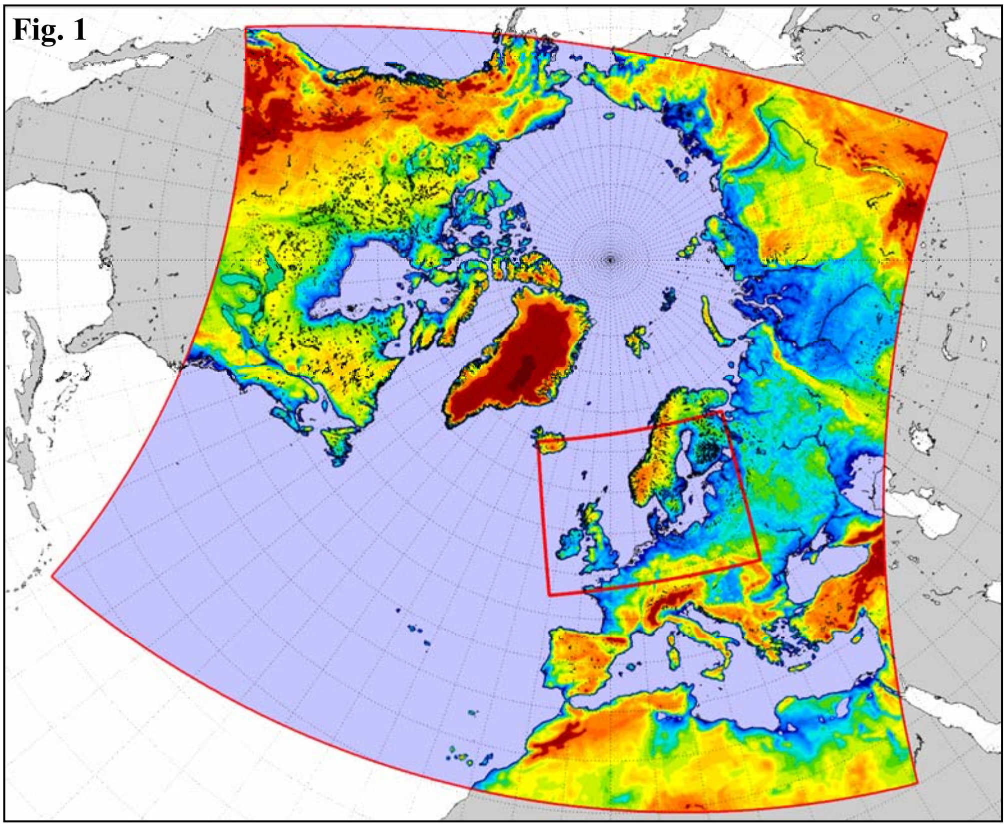
New DMI-HIRLAM
from 14 June 2004

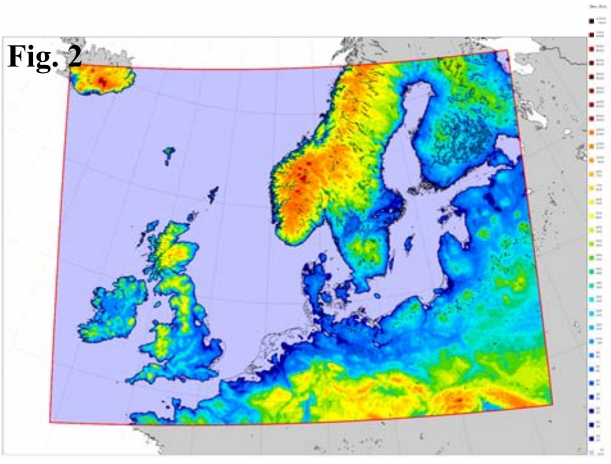
Fig. 1



A new computationally demanding model-system on the upgraded NEC SX-6 facility at DMI has become operational on 14 June 2004. The model set-up has been simplified by reducing the model domains from four to two with increased resolution of 15km and 5km respectively. The new model domains, with names DMI-HIRLAM-T15 and DMI-HIRLAM-S05, are shown in Fig. 1. The T15 domain is the same as in the old system, but the horizontal resolution is three times higher, i.e. 15km. T15 utilizes 3-hourly boundary values from ECMWF and makes restarts from 00 and 12 UTC ECMWF analyses. DMI-HIRLAM-S05 utilizes 1-hourly boundary values from T15 and covers a much larger area than the previous 5km model (Fig. 2). This makes S05 suitable for short-range forecasts, including storm surge forecasts, for Denmark and surrounding waters.

