Verification of HIRLAM numerical forecasts and connection between scores and improvements in the model

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1. Introduction

HIRLAM (High Resolution Limited Area Model) (Undén et al., 2002) has been run operationally at the Finnish Meteorological Institute (FMI) since January 1990 and monthly verification scores have been collected since then. So at the moment there is almost 20 years' time-series of verification scores.

The scope of this poster is to show the general trend in the verification scores and to show examples how the modifications in the HIRLAM system are reflected in the monthly verifications scores.

The verification scores are computed against the valid HIRLAM analysis fields. Therefor it is reasonable to concentrate to the mean sea level pressure and upper-air fields and skip the real weather parameters, like 2-meter temperature, 10-meter wind or precipitation.

2. Brief history of HIRLAM at FMI

During the years several versions of the HIRLAM systemhas been used. Figure 1 shows the implementation times and important new features of the different HIRLAM versions.

	Implemented	Remarks
FIN	01/1990 ...	Δx=0.5°, 130*100 points, 16 levels
SFI	06/1994 ...	31 levels, New physiography, Savijärvi radiation
NSF	06/1996 ...	Δx=0.4°, 194*140 points
ATL	09/1997 ...	
ATA	11/1999 ...	CBR turbulence, ECMWF boundaries 4/day
ATX	03/2003 ...	Δx=0.3°, 258*186 points, 40 levels, 3DVAR, ISBA, Semi-Lagrangian advection
V621	02/2004 ...	Δx=0.2°, 436*336 points, Turning of stress vector
V637	06/2005 ...	
V641	06/2006 ...	LSMIX-concept
V71	04/2007 ...	Δx=0.15°, 583*448 points, 60 levels
V72	09/2008 ...	4DVAR

Figure 1: *New features in the different HIRLAM versions relative to the previous operational version.*

The complexity of the system reflects the available computer power. For example, the total number of computational points (nx×ny×nz) is now 75 times of that of the first HIRLAM version in 1990.

