

-Additional comments: All models predict an intense low passing over Finland east followed by a ridge of high.

3.6 Reports on any significant failures

The most prominent problem in the RCR forecasts for spring and summer has been the poor quality of the predicted 2-metre temperature (T_{2m}).

Järvenoja (2004) reported about the warm T_{2m} bias for winter 2004 in northern latitudes. In April, the geographical distribution of the T_{2m} bias was different. Figure 15 shows a complicated structure of the bias: in high latitudes, over Russia and America, winter-type positive bias dominates. But in Scandinavia and in Russia just east of Finland, negative bias dominates. This is just like the problem in older FMI HIRLAM models. A closer examination with the aid of Sodankylä mast data has shown that the surface fluxes in the RCR system are not correct: the model latent heat flux is several times larger than the observed flux, and consequently the model sensible heat flux is only a fraction of the corresponding observed flux. There is work going on to correct this problem.

In summer, we have a new type of bias problem. Figures 16 and 17 show the geographical distribution of the July T_{2m} bias for forecasts valid at 12 UTC (day) and 00 UTC (night), respectively. The figures reveal a considerable cold bias both in the daytime and at night, and all over the model domain. This result is clearly seen also in Fig. 4. This kind of problem has been never before met in older operational HIRLAM systems at FMI. Work is going on to understand the origin of the problem and then try to fix it. Concerning this work, there are some good news already now. Several members of the HIRLAM project have been working on a corrected and cleaned physics version (called FAK, i.e., the First Aid Kit) that has been tested for July 2004. Results indicate that much improved T_{2m} forecasts are obtained from the FAK version, as Fig. 18, showing the bias for July at 12 UTC, suggests.

References

Eerola, K., 2004 : Monitoring of the RCR - First impressions and findings. *HIRLAM Newsletter*, **45**,72-80.

Järvenoja, S., 2004: Towards the RCR system - results from pre-operational runs. *HIRLAM Newsletter*, **45**, 48-62.

Kangas, M.,2003 : Sodankylä mast data for model comparison studies. Proceedings of the Baltic HIRLAM Workshop on atmospheric fine scale and boundary layer modelling, St. Petersburg, Russia, 17-20 November, 2003, 35-38.

Kangas, M.,2004 : The operational Hirlam at FMI. *HIRLAM Newsletter*, **45**, 15-22.

