

## Introduction

The Hirlam system is used at Met Éireann – the Irish Meteorological Service – to produce operational forecasts out to 48-hours. The model [version 5.0.1 with 3DVAR] is run four times per day using an IBM RS/6000 SP with 9 nodes each with 4 processors sharing 2 Gbytes of memory [i.e. a total of 36 CPUs and 18 Gbytes of memory].

## Data Assimilation

*Observations* : SYNOP, SHIP, BUOY, AIREP, AMDAR, ACARS TEMP, TEMPSHIP, PILOT, SATOB and SATEM observations are used. The data are packed into BUFR format both for storage and for input to Hirlam.

*Analysis* : Hirlam 3D-Var [3-dimensional variational assimilation]. The analysis runs on 31 hybrid [eta] levels. Upper-air observational data is accepted on all standard and significant levels (10 hPa to 1000 hPa) and interpolated to eta levels.

*Assimilation Cycle* : Three-hour cycle using the forecast from the previous cycle as a first-guess. [It is also possible to use an ECMWF forecast as a first-guess].

*Analysed Variables* : Wind components (u,v), geopotential and specific humidity.

## Forecast Model

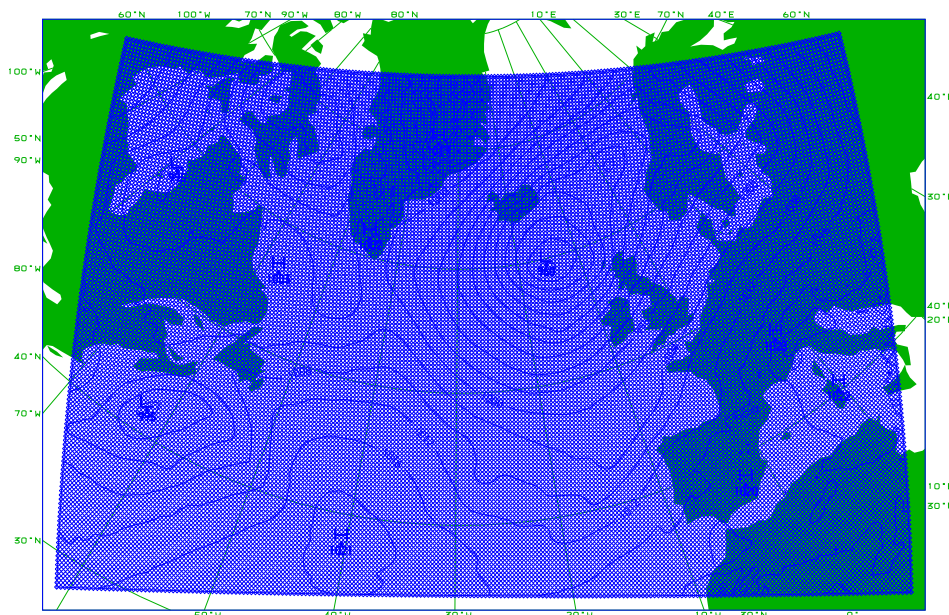
*Forecast Model* : Hirlam 5.0.1 reference system grid point model.

*Horizontal grid* : A rotated latitude-longitude grid is used with the South-Pole at ( $-30^\circ$  longitude,  $-30^\circ$  latitude). Fields are based on a 438x284 grid corresponding to a  $0.15^\circ \times 0.15^\circ$  horizontal Arakara C-grid [see diagram below].

*Vertical Grid* : Hybrid [eta] coordinate system with 31 levels.

*Initialisation* : Digital Filter.

*Integration Scheme* : We use a two time-level three-dimensional semi-Lagrangian semi-implicit scheme with a time-step of 300 seconds.



*Filtering* : Fourth order implicit horizontal diffusion.

*Physics* : CBR vertical diffusion scheme; Sundqvist condensation scheme with the 'STRACO' (Soft TRAnSition COndensation scheme) cloud scheme; Savijarvi radiation scheme.

