

Biennial Scientific Report 2001–2002

*Meteorological
Research*



Koninklijk Nederlands Meteorologisch Instituut



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Preface

Recent heatwaves in Europe and the large-scale flooding of last year, caused by excessive rainfall, have shown again that our complex society remains vulnerable, in particular to the extremes in the weather. Severe weather still causes loss of human lives and damage that could have been prevented by better forecasts and warnings. Therefore continuing effort in meteorological research, especially with regard to severe weather events, is more than ever of great importance.

KNMI contributes to this meteorological research in close collaboration with international partners. The meteorological research at KNMI is concentrated in the ‘Observations and Modelling Department’. It is organised in such a way that the results of the research immediately contribute to the quality of the meteorological observational and model data that are made available to the national and international society.

It is with great pleasure that I present this Biennial Scientific Report of the ‘Observations and Modelling Department’.

Prof. Dr. Joost de Jong
Director KNMI



Meteorological research at KNMI

The ultimate goal of meteorology is to contribute to safety, economy and environment as far as meteorological circumstances are a limiting factor. This is done by supplying precise and reliable information about the meteorological conditions now, in the past, and in the future. This information provides the answer to questions posed by both the public and the professional meteorologists. Meteorological research at KNMI tries to formulate these answers directly or tries to understand the atmospheric processes so that methods can be developed to supply the answers in an operational way. Thus meteorological research at KNMI covers the whole range from research to development (R&D).

In short the questions of society can be summarized as follows:

What is the weather going to be like?

This question not only concerns the traditional weather forecasts and warnings but also questions like ‘in which direction will a toxic cloud move in case of a chemical or nuclear disaster?’

What is the weather like at present?

‘Can I perform my operations safely?’ For aviation e.g. it is important to be aware of the presence of low-level jets or down drafts. A precise 4-D description of the lower atmosphere is needed.

What was the weather like, and what can be considered normal?

‘What is the risk that certain critical limits will be exceeded in a given area?’; ‘What is the best region for wind energy?’ These are examples of questions that are addressed by climatology. Long homogeneous and representative records of observations are also important input for climate research.

What impact does the weather have on my activities?

Many people are not aware of the possibilities that are offered by meteorology to optimize safety and economy of their activities. Application research helps to find adequate and cost-saving solutions.

How do I get the meteorological information that I need?

Fast and unrestricted access to the relevant meteorological information can save human lives. Modern ICT techniques are indispensable to fulfill this task.

Since the questions pointed out above are more or less the same for many places on earth the meteorological research at KNMI is carried out in close collaboration with international partners, mainly in Europe. It is organised in such a way that the results contribute directly to the accuracy and reliability of the meteorological basic data: observational data and model output. Professional meteorologists, broadcasters and meteorological service providers can provide society with the relevant information based upon this basic data.

This biennial report is an account for the meteorological research activities in 2001 and 2002: what were the objectives and what did we do to attain them? This is presented in 'Goals and achievements', followed by a selection of highlights. More details are given in the appendices. We hope this gives a good and concise overview of our achievements.

Dr. Leo Hafkenscheid

Head Observations and Modelling Department

Goals and achievements



Goals and achievements

Meteorological research at KNMI primarily aims at improving the quality, cost-effectiveness and accessibility of meteorological observations and model data. A balance is sought between exploiting new opportunities offered by scientific and technological developments, and meeting the needs of users of meteorological data. Research output consists of knowledge and knowledge transfer (in the form of publications, commissioned research, presentations and educational activities), and of improvements in, or extensions to, the operational systems providing weather observations, applications and model data.

The main research objectives

In the years 2001 and 2002, research and development activities have focused on the following key issues:

- **Obtaining a more detailed description of the atmosphere and sea state in the Netherlands and its immediate environment, particularly in situations of “severe weather”.**
New mesoscale (8-20km horizontal resolution) forecast models for atmosphere and sea state were developed and implemented operationally. Downscaling techniques by which near-surface weather parameters are derived at even finer scales were set up and validated. High-resolution remote sensing observations have increasingly been employed in weather analysis and forecasting (e.g. ground-based and satellite radar winds, NOAA sea surface temperature).
New or improved detection and forecast methods have been introduced for storms and gusts, strong convection, extreme precipitation, hail, and storm surges. For wind, detailed climatologies and extreme statistics have been derived for the Dutch coastal zone and Schiphol airport.

- **Improving the efficiency of operational systems**
In order to obtain a modernized and cost-effective observational system, KNMI has been involved in an extensive redesign of both the European synoptic network and the national observational infrastructure. Studies have been performed on the future design of various components of the Dutch meteorological network. The model computer infrastructure has been replaced entirely by more powerful platforms. The automation of routine meteorological production and control activities has continued; examples are the automation of visual synoptical observations, and the introduction of automated production systems for (very) short term forecasts for aviation.
- **Tailoring weather information to user needs**
The specific needs of several groups of intermediate and end users for meteorological data and expertise have played an important role in our research activities. Close contacts on research and development issues have been maintained with e.g. authorities and scientists in the field of water management and flood prevention, aviation, environmental agencies, the energy industry, and (as intermediate users) the meteorological and climate research communities.
- **Improving the accessibility of meteorological and climatological data and knowledge**
KNMI actively pursues an open data policy for meteorological and climatological information. Much effort has therefore been spent in increasing the ease of access to observations and model data. The major databases containing KNMI's data collections are being redesigned to allow for faster and easier access to and selection of a wide range of observations and model information. Important datasets have been made available to users by means of internet.

R&D activities are carried out in four subject areas: meteorological observations, numerical modelling, climatology, and data infrastructure. Below, the main achievements in 2001 and 2002 for each of these areas are described.

Observations

One of the main goals has been to achieve an optimal and cost-effective meteorological observing system on both the European and the national scale. Within EUMETNET, KNMI participates actively in the programme to construct a synoptical European composite observing system, named EUCOS. KNMI contributions to EUCOS among others consist of participation in observing system simulation experiments, the quality assurance of observations from commercial airliners (Aircraft Meteorological Data Relay or AMDAR observations), and its involvement in the Voluntary Observing Ships (VOS)



programme. In 2002, a start has been made with the operational implementation of EUCOS.

A restructuring and modernization of the Dutch national meteorological observing system is being planned as well. In a number of studies, designs have been made for various components of the future Dutch observational network: upper-air observations, the synoptical network, and meteorological observations in coastal areas. These designs are to be implemented in the coming years. Visual observations in the Dutch synoptic network have been replaced by fully automated systems. Automated alternatives for visual observations at airports are still under consideration. Extensions of the runway system of Schiphol airport have forced an extensive reorganisation of the local observational infrastructure.

Investigations in the interpretation and use of satellite observations has mainly taken place in the context of EUMETSAT Satellite Application Facility (SAF) projects. KNMI participates among others in the Ocean and Sea Ice (OSI) and Numerical Weather Prediction (NWP) SAF projects; there it is primarily responsible for the development of improved quality control, ambiguity removal and assimilation algorithms for satellite radar wind observations.

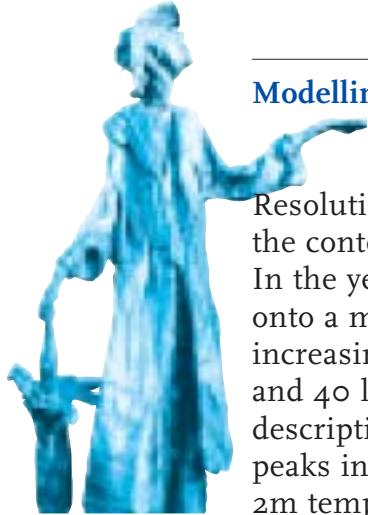
For the ESA Core Explorer Atmospheric Dynamics Mission (ADM), KNMI has contributed to the specification of the Doppler wind lidar system to be flown (Aeolus), and to simulation studies of the expected impact of the mission. A new reception and processing system for remote sensing data has been prepared for operational use in 2003. A new architecture was required to allow for the collection of data from new instruments, such as the Meteosat Second Generation (MSG) satellite and the MetOp/ European Polar System (EPS).

The weather radar is without question the single most important element in any national weather observation system. Several algorithms have been developed in order to better exploit the full potential of KNMI's two Doppler radars. A radar hail detection method has been implemented after extensive validation. Radar precipitation sums have been carefully tested and calibrated against in-situ precipitation observations, in order to make radar rainfall data more useful as a quantitative source of information for water managers. Vertical radar wind profiles have been made available on a routine basis and are ready for operational implementation. A new Doppler ambiguity removal and cleaning procedure has been developed for the radar Doppler wind fields.

Monitoring of European Global Positioning System (GPS) stations in the concerted action COST-716 has shown that GPS integrated water vapour (IWV) data generally are available within the assimilation time limits relevant for most limited area models (~2 hours). IWV observations have been validated against model data, and found to be of good quality.

To facilitate the reliable collection of meteorological information by Voluntary Observing Ships, KNMI has developed the TURBO-WIN data collection software package. A new version of TURBO-WIN, with a more user-friendly interface, has been introduced and made available internationally.

Stricter quality control procedures have been implemented for directional wave spectra from North Sea buoys. A presentation system for observed 1- and 2-dimensional directional wave spectra has been introduced, which also enables a direct comparison between observed and model spectra.



Modelling

KNMI's main operational weather forecast model is the High Resolution Limited Area Model (HIRLAM). Research on HIRLAM takes place in the context of the international HIRLAM project.

In the years 2001 and 2002 a major effort was required for migrating HIRLAM onto a more powerful computer, introducing an improved model version, and increasing the model resolution significantly (up to 11 km horizontal resolution and 40 layers in the vertical). The new mesoscale HIRLAM model yields a better description of small-scale structures and sharp weather gradients, and of strong peaks in e.g. wind and precipitation. The quality of mean sea level pressure, 2m temperature and precipitation forecasts has improved significantly.

Research on HIRLAM has concentrated on improving the description of precipitation and boundary layer temperature and wind. A new turbulence scheme has been extensively tested and modified in order to obtain a realistic amount of vertical mixing in the atmosphere. To improve the precipitation behaviour of the model, adaptations have been made to the present convection scheme, STRACO; case studies have been performed with the new Kain-Fritsch scheme. The climate field system has been extended and adapted to accommodate the introduction of an Improved Surface Analysis Scheme, ISBA. Scatterometer wind observations and NOAA Sea Surface Temperature (SST) data were introduced into the HIRLAM analysis system. This resulted in a better description of storm tracks, and more realistic temperature profiles and stability behaviour over large water bodies. Validation of GPS moisture observations against HIRLAM has shown that these data are of promising quality; assimilation impact studies will follow soon. The HIRLAM initialization system was shown to suffer from severe spin-up effects; alternative initialization approaches were investigated and found to result in significantly shorter spin-up times.

Novel approaches are required to evaluate, compare and verify atmospheric models of mesoscale or higher resolution. New methodologies have been devised for the verification of high-resolution models, in particular for precipitation. The HIRLAM verification package has been extended with some of these tools.

Research in atmospheric modelling other than HIRLAM has dealt mainly with the forecasting of severe weather and of weather on small spatial scales.

A downscaling technique has been developed by which boundary layer wind fields of ~1 km horizontal resolution are derived from HIRLAM and local

upwind roughness information. This method was designed to provide accurate meteorological input for high-resolution water transport and wave models. The downscaling system has been validated successfully against observations in the estuaries of Zeeland; it has also been employed to make cross- and tailwind forecasts for the runways of Schiphol airport, and predictions of wind energy production. An alternative downscaling method makes use of a combined physical - statistical approach: systematic model errors are corrected for statistically, and then model wind values are transformed to local winds by means of the local roughness. This approach, shown to be successful for wind forecasts, is also applicable to other weather parameters, e.g. T2m.

An automated system, AUTOTAF, has been introduced to produce short-range (0-24h) weather and visibility forecasts for airports, in the form of Terminal Area Forecast (TAF) bulletins. A similar module, AUTOTREND, has been developed to provide very short range (0-2h) forecasts and so-called TREND bulletins of sudden atmospheric changes around airports. The quality of both systems compares well to the performance of human forecasters. A method devised to estimate the strength of gusts at or near the runways of Schiphol airport from local roughness information and 10m wind forecasts remains to be implemented.

