JOINT WMO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA PROCESSING AND FORECASTING SYSTEM AND NUMERICAL WEATHER PREDICTION RESEARCH ACTIVITIES FOR 2006

SMHI

Swedish Meteorological and Hydrological Institute

Lars Meuller
Per Undén

1. Summary of highlights

During 2006 there were only small changes to the operational NWP system at SMHI:

20060202 - the area for the 5.5 km resolution HIRLAM was extended to cover all of Sweden
20060209 - incremental DFI introduced instead of full DFI
20060214 - boundary data from the new BC-project at ECMWF
20060315 – small update of the physics scheme

2. Equipment in use

SMHI operational forecasts are run at computers at NSC, the National Supercomputer Centre, at the University of Linköping.
SMHI operational forecasting system, HIRLAM weather forecasting and the oceanographic HIROMB model, are for backup reasons, run on 2 separate computer systems.
SMHI are now entirely using Linux cluster's for operational NWP.

BLIXT. Operational machine
- 60 dual Intel XEON 3.2 GHz nodes.
- Infiniband interconnect
- PCI Express
- Scali MPI connect
- 768 GFlops peak performance
- 5.6 TB disc

- BRIS. Backup machine
  16 dual Intel XEON 2.2 GHz nodes.
  SCALI interconnect

BRIS and BLIXT are dedicated entirely for SMHI operational forecasts and are placed in computer halls at SMHI.

The preprocessing of observational and boundary input to the models are run on Alpha servers
The output of the models are stored on a file-server and also put into SMHI operational database

3. Data and Products from GTS in use

SYNOP, SYNOP SHIP, TEMP, PILOT, BUOY, AIREP, AMDAR

HIRLAM is written to accept observational input in BUFR format.
ECMWF preprocessing has been implemented at SMHI to convert WMO Alphanumerical Codes in telegrams from GTS to BUFR format.

4. Forecasting system

SMHI is part of the international HIRLAM project which has a goal to produce a Limited Area Model for operational use for short-range Numerical Weather Prediction in the participating National Meteorological Institutes. SMHI runs the HIRLAM analysis and forecast model for national use for forecasts up to +48 hours.

SMHI is also a member of ECMWF, European Centre for Medium-Range Weather Prediction and uses the operational output, which is received in real time from ECMWF dissemination system. The products from ECMWF is mainly a +240 hours deterministic forecast twice a day and products from ECMWF EPS, Ensamble Prediction System once a day and also products from the BC-project to provide horizontal boundaries for HIRLAM 4 times a day.

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4.1 System run schedule and forecast ranges

At SMHI the short-range NWP system are run on three different domains, C22 , E11 and G05 (see figure 1) with different resolutions. Both areas are run 4 times a day at 00, 06, 12 and 18 UTC with their own data assimilation cycle.

The C22 domain with a horizontal resolution of about 22 km (0.20 degree on the rotated lat/long grid) and 40 vertical hybrid levels are run to +48 hours with a +2 hour data cut-off time. Lateral boundaries come from the ECMWF BC project with a 3 hour time resolution. The BC (Boundary Condition) project is run 4 times a day and provides 6 hour old boundaries.

The E11 domain has a horizontal resolution of about 11 km (0.10 degrees on the rotated grid) and 60 vertical hybrid levels. It is run to +48 hours with a data cut-off of 1 hour 15 minutes. The lateral boundaries come from the ECMWF BC project.

The G05 domain has a horizontal resolution of 5.5 km (0.05 degree on the rotated lat/long grid) and 60 vertical levels. Lateral boundaries come from the E11 run with a 1 hour time resolution. Forecast length is +24 hours.

4.2 Medium range forecasting system (4-10 days)

No medium range forecasts are run at SMHI. Products from ECMWF are used.

4.3 Short-range forecasting system (0-72 hrs)

The HIRLAM analysis and forecast system are described in HIRLAM-5 Scientific Documentation (Undén, P et. al. 2002)

The three HIRLAM domains at SMHI are run with the same version of the NWP system. The only difference is that satellite data are not used in the small-scale E11 and G05 setup.

4.3.1 Data assimilation, objective analysis and initialization

4.3.1.1 In operation

The analysis is 3D-VAR with HIRLAM HIRVDA version 6.2.1
Initialization is done with DFI, Digital Filter Initialization, developed within the HIRLAM project.

4.3.1.2 Research performed in this field

The background constraint in 3D-VAR has been developed to include some horizontal variations of the standard deviation of the errors 1) and 2) to use statistical balance instead of analytical one. Tuning and

derivations of new statistics is involved in the work. Furthermore, a change of the control variable for moisture has been developed, close to what has been done at ECMWF.

A multi-incremental 4D-VAR has been developed in HIRLAM over a number of years. It has been enhanced with the statistical balance also used for 3D-VAR and importantly, a digital filter noise constraint has been developed and shown to eliminate the need for external initialization. It has important benefits for the diabatic processes in the forecast model.

