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Cloud advection in HIRLAM

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1. Introduction

This paper presents additional results on cloud initialisation experiments, that were also described in the Hirlam Newsletter, No. 38, June 2001, see (4). In this latter article it was hypothesized that the rapid decrease of cloudiness during the first hour of the forecast was due to increased rainfall. Though rainfall had indeed increased because of additional initial clouds, the higher precipitation rates appeared not to be responsible for the disappearance of clouds.
Instead, it was found that horizontal diffusion was the cause of the fast 'evaporation' of clouds. As it is dangerous to simply switch off horizontal diffusion in the Hirlam model, we tested an alternative advection scheme with small implicit diffusion, which is positive definite and based on the 'upstream' scheme.

2. Cloud advection experiments

We have repeated all the Kain-Fritsch / Rasch-Kristjansson experiments described in (4) while using the advection scheme (1) only for the water vapour. Scheme (1) is defined for an equidistant grid, also in the vertical, so it is necessary to transform the 3-D humidity fields from the Hirlam grid to this new grid and back. This was done each hour. The horizontal grid is the same of that of Hirlam (0.5 degree grid spacing in these experiments).

It turned out that using this scheme caused a dramatic improvement of the cloud forecasts for the first three hours, and the clouds stopped vanishing during the first forecast hour. In figure 1 the forecast total cloud cover is shown for both the reference run (the same as in (4)), and the MetClock run. It is seen that in e. g. the +1 hour forecast (right picture) the amount of clouds is similar to that of the initial cloud field. This result is in sharp contrast with the findings presented in (4). Even after 6 hours a clear difference between reference run and MetClock run can be observed. In the runs described in (4) hardly no difference could be seen between the two +6 hour runs.

3. Verification of case studies

We have performed the same case studies as in (4), plus two supplementary ones: June 6, 1998 (severe thunderstorms over the Netherlands), and April 28, 1998 (Stratocumulus advection from the North Sea). The verification of these 7 case studies is presented in figure 2 (rms error and bias of predicted total cloud cover). It should be mentioned that in both the reference runs and the MetClock runs advection of water vapour was computed with (1), and the verification area is the same as in (4). We may conclude that the cloud initialisation leads to an improvement of the forecast total cloud amount, primarily because the strong negative bias no longer occurs.
Furthermore we may conclude that the quality of cloud forecasts is improved for the first 5 hours.

It is foreseen that additional case studies will be performed, also with a higher resolution of the Hirlam model (e. g. 0.2 degrees). In addition, some experiments with different depths of the various cloud layers will be carried out.
Furthermore, it is planned to verify rainfall rates, which are modified due to the cloud initialisation.

