Precipitation and temperature foreasts in two HIRLAM versions

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1 Introduction

The concept of RCR (Regular Cycle with the Reference) was created in the HIRLAM project to give a higher status to the HIRLAM reference system. According to it, FMI (Finnish Meteorological Institute) runs operationally a suite called RCR, which is as close as possible to the reference system. In this way the reference system is run regularly and verified on daily basis, which allows to learn more about its strong and weak points. Because the results of RCR runs are archived at ECMWF, testing of new developments is also convenient, as the control run for new experiments is available and the same observations and boundaries as RCR can be used.

All new developments must be carefully tested different meteorological conditions and at different seasons before they are accepted. In this paper we compare precipitation and temperature forecasts of two HIRLAM versions, 6.3.5 (H635) and RCR, in early autumn conditions. The setup of experiment H635 resembles as much as possible that of RCR: it has the same area, the same resolution in the horizontal and vertical and it uses the same boundaries and observations as RCR. Especially it is worth mentioning, that it uses the same forecast frame boundaries from ECMWF as RCR, thus being very close to operational system.

The main developments included in H635 after RCR are described by Eerola (2005) and references there, and are not repeated here. An exception from that list is, that by mistake the smoothed orography is not used in our present H635 experiment.

The time of this experiment covers September 2004. Thus the comparison represents the behavior of the system in late summer/early autumn conditions.

2 Monthly accumulated precipitation forecasts

In this chapter we look at the monthly accumulated precipitation amounts in Scandinavia. September 2004 was very rainy in Finland. The observed precipitation amount was everywhere above normal and in large parts of Finland it rained more than double the normal.

Figure 1 shows the accumulated monthly precipitation from experiments RCR (left panel) and from H635 (right panel). In both cases the monthly accumulated precipitation has been computed as a sum daily precipitation of the second day of forecasts, ie. +24-+48-hour forecasts. Over the Scandinavian mountains the precipitation amounts are very similar. When looking at Finland we see that H635 produces more rain than RCR, especially in the southern and central parts of Finland. The maximum amount exceeds 140 mm at the southern coast and 110 mm is exceeded in many parts of the country. When comparing to observed precipitation (not shown), H635 fits better to it. Observed precipitation amount of 140 mm is exceeded in south-eastern corner of Finland and 110 mm in several locations in Central Finland.

If we look at the structure of precipitation pattern, we see that H635 produces a smoother pattern of accumulated precipitation. Especially this is true over the Scandinavian mountains and in Sweden, where a lot of small-scale structures are seen in the RCR experiment. Figure 2 shows only the convective part of the monthly accumulated precipitation. Here we see clearly that the structure in H635 is smoother. In principle, there are two modifications (in addition of smoothed orography, which was not used here) in H635, which should give smoother structures: physics-dynamics coupling (Martinez, 2004) and Tanguay-Ritchie semi-Lagrangian correction in temperature equation (McDonald, 2002). It is difficult to say, which is more important in this case.

The large scale precipitation amounts in RCR and H635 are rather similar (not shown). On the other hand, Figure 2 also reveals that H635 produces more convective precipitation. Thus the increase of total precipitation in H635 compared to RCR is a mainly due to the increase in convective part during this late summer/early autumn period.