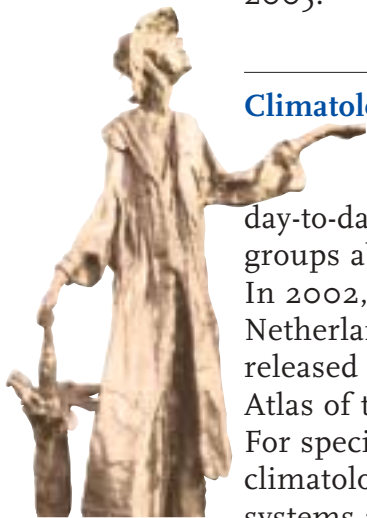
For the modelling of air pollution in case of nuclear or chemical accidents, KNMI maintains the dispersion model PUFF and the trajectory model EUROTRAJ. Both models have been tested and compared to some 15 other European models in a set of experiments in the EU Fifth Framework project ENSEMBLE. These model intercomparisons have provided a wealth of information on the parameters of greatest relevance to pollution forecasts.

Research on statistical forecasting methods has focussed on severe convection and (extreme) precipitation. Probabilistic predictions, and the uncertainty information contained therein, are increasingly recognized to have important added value to deterministic forecasts; this is particularly true in cases of severe weather. Predictors from the Ensemble Prediction System (EPS) have been included in many statistical forecast products, and new forecast methods for risks of severe weather, e.g. thunderstorms, have been developed. An example of the possible use of EPS information was the Elbe study, in which a projection of the extreme precipitation observed in the Elbe region in August 2002 onto the Rhine and Meuse river basins was justified on the basis of EPS statistics. Probabilistic techniques have also been shown to be useful for the verification and intercomparison of high-resolution weather models. Cost-loss analyses as a tool for decision-making processes have been designed and presented to users in regional water management and aviation. Improved local statistical predictions of precipitation and temperature, based on Model Output Statistics (MOS), have been derived and implemented. Research has begun on methods to derive 1- and 2-day forecasts of area-averaged precipitation sums for the Dutch Water Boards, employing e.g. radar data.

KNMI's operational marine forecast models are the storm surge model WAQUA and the North Sea wave model Nedwam. An improved version

of the WAQUA model, DCSM-98, with a mesh size reduced from 16 to 8 km, was introduced and tuned to wind input from the new HIRLAM mesoscale model. The number of tidal gauge stations available for assimilation in WAQUA has been extended with many stations in the UK. Together with the introduction of a stricter quality control, this has led to more accurate water level analyses and forecasts.

The Nedwam wave model was revised as well, introducing a new formulation of the air-sea interaction, a retuned balance of the source terms, and an improved quality control of assimilated wave spectra. In answer to requests from water managers for the IJsselmeer, a detailed experimental version of the model (resolution 2 km) has been set up for that region; validation against available observations is now in progress. In air-sea interaction studies, the wind-over-waves-coupling theory of Kudryavtsev and Makin was successfully verified against laboratory and field experiments. It has formed the basis of a new parametrization of the sea drag, which will be implemented in Nedwam in 2003.



Climatology

R&D in the area of climatology directly supports KNMI's routine day-to-day information and data services to the general public and specific user groups about the weather of the past.

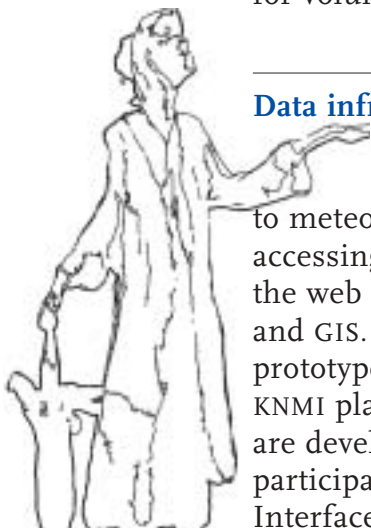
In 2002, a major update was made of the climatological description of the Netherlands. New normal values, based on the 30-year period 1971-2000, were released and combined with a multitude of climatological maps in the Climate Atlas of the Netherlands.

For specific weather parameters and areas, more detailed local or regional climatologies have been derived. The design criteria of the flood defense systems along the Dutch coast, in the IJsselmeer and along the rivers, need to be tested periodically. For the determination of the required strength of these waterworks, knowledge of the local climatological probability distribution of wind speed is essential. In the HYDRA project, an improved wind climatology has been derived along the Dutch coast by analyzing time series of surface wind speed measurements. For sites without observations, a novel technique was developed to interpolate wind speed on the basis of detailed surface roughness information. Likewise, the wind climate has been determined along the runways of Schiphol airport. The possibilities for deriving a more regionalized precipitation climatology are still being explored.

National and international historical observations have been made available for climate research. The activities were a combination of dataset construction, quality control, web-based dissemination and data analysis. Within the European Climate Support Network (ECSN), KNMI has played a leading role in carrying out the European Climate Assessment (ECA). As a part of ECA, a dataset of daily weather parameters has been collected for the whole of Europe, together with meta-information on the observational sites and

instruments used. This unique dataset has been made easily accessible to the climate research community by means of Internet. Time series of station observations at daily resolution, spanning multiple decades, are of key importance for monitoring extremes and detection of changes in extremes. Trends in extremes have been analysed using descriptive indices. The results were incorporated in international studies in the framework of WMO-CCL, CLIVAR and IPCC. Studies on the homogeneity of the ECA dataset and the best ways to improve this are ongoing.

At a national level, a large number of historical weather data has been digitized from paper archives, and tested for reliability and homogeneity as part of the KNMI historical climatology programme HISKLIM. The comprehensive book series of Buisman et al. describing the climate in the Netherlands now covers the period 875-1675 (volumes I-IV). The manuscript for volume V (1675-1700) is in preparation.



Data infrastructure

The major goal in this area has been to increase the ease of access to meteorological and climatological data. The possibilities of inspecting and accessing satellite data, model information and historical observations through the web have been enhanced by means of new user interfaces based on Java and GIS. Examples are the construction of the Sciamachy Data Center and the prototype of a possible interface to the European Climate Assessment dataset. KNMI plays an active role in the concerted action COST-719, in which GIS tools are developed for new applications in meteorology and climatology. It also participates in the EUMETNET programme UNIDART (UNiform Data Request Interface), which aims at the development of a web portal providing uniform access to meteorological data (regardless of data format, location or source).

Information systems capable of collecting and supplying relevant meta-data, indispensable for the interpretation of observations and model output, are under construction. A complete redesign is taking place of the databases containing KNMI's collections of weather information, and of the inspection and extraction tools by which they can be accessed. More user-friendly formats such as HDF-5 are being introduced. By 2003, the first of these restructured database systems, the database with images from radar, satellites and the SAFIR lightning detection system, will be ready for operational use.

Highlights



Profiling the atmosphere with aircraft

Jitze van der Meulen

Introduction

Weather forecasts and reports are based on the current and expected states of the atmosphere and in particular on developments in its layers. Frequent and accurate observation of these atmospheric layers is required, in particular with regard to temperature, humidity and wind.

For decennia, in situ measurements have been made by meteorological services worldwide launching balloons either twice or four times per day. Although these observations are accurate, the frequency of balloon launches is low due to budgetary limitations. As a consequence, both short term forecasting and nowcasting suffer from a lack of recent updates on the state of the atmosphere. Therefore, alternative observation systems are considered.

Fortunately, many civil aviation aircrafts perform continuous observations during their flights and especially during ascent and descent. Around the major international airports many recent observations are available (see Figure 1). Data exchange is organised within the meteorological community in close co-operation with airlines. This worldwide data relay system is called AMDAR.

Objectives

The AMDAR system disseminates observations to the meteorological services in near real time, i.e. 50% of

all data are available for processing within 10 minutes. More accurate and timely weather information can be provided to forecasters by the presentation of atmospheric profile diagrams derived from these data. For this practice a facility to provide such diagrams based on frequently refreshed AMDAR data has been developed.

Because the data are generated by a variety of aircraft, quality monitoring services and rapid feed back to the AMDAR operations system are essential. Using a forecasting model with sufficient refreshment cycle and adequate resolution (HIRLAM) as a background reference, erroneous data are filtered and removed until the defective sensor is repaired.

Results

At the end of 1999 a Quality Evaluation Service was started providing daily evaluation results to the AMDAR operators. Reports on trends and statistical analyses of the performance of the AMDAR system are published on a monthly and on a quarterly base. The monthly reviews present availability and quality of the data in terms of simple statistics. The quarterly reports present both statistical analyses and in depth studies on performance of the AMDAR system, and give insight in the power of this facility. All evaluation results are available on-line to the public¹⁾. Typical results are figures, e.g. Figure 2,

Figure 1. Typical contour plot presenting the density of available observations obtained during ascent or descent of aircraft (density characteristics: 1:10:100:1000)

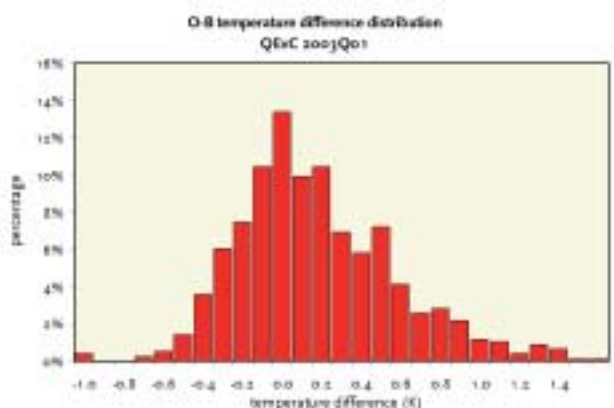
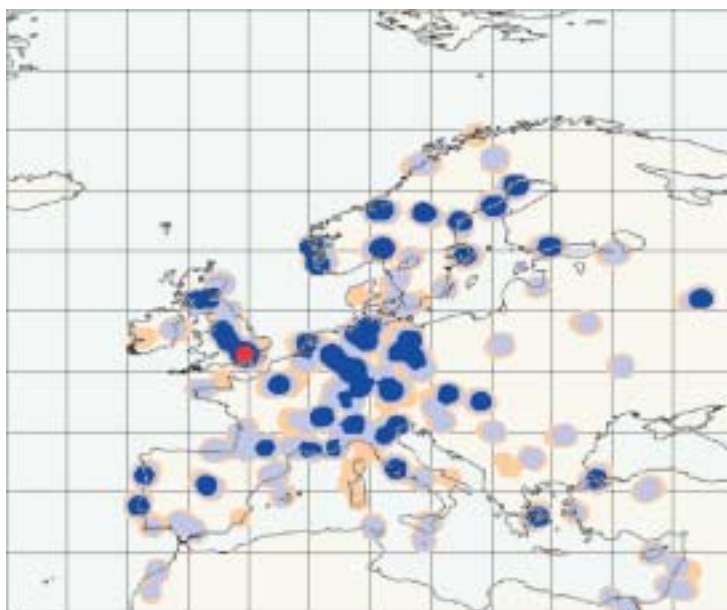


Figure 2. Distribution of the average temperature biases of all aircraft joined in the European AMDAR system (E-AMDAR)

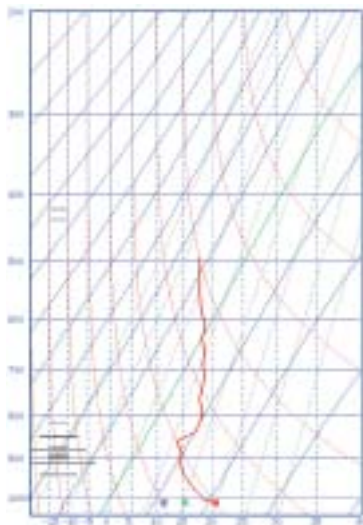


Figure 3. Example of a profile diagram obtained from a set of aircraft heading for Schiphol. The observations were obtained during descents and ascents. The temperature (—, in °C) is presented as a function of atmospheric pressure (in hPa)



Figure 4. Typical example showing the location of the observations from one single aircraft during ascent.

Atmospheric profile information, based on AMDAR observations, provide a new powerful tool for weather analysis

indicating the generally high accuracy of the observations in terms of the mean biases of all aircraft.

An application providing profiling diagrams in near real time has been developed and has been demonstrated to the forecasters. A typical example of such a profile is given in Figure 3, which is based on observations from a set of aircraft in the vicinity of Schiphol (both before landing or after take off). In this figure the temperature profile is shown together with the measured wind as a function of pressure. An impression of the observation frequency and measurement locations is given in Figure 4, where the track of one single ascending aircraft is shown.

Outlook

Applications to present the current state of the atmosphere, using frequently and timely received AMDAR data, have demonstrated²⁾ to be powerful additional tools for meteorological forecasting. In particular short-term forecasting and nowcasting will profit. Moreover, the expensive traditional observing methods will become of less interest. Next to the development and introduction of new applications in the operational environment, the quality monitoring will be intensified. This is necessary because the success of the AMDAR system relies on the performance of the many different aircraft, with different characteristics, joined in the AMDAR system.

