# Annual WWW Technical Progress Report 1999
# - The Danish Meteorological Institute -

## 1. Summary of highlights

At the Danish Meteorological Institute (DMI) the limited area forecasting system DMI-HIRLAM has been upgraded during 1999. Two additional 3-dimensional prognostic variables namely 'cloud condensate' and 'turbulent kinetic energy' have been implemented . A new cloud and convection scheme as well as a new turbulence scheme have been introduced together with the new variables. Also a new method for coupling the model dynamics and physics has been successfully implemented. The dynamical tendencies averaged over several time steps are used as input to the physical parameterizations resulting in a less 'noisy' interaction between physics and dynamics. The new coupling allows for longer time steps in the physics. A new climate generation has been implemented combining global data bases ('GTOPO30' and 'GLCC') and local high resolution physiographic data over Denmark using the new data format HDF (Hierarchical Data Format). In addition, a new improved data assimilation strategy has been put into operations.

## 2. Equipment in use

The operational HIRLAM system is run on an NEC-SX4 supercomputer with 16 processors and a peak performance of 32 Gflops (See figure 1). The lateral boundary values and observations are received on an 8 processor ORIGIN 200 computer. Boundary values from ECMWF (European Centre for Medium-Range Weather Forecasts) are received twice a day. The GTS messages are processed and encoded to BUFR format. The SGI ORIGIN computer also contains an operational database with files produced by the operational runs. The computationally demanding operations take place on an NEC-SX4 supercomputer (analyses and forecasts). 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.

## 4. Data input system

Automated.