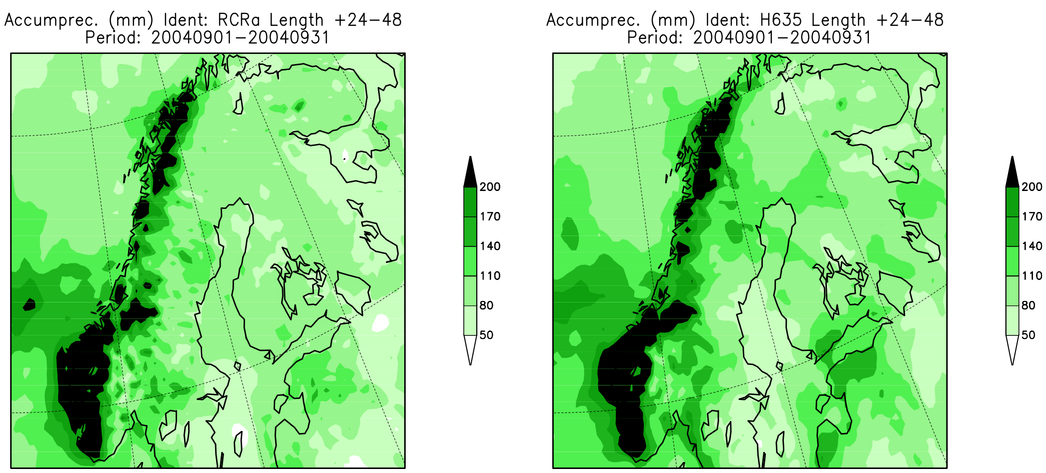

Figure 1: *Monthly accumulated total precipitation for Scandinavia from RCR (left panel) and H635 (right panel). The accumulated precipitation is computed from daily precipitation of the second day of forecasts (+24-+48 hours).*

3 Temperature forecasts

Figure 3 shows the verification scores of two-meter temperature and two-meter relative humidity as a function of forecast length for the EWGLAM stations for September 2004. Only forecasts starting at 00 UTC analysis are taken into account in order to get information about the diurnal cycle. We can see that at nighttime (+24 and +48 hours forecasts) the negative bias of about one degree, present in RCR, has almost totally disappeared: H635 is almost unbiased. At day time the negative bias, present in RCR, is decreased, but not totally disappeared in H635.

RCR has a clear positive bias in the two-meter relative humidity. This has almost totally disappeared in H635. Partly this is due to the decreased temperature bias.

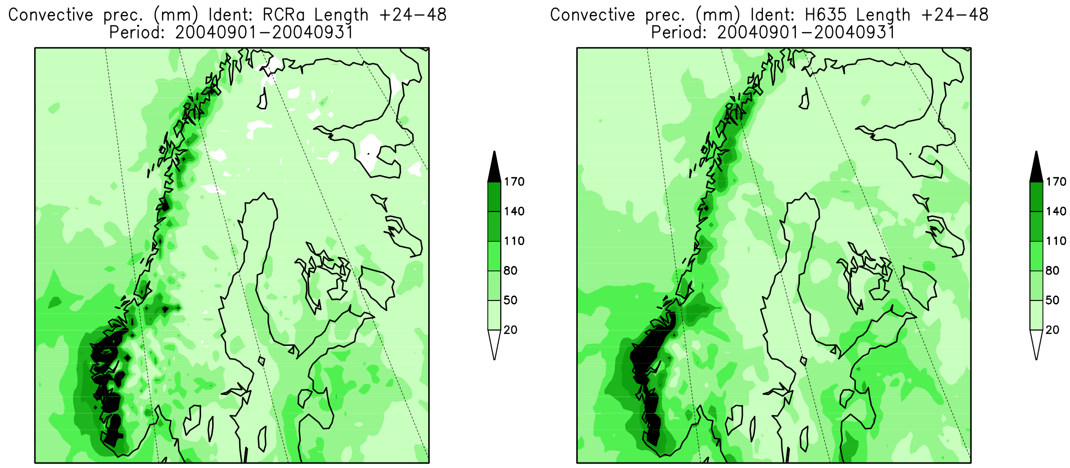

Figure 2: *As Figure 1, but for convective part of the precipitation. Note that scale in this figure is different than in Figure 1*

Eerola (2005) has described the the geographical distribution of the bias in two-meter temperature and relative humidity. The figures are not repeated here, but the main conclusions of that paper were:

- During nighttime the negative bias in the two-meter temperature (too cold night temperatures) of RCR is clearly reduced almost everywhere in the experiment H635. In the Eastern Europe there is now even positive bias over quite a large area.
- The day-time bias is negative (too cold day temperatures) in both models over the European continent. However, the bias is clearly reduced in experiment H635 as compared to RCR.
- Both models are rather good in the Southern Europe and the improvements are therefore smaller in H635.
- The improvements in the two-meter temperature are reflected in improved relative humidity forecasts.

