The HIRLAM-5 Project 2002.

Per Undén
Project Leader, HIRLAM-5, SMHI, S-60176 Norrköping, SWEDEN.

1 Introduction

The HIRLAM-5 Project is the LAM NWP research cooperation between the meteorological institutes in Denmark, Finland, Iceland, Ireland, Netherlands, Norway, Spain and Sweden as well as with Météo-France. The Hirlam Data assimilation and Forecast model is run operationally in 7 of the institutes in a many different configurations. Synoptic scale models with resolutions from 15-50 km are run with ECMWF boundary conditions, and within these models there are nested ones from 20 km down to 5 in some countries. The Project has continued development of its Variational Data Assimilation and use of non-conventional data and a number of modelling areas, particularly physical parameterisation have been worked on intensively. The Project is preparing to go into its 6th phase and with fairly similar objectives. The need for synoptic scale modelling persists, for e.g. Atlantic developments whilst gradually more emphasis will be put in the meso-scale non-hydrostatic very short range model. Use of non-conventional data and optimal use in 3D or 4D-VAR will be even more important.

2 Scientific Progress

2.1 Data Assimilation

The Hirlam institutes using 3D-VAR operationally show better general (upper air) forecast scores than the ones still using OI and this confirms the benefits documented for 3D-VAR. The Hirlam Variational DA system (HIRVDA) has been further updated and a number of corrections and new features have been added. The internal observation structure has been changed. The use of SHIP anemometer height is now included. First Guess at Appropriate Time (FGAT) has been introduced as an option and has been shown to give positive impact.

The use of background error (σ_b) values in HIRVDA software has been unified in the transforms of the background error constraint term, on one hand, and in the quality control, on the other hand. The so called "index-field" describing the spatial variations of the σ_b values owing to the climatological background errors and observation station density has been implemented. The 3D-VAR analysis then performs in the expected way. Further tuning and testing remains to be done. The computation of background

errors in observation space, necessary for non-conventional data has been implemented. Diagnostics and plotting software has been assembled and provided with the system.

A HIRLAM mini-Workshop on "Singular vectors and alternative methods used for estimation of forecast errors" was organised at SMHI 19-20 November 2001. The presentations and working groups recommendations have been published as a HIRLAM workshop report in March 2002. A full HIRLAM Workshop on Variational assimilation and remote sensing was then held i Helsinki 21-23 January 2002. Both were well attended and conclusions were drawn for guiding future developments.

The very simplified physics (Buizza) has been introduced in 4D-VAR and comparisons have been done between the different physics options. Results are good and the 4D-VAR convergences well. The minimisation can be done at a cost of about 6 times that of 3D-VAR and the forecast performance is so far similar to 3D-VAR, judging from the feasibility studies done so far.

The semi-Lagrangian version of the spectral model has been revived and its tangent linear and adjoints coded, in order to make 4D-VAR much more economical.

Software has been developed and introduced to compute eigenvectors of the Hessian of the cost function.

The new re-written surface analysis has been developed and implemented with ISBA. The soil moisture assimilation scheme has been tested with emphasis on usage of filters for T_{2m} errors and smoothing of soil water increments. Parameters controlling the limiting conditions for soil moisture analysis have been tuned (wind speed, cloudiness, local solar time...). The whole new package along with the new surface scheme has been tested in long assimilation experiments (INM and FMI).

The Quikscat scatterometer cost function from the KNMI SAF has been implemented in HIRVDA. De-aliasing code with the alternative DAR is being introduced as well, for comparison. KNMI has implemented a near-real time data stream of the data into operations, using the 2D-VAR retrieval.

The work on using ATOVS data has continued. Further work on bias correction and quality control and observation error statistics has been done. EUMETSAT is preparing a rapid delivery service of locally received data for real time data exchange over a large area. Further assimilation experiments have been run. A code for thinning of the ATOVS data has been implemented. Code for use of multiple satellites is ready and being tested. Preparations for the use of (A)TOVS radiances over ice has been done. An impact study has been performed for December 1999 when three deep depressions hit Western Europe. Over the month the impact was neutral, after correcting for a few problems. A definite positive impact was however noted particularly for the 2nd Christmas storm over France. The parallel run at DMI using their two receiving stations has now shown positive impact.

Work on humidities from GPS stations has mainly been organisational, securing funding and data exchange.

There has been further work on determining the error characteristics for Doppler wind data. The background errors in observation space are used for quality control. A radar simulation model has been implemented in Hirlam at FMI and used for validation of precipitation.

2.2 Forecast model

The CBR turbulence scheme has been revised and the KNMI length scale formulation introduced in the Reference system. This revision reduces the 10 wind bias significantly and also reduces the low cloud cover in winter somewhat. A further modification to make the scheme conservative by including density variation has been developed and shows small improvements. Unfortunately, the model still tends to show an increasing negative bias of MSL pressure. This bias was shown to be strongly correlated with too slow filling of the lows. Based on arguments of sub-grid scale variations of stability and non-linear effects when averaging and existence of non-resolved gravity waves, extra terms have been added for the stable regime. These terms have been shown to address much of the problem with only small effects on other forecast parameters.

The new surface scheme, ISBA, has now been tested and evaluated extensively and some remaining problems were corrected before implementation into the Reference system. Apart from many assimilations and very long runs evaluating ISBA alone, it has also been tried in combination with the other new developments. The CBR revision and ISBA were tested over 4 periods for the Reference system release. The strong positive impacts on 2m temperatures (and humidity) in the Nordic spring have been confirmed and there are positive or at least neutral impacts for all periods. Further diagnostics are being documented from the long runs of 5-6 months. Work on an alternative snow formulation has progressed further. It uses a separate snow fraction and an additional layer in the ground.

