Recent results of the radar wind data assimilation

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Abstract

Radar wind observations can be input for HIRLAM 3D-Var either as radial wind super-observations or as vertical profiles of horizontal winds obtained with the Velocity Azimuth Display (VAD) technique. Background error standard deviation is estimated for radar wind observations by applying a randomization method developed at ECMWF. These statistics are needed in the background quality control and they are useful in the tuning of observation error standard deviations. Parallel data assimilation and forecast experiments confirm well tuned error statistics and indicate a slightly positive impact of radar wind data on the verification scores, both for radar radial wind super-observations and for VAD profiles.

1 Introduction

The Velocity Azimuth Display (VAD) technique can be used for providing vertical profiles of horizontal winds from raw radial wind data (Browning and Wexler, 1968). These can be treated in data assimilation as conventional PILOT soundings. An alternative pre-processing is to spatially average raw radial winds and to create super-observations (Lindskog et al., 2000). These will be smoother than the raw data and representative at a desired spatial scale. (Fig. 1).

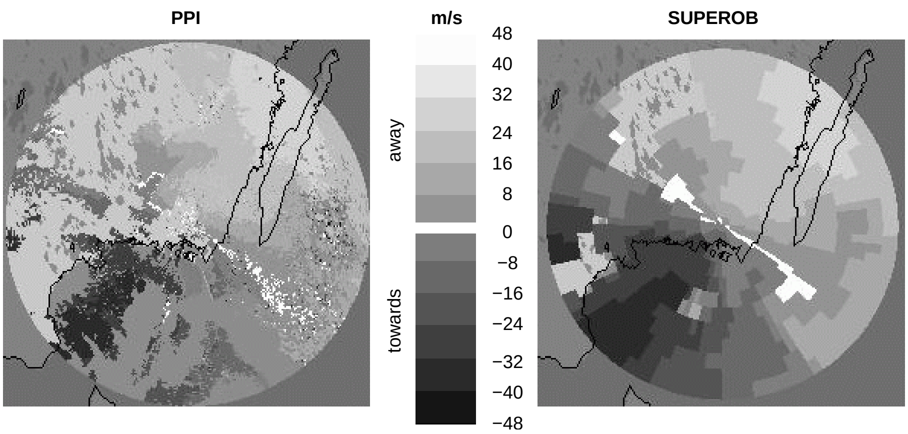

Figure 1: Doppler radar radial wind raw data (left) as super-observations (right).

2 Estimation of radar wind error statistics

The background error standard deviations (σ_b) are specified in the HIRLAM 3D-Var (Gustafsson et al., 2001) for the minimization control variables ($\ln p_s$, T, u_{ag}, v_{ag} and q). σ_b is neither specified for the full wind field nor for the quantities which are not model variables, such as radar radial wind super-observations. For these quantities, σ_b need to be experimentally determined as σ_b is used in the background quality control, and they are useful for the tuning of observation error standard deviations (σ_o). σ_b in the VAD profile and in the radial wind observation spaces has been determined using the randomization method (Fig. 2). The variation of σ_b is small at low elevation angles.

