Effect of thinning vertical levels in lateral boundary data from ECMWF

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Abstract

We examine in this study the adequacy of applying vertical thinning to ECMWF BC analysis and boundary data in the HIRLAM forecasting system. Results from a parallel experiment indicate a strikingly negative impact of thinned ECMWF data on forecasts of the MSLP and upper air geopotential heights.

1 Introduction

ECMWF upgraded the horizontal and vertical resolution of their deterministic model on 1 Feb 2006 from T511 to T799 and from 60 to 91 vertical levels, see more details in

`http://www.ecmwf.int/products/changes/high_resolution_2005.html.`

In connection with the resolution change of its main forecast suite and BC suite, ECMWF offered to provide a modified dissemination specification for member states requiring disseminated BC data. The modification was done in such a way that those levels from the new suite (L91) closest to the original levels in L60 were chosen. This effectively means a vertical thinning of the L91 ECMWF data.

In the interest of easing the transition to the model upgrade at ECMWF, DMI has chosen a two step strategy. Step one was simply to adapt to the recommended dissemination specification change, which means no change in the amount of data that DMI receives, and no action required. Sometime later, in step two, an increased resolution in the vertical and the horizontal dissemination requests was to be tested.

Thanks to fruitful discussions within the international HIRLAM community regarding the (in-)adequacy of applying vertical thinning to ECMWF data, we were able to start and intensify the preparation of step two above at a much earlier stage. In late February 2006, the operational DMI-HIRLAM started utilizing full vertical resolution ECMWF data.

This note reports a parallel study examining the impact of vertical thinning of the lateral boundary data in the HIRLAM forecasting system after the ECMWF model resolution was increased.

2 The Experimental Set-up

In this study, data from M1T, the real time experimental DMI-HIRLAM suite, is used. M1T is designed to be equivalent to DMI's operational model T15 but with a reduced domain size. M1T has 390x448x40 grid points and 0.15 degree grid spacing in the horizontal. The disseminated ECMWF BC forecast frames for M1T runs include all ECMWF vertical levels aside from the uppermost 11 levels, (i.e, a total of 80 levels out of the 91), while the ECMWF BC analyses contain all 91 levels.

For comparison, M1L, a suite equivalent to M1T except for its use of vertically 'thinned' ECMWF data as described above, has been run for the period between 12 UTC 27 Feb and 19 Mar 2006. Thus the experiment has been set up as a pure comparison to determine the sensitivity to vertical thinning of host model data.

3 Results

The effect of the vertical thinning of the ECMWF data turns out to be very dramatic. In Figure 1, we present the 6 hour forecasts of the mean sea level pressure (MSLP) field with full (M1T) and thinned (M1L) vertical resolution ECMWF lateral boundary data, respectively, for the very first forecast in this three week long parallel period. A strikingly large difference is already apparent in the forecasted center lows and highs.