*Lateral Boundary Treatment* : Davies-Kallberg relaxation scheme using a cosine dependent relaxation function over a boundary zone of 8-lines. The latest available ECMWF 'frame' files are used [based on 4 ECMWF runs per day at 00Z, 06Z, 12Z and 18Z, respectively]. ECMWF data is received on a  $0.3^\circ \times 0.3^\circ$  rotated latitude-longitude grid on a selection of the 60 ECMWF eta levels. The data is interpolated both horizontally and vertically to the Hirlam  $0.15^\circ \times 0.15^\circ$  rotated latitude-longitude grid at [Hirlam] 31 eta levels. [The selected  $0.3^\circ \times 0.3^\circ$  grid corresponds to half the resolution of the  $0.15^\circ \times 0.15^\circ$  grid, the line speed is not sufficient to receive the data at full resolution].

In general the ECMWF boundary files are just provided as 'frame' boundaries where the data is not defined in the central section of the grid. However, the ECMWF analysis fields are received on a 'full' grid and so can be used as a 'first-guess' in the case of a 'cold-start'.

## Data Monitoring

The analysis departures/flags are fed back to the original BUFR reports to create 'feedback' files which are used to monitor the quality of the data on an ongoing basis and to identify problems [e.g. station elevation errors].

## Operational Usage

*General Forecasting* : Hirlam forecasts are used for general forecasting in Met Éireann out to 48-hours. [ECMWF forecasts are used beyond that period]. Hirlam output can be displayed using an interactive graphics system called *xcharts* (developed at Met Éireann).

*WAM model* : Forecast 10-metre winds from Hirlam are used to drive a WAM wave model.

*Roadice Prediction System* : Forecast surface parameters [temperature, wind, cloud-cover, humidity and rainfall] are used [after forecaster modification] as input to a roadice model.

*SATREP* : Hirlam output can be overlaid on satellite plots as part of the ZAMG SATREP analysis scheme.

## Verification

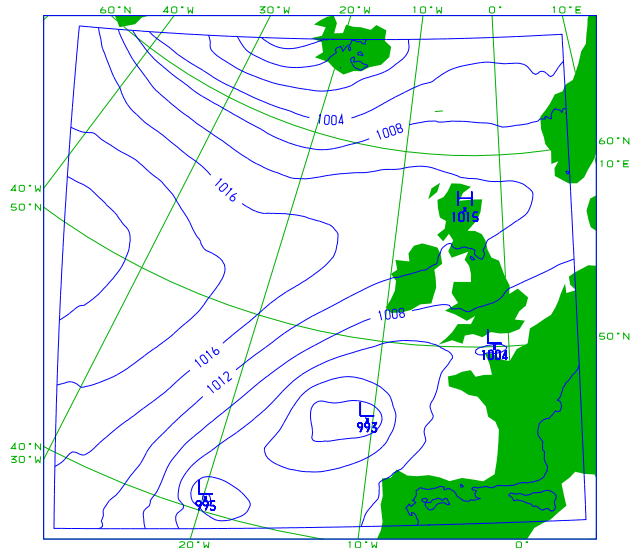
*Verification against Fields* : A small number of Hirlam parameters are verified against the corresponding Hirlam analysis fields. [This is to provide continuity with an earlier model which was used before Hirlam became operational].

*Verification against Observations* : The Hirlam verification system is used to verify forecasts against observations from EGWLAM stations within the area.

## Nested Hirlam

A nested version of Hirlam is also run on the IBM RS/6000 SP. It works on a three hour cycle producing 27-hour forecasts at the intermediate hours [viz. 03Z, 09Z, 15Z and 21Z]. It runs on a  $222 \times 210$  grid, with 40 levels in the vertical. [The grid spacing is  $0.12^\circ \times 0.12^\circ$  which is slightly finer than the main Hirlam grid of  $0.15^\circ \times 0.15^\circ$ ].

