Towards the use of Doppler radar radial winds in NWP

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1 Introduction

Present-day numerical weather prediction (NWP) models are global atmospheric models with resolutions from 20 to 50 km, and limited area models running with around 10 km resolutions. The interest and development in limited area NWP modelling focus increasingly on forecasting of quickly developing mesoscale phenomena in high resolution and observations are needed with high temporal and spatial resolution. Remote sensing observations are very appealing for this purpose because they have very good spatial and temporal coverage. This report concentrates on using Doppler radar radial winds in HIRLAM (High Resolution Limited Area Model) model.

2 Observation preprosessing

Doppler radars produce radial wind data with high temporal and spatial resolution. To correspond the observations to the often much coarser model resolution, some preprosessing is required. One method is to thin the raw observations to coarser resolution. The disadvantage of this method is that the resulting wind field can be very noisy, if the wind field is partly contaminated by non-meteorological echoes. Another possibility is to generate spatial averages, so called superobservations (SO), from the raw data. Superobservation generation averages out the random errors from the wind field quite effectively.

3 Observation operator

An observation operator for Doppler radar radial winds (Salonen et al., 2003) has been developed and implemented for the HIRLAM 3-dimensional variational assimilation system (Gustaffson et al., 2001). The formulation of the observation operator involves:

1. Horizontal and vertical interpolation of the NWP model wind components u and v to the observation location.
2. Projection of the interpolated NWP model horizontal wind towards the radar, and finally on the slanted direction of the radar beam.

The broadening of the radar beam is modelled by using Gaussian averaging kernel in the vertical interpolation. The obscuring effect of the radar horizon is taken into account by assuming a radar horizon of 0° elevation angle, below which the model information is not used. An empirical upper integration limit is set to 1.5 times the beamwidth. This is based on the fact that the radar reflectivity usually decreases rapidly above that height. Radar beam bending is taken into account by applying the Snell's law. The calculated effective elevation angle is used in the projection of the horizontal wind on the slanted direction of the radar beam. This approach modifies also the observation height from the value obtained by applying the $\frac{4}{3}r$-law.

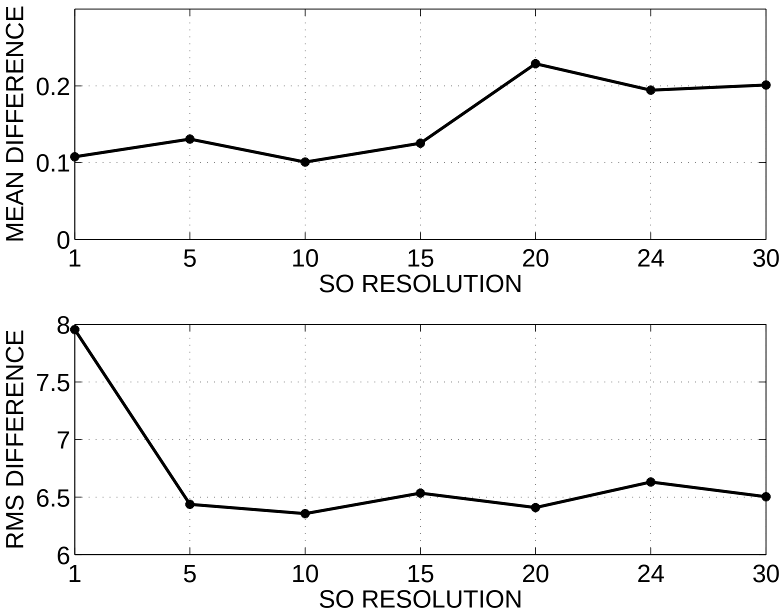

Figure 1: Mean (upper figure) and rms (lower figure) difference between the observations and the model counterpart as a function of SO resolution.

4 Optimal SO resolution

A set of one month (January 2002) experiments have been performed to study the fit of the SOs generated with different resolutions to the model counterpart calculated from HIRLAM model. SOs are generated with 5 km, 10 km, 15 km, 20 km, 24 km and 30 km resolutions, and also thinned raw data is studied. The model resolution is 22 km on 40 vertical levels.

Figure 1 shows the mean and the rms difference between the SOs and the model counterpart as a function of SO resolution. Resolution 1 km corresponds to the thinned raw data. In general, the mean difference is always positive, i.e. the observed wind is stronger than the modelled wind. The mean difference is smallest for the SO resolution of 10 km. The rms difference for the thinned raw data is approximately 1.5 m/s higher than the rms difference for any of the SO resolutions. One reason for this behaviour is that in the SO generation the random errors are averaged out quite effectively. Another possible source of rms difference is that the raw data includes wind field variations which are not represented in the 22 km resolution model.

References

Gustafsson, N. and Coauthors, 2001: Three-dimensional variational data assimilation for a limited area model. Part I: General formulation and the background error constraint. *Tellus*, **53A**, 425-446.

Salonen, K., H. Järvinen and M. Lindskog, 2003: Model for Doppler radar radial winds. *31st American Meteorological Society Conference on Radar Meteorology Volume I*, 142-145.