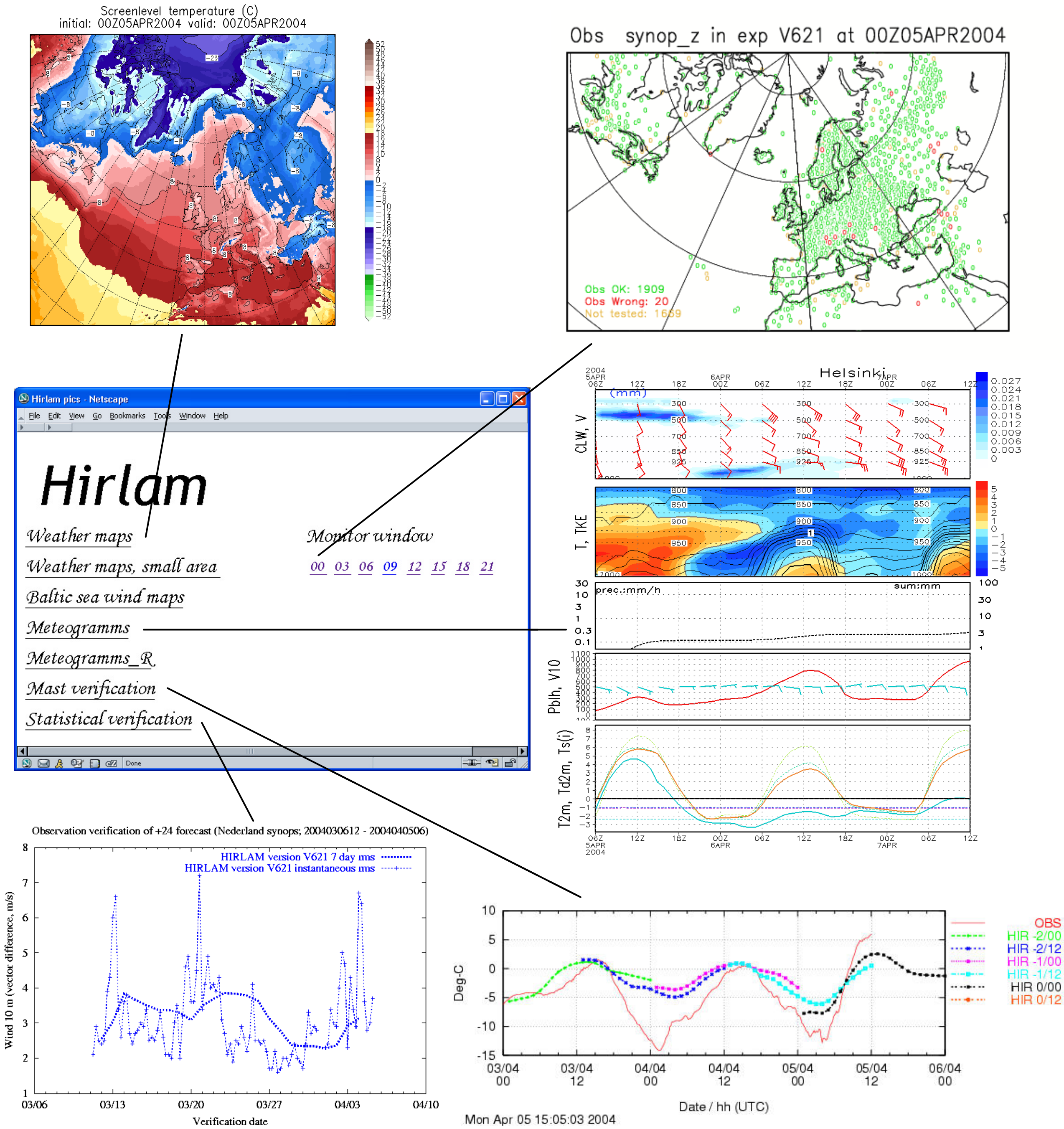


Figure 1: *Graphical monitoring interface with some example pictures.*

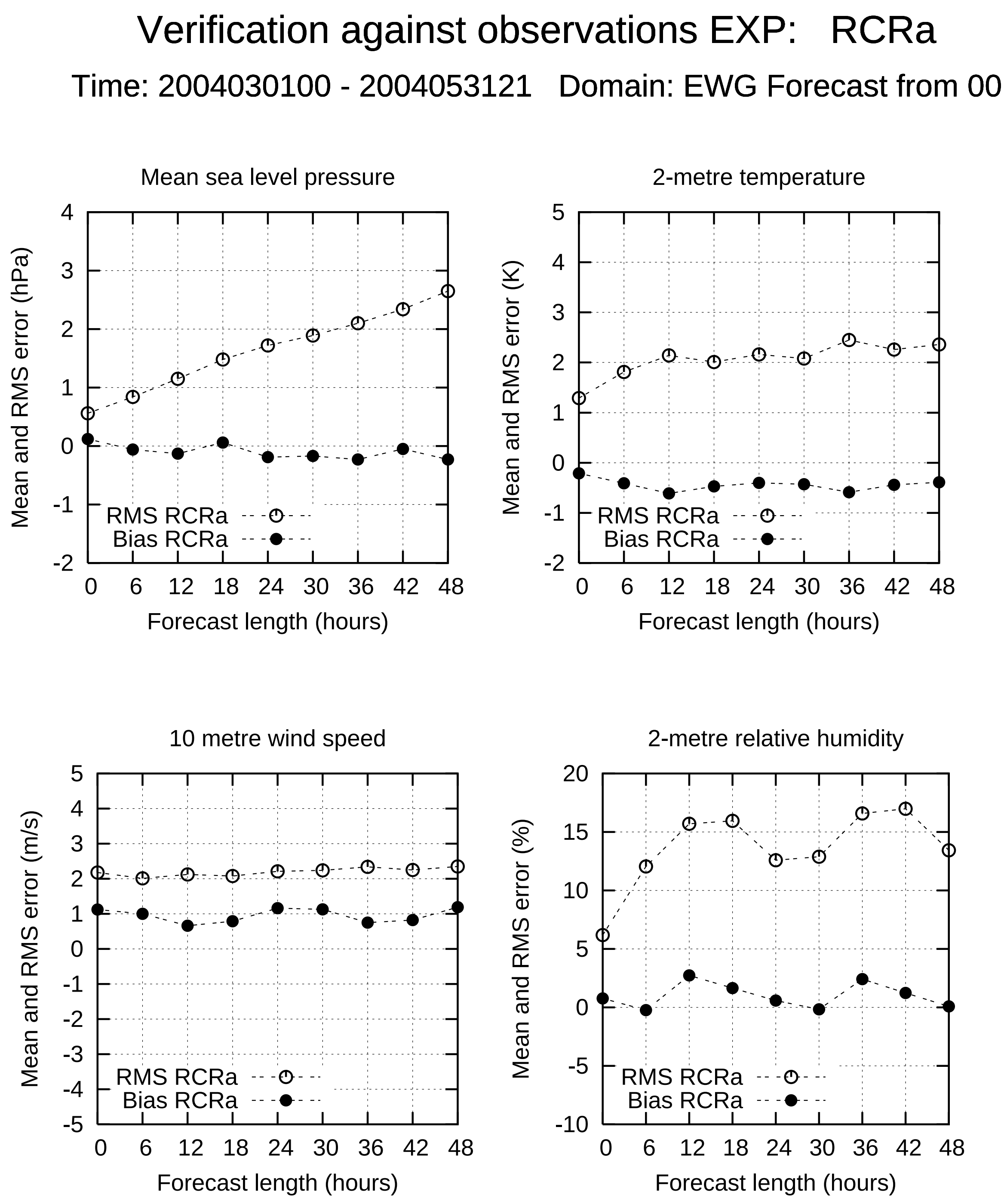


Figure 2: *Verification scores of surface pressure, 10-metre wind speed, 2-metre temperature and 2-metre relative humidity as a function of forecast length, computed for the spring season (March, April, May) 2004. Only forecasts from 00 UTC analyses are included so as to see the possible diurnal cycle in error. Verification scores are computed against observed values at EWGLAM stations.*

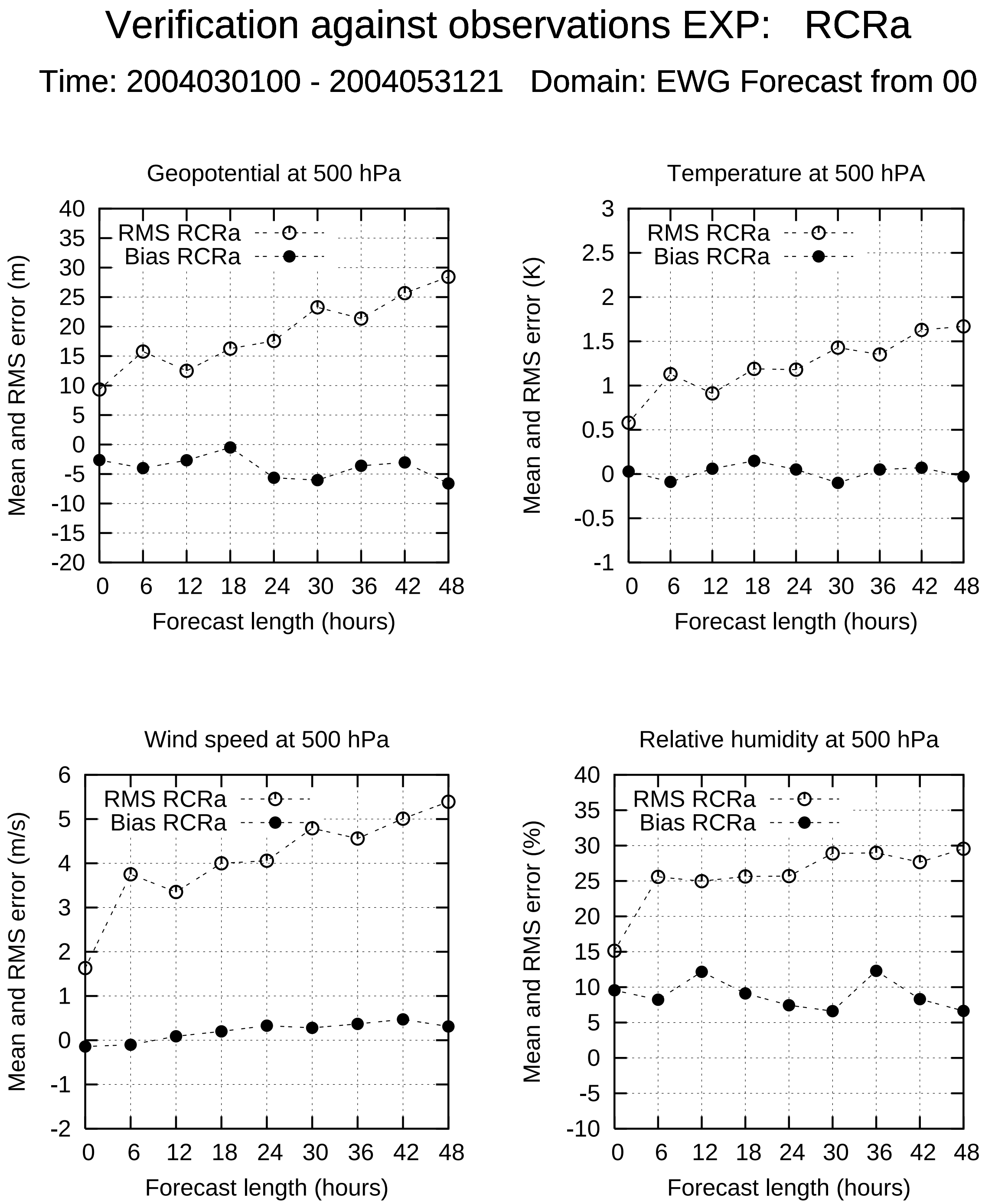


Figure 3: *Verification scores of geopotential, temperature, wind speed and relative humidify at the 500 hPa level as a function of the forecast length. Otherwise as Fig. 2.*

