# DANISH METEOROLOGICAL INSTITUTE

# Report 2007

## 1 Summary of highlights

A contract with respect to installation of a new supercomputer system in 2008 was signed in November 2007. The NEC-SX6 computer system will be replaced by Cray XT4 and XT5 systems. – Important steps have been taken towards online coupled modelling of air pollution and urban meteorology. – In the meteorological data assimilation system analytical structure functions were replaced by statistical structure functions - The NWP cloud and convection treatment was revised leading to some improved model behaviour including a better prediction of fog.

## 2 Equipment in use

The NWP forecasting system is run on an NEC-SX6 supercomputer which is a vector system with 8 nodes. Each node consists of eight-vector processors with a peak performance of eight gigaflop each. Six nodes have 32 GB shared memory available, and the remaining 2 nodes have 64 GB shared memory available.

In message passing programs, data in memory is exchanged inter node wise via a proprietary high speed memory crossbar switch. All nodes have direct access to a global 4 TB file system via fibre channel communication.

The computer installation also consists of 2 ASAMA scalar computers. In addition, 2 AZUSA computers control the availability of the global file system.

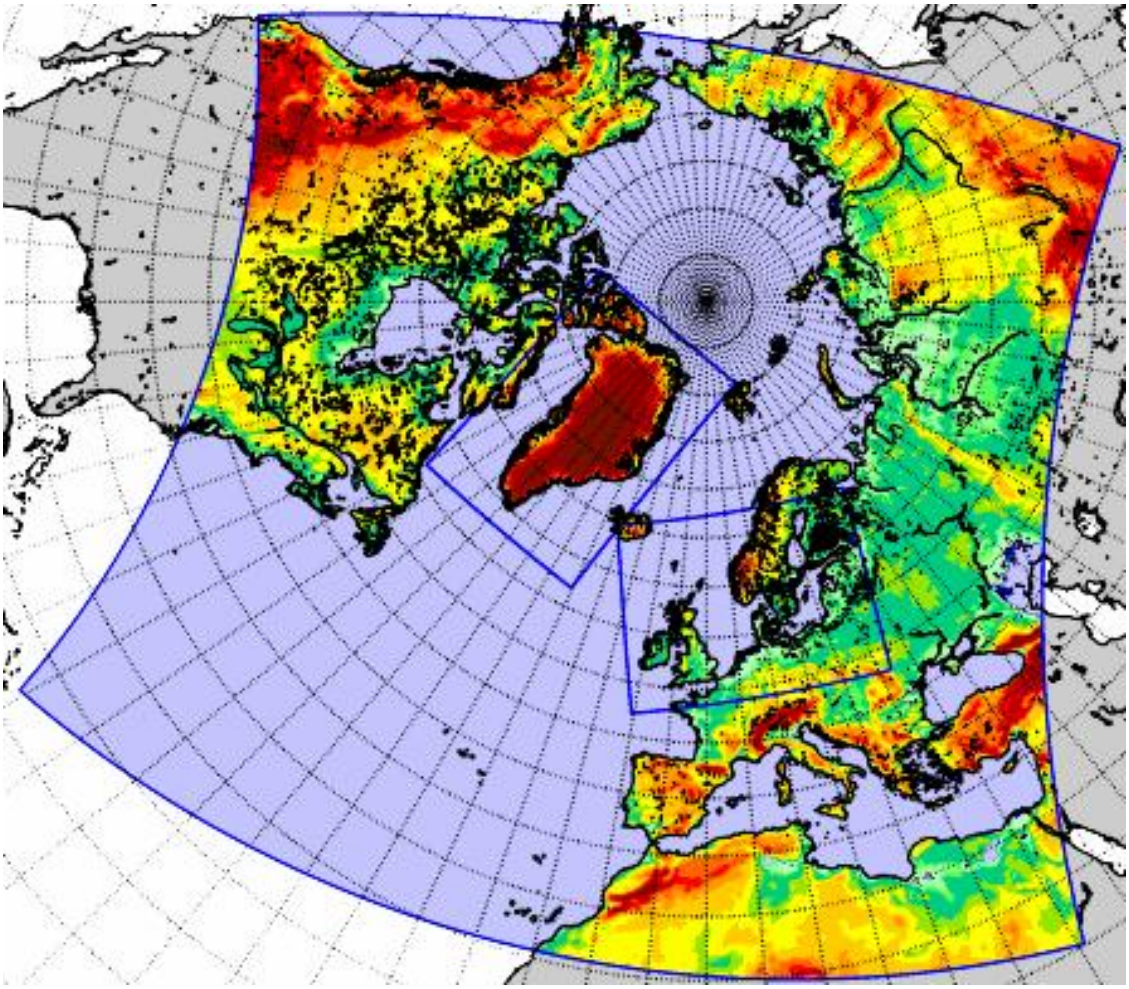
The observation decoding is a modified version of a corresponding system at ECMWF. This system is run on a double system of Linux servers ( “decode1” and “decode2”)

