The operational HIRLAM at the Finnish Meteorological Institute

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1 Introduction

The present operational Hirlam system at the Finnish Meteorological Institute is based on the Hirlam version 4.6.2, although many local modifications and updates from later Hirlam versions have been implemented since the first installation. The first version of the current system was implemented on 15 November 1999.

The basic meteorological setup and technical environment has been described in Eerola (2000) and later modifications in Eerola (2001). This report discusses mainly the modifications made during the year 2001 and the first part of the year 2002, although a short review is given about the overall system.

2 Technical environment

The co-operation between the Finnish Meteorological Institute (FMI) and the Center for Scientific Computing (CSC) has continued during the latest year, and the CSC computers have been used for running of the operational Hirlam.

The main computing facility for Hirlam is the T3E system, but an identical system has been implemented on the SGI Origin 2000 for backup purposes. On the T3E, we use 128 processors for the forecast and 40 processors for the analysis. System Monitor Scheduler (SMS), developed at ECMWF, controls all the jobs and takes care of scheduling and dependencies between Hirlam jobs as well as all operational tasks at FMI.

At the moment, the ATA suite (see below the definitions of ATA and ENO suites) is ready about 40 minutes after the cut-off time and the ENO suite is ready about 90 minutes after the cut-off time.

3 Meteorological setup

The operational setup contains two suites, the ATA suite and the ENO suite. The integration area of the Atlantic suite (ATA) contains Europe, the North Atlantic and parts of North America and the horizontal resolution is 0.4°. The number of vertical levels is 31.

The European suite (ENO) is run on a smaller area containing mainly Northern Europe and the resolution is 0.2°. A remarkable change in this suite took place in September 2001, when a new ENO suite, including a two-way coupled wave model inside Hirlam, replaced the old ENO suite after a long parallel testing period in spring and summer 2001 (Järvenoja and Tuomi, 2002). This model is a result of the co-operation between the Finnish Institute of Marine Research (FIMR) and FMI.

The atmospheric part of the coupled model is identical to the old ENO suite. The link from Hirlam to the wave model is the wind on the lowest model level, and the link from the wave model to Hirlam is the roughness length over sea. As shown in Järvenoja and Tuomi (2002), it appears that 10-metre winds are in the mean slightly weaker over the sea in the coupled model than in the old ENO suite. The differences are mainly due to the reduction in speed of strong winds in the coupled model due to larger roughness length. The effect is more prominent over the Atlantic, but can be seen also in the Baltic Sea.

As an example of the output of the wave model, Figure 1 shows a six hour forecast of the wave height and direction in one test case.