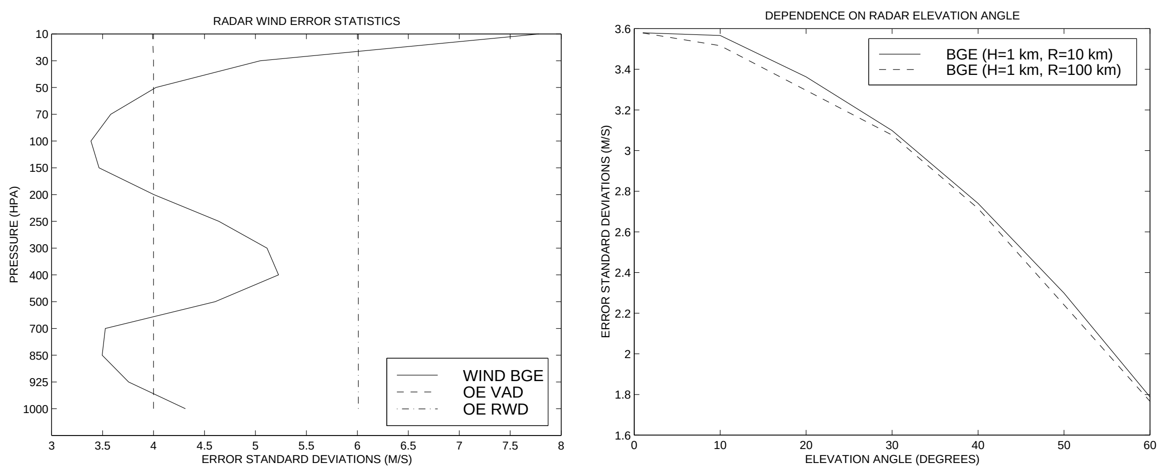

Figure 2: Vertical profile of horizontally averaged σ_b for wind and the prescribed σ_o for radar wind observations (left). The dependency of σ_b in radial wind space on the radar antenna elevation angle, according to the randomization method (right).

3 Assimilation experiments

A 10 day assimilation and forecast experiment (1-10 Dec 1999) has been performed over an area covering Northern Europe and the northern Atlantic. The period was characterized by deep cyclones passing over the Baltic Sea area. Three parallel runs were performed:

1. Only conventional observations used in assimilation.
2. Conventional observations and VAD profiles based on data from the Swedish radar network used in assimilation.
3. Conventional observations and radial wind super-observations based on data from the Swedish radar network used in assimilation.

The forecast model setup consists of 31 vertical levels, 0.2° horizontal resolution, Louis-vertical diffusion, Sundqvist cloud and condensation scheme with Eulerian time integration. Background and analysis fit to observations in this experiment is diplayed in Fig. 3

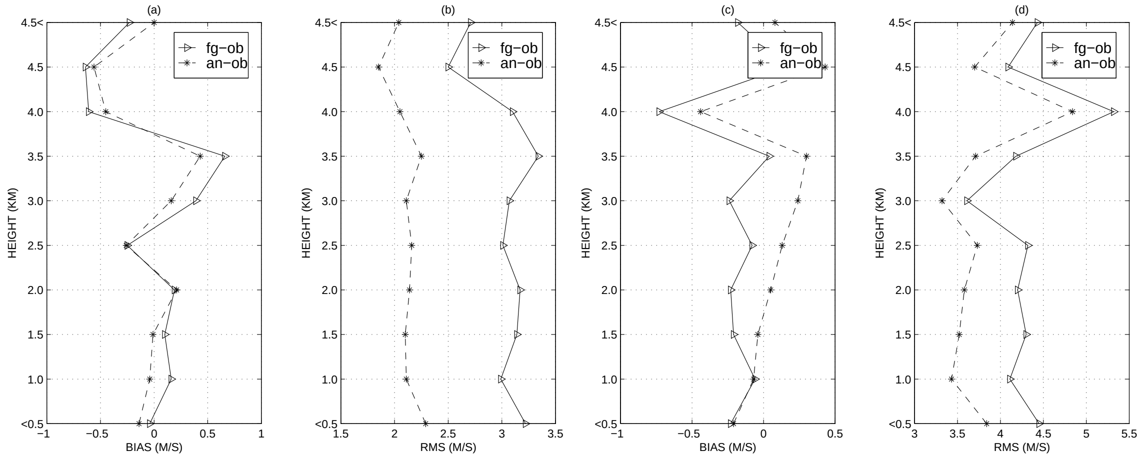

Figure 3: Statistical fit of the radar wind data in the assimilations during 1-10 Dec 1999. Bias and RMS for background (analysis) minus observation is denoted by full (dashed) lines. Statistics for VAD profiles are in (a) and (b), and for radar radial winds in (c) and (d). Unit: m/s.

The model is unbiased with respect both the VAD profiles and the radial wind super-observations. Furthermore, the RMS values for the analysis departures are smaller than for the background departures. The analysis draws more to VAD profiles than to super-observations. The RMS of the background departures show that σ_o of the VAD profile is smaller than σ_o for the radial wind super-observations. It seems however, that the specified σ_o of 4 and 6 m/s for the VAD profile and the radial wind super-observations, respectively, are slightly overestimated.

