

Operational Verification of Vertical Profiles at DWD

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The operational upper-air verification at Deutscher Wetterdienst uses all available TEMP stations over the integration domain to verify the vertical structure of the forecasts. Vertically the atmosphere is divided into bins with steps of 25 hPa below 800 hPa level and 50 hPa between 800 hPa and 100 hPa level. Above 100 hPa the bins are now bounded by the pressure levels 100, 70, 50, 30, 20 and 10 hPa. Complying with the height every measurement respective every forecast increment is allocated to one bin.

Due to a bug in the calculation of the mean error (wrong sign for the wind component increments) wrong results for the mean error (bias) of wind speed and wind direction were presented up to now. In the calculation of root mean square error (rmse) this bug had no effects. It concerns Figure 30 and 31 in COSMO Newsletter 1 and Figure 31 and 32 in COSMO Newsletter 2. Figure 1 and Figure 2 now show the correct results for bias of wind speed and wind direction in the second half of year 2000 (at the top left) and year 2001 (on the bottom left). On the right hand the appropriate results for the rmse are shown.

In principle nothing but the sign of bias has changed in the Figures, there are slight differences in the year 2001 which are due to a changed limit value in the exclusion procedure of calms in wind direction statistics (former 0.8 m/s, now 3 m/s). The relative big differences above 100 hPa are caused by a changed arrangement of the bins (see above). Above 50 hPa are relativ few and probably inexact measurements, this could be an explanation for the strong increase of rmse and bias in that height.

Figure 3 shows the mean error (left column) and the root mean square error (right column) in the year 2002 (01.01.2002 - 31.12.2002) averaged over verification time 00 UTC for geopotential, relative humidity, temperature, wind direction and wind speed. To the right of each chart the bin occupancy is shown as a bar chart. Figure 4 shows the same illustration but averaged over verification time 12 UTC.

Like in the year before, most noticeable in the verification plots for geopotential and temperature is the strong increase of mean error above 250 hPa. The reason for this is assumed in an error in the interpolation scheme for temperature and pressure. Additionally a strong increase of rmse and bias for wind and temperature above 50 hPa is striking. As mentioned above one reason for that could be the relative few and probably inexact measurements in that height.

In the year 2001 the bias of geopotential in the analysis was below 250 hPa negative and nearly constant with height (-1 to -2 m). In 2002 there is now a prevalent positive bias (except 12 UTC verification time below 900 hPa), which is increasing from 1 m (-1 m for 12 UTC) in the lower troposphere until 6 to 7 m in 250 hPa. Compared to 2001 the bias for the forecasts didn't change very much below 600 hPa. Above, the decrease to negative values has disappeared. At 00 UTC the bias of the forecasts is nearly all over smaller than the bias of analysis, at 12 UTC this is only true for the 36 and 48 h forecast. The rmse below 250 hPa didn't change significantly, the strong increase with height of rmse begins in the analysis about 50 hPa lower than in 2001.

Compared to 2001 an increase of bias of relative humidity below 800 hPa can be stated, otherwise bias and rmse of relative humidity look very similar to those of 2001.

The negative bias of the temperature forecasts in the upper troposphere (between 500 to 300 hPa Max. -0.6 K in 2001) is reduced more than half at both verification times. The slight negative bias in the analysis (about -0.15 K, height constant between 900 and 400 hPa in 2001), is now positiv and less than 0,05 K. The negative bias below 900 hPa has increased for the forecast and decreased for the analysis at verification time 00 Z. At verification time 12 UTC there is diagnosed an increase of the positive bias of analysis and a tendency to negative values in the forecasts.

Compared to 2001 at both verification times the small bias in wind direction remains more or less unchanged as well as the root mean square error.

Basically the bias of wind speed below 400 hPa remains unchanged, except the 12 UTC verification time below 900 hPa, there the analysis bias is reduced to half the value of 2001. Between 400 hPa and 150 hPa at both verification times the bias of the analysis is slightly reduced. The forecast bias reduces with increasing time to about half the value of the year 2001.

Upcoming annual and/or continuous Time Series since April 2000 for each parameters bias and rmse (based on monthly mean profiles of all Temps) will be presented at the COSMO website.

As an example Figure 5 shows the continuous Time Series up to now (since April 2000) of temperature bias for the analysis (at the top) and the 12,24,36 and 48 h forecast (at the bottom) at verification time 00 UTC. The mean error for February 2003 is calculated with the data until 18th, and should still change.