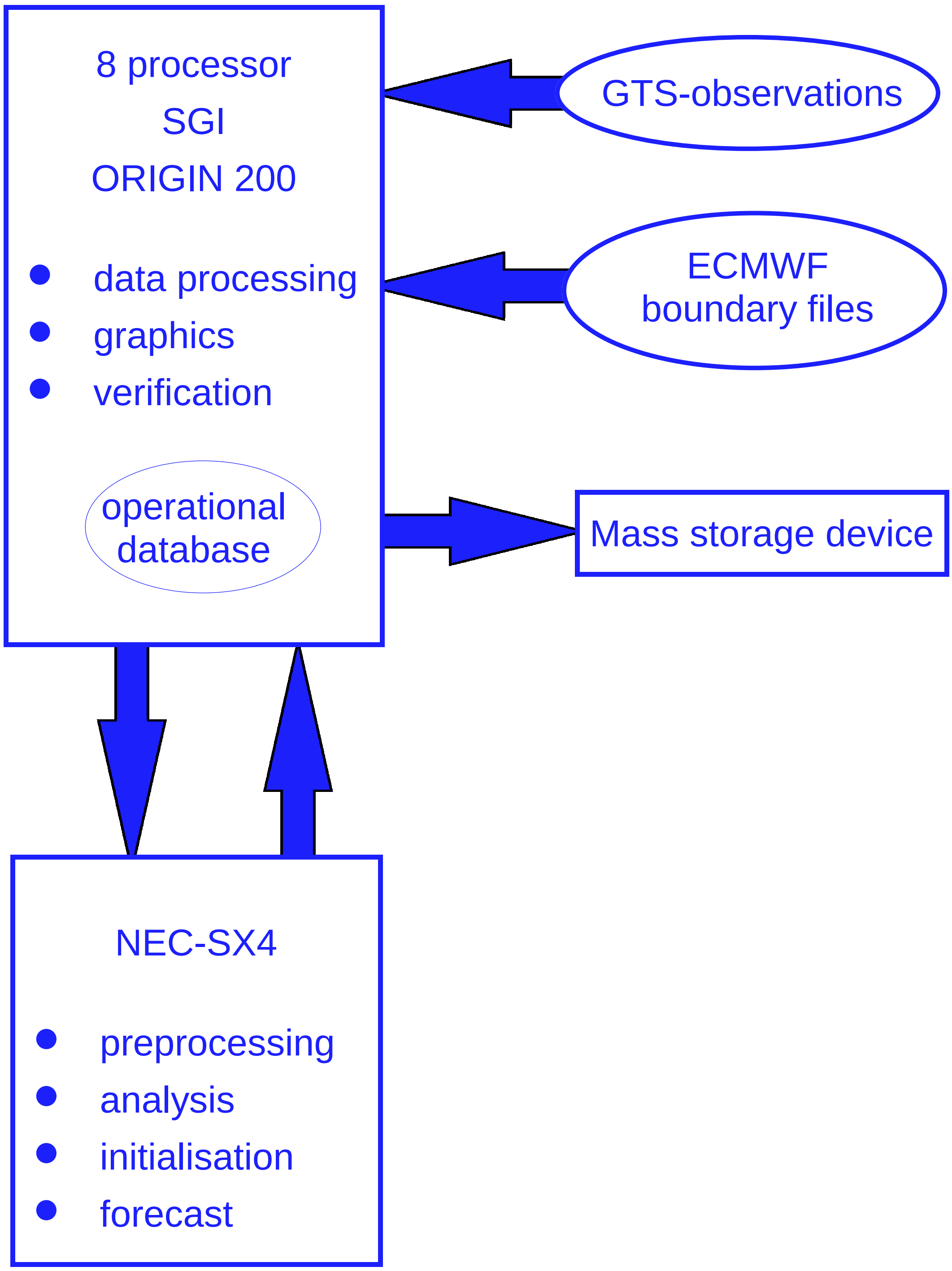


Figure 1: Computers and data flows

## 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

A numerical weather prediction system "DMI-HIRLAM" is run operationally at the Danish Meteorological Institute (DMI). The goal of the DMI 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 and a road conditions model). HIRLAM stands for HIgh Resolution Limited Area Model.

The DMI operational forecasting system originates from the international HIRLAM project (Machenhauer, 1988). This collaboration started back in 1985 and has continued since then. The national meteorological institutes of Sweden, Spain, Norway, Ireland, Iceland, Holland, Finland and Denmark participate in the development of the forecasting system. Since 1992 Météo-France has been an associated partner. Although most components in the operational forecasting systems come from the international collaboration the implementations differ among the HIRLAM countries because of differences in computer facilities and various technical strategies chosen. A documentation of the current operational HIRLAM system at DMI is available (Sass et al., 1999)

The operational system consists of several nested models named 'DMI-HIRLAM-G', 'DMI-HIRLAM-N', 'DMI-HIRLAM-E' and 'DMI-HIRLAM-D', respectively. In short, the models are often abbreviated by the letters 'G', 'N', 'E' and 'D', respectively. The model integration areas are shown in figure 2 below.

The system setup with respect to resolution, time step, boundaries and data assimilation is illustrated in table 1. The boundary files of model 'G' are always the latest available from ECMWF. The model 'G' provides the lateral boundaries of models 'N' and 'E'. Finally, model 'E' supplies the boundaries for the very high resolution model 'D' around Denmark. The most important products from an operational point of view are produced by the high resolution models 'E' (for the European area), 'D' (for the Danish area) and 'N' for Greenland. The boundary age 0 h* in table 1 means that 6 hours old model 'G' boundary values actually are used in the long forecasts from 06 UTC and 18 UTC. Also a 1 hour boundary update cycle is used (se '1/(3h)*' in table 1).

A special data-assimilation feature applies to DMI-HIRLAM-G. At about 11 UTC the assimilation is restarted from the interpolated operational analysis provided by the

ECMWF model at 00 UTC initial time. However, there is not full weight given to the ECMWF field values. The following vertical weighting is used.

$$\gamma^*_{hir} = (p/p_s)^2 \gamma_{hir} + \left(1 - (p/p_s)^2\right) \gamma_{ecm} \tag{1}$$

In (1) $p$ is pressure, $p_s$ is surface pressure, $\gamma^*_{hir}$ is the adjusted HIRLAM value while $\gamma_{hir}$ and $\gamma_{ecm}$ are the uncorrected values from HIRLAM and from ECMWF, respectively. The reason for the restart is the current situation that more data have been available to the ECMWF analysis over the Atlantic region, with the effect that the largest atmospheric scales are often analysed better with the ECMWF data assimilation system. A vertical weighting is used because it is considered important to retain the HIRLAM model specific features close to the ground. Subsequently a 3-hourly assimilation cycle is run (from 00 UTC) until 09 UTC. The model output is averaged over a period of $\pm M$ minutes around the valid output time, in order to avoid the risk of short period fluctuations in the case of short time steps. Currently $M = 15$ minutes is used. A similar restart procedure is initiated in the evening from 12 UTC ECMWF analyses.

The other models run their own data assimilation using the HIRLAM data assimilation system and forecast model. The run schedule is shown in table 2.

Table 1: Important parameters describing the operational HIRLAM models at DMI (∗: see text).

| Model Identification | G | N | E | D |
|---|---|---|---|---|
| grid points (mlon) | 202 | 194 | 272 | 182 |
| grid points (mlat) | 190 | 210 | 282 | 170 |
| No. of vertical levels | 31 | 31 | 31 | 31 |
| horizontal resolution | 0.45° | 0.15° | 0.15° | 0.05° |
| time step (dynamics) | 240 s | 100 s | 100 s | 36 s |
| time step (physics) | 720 s | 300 s | 300 s | 108 s |
| host model | ECMWF | G | G | E |
| boundary age | 12 h | 0 h | 0 h∗ | 0 h |
| boundary update cycle | 1/(6h) | 1/(1h) | 1/(3h)∗ | 1/(1h) |
| data assimilation cycle | 3h | 6h | 3h | 6h |
| forecast length (long) | 60h | 36h | 48h | 36h |
| long forecasts per day | 2 | 2 | 4 | 2 |

