Additional verification of CBR updates

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Introduction

Different countries who run Hirlam with the CBR turbulence scheme (Cuxart et al., 2000) reported positive biases in the 10m wind speed. Using Cabauw tower data, De Rooy (2000) showed that this can be explained by the excessive mixing of momentum by the CBR scheme during (near) neutral conditions, leading to unrealistic wind profiles for the lowest model levels. During the ASM in Reykjavik, May 2001, the decision was made to choose on a short term between the two possible updates of the CBR scheme for the new reference version. The two possible versions are validated in Järvenoja (2001) and in De Rooy (2001) and are called CBR_INM and CBR_KNMI (Lenderink & De Rooy, 2000). From the results presented at the aforementioned ASM and verification studies, it became clear that both updates result in much more realistic vertical momentum mixing. Nevertheless it was decided to do some additional tests. This note describes additional verification against Cabauw tower data for a winter and a summer month, running Hirlam version 5.0.1. For the winter month we also present recent results for the CBR_KNMI version in combination with Hirlam version 5.0.5. The most important difference between version 5.0.1 and 5.0.5 is the updated STRACO scheme with revised shallow convection. Finally, in De Rooy (2001) the hypothesis was put forward that the development of a negative pressure bias during the forecast is caused by too small roughness length and consequently not enough drag in the model. This hypothesis is tested here by running the model with significantly larger (more realistic) roughness lengths.

Results

Winter period

De Rooy (2001) (from hereon R38) shows that the verification results for February 2001 are to a large extent dominated by the problem of too much and too persistent low-level clouds which occurs during winter periods. This problem leads to too unstable profiles and consequently too much mixing. Hence, we decided to try another winter month, namely November 1996, for verification of both CBR updates. Unfortunately, we found out that also this month suffers from too unstable temperature profiles. Different from R38, for this month it is not certain that the low level cloud problem is really the cause of the too unstable profiles. For November 1996, hours are found with no cloud liquid water in the model and this was confirmed by cloud cover observations. Nevertheless, the model produces unstable temperature profiles, whereas observations show stable profiles. The output of the verification runs does not contain cloud cover, so it is difficult to investigate this matter thoroughly. Anyhow, again the scatterplot for the temperature difference between the

lowest two model levels (Figure 1) is dramatically bad (comparable with Fig. 5 in R38).

Figure 1 Observed and modelled temperature difference between the lowest two model levels for November 1996. Hirlam runs are made with CBR_INM (on the left) or CBR_KNMI (on the right)

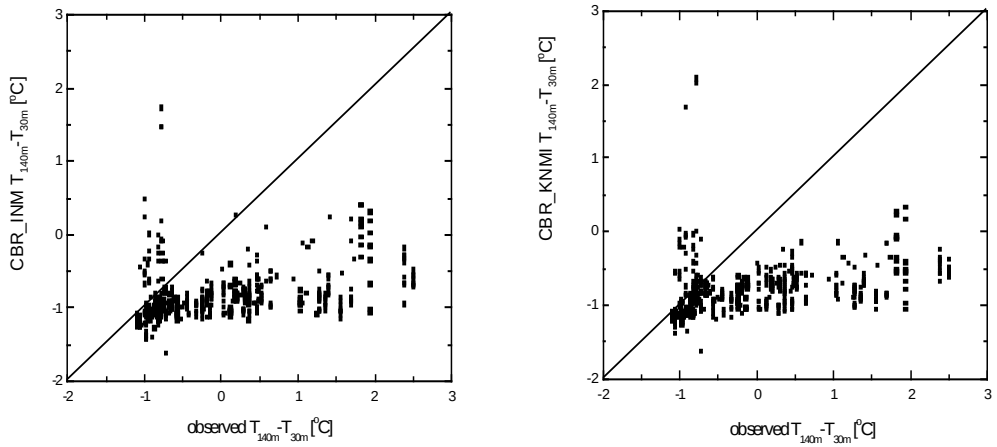
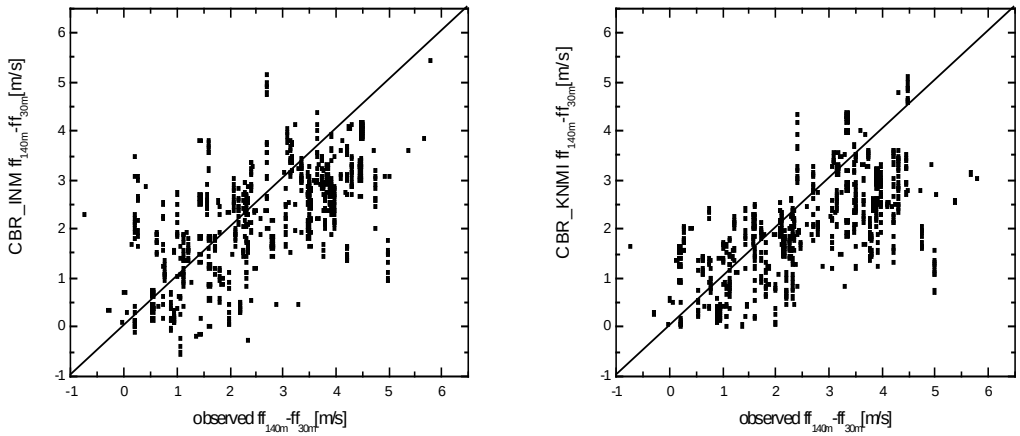