DMI makes use of the product TSM HSM for data archiving. The HSM system is installed on an IBM power 52A machine with 11 TB disk cache and an IBM 3584 tape library, which can contain 1600 tapes.
Every tape has a storage capacity of 800 GB, implying that the entire storage capacity is 1280 TB. In the tape library there are 5 LTO-4 tape drivers.

## 3 Data and Products from GTS in use

TEMP, SYNOP, SYNOP SHIP, BUOY, AIREP, AMDAR, ACARS from GTS.
ATOVS AMSU-A, Meteosat-8/9 AMV from EUMETCast.
QuikScat from ftp-server.

# 4 Forecasting system



## 4.3 Short range forecasting system

Different versions of the HIRLAM forecasting system are used operationally at DMI. The main model areas are shown in the Figure. The big limited area T15

(0.15 ° horizontal resolution, 40 model levels) is run on an area comprising the European-Atlantic area including also the North Pole. (forecast length 72 hours on 00 UTC data, otherwise 60 hours).

Model S05 ( 0.05 º, 40 levels, model area covering Northwestern Europe, see figure). Forecast length: 54 hours.

Model G05 ( 0.05 º, 40 levels, model area covering Greenland). Forecast length: 36 hours.

All models are run 4 times a day (00 UTC , 06 UTC, 12 UTC, 18 UTC)

### 4.3.1 Data-assimilation and initialization.

Cut-off time = 1h 40 min. - T15 is run with the HIRLAM 3D-VAR and FGAT Data-assimilation, with lateral boundaries from the ECMWF global model. The data-assimilation is improved by delayed-mode reanalyses using ECMWF data and HIRLAM analyses. – The S05 and G05 models are starting from interpolated fields based on T15, and all models are initialized by an incremental Digital Filter method.

### 4.3.2 Model

HIRLAM forecasting system ( See http://www.hirlam.org , "the programme", " Documents", and "Publications"). Some specific DMI features have been implemented which are described in special reports, e.g. DMI reports.
Surface analysis based on HIRLAM ISBA analysis. SST and Ice data input based on ECMWF data and sst/ice SAF gridded data.

#### 4.3.2.1 In operation

Model physics similar to HIRLAM version 7.2

#### 4.3.2.2 Research performed in this field

Research linked to the international HIRLAM-A project**.**

### 4.3.3 Operationally available NWP products

GRIB files produced by the operational HIRLAM model setups.

### 4.3.5 Ensemble prediction system

#### 4.3.5.2 Research performed in this field

Research linked with the international HIRLAM-A project – Current emphasis on studies with ensembles based on physics perturbations.

#### 4.3.5.3 Operationally available EPS products

Emphasis on products received from ECMWF.

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

### 4.4.2 Models for Very Short-range Forecasting Systems

#### 4.4.2.1 In operation

Forecasts with special version of HIRLAM used for road-weather prediction.

#### 4.4.2.2 Research performed in this field

Data-assimilation methods (nudging) used in the context of road-weather modelling and very short range atmospheric predictions.

## 4.5 Specialized numerical predictions

### 4.5.2 Specific models (as appropriate related to 4.5)

#### 4.5.2.1 In operation

Danish Emergency Response Model of the Atmosphere (DERMA) – Lagrangian regional atmospheric dispersion model for nuclear, chemical and veterinary emergency preparedness.

Danish Atmospheric Chemistry Forecasting System (DACFOS) – Lagrangian regional chemistry-transport model for ground-level smog and ozone forecasting
Multi-trajectory Ordinary Differential Equations Numerical Box model (MOON) – Lagrangian regional chemistry-transport model for ground-level smog and ozone forecasting.

