Annual WWW Technical Progress Report 2003
- The Danish Meteorological Institute -

1. Summary of highlights

The numerical weather prediction system DMI-HIRLAM which is operational at the Danish Meteorological Institute (DMI) originates from the international HIRLAM project (Lynch et al., 2000; Undén et al., 2003). There have been several operational changes at DMI during 2003. In particular new sources of satellite data have been successfully assimilated in the operational models. Also changes in run schedule have been made in connection with modifications to the data-assimilation. The main changes are briefly summarized below: A detailed description of the operational system used at DMI (Sass et al., 2002) is available at www.dmi.dk.

- Use of more ATOVS data, e.g. from EUMETSAT's ATOVS retransmission service (EARS) with data from both NOAA16 and NOAA17. In December 2003 NOAA15 ATOVS AMSU-A data has been used instead of NOAA17 ATOVS AMSU-A due to instrumental failure of the latter in October 2003.
- Use of QuikScat data giving information about the wind field over sea.
- The data window for AMDAR/ACARS has been increased from 30 min. to 90 min.
- A seasonal dependency of the structure functions has been introduced in the variational data assimilation (3D-VAR).
- First guess at appropriate time (FGAT) has been implemented.
- Changes have been made to the run schedule, e.g. the high resolution model ($0.05°$ resolution) is now run 4 times a day compared to 2 times a day previously.
- SST fields from ECMWF used for surface analyses are received at improved resolution ($0.5°$ compared to $1.0°$ previously).
- The NEC-SX6 supercomputer system has been upgraded to its final configuration by the end of 2003, consisting of 8 nodes with 8 processors each.

2. Equipment in use

The operational DMI-HIRLAM system is run on one NEC-SX6 node with 8 processors, but a multinode setup has been in preparation for the future operational setup (see section 9). The observation processing takes place on two 4 processor ORIGIN 200 computers. The GTS messages are processed and encoded to BUFR format. The lateral boundaries from ECMWF (European Centre for Medium-Range Weather Forecasts) are received four times a day, with origin time 00 UTC, 06 UTC, 12 UTC and 18 UTC respectively. The SGI ORIGIN computers also contain an operational database with results produced by the operational runs. The computationally most demanding operations take place on the NEC-SX6 supercomputer (analyses, forecasts and postprocessing). Some of the produced model level files are archived on a mass storage device.

3. Data from GTS in use

SYNOP, SHIP, DRIBU, PILOT, TEMP, AIREP, AMDAR/ACARS.
(ATOVS AMSU-A data is used, but is not retrieved via the GTS)

4. Data input system

Automated.

5. Quality control system

Non-controlled national observations as output on GTS.

6. Monitoring of observing system

Regional monitoring of observations implemented in order to assure high quality LAM products.

7. Forecasting system

The goal of the DMI-HIRLAM weather prediction system is to provide high accuracy meteorological forecast products, with a special priority on forecasts valid for the short range, up to about two days ahead. The system provides guidance to both meteorological staff (forecasters) and to numerous customers in general. Furthermore, the results are used as input (forcing) to specialized forecasts (e.g., a storm surge model , a road conditions model and an ozone forecasting system).

HIRLAM stands for HIgh Resolution Limited Area Model. The operational system consists of four nested models named DMI-HIRLAM-G, DMI-HIRLAM-N,