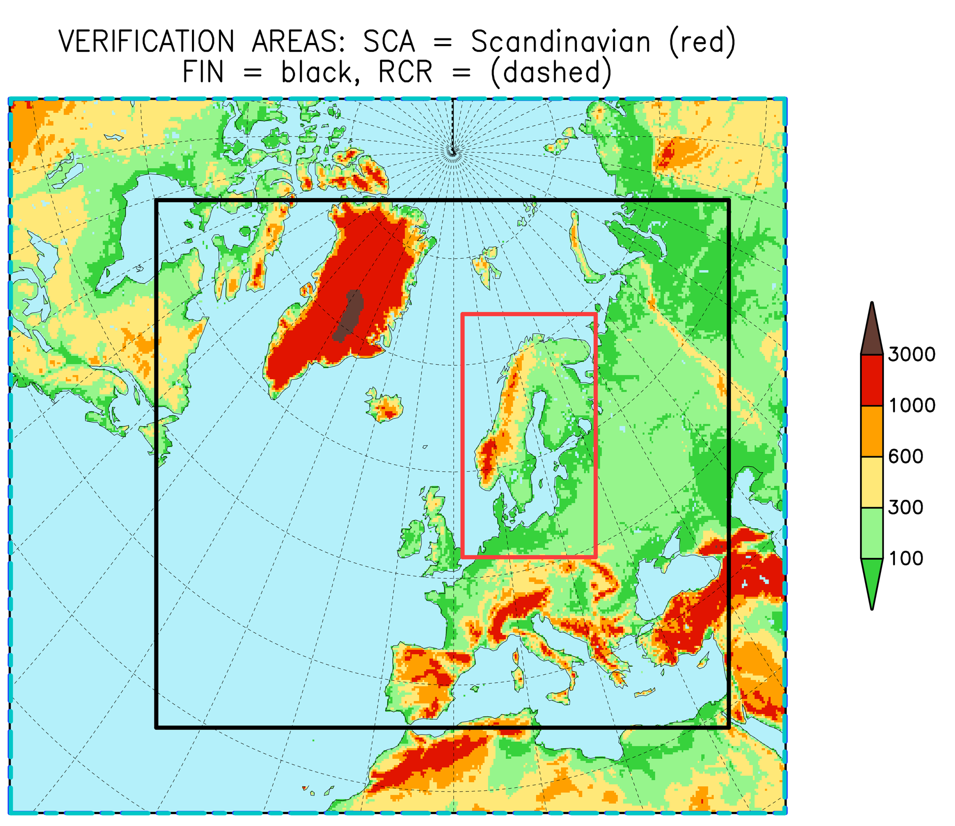

Figure 2: *The verification area (blue line).*

3. Verification method and scores

We concentrate on two verification scores, bias (mean-error) and root-means-square error (rms-error). The monthly or seasonal rms-error is computed as double sum over the time (over month or season) and space (over every grid point) to take into account both the spatial and temporal variation:

$$rms = \sqrt{\frac{1}{n_s}\sum_{s=1}^{n_s}\frac{1}{n_t}\sum_{t=1}^{n_t}(\widehat{x_{st}} - x_{st})^2}, \qquad (1)$$

where n_s is the number of grid points the area and n_t is the number of forecasts in a month or season.

The results are shown for the area containing Europe and northen Atlantic (black line in Figure 2).

4. Results

The most prominent feature in the monthly bias and rms-error of mean sea level pressure (Figure 3) is the seasonal variation in the rms-error, which is a natural consequence of the stronger general circulation in winter time. There is a clear reduction of rms-error from an approximate yearly value of 4 hPa to the value of 2 hPa (black curves). Thus, measured by the rms-error, the current +48 hours' surface pressure forecasts are better than +24 hours' forecasts in the early 1990s' and almost as good as +12 hours' forecasts then.

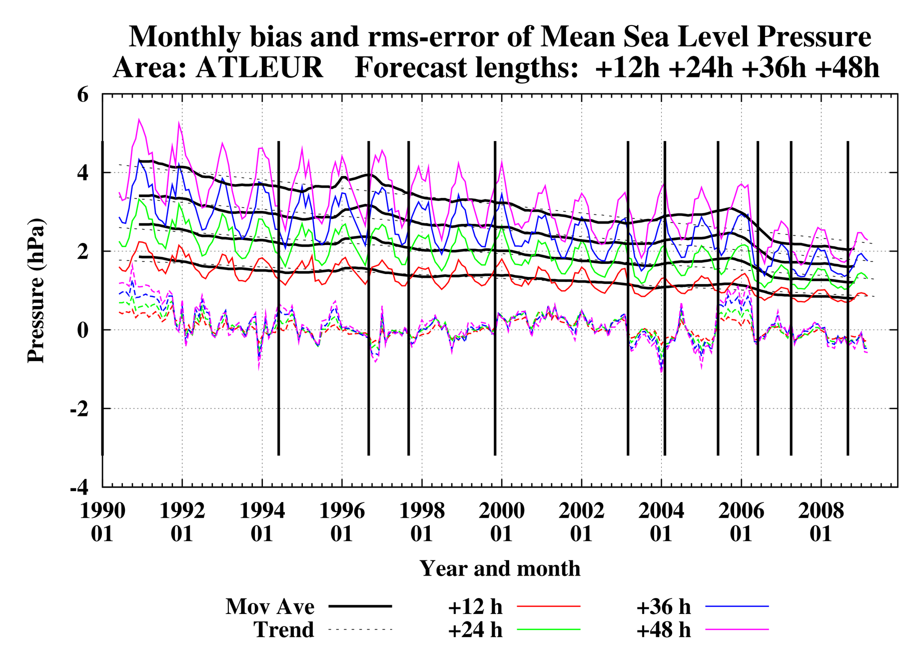

Figure 3: *Monthly bias and rms-error of mean sea level pressure of +12, +24, +36 an +48 hours' forecasts. The black solid line shows the 12 months' moving average. Vertical bars show the implementation times of new HIRLAM versions.*

In the 500 hPa scores (Figure 4) the quick improvement after introducing the version V641 in June 2006 is due to the introduction of large-scale mixing (LSMIX) of the ECMWF data into the first guess of HIRLAM analysis via the re-cycle phase (Yang, 2005). The ECMWF global data assimilation system uses a long cut-off time for observations and utilizes a lot of satellite data. So it supposed to improve the HIRLAM initial analysis in the area of sparse conventional observation network. Thus the HIRLAM system benefits from the high-quality ECMWF analysis and boundary fields. The positive development of verification scores is even more pronounced in 300 hPa scores (not shown).