1) EUMETNET and KNMI, 1993 – 2003, *Quarterly Reports of the E-AMDAR Quality Evaluation Centre on AMDAR Data* (Ed. J.P. van der Meulen), KNMI, De Bilt; available on www.knmi.nl/~meulenvd/eumetnet/E-Amdar/QEvC/

2) Van der Velde, O., et al., *Gecombineerde weergave van AMDAR en METAR: De eerste stap naar de synthetische TEMP* (Combined presentation of AMDAR en METAR: the first step towards the synthetic TEMP), KNMI Internal report (KNMI-IR), De Bilt, to be published in 2003. (in Dutch)

Winds at sea from satellite radar measurements

Ad Stoffelen, Jeroen Beysens, Jos de Kloe and John de Vries

Introduction

Winds at sea are important for many routing and off-shore activities, moreover, they are essential to drive ocean wave and circulation models. KNMI investigates satellite scatterometer measurements, and is processing the corresponding winds in near real-time. A scatterometer measures radar backscatter from the sea surface from which wind information is inferred¹⁾.

Objectives

The European Meteorological Satellite Organisation (EUMETSAT) is planning for the launch of the ASCAT wind scatterometer on the Meteorological Operational series of satellite platforms (MetOp)²⁾. This will most likely prolong by 15 years the continuous series of scatterometer wind missions since 1991, when the first European scatterometer was put into orbit. To prepare for MetOp, EUMETSAT in collaboration with national meteorological services set up so-called Satellite Application Facilities (SAF)³⁾. Given our experience and background in scatterometer wind processing, KNMI is responsible for:

- The software for wind scatterometer data assimilation in weather forecast models (Numerical Weather Prediction SAF);

- The production, distribution, and archiving of the ASCAT wind product in the EUMETSAT ground segment (Ocean and Sea Ice SAF); and
- The generation of scatterometer climate products (Climate SAF);

This indicates that the KNMI scatterometer group activities span from research to operations. The current focus is on the NASA SeaWinds scatterometer to span the time gap between the successive European scatterometers.

Results

The KNMI scatterometer research has been diverse in the past few years:

- KNMI was the first to propose an effective SeaWinds rain elimination procedure in 2000, shortly after launch;
- A new and generic wind retrieval module was developed and applied in a simulation study on a rotating fan beam scatterometer, but at the same time in the SeaWinds wind processing software at KNMI;
- The method for assimilation of scatterometer winds in weather forecast models was made more generic and made applicable for SeaWinds. Its impact was successfully tested in a two-dimensional variational analysis procedure that is used for wind direction ambiguity removal;
- In an European collaboration, a set of wind direction ambiguity removal algorithms was compared, which lead to some new insights and improvements in ambiguity removal;
- A real-time monitoring flag and report were developed for boosting the user confidence in product reliability.

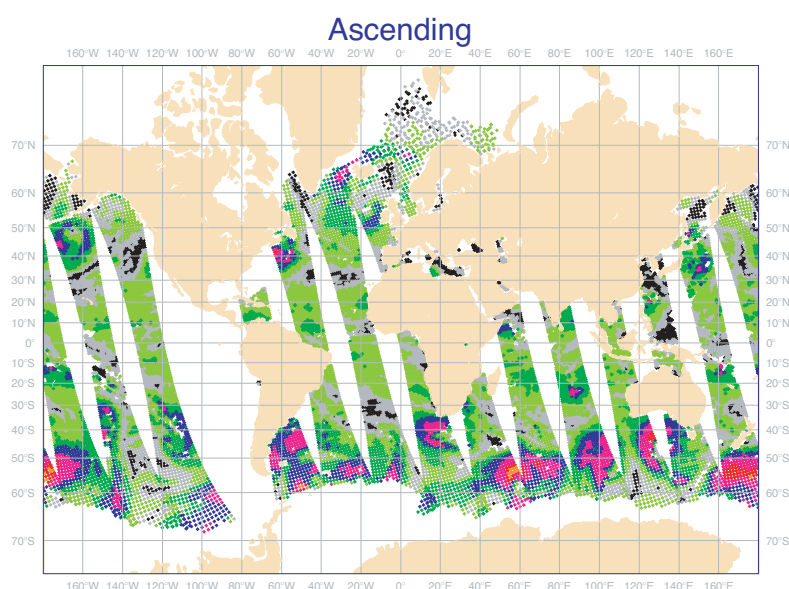


Figure 1. KNMI SeaWinds product overview as available on the web⁴⁾.

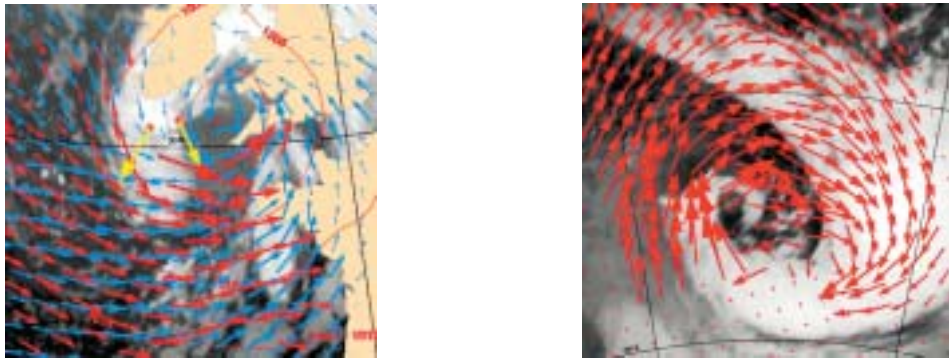


Figure 2. Examples of successfully processed SeaWinds data at KNMI, as visualised on the KNMI web⁴⁾. Red and yellow arrows represent the scatterometer winds with quality annotated as correct and suspicious, respectively. For reference, blue arrows represent winds from a numerical weather prediction model and grey-tones a MeteoSat infrared image.

Apart from the wind products, also the SeaWinds processing software is made available to the meteorological community at large, and several national weather services assimilate SeaWinds data based on the KNMI methodology

Besides the progress in SeaWinds interpretation over open water, the KNMI scatterometer group developed an improved C-band sea ice model. This will aid in the discrimination of open water and ice areas in the scatterometer wind (re-)processing, but also in improved ice characterisation in a wider context.

In 2001 KNMI started the production of a near real-time SeaWinds 100-km product, based on some of the above developments⁴⁾. A global overview of the products is displayed on the KNMI web site, from where, by clicking on an area of interest, a full resolution SeaWinds map can be obtained, including satellite imagery for reference. Several national weather services use the product to their benefit, e.g. see⁵⁾.

Outlook

Apart from the wind products, also the SeaWinds processing software is made available to the meteorological community at large, and several national weather services assimilate SeaWinds data based on the KNMI methodology. KNMI develops, manages, and maintains the operational software and the wind production configuration.

Our aim is to increase the resolution of the wind processing without compromising the required wind quality, and to make scatterometer wind retrieval more generic⁶⁾.

- 1) Portabella, M., *Wind field retrieval from Satellite Radar Systems*, Barcelona University, Physics Department, ISBN 90-6464-499-3, November 2002, www.knmi.nl/scatterometer/seawinds/pdf/PhD_thesis.pdf
- 2) Figa-Saldaña, J., J.J.W. Wilson, E. Attema, R. Gelsthorpe, M.R. Drinkwater, and A.C.M. Stoffelen, 2002, *The Advanced scatterometer (ASCAT) on the meteorological operational (MetOp) platform: A follow on for the European wind scatterometers*, Can. J. Remote Sensing, 28, 404-412.
- 3) EUMETSAT SAFS, www.eumetsat.de, "programmes under development", "SAFS"
- 4) KNMI scatterometer web site, www.knmi.nl/scatterometer
- 5) Frank Thomas Tveter, 2002, *Assimilation of QuikScat in HIRLAM 3D-Var*, DNMI Research Report, Oslo, Norway.
- 6) NWP SAF scatterometer plans, www.metoffice.com/research/interproj/nwpsaf/scatterometer/

Design of a satellite wind profiler

Ad Stoffelen and Gert-Jan Marseille

Introduction

The European Space Agency (ESA) is preparing for the flight of a wind profiler in space by 2007¹⁾. The measurement of vertical profiles of the horizontal wind is a prime meteorological need. KNMI contributed to the design of the satellite system through the simulation of its expected performance and impact on user applications, NWP in particular.

Objectives

In the requirements for the global observing system, published by the World Meteorological Organisation (WMO), the prime need for complementary wind profile observations is expressed²⁾. This requirement can be understood from a simple rationale. Traditionally, wind profile information is provided by radiosondes, but these are mainly available over the densely-populated land areas, thus lacking uniform global coverage. By flying a Doppler wind lidar on a polar-orbiting satellite, the current wind profile coverage over land may be achieved elsewhere. Furthermore, if the quality of the space-borne wind profiles is similar to that of the radiosondes, one may expect improvements to the NWP atmospheric wind analyses, since the radiosonde wind profiles are known to be a major contributor to analysis quality and weather forecast skill.

Improved three-dimensional wind analyses also contribute to our better understanding of global

atmospheric dynamics and transport. This is very relevant for the characterisation of climate processes on time scales from months to decades. Moreover, precise knowledge of the transport of water vapour, ozone, CO₂, and other gases and particles in the atmosphere can be obtained to the benefit of atmospheric chemistry and Greenhouse effect studies. Particularly, the circulation in the tropics in both troposphere and stratosphere, which is a main contributor to the uncertainty in all these areas of research, is poorly known.

Taking the above applications in mind, KNMI contributed to the specification of the Doppler Wind Lidar system that will be flown within the ESA Core Explorer Atmospheric Dynamics Mission (ADM), now called Aeolus³⁾.

Results

In cases of stable and uniform flow, and without cloud or aerosol variability, it is relatively straightforward to predict the performance of a space-borne wind profiler. However, in tropical or storm-track areas there is a greater need for precise knowledge on the atmospheric flow and dynamics. Cloud structures associated with dynamical weather potentially limit the view of the profiler, operating in the ultraviolet light range. Moreover, dynamic conditions usually correspond to increased wind variability, which potentially may bias the interpretation of the measurements⁴⁾. KNMI has taken the specifications of the instrument and simulated its performance in such heterogeneous atmospheres⁵⁾. These efforts are continuing in the hardware design phase of the ADM-Aeolus mission, in order to safeguard the user interests.

Our experience in optical profiling of heterogeneous atmospheres is currently being exploited for the simulation of dual-frequency (DIAL) water vapour



Figure 1. Artist impression of the ESA ADM-Aeolus wind profiler © ESA

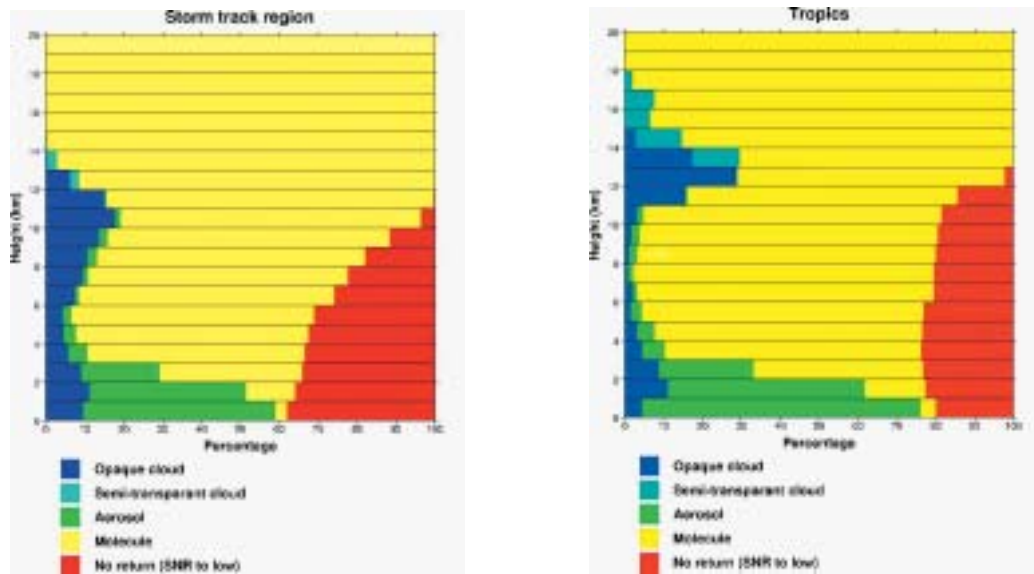


Figure 2. KNMI classification of Doppler Wind Lidar responses in a variable and cloudy atmosphere. The red areas in the plot indicate where no useful wind can be determined.

