Swedish Meteorological and Hydrological Institute

Norrköping, Sweden

1. Summary of highlights

HIRLAM at SMHI is run on a CRAY T3E with 272 PEs at the National Supercomputer Centre (NSC) organised together with the University of Linköping and SAAB Aircraft Corporation, both in the town of Linköping some 45 km from SMHI. The suite is still run on the C90 as well, as a hot backup in case of the T3E being down. The CRAYs are connected to SMHI via a dedicated 4 Mbit/sec line for the operational production and a shared 100Mbit line for research and development.

Observation statistics (against background and analysis) are used for some monitoring, mainly of DRIBUs and SHIPs. Blacklisting of some platforms has been done on an approximately monthly basis. The Optimum Analysis was upgraded in November so that DRIBUs and AIREPs now go through a thinning procedure in order not to use redundant data. Analysis boxes have been enlarged in size and the observation error statistics has been considerably revised.

Certain parts of the suite on the T3E, which were particularly inefficient, have been optimised. Shell commands and job submissions in connection with forecast outputs have been reduced and the I/O in the analysis reduced by 90%.

A lot of effort throughout the year has been put into implementing a HIRLAM Y2K version on T3E, C90 and on local servers for post-processing. The operational T3E version has otherwise been kept unchanged whereas on the backup machine, C90, a much more recent version of HIRLAM, 4.6.4, was installed at the end of 1999. Two ECMWF vertical resolution increases have been successfully interfaced (for the boundary conditions).

2. Equipment in use for numerical weather forecasting

Cray T3E with 272 processors (256 application PEs) (96 with 256 MB memory, the rest 128). SMHI has 23% of the resources available for operations and research. The forecast model uses 100 or 110 PEs and the OI analysis 48 PEs.

Cray C96 with 6 processors and 2 Gbyte primary memory (backup)
The above systems are shared with other users at the NSC.

DEC Alpha servers (2 computer servers, 2 file servers, one of each as backup).

VAX cluster system.
Sun workstations/servers.

The operational suite - all in Unix - is run remotely from SMHI using an interface that conforms with the high security requirements of some NSC users. Observations, lateral boundary conditions and other external forcings are prepared at SMHI and transferred to NSC when needed. Pre-processing and postprocessing are done at SMHI on the DEC Alpha server.

3. Data used for NWP

SYNOP, DRIBU, TEMP and AIREP and AMDAR.

4. Data input system

Automated.

5. Quality control system

Format, basic consistency and climatological checks, check against background field and analysis quality control against other observations.

6. Monitoring of the observations

Limited monitoring at the moment. Observation statistics accumulated and plotted and inspected almost daily. Monitoring of DRIBUs and SHIPs has been done approximately on a monthly basis and some offending platforms have been blacklisted.

7. Forecasting system

The forecasting system consists of the HIRLAM analysis and forecast models for data assimilation and short-range forecasts in a limited area. It is run in two resolutions; the small area is nested with boundary values from the large area. In addition there is a mesoscale analysis (MESAN), which uses a lot of additional non-conventional observations and it is used for now-casting purposes. Near surface and cloud information from MESAN together with first guess from HIRLAM 22 km are used to run a 1-dimensional version of HIRLAM for very short range aviation purposes, mainly.

7.1. System run schedule

Analysis and forecasts four times a day, from 00, 06, 12 and 18 UTC observations. Data cut-off is 1 hour 55 minutes past the main analysis hours. The 0.4° model (H44) is run out to 48 hours. The boundary conditions are provided by the most recent ECMWF forecast. After each H44 forecast has finished, the 0.2° resolution version (H22) run is out to 36 hours with boundaries from the 0.4° run. Analyses are additionally run at the intermediate hours, 03, 06, 15 and 21 UTC.

7.2. Medium range forecasts

The ECMWF products are used together with products from UKMO and DWD.

7.3. Data assimilation, objective analysis and initialization.

Optimum interpolation HIRLAM analysis using the 6-hour HIRLAM forecast from preceding analysis as background. Non-linear adiabatic implicit normal mode initialization of the first 4 modes.