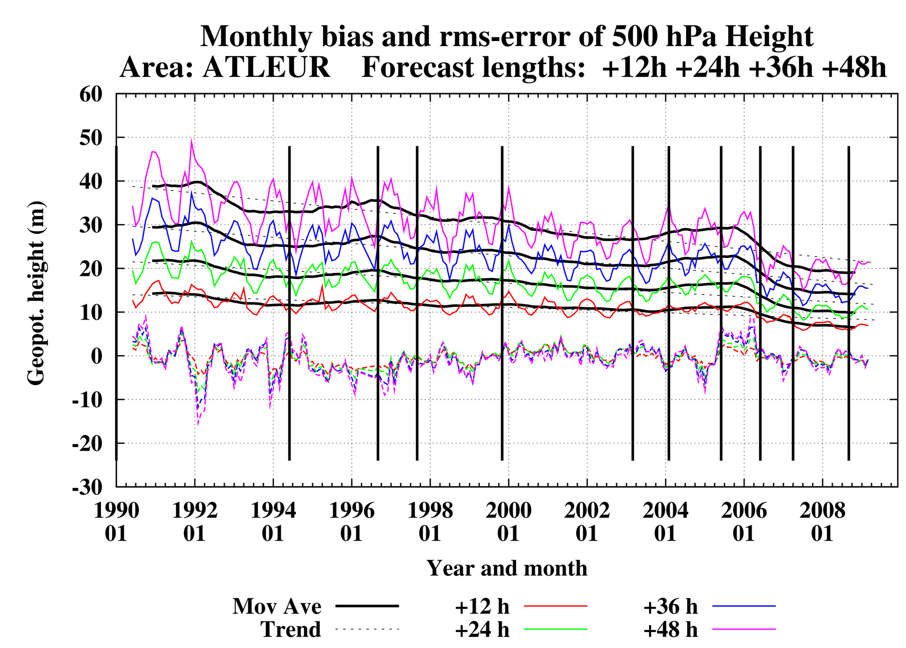

Figure 4: *As Figure 3, but for 500 hPa height.*

In the 850 hPa temperature scores we see a very prominent negative bias in the first version of HIRLAM (Figure 5). This was traced back the radiation parametrization and was corrected in the next HIRLAM version by introducing a new radiation scheme (Savijärvi, 1990). The introduction of ATX (new features: 3DVAR, more vertical levels, ISBA surface scheme and semi-Lagrangian advection) has a clear signal both in the rms-error and bias.