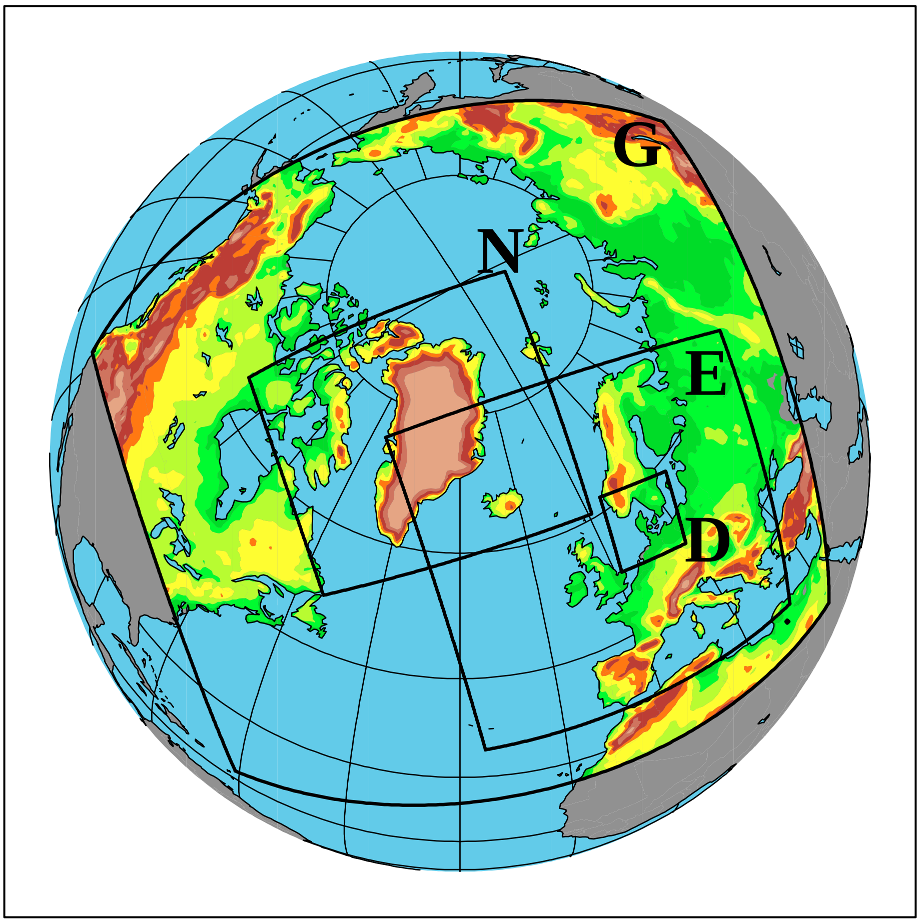


Figure 2: The DMI operational model integration areas.

Table 2: Operational time schedule. G_E denotes restart from ECMWF analysis. See text.

| UTC | G | N | E | D |
|---|---|---|---|---|
| 1:40 | G00+48h | | | |
| 1:50 | | | E00+48h | |
| 2:05 | | | | D00+36h |
| 2:45 | G00+60h | | | |
| 2:55 | | N00+36h | | |
| ECMWF 00 UTC | | | | |
| 7:40 | | | E06+48h | |
| 10:00 | G_E00+03h<br>G03+03h<br>G06+06h<br>G09+03h | | | |
| 10:10 | | | E03+03h<br>E06+06h<br>E09+03h | |
| 10:20 | | | | D06+06h |
| 10:25 | | N06+06h | | |
| 13:40 | G12+48h | | | |
| 13:50 | | | E12+48h | |
| 14:05 | | | | D12+36h |
| 14:45 | G12+60h | | | |
| 14:55 | | N12+36h | | |
| 19:40 | | | E18+48h | |
| ECMWF 12 UTC | | | | |
| 22:45 | G_E12+03h<br>G15+03h<br>G18+06h<br>G21+03h | | | |
| 22:55 | | | E03+03h<br>E06+06h<br>E09+03h | |
| 23:05 | | | | D06+06h |
| 23:10 | | N06+06h | | |

## 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 main modifications planned for 2000 is the operational implementation of a variational data assimilation (3D-VAR) developed in the international HIRLAM collaboration. Secondly, a new surface parameterization scheme, that is, a version of the ISBA scheme (Integrated Soil Biosphere Atmosphere) is likely to be introduced together with a surface analysis and a soil moisture assimilation procedure.

## References

Machenhauer, B. (1988). HIRLAM final report. *HIRLAM Tech. Report*, 5:1–116.

Sass, B. H., Nielsen, N. W., Jørgensen, J., and Amstrup, B. (1999). The operational HIRLAM system at DMI. Dmi tech. rep. no. 99-21, Danish Meteorological Institute.