Model identification	T15	S05
grid points (mlon)	610	496
grid points (mlat)	568	372
number of vertical levels	40	40
horizontal resolution (deg)	0.15°	0.05°
time step (dynamics)	360s	120s
time step (physics)	360s	120s
host model	ECMWF	T15

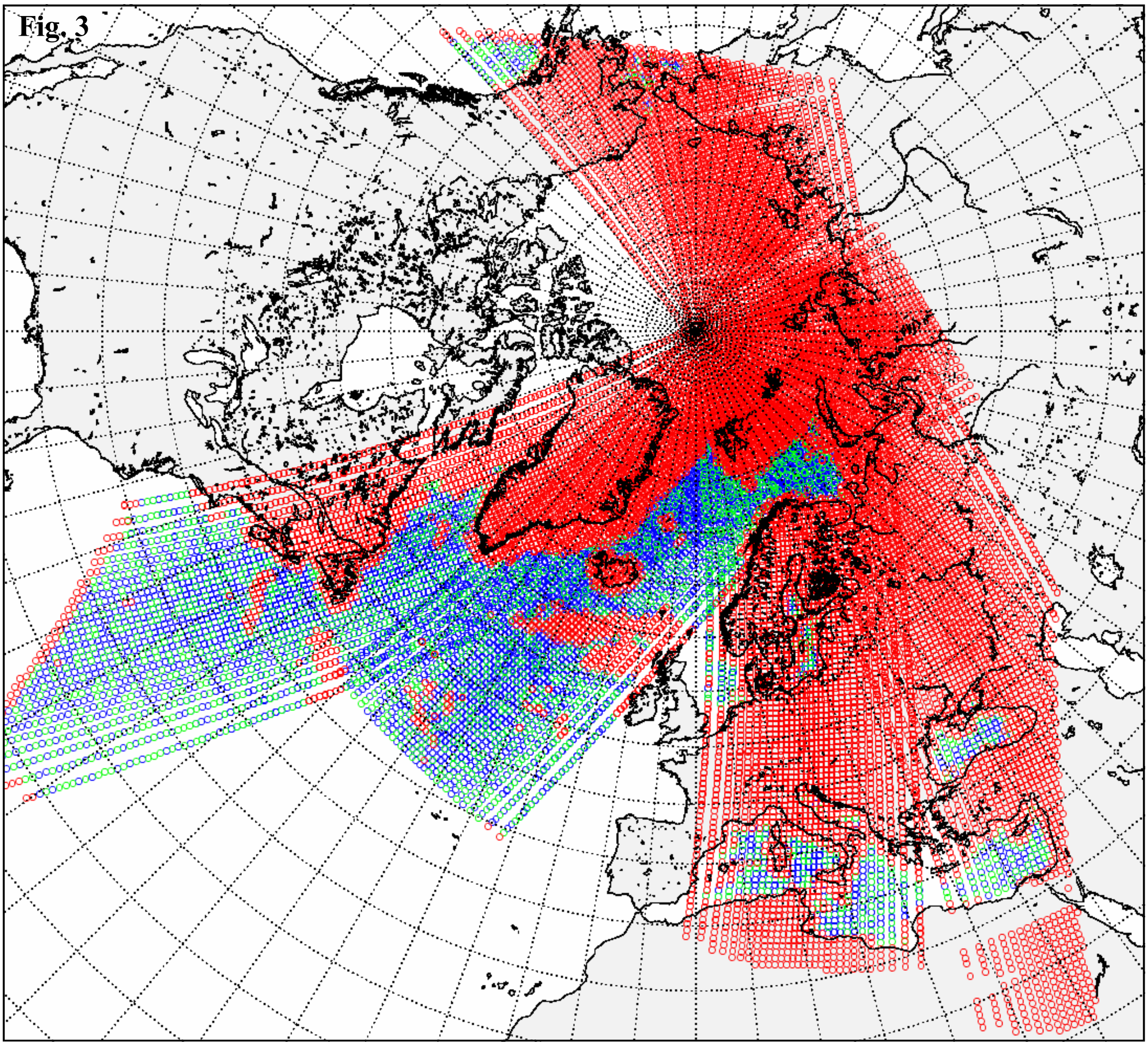
Fig. 2



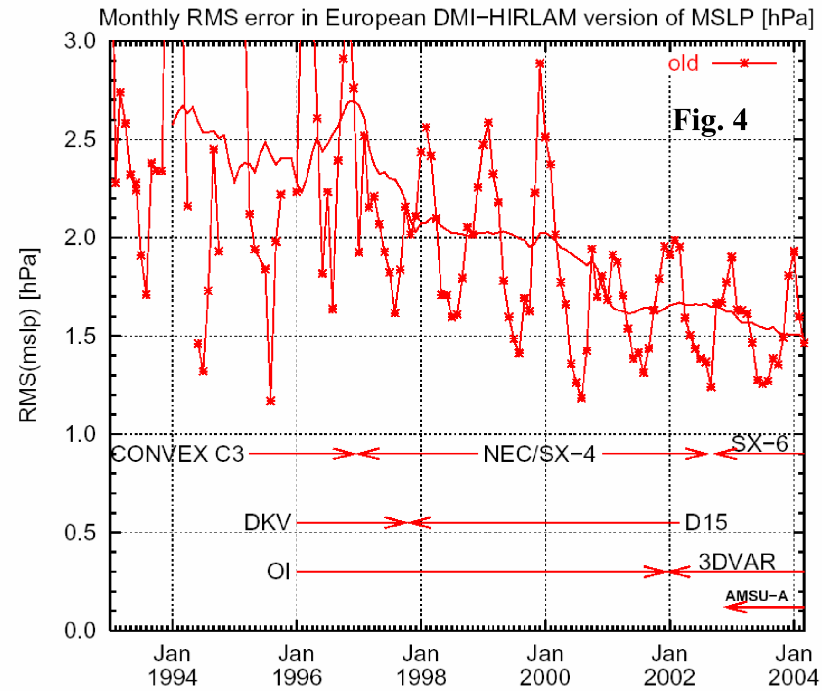
T15 and S05 are run to 60 and 54 hours, respectively, four times per day, starting from analyses at 00, 06, 12 and 18 UTC. Host models, domain size and resolution in space and time of T15 and S05 are listed in the table. The new model code is based on the HIRLAM reference model, version 6.3, but includes a number of modifications for optimizing the execution on NEC SX-6. Relative to the old operational system, substantial changes have occurred in most of the model-system components. The changes include: analysis of near-surface temperature and relative humidity, replacement of nonlinear normal mode initialization with digital filter initialization, replacement of Eulerian advection with semi-Lagrangian advection, replacement of linear 4th order horizontal diffusion with 6th order diffusion, replacement of a simple three-layer surface model with a more advanced Integrated Soil Biosphere Atmosphere (ISBA) scheme and finally modifications to the parameterisation of physics.