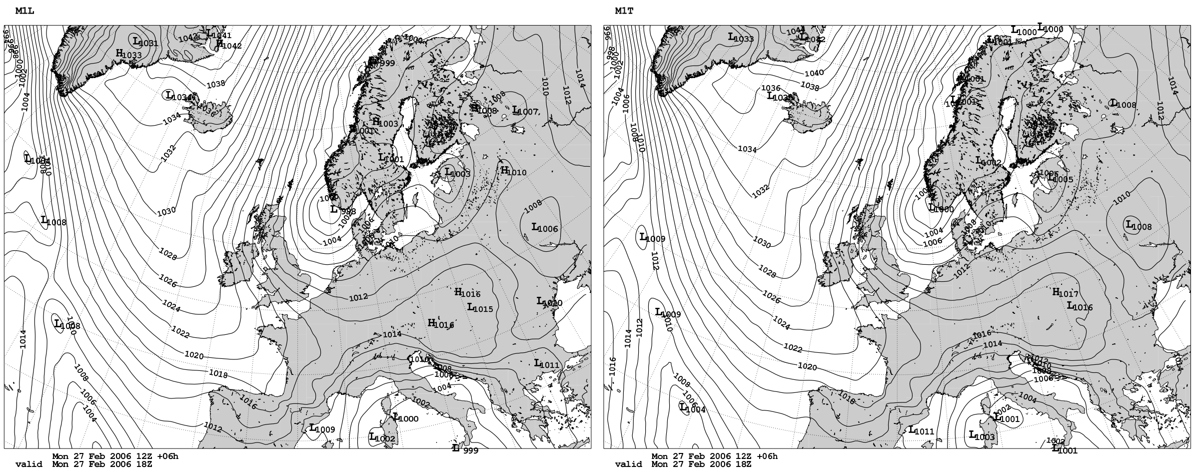

Figure 1: 6 hour forecasts of mean sea level pressure from a) M1L, left panel, and b) M1T, right panel, valid at 18 UTC, 27 Feb 2006.

Figure 2 shows a comparison of the observation verification for key parameters against the EWGLAM station list for the three week period between 27 Feb and 19 Mar 2006. Obviously, with vertically thinned ECMWF analysis and boundary data (M1L), the averaged MSLP and upper air geopotential height biases are significantly worse than the run with full vertical resolution boundary data (M1T). For 48 hour forecasts for example, the M1L bias is more than 1 Hpa more negative than for M1T. Note that the HIRLAM model for this period in general suffers from a relatively large negative MSLP bias.

A daily averaged forecast error time series for MSLP is shown in Figure 3, which reveals that the change in the MSLP bias score due to vertical thinning of ECMWF data is systematic and consistent on a daily basis. Presumably, the much poorer fit in the surface pressure scores for M1L is due to a less accurate temperature profile in the vertical, resulting in a poorer estimate of the surface pressure due to the hydrostatic relationship. On the other hand, the impact of the data thinning on other parameters appears to be insignificant from Figure 2, with the exception of upper air temperatures, especially at 250 Hpa, for which a reduced resolution results in a noticeably poorer bias.

4 Conclusion

Given the results reported in this study, we are convinced that it is both necessary and crucial, in the current HIRLAM system framework, to use full vertical resolution in the interpolation procedure for host model data.