During the whole period the analysis and all forecasts have between 50 hPa and 300 hPa a positive temperature bias increasing with forecast time. This can therefore also be seen in the annual mean diagram (Figure 3. Beneath this range the analysis has with exception from April to November 2002 predominantly a slight negative temperature bias. In the forecasts there is a range of negative temperature bias (increasing with forecast time) between 300 hPa and 600 hPa (excepted May - October 2002). Between 600 and 850 hPa there is a annual change in temperature bias with negative bias during the winter halfyears and positive bias in summer halfyears. Between 850 hPa and ground the circumstances are rather vice versa. A relative strong negative temperature bias during almost the whole year 2002 and in summer halfyear of 2001 is noticeable.

Figure 6 shows in a similar manner the Time Series of temperature rmse. Noticeable is a annual period in rmse with larger errors in winter and smaller errors in summer. Near the ground exist secondary maxima during spring/summer (rmse greater than 2 K at 48 h forecast).

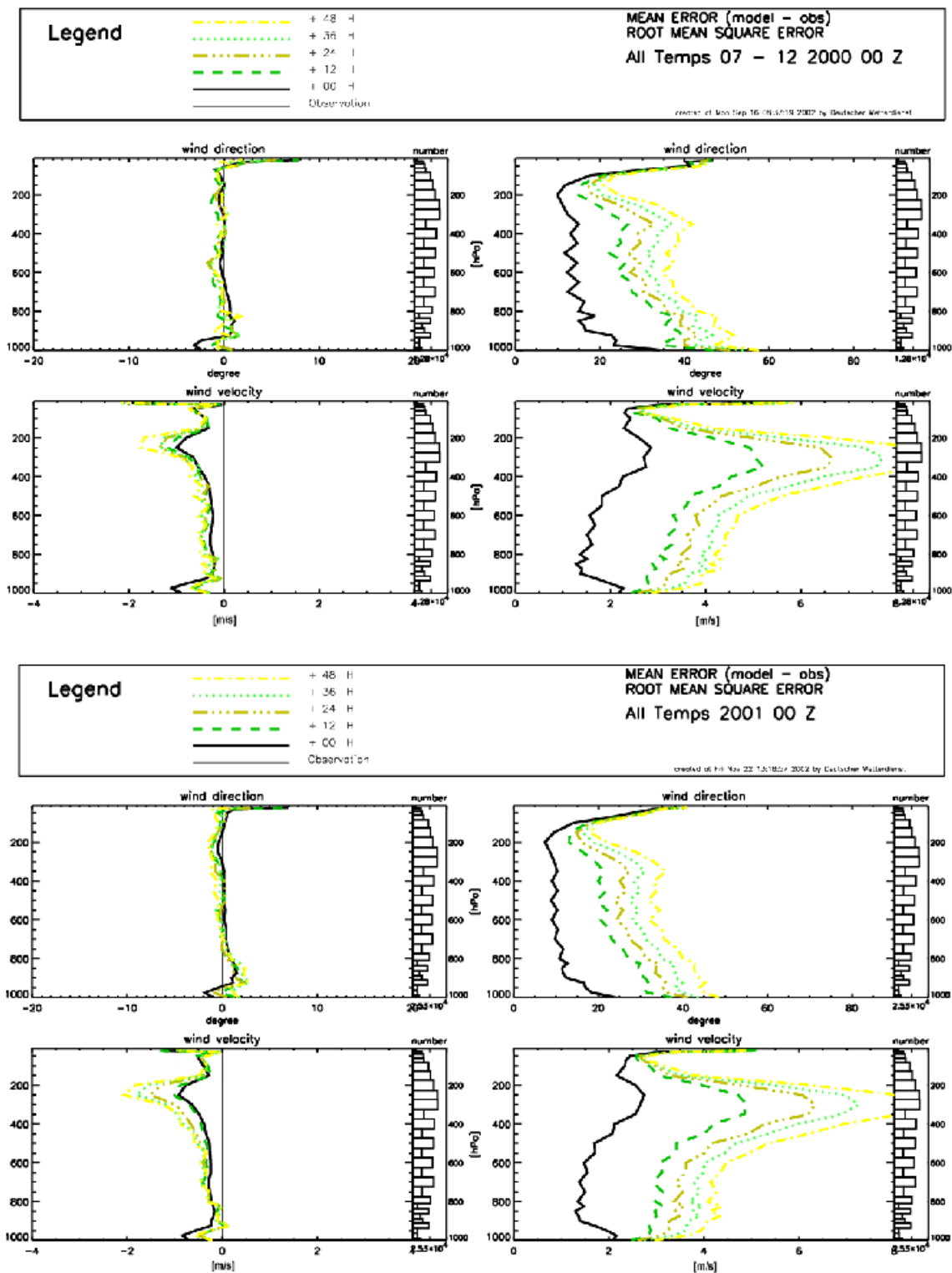


Figure 1: Corrected vertical profiles at all TEMP stations for 00 UTC LM runs at DWD for different forecast times. From top to bottom: wind direction, wind velocity at each case July - December 2000, wind direction, wind velocity at each case year 2001. Left: bias. Right: rmse.

