

# The operational HIRLAM at the Finnish Meteorological Institute

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## 1 Introduction

This report gives an overview of the operational Hirlam at the Finnish Meteorological Institute (FMI). The present operational setup is meteorologically based on the Hirlam version 4.6.2 and was installed into operational use in November 1999. It is in more detail described earlier [1]. However, the essential features are repeated here and also some new features are described. The report contains also some verification results and very shortly plans for the near future.

## 2 Meteorological setup

The operational setup contains two suites, the ATA suite and the ENO suite. Except area and resolution and related features the two suites are very similar. The integration area of the Atlantic suite (ATA) contains Europe, North Atlantic and parts of North America and the horizontal resolution is  $0.4^\circ$ . The European suite (ENO) is run on a smaller area containing mainly Northern Europe and the resolution is  $0.2^\circ$ . In both suites the number of vertical levels is 31. The horizontal areas of the two suites are shown in Figure 1.

The both suites are meteorologically very similar and the main features are listed in Table 1 for the ATA suite and in Table 2 for the ENO suite. Here we repeat only the most important features. A more complete description is given in the last year's report [1]. On the analysis side the cut-off time for observations is 2h 30min. The OI analysis scheme is parallelized using the SHMEM communications library. In the surface analysis we have added a module, which creates climatological pseudo observations for the Scandinavian lakes. The initialisation scheme is the adiabatic non-linear normal mode scheme. In the forecast model we use the CBR turbulence scheme and Eulerian time-stepping.

Both suites, ATA and ENO, are run four times a day and the forecast length is 54 hours. This was the user's request to get an effective forecast length of two days in the end-products. The forecasts are available, both on model and pressure levels, at the frequency of one hour.

A new feature in the surface analysis scheme is the use of sea surface and ice data. In the wintertime we receive twice a week digital sea surface temperature and ice data from the Marine Research Institute. The original resolution of this data is  $0.333 \times 0.1666^\circ$ , but only every third point is used. Even in this way we obtain a good observation coverage for the Baltic Sea north of  $58^\circ\text{N}$ . During the summertime, when the digital analysis is not available, we receive more ship observations from the Marine Research Institute.

In summer 2000, the pseudo observation handling in case of ECMWF data was adjusted to the changes caused by the ECMWF new boundary scheme. Since July 2000 the boundary fields are received in the rotated latitude/longitude grid with a resolution of  $1.5^\circ$ .

Together with the Marine Research Institute we have tested a two-way coupled wave model inside Hirlam. The atmospheric part is identical to the ENO suite. The link from Hirlam to the wave model is the wind on the lowest atmospheric level, and the link from the wave model to Hirlam is the roughness length. The coupled model has been run in parallel with the ENO suite during the winter and spring 2001. Preliminary results show that 10-metre winds are in the mean slightly weaker in the coupled model compared to the ENO suite. This differences are mainly due to the reduction in speed of strong winds

