Use of radar data in the HIRLAM modelling consortium

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1.Introduction

A radar is a actively remote sensing instrument that scans the atmosphere by sending out electromagnetic pulses at various horizontal and vertical angels. The intensity of signals reflected by hydrometeors may be used to estimate precipitation, both at the level of reflection and also surface precipitation. In the case of a Doppler radar the phase shift of reflected signals provide a measure of the radial wind velocities, in the direction towards the radar.

The main components of the HIRLAM system are the assimilation scheme and the forecast model. The assimilation produces the best possible initial model state by combining observations with a background state in the form of an old short range forecasts valid at the time of the observations. The assimilation is based on a three-dimensional variational (3D-Var) approach. The forecast model predicts future atmospheric states. Radar wind data have been assimilated within the HIRLAM 3D-Var (Gustafsson *et al*., 2001; Lindskog *et al.* 2001). Radar reflectivities and radar derived precipitation have been used for verification of forecasts.

2. Radar wind assimilation and processing

Before the radar wind data are presented to the model various kinds of processing are performed. First, since too high radial wind velocoties are interpreted wrongly a de-aliasing of raw radial wind data is needed. wind velocities with tooa de-aliasing of raw data is carried out. Various methods have been applied within HIRLAM. KNMI in the Netherlands has been working with one approach and SMHI in Sweden with another approach (see extended abstract by Haase in this volume).

For meso-scale applications one should do some filtering of radial wind raw data to match the scales that can be represented by the forecast model.

One type of spatial filtering is to process the radial wind raw data to obtain one vertical profile of horizontal winds for each radar. VAD- and VVP-algorithms (Browning and Wexler, 1968) are such processing techniques. At KNMI different techniques have been evaluated, both with regard to data availability and quality, by extended comparisons with radiosondes (see extended abstract by Holleman in this volume). Similar types of studies have be carried out at INM in Spain.

Another approach for filtering that have been tried within the HIRLAM community is to generate radial wind superobservations, through averaging of raw data in polar space (see Figure 1). With the superobservation approach spatial wind structures within the domain of the radar is accounted for. The superobservations may also be subject to a median time-filter, to better match the time scales of the model.

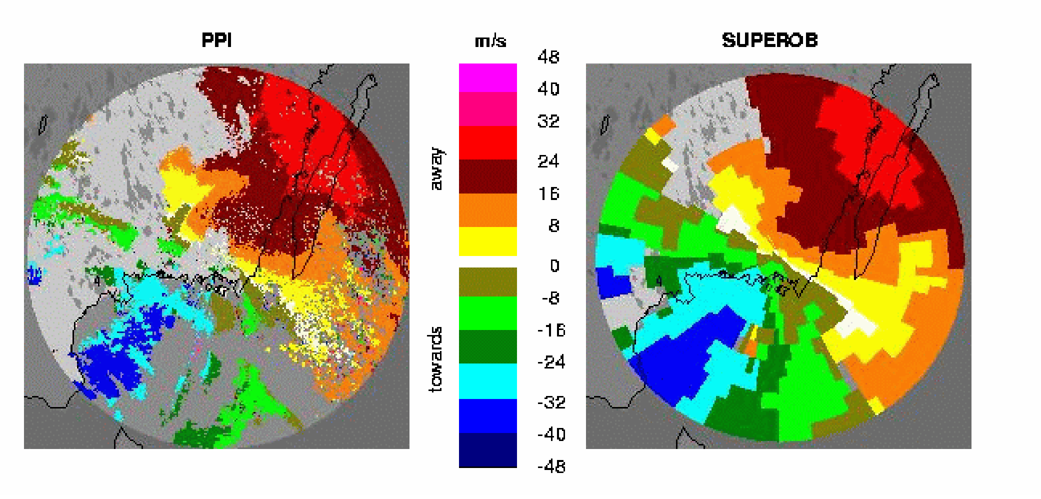


Figure 1: Radial wind raw data (left) and superobservations generated through horizontal averaging (right).