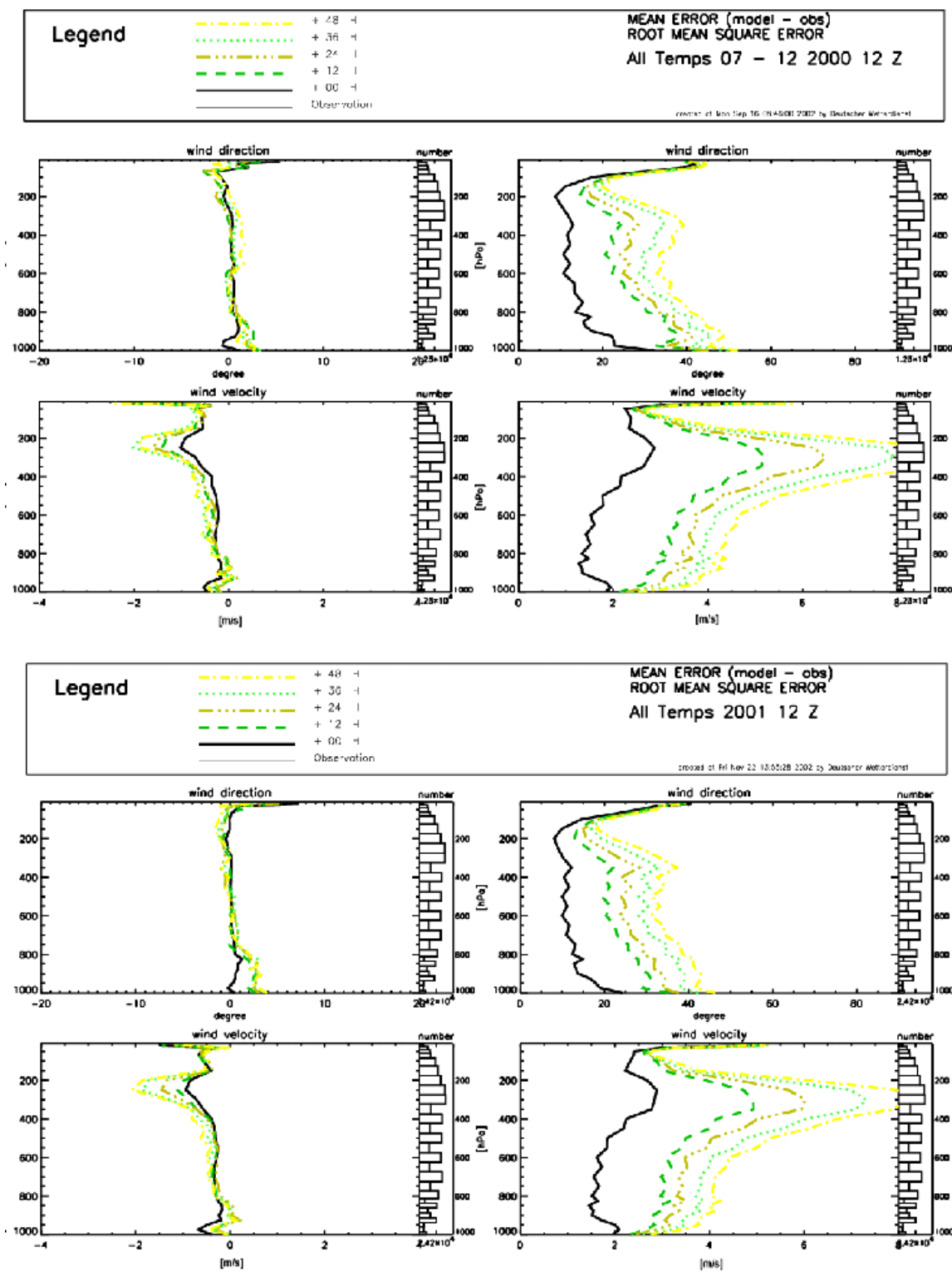


Figure 2: Corrected vertical profiles at all TEMP stations for 00 UTC LM runs at DWD for different forecast times. From top to bottom: wind direction, wind velocity at each case July - December 2000, wind direction, wind velocity at each case year 2001. Left: bias. Right: rmse.