Precise knowledge of the transport of water vapour, ozone, CO₂,
and other gases and particles in the atmosphere can be obtained
to the benefit of atmospheric chemistry and Greenhouse effect studies

profile measurements from space in the context of the ESA WALES mission⁶⁾, and will be important in the design of the ADM-Aeolus ground processing.

Outlook

By impact simulation of the space-borne wind profiler in atmospheric analyses and numerical weather forecasts, one obtains an end-to-end simulation of the expected benefit of the ADM-Aeolus

mission. KNMI has set up such study in collaboration with ECMWF and indeed showed positive impact³⁾. KNMI now undertakes similar studies, but this time to answer questions related to cost-benefit of operational follow-on wind profiler missions. This is essential for moving space-borne wind profilers into an operational era.

- 1) European Space Agency, 1999, *Atmospheric Dynamics Mission*, ESA SP-1233(4).
- 2) World Meteorological Organisation (WMO), 2001, *Statement of Guidance Regarding How Well Satellite Capabilities Meet WMO User Requirements in Several Applications Areas*, Sat-26, WMO/TD No.1052.
- 3) Stoffelen, A., P. Flamant, E. Källén, J. Pailleux, J.M. Vaughan, W. Wergen, E. Andersson, H. Schyberg, A. Culoma, M. Endemann, P. Ingmann, and R. Meynart, *The Atmospheric Dynamics Mission for Global Wind Field Measurement*, submitted to the Bull. American Met. Soc.
- 4) Stoffelen, Ad, Pierre Flamant, Måns Håkansson, Erland Källén, Gert-Jan Marseille, Jean Pailleux, Harald Schyberg, Michael Vaughan, 2002, *Measurement Error and Correlation Impact on the Atmospheric Dynamics Mission (MERCI)*, ESA project report.
- 5) Veldman, S.M., A. Stoffelen, G-J Marseille, 1999, *LIPAS Executive Summary*, NLR, the Netherlands.
- 6) European Space Agency, 2001, *WALES – Water Vapour Lidar Experiment in Space, Report for Mission Selection*, ESA SP-1257(2).

Hail detection using radar

Iwan Holleman

Introduction

Large hail related to summertime thunderstorms can cause severe damage to crops and goods, and it can be dangerous for aviation (Figure 1) and traffic. This so-called summer hail is a small-scale phenomenon and due to the wide spacing of the surface meteorological observation stations it remains mostly undetected by these stations. Although ambiguous, the reflectivity factor observed by single-polarization weather radar provides information about the presence of large hail. Within the framework of a project for detection of severe weather phenomena, a tool for detection of summer hail using weather radar and HIRLAM numerical weather prediction model data has been developed and implemented.

Objectives

The main purpose of the hail detection method is aiding in the nowcasting of thunderstorms for general public, traffic, agriculture and aviation. The hail detection algorithm will become part of a general severe weather display with indication of

high rainfall intensities, wind shear and convergence, mesoscale rotation, and lightning activity. In addition, the results can be used as reference information to insurance companies investigating the legitimacy of hail damage claims. Finally, large hail causes overestimation of the rainfall intensities observed by weather radar, and the hail detection tool can be used to improve radar-based hydrological products.

Results

An extensive comparison and verification against surface observations of several methods for radar-based detection of summer hail have been performed^{1,2}. Hail reports from 325 voluntary observers and damage reports from 3 insurance companies have been used to complement the sparse surface station observations. The method of Waldvogel³, which combines a radar indicator for strong updrafts and large amounts of hydrometeors with freezing level height data from the HIRLAM model (Figure 2), performed the best by far. Using the verification results, this method has been tuned



Figure 1. KLM airplane at Amsterdam Airport Schiphol damaged by large hail.

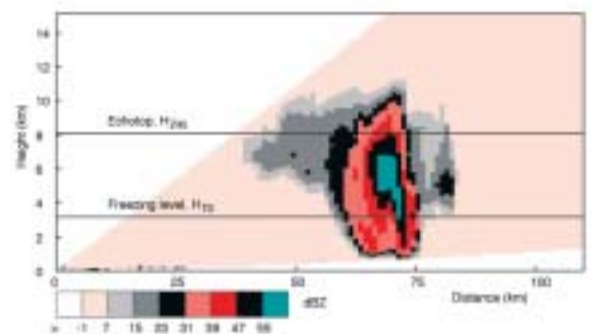


Figure 2. Vertical cross section through a thunderstorm as observed by weather radar. The radar height signature for strong updrafts and large amounts of hydrometeors (HZ45) and the freezing level height (HTO) are indicated.

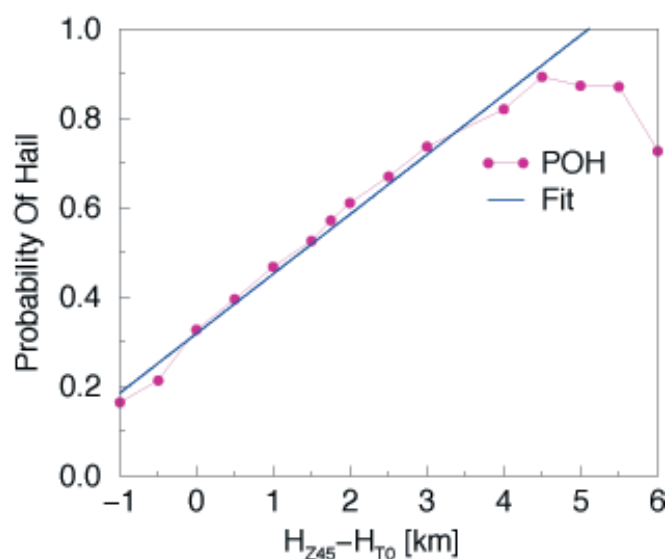


Figure 3. The probability of hail (POH) as a function of the height difference between radar echo top and freezing level. The POH is obtained using verifying data.

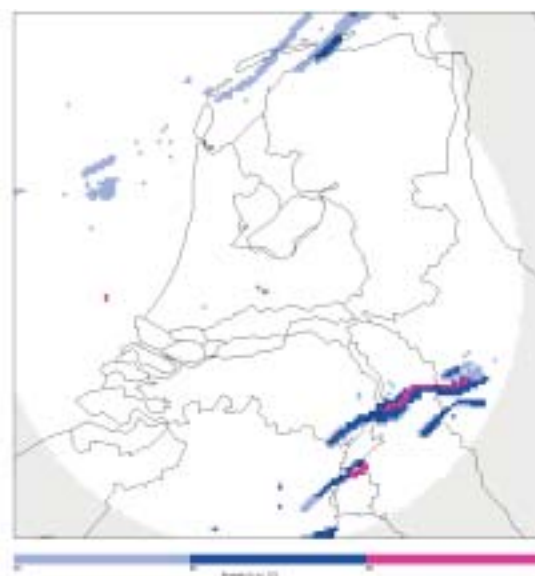


Figure 4. Example of a daily accumulation of all detected hail using weather radar and HIRLAM model.

The combination of weather radar and HIRLAM model data enables an effective detection of large hail

to the local meteorological setting and sensitivity to hail damage (Figure 3).

An example of a hail detection radar image is presented in Figure 4. It contains a daily accumulation of all detected hail for 23 June 2003. The 96 real-time images have been binned by collection of the maximum observed hail probability for each image pixel. The figure shows a few tracks of hail-producing thunderstorms. The thunderstorms in the southern part of the Netherlands have almost certainly produced damaging hail (>90%).

Outlook

The hail detection tool became fully operational just before the summer of 2001 and from June 2003 it is

also available to the Dutch meteorological service providers. At KNMI it is currently used in real-time by operational forecasters and off-line by climatologists. The positive feedback from the users strengthens the conclusion that the combination of weather radar and HIRLAM model data enables an effective detection of large hail. At other national meteorological institutes the interest in operational application of this hail detection technique is rising. In collaboration with RMI (Belgium) the sensitivity of the deduced hail probabilities on anomalous propagation effects has been investigated⁴⁾. At KNMI work on other components of the severe weather display, like wind shear and convergence, and work on hydrological applications of weather radar is in progress.

1) Holleman, I., 2001, *Hail Detection using Single-Polarization Radar*, KNMI Scientific Report, WR-2001-01.

2) Holleman, I., H.R.A. Wessels, J.R.A. Onvlee, and S.J.M. Barlag, 2000, *Development of a Hail-Detection-Product*, Phys. Chem. Earth B, 25, 1293-1297.

3) Waldvogel, A., B. Federer, and P. Grimm, 1979, *Criteria for the Detection of Hail Cells*, J. Appl. Meteor., 18, 1521-1525.

4) Delobbe, L., and I. Holleman, 2003, *Radar-based Hail Detection: Impact of Height Assignment Errors on the Measured Vertical Profiles of Reflectivity*, 31th conference on Radar Meteorology, AMS, 475-478.

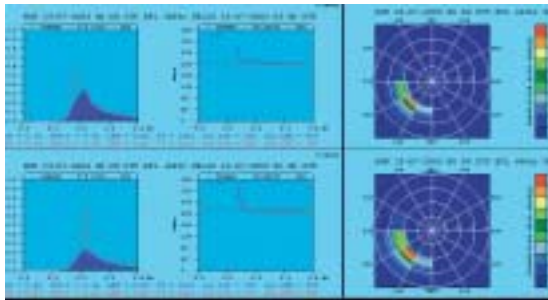


Figure 2. Model spectra for the location Europlatform (EPL). In the figure the +3 and +6 hours forecasts are shown in the upper and lower panel, respectively. From left to right are shown the one-dimensional wave energy spectrum, spectrum averaged over all directions, and a polar presentation of the full directional wave spectrum. Observed spectra (red lines) are included when available.

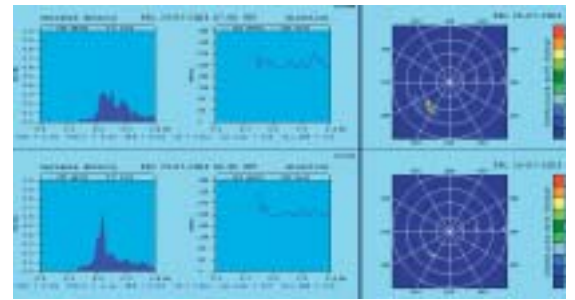


Figure 3. Observed spectrum only, with a polar representation of the spectrum as determined from the observed mean wave direction and directional spread.

*The present state of technology has made it relatively easy
to display NEDWAM spectra together
with simultaneous spectra from observations*

Results

A web-oriented presentation system has been developed, of which a few examples are shown here. One of the options is to display forecasted model spectra, see Figure 2. A similar presentation of the observations only is also available, with a polar representation of the spectrum. This requires a two-dimensional (frequency, direction) spectrum, which is determined from the heave spectrum, mean direction and directional spread using the Cauchy distribution function, see Figure 3.

Outlook

The present status of this presentation tool is still 'experimental'. The system is to be evaluated by operational marine forecasters. On the basis of their feedback, decisions can be made on future operational use.

- 1) Hasselmann, K., et al., 1973, *Measurements of wind-wave growth and swell decay during the Joint North Sea Wave Project (JONSWAP)*, DHZ, Reihe A(8°), nr.12.
- 2) WAMDI Group, 1988, *The WAM model – A third generation ocean wave prediction model*, J. Phys. Oceanogr., 18, 1775-1810.
- 3) From: www.actuelewaterdata.nl/golfgegevens/kaart.html (Rijkswaterstaat)

High Resolution Limited Area Model HIRLAM

Sander Tijm, Ben Wichers Schreur, Wim de Rooy, Han The, Cisco de Bruijn, Toon Moene and Gerard Cats

Introduction

The international HIRLAM project is a continuing effort to develop and maintain a state of the art high resolution limited area model for operational use in the participating institutes. By 2001 HIRLAM research developments had outstripped the operational HIRLAM system at KNMI through a substantial increase in model resolution and many improvements in the model formulation.

Objectives

An experimental mesoscale model version at KNMI, at 11km resolution and including the latest model developments from the HIRLAM project, showed significant gains in forecast quality, in particular in cases of severe weather. This motivated the Ministry of Transport, Public Works and Water Management to provide funding for a more powerful computer. Thus KNMI was able to benefit from a higher resolution and international research developments, and still deliver operational forecasts within operational time constraints.