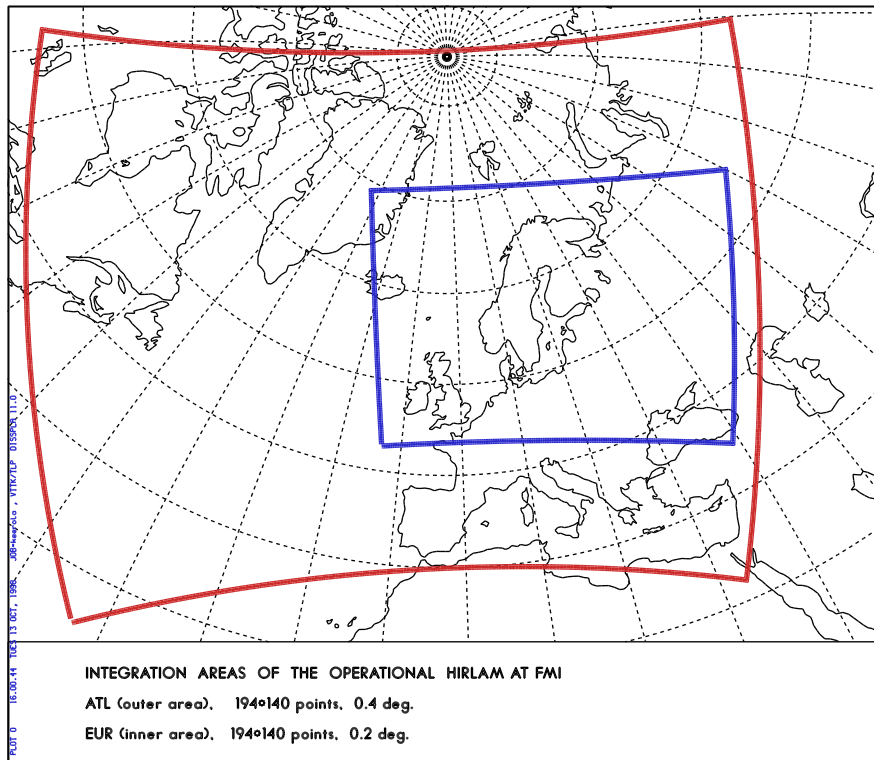


Figure 1: The integration areas of the operational HIRLAM at FMI.

in the coupled model due to increased roughness length. The effect is more prominent over the Atlantic, but can be seen also in the Baltic Sea.

### 3 Technical changes

Concerning computers, we use, as before, the computers of the Center for Scientific Computing (CSC). The T3E system is the primary computer used for computations, while Origin 2000 system serves as the backup system. Identical Hirlam versions exist on both computers. SMS (System Monitoring Scheduler), running at FMI, is used to control Hirlam as well as all operational tasks at FMI.

Several optimisations have been done during the year. By using new compiler options we could speedup the computations by about 10 %. Also the introduction of "pseudo parallel" output decreases the total elapsed time. In this approach only the encoding to GRIB is done in parallel, but the actual writing to disk is done with one processor only. This improves the efficiency on rather slow T3E processors, when large amounts of data have to be encoded and written. At the moment the ATA suite is ready about 40 minutes and the ENO suite about 90 after the cut-off time.

### 4 Monitoring tools

Technically the operational Hirlam can be run automatically: the computer operators can in most cases run the system so that it does not abort. However, this is not enough. We have several examples where also the meteorological monitoring is essential. For example, one weekend was run without TEMP-sounding observations, which are the most important observation type in Hirlam. In order to improve the detection of possible problems, a set of useful diagnostic products are collected on our internal WWW-pages. At the moment the monitoring window contains:

- The observation coverage maps for every observation type.
- The analysis increments for geopotential and wind components on the following pressure levels: 200 hPa, 500 hPa, 925 hPa and 1000 hPa.
- Maps of the following surface fields
  1. sea surface temperature and the corresponding observations
  2. ice coverage of the sea and corresponding observations
  3. surface temperature
  4. soil moisture
  5. snow depth and the corresponding observations
- The EWGLAM verification scores for the latest full month

These products provide a good starting point for the meteorological monitoring and it is easy to add new windows, because the general framework is ready. However, the technical side is less of a problem. The real problem is to organise the operational monitoring tasks in practice. Note that at FMI we don't have a special group to take care of the operational Hirlam, but the same people, who develop Hirlam, also take care of the operational system.