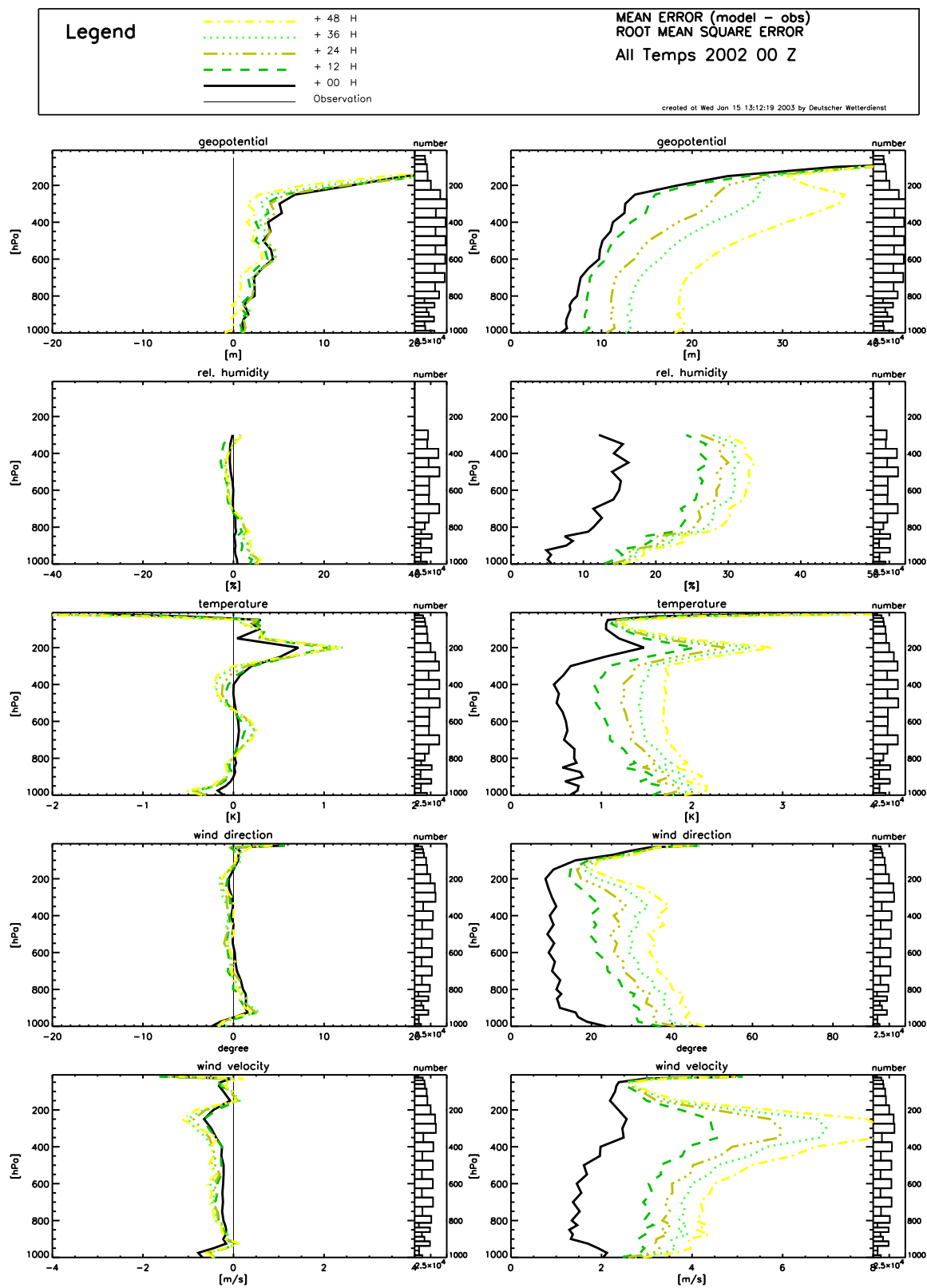


Figure 3: Vertical profiles at all TEMP stations for 00 UTC LM runs at DWD from January - December 2002 for different forecast times. From top to bottom: geopotential, relative humidity, temperature, wind direction and wind velocity. Left: bias. Right: rmse.