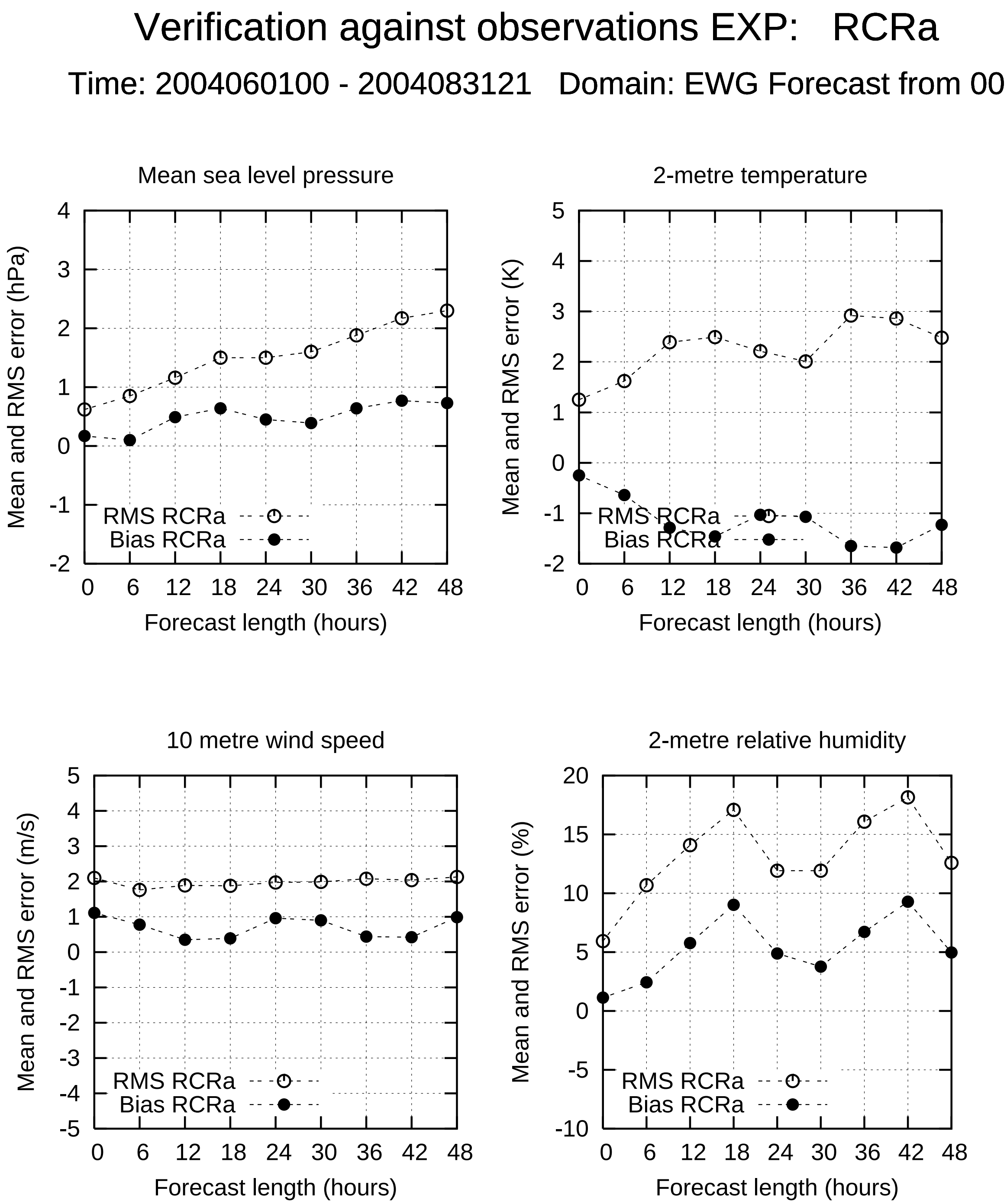


Figure 4: *As Fig. 2, but for summer period (June, July, August) 2004.*

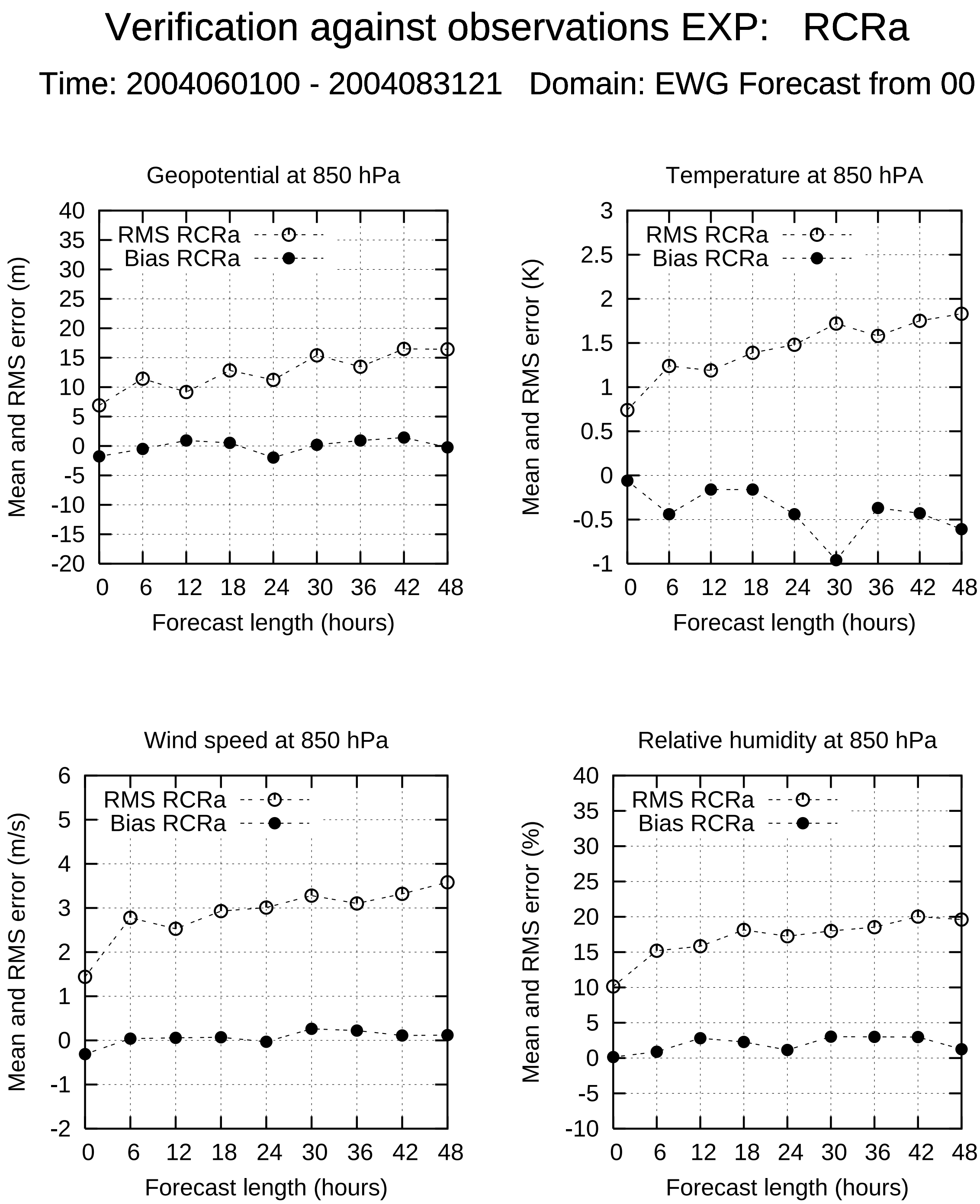


Figure 5: *As Fig. 3, but for 850 hPa level and summer period (June, July, August) 2004.*

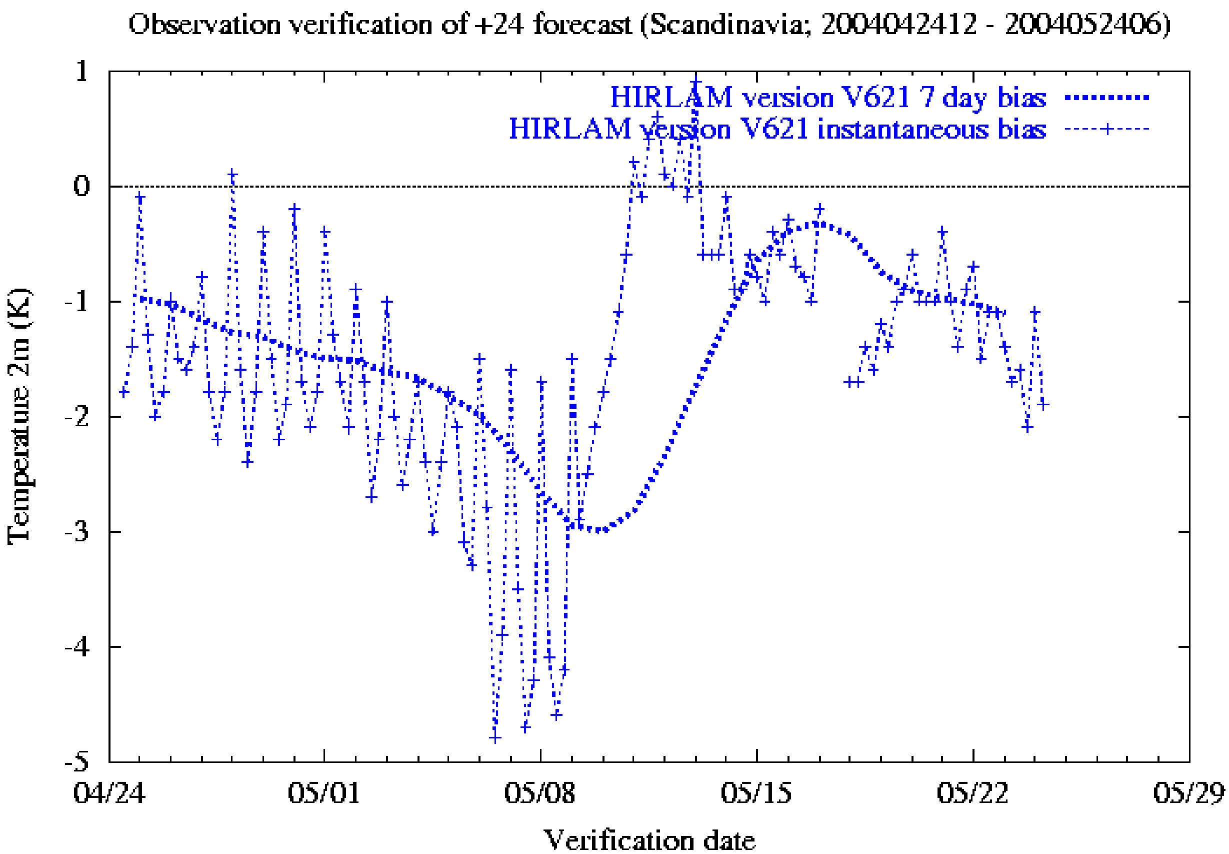


Figure 6: *Time series of the 2-metre temperature bias in 24 h forecasts for the period from 24 April to 24 May, computed against Scandinavian observations.*