HIRLAM 3D-VAR (and 4D) is prepared for using a large number of remote sensing data. Particularly the extended use of AMSU-A data and inclusion of AMSU-B as well as MSG SEVIRI IR radiances are subject to ongoing research.

4.3.2 Model

4.3.2.1 In operation

The forecast model used is a somewhat modified HIRLAM version 6.3.5 with the following characteristics:

ISBA surface scheme
Kain-Fritsch convection scheme
Rasch-Kristjansson large scale scheme
CBR turbulence scheme
Savijärvi radiation scheme

4.3.2.2 Research performed in this field

An explicit treatment of snow cover has been developed during several years, as a separate tile. The soil part
is in this version handled as heat conduction with more layers and thus deviates from ISBA in this version. ISBA is used for the surface exchanges. The scheme is more realistic but difficult to tune and couple with the atmospheric conditions.

The convection and condensation schemes are being enhanced and some problems related to the ice phase and time scale of convection are being addressed.
A novel way of parameterising the surface and turbulent fluxes based on so caller spectral theory has been developed and is undergoing extensive evaluation.

4.3.3 Operationally available NWP products

The HIRLAM model produces output on files containing the model parameters like wind, temperature, specific humidity, cloud water and TKE (Turbulent Kinetic Energy) on all model levels as well as parameters that describe the state of the ground like temperature and available water on the different land tiles in the model and on the soil levels. The model files also contain physiographic data like orography and roughness.
In addition the model files the output can also, by name list arguments, produce post-processed files for parameters on pressure levels and parameters like 2 m temp and 10 m wind.
Output from HIRLAM is written with 1 hour time resolution to disk and is also written to SMHI database ROAD.

4.3.4 Operational techniques for application of NWP products

4.3.4.1 In operation

Forecast products from different model, HIRLAM C22, E11 and ECMWF, are selected to create a *forecast database*, PMP. This database can also be manually edited. This database is then used to produce, automatically, different customer products. Other applications, like other models, can then also use this database for their meteorological input.

4.3.4.2 Research performed in this field

Statistical adaptive Kalman filtering methods have been put into use and are regularly checked or extended

for new applications. They are effective for correcting model biases of the constant kind and systematic errors that are situation dependent.

4.3.5 Ensemble Prediction System

4.3.5.1 In operation

No EPS system is run at SMHI

4.3.5.2 Research performed in this field

Ensemble assimilations have been performed, mainly for the purpose of better statistics for the data assimilation, but perturbations may be used for ensemble forecasts as well. There is a shared interest in work erformed at the Stockholm University on breeding methods, both for a global (ECMWF) model and for a regional (MM5) model. In HIRLAM work on developing singular vector calculations are being done and SMHI has been supporting this work.

4.3.5.3 Operationally available EPS Products

EPS products from ECMWF are available and used.

4.4 Nowcasting and Very Short-range Forecasting Systems (0-6 hrs)

MESAN. An analysis model for analysis of weather parameters not normally analysed by meteorological models such as fresh snow-cover, visibility and 10 meter winds.
MESAN is used for diagnostic and now-casting purposes and uses an Optimum Interpolation technique.

4.5 Specialized numerical predictions

HIRLAM output is used as input data for a number of other models:

- HIROMB. An oceanographic forecast model for temp, salinity, currents, ice cover and water-level.
- Wave model. SWAN
- MATCH. A Transport and Dispersion model.
- HBV model. A hydrological run-off model for different catchment areas.

4.6 Extended range forecasts (ERF) *(10 days to 30 days)*

No Extended range forecasts are made at SMHI

4.7 Long range forecasts (LRF) *(30 days up to two years)*

No Long-range forecasts are made at SMHI

5. Verification of prognostic products

HIRLAM output is continually verified using the EWGLAM (European Working Group on Limited Area Models) verification scheme to verify model output against observations in well specified station lists.

The forecasts are also verified to see its possibility to forecast specified events, like e.g winds above a certain limit.

Verification results are published at the SMHI internal Website

6. Plans for the future *(next 4 years)*

6.1 Development of the GDPFS

6.1.1 [major changes in the Operational DPFS which are expected in the next year]

The plans for 2007 are:

- Upgrade the HIRLAM suites with HIRLAM version 7.1
- Spring 2007 - Introduce 4DVAR analysis in HIRLAM C22 suite
- End of 2007 – combine the HIRLAM C22 and E11 suites into one suite with 11 km/60 level resolution on the C22 horisontal area with 4DVAR analysis.
- Starting test with ALADIN/AROME model in the new HIRLAM-MeteoFrance collaboration in very high resolution modeling.

6.1.2 [major changes in the Operational DPFS which are envisaged within the next 4 years]

Operational or pre-operational runs with ALADIN/AROME model in the new HIRLAM-MeteoFrance collaboration in very high resolution modeling.

6.2 Planned research Activities in NWP, Nowcasting and Long-range Forecasting

SMHI will continue to take part in the research work decided within the HIRLAM consortia and within the HIRLAM/ALADIN cooperation in high resolution modelling.

7. References

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FIG 1