Tests with different convection- and condensation schemes for a moist period in summer.

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February 15, 2002

1 Introduction

The present operational HIRLAM version used at SMHI is 5.0.0, but we still use Louis vertical diffusion scheme and Sundqvist condensation scheme. The reason is that verification have shown that the reference STRACO scheme produces worse forecasts of total cloud cover, which also affects 2 meter temperature in a negative way, especially in spring at daytime. The goal for this year is to replace the current physics in the model which Kain-Fritsch convection scheme, Rasch-Kristjansen condensation scheme, CBR vertical diffusion scheme and ISBA surface scheme.(A project called HIRLAM-X have been started for that purpose) The difference between different vertical diffusion schemes, as well as different surface schemes have been evaluated earlier (Järvenoja ,2002) but Kain-Fritsch convection scheme and Rasch-Kristjansen condensation scheme have so far not been tested separately. The reason for doing such an experiment is to examine the effect of each scheme in order to make it easier to find the reason for systematic errors etc. Here, such an experiment is presented.

2 The experiment

The experiment is based on HIRLAM 5.0.0. The forecast area covers Europe and surrounding areas, especially a large part of the north Atlantic. 166x156 grid-points with 0.3 degrees. resolution and 31 levels are used. Louis vertical diffusion scheme is used except for the reference scheme, where the reference version of CBR is used. The data assimilation is based on HIRVDA 4.4.3. The forecast length is 36 hours and the period is July 5 to 16, 2001. This is a warm and rather wet period with a great number of thunderstorms and other cases with strong convection. Four versions are going to be compared here:

1. The reference HIRLAM 5.0.0 with STRACO and CBR, called REF500
2. Sundqvist scheme, it corresponds closely to the current operational run. It is called KUOSUN.
3. Sundqvist scheme with Kain-Fritsch. It is called KFSUN.
4. Rasch-Kristjansen scheme with Kain-Fritsch. It is called KFRK.

In Rasch-Kristjansen scheme, a correction have be done so that the condensation process have been dependent on cloud thickness. Without that change, the precipitation for stratocumlus clouds start to easily and stratocumulus clouds get to thin, or disappear. The effect of this correction is not very large here, but the effect will probably be more significant when higher vertical resolution is used.

3 Results

For near surface parameters, all the stations in the Swedish meso-scale analysis area are used for verification, not the EWGLAM stations. This area covers mainly northwest Europe. The RMS-error and bias for 2-m temperature and dewpoint temperature are shown in Fig. 1. There are only small differences for 2-m temperature, but the REF500 have somewhat worse RMS for dewpoint than the other three. For cloudiness, (Fig. 2) the reference run is also somewhat worse than the others. KFSUN and KFRK have larger negative bias than KUOSUN and also slightly higher RMS-error. This is probably caused by to little convective clouds in the Kain-Fritsch scheme, at least in case of weak or moderate convection. (shallow convection)

The RMS- error for mean sea level pressure is lower for REF500 than the other three. The RMS- error for 10-m wind speed is not very different between the four runs.

The precipitation forecasts have been verified for 6 hour periods, which is a tougher test than 12 hour periods which is common. The ability of forecasting large amount of precipitation is of great importance. The probability of detection (POD) and false alarm rate (FAR) for 10 mm in 6 hours is seen in table 1. The result for all forecast lengths are put together. Here, KFSUN and KFRK is superior the other runs, based on KUO schemes. Note the rather lagre improvement between KUOSUN and KFSUN. This difference is only due to the Kain-Fritsch scheme. For 2 mm threshold, the differences between the runs is not that big.(not shown) The number of cases with small precipitation amount is about twice the observed number of such cases in REF500. (The trehold is set to 0.1 mm in 6 hours.) One reason is that the value of the grid square is compared with single observations in that square, but it seems likely that small precipitation amounts are forecast too often. This bias is reduced in the other runs, especially in KFSUN.

Table 1 : POD and FAR for 10 mm precipitation during 6 hour periods the four runs.

Run	POD	FAR
REF500:	17	64
KUOSUN :	12	73
KFSUN :	20	63
KFRK:	20	66

The verification against EWGLAM sounding stations is seen i Figs 4-7. 30 hours and 36 hours forecasts are put together. The RMS error and bias for temperature is seen in Fig. 4. The RMS error is slightly larger for KUOSUN than the others. All runs have a small positive bias around 300 hPa. KFSUN and KFRK have a positive bias around 700 hPa. This feature is also found in other tests eg., a very preliminary test of the runs from HIRLAM-X mentioned in the introduction. A negative bias in relative humidity is found near 700 hPa and a positive one at 500-300 hPa, especially in KUOSUN (Fig. 5). REF500 is excluded since the post-processed relative humidity is not with respect to water. There are no large difference between the runs for geopotential hight (Fig.6), except that KUOSUN has a negative bias in upper troposphere. Also the results for wind speed (see Fig. 7) is rather similar, but a small reduction of RMS-error can be seen near tropopause level for the two runs based on the Kain-Fritsch scheme.