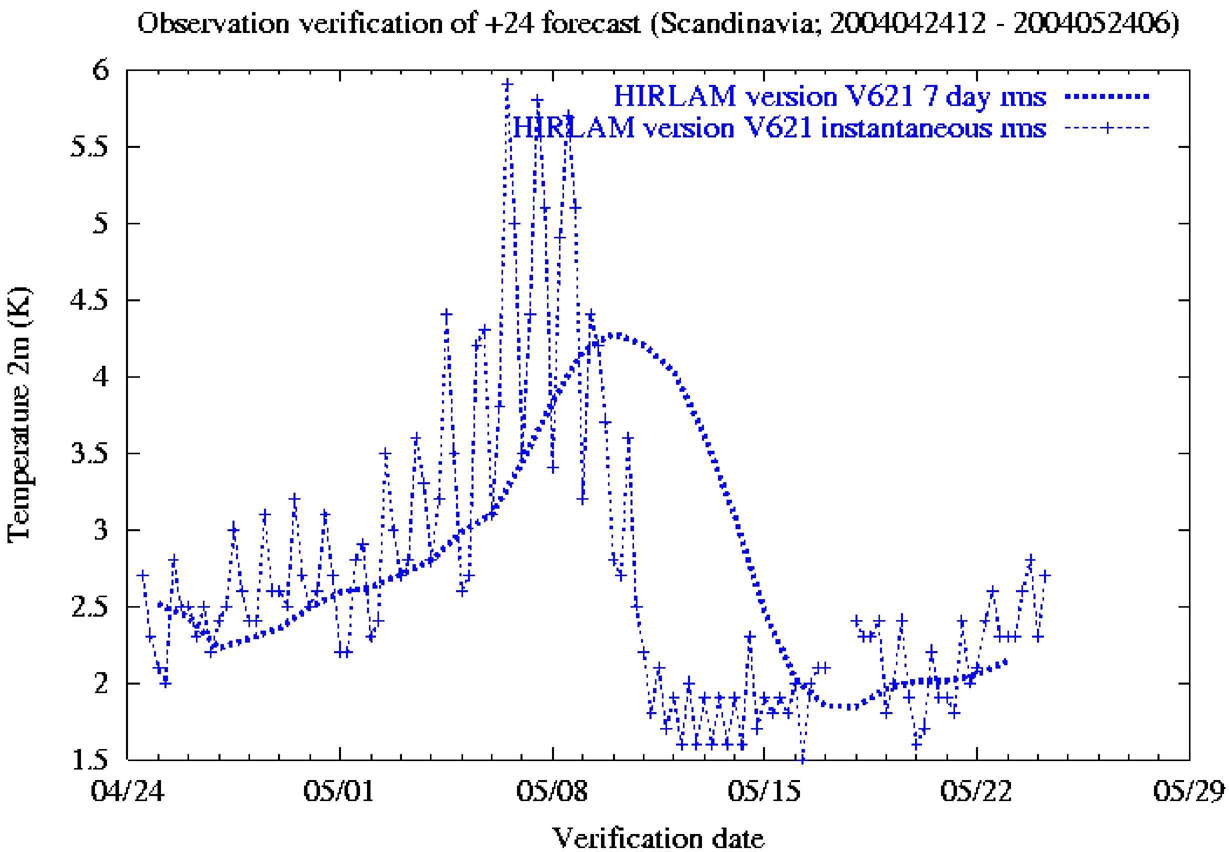


Figure 7: *The same as Fig. 6, but for the rms error.*

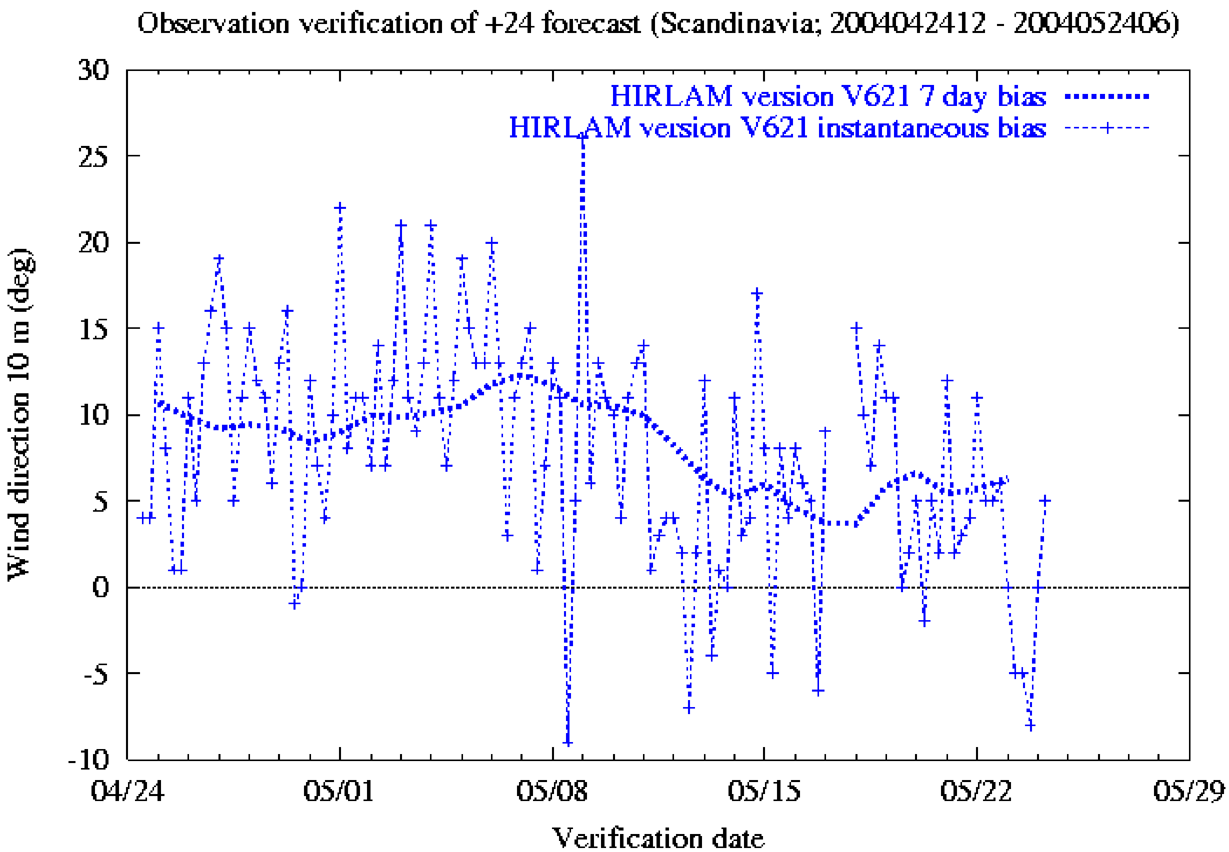


Figure 8: *The same as Fig. 6, but for 10-metre wind direction.*

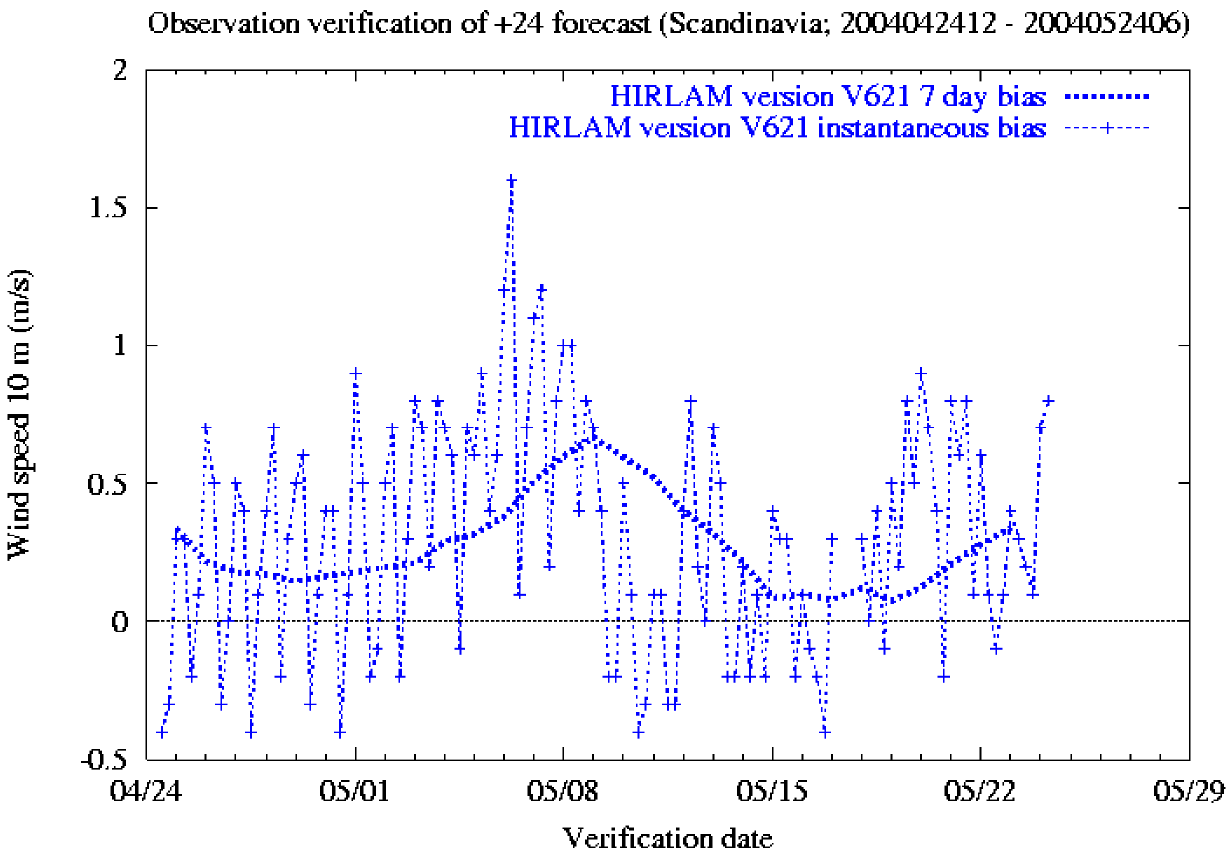


Figure 9: *The same as Fig. 6, but for 10-metre wind speed.*