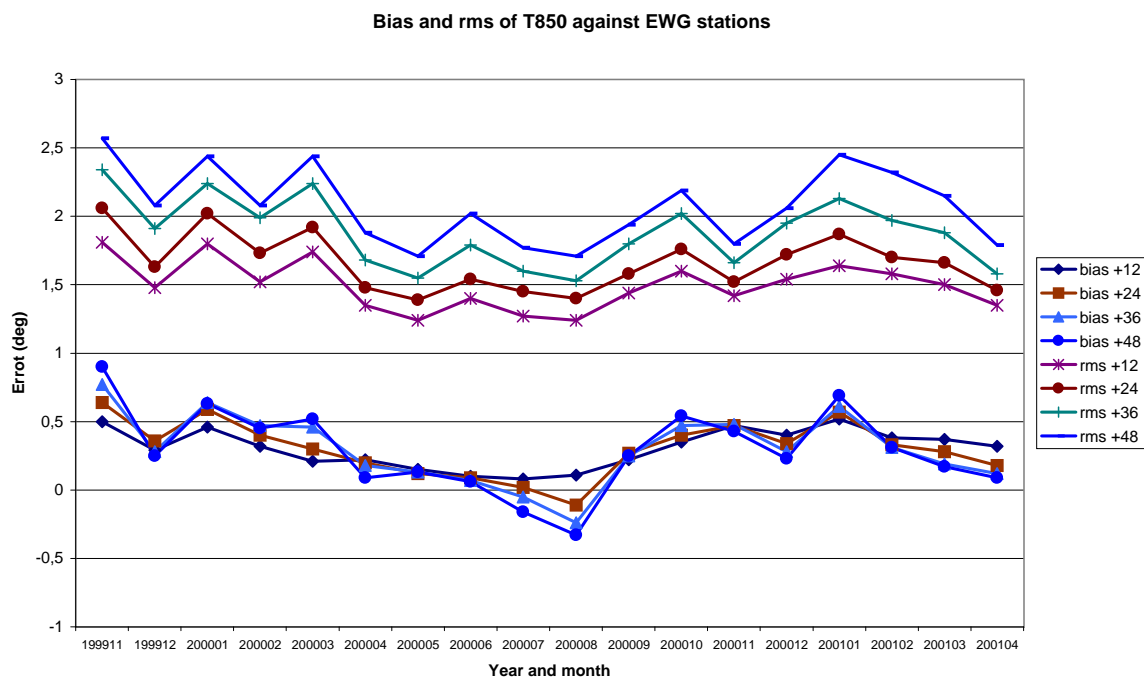


Figure 2: Monthly bias and rms error of 850 hPa temperature for different forecast lengths against EWGLAM observations.

## 5 Verification

Some results are shown from the verification of ENO forecasts against observations. Figure 2 shows monthly bias and rms error of 850 hPa temperature for different forecast lengths against observations at EWGLAM stations since November 1999, when the present Hirlam was introduced into operational use.

There seems to be some improvements, which may be due to the correction of some errors in the initial installation. During autumn and winter we have a small positive bias, of the order +0.5 K. Last summer there was practically no bias. The negative bias in August 2000 is probably due to the erroneous snow coverage over the whole Europe in our Hirlam due to an error in the observation handling.

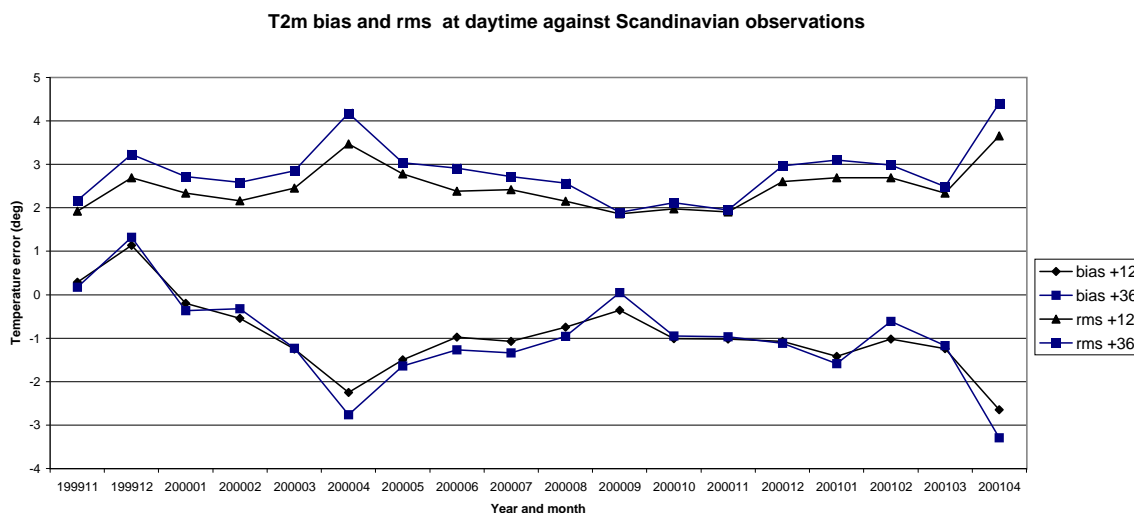


Figure 3: Monthly bias and rms error of two-metre temperature against Scandinavian observations in the day time. The forecasts are based only on 00 UTC runs.

The following two figures point out some of the problems that we have had in the treatment of boundary layer temperature, wind and humidity. The problems are serious in the sense that there is more and more a trend towards automatic creation of customer products from the meteorological fields produced by a numerical model and then corrected by a duty forecaster. This winter this meant a lot of manual editing of the surface fields.

Figures 3 and 4 show the monthly bias and rms error values of two-metre temperature against Scandinavian observations during day (Figure 3) and during night (Figure 4). In both cases only forecasts based on 00 UTC are used in the verification.