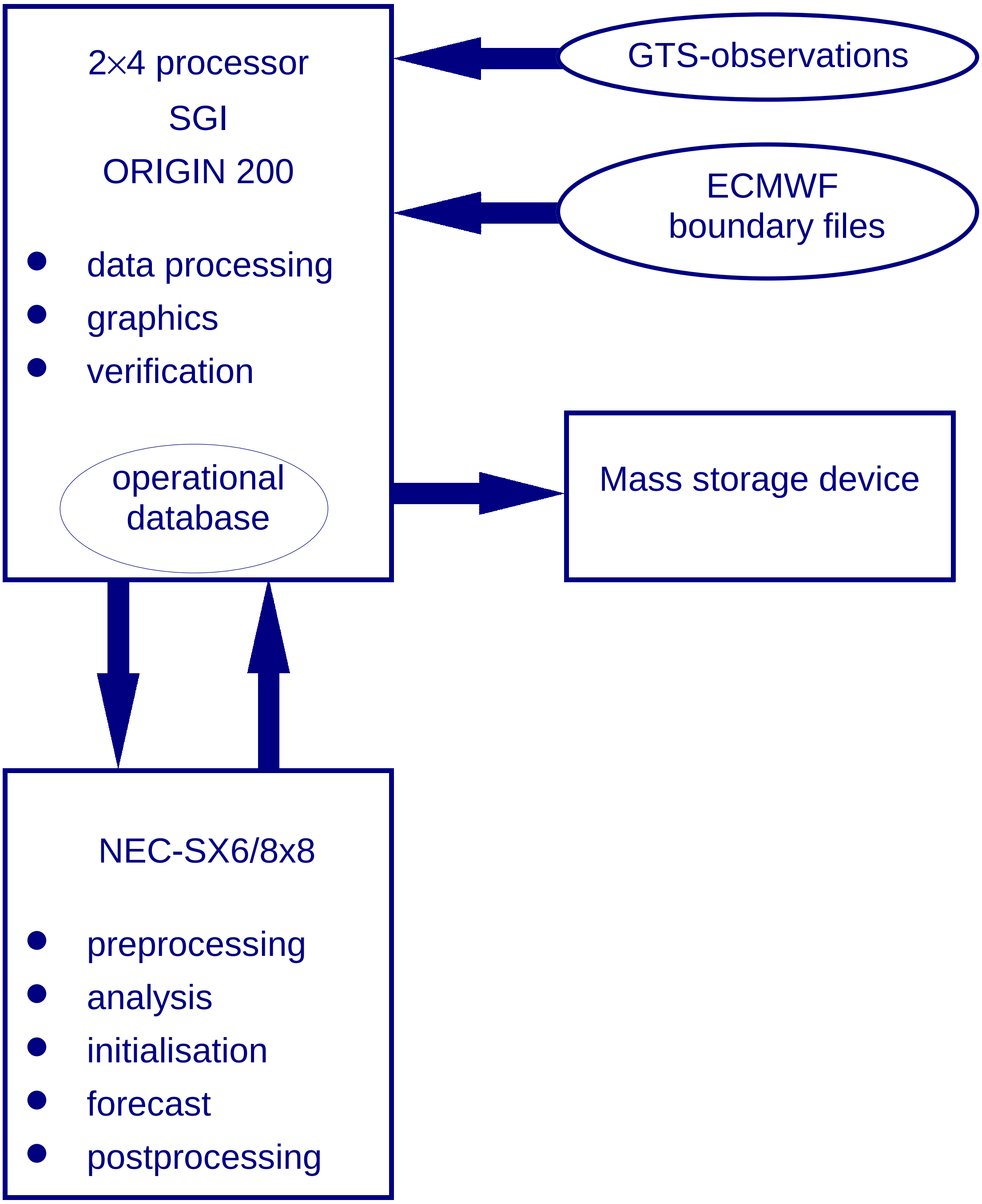

Figure 1: Computers and data flows.

DMI-HIRLAM-E and DMI-HIRLAM-D, respectively. In short, the models are abbreviated 'G', 'N', 'E', and 'D', respectively. The model integration areas are shown in figure 2.

The lateral boundary values of model 'G' are provided by the ECMWF global model. The 'G' model provides the lateral boundary values of the models 'N' and 'E'. Finally, model 'E' supplies the boundaries for the very high resolution model 'D' around Denmark.

Table 1: Basic information related to model grid, resolution, time step, coupling strategy, forecast length and number of forecasts per day.

Model identification	G	N	E	D
grid points (mlon)	202	194	272	182
grid points (mlat)	190	210	282	170
number of vertical levels	40	40	40	40
horizontal resolution(deg)	0.45	0.15	0.15	0.05
time step (dynamics)	120 s	50 s	50 s	18 s
time step (physics)	360 s	300 s	400 s	216 s
host model	ECMWF	G	G	E
boundary age(forecast)	6 h	0 h	0 h	0 h
boundary age (assimilation)	0 h-6 h	−3 h - 0 h	−3 h - 0 h	−3 h - 0 h
boundary update cycle	3 h	1 h	1 h	1 h
data-assimilation cycle	3 h	3 h	3 h	3 h
forecast length (long)	60 h	36 h	54 h	36 h
long forecasts per day	4	2	4	4