4 Conclusions

The reference HIRLAM 5.0.0 physics have been compared to a version with Louis vertical diffusion scheme and Sundqvist condensation and convection scheme, a version with Louis vertical diffusion scheme and Sundqvist condensation scheme but with Kain-Fritsch convection scheme and finally Louis vertical diffusion together with Kain-Fritsch convection scheme and Rasch-Kristjansen condensation scheme. The introduction of the Kain-Fritsch convection scheme seems to have more impact than changing from Sundqvist to Rasch-Kristjansen. With Kain-Fritsch scheme, the forecasts of especially large amount of precipitation are improved, this is clearly demonstrated when KUOSUN and KFSUN are compared. The 2-d cloud field is slightly worse when Kain-Fritsch scheme is used. This is probably caused by to little convective clouds in the Kain-Fritsch scheme, and the result is a with a negative bias in the cloud field. A moderate negative bias in relative humidity is found for the 700 hPa level.

The results presented here also puts a question mark on paying large attention on the verification of mean sea level pressure. Here, the reference HIRLAM 5.0.0 has the lowest RMS error for mean sea level pressure, but is worst in several other parameters, especially the cloud field.

ACKNOWLEDGMENTS: The author wishes to thank Colin Jones for the help with preparating the code for these tests and for including the latest corrections of the Rasch-Kristjansen scheme.

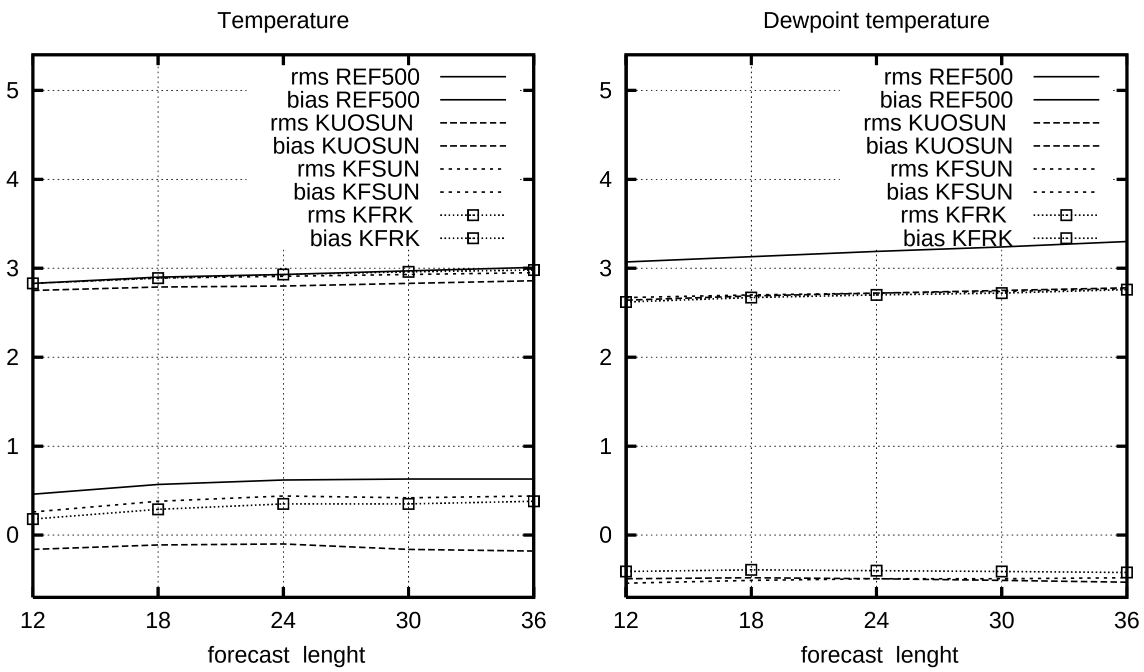

Fig. 1 : Bias and RMS- error for 2 meter temperature (left) and 2-m dewpoint temperature (right). The meaning of the different runs is explained earlier in the text.