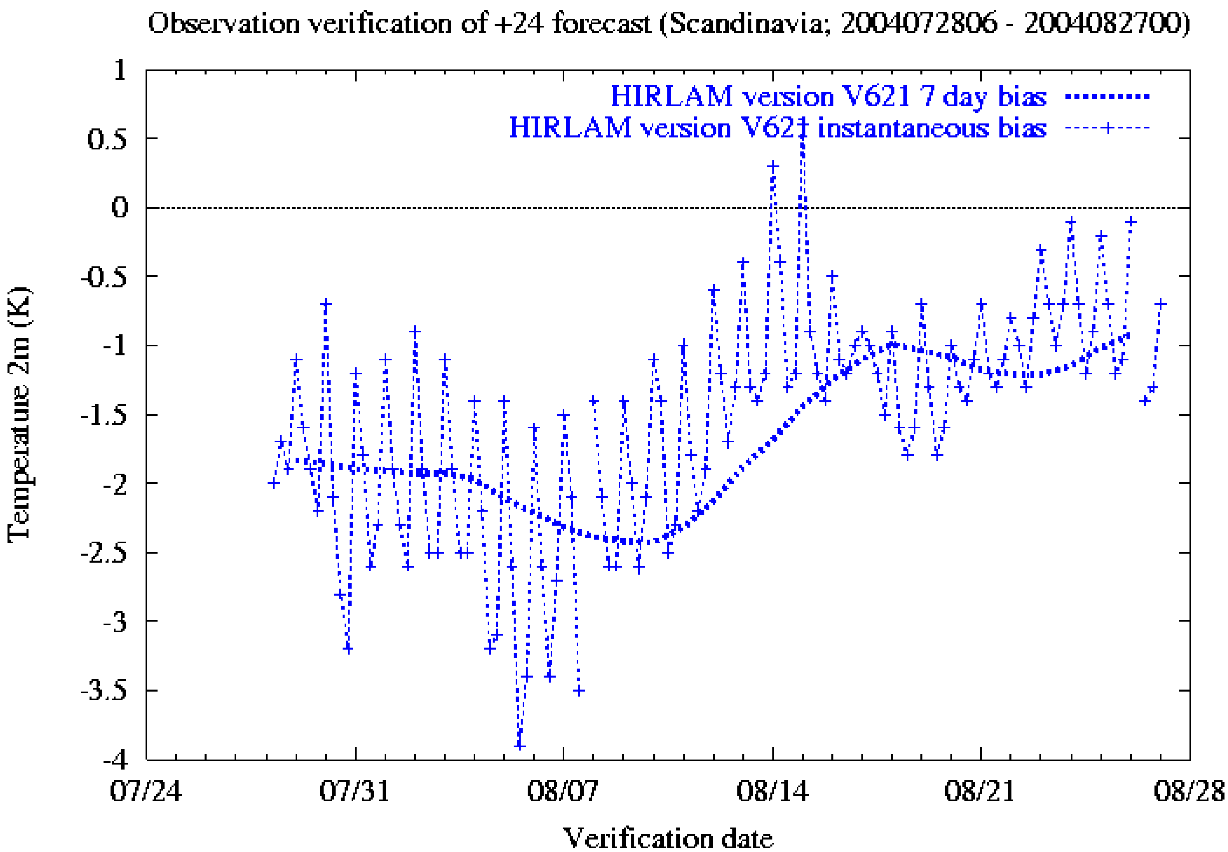


Figure 10: *The same as Fig. 6, but for the period 28 July to 28 August.*

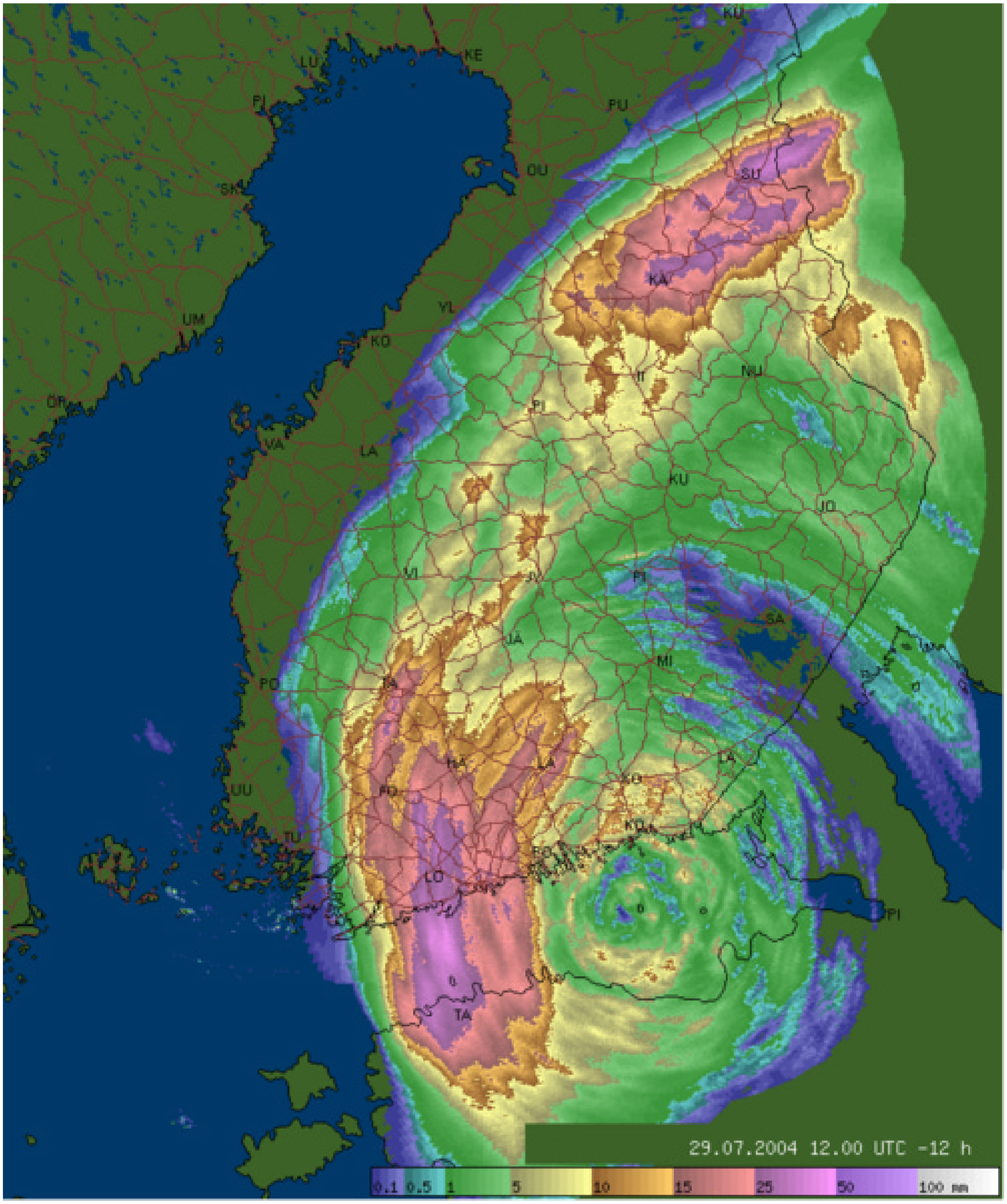


Figure 11: *Accumulated 12 h precipitation [mm] retrieved from the Finnish radar network. Valid time is 29 July 2004 12 UTC.*