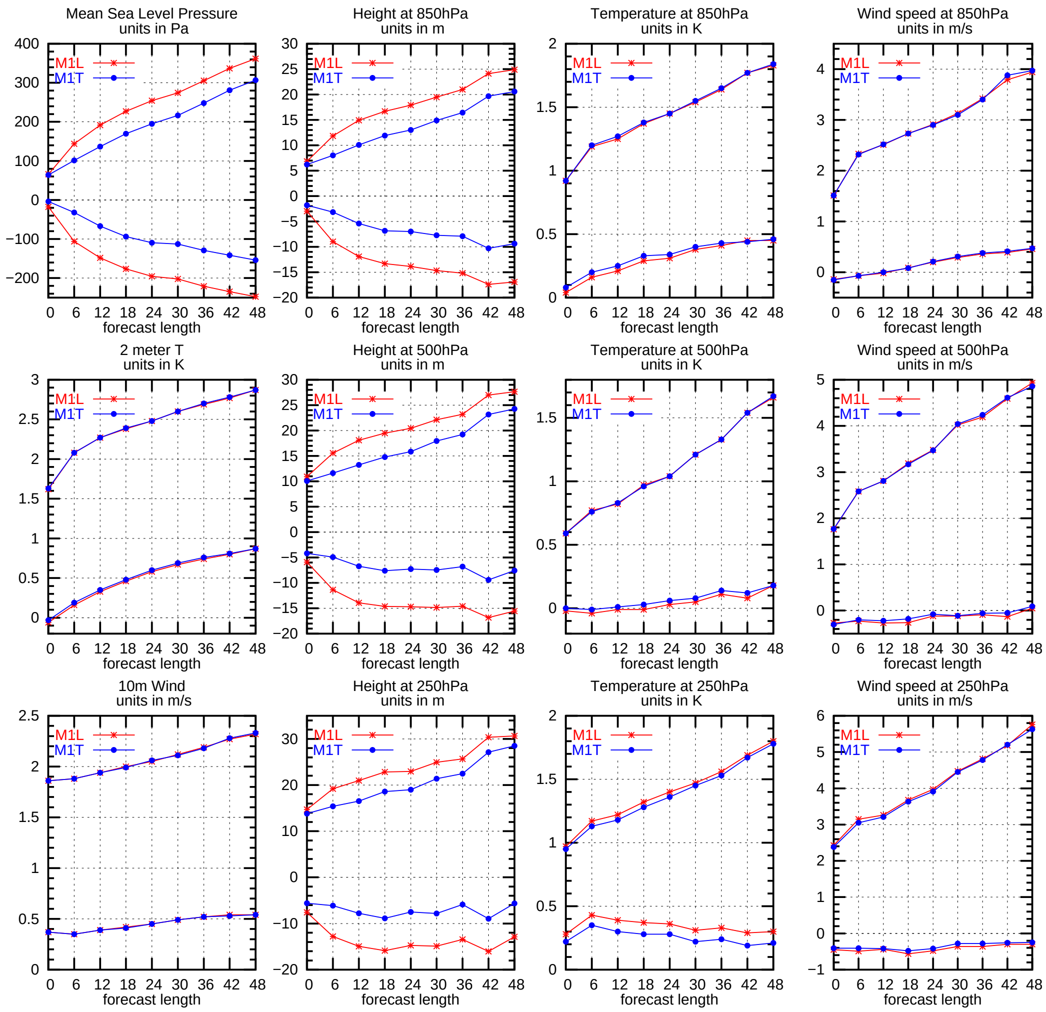

Figure 2: Observation verification of key parameters in root mean square and bias against the EWGLAM station list for the period between 12 UTC 27 Feb and 18 UTC 19 Mar 2006, comparing the runs made with DMI-HIRLAM a) M1L, using thinned 60 level lateral boundaries from ECMWF; b) M1T, using 80 level ECMWF frames (the 11 uppermost levels being excluded) and analyses containing all 91 vertical levels.

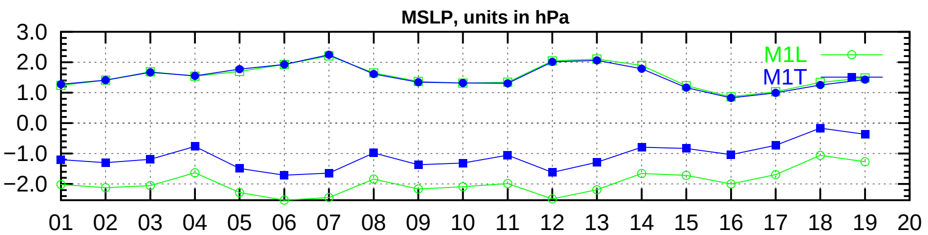

Figure 3: Daily averaged time series for 1-19 March 2006 of standard deviation and bias of MSLP from observation verification against the EWGLAM station list, for 24 hr forecasts of runs with M1L and M1T.

5 Acknowledgements

This work has been inspired by relevant e-mail discussions in the international HIRLAM community in early February 2006. The authors are especially thankful for suggestions

from Nils Gustafsson, SMHI, who stressed the need to preserve balance in the boundary interpolation procedure. Nils pointed out that the balanced wind at a particular HIRLAM level is dependent on all temperatures below it, thus when doing interpolation, full vertical resolution ECMWF data is needed for vertical integration, whereas vertically thinned ECMWF data will not retain balanced information (3 Feb 2006, personal communication). Bjarne Amstrup and Claus Petersen, DMI, have contributed to related work.