Results

In the autumn of 2001 a SUN Fire 15K was installed at KNMI, increasing computer capacity by a factor of 10. After two months of concentrated effort, a model version at 22 km horizontal resolution (H22) was started at December 19, 2001. With this update, which also included improved model physics, more efficient dynamics and the assimilation of new data

types, HIRLAM at KNMI was brought in line again with the HIRLAM Reference System¹. The operational switch from the old model (H55) to H22 was made on March 5, 2002. A parallel 11 km version of HIRLAM, H11, nested within the H22 model, became operational on May 15, 2001.

The introduction of H22 has led to clear improvements in model performance. Problematic features in the H55 model, such as a large negative temperature bias in winter, have been resolved in the new HIRLAM version. A typical example of improvement on traditional scores is given in figure 1, which shows the behaviour of the standard deviation in 10-meter wind speed for the period 1998-2003. H22 performance is better overall.

The increase in detail of the model forecasts has brought the problem of mesoscale verification to the fore. In response, alternative verification methodologies were developed (see e.g. Kok et al., this volume and²). A new precipitation verification system was introduced. Figure 2 shows the results of a comparative verification of H22 and H55 precipitation. H22 makes more skillful forecasts of extreme precipitation events.

Another consequence of the resolution increase is that users of numerical weather prediction forecasts are now confronted with a level of spatial detail that they are unfamiliar with. This has led to interpretation problems. To help overcome this difficulty, a presentation system has been developed

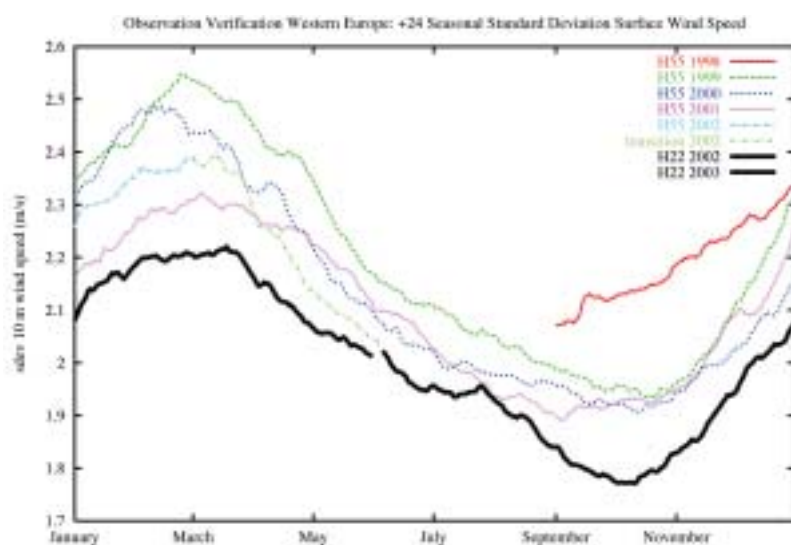


Figure 1. Three-month running average of the standard deviation of +24h forecasts for 10-meter wind speed for the period 1998-2003 for H55 and H22.

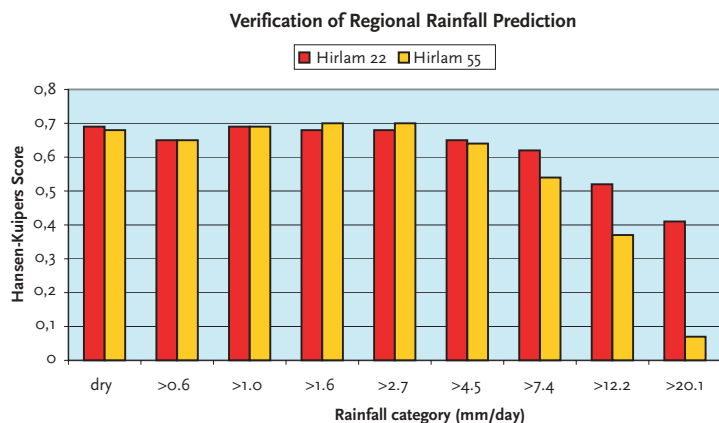


Figure 2. Verification of the prediction of regional daily rainfall amounts for the first half of 2002. The new H22 model is compared to the old H55 system using the Hansen-Kuipers Score (HKS), which encompasses both the Probability Of Detection (POD) and the False Alarm Rate (FAR): $HKS = POD - FAR$. H22 is significantly better for extreme rainfall events.

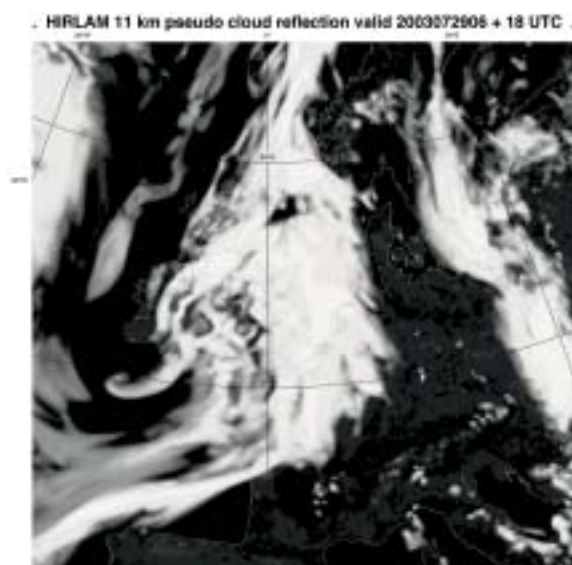


Figure 3. H11 pseudo cloud reflection image based on the cloud water content of the atmosphere valid on 30 July 2003, 00 UTC. This image is comparable to the visible satellite images (during the daytime).

Implementation of the HIRLAM reference system is of mutual benefit to the HIRLAM research and the operational model at KNMI

in which HIRLAM output is visualized as pseudo satellite imagery (Figure 3). This presentation gives the forecaster a more familiar view of dynamical developments in the atmosphere, which also allows for a more direct comparison with satellite observations.

The new mesoscale HIRLAM model formed the basis for fresh developments at KNMI, such as the introduction of downscaling methods, and improvements to severe weather detection and prediction systems, see e.g. the contributions of Jacobs and Kok et al. in this volume.

Outlook

Operational implementation of the HIRLAM reference system is of mutual benefit to the HIRLAM research and the operational model at KNMI. It has permitted the operational system to keep abreast with the latest international research developments. Conversely, operational experience with model weaknesses has led to modifications to the convection scheme³⁾ and an improved version of the initialization scheme. These changes, together with a moist vertical diffusion scheme, a new surface scheme including a soil analysis and a 3D variational assimilation scheme, will be implemented in several updates planned for the near future.

- 1) Undén, P., et al., 2002, *HIRLAM -5 Scientific Documentation*, HIRLAM -5 Project, SMHI, Norrköping, Sweden.
- 2) SRNWP Mesoscale Verification Workshop 2001, *Proceedings*, HIRLAM -5 Project, SMHI, Norrköping, Sweden.
- 3) Tijm, A.B.C., 2002, *Further updates to STRACO*. HIRLAM Newsletter 42, 18-25.

Downscaling

Albert Jacobs, Sander Tijm, Job Verkaik & Wim de Rooy, Kees Kok

Introduction

The highest resolution weather model at KNMI presently is the HIRLAM-11km model. For various important applications, however, wind information on smaller scales, 1 km or less, is required. Hence, techniques have been developed to downscale model winds to very high resolutions. These detailed wind fields are used for example as input for storm surge models, and to support runway allocation at Schiphol Airport.

Objectives

The objective was to develop an operational downscaling method for wind. Furthermore, the potential was investigated of combining physical and statistical methods in a downscaling approach capable of accounting also for large-scale model deficiencies.

Results

The downscaling method developed for operational use¹⁾ is based on a simple model of the Planetary Boundary-Layer (PBL) and on high-resolution surface roughness information. The PBL model consists of two layers: the Ekman layer and the surface layer. Roughness lengths Z_0 are determined for both layers, by averaging geographical variations in surface roughness over the upstream area of the airflow. The resulting high-resolution roughness lengths are wind direction dependent (Figure 1).

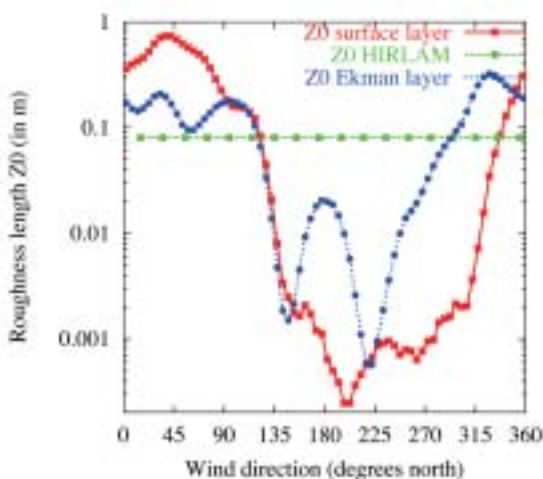


Figure 1. High-resolution, wind direction dependent, surface roughness (derived from land-use maps) compared to uniform HIRLAM 11 km roughness for location Hansweert.

The two-layer PBL model can be used to derive the wind in the surface layer from the wind at the top of the PBL and vice-versa. At present the model transforms HIRLAM surface winds to the top of the PBL, using a HIRLAM grid box roughness, and then down again to the surface, this time using high-resolution local roughness information. This leads to a reconstruction and refinement of HIRLAM surface wind to a much higher resolution.

The method has been validated successfully for locations near the coast and on land²⁾. Figure 2 presents verification results for location Hansweert on the northern shore of the Scheldt estuary. As downscaled wind fields are more representative for local conditions than the HIRLAM-11km results, downscaling leads to a significant reduction in mean wind speed error.

In contrast with purely physical downscaling methods, a combined physical/statistical approach³⁾ is capable of handling large-scale model deficiencies. Key factor is the decomposition of the total error (model - observation) into a small-scale representation mismatch (difference between “true” model grid box mean and the observed local value) and a large-scale model error. For 10m-wind speed, the representation mismatch (RM) is dominated by the difference between model roughness and local

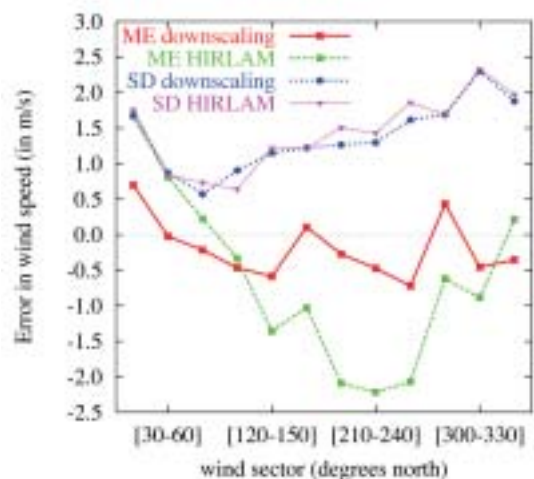


Figure 2. Error in surface wind speed +3h forecasts, per wind sector for Hansweert. Presented are the mean error (ME) and Standard Deviation (SD) in u_{10} for downscaled and HIRLAM-11 km winds.

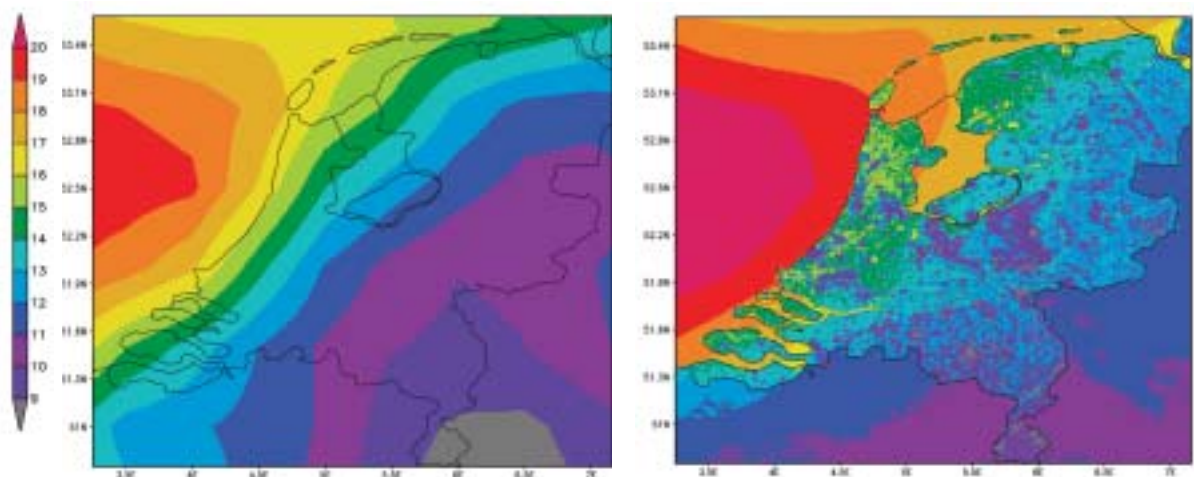


Figure 3 (left) shows a 10m wind field forecast [ms^{-1}] of HIRLAM-11km; (right) shows the downscaled wind speed field (1km resolution) following the combined physical/statistical approach. Outside the Netherlands no roughness information is available and local wind speeds over land should be ignored.