To evaluate the impact of VAD profiles and radial wind super-observations on the 3D-Var analyses and subsequent forecasts, the analyses and forecasts of the three parallel runs are verified against EWGLAM SYNOP and TEMP observations of 850, 700 and 500 hPa wind and temperature (Fig. 3). The results can be summarized:

- bias of the wind and temperature forecasts is small for all vertical levels and forecasts lengths,
- bias is similar for both of the radar wind runs and the control run,
- RMS is smaller with than withour radar winds, and
- RMS is similar when using VAD profiles or radial wind super-observations.

For all the bias and RMS scores with various configurations, as described above, large temporal variability in observation verification scores is seen. As an example, Fig. 3 shows the bias and RMS values of the +24 h wind and temperature forecasts at the 850 hPa level, in comparison to verifying observations for the 10 day period. It is evident that for almost all +24 h forecasts during the period the scores of the runs using radar wind information (VAD or super-observations) are superior.

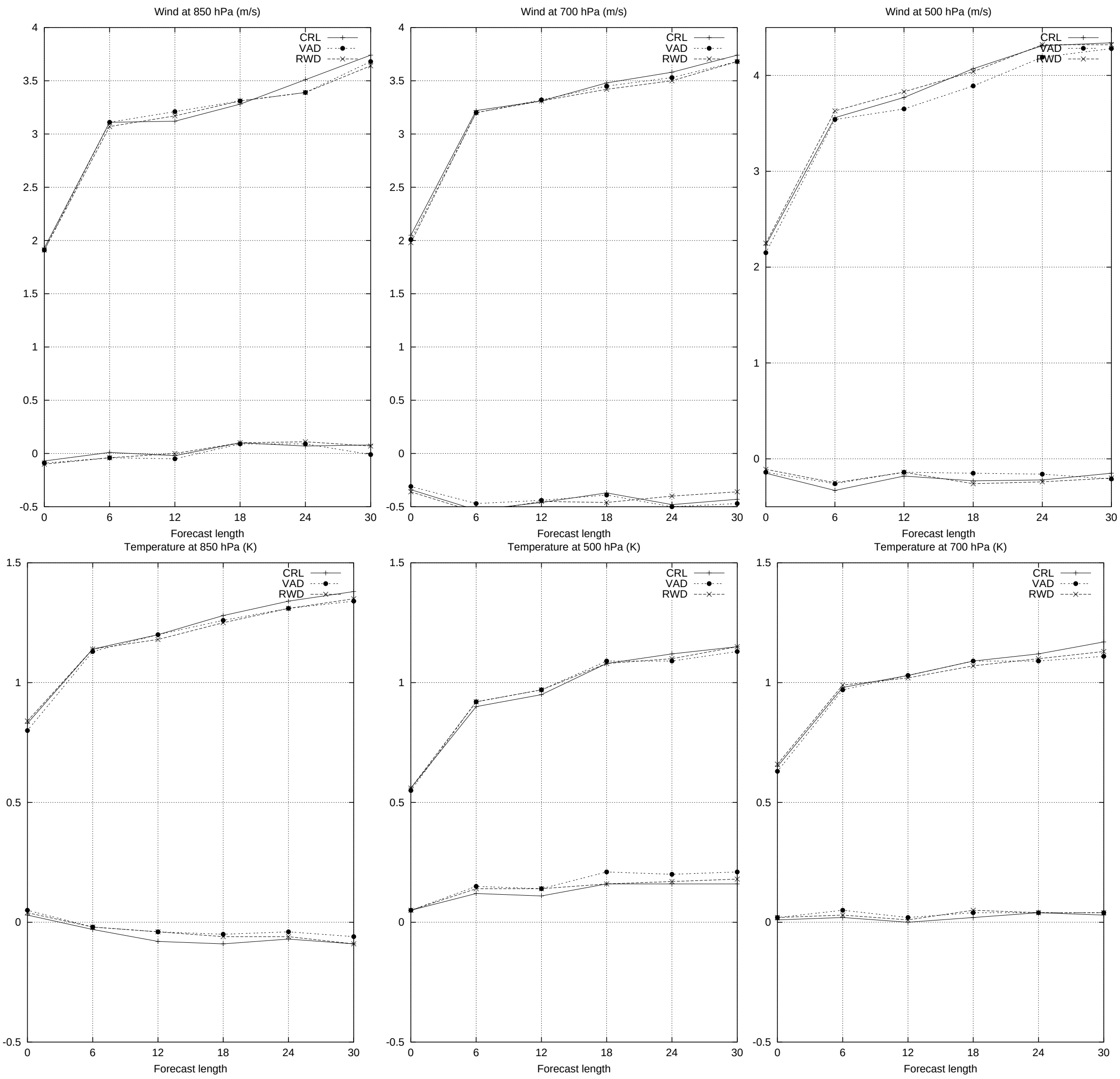

Figure 4: Average bias and RMS scores for the 10 day assimilation period (1 - 10 December 1999), as functions of forecast length (h). Wind speed scores (m/s) at 850 hPa (upper left), 700 hPa (upper middle) and 500 hPa (upper right) as well as temperature scores (K) at at 850 hPa (lower left), 700 hPa (lower middle) and 500 hPa (lower right). The sores are for the run