It uses a more advanced version of the physics than the main Hirlam i.e. it uses the Kain-Fritsch/Rasch-Kristjansson convection/condensation scheme and the ISBA surface scheme. Many of the outputs of the model are post-processed using MOS. The following diagram shows the area :



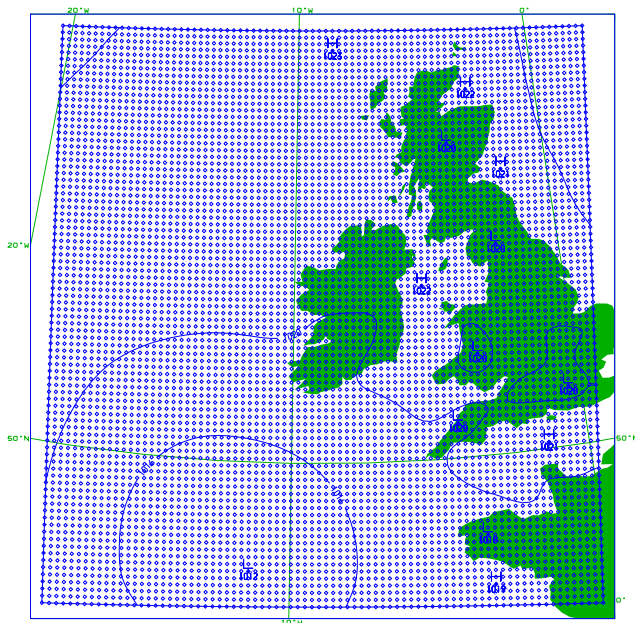
### Nested Hourly Analysis

A separate nested version of Hirlam is run every hour on a dual-processor 500Mhz PC running Linux. The run provides an hourly analysis and also a short range [3-hour] local forecast.

*Forecast Model* : Hirlam 4.3 forecast model in conjunction with the Hirlam 4.8 OI analysis scheme.

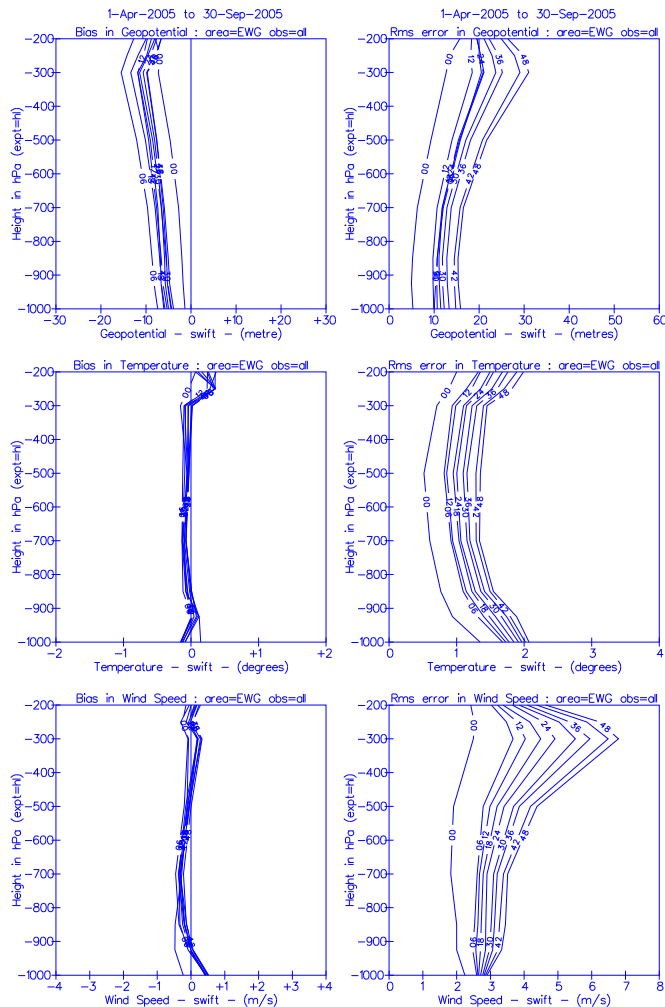
*Vertical grid* : A set of 24 hybrid [eta] levels.

*Horizontal grid* : A rotated latitude-longitude grid is used with the South-Pole at ( $-9^{\circ}$  longitude,  $-38^{\circ}$  latitude). There are 97x98 grid points with a resolution of  $0.15^{\circ} \times 0.15^{\circ}$ . The following diagram shows the area :



## Verification Statistics

The following diagram shows some verification statistics for Hirlam, against the list of EWGLAM stations, covering the period Apr-Sept 2005 :



## Research Activities

Better specification of boundary conditions for NWP models; Operational Implementation of a Nested System; Regional Climate Analysis, Modelling and Prediction Centre [RCAMPC] and Community Climate Change Consortium for Ireland [C4I].