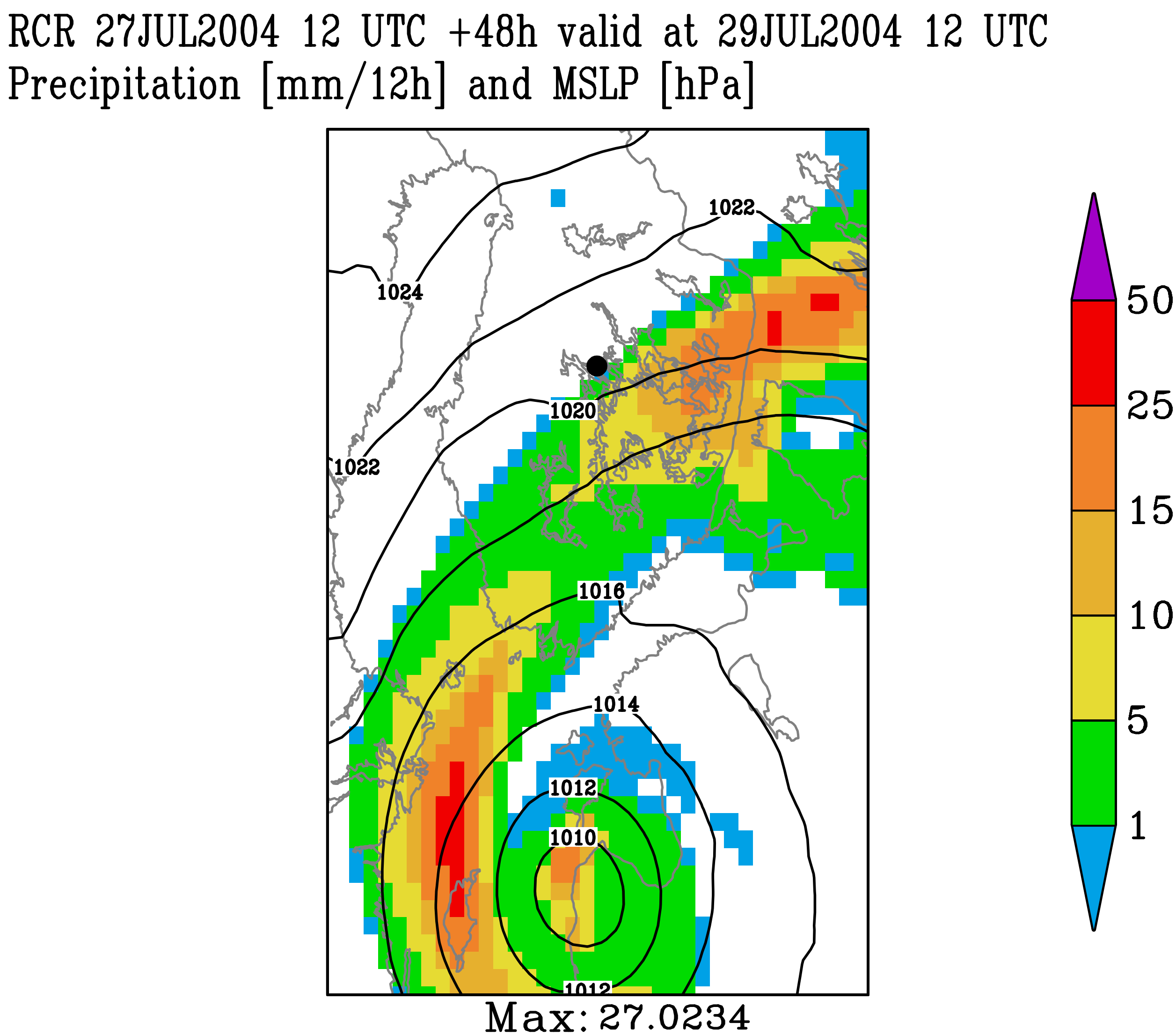


Figure 12: *Accumulated 12 h precipitation [mm] and mean sea level pressure [hPa] from the 48 h forecast starting from 27 July 2004 12 UTC. Valid time is 29 July 2004 12 UTC.*

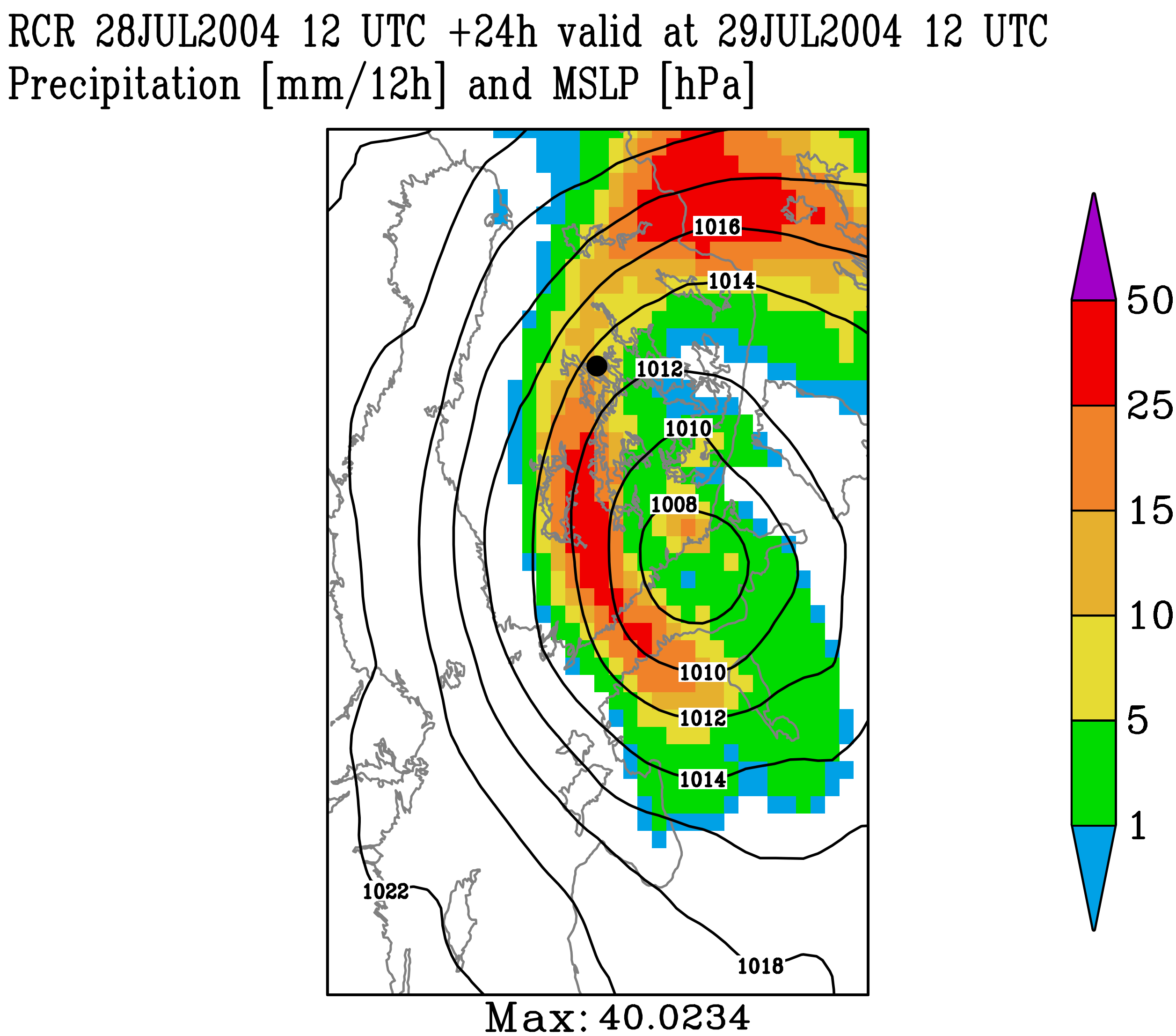
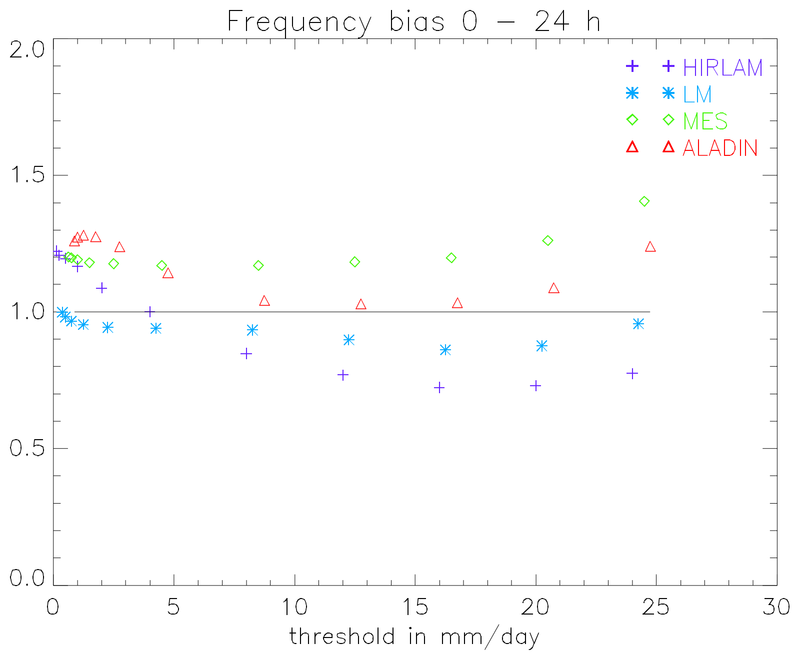


Figure 13: *Accumulated 12 h precipitation [mm] and mean sea level pressure [hPa] from the 24 h forecast starting from 28 July 2004 12 UTC. Valid time is 29 July 2004 12 UTC.*