Key parameters of the system setup with respect to resolution, time step, boundaries and data-assimilation are shown in table 1. Here 'mlon' is the number of longitude grid points and 'mlat' is the corresponding number of latitude points. Also the table shows the number of vertical levels in the models and the horizontal resolution (°) measured between neighbouring grid points. The time step used in the dynamics and in the physics are different. The boundary age means the age of the host model relative to the start time of the forecast. A distinction is made between boundary age during forecast and during data-assimilation. A negative value of the boundary age during data-assimilation means that analyses of the host model are available and will be used as lateral boundaries. The boundary update cycle is given as the number of hours between boundary files of the host model used for time interpolation in boundary zone between the models. The data assimilation cycle is the number of hours between new analysis states of the model. Finally, the table provides information about the forecast length in hours and the number of long forecasts per day for each model.

The data-assimilation procedure is shown in table 2 showing the operational time schedule.

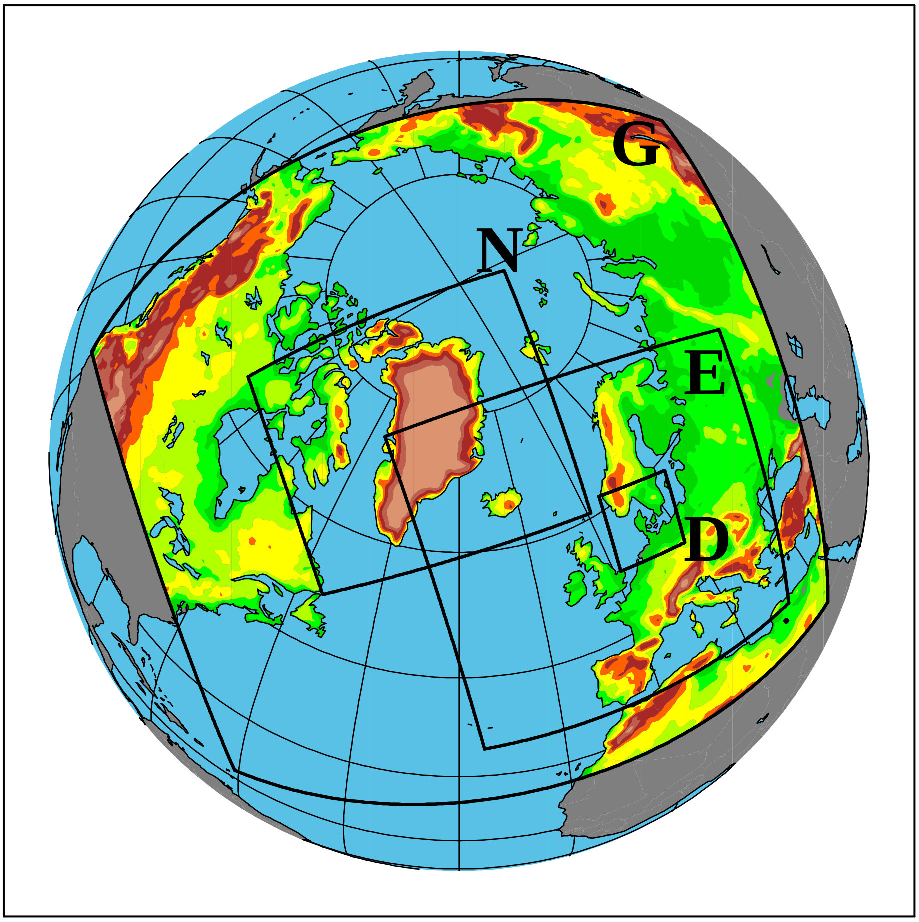

Figure 2: The DMI operational model integration areas.

The first column shows the model startup time in UTC. A given run is indicated by a letter followed by two digits describing model initial time and finally an indication of forecast length in hours. For example, ‘G00+60h’ means a 00 UTC analysis followed by a 60 hour forecast carried out for model ‘G’.

An analysis increment method is used for model ‘D’ (see below).

The initial states of the DMI forecasts are produced by analyses valid at 00 UTC, 06 UTC, 12 UTC and 18 UTC, respectively. The analysis states at 00 UTC and 12 UTC are achieved by retrospective analysis cycles (see below). The first guess of the analyses at 00 UTC and 12 UTC is a 3 hour forecast while a 6 hour forecast is used as input to the analyses valid at 06 UTC and 18 UTC. Forecasts with the model ‘N’ (‘Greenland model’) is run only twice a day from the 00 UTC and 12 UTC analyses.