A ten-day assimilation and forecast experiment extending from 1 to 10 December, 1999, has been carried out over an area covering Northern Europe and the Northern Atlantic. The three parallel data assimilation experiments are characterized as follows:

- Only conventional observations used
- Conventional observations and VAD-profiles based on data from the Swedish radar network are used.
- Conventional observations and radial wind superobservations based on data from the Swedish radar network are used.

The model integration area and the location of the Swedish radar sites used in the study are illustrated in Figure 2.

Figure 2: Model integration area and the Swedish radar sites utilized in the study.

The rms-scores for verification against observations, as function of assimilation cycle within the ten day period are show in Figure 3. The scores are for 24 h wind forecasts at the 850 hPa level. The scores of the forecasts launched from initial states utilizing radar wind data are better than the scores of the run utilizing conventional types of observations only. Encouraging results, but one should note that the time-period of the experiment is rather short.

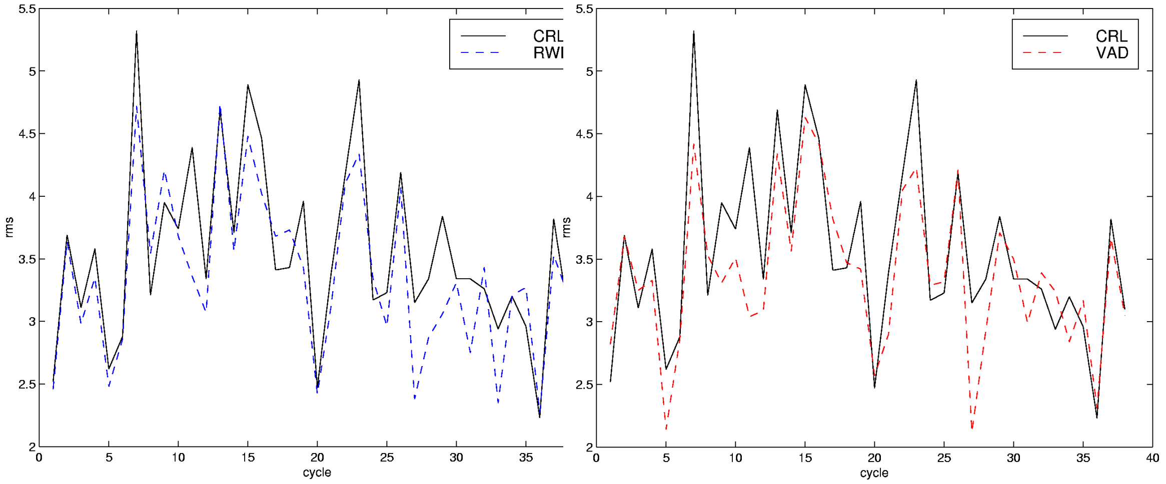
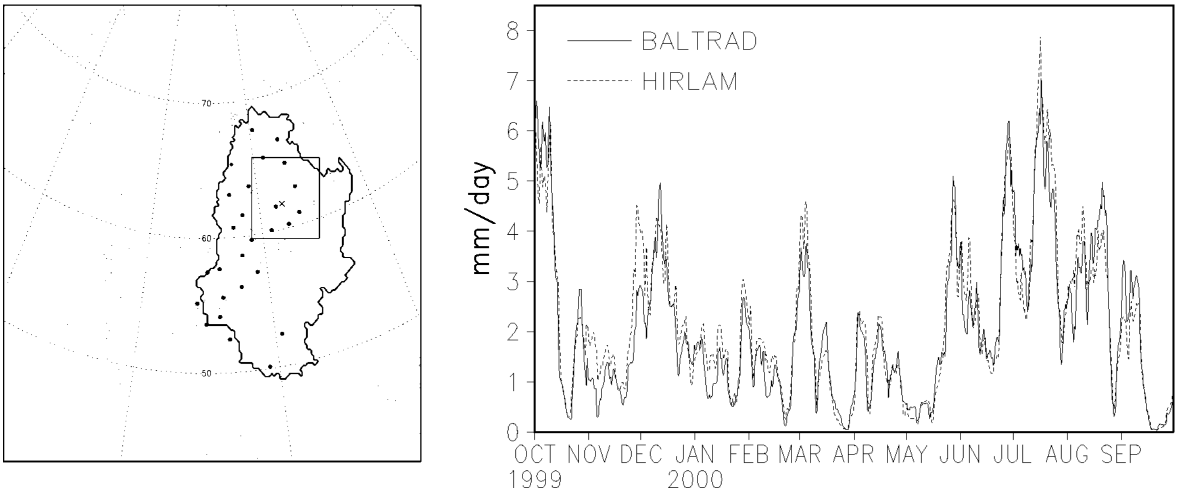


