Annual WWW Technical Progress Report

On the Global Data Processing and Forecasting System 2004

DENMARK

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). A major change in DMI-HIRLAM was introduced in June 2004 where a new version of the model replaced the old version. At the same time a simplified set-up with two new model domains covering bigger areas with increased spatial resolution became operational. The run schedule was changed as well in connection with modifications to the initialisation scheme. The main changes are briefly summarized below:

- New model areas and improved resolution (0.15 deg.) in the outer model area. The very high resolution model area around Denmark has been increased in size.

- The model is based on HIRLAM version 6.3 with Semi-Lagrangian advection. The old DMI-HIRLAM used an Eulerian time stepping scheme.

- The initialisation is based on digital filtering whereas the old version used normal mode initialisation.

- The surface scheme is now based on a version of ISBA (Integrated Soil Biosphere Atmosphere), and it is used in the model as well as to make analysis for temperature and humidity at the surface.

2. Equipment in use

The computer system at DMI consists of a NEC SX6 computer with 8 nodes each with 8 cpu of vector capability, and two NEC TX7 systems for scalar computing. The operational DMI-HIRLAM system is presently run on three NEC-SX6 nodes, but a utilization of more nodes is possible and may become necessary in a 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. Testing of the pre-processing on new equipment are under way on e.g. the NEC TX7 platform. The NEC TX7 and NEC SX6 share the file systems containing the operational database and post processing may be carried out on both platforms depending on demands. Archiving is done on a mass storage devise handled by an IBM server.

3. Data from GTS in use

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

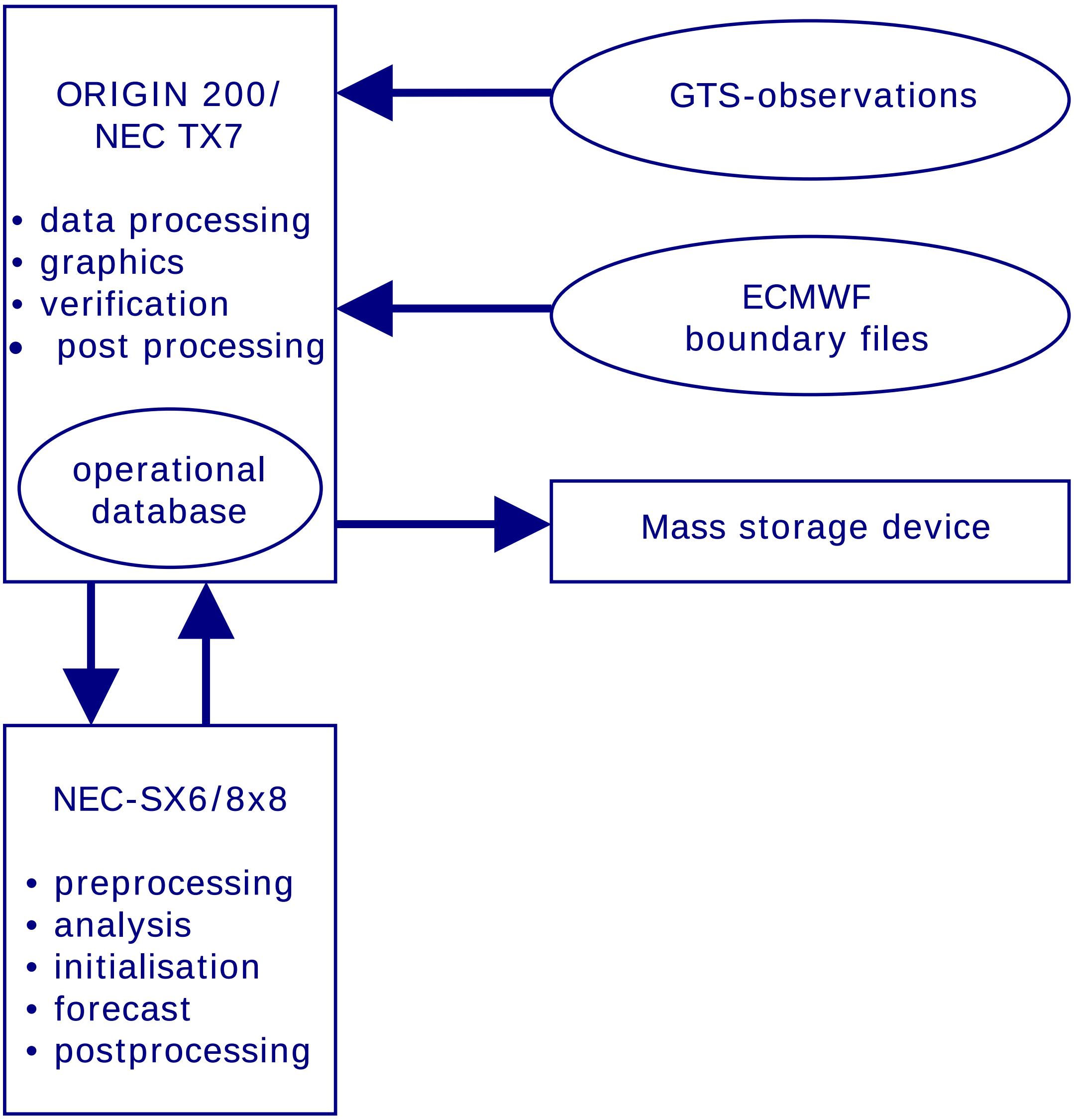

Figure 1: Computers and data flows.

