THE NETHERLANDS

ROYAL NETHERLANDS METEOROLOGICAL INSTITUTE KNMI

1. Summary of highlights.

- The critical dates 1 January, 29 February of the year 2000 passed without any interruption in the production schemes.
- The same holds for 1 January 2001, at which day the century information in the Grib-bulletins changed
- In June 2000 the assimilation of spectral information from buoys was implemented in NEDWAM
- Implementation of AMDAR quality control system

2. Equipment in use for numerical forecasting at the institute

SGI Origin 2000

16 processors, 2.6 Gbyte memory, IRIX6.2, 4 Gigabyte disk, Ethernet and FDDI, HIRLAM runs and research:

Compaq Personal Workstation 600 AU

Visualisation using the Meteorological Work Station at 20 locations

Compaq Cluster

Alpha server 4100, running NEDWAM-, WAQUA-, PUFF- and VIMOLA-model and MOS-statistical interpretation

3.Data and products from GTS in use

GTS bulletin-types in use and daily statistics:

type	**number/day**
SYNOP/SHIP	20000
METAR	2000
TEMP/PILOT	1500
AIREP/AMDAR	12000
SATEM/SATOB	2000
BUOY	900
BUFR	2500
GRID	1300
GRIB	1200
RADAR(Picture)	400

Bulletins with COR-,CCX, RTD, RRX and AMD are not counted.

4. Data input system

Automated

5. Quality control system

Incoming observations:

automated CSN field checks
automated abbreviated heading checks
automated end of message signal
automated internal format checks during extraction
no consistency checks
The various numerical models have their own quality control system

Outgoing observations:

automated internal format checks
checks the meteorological contents only by hand

Within the scope of EUMETNET we implemented an AMDAR quality control system. Incoming AMDAR observations are compared with HIRLAM forecasts and the incoming bulletins are retransmitted with a quality indicator included. The main contractor for this project is UK-MO.

6. Monitoring of the observing system

All observations are monitored continuously on the national level. Each year results of a 15 days monitoring period organised by WMO are sent to the secretariat. Observations from abroad are also monitored continuously but the results are only for local use.

7. Forecasting system

The KNMI short range forecasting system is based on the HIRLAM model, driving marine forecasting models (NEDWAM and WAQUA), an air pollution model (PUFF) and hourly now-casting and very short range forecasting system (VIMOLA). On an experimental basis we run a high resolution HIRLAM (XHIRLAM) 8 times a day out to 9 hours. Next to it NWP products from ECMWF and Bracknell are being used. For medium range forecasting ECMWF products are the most important source of information.

NEDWAM is a wave prediction model for the North Sea. This is a KNMI limited area version of the international wave model WAM. HIRLAM wind forecasts are used as input. Directional wave spectra measured by buoys are assimilated in real-time, using an optimum interpolation method.

WAQUA is a model for real-time storm surge forecasting for the North Sea. HIRLAM wind and pressure forecasts are used as input. Observed sea levels are assimilated by means of a Kalman filter.

PUFF is an air pollution 'puff' model. This model describes the transport and dispersion of air pollution, and calculates the concentrations near the surface and deposition on the ground. HIRLAM wind and precipitation forecasts are used for the first 48 hours, ECMWF wind forecasts are used for the next 60 hours. The model is used in case of nuclear or chemical disasters in which case information about the source has to be supplied.

7.1 System-run schedule

HIRLAM, NEDWAM, WAQUA and PUFF are used for short range forecasting up to 48 hours, XHIRLAM and Vimola up to 9 hours. A brief description of the production cycle is given below:

Model	Initial times (HH)	Start of run	Product available at
HIRLAM analysis	00,03,06,09 etc	HH+2	HH+2:15
HIRLAM +48	00,06,12 and 18	HH+2:15	HH+3:00
HIRLAM +9	03,09,15 and 21	HH+2:15	HH+2:30
XHIRLAM	00,06,12,18	HH+3:00	HH+4:00
WAQUA	00,06,12 and 18	HH+3:00	HH+3:30
NEDWAM	00,06,12 and 18	HH+3:00	HH+3:25
VIMOLA	00,01,02,03 etc	HH+0:15	HH+0:20

7.2 Medium range forecasting system (4-10 days)

No systems implemented.