Both the new and the old DMI-HIRLAM systems employ 3D-var analysis. The following observation types are used in the new DMI-HIRLAM: SYNOP, SHIP, DRIBU, PILOT, AIREP, TEMP, AMDARS / ACARS, QUICKSCAT, ATOVS AMSU-A.

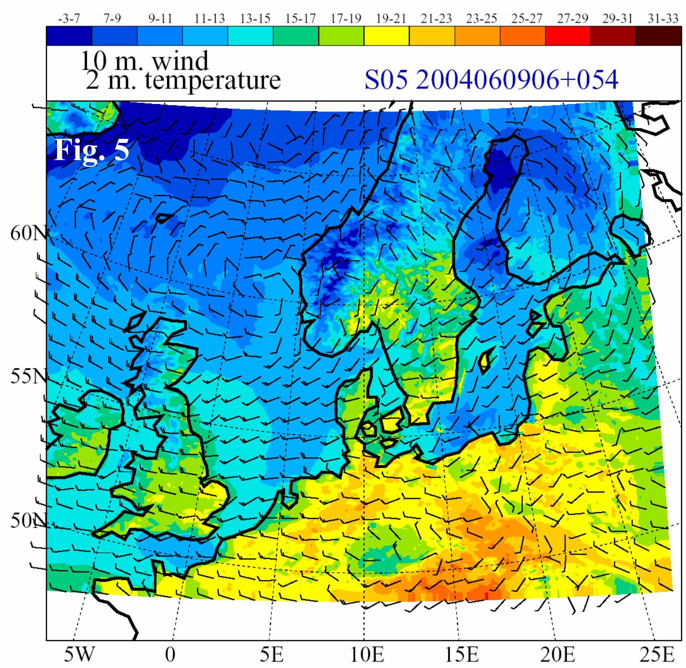
Fig. 3



The DMI-HIRLAM 3D-var analysis system makes steadily increasing use of satellite observations. Fig. 3 shows an example of the use of observations from NOAA satellites received from antennas in Denmark and Greenland as well as EUMETSAT ATOVS Retransmission Service (EARS). This figure shows the NOAA observations from NOAA15 and NOAA16 included in the analysis prior to the 60 hour DMI-HIRLAM-T15 forecast from 06 UTC. Data from two NOAA15 passes and from two NOAA16 passes are available. Red circles show rejected data, blue circles show redundant data and green circles show data used by the analysis. Data is rejected when the surface has a more complicated radiation signature than open water (i.e. land and ice) or when the atmosphere is very cloudy.