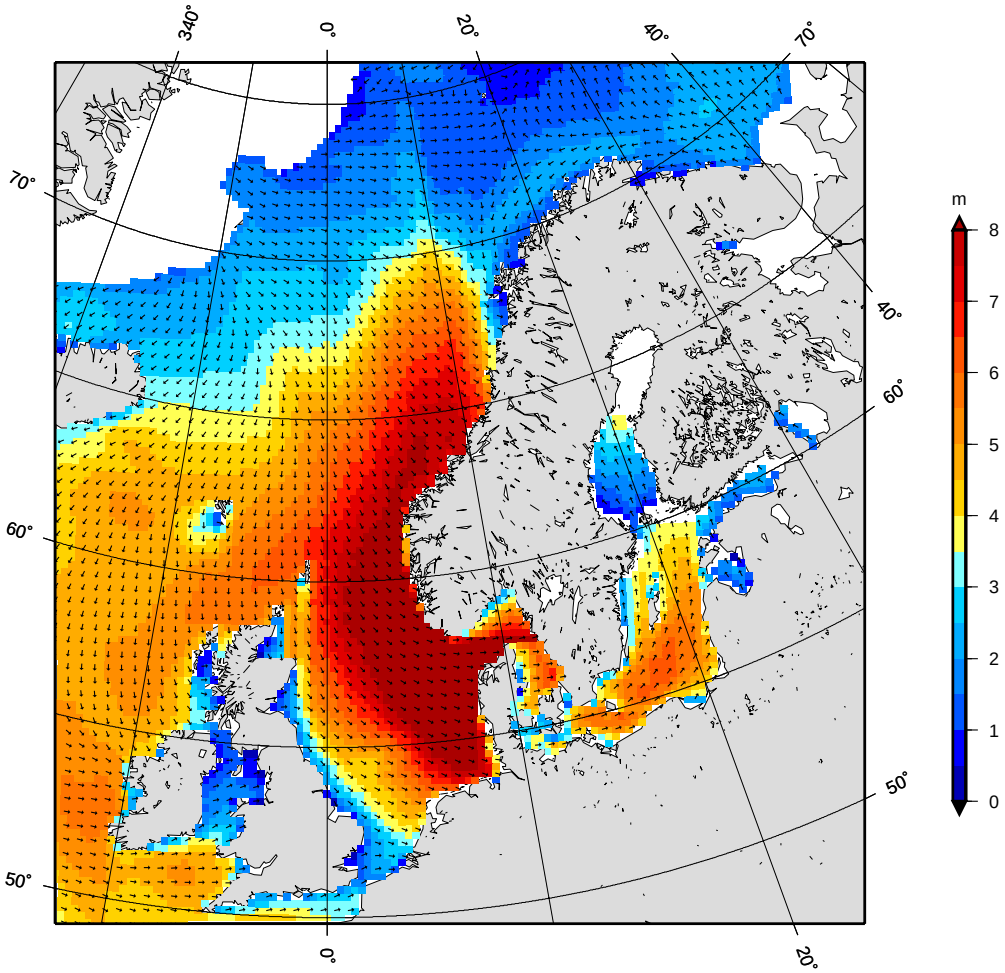

Figure 1: An example of the output of the wave model: a six hour forecast of the wave height and direction at 30 January 2001 at six o'clock.

The horizontal areas of the ATA and ENO suites are shown in Figure 2. The main features are listed in Table 1 for the ATA suite and in Table 2 for the atmospheric part of the ENO suite.

Both suites, ATA and ENO, are run four times a day and the forecast length is 54 hours. This was the users' request to get an effective forecast length of two days in the end-products.

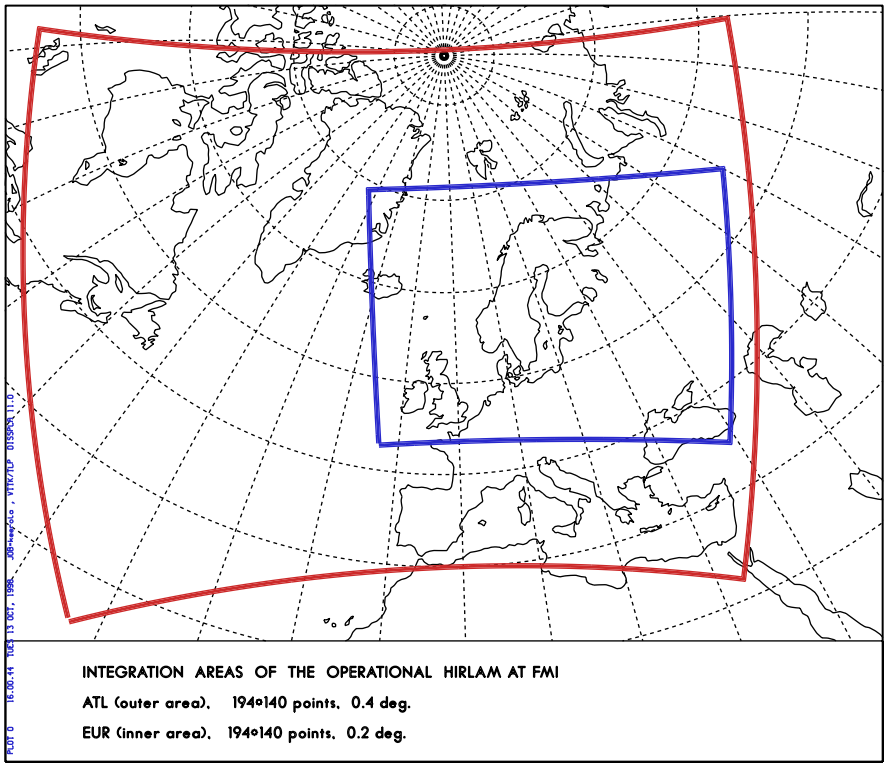

Figure 2: The integration areas of the operational Hirlam at FMI.

The forecasts are available, both on model and pressure levels, at the frequency of one hour.

4 Recent changes in the Hirlam system

The biggest change, the introduction of the wave model inside Hirlam, was already mentioned in the previous chapter.

Since July 2001, we have used the ECMWF lateral boundary conditions in a form of so-called frames for the ATA suite. This means that we receive fresh boundaries at the horizontal resolution of our Hirlam system four times a day. So we have fresh boundaries, only six hours old in the beginning of the forecast, in every daily Hirlam run. The ECMWF orography for vertical interpolation is received every day.

The Hirlam OI analysis system was raised to the level 5.0.0 in July 2001. This allowed us to take the AMDAR observations into operational use in the beginning of September 2001. An example of the data coverage of AIREP and AMDAR is shown in Figure 3.