utilizing conventional observations only (full line), for the run utilizing conventional observations and radar radial wind super-observations (dashed with dots), and for the run utilizing conventional observations and radar VAD winds (dashed with crosses).

4 Discussion and conclusions

The HIRLAM 3-dimensional variational data assimilation scheme has been prepared for assimilation of radar wind data either in the form of radar radial wind super-observations or VAD profiles. A randomization method has been used to make a first estimate and tuning the radar wind error statistics. Observation fit statistics from a 10 day parallel run reveal a high quality of the radar wind data and acceptably tuned error statistics. Verification scores from the 10 day parallel run indicate improved forecasts of

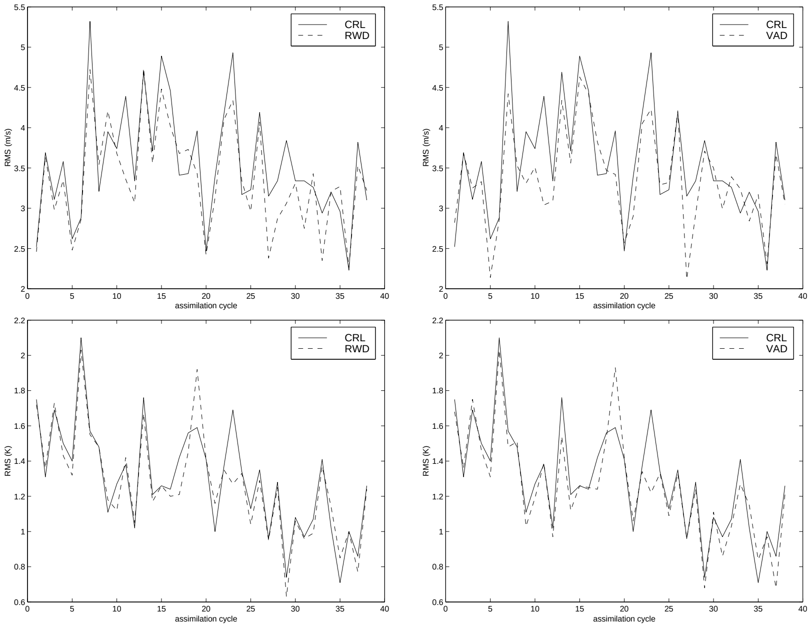

Figure 5: Time variability of the +24 h 850 hPa wind (upper row) and temperature (lower row) RMS scores for the run utilizing conventional observations only (CRL), for the run utilizing conventional observations and radar radial wind super-observations (RWD), and for the run utilizing conventional observations and VAD profiles. The units are m/s and K.

winds and temperature forecasts in the low and middle troposphere, when the forecasts are based on analyses utilizing also radar wind data. The scores are however insensitive for the choice of pre-processing (VAD profiles vs. radial wind super-observations).

5 Acknowledgements

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