4. Data input system

Automated.

5. Quality control system

Comprehensive testing of incoming data is an integrated part of the HIRLAM analysis scheme.

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 two days ahead. The system provides guidance to both meteorological 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 consisted of four nested models named DMI-HIRLAM-G, DMI-HIRLAM-N, DMI-HIRLAM-E and DMI-HIRLAM-D, respectively, until the middle of June. In short, the models are abbreviated 'G', 'N', 'E', and 'D', respectively. In the middle of June, this setup was changed to a nested system consisting of two models named DMI-HIRLAM-T15 and DMI-HIRLAM-S05. The new model integration areas are shown in figure 2.

Figure 2: The DMI operational model integration areas.

The lateral boundary values of model 'T15' (and 'G' in the old setup) are provided by the ECMWF global model. The 'T15' model provides the lateral boundary values for the very high resolution model 'S05' around Denmark. In the old set-up 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.

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. In the old set-up (G/E/N/D) 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.

Model identification	**G**	**N**	**E**	**D**	**T15**	**S05**
grid points (mlon)	202	194	272	182	610	496
grid points (mlat)	190	210	282	170	568	372
number of vertical levels	40	40	40	40	40	40
horizontal resolution(deg)	0.45	0.15	0.15	0.05	0.15	0.05
hor. res. (assimilation, deg)	0.45	0.45	0.45	—	0.45	—
time step (dynamics)	120 s	50 s	50 s	18 s	300 s	90 s
time step (physics)	360 s	300 s	400 s	216 s	300 s	90 s
host model	ECMWF	G	G	E	ECMWF	T15
boundary age(forecast)	6h	0h	0h	0h	6h	0h
boundary age (assimilation)	0 h-6 h	-3h - 0h	-3h - 0h	-3h - 0h	0 h - 6 h	0h
boundary update cycle	3h	1h	1h	1h	3h	1h
data-assimilation cycle	3h	3h	3h	3h	3h	3h
forecast length (long)	60 h	36 h	54 h	36 h	60 h	54 h
long forecasts per day	4	2	4	4	4	4

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

UTC	**T**	**S**
1:37 2:29	T00+60 h	 S00+54 h
ECMWF 00UTC		
7:30 8:29	T06+60 h	 S06+54 h
ECMWF 06UTC		
11:45	T E00+05 h T03+05 h T06+05 h T09+05 h	
13:37 14:29	T12+60 h	 S12+54 h
ECMWF 12UTC		
19:30 20:29	T18+60 h	 S18+54 h
ECMWF 18UTC		
23:50	T E12+05 h T15+05 h T18+05 h T21+05 h	

Table 2: Operational time schedule used after June 14th 2004. The time indicate the start of the pre-processing of boundary data and ISBA. The 3D-VAR analysis (for

DMI-HIRLAM-T15) begins ca. 5-7 min. later. (T E denotes restart from ECMWF analysis. See text for details).
The first column shows the model start-up 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, ‘T00+60h’ means a 00 UTC analysis followed by a 60 hour forecast carried out for model ‘T15’.

The DMI-HIRLAM is a nested model system where DMI-HIRLAM-T15 is coupled to the ECMWF model through fields from the Boundary Condition (BC) suite at ECMWF. The DMI-HIRLAM-S05 is then nested in DMI-HIRLAM-T15. Furthermore at DMI a coupling between ECMWF BC products are made in a re-analysis cycle aiming at utilizing late arriving data as well as fresher boundaries from ECMWF. The coupling strategy is explained in more details by X. Yang, 2004.

The key aspects of such nesting or coupling include scheduling of combined normal assimilation and re-analysis cycles, choice and update-frequency of the host model forecast as lateral boundaries, and the use of the host model analysis or analysis increment in different assimilation cycles. In previous DMI-HIRLAM, an initial condition blending procedure, combining various fields from the analysis, first guess and host model analysis, (the latter through an interpolation procedure), is applied. The blending of a "large scale" analysis and the smaller but balanced scale features is achieved through summation of a "large scale" increment and the nested model first guess fields. The former is obtained by subtracting the analyzed prognostic quantities of the interpolated host model analysis from the nested model first guess, at a resolution which is arbitrary chosen and typically several times coarser than that of the nested model. The scheme is simple but efficient. It absorbs the large scale correction of the host model data assimilation, and maintains the nearly noise-free high resolution feature resolvable in the nested model.

In current DMI-HIRLAM, IDFI is used to combine the tasks of initial condition blending and initialization. There are two coupling situations in the suite: one is the blending of the ECMWF BC (3DVAR) analysis at 00 and 12 UTC with the corresponding DMI-HIRLAM-T15 first guess in the 're-analysis' run, the other is the blending of the DMI-HIRLAM-T15 analysis with the corresponding DMI-HIRLAM-S05 first guess. Data assimilation is not performed for DMI-HIRLAM-S05 except that of an ISBA surface analysis.

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.

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. DMI-HIRLAM-T15 starts from the 00 UTC ECMWF analysis data prepared by the increment method. 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

‘T15’ model is used as boundaries for the nested model 'S05’. This high resolution model is using the analysis increment method only.

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.

9. Plans for the future

The new model set-up with DMI-HIRLAM-T15 and -S05 introduced in 2004 will be maintained during 2005. However, tests are ongoing to increase the vertical resolution in the -S05 version from 40 to 60 layers in the vertical. In addition, several new model components will be introduced. A model version covering an area around Southern Greenland with a high horizontal resolution (0.05 deg.) will also be tested.

References

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