In spring 2002, a temporary correction was introduced to improve the two-metre temperature forecasts in spring. The evaporation over land was set to a half of the original value. This partly corrected the large negative bias in the predicted two-metre temperature in spring. This correction will be removed before summer.

A local correction to the sea surface temperature analyses over lake Ladoga was introduced. In the modified version the lake Ladoga is treated as sea and the pseudo observations of the Gulf of Finland are also used over Ladoga. In this way the sea surface temperature of Ladoga

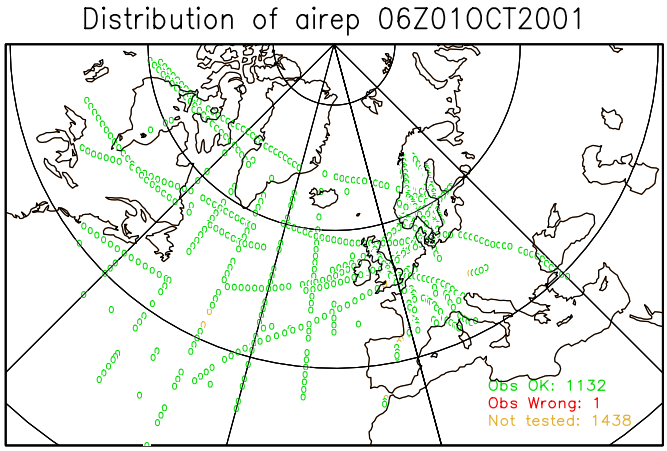

Figure 3: An example of the data coverage of AIREP and AMDAR observations.

follows closely the values of the Gulf of Finland instead the climatological temperatures of the shallow lakes of Finland used for the Finnish lakes.

Some other minor modifications has been done, including the improvement of the backup system on SGI, avoiding too low or too high relative humidities in post-processed fields.

5 Plans for the future

The T3E system at CSC is available for us untill the end of 2002 and the next supercomputer strategy at CSC is based on the IBM technology. The first nodes of the new IBM pSeries 690 nodes have been installed at CSC. In each node there is 32 Gb of memory and 32 processors with the clock frequency of 1.1 GHz. The theoretical peak performance of one node is 140 Gflop/s. In the final installation there will be 16 nodes.

After solving some technical problems, the Hirlam version 5.1.4 and the 3DVAR analysis system have been now installed on the IBM system and the meteorological testing has started. In the next operational Hirlam configuration the area is slightly larger than the present ATA area and the resolution is 0.2°. The number of vertical levels is 40. Instead of miniSMS, the Hirlam reference system has been adapted to use the full SMS with a slightly simplified portioning to tasks.

References

Kalle Eerola, 2000. The new operational Hirlam at the Finnish Meteorological Institute. *Hirlam Newsletter*, **35**,36–43.

Kalle Eerola, 2001. The operational Hirlam at the Finnish Meteorological Institute. *Hirlam Newsletter*, **38**,22–28.

Simo Järvenoja and Laura Tuomi, 2002. Coupled atmosphere-wave model for FMI and FIMR. *LAM Newsletter*, **40**,9–22.

Objective analysis and initialization	**ATA suite**
Analysis system:	**3-dimensional multivariate statistical interpolation, univariate for relative humidity (limited area version of the ECMWF OI scheme)**
Version:	**HIRLAM 5.0.0, (SHMEM parallel version)**
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, AMDAR, 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"**

Forecast model	**ATA suite**
Version:	**Hirlam version 4.6.2**
Basic equations:	**primitive equations in flux form**
Independent variables:	**λ, θ (transformed latitude-longitude coordinates), η, t**
Dependent variables:	**T, u, v, q, p_s, 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:	**0.4° (44 km)**
Grid:	**staggered grid (Arakawa C)**
Integration scheme:	**Eulerian leapfrog semi-implicit (Δt = 3 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:	**"frames" from ECMWF 00, 06, 12 and 18 UTC boundary condition runs with the interval of six hours**

Table 1: Characteristic features of the ATA suite.

Objective analysis and initialization	**ENO suite**
Analysis system:	**3-dimensional multivariate statistical interpolation, univariate for relative humidity (limited area version of the ECMWF OI scheme)**
Version:	**HIRLAM 5.0.0, (SHMEM parallel version)**
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**
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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"**

Forecast model	**ENO suite**
Version:	**Hirlam version 4.6.2**
Basic equations:	**primitive equations in flux form**
Independent variables:	**λ, θ (transformed latitude-longitude coordinates), η, t**
Dependent variables:	**T, u, v, q, p_s, 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 (Δt = 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 suite with the interval of three hours**

Table 2: Characteristic features of the ENO suite.