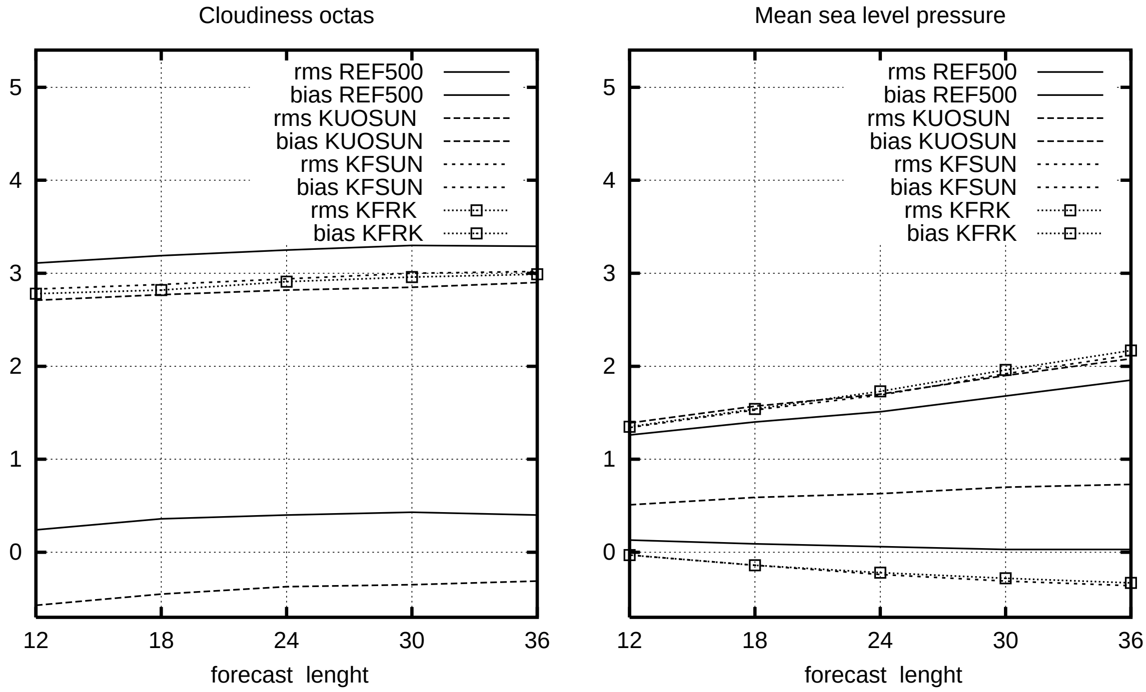

Fig. 2 : Bias and RMS- error for cloud forecasts (left) and mean sea level pressure (right).

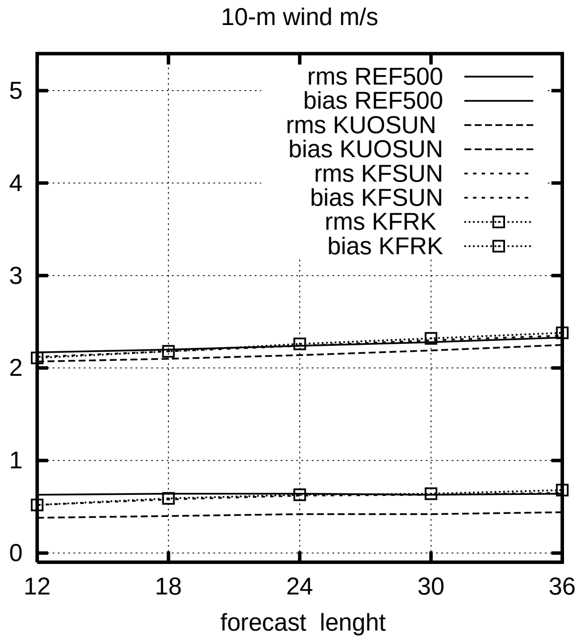

Fig. 3 : Bias and RMS- error for 10 meter wind speed.