Assimilation runs with a cycling of 3 hours are managed as a sequence of retrospective analyses which are run twice a day in delayed mode. The first series of runs starts around 11.50 UTC. Model ‘G’ starts from the 00 UTC ECMWF analysis data prepared by an increment method where the available analysis for ‘G’ is interpolated to a coarse mesh data grid with ECMWF analysis data. The difference between this interpolated field and the new ECMWF analysis is an increment (‘large scale increment’) which is interpolated back to the DMI-HIRLAM field in normal resolution and added to get an updated HIRLAM analysis. Normal HIRLAM 3D-VAR cycles then follow immediately after (analyses valid at 03 UTC, 06 UTC, 09 UTC) to produce an ‘up-to-date’ state of the atmosphere. The short forecasts providing information to the analyses are run out to +5 hours in order to give the required information to the FGAT setup. The retrospective runs with the ‘G’ model is used as boundaries for the nested models ‘N’ and ‘E’. These models also run with FGAT assimilation. Currently, however, the high resolution model ‘D’ is using an analysis increment method only. In this case the first guess of model ‘D’ is corrected using analyses from model ‘E’. This method is applied to all the 3-hourly cycles of model ‘D’.

The second series of retrospective runs are carried out around midnight, using 12 UTC ECMWF analysis data in the processing along the same principles as mentioned above. These runs produce 3D-VAR analyses valid at 12 UTC, 15 UTC, 18 UTC and 21 UTC, respectively.

8. Verification of prognostic products

Objective verification comprising both field verification and ’OBS-verification’ has been implemented. The latter concerns comparison of forecast values with data from SYNOP- and radiosonde stations over the European area according to a station list originating from EWGLAM (European Working Group for Limited Area Models). Special efforts are devoted to forecast verification over Denmark.

Table 2: Operational time schedule used (G_E denotes restart from ECMWF analysis. See text for details)

UTC	G	N	E	D
1:40	G00+60 h			
1:53			E00+54 h	
2:20				D00+36 h
2:55		N00+36 h		
ECMWF 00 UTC				
7:40	G06+60 h			
7:53			E06+54 h	
8:20				D06+36 h
ECMWF 06 UTC				
11:50	G_E00+05 h G03+05 h G06+05 h G09+05 h			
12:09			E00+05 h E03+05 h E06+05 h E09+05 h	
12:31				D00+05 h D03+05 h D06+05 h D09+05 h
12:40		N00+05 h N03+05 h N06+05 h N09+05 h		
13:40	G12+60 h			
13:53			E12+54 h	
14:20				D12+36 h
14:55		N12+36 h		
ECMWF 12 UTC				
19:40	G18+60 h			
19:53			E18+54 h	
20:20				D18+36 h
ECMWF 18 UTC				
23:55	G_E12+05 h G15+05 h G18+05 h G21+05 h			
24:15			E12+05 h E15+05 h E18+05 h E21+05 h	
24:38				D12+05 h D15+05 h D18+05 h D21+05 h
24:45		N12+05 h N15+05 h N18+05 h N21+05 h		

9. Plans for the future

A new multi-node operational setup has been in preparation during 2003. The increased computer power will be used to increase the horizontal resolution of model 'G' by a factor of 3 to 0.15°. The previous models 'N' and 'E' will no more be run since they are covered by this new model. The area of model 'D' will be expanded to cover almost the entire Scandinavia, the North Sea, the British Isles and a part of the Norwegian Sea. In addition, several new model components will be introduced as parts of a new operational system. Late in 2004 it is planned to increase the vertical resolution from 40 to 60 levels.

References

Lynch, P., Gustafsson, N., Sass, B., and Cats, G. (2000). Final report of the hirlam 4 project, 1997-1999. *HIRLAM 4 Project Report, 59 pp.*

Sass, B. H., Nielsen, N. W., Jørgensen, J. U., Amstrup, B., Kmit, M., and Mogensen, K. (2002). The operational DMI-HIRLAM system 2002 version. DMI Tech. Rep. no. 02-05, Danish Meteorological Institute.

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