The DMI-HIRLAM forecasts are monitored by observation verification. An example is shown in Fig. 4. This figure shows the evolution of the RMS error of mean sea level pressure (MSLP) as forecasted for 24 hours by DMI-HIRLAM during the last 11 years. The observation verification score is based on observations from all of Europe, but with a higher density over Scandinavia and in particular Denmark. Major changes in computers, model versions, data-assimilation methods and data usage can be seen in the RMS error. Due to these changes the RMS error has decreased substantially during the period. More stable computers and increased monitoring of data and systems as well as use of ECMWF analysis twice daily have made their contribution to the decrease in RMS error.



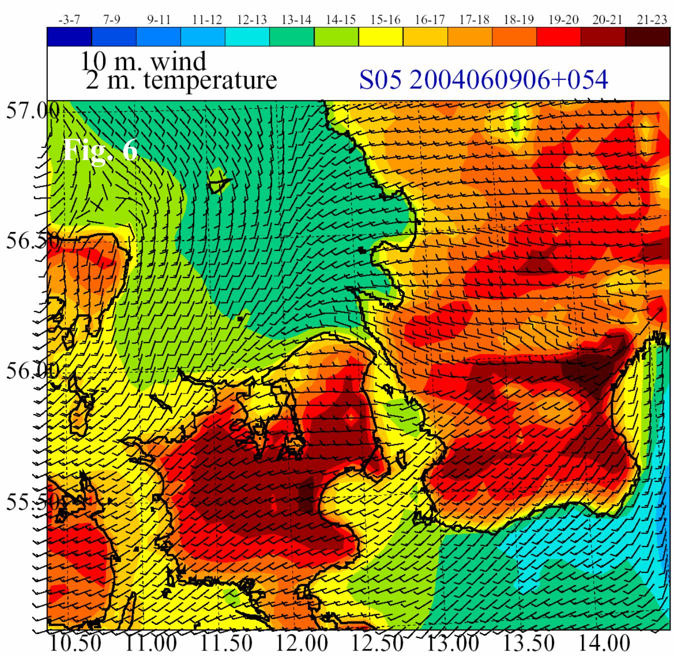
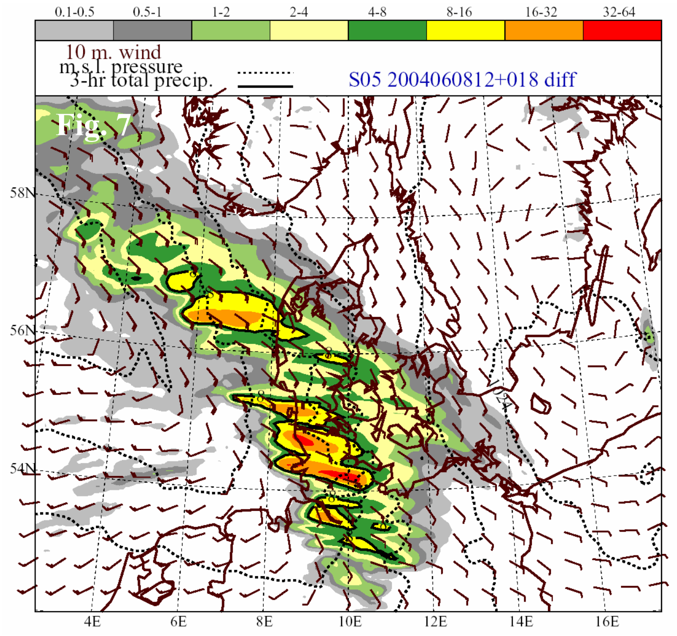
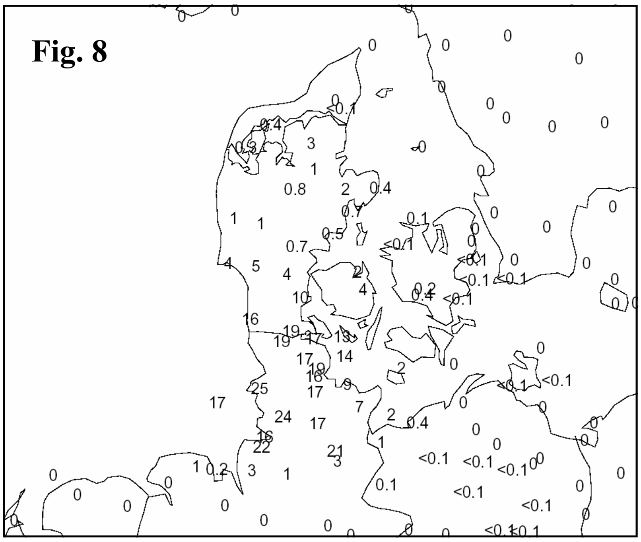
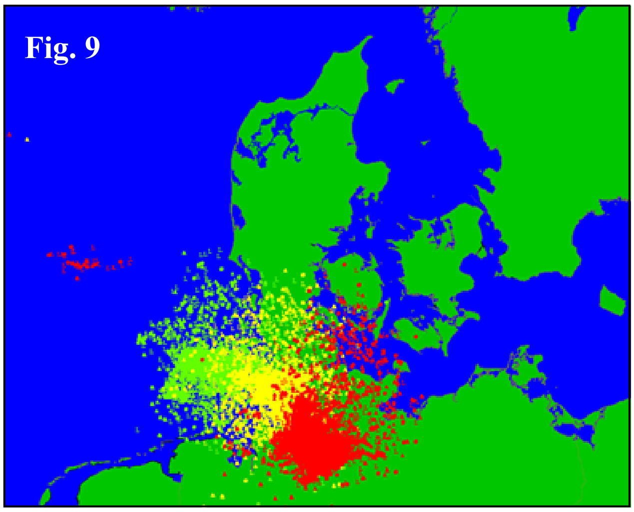
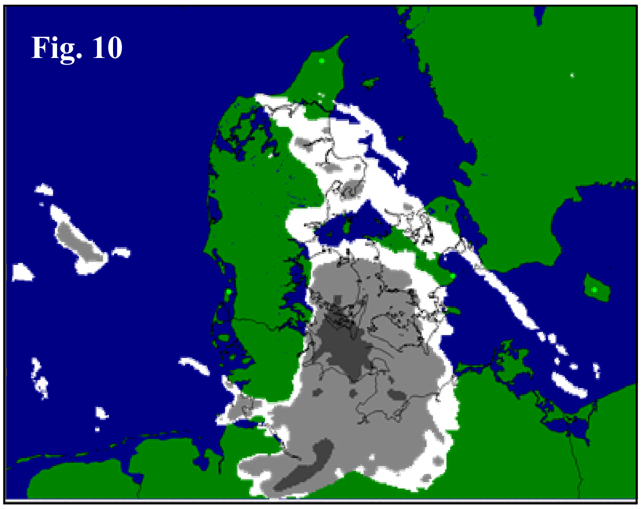