7.2.4. Operational techniques for application of NWP products

MOS-statistics based on ECMWF products are available for De Bilt. Guidance forecasts are produced for a large number of predictands such as minimum and maximum temperature, percentage of sunshine, probability of precipitation in a 12 hour and a 24 hour period, snow and thunderstorms. In addition statistical forecasts of windspeed and wave height and period are presented for 5 locations on the North Sea.

7.3. Short range forecasting system

Two systems have been implemented: HIRLAM (High Resolution Limited Area Model: the HIRLAM system) and VIMOLA (Vertically integrated model on a limited area).The HIRLAM-system has been developed jointly with the Nordic countries, Ireland and Spain. Model characteristics of both models are summarised below.

7.3.1.Data assimilation, objective analysis and initialisation

	HIRLAM/XHIRLAM	**VIMOLA**
Assimilated data	SYNOP,SHIP,TEMP,PILOT,SATEM, SATOB,AIREP, AMDAR,BUOY	SYNOP,SHIP,METAR
Assimilation cycle	3 hours	1 hour
Method of analysis	3D multivariate statistical interpolation, univariate for relative humidity	Assimilation of pressure and wind
Analysed variable	z,u,v,q	p, u, v
first guess	3 hour forecast	1 hour forecast
Coverage	North Atlantic and Europe	North sea and surroundings
Initialisation	adiabatic nonlinear normal mode initialisation, 4 vertical modes	None

7.3.2 Model

	HIRLAM/*XHIRLAM*	**VIMOLA**
basic equations	primitive equations in flux form	two parameter filtered equations
Independent variables	x, y (shifted pole), eta, t	x, y, p, t
Dependent variables	u, v, T, q, ps, surface parameters	z500, z1000
Numerical technique	semi-implicit Eulerian	Eulerian
Integration domain	164*130 gridpoints, *166*150* 31 vertical layers	35x35 gridpoints, 2 layers
Forecast period	48 hours	9 hours
Resolution	.5 degrees (55 km), *0.1 degrees*	50 km
time step	4 min, leapfrog semi-implicit	400 seconds
Orography, gravity wave drag	smoothed US Navy mean orography	No
Horizontal diffusion	4^{th} order	n^{th} order 3 point filter
Vertical diffusion	HIRLAM	No
Boundary layer	HIRLAM	No
Treatment sea surface, earth surface	HIRLAM	related to vorticity
Radiation	HIRLAM	No
Convection	HIRLAM	No
Atmospheric moisture	dependent variable	related to vertical velocity
Boundaries	Davies boundary relaxation, ECMWF boundaries, T, u, v, q on 31 levels	UK file mesh or HIRLAM hourly, 500 and 1000 mbar

7.3.3 Numerical weather prediction products

The HIRLAM model supplies forecast fields of MSL pressure, 10 m wind, 2 m temperature, precipitation and wind, temp and humidity on significant levels together with meteograms consisting of time series of cloud cover, precipitation, pressure, temperature, dewpoint and wind for various locations. The Vimola model supplies forecast fields of pressure and wind.

7.4.1.Data assimilation, objective analysis and initialisation

	NEDWAM	WAQUA
Assimilated data	spring '98: wave spectral data	water level data
Assimilation cycle		Kalman filter
Method of analysis	continuous assimilation of spectra; winds update every 90 minutes	continuous assimilation during first 3 hours
Analysed variable	total wave energy E, and deep water wave number $k = (\text{mean period})^{-2}$	water level height Z, depth averaged current
first guess	continuous 10 min. Forecast	continuous, 10 min. Forecast
Coverage	North sea and large part of Norwegian Sea	European continental shelf, 12^0 W-13^0 E, 48^0N- 62^0N

7.4.2 Model

	NEDWAM	WAQUA
basic equations	evolution of wave spectrum	shallow water equations
Independent variables	f, Θ, x, y, t	x, y, t
Dependent variables	F, S	Z, u, v
Numerical technique	discretization of energy balance equation	alternating direction implicit method
Integration domain	49x59 gridpoints	201x173 gridpoints
Forecast period	48 hours	48 hours
Resolution	Wavevector 25 frequencies, 12 directions 1/2° WE, 1/3° SN (~32 km)	1/8°WE direction. 1/12°SN direction
time step	10 min.	10 min.
Boundaries	HIRLAM winds at sea surface	HIRLAM wind and pressure at sea surface, tide at open boundaries

7.4.3 Numerical weather prediction products

The most important products from NEDWAM are significant waveheight, mean wave period and direction, low frequency energy (E_{10}) mean E_{10} direction, and the height, mean period and mean direction of swell. Principally the complete spectrum is available at each gridpoint. Time series of integrated parameters and full wave spectra are available for 29 locations.
WAQUA supplies time series of sea level heigths and tidal plus total residual current at each gridpoint especially along the coast.