*In contrast with purely physical downscaling methods,
a combined physical/statistical approach is capable of handling
large-scale model deficiencies*

roughness. This RM can be corrected for by a physical downscaling method based on Monin-Obukhov theory. The model error is accounted for by a linear regression derived on a pool of local estimates (resulting from the physical method) and corresponding observations. In this way the linear regression primarily handles the large-scale model error, and can therefore be applied to areas without observations. Figure 3 shows an example of a HIRLAM forecast and the corresponding downscaled wind field.

Verification shows that the combined physical/statistical approach results in an almost perfect reduction of wind speed bias. Comparison of the results of physical downscaling with those of the

combined approach shows that the linear regression equation also applies to locations without observations.

Outlook

Combining physical and statistical techniques for downscaling turned out to be successful. Not only because in this way both representation mismatch and model error are corrected for, but also because this approach offers many opportunities to optimize the system for a particular use (such as high wind speeds). The combined statistical/physical approach might also be extended to other parameters. Finally, the concept of error decomposition is valuable in a more general sense (such as for validation purposes).

- 1) Verkaik, J.W., A.B.C. Tijm, and A.J.M. Jacobs, *Computation of the Local Wind Flow by Downscaling Numerical Weather Predictions*. Part A: Model Concepts and Derivation of a High Resolution Roughness Map. To be submitted to Weather and Forecasting.
- 2) Jacobs, A.J.M., J.W. Verkaik J.W., and A.B.C. Tijm, *Computation of the Local Wind Flow by Downscaling Numerical Weather Predictions*. Part B: Application, validation and verification. To be submitted to Weather and Forecasting.
- 3) De Rooy, Wim C. and Kees Kok, 2003, *A combined physical/statistical approach for the downscaling of model wind speed*. Accepted for publication in Weather and Forecasting.

AUTOTREND – Automated guidance for short-term aviation forecasts

Albert Jacobs

Introduction

Although recent advances in Numerical Weather Prediction (NWP) modelling at KNMI have been substantial, these models still have not reached a state where they can resolve clouds and precipitation at the resolution and accuracy required for aviation meteorological forecasting. Aviation forecasters compensate for these deficiencies by combining model data with detailed recent observations and topographical information on the vicinity of the airport. In particular the quality of short-term forecasts (up to two hours ahead and provided in the form of TREND bulletins) is highly dependent on the availability of local observations and observations from upstream areas.

Objectives

The aim of AUTOTREND was to develop tools, which objectively integrate available observations and topographical information with existing model data. The main purpose has been to develop and implement these tools in an operational environment, and use them to provide detailed guidance on weather conditions such as winds, visibility, clouds and precipitation, that affect air traffic at civil airports in the Netherlands.

Results

In cooperation with the German company Meteo Service Weather Research¹⁾, KNMI has developed a TREND-guidance, consisting of a short-term (0-2h) weather forecast. This weather forecast is provided for support of all air traffic during landing and take-off.

The TREND-guidance has been integrated into the operational environment at KNMI to support the aviation weather forecaster. The guidance is based on statistical and physical post-processing of NWP model data and observations. The technique used for the statistical post-processing is Model Output Statistics (MOS). The guidance contains site-specific information on the development of clouds, visibility, significant weather, and wind within the next 6 hours. Figure 1 shows an example of forecasted cloud amounts in the TREND-guidance.

The guidance is updated every 30 minutes with model data from KNMI's NWP model HIRLAM²⁾, and recent local and upstream observations. Encoding software has been provided that translates the guidance into the required aeronautical TREND-code³⁾. A graphical user-interface with an integrated code editor enables the forecaster to modify the suggested 'first guess' code. Figure 2 shows how the TREND-guidance and TREND-code have been integrated into the userinterface.

TREND forecasts depend on actual observations and are required to be added to those observations, quasi-instantaneously. Actual observations are provided as half hourly Meteorological Aviation Routine Weather Reports (METARS) or Special Aerodrome Weather Reports (SPECI's). The TREND-guidance based on those observations is not yet available at that time, which forces us to add the guidance of 30 minutes previously to the METAR instead. This 30-minute delay has a large impact on the quality of the guidance, which can be demonstrated by objective verification.

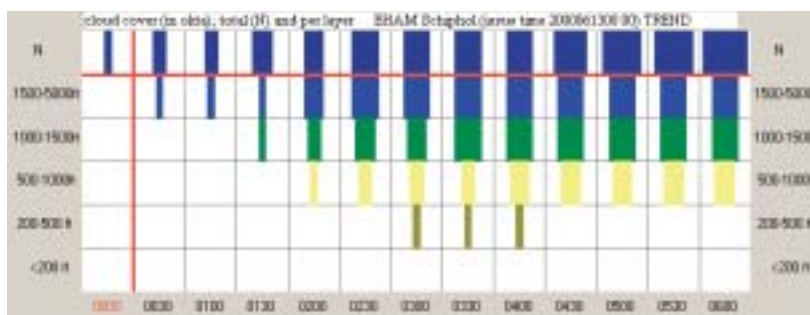


Figure 1. TREND-guidance total cloud cover (N, upper panel) and cloud cover per layer (lower panels, abscissa indicate layer levels in ft). The breadth of the bands indicates the number of okta's. This example shows an increase in cloud amount, due to advection of low stratus clouds from upstream locations.

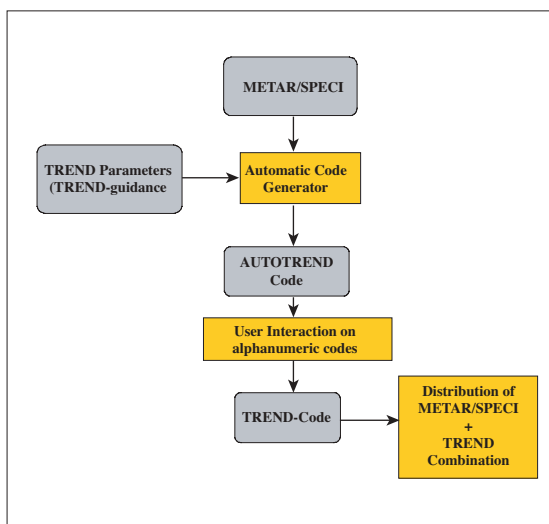


Figure 2. Operational configuration of the AUTOTREND system.

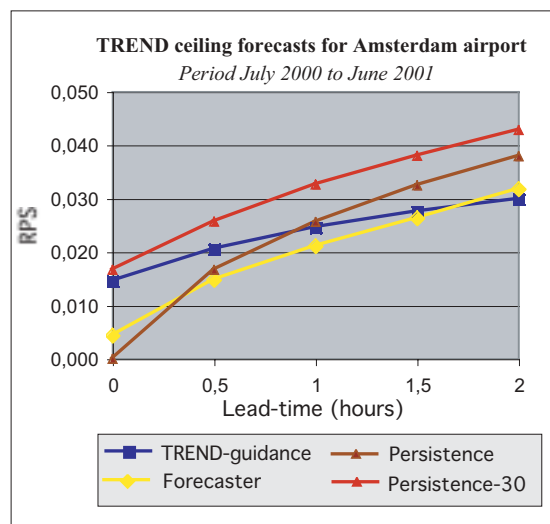


Figure 3. Verification scores (RPS) for cloud ceiling forecasts. Here the ceiling is defined as the first cloud layer with coverage of at least 5 okta (or 62.5%).

A guidance system consisting of post-processing of NWP model data in combination with local and upstream observations is able to provide more detailed and accurate meteorological information on changing weather conditions at airports

Verification results are presented in Figure 3 in terms of Ranked Probability (skill) Scores (RPS); the TREND guidance is compared to the forecasters' TREND-code and to persistence of the observation at issue time and 30 minutes before that. Lower RPS values represent a better forecast skill.

Outlook

A guidance system consisting of post-processing of NWP model data in combination with local and upstream observations is able to provide more detailed and accurate meteorological information on changing weather conditions at airports. By presenting this guidance information to the

forecaster, aviation weather forecasts can be produced more efficiently. For short-term, TREND forecasts, the forecast skill, however, is reduced significantly when the guidance depends on observations which are too old. In order to benefit optimally from the detailed information available in the guidance, the update frequency of the guidance needs to be increased and the delay times minimised.

- 1) Knüppfer, K., 1997, *Automation of Aviation Forecasts – The Projects Auto-TAF and Auto-GAFOR*, Seventh Conference on Aviation, Range, and Aerospace Meteorology 77th AMS Annual Meeting, 2-7 February 1997, Long Beach, CA, U.S.A.
- 2) Undén, P., et al., 2002, *HIRLAM -5 Scientific Documentation*, HIRLAM -5 Project, SMHI, Norrköping, Sweden.
- 3) ICAO, 1998, *International standards and recommended practices – Meteorological service for international air navigation*, Annex 3 to the convention on international civil aviation, thirteenth edition – July 1998, ICAO, Montreal, Canada.

3D wind modeling of Amsterdam Airport Schiphol

Ben Wichers Schreur

Introduction

The steady increase of air traffic at Amsterdam Airport Schiphol (AAS) requires an increase of its handling capacity, resulting in an increased density of airport buildings. The growth of Schiphol is matched by economic growth in the airport's region, supported by expanding infrastructure and industrial accommodations in the immediate vicinity of the airport. This increase in building density influences the wind regime at the airport. Without careful planning, based on detailed knowledge of the changes in the wind regime, this may hinder air traffic, reduce the representativeness of wind reports, requiring additional safety constraints, and eventually limit the airports capacity.

Objectives

Following up on the recommendations of earlier research by KNMI of the wind conditions at the airport¹⁾, numerical studies of the 3D wind field around existing airport buildings were conducted by Cyclone Fluid Dynamics BV, in conjunction with KNMI and in permanent consultation with the principal, Amsterdam Airport Schiphol. Purposes of the simulations were:

- To provide a qualitative insight in the existing disturbances of the wind regime;
- To study the mechanisms behind these

disturbances and the influences thereupon of the design and relative placement of buildings;

- To quantify the disturbances by calibration and validation of the computational fluid dynamics (CFD) model using detailed series of historical wind observations.

Results

The role of KNMI was to relate the modeled wind behaviour to reality. A complete set of wind observations of all six wind masts at AAS at 12 second intervals for a 3 year period, March 1996 through to March 1999, was used to derive the wind direction dependent effective surface roughness, turbulence intensity and wind shelter factor at the wind masts. These derivations were based on a gust theory adopted from earlier work by Beljaars²⁾. It was found that this theory gave a better fit between observed wind speed variations and gusts than the competing theory of Wieringa³⁾.

The derived results were used to calibrate and validate the CFD model, to select relevant model situations and to specify inlet conditions for the model. Most importantly, the measurements were used as a reference in the evaluation of model results. Criteria for the evaluation were developed on the basis of international regulations and recommended practices^{4,5)}.

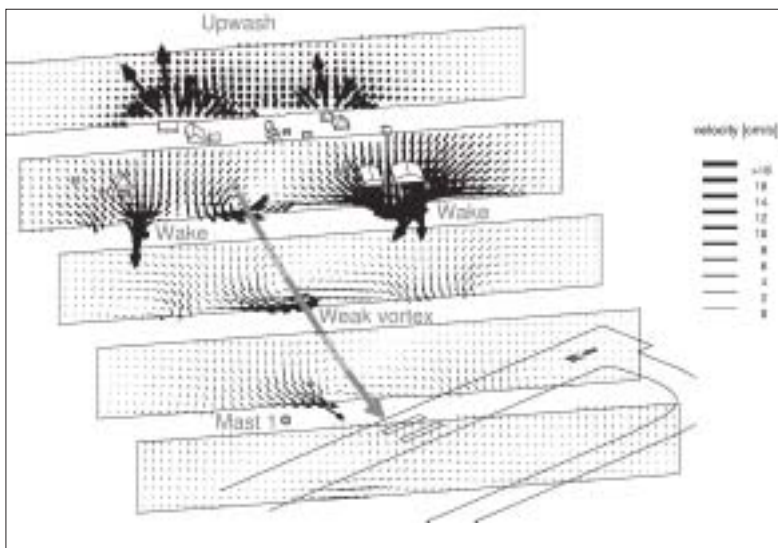


Figure 1. Cross sections of wake flow and vortices behind farm buildings.