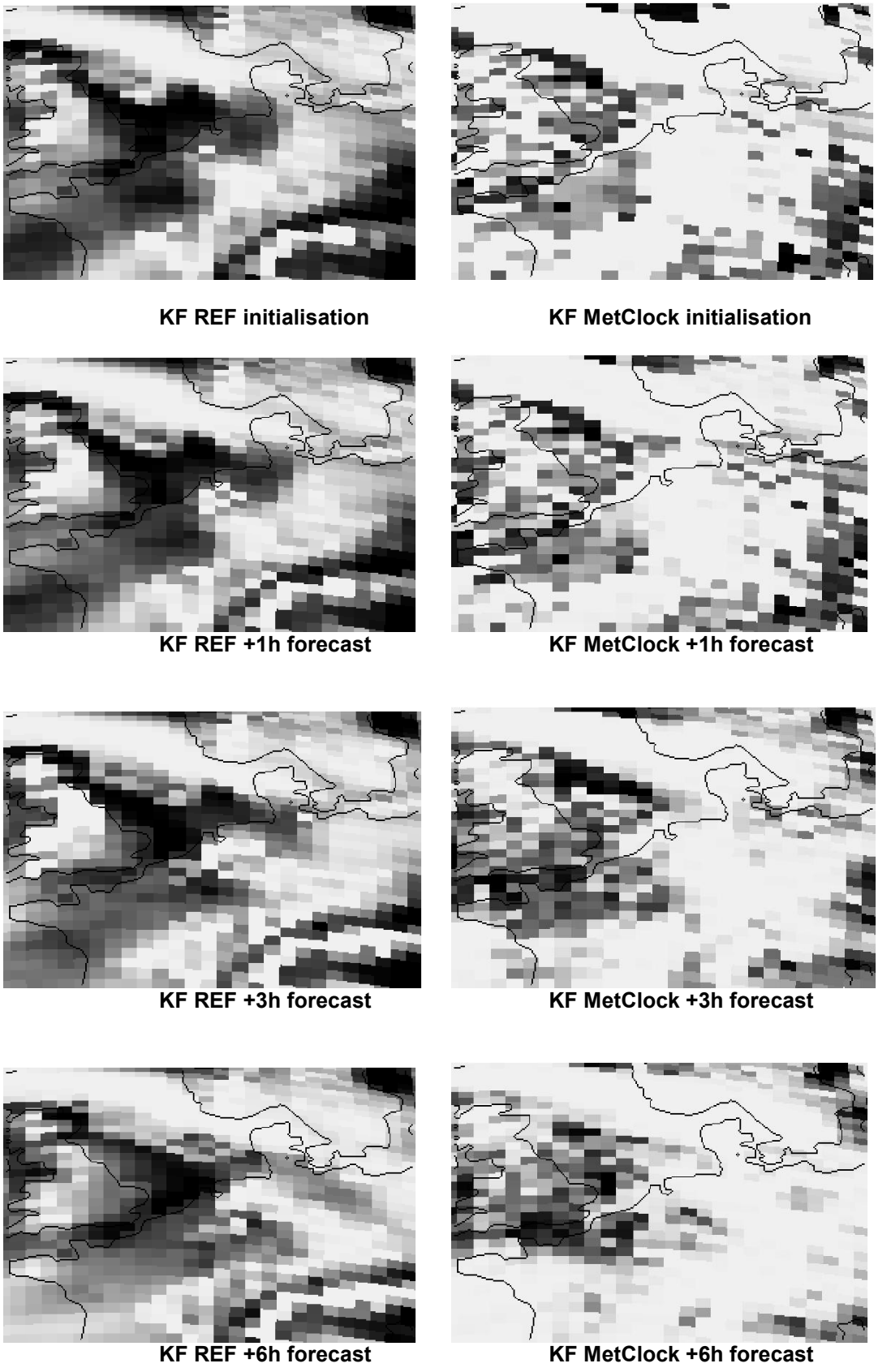

Figure 1 Total cloud cover of predicted cloudiness in oktas (KF: Kain-Fritsch / Rasch-Kristjansson, forecast length is indicated in hours) for 10 May 1999. Black: clear sky, white: 8 oktas.

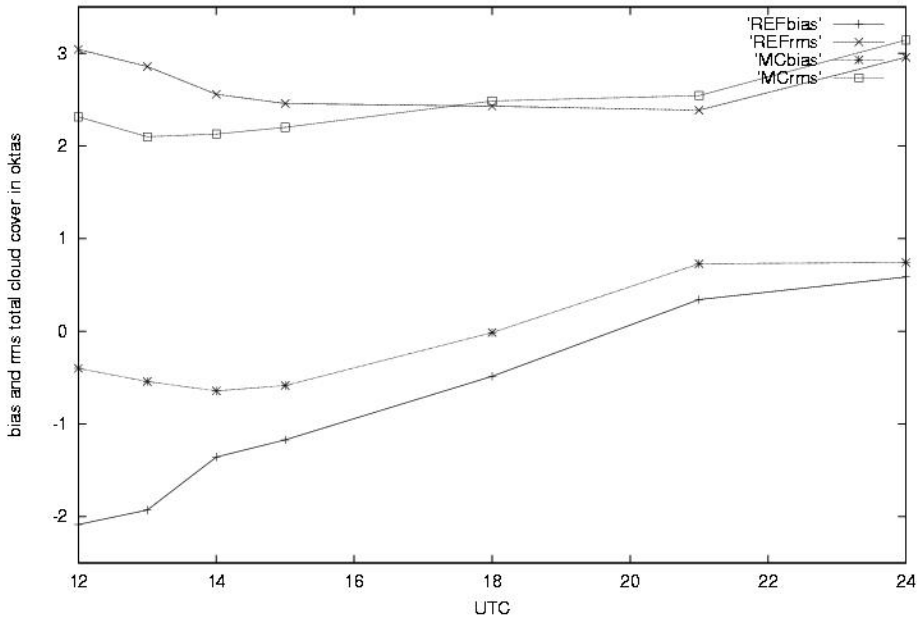

Figure 2 Rms and bias of errors in predicted cloud cover

4. References

(1) 'A fully multidimensional positive definite advection scheme with small implicit diffusion', P. K. Smolarkiewicz, *Journal Comput. Phys., 54, 1984, 325-362.*

(2) 'Liquid water initialisation in a cloud prediction model using Meteosat imagery', S. H. van der Veen and A. J. Feijt, *1996 Meteorological Satellite data users' Conference (Eumetsat), Vienna, September 1996, 257-264.*

(3) 'Cloud detection using Meteosat imagery and Numerical Weather Prediction model data', Arnout Feijt, Paul de Valk and Sibbo van der Veen, *Journal of Applied Meteorology, July 2000, 1017-1030.*

(4) 'MetClock cloud initialisation in HIRLAM', Sibbo van der Veen*, Hirlam Newsletter No. 38, June 2001, 57-60.*