The work towards implementing the Kain-Fritsch convection plus Rasch-Kristjánsson condensation schemes has continued with and a subgroup has perfored coordinated testing. The results show some improvements of cloudiness and humidity but some deterioration of pressure and this is being investigated. Experience will show how much need there is for an optimised version. The Météo-France version may be an alternative, as the code is re-written in a more efficient way.

Further work on Reference condensation/convection STRACO scheme has been carried out to improve properties of the STRACO cloud scheme. The aim was to reduce the overprediction of small precipitation amounts and the parallel runs, that have been made so far, have been quite successful.

Tuning for the HIRLAM system and testing of the Météo-France mesoscale orography (MSO) parametrization scheme has continued. The scheme behaves in the expected way but gives so far overall neutral impact. Still, the drag processes are now treated separately by the turbulence scheme and the MSO scheme in a more correct way. It allows for adequate tuning in the future. It is being prepared for implementation and the climate system has been upgraded to allow for this. A Technical Report has been written.

The inclusion of the ECMWF physics has continued with data assimilation and forecast for a month's period and preliminary results show reduced forecast errors for pressure and 2m temperatures, compared with the pre-ISBA Hirlam surface scheme.

The increased noise in the vertical velocities with long semi-Lagrangian time steps and at 10 km resolution has being documented and investigated. An instability has been shown to occur due to orographic resonance in the temperature equation and this can be cured

by using a constant reference profile (Ritchie-Tanquay method). Another option for the semi-Lagrangian scheme reduces the noise further, to a level which is no different in the Eulerian scheme.

The natural next step on transparent Lateral Boundary Conditions (LBC) work was the setting up of the case of non-linear shallow water equations together with real data. A TR describing results has been published. Results are slightly better than the current Davies scheme when characteristic boundary conditions are applied.

The semi-implicit version of the non-hydrostatic Hirlam has been developed, tested and documented. It improves the economy of the model. Further assimilations have been run at various resolution and indicate stable and rather similar results compared with the hydrostatic version. The non-hydrostatic version has been set up in also in Sweden and Norway and has been run in a number of places now.

Investigations have been done on the effects of Digital Filter Initialisation (DFI), which in some aspects has a damping effect on physical (diabatic) processes. The incremental version does not suffer from this problem.

3 System developments

The Reference system has evolved with a new Reference release and many beta-releases.

A much more efficient I/O scheme for parallel execution was devised first at FMI/CSC and then a more advanced scheme by Jan Boerhout, when at SUN (as presented at the 2001 EWGLAM meeting). This has been developed further and generalised for the various systems (MPI and shared memory segments). It leads to a very significant improvement in performance and will be implemented soon.

The Delayed Mode Runs at ECMWF runs have continued but still remain to be brought under the control of mini-SMS.

The ECMWF Optional Project for Boundary Conditions with short cut-off forecast runs is used by the Hirlam members. The impact has been seen to be fairly small and the Project Leader has raised the question of verification of those forecasts with ECMWF. Such verifications are routinely available from the 00 UTC runs and show the expected results, not quite as good as the late cut-off 4D-VAR, but not so may hours behind. It will be discussed further(with ECMWF).

The latest Reference system releases (5.2) has been very extensively tested for four periods.

Further discussions, about how an overhauled Hirlam system should be, have taken place. A proposition paper about coding standards is available and the ideas for the European cooperation on a common NWP interface are in the announcement for the Météo-France Workshop in May. At this workshop agreements on provision of certain common tools and exchanges were made.

The planned activities of the verification system have now been implemented. These include the field verification, masking tools, new formats, and precipitation verification. A survey of user demands on verification has been done and compiled and developments following the main lines in the responses are taking place.

4 Meetings and Publications

- Hirlam singular vector mini-workshop, 19-20 November, SMHI, Norrköping.
- Variational Data Assimilation and remote sensing, 21-23 January 2002, FMI.
- Hirlam All Staff Meeting, 3-5 April 2002, DMI, Copenhagen.
- SRNWP Workshop on NWP system design, 13-15 May, Météo-France, Toulouse.

Reports from the meetings and also one Newsletter have been published:

HIRLAM Newsletter No. 39, October 2001.

SRNWP/HIRLAM workshop on surface processes, turbulence and mountain effects, January 2002.

HIRLAM mini-workshop in singular vectors and alternative methods used for estimation of forecast errors. February 2002.

HIRLAM Newsletter No. 40, February 2002.

HIRLAM workshop on variational data assimilation and remote sensing, March 2002.

The recent Technical Reports are available on the open HEXNET, http://www.knmi.nl/hirlam. During the period, the following ones have appeared:

50. Bent Hansen Sass. Modelling of the time evolution of low tropospheric clouds capped by a stable layer. Norrköping, October, 2001.

51. Günther Haase and Carl Fortelius. Simulation of radar reflectivities using Hirlam forecasts. Norrköping, October, 2001.

52. Magnus Lindskog, Heikki Järvinen and Daniel Michelson. Development of Doppler radar wind data assimilation for the HIRLAM 3D-Var. Norrköping, February, 2002.

53. Xiang-Yu Huang and Xiaohua Yang. A new implementation of digital filtering initialization schemes for HIRLAM. Norrköping, February, 2002.

54. Aidan McDonald. Testing transparent boundary conditions for the shallow water equations in a nested environment. Norrköping, March, 2002.

55. Rein Rõõm and Aarne Männik. Non-hydrostatic adiabatic kernel for HIRLAM. Part III. Semi-implicit Eulerian scheme. Norrköping, August, 2002.