7.4.4 Operational techniques for application of NWP product

MOS-statistics are available for short range forecasting of amount of rainfall, (maximum and minimum) temperature, windspeed and probability of fog (visibility less than 1 km) for 6 station in the Netherlands for forecast ranges up to 36 hours with steps of 6 hours. Besides ECMWF gridpoint output the most recent observations are used.

8. Verification of prognostic products

There are systematic verification procedures; their results are available to the forecasters on a real time basis and summarised in monthly/seasonal reports (see below for an example).

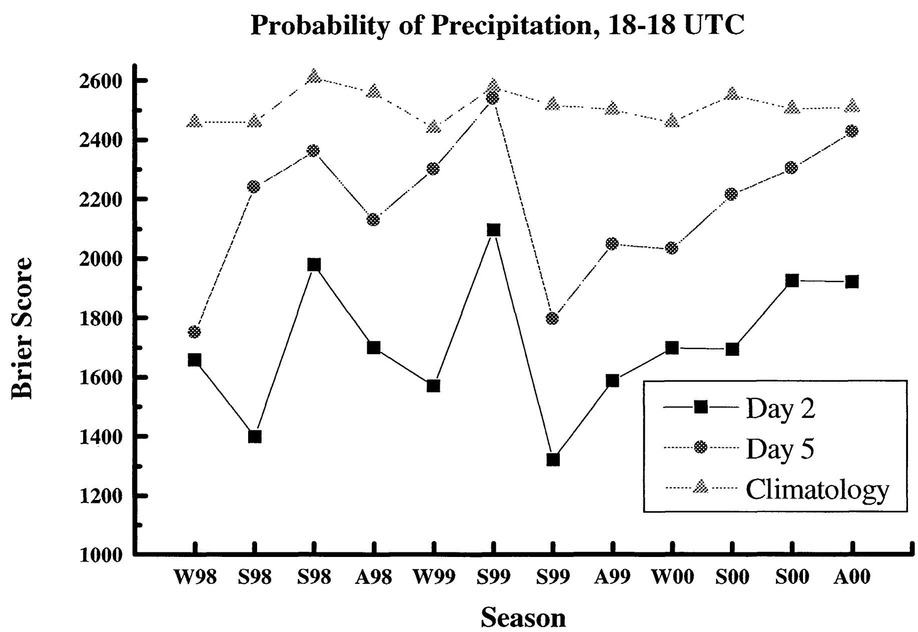

Fig.1. Brier Score for day 2, day 5 and climatology forecasts for the Probability of Precipitation in a 24 hour period at De Bilt.

9. Plans for the future

- Upgrading the HIRLAM system to HIRLAM version 5 at a resolution of 22 km.
- Implementation of a nested XHIRLAM version at a resolution of 5 or 10 km.
- Development and implementation of MOS based forecasts using EPS results
- Development of MOS techniques for postprocessing WAQUA output
- introduction of a nested version of the wave model NEDWAM, based on ECMWF-WAM.

10. Reference

Bruijn E.I.F, 1997, Experiments with horizontal diffusion and advection in a nested fine mesh meso-scale model, Scientific Report, 97-08

Gerritsen H, J.W.de Vries, and M.Philippart, 1995 Quantitative Skill Assessment for Coastal Ocean Models, Coastal and Estuarine studies Volume 47, Pages 5425-5467

Gunther et al - Implementation of a third generation ocean wave model at the European Centre for Medium-Range Weather Forecasts. Tech. Rep 68.

Heijboer, L.C., H.Timmerman and A. Van der Hoek, 1989, Description and performance of an hourly nowcasting and very short-range forecasting system, Q.J.R. Meteor. Soc., 115, pp.93-125.

Komen et al ,1994 , Dynamics and modelling of Ocean Waves, University Press, Cambridge, 532p.

Voorrips et al ,1997, Assimilation of wave spectra from pitch-and-roll buoys in a NorthSea wave model , J.Geoph.Res 102 5829.

Bruijn de E.I.F. and T. Brandsma, Rainfall prediction for a flooding event in Ireland caused by the remnants of hurricane Charley, Journal of Hydrology, 239(2000), 148-161