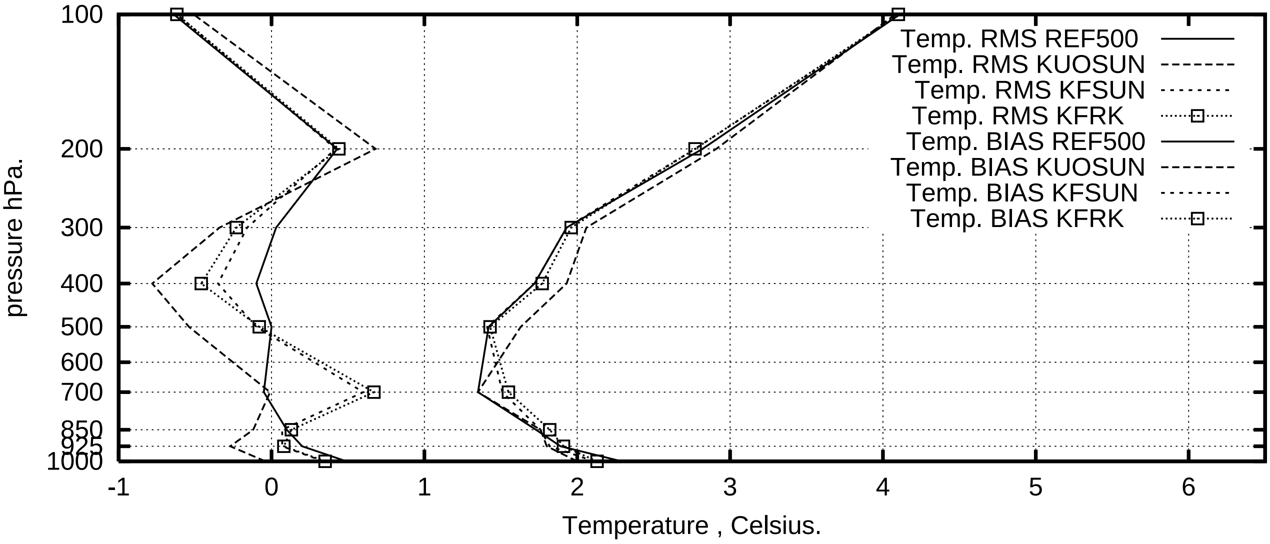

Fig. 4 : Bias and RMS- error for temperature. Verification against EWGLAM soundings.

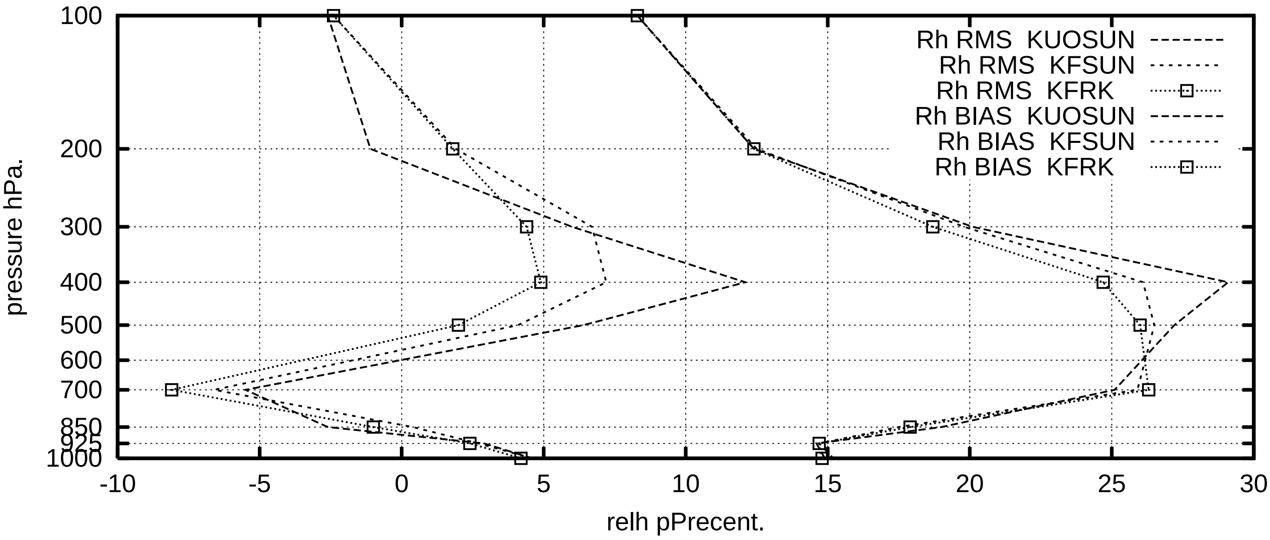

Fig. 5 : Bias and RMS- error for relative humidity. Verification against EWGLAM soundings.