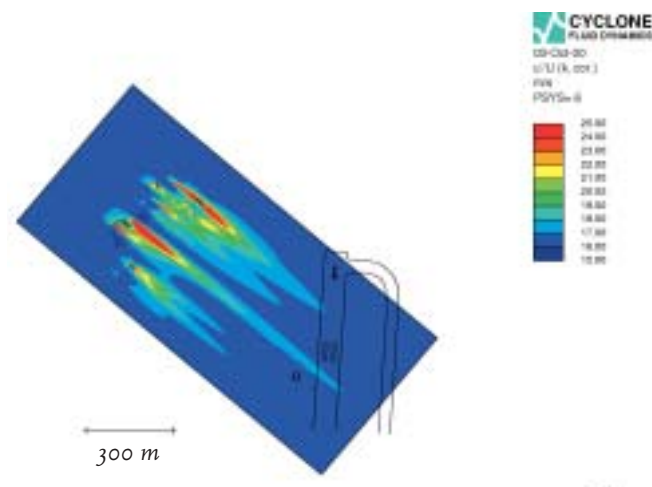


Figure 2. Calculated turbulence intensity. The positions of the runway and wind mast are indicated.

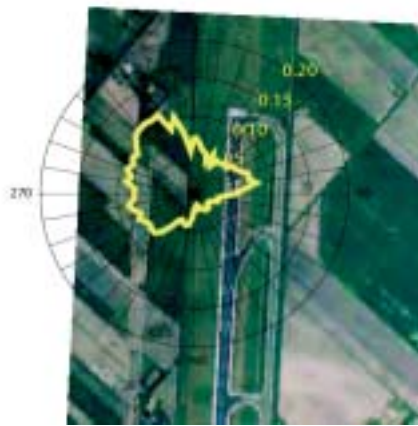


Figure 3. Effective surface roughness as a function of wind direction, derived from observations, superposed on an aerial photograph of the situation at 19R, used to identify sources of disturbances to wind measurements.

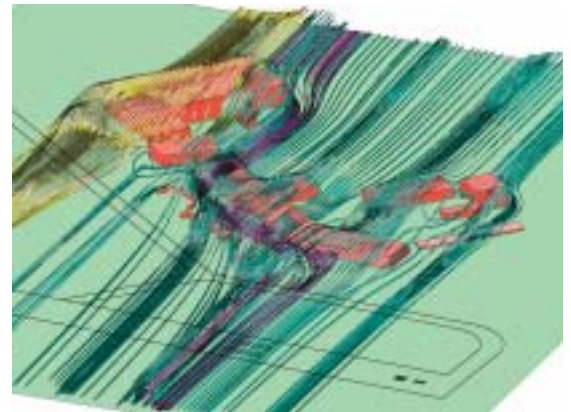


Figure 4. Visualization of the simulated topology of the flow provides insight into the mechanisms that influence the flow around buildings. This qualitative insight is essential for the quantitative interpretation of the calculations and the validation of model results using series of historical in-situ observations

Combining numerical modelling with in-situ observations provides a reliable quantification of the disturbance of the wind, wind measurement and thus the representativeness of wind reports

Site inspection and in-situ observations were used to calibrate, validate, initiate and evaluate model results. Figures 1 to 3 show the results for position AAS-19R. Visualization of the simulated topology of the flow, Figure 4, provided insight into the mechanisms that influence the flow around buildings. This qualitative insight is essential for the quantitative interpretation of the calculations and the validation of model results versus in-situ observations.

From this research it is concluded that combining numerical modelling with in-situ observations provides not only a qualitative insight in the mechanisms of wake flows, but also a reliable quantification of the disturbance of the wind, wind measurement and thus the representativeness of

wind reports. Based on this conclusion, it has now become practice to model the disturbance generated by proposed new developments on the airport and in its vicinity during the planning phase.

Outlook

Numerical modelling can help, to a degree, in the relocation of wind masts where measurements are disturbed too much by their surroundings; but it will not help to improve the representativeness of wind reports, as long as the wind hindrance persists. Unfortunately such situations potentially will occur more frequently as the building density increases. This demands increasingly detailed knowledge of building-induced wind variations through numerical modelling.

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Probabilistic forecasting research

Kees Kok, Daan Vogelesang and Maurice Schmeits

Introduction

Professional users can benefit greatly from knowing the inherent uncertainty in numerical weather predictions. This uncertainty can be expressed in an objective, quantitative and reliable manner using Model Output Statistics (MOS)¹⁾.

Objectives

Probabilistic forecasting research at KNMI aims at implementing MOS techniques in support of:

- The use of ensemble predictions (EPS)
- The shift of forecast attention towards extreme and hazardous weather
- The statistical improvement of field forecasts
- The verification of small-scale information in high-resolution forecasts

The interpretation and use of probabilistic forecasts is a notoriously difficult subject for the untrained mind. Substantial effort therefore is put in educating forecasters in this area with a focus on the potential benefits for end-users.

Results

Predictors from EPS have been included in many probabilistic and deterministic MOS products. Also 'direct' probabilistic information from EPS is used. An extensive calibration of these probabilities obtained from EPS weather parameter time-series

has been carried out. This has resulted in improved applicability of probabilistic forecasts of temperature, precipitation, cloudiness and wind speed for 6 land stations and wave height predictions for 3 North Sea platforms²⁾. An example is given in Figure 1.

In cooperation with the Union of Water Boards, a project was initiated aiming at providing optimal meteorological information in cases of risk of flooding. Water Boards need such information for taking adequate precautionary actions, and thus preventing large economic losses. A skilful and reliable probabilistic forecasting system for precipitation amounts exceeding critical levels for individual Water Boards is under development. This system is to be combined with cost-loss analyses of precautionary measures, which can be used in decision-making models of the Water Boards. Analyses are made for each of the 5 Water Boards participating in the project for a number of critical precipitation levels in the forecast range up to 9 days.

In the INDECS (Indices for Extreme Convective Situations) project, traditional hazardous weather indices are assessed on their predictive potential for severe weather events in the Netherlands. The most skilful combination of predictors, derived from the HIRLAM and ECMWF deterministic models and

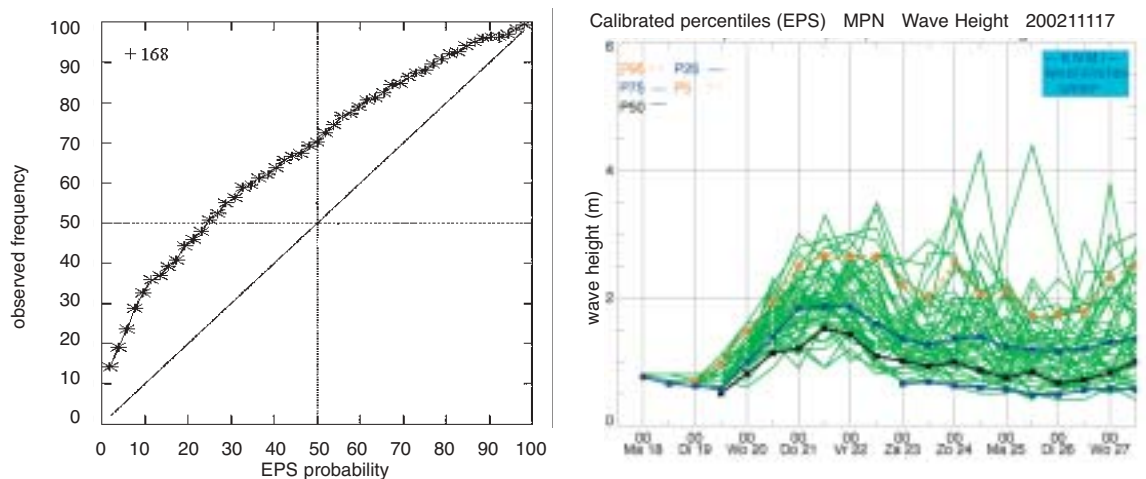


Figure 1. Example of calibrated wave height probability forecasts (right) for platform Meetpost Noordwijk (MPN). It is based on cumulative rank histograms for each forecast time (+168 is shown on the left) in which EPS probabilities (in steps of ~2 %) are verified against the frequency of observation on a 2-year dataset.

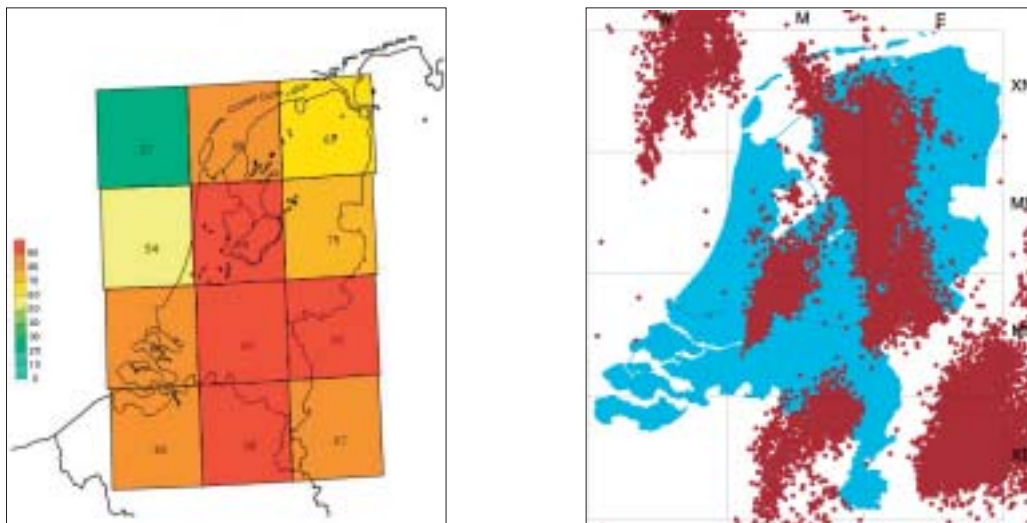


Figure 2. Probability of thunderstorms (%) for June 2nd 2003 (09-15 UTC), computed by the INDECS Perfect Prog system (left). On the right the location of all lightning flashes observed during the same period are indicated.

Probabilistic forecasting by Model Output Statistics remains a powerful and cost-effective tool for adding value to deterministic and ensemble prediction forecasts

including these indices, has been determined statistically. This has resulted in a Perfect Prog¹⁾ forecasting system for the probability of thunderstorms in 6-hour time intervals for 12 regions covering the Netherlands (Figure 2). It will soon be replaced by a MOS system and extended to more hazardous weather phenomena³⁾.

A well-known problem in the comparative verification of deterministic forecasts is that high-resolution forecasts, while providing useful additional information, often verify worse on traditional scores than their low-resolution counterparts. A MOS technique has been applied to assess objectively the skill of small-scale information contained in high-resolution models; the added value of high-resolution models is quantified by the improvement of probabilistic

forecasts using their small scales. The method thus objectively rates the presence of the 'right indications' that can be inferred from the small scales, much as a human forecaster does. The validity of this approach has been demonstrated in a simplified setting⁴⁾.

Outlook

Probabilistic forecasting by Model Output Statistics remains a powerful and cost-effective tool for adding value to deterministic and ensemble prediction forecasts. The research focus will shift further to short-range, high-resolution forecasts of extreme and hazardous weather. Realization of its potential benefit to end-users will require an investment in the maintenance of statistical knowledge and the transfer of this knowledge to forecasters/advisers and end-users.

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Wind-over-waves coupling – a modern theory of air-sea interaction

Vladimir Makin

Introduction

Interaction between the atmosphere and the ocean occurs by means of the transfer of momentum, heat, moisture and gases at the air-sea interface. A correct description of these surface fluxes is of importance to predict the global and mesoscale atmosphere and ocean circulation and changes therein. This requires a good understanding of the physics of microscale air-sea interaction, which is to a large extent determined by wind-wave interaction.