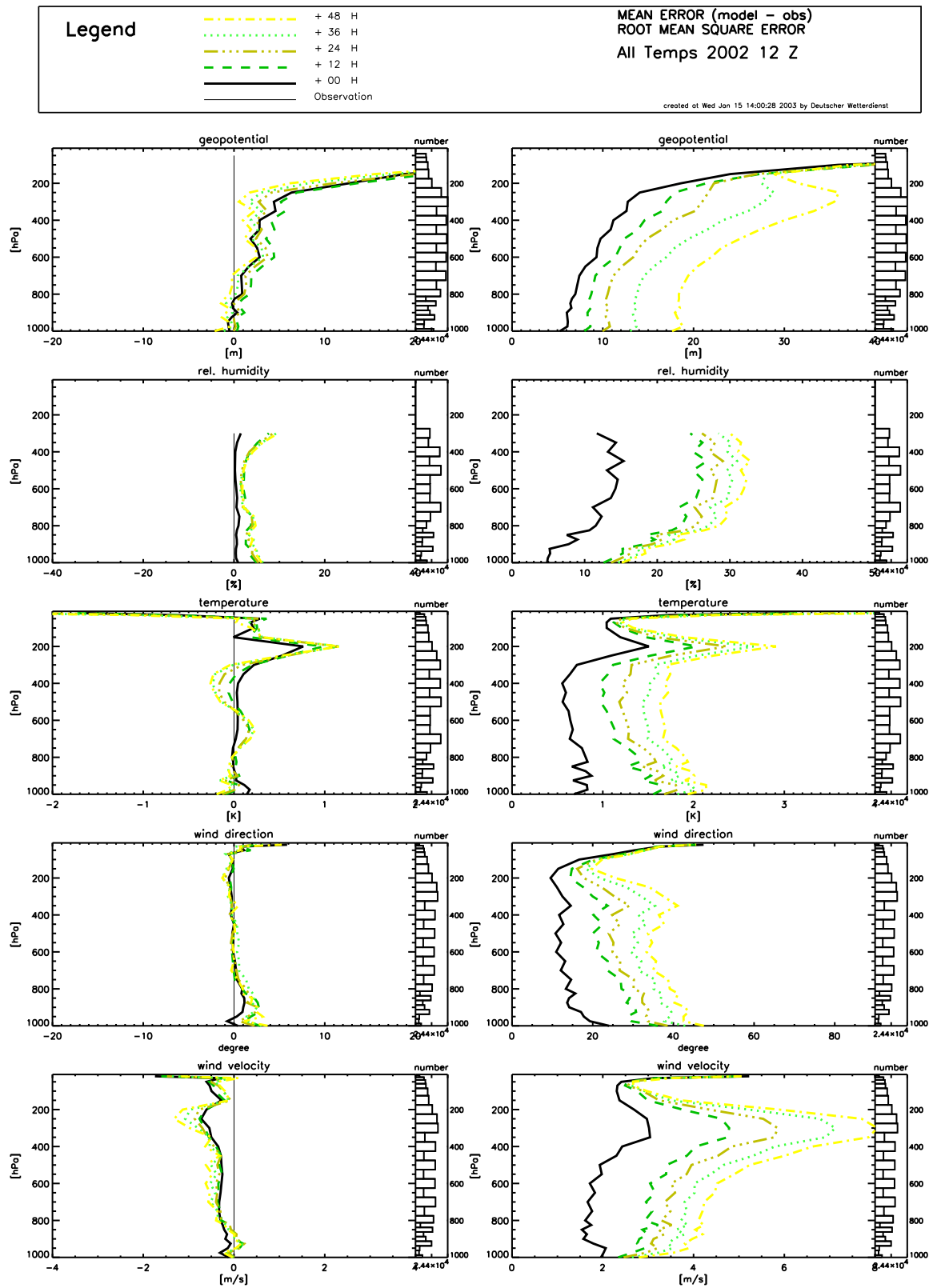


Figure 4: Vertical profiles at all TEMP stations for 12 UTC LM runs at DWD from January - December 2002 for different forecast times. From top to bottom: geopotential, relative humidity, temperature, wind direction and wind velocity. Left: bias. Right: rmse.