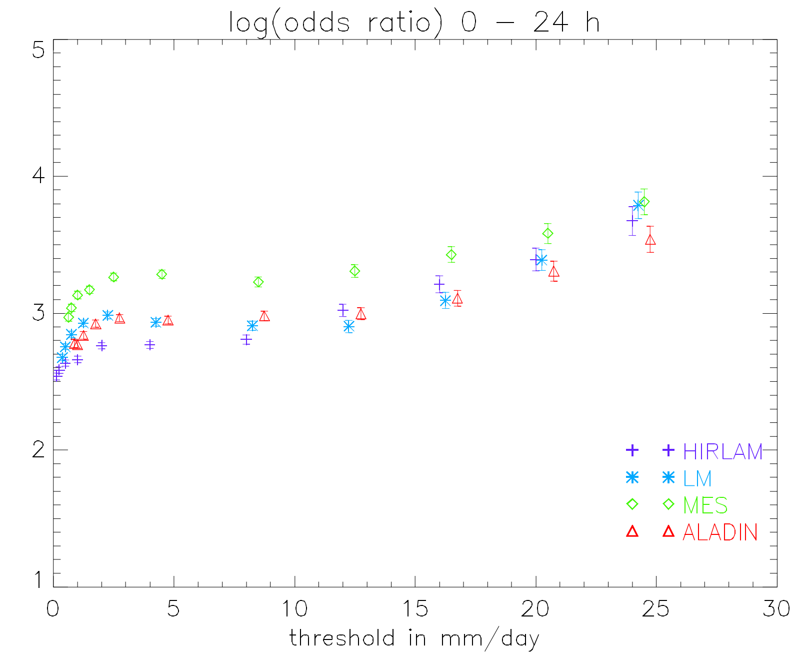


Figure 14: *Frequency bias and log(odds ratio) scores from June, July and August 2004 for 0-24 h forecast precipitation accumulations for the UK mesoscale (12 km), the DWD Lokal (7 km), the Hirlam reference (22 km) and Aladin France (10 km) models. (Material by courtesy of Marion Mittermaier and UKMO)*

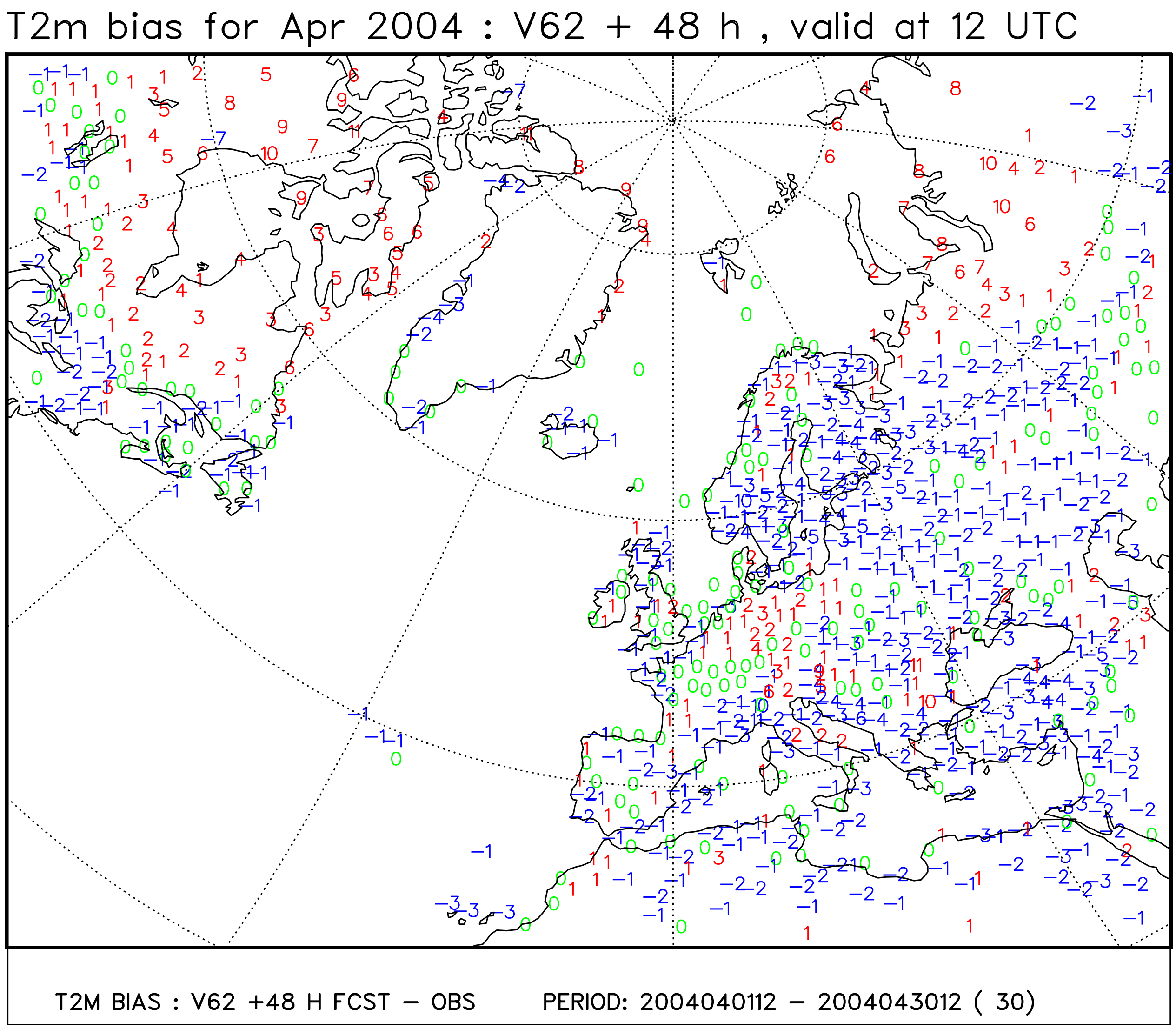


Figure 15: *T_{2m} bias (forecast minus observation) in 48 h RCR forecasts, valid at 12 UTC, for April 2004.*

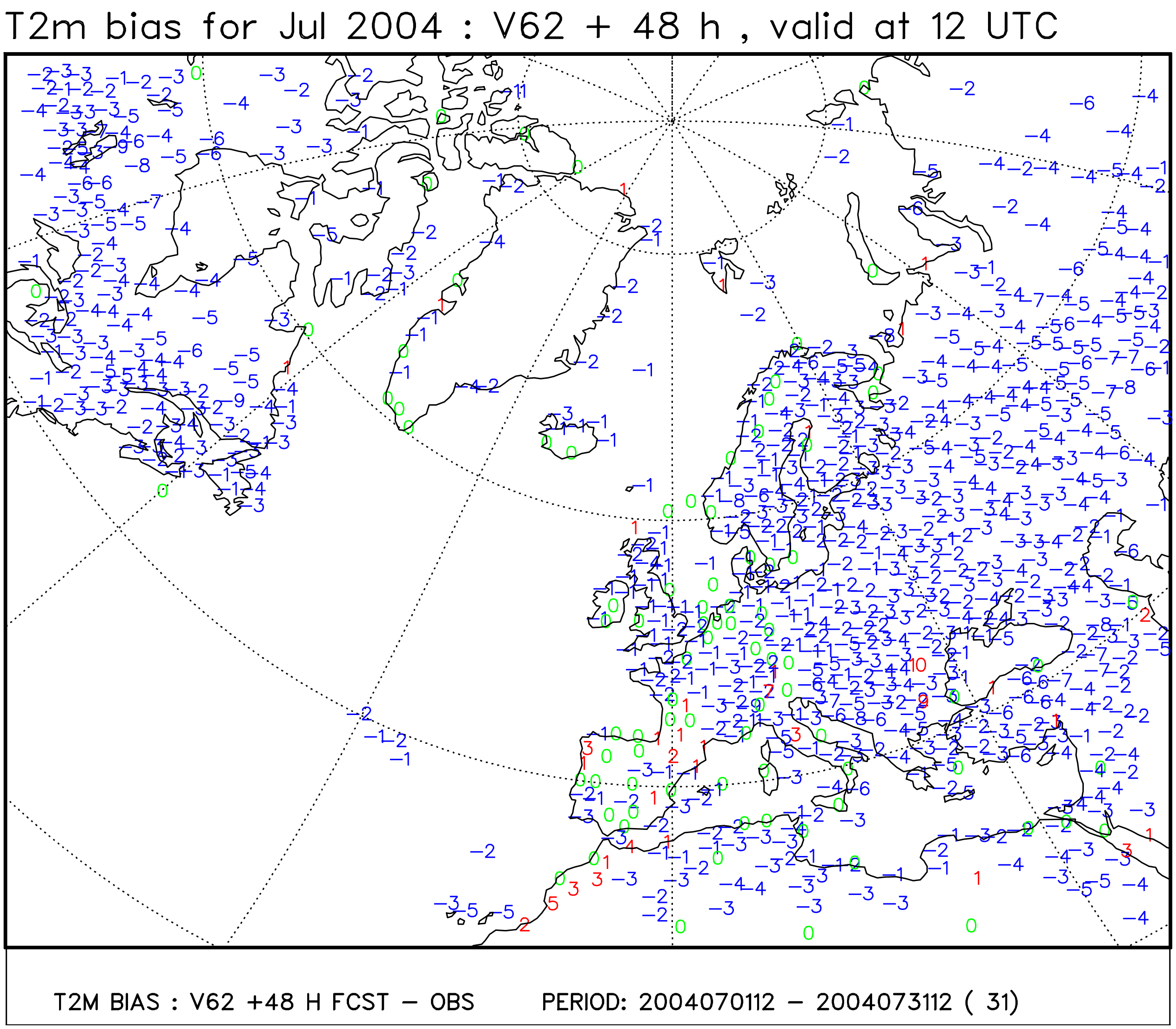


Figure 16: *T_{2m} bias (forecast minus observation) in 48 h RCR forecasts, valid at 12 UTC, for July 2004.*