Figure 1 shows qualitatively the same picture for CBR_INM and CBR_KNMI. Also the RMSE and Bias for the temperature difference are not significantly different between both updates. Again we have the problem of extracting the relatively small signal between two different turbulence schemes in the large "noise" produced by a model error. Unfortunately, for this month the updated STRACO with revised shallow convection is not a solution for the too unstable temperature profiles. The CBR_KNMI run with Hirlam version 5.0.5 (updated STRACO) resulted in comparable scatterplots as presented in Figure 1. Therefore this scatterplot is not presented.

Figure 2 Observed and modelled wind speed difference between the lowest two model levels for November 1996. Hirlam runs are made with CBR_INM (on the left) or CBR_KNMI (on the right)



Probably the most important result for this winter month is given by the wind speed difference scatterplot. Remember that with the original CBR scheme wind speed differences are always smaller than 2 m/s (Figure 3 Lenderink and De Rooy, 2000). So it is clear that both updates result in much more realistic momentum mixing. Consistent with the results in (R38) the results for wind speed difference in November 1996 are somewhat in favour of the CBR_KNMI scheme. Especially if we remember that underestimations in the wind speed difference might be ascribed to the too unstable temperature profiles. The too unstable profiles (Fig. 1) will cause too much mixing and therefore underestimations of the wind speed differences. Because of this problem it is preferable to look at Standard Deviation (SD) (about 0.1 m/s smaller with CBR_KNMI) instead of RMSE (non-significantly smaller with CBR_KNMI) or Bias (about 0.15 m/s larger with CBR_KNMI). CBR_KNMI in combination with the updated STRACO scheme did not result in large differences in the momentum mixing.

The results for temperature and wind speed separately at synoptic level and the lowest two model levels show only very small non-significant differences between the two CBR updates. Generally CBR_KNMI has a smaller SD, whereas CBR_INM shows smaller biases. Only the rather peculiar figure with the pmsl bias as a function of the forecast period is presented here.

Figure 3 November 1996 Verification of pmsl against EWGLAM and synops stations in the Netherlands as a function of the forecast period