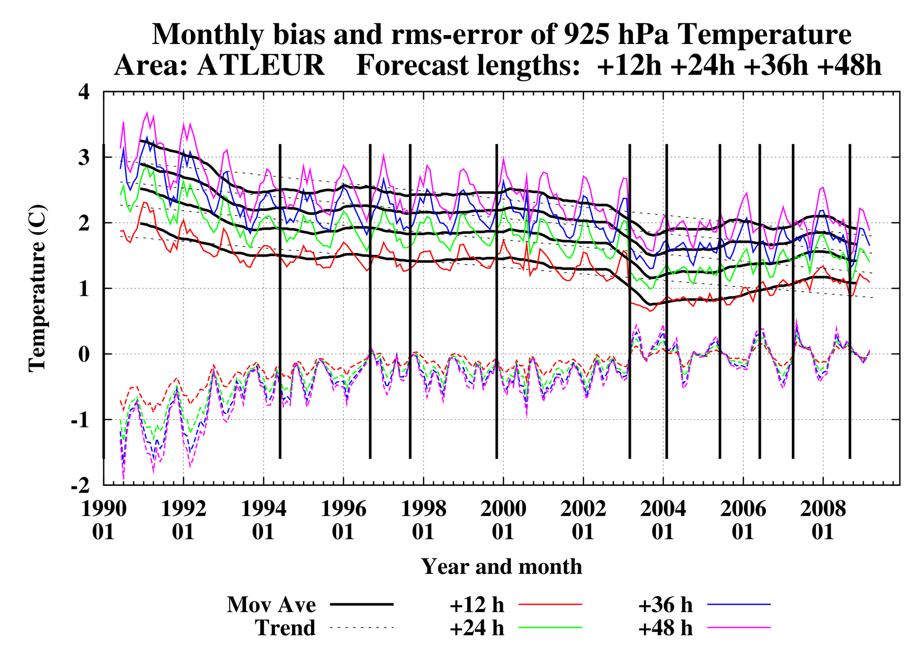

Figure 5: *As Figure 3, but for 500 hPa height.*

Figure 6 shows the growth of rms-error and bias of mean sea level pressure in winter (December, January, February) as a function of forecast length, blue curves show the first five winters in the 1990's and the red curves the latest five winters. Clearly, the rate of error growth (slope of the curves) has decreased, but also there are also improvements in the +6-hour forecasts. This is important for the data assimilation, because six-hour forecast is used as a first-guess in the data assimilation.

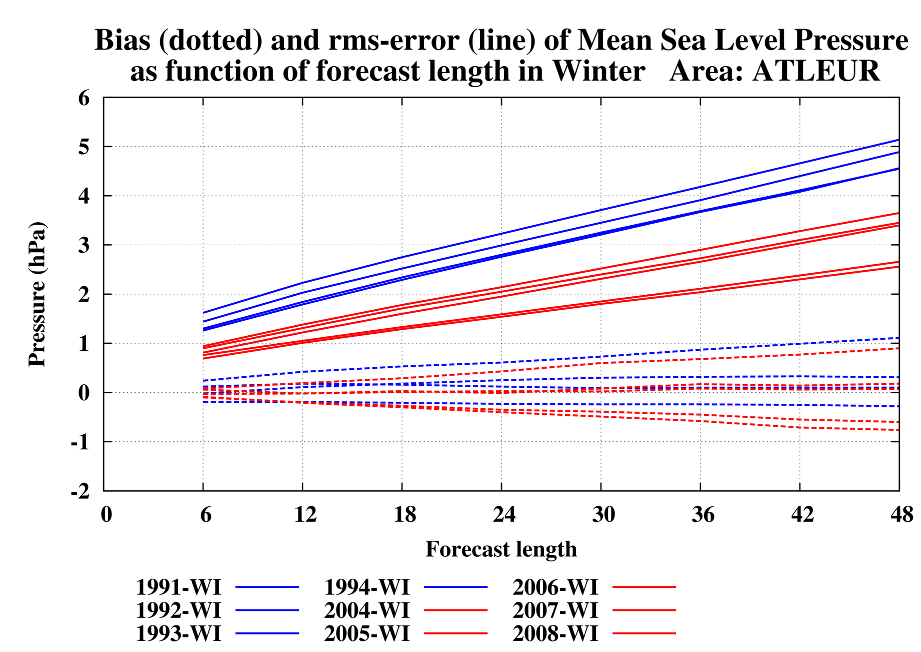

Figure 6: *Error growth of the mean sea levels pressure as a function of forecast length on selected years. Blue curves for years 1990 ... 1995 and red curves for the years 2006 ... 2008.*

References

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Undén, P., L. Rontu, H. Järvinen, P. Lynch, J. Calvo, and coauthors, 2002: *The HIRLAM-5 Scientific documentation*, 144pp. Available at http://hirlam.org.

Yang, X., 2005: Background blending using an incremental spatial filter. *Hirlam Newsletter*, **49**, 3–11.