Objectives

Wind blowing over the ocean excites wind waves, which strongly affect surface fluxes. Waves enhance transfer rates even when the surface is fairly smooth and continuous, and further enhance them when it breaks. Bulk parameterizations, traditionally used in atmosphere and ocean models, relate fluxes to the local wind speed. Since waves grow, evolve and decay on their own dynamical time/length scales, the fluxes in general cannot be described by wind speed alone. This is especially true in coastal regions, in synoptic frontal zones, and in small water bodies like lakes, where the sea state varies rapidly in space and time. Therefore, a theory that takes into account the sea state for the calculation of fluxes is required. Short waves are strongly coupled to the wind and serve as roughness elements to scatter electromagnetic waves. A theory describing the coupled evolution of wind and waves is thus required for the interpretation of

measurements from instruments depending on such scattering, such as satellite radars.

Results

A wind-over-waves coupling (wowc) theory¹⁻⁴ has been developed. It is a modern, and internationally recognized theory of microscale air-sea interaction. The theory allows to relate the momentum flux (or surface stress) directly to the properties of wind waves, and to explain the formation of fluxes and their variability. It is valid for all sea state stages, starting from very low winds and a smooth sea surface, up to hurricane winds when the surface is disrupted and waves actively break.

It has been shown that the form drag of the sea surface, which is a correlation between the wave-induced surface pressure field and the wave slope, is responsible for the momentum transfer. The scheme shown in Figure 1 sketches our current understanding as to how changes to waves impact on the surface stress. The atmosphere provides the energy input to the wave field. Waves in turn support stress to the atmosphere. Thus atmosphere and waves together form a self-consistent, balanced system. If ocean surface phenomena such as currents, swell or slicks affect the wave field, the coupled atmosphere-waves system will adjust itself to a new balance. This explains the variability of fluxes as a result of interaction of waves with the ocean surface phenomena. The wowc theory was

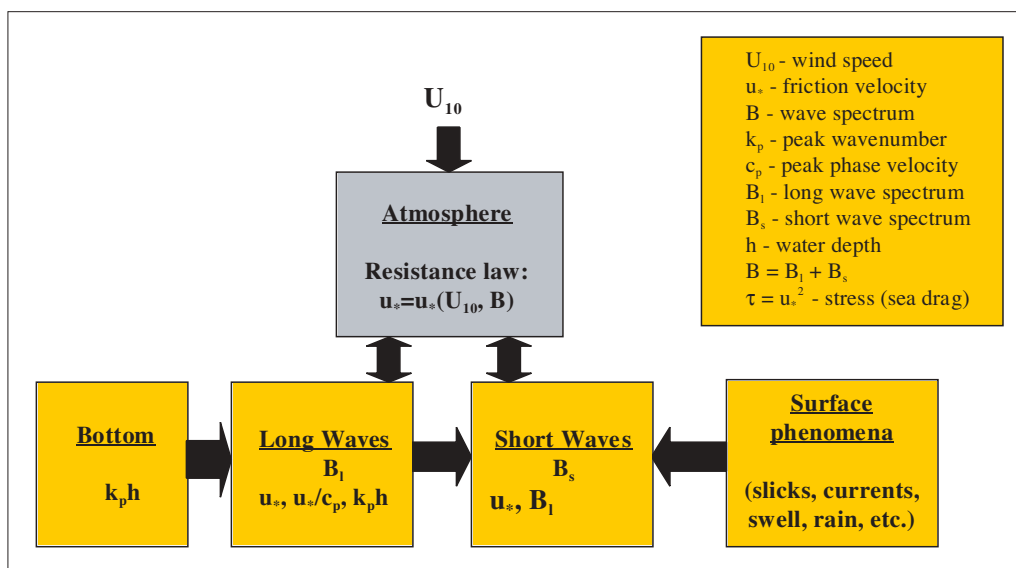


Figure 1. Schematic description of the wind-over-waves coupling. Arrows indicate impacts.

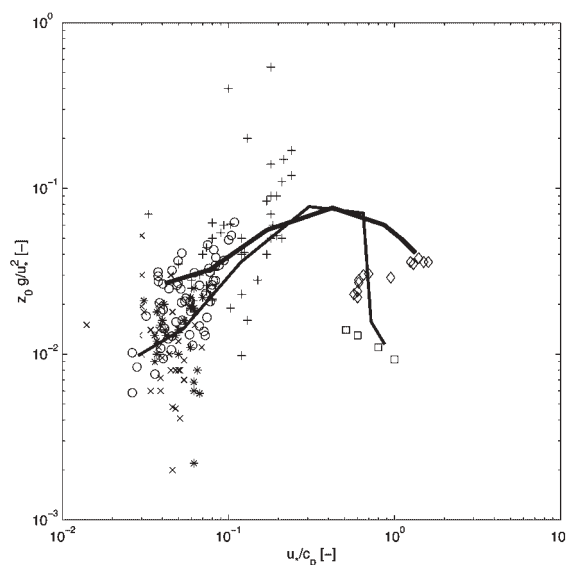


Figure 2. Charnock parameter $z_0 g / u_*^2$ versus inverse wave age u_* / c_p . Model results: thin solid line - $U_{10} = 7.5 \text{ ms}^{-1}$; thick solid line - $U_{10} = 20 \text{ ms}^{-1}$. Symbols indicate data: circles - North Sea; pluses - Lake Ontario; stars - Atlantic Ocean, long fetch; x-marks - Atlantic Ocean, limited fetch; diamonds and squares - wave tanks.

The wind-over-waves coupling theory allows to relate sea surface fluxes directly to the properties of wind waves and the peculiarities of their interaction with wind and ocean surface phenomena

successfully verified on several experimental data sets covering a wide range of conditions⁴⁾, see Figure 2.

An advanced parameterization of the sea stress based on the wowc theory has been developed⁵⁾. This parametrization takes both wind speed and sea state into account, and is intended to be used in operational ocean and atmosphere models. Possible applications of the wowc theory to the interpretation of remote sensing data are described in⁶⁾.

Outlook

The wowc theory forms a new framework in which transfer processes at the ocean surface can be studied. Further developments will include the impact of swell, stratification effects, and the impact of spray under extreme hurricane conditions. It allows also the development of advanced models of the sea surface, to serve as a basic element in algorithms interpreting remote sensing data, thereby improving the monitoring of the ocean surface.

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Climatology of extreme winds for the Dutch coastal areas

Janneke Ettema, Job Verkaik and Ilja Smits

Introduction

Wind is an important driving force for wave growth and surge. Knowledge of extreme wind speed levels in the coastal regions of the Netherlands and over inland water bodies is therefore of vital importance for determining the risks of flooding. Every 5 years, Dutch authorities require updates of the required safety levels for the sea and river dikes, the so-called hydraulic boundary conditions. The KNMI-HYDRA project aims at providing an updated wind climatology for the Dutch coastal zone (including extremes) on the basis of a thorough analysis of historical time series of surface wind speed observations.

Objective

Levels of wind speed with return periods from 0.5 year up to 10,000 years are requested for offshore locations and over the inland water bodies of the Netherlands. To accomplish this, extreme value theory has to be applied to series of past surface wind speed measurements. This will yield marginal statistics for individual wind direction sectors and seasons, as well as omni-directional, yearly statistics. In addition, an interpolation method is required to translate the wind speed statistics from the observation sites to relevant locations in the land-water transition zone. The newly derived wind climatology is intended to replace the previous assessment by Wieringa and Rijkoort¹⁾.

Results

A high quality dataset has been prepared comprising time series of hourly-averaged wind speed and

direction from 51 Dutch meteorological stations. All series are corrected for time-dependent observational changes and changes in local disturbances. From this dataset, 31 stations with at least 19 years of data since 1950 have been selected for extreme value analysis. In each series, independent storm events are identified. They have been modelled using the conditional Weibull distribution (CWD) and the generalised Pareto distribution (GPD) (see Figure 1). The statistical analysis has clarified many obscurities in the analysis performed by Rijkoort and Wieringa²⁾.

The interpolation method has enabled the inclusion of detailed surface roughness information in the wind climatology. The spatial interpolation from the observation sites to the required coastal locations has been performed using the two-layer model of Wieringa³⁾. The model parameters have been derived from a newly developed high-resolution surface roughness map, which is produced by evaluation of land-use maps with a simple footprint model. It turns out that the resulting wind speed estimates over open water are considerably higher than former estimates⁴⁾.

The integration of the statistical analysis and the interpolation method has not yet been entirely successful. The spatial dimension of high wind speed events is often small compared to the density of the measuring network. The smoothing effect of the interpolation method then leads to strong underestimation of wind speed extremes. This effect can be avoided by applying the statistical analysis first and interpolating the derived extreme

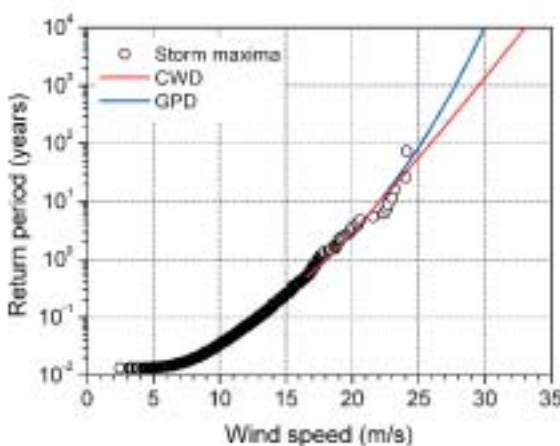


Figure 1. Observed storm maxima and modelled storm maxima using the conditional Weibull distribution (CWD) and the generalised Pareto distribution (GPD) for station Eelde.



Figure 2. Visualisation of the 10,000-year return levels for 19 stations. The values at the station locations have been derived by spatial interpolation of estimated extreme wind speeds of the surrounding stations.



Figure 3. Visualisation of the 10,000-year return levels for 19 stations. The values at the station locations have been derived by statistical extrapolation of the station observations.

Proper integration of wind statistics derived from station locations and spatial interpolation to areas of interest is expected to reduce statistical uncertainties significantly

wind speed levels, rather than interpolating the underlying time series. As an example, the resulting geographical pattern of the wind speed with return period 10,000 years is plotted in Figure 2 for a subset of the data (19 stations, period 1972–2001). Comparison with statistical estimates at the station locations without interpolation (Figure 3) shows large differences in particular in the southwest coastal region of the Netherlands. This implies that the geographical pattern of extreme wind speed levels cannot be fully understood from differences in surface roughness only.

Outlook

Proper integration of wind statistics derived from station locations and spatial interpolation to areas of interest is expected to reduce statistical uncertainties significantly. The relatively low extreme wind speed levels found in the southwest coastal region of the Netherlands demand a better understanding of the physical nature of the selected storm events. Confidence in the interpolated wind speed estimates over water and in the land–water transition zone can be enhanced by in situ verification.

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European Climate Assessment

Janet Wijngaard and Albert Klein Tank

Introduction

Climate extremes, such as flood-producing rains, droughts, and severe heat and cold, have major impacts for our living conditions and activities. The wish to anticipate changes in the occurrence of such extremes and the concern about anthropogenic climate change triggered the decision of the European network of meteorological services EUMETNET to start the European Climate Assessment (ECA) project. KNMI was appointed responsible member in 1998 and we immediately recognised that changes in extreme events could only be objectively identified by a thorough analysis of observations at meteorological stations.

Objective

ECA aimed at gathering of daily series of observations at meteorological stations in Europe and the Middle East (Region VI of the World Meteorological Organisation, WMO), analysing the data and subsequently disseminating the data and the analysis results. The daily station series needed rigorous quality control and tests for homogeneity before being submitted to trend analysis of extremes. The key questions addressed in the trend analysis were: 'how did the past warming affect the occurrence of temperature extremes' and 'was the past warming accompanied by a detectable change in precipitation extremes'. These are questions that require an accurate, dense and consistent dataset with at least a daily resolution.

Results

Daily series of temperature and precipitation collated for stations from countries all over Europe (Figure 1) have been made freely available for scientific use at the project website¹⁾. Most station series cover a period of 50 years or more. Metadata information on station history, data quality flags and homogeneity flags have been included. The homogeneity flags classify each series as "useful", "doubtful" or "suspect" on the basis of four tests (Figure 2). Only series classified as "useful" are subjected to further trend analysis.

The final report, which addresses the climatological and impact communities, policy makers and the general public, describes all results²⁾.

With respect to trends in extremes it concludes that:

- The observed decreases in cold extremes and increases in warm extremes (e.g. Figure 3) are generally consistent with a mean warming for Europe. Remarkably, the cold and warm trends do not always match. For instance during the warm recent decades, the number of cold extremes has decreased at a lower rate than the rate of increase in the number of warm extremes.
- For precipitation, the dominant warming trend between 1946 and 1999 was generally accompanied by a slight increase in wet extremes. This is seen in particular at locations where the annual amount of rainfall has increased.