Risø Mesoscale Puff model system (RIMPUFF) - Lagrangian mesoscale atmospheric dispersion model for veterinary emergency preparedness.
2- or 3-d trajectory model – all purpose
Hir-Pol - statistical pollen forecasting system using DMI-HIRLAM-data

#### 4.5.2.2 Research performed in this field

Chemistry Aerosol Cloud (CAC) model - used for regional air quality forecasting within the GEMS EU project.
Enviro-HIRLAM - integrated coupled air pollution/meteorology model including feed-back effects, also used for birch pollen dispersion studies.
Urbanisation effects: Microscale Model for Urban Environment (M2UE) – an obstacle resolving CFD model.

## 5. Verification of prognostic products

The NWP models applied at DMI are quality controlled by verification against observations in quarterly internal reports available by special request. Obs-verification in terms of root mean square error/standard deviation and bias is done separately for surface observations in Denmark, the Faroe Islands, Greenland – and for the whole of Europe against a common list of surface and radiosonde observations agreed upon among European countries (EWGLAM)

Verified surface observations are:
mean sea level pressure, accumulated precipitation, temperature, relative humidity

and visibility at 2 meter height and wind velocity at 10 meter height. Special verification products (including verification against hourly observations and Weibull distributions for wind at coastal stations in Denmark) are available for temperature and relative humidity at 2 meter and for wind at 10 meter. Verification results for accumulated precipitation and visibility are presented in contingency tables. In addition maps of predicted accumulated precipitation versus the corresponding observed precipitation for Denmark are presented monthly.

Verified upper level parameters are:
geopotential height, wind velocity, temperature and relative humidity at standard pressure levels. All the variables are verified at 12 hour intervals from 0 to 48 hour forecast lead time. In addition geopotential height, temperature and wind are also verified 6 hourly for pressure levels 850, 500 and 250 hPa.

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

### 6.1 Development of the GDPFS

The NEC SX6 super computer will be replaced by two Cray super computers. A Cray XT4 is installed in early March 2008. The more powerful Cray XT5 will be installed in October 2008 and will provide an order of magnitude increase of computer power.

New HIRLAM model versions with increased resolution will be set up in late 2008 and in 2009:

a) New operational HIRLAM areas (new large synoptic area, new model setups or Greenland, Northwestern Europe, Middle-East ). Model for Denmark will run with frequent updates and should provide special predictions for road-weather by calling a special road-weather module inside the HIRLAM model.

b) Operationalisation of Aladin or Arome ( limited area model based on IFS forecast environment) for Denmark and Greenland domains.

c) Operationalisation of 4D-VAR for synoptic scale HIRLAM ( large model domain similar to largest area shown above)

d) Operational ensemble prediction system based on HIRLAM to be established.

e) Setups of Enviro-HIRLAM (see Baklanov et al.) to be established and later made operational providing specific new products related to environmental and chemical modelling.

### 6.2 Planned Research Activities in NWP, Nowcasting and Long-range Forecasting.

#### 6.2.1 Planned Research activities in NWP and very short range forecasts.

New data-assimilation techniques related to Nowcasting and very short range forecasting will be studied. Test of the impact of new observation types ( Metop,

surface based GPS-data, AMSU-B, radar data and possibly other data. Research on the use of 4D-VAR (expected to become operational in 2009). In addition, 'rapid update cycles' will be studied. – The performance of very high resolution models ( IFS/ALADIN) on kilometric scale will be studied, e.g. for special areas such as fjords in Greenland. – The Enviro-HIRLAM developed in the context of on-line coupling for air pollution and chemistry will be further developed.

### 6.2.3 Planned Research activities in Long-Range Forecasting.

Statistically significant correlations can be found between the stratospheric circulation and surface weather parameters when the stratosphere leads with 5-60 days. At DMI it is investigated to which extent this stratosphere-troposphere coupling is already represented in ECMWFs new dynamical seasonal prediction model (system 3). With this system re-forecasts are available for 25 years starting in 1980. Comparisons are made with results obtained with a simple linear statistical forecast model.

## 7 References

Publications for 2007 are listed from the DMI web page: www.dmi.dk → "VIDEN" → "DMI-publikationer".

Baklanov, A., U. Korsholm, A. Mahura, C. Petersen, A. Gross, 2008: EnviroHIRLAM: Online coupled modelling of urban meteorology and air pollution. *Advances in Science and Research* (accepted)