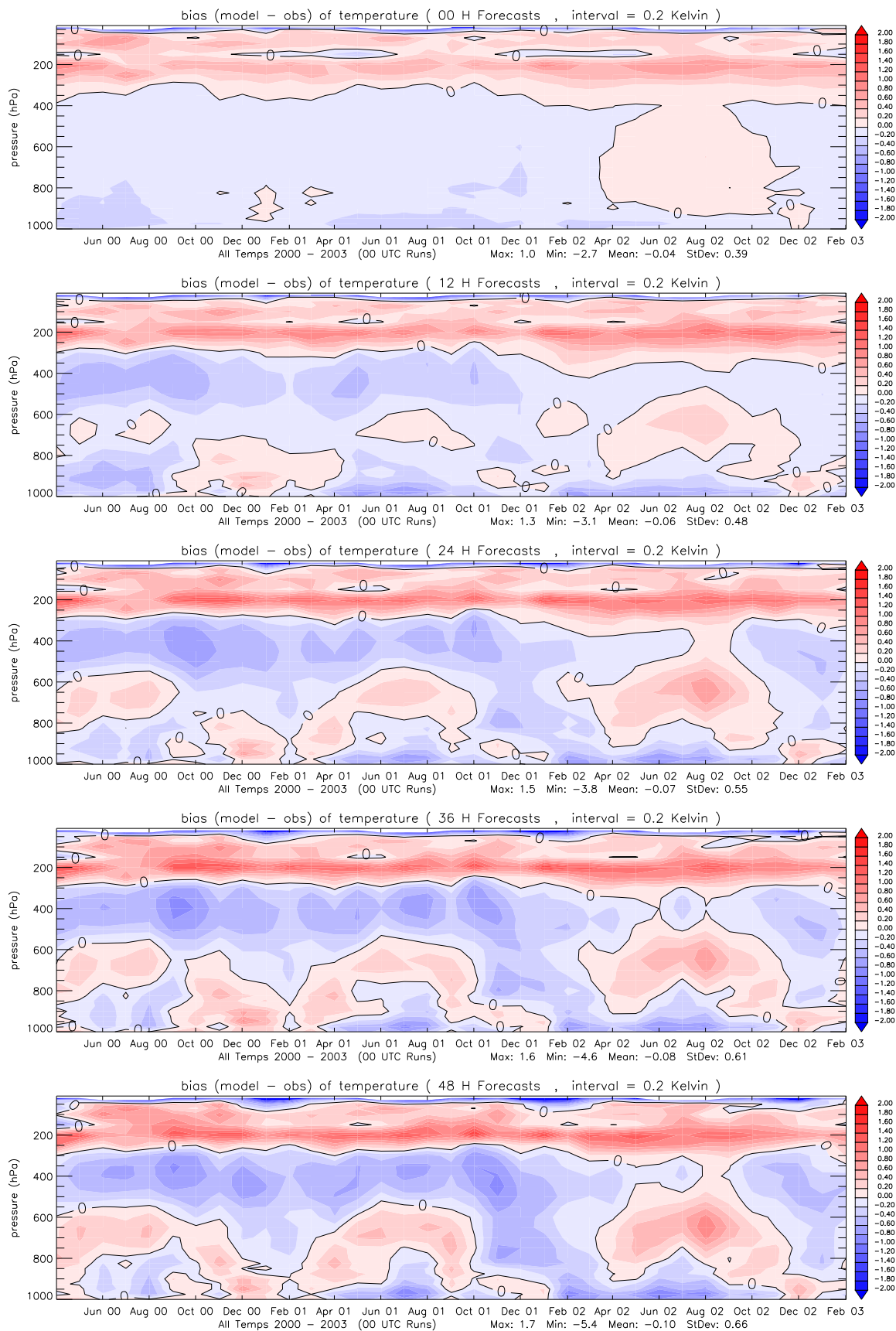


Figure 5: Time Series (April 2000 - February 2003) of temperature bias based on monthly mean profiles for 00 UTC LM runs at DWD. From top to bottom: Analysis, 12, 24, 36 and 48 h forecast.