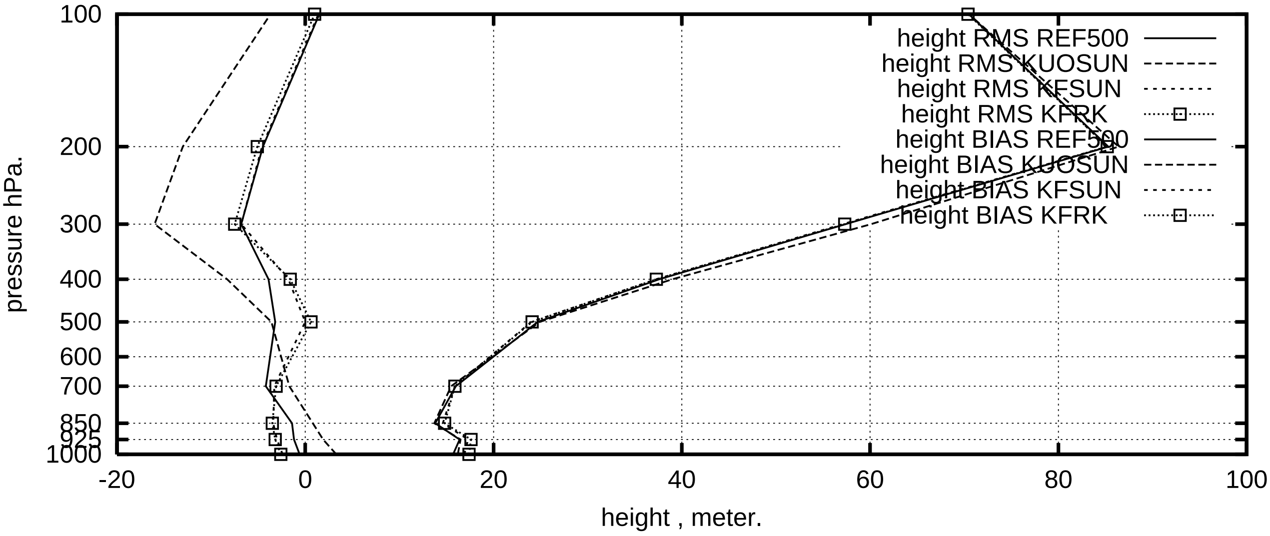

Fig. 6 : Bias and RMS- error for geopotential height. Verification against EWGLAM soundings.

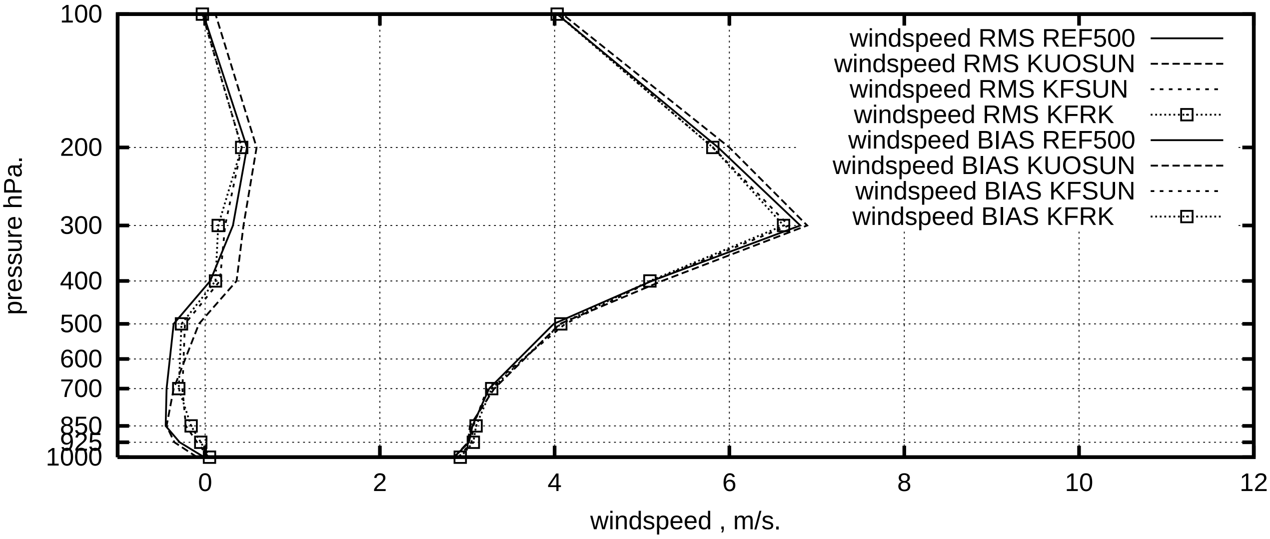

Fig. 7 : Bias and RMS- error for wind speed. Verification against EWGLAM soundings.

5 REFERENCES.

Järvenoja ,2002. 'ISBA test in a Nordic area' *Hirlam workshop on surface processes, Turbulence and mountain effects. Istituto Nacional de Meteorlogica, Madrid 22-24 october 2001.*