## Experiments with Linux Cluster

Met Éireann started to experiment with running Hirlam on a Linux cluster in early 2004. The experiences have been generally good.

*Cluster Hardware* : The cluster consists of 10 rack mounted Dell Poweredge 1750 nodes (i.e. 1 master node and 9 compute nodes). The master node has dual 2.8GHz Xeon processors with 4 Gigabytes of ECC DDR RAM; each compute node has dual 3.2GHz Xeon processors with 2 Gigabytes of memory. The compute nodes are connected as a two-dimensional torus via 4 Port Dolphin SCI HBA cards.

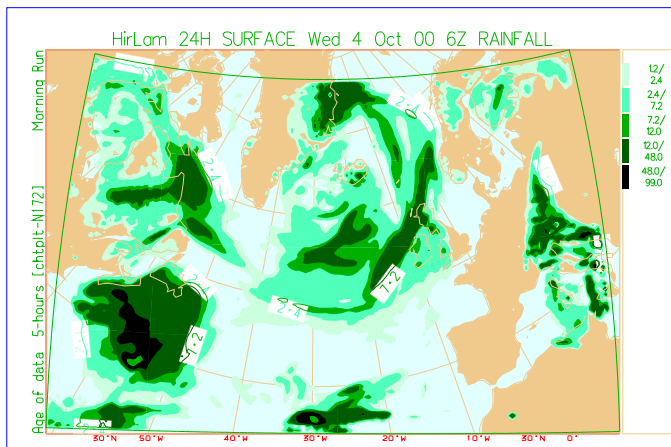
*Cluster Software* : (a) Operating system: Redhat ES 3.0 / WS 3.0 (b) Networking software: Scali MPI connect, Scali TCP connect, Scali Manage; (c) Compilers: PGI cluster development kit and Intel Fortran compiler.

*Forecast Suite* : The same as the main operational model viz. Hirlam 5.0.1 with 3DVAR analysis. It runs on the same grid and with the same options. This allows us to make direct performance comparisons between our IBM mainframe and the cluster. [In addition we are implementing Hirlam 6.4].

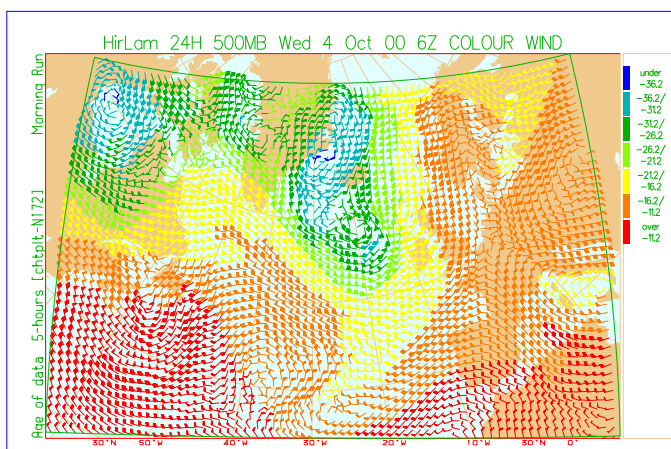
*Cluster Performance* : A typical 48-hour Hirlam forecast takes 62 mins on the mainframe and 71 mins on the cluster; a typical 3DVAR analysis takes 15 mins on the mainframe and 9 mins on the cluster [the cluster version of the analysis uses fftw]. A total run [analysis+forecast] takes 77 mins on the mainframe and 80 mins on the cluster. All cluster runs are with the PGI compiler.

## Sample Output

The following are some examples of typical Hirlam output as displayed on the forecaster's workstation [using the **xcharts** graphics program]. The first chart shows accumulated rainfall :



The next chart shows wind-arrows at 500hPa. The colour of each arrow has been chosen to indicate the temperature at that level :



## Future Plans

We hope to continue our experiments with the cluster and investigate the use of the Intel compiler and the Intel mathematics libraries [both of which are said to improve performance]. At present we are in the process of implementing the latest [6.4] version of Hirlam on the cluster.