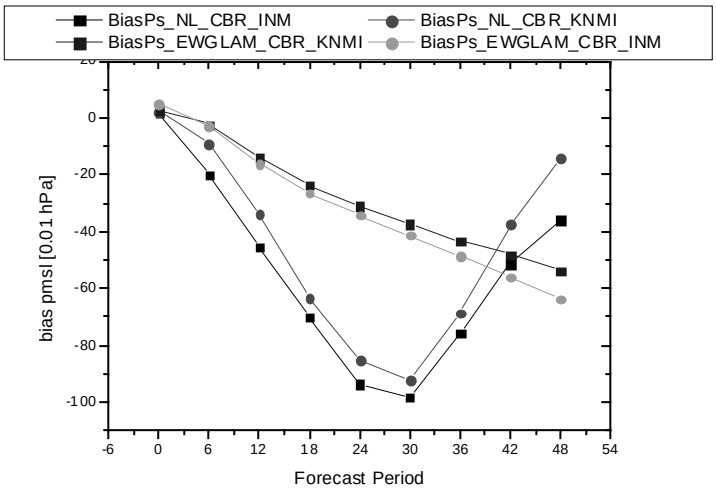
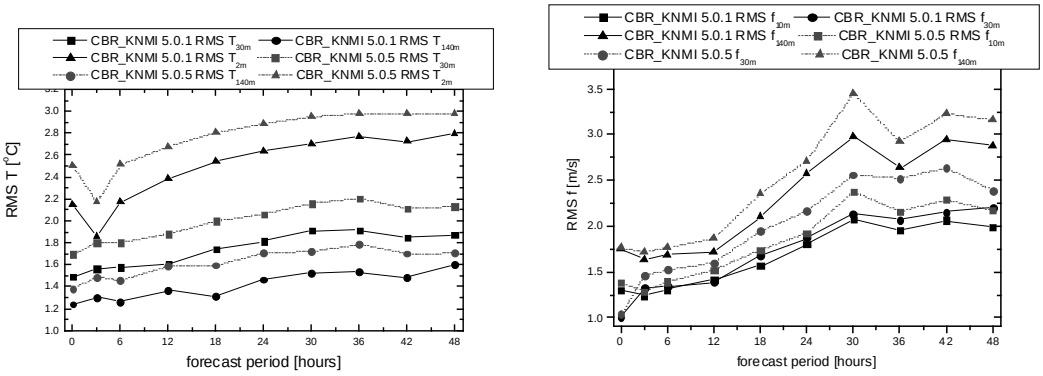


Figure 3 shows that the CBR_KNMI scheme produces a slightly smaller pmsl bias when verified against EWGLAM or stations in the Netherlands. The bias in pmsl verified against synops stations in the Netherlands increases strongly during the first 24 hours and almost disappears during the last 24 hours of the forecast. The reason for this strange behaviour is yet unclear.
The pmsl scatterplots for Cabauw for this month are qualitatively the same as in Figure 7 in R38, so the bias for high pressures remains about 0 during the forecast but low pressures become too low. A possible explanation for the development of a negative bias in pmsl during the forecast is given in R38, namely too small roughness lengths for large parts of Europe. To test this hypothesis, we rerun the experiment for February 2001 with the CBR_KNMI scheme but this time with increased, but realistic, roughness lengths (for large areas in Europe with too low z_0, the roughness

length is about doubled). Unfortunately, the enhanced surface drag turned out to have no effect on the development of the negative bias in the low surface pressures. For EWGLAM stations the bias in the 10m-wind speed stays about the same for the analysis but is reduced with approximately 0.3 m/s for other forecastperiods using the increased roughness length field.

When CBR_KNMI is run with Hirlam version 5.0.5 the results for temperature and wind speed at synoptic level and the lowest two model levels deteriorate remarkably (see Figure 4a and b). Most likely the differences are caused by the updated STRACO scheme with revised shallow convection. The increased temperature error is primarily the result of higher temperatures at the lowest two model levels and 2m. This might be explained by the increased entrainment due to the STRACO update. Because the temperature rises with approximately the same amount for all the investigated low levels, the stability problem stays the same (like Figure 1). The worse temperature results are confirmed by the standard verification results against EWGLAM stations (temperature bias at 1000hPa increases with about 0.15 ^{o}C). For wind speed the larger RMS with the new STRACO scheme is caused by an increase in standard deviation and bias. The results with the STRACO update should be investigated in more detail and for other conditions.

Figure 4a and b. Verification of temperature and wind speed for the lowest two model levels and synoptic level against Cabauw tower observations. Runs are made with CBR_KNMI and Hirlam version 5.0.1 and 5.0.5 (the last one includes the STRACO update)



Summer period

July 2000 is chosen as summer verification period. Figure 5 and 6 show the vertical wind speed and temperature differences between the lowest two model levels.