Looking at the daytime temperature we can see all time the negative bias, indicating too low temperatures at daytime. Especially in spring the bias is large, more than 2 K in the mean. This poor behavior in spring has been also in the previous operational Hirlam.

Looking at the night temperatures we can see a positive bias in September 2000 and in March 2001, when we had cold nights. November, December 2000 and January 2001 were very mild and cloudy. In these cases Hirlam forecasts were too cold.

## 6 Plans for the future

The most urgent problem to be solved is to correct the boundary layer problems during the cold season. The problem is hardly seen in the summer season. The corrections to STRACO and CBR scheme, which have already been tested (see for instance [2]), clearly reduce the problem, but do not solve it completely.

At the moment we receive a large amount of AMDAR observations, but we cannot yet use them, because our analysis version does not contain the thinning procedure for AMDAR observations. Our plan is to update still once the OI analysis scheme to the latest version mainly to allow the use of AMDARs.

The T3E system at CSC is available for us to the end of 2002 and the next supercomputer strategy at CSC is based on the IBM technology. The preliminary IBM system is already available. In autumn

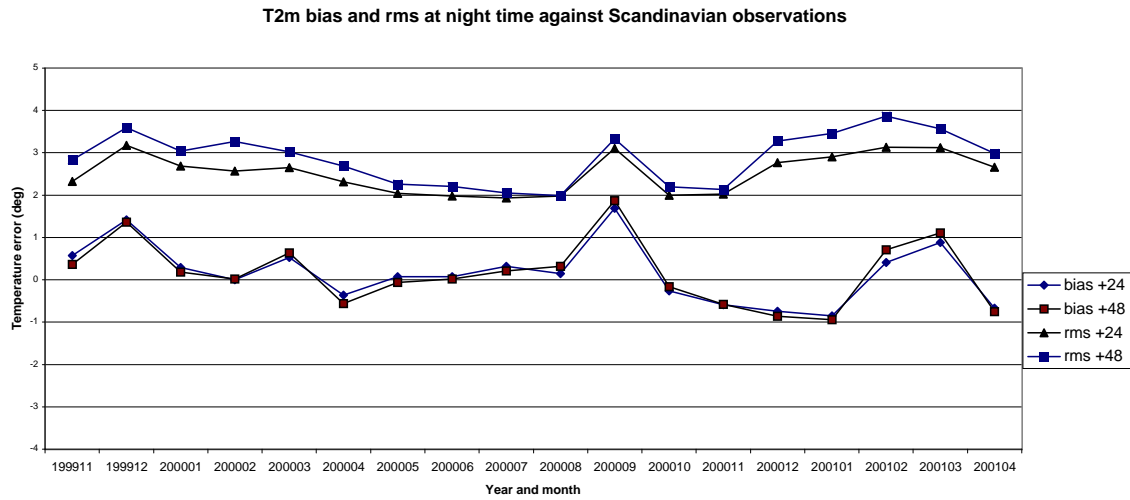


Figure 4: Monthly bias and rms error of two-metre temperature against Scandinavian observations in the night time. The forecasts are based only on 00 UTC runs.

2001, we start the planning and implementing of the next generation operational Hirlam system including 3DVAR analysis system. On the forecast model side semi-Lagrangian version will be used, but the details of the physics are still open. The whole physics configuration will very much depend on the tests during the summer and autumn.

## References

- [1] Kalle Eerola. The new operational HIRLAM at the Finnish Meteorological Institute. *Hirlam Newsletter*, 35:36–43, 2000.
- [2] Simo Järvenoja. Tests with different CBR versions. *Hirlam Newsletter*, 38:??–??, 2001.

<b>Objective analysis and initialization</b>	<b>ATA suite</b>
<b>Analysis system:</b>	3-dimensional multivariate statistical interpolation, univariate for relative humidity (limited area version of the ECMWF OI scheme)
<b>Version:</b>	HIRLAM 4.6.2, modified for parallel processing
<b>Parameters:</b>	surface pressure, geopotential, wind components, relative humidity
<b>Surface analysis</b>	a separate analysis for snow depth, sea surface temperature, and ice coverage using surface observations and possible pseudo observations
<b>Levels:</b>	31 hybrid levels defined by A' and B'. Levels are (assuming the surface pressure of 1000 hPa): 996, 983, 959, 928, 891, 850, 807, 762, 717, 671, 626, 581, 538, 495, 453, 413, 374, 338, 302, 269, 237, 208, 181, 156, 132, 111, 90, 70, 50, 30, 10 hPa
<b>Observation types:</b>	TEMP, PILOT, SYNOP, SHIP, BUOY, AIREP, SATEM and SATOB
<b>First guess:</b>	6 hour forecast of the previous cycle
<b>Initialization:</b>	adiabatic non-linear normal mode initialization
<b>Cut-off time:</b>	2 h 30 min.
<b>Remarks:</b>	Suspicious stations are on the "grey list"