Fig. 5 and 6 show an example of a 54 hour DMI-HIRLAM-S05 forecast of temperature at 2m height and wind velocity at 10m height from analysis time 06 UTC on 9 June 2004. The full model domain is shown in Fig. 5 and a small fraction of the domain (an area around Copenhagen) is shown in Fig. 6. Fig. 5 displays synoptic-scale to meso-scale structures in the wind field, while the focus in Fig. 6 is on local-scale structures in the wind field. Fig. 6 also indicates the potential of DMI-HIRLAM-S05 to resolve and predict land-sea breeze circulations in Denmark and surrounding waters.









Precipitation forecasts with the new model DMI-HIRLAM-S05 are illustrated in the figures above valid for a case on 9 June 2004, where intense precipitation develops in connection with a warm front approaching Denmark from the southwest.

Fig. 7 shows the model produced accumulated 3hour precipitation from 15h-18h of a forecast starting at 12UTC on 8 June. Fig. 8 shows the corresponding observed precipitation as available from a coarse net of synoptic observations. It is seen that the area of heavy precipitation in southernmost Jutland and south of the border to Germany is well captured by the model. The model predicts local extremes in excess of 32mm. Such values may have occurred in reality since 25mm was observed in the coarse net of observations. The large amounts of precipitation in this region are also revealed by the lightening detection system (Fig. 9) showing lightning registrations during the first hour of the period (green dots), the second hour (yellow dots) and the third hour (red dots) respectively. A radar picture (Fig. 10) valid at the end of the period (06 UTC) shows that the precipitation limit going from northern Jutland towards the southeast agrees well with the model computed precipitation border.

The new DMI-HIRLAM system will be upgraded in accordance with progress in Research and Development. An increase in the number of vertical levels from 40 to 60 is under investigation and also an increase in spatial resolution in the 3D-var analysis are under way. Ongoing work in parameterisation of turbulence will most likely result in an operational upgrade.