Figure 3: Day-to-day variability of the 24 h 850 hPa wind speed rms scores for the run utilizing conventional observations only (CRL), for the run utilizing conventional observations and radar radial wind superobservations (RWD) and for the run utilizing conventional observations and radar VAD winds [Unit: m/s].

More details about radar wind assimilation within HIRLAM can be found in Lindskog *et al.* (2002) and Salonen (2002).

3. Radar derived precipitation estimates

Within the BALTEX reanalysis project (Fortelius et al., 2002) the HIRLAM 3D-Var and forecats have been carried out for a one year period (Sep. 1999-Oct. 2000) over the domain shown in Figure 4a. Gauge adjusted radar precipitation estimates have been used to verify the HIRLAM precipitation estimates over the area indicated with thin rectangle in Figure 4a. The results reveal a remarkable agreement between these two totally independent sets of data (Figure 4b).



(a) **(b)**

Figure 4: The BALTEX reanalysis area, drainage basin of the Baltic Sea (closed contour), weather radars (dots) and verification area (thin rectangle) (a). Areal precipitation (mm/day) estimates from gauge adjusted radar (full) and forecasts (dashed) over the rectangular area (b).

4. Direct use of radar reflectivities

Another approach is to use hydrometeors and state variables from HIRLAMto model the radar reflectivities. This method has been applied in Finland and at INM, utilizing the radar simulation model developed by Günther Haase (Haase and Fortelis, 2002). The method is very well suited for verification of high resolution forecasts. As an illustrative example, Figure 5 shows results from a study of the characteritics of non-hydrostatic and hydrostatic HIRLAM forecasts at different horizontal resolutions, for a convective spring case (results from the University of Helsinki).