7.4. Model

The HIRLAM level 2 version 2.7.15 gridpoint model with 0.4 or 0.2° horizontal resolution on a rotated grid. The integration areas can be seen in Figures 1 and 2. The number of grid points is 202x178 and 162x142 points, respectively. Both versions have 31 hybrid model levels. The time integration scheme is semi-Lagrangian with time steps of 7.5 and 3.

The physics parametrization include:

- The Sundqvist cloud scheme with prognostic equations (including advection) for liquid and frozen cloud water.

- Condensation by stratiform processes and initially a Kuo-type convection which is being replaced by a mass-flux formulation.

- Savijärvi-Sass radiation.

- K-type planetary boundary layer.

Coupled models for ice-drift in the Baltic Sea and for lake temperatures and ice are also included in the operational suite. They are supplemented by NCEP (Reynolds) SST analyses taken from ECMWF.

7.5. Numerical weather prediction products

All postprocessing and product generation is carried out by stand-alone packages run on workstations at SMHI. Various statistical interpretation systems are applied.

7.6. Operational techniques for application of NWP products

Analyses with observations and forecasts are plotted and displayed on paper. Graphic files are available on the Intranet and displayed with browsers on PCs or workstations. The hourly write-ups are used for animations of the forecasts. A large number of tables and maps are produced with forecast values, direct output, interpreted values and derived parameters. A one-dimensional (1D) HIRLAM with high vertical resolution and mesoscale analysis data input is run from the H22 model. HIRLAM forecast fields are used to as input to trajectory, air pollution, ice, ocean and wave models. Forecast fields are also used for ship routing and for radar precipitation forecasts.

Some commercial automatic weather forecasts are produced with direct model output.

Hourly forecast fields are available on the new workstation based forecast system, where forecast fields are selected and can be edited. Certain products can then be generated automatically.

7.7. Meso-scale analysis

There is also a meso-scale objective analysis (MESAN) of weather parameters. The analysis variables include precipitation, snowfall, snowdepth, 2-meter temperature, 10-meter mean wind and gustiness, near-surface relative humidity, cloud amounts and cloud base and visibility. The analyses are uni-variate and based upon a statistical Optimum Interpolation scheme. A prominent property of the scheme is the use of anisotropic, geographically dependent structure functions, where features such as the orography and the distance from the sea are taken into account. Background fields are usually taken from HIRLAM or from the most recent previous meso-analysis. In addition to conventional SYNOP and METAR-data, observations from a dense network of automatic roadside stations run by the road authorities, radar observations of precipitation and spectrally classified AVHRR-imagery are used. At present the MESAN analyses are carried out on a 22km rotated latitude-longitude mesh.

The analyses are produced hourly and are plotted with the observations as large multi-coloured charts on an A0 inkjet plotter. The MESAN analyses have been found to be of a quality comparable to manual analyses and MESAN has now replaced much of the manual analysis effort by the synopticians.

8. Verification

Verifications are made against observations and analyses for the HIRLAM system and for the ECMWF products over the same limited area.

9. Plans for 2000

A coupled lake model will be introduced in the first half of 2000.

The data assimilation and forecasts will be run with fresher ECMWF boundaries, from forecasts every 6 hours. Possibly the data assimilation will be re-run with more observations from a later cut-off. This is expected to reduce forecast errors somewhat.

The latest HIRLAM level 4.7 system with new convection, turbulence and initialisation (DFI) will be tested and implemented. Small-scale features in the 0.2° version will be investigated and a new convection scheme will be explored.

VAD-winds from the NORDRAD radar network are available and deemed to be of good quality. They will be used in the data assimilation when the technical issues of including them in the appropriate BUFR format together with the conventional observations are addressed.

The HIRLAM 3D-VAR data assimilation will be evaluated in parallel during 2000 with the aim of becoming operational later in the year.

Map 1. Integration area for the SMHI 0.4° (44 km) HIRLAM.

Map 2. Integration area for the SMHI 0.2° (22 km) HIRLAM.