Thus there are remarkable improvements in temperature and relative humidity in H635 when compared to RCR. Concerning cloudiness, it is difficult to compare directly observed and modeled cloudiness. Eerola (2005) concludes that cloudiness in H635 is reduced as compared to RCR. The decreased cloudiness helps to give higher, more correct day-time temperatures.

4 Concluding remarks

In this study we first compared the monthly accumulated precipitation forecasts of RCR to HIRLAM beta-version H635. It appeared that H635 produces more precipitation in Finland than RCR, and is more close to observations one than RCR. Also the accumulated precipitation field is smoother in H635 than in RCR. The increase in precipitation is mainly due to the increase of convective precipitation.

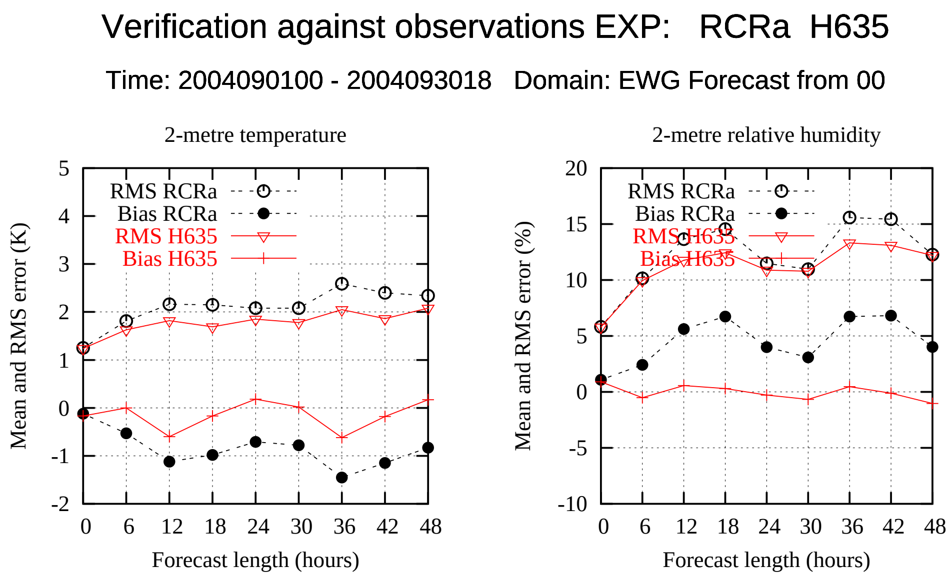

Figure 3: *The verifications scores (bias and rms) of two-meter temperature and two-meter relative humidity for experiments RCR and H635 as a function of forecast length in September 2004. The verification is done against EWGLAM stations and only forecasts starting at 00 UTC analysis are taken into account.*

Also two-meter temperature forecasts are better in H635. Especially the night temperatures are much closer to observations, but there are improvements also in day temperatures.

The current results may be compared to those presented by Järvenoja (2005). He compared RCR and the meso-beta-scale operational model at FMI, called MBE. The MBE model differs from RCR only in the horizontal resolution: RCR has a resolution of 22 km, while MBE uses resolution of 9 km. In summer conditions Järvenoja (2005) gets very similar results as the present study: increased precipitation and improved two-meter temperatures in the sense that the negative bias has significantly decreased. The possible explanation in both cases is the decreased cloudiness. An open question is why the improved horizontal resolution in MBE and several meteorological corrections in H635 produce similar improvements in the summer/early autumn conditions.

References

Eerola, K., 2005: Verification of Hirlam version 6.3.5 against RCR in autumn conditions. *HIRLAM Newsletter*, **47**, xx–xx.

Järvenoja, S., 2005: A new meso-b-scale hirlam at fmi. *HIRLAM Newsletter*, **47**, xx–xx.

Martinez, I., 2004: Final version of the physics-dynamics coupling. *HIRLAM Newsletter*, **46**, 37–47.

McDonald, A., 2002: Changes to the HIRLAM needed for finer grids? *HIRLAM Newsletter*, **42**, 9–17.