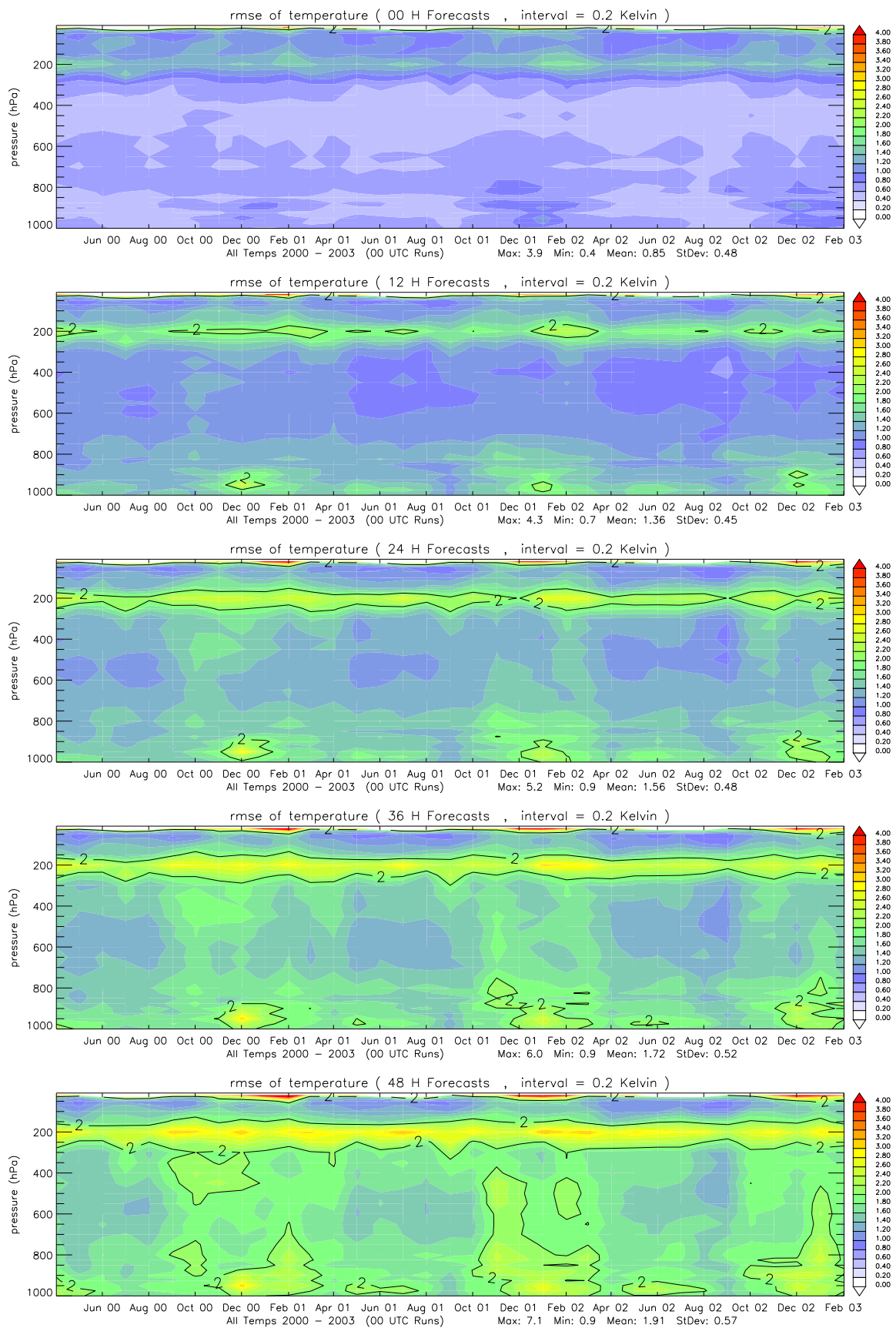


Figure 6: Time Series (April 2000 - February 2003) of temperature rmse based on monthly mean profiles for 12 UTC LM runs at DWD. From top to bottom: Analysis, 12, 24, 36 and 48 h forecast.