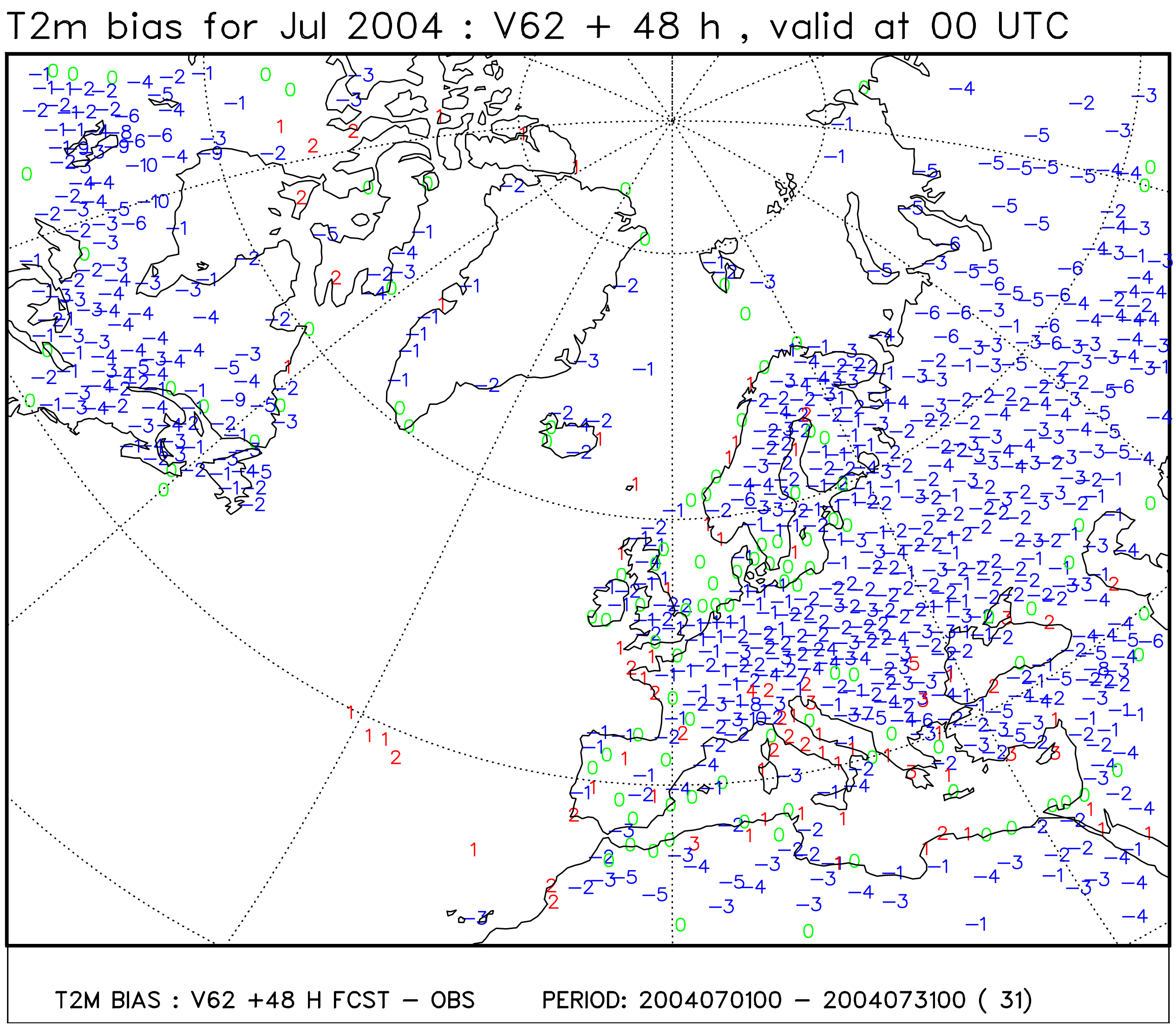


Figure 17: *T_{2m} bias (forecast minus observation) in 48 h RCR forecasts, valid at 00 UTC, for July 2004.*

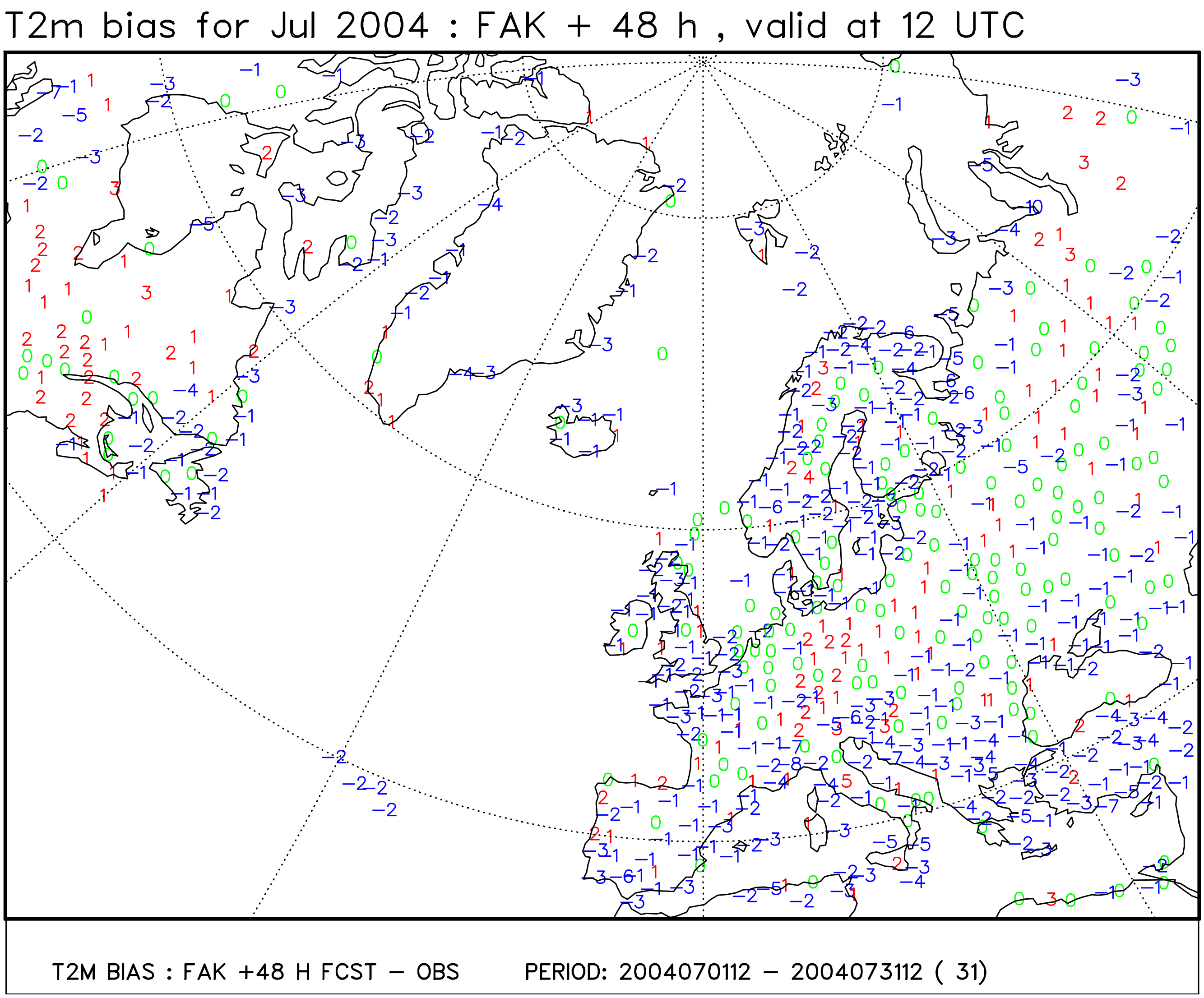


Figure 18: *T_{2m} bias (forecast minus observation) in 48 h experimental FAK forecasts, valid at 12 UTC, for July 2004.*