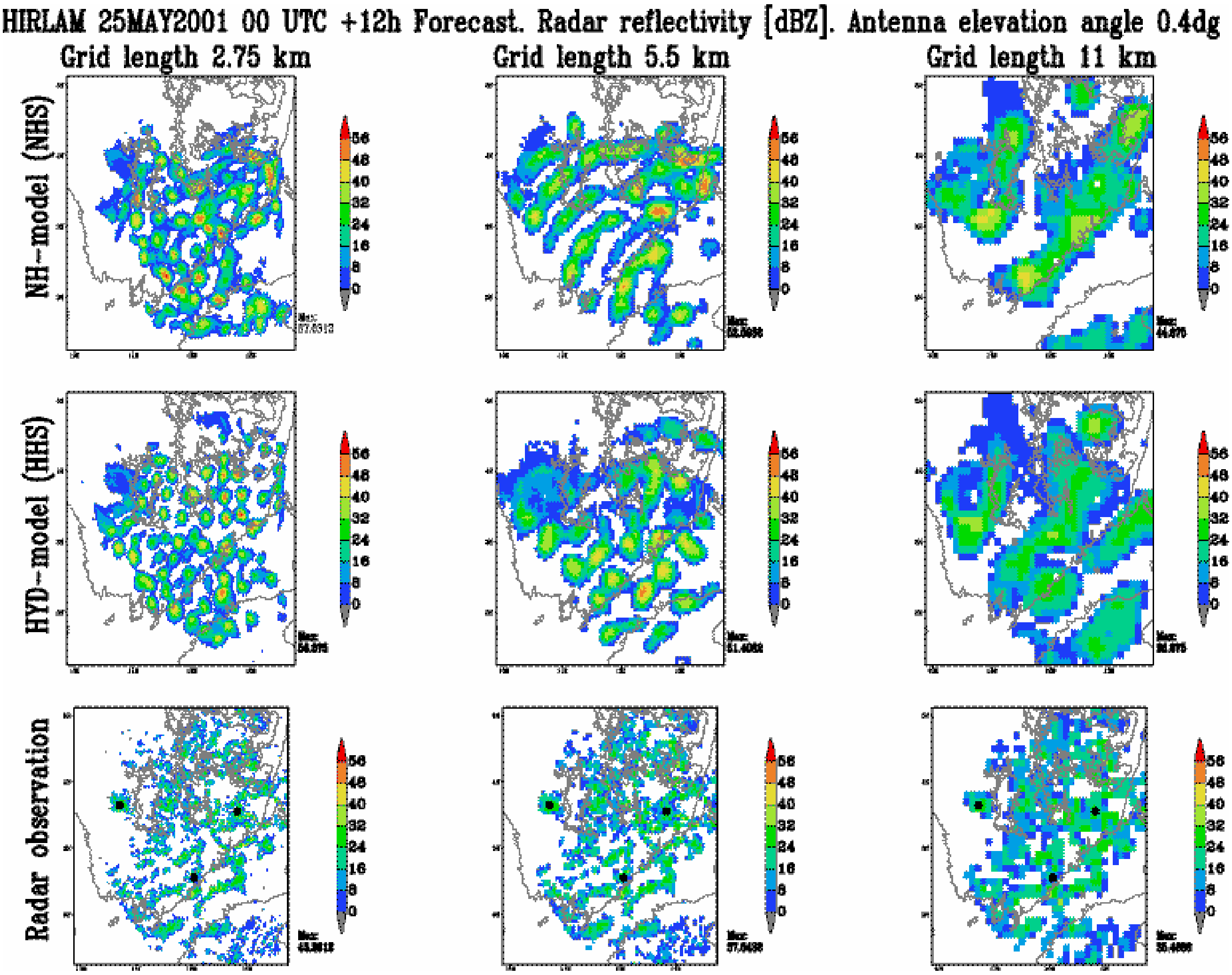


Figure 5: 12 h HIRLAM modeled reflectivities at different horizontal resolutions using the non-hydrostatic HIRLAM version, for different horizontal resolutions (first row), the same but for the hydrostatic HIRLAM version (second row), and corresponding radar observations at comparable resolutions (third row). Valid times for forecasts and observations are 25 May 2001, 12 UTC.

The cellular structure of the convection is better represented when increasing the resolution, both for the non-hydrostatic and the hydrostatic HIRLAM versions. Furhermore, for this particular case, the HIRLAM predicted reflectivities seem to be too high.

5. Future plans

SMHI aim at an operational assimilation of VAD-profiles from the Swedish radar sites very soon. More extended parallel runs investigating the benefits of radar radial wind superobservation assimilation is planned, to confirm the encouraging results obtained so far. An investigation of the quality and characteristics of the superobservations can be found in this volume (Salonen). With increased model resolutions wee there will be an increased use of radar data for verification of models. Assimilation of radar derived precipitation and/or reflectivities utilizing HIRLAM 4D-Var are among the future plans. Last but perhaps most important, the HIRLAM project support ideas towards an operational exchange of radar data.

6. References

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