Figure 5 Observed and modelled wind speed difference between the lowest two model levels for July 2000. Hirlam runs are made with CBR_KNMI (on the left) or CBR_INM (on the right)

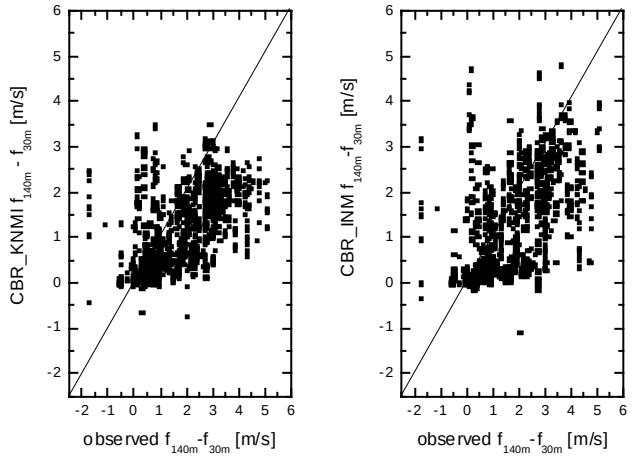
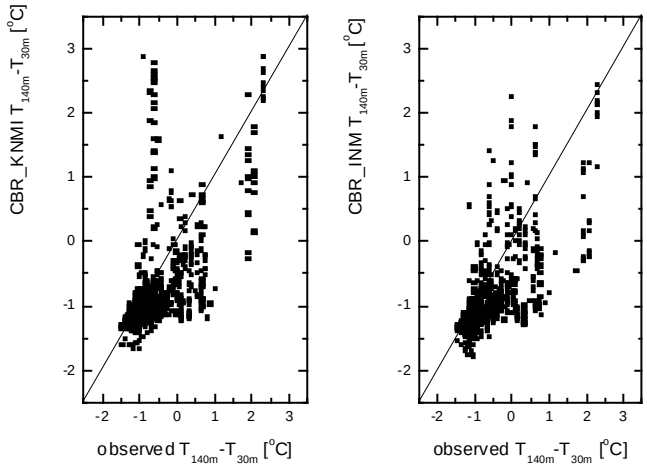


Figure 5 shows surprisingly resemblance with figure 1 in R38 (which is the same scatterplot but for July 1996). Again the CBR_KNMI looks somewhat better.

Figure 6 Observed and modelled temperature difference between the lowest two model levels for November 1996. Hirlam runs are made with CBR_KNMI (on the left) or CBR_INM (on the right)



For temperature difference the CBR_INM scatterplot looks somewhat better, mostly due to the remarkable vertical line with overestimations in the scatterplot of CBR_KNMI. Because these scatterplots include all forecast periods, this line of overestimations consists of only a few sun rise hours.

Conclusions

CBR_INM versus CBR_KNMI

- The most important signal is in the wind speed difference, which reflects the vertical momentum mixing. For all verification periods (winter and summer) results with the CBR_KNMI version show somewhat smaller RMS and SD. For November 1996, the wind speed difference results with the CBR_KNMI scheme seem to be physically more consistent (too unstable temperature profiles give too small wind speed differences). The results for the wind speeds at different heights separately show no significant differences between both updates.
- Temperature results are less conclusive. For one summer month the CBR_INM performs somewhat better with respect to the temperature difference. Whereas for other months no significant differences are found. Again results at different heights separately show no signal. The temperature results for winter months are strongly influenced by the persistent too unstable temperature profiles (possibly associated with the low-level cloud problem).

Other results

- The too small roughness lengths for large parts of Europe can not explain the development of a negative pressure bias for lows in Cabauw. However, as could be expected, increasing the roughness length to more realistic values does improve the bias in the 10m-wind speed for EWGLAM stations.
- For November 1996, the updated STRACO scheme with revised shallow convection does not reduce the too unstable temperature profile in Cabauw. Verification for this month shows deterioration of wind speed and temperature at the lowest levels. Possibly due to enhanced entrainment, the positive temperature bias increases at the lowest two model levels and 2m (also observed for verification against EWGLAM stations). This subject certainly requires further study.

Acknowledgements
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Editor's comment

After the submission of this article a most likely reason for the unexpected behaviour of the updated STRACO scheme together with the revised CBR_KNMI emerged. The shallow convection introduced in STRACO in 5.0.4 and 5.0.5 uses TKE as a closure assumption. The CBR_KNMI revision redefines TKE from being on full levels to half levels. The shallow convection would thus use half-way the wrong level in combination and probably use TKE in cloud, rather than just above, and this is normally too high a value. Because of this incompatibility and of the high priority of the CBR revision, the STRACO shallow convection has temporarily been taken out of the beta-releases following 5.0.6.

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