<b>Forecast model</b>	<b>ATA suite</b>
<b>Version:</b>	Hirlam version 4.6.2
<b>Basic equations:</b>	primitive equations in flux form
<b>Independent variables:</b>	$\lambda$ , $\theta$ (transformed latitude-longitude coordinates), $\eta$ , $t$
<b>Dependent variables:</b>	T, u, v, q, p <sub>s</sub> , cloud water content and turbulent kinetic energy
<b>Integration domain:</b>	194 * 140 gridpoints in transformed latitude-longitude grid, 31 vertical levels (as in the analysis)
<b>Grid length:</b>	0.4° (44 km)
<b>Grid:</b>	staggered grid (Arakawa C)
<b>Integration scheme:</b>	Eulerian leapfrog semi-implicit ( $\Delta t = 3$ min)
<b>Orography:</b>	HIRLAM physiographic database, no gravity wave drag
<b>Physical parametrization:</b>	i) prognostic cloud scheme ii) turbulence based on turbulent kinetic energy iii) Hirlam radiation scheme iv) Hirlam old surface parameterization scheme
<b>Horizontal diffusion:</b>	implicit fourth order
<b>Forecast length:</b>	54 hours, forecast products available hourly, extra products available
<b>Frequency:</b>	four time per day
<b>Boundaries:</b>	lateral boundary conditions from ECMWF 00 and 12 UTC forecasts with the interval of six hours

Table 1: Characteristic features of the ATA suite.

<b>Objective analysis and initialization</b>	<b>ENO suite</b>
Analysis system:	3-dimensional multivariate statistical interpolation, univariate for relative humidity (limited area version of the ECMWF OI scheme)
Version:	HIRLAM 4.6.2, modified for parallel processing
Parameters:	surface pressure, geopotential, wind components, relative humidity
Surface analysis	a separate analysis for snow depth, sea surface temperature, and ice coverage using surface observations and possible pseudo observations
Levels:	31 hybrid levels defined by A' and B'. Levels are (assuming the surface pressure of 1000 hPa): 996, 983, 959, 928, 891, 850, 807, 762, 717, 671, 626, 581, 538, 495, 453, 413, 374, 338, 302, 269, 237, 208, 181, 156, 132, 111, 90, 70, 50, 30, 10 hPa
Observation types:	TEMP, PILOT, SYNOP, SHIP, BUOY, AIREP, SATEM and SATOB
First guess:	6 hour forecast of the previous cycle
Initialization:	adiabatic non-linear normal mode initialization
Cut-off time:	2 h 30 min.
Remarks:	Suspicious stations are on the "grey list"

<b>Forecast model</b>	<b>ENO suite</b>
Version:	Hirlam version 4.6.2
Basic equations:	primitive equations in flux form
Independent variables:	$\lambda$ , $\theta$ (transformed latitude-longitude coordinates), $\eta$ , $t$
Dependent variables:	T, u, v, q, p, cloud water content and turbulent kinetic energy
Integration domain:	194 * 140 gridpoints in transformed latitude-longitude grid, 31 vertical levels (as in the analysis)
Grid length:	0.2° (22 km)
Grid:	staggered grid (Arakawa C)
Integration scheme:	Eulerian leapfrog semi-implicit ( $\Delta t = 2$ min)
Orography:	HIRLAM physiographic database, no gravity wave drag
Physical parametrization:	i) prognostic cloud scheme ii) turbulence based on turbulent kinetic energy iii) Hirlam radiation scheme iv) Hirlam old surface parameterization scheme
Horizontal diffusion:	implicit fourth order
Forecast length:	54 hours, forecast products available hourly, extra products available
Frequency:	four time per day
Boundaries:	lateral boundary conditions from the ATA with the interval of three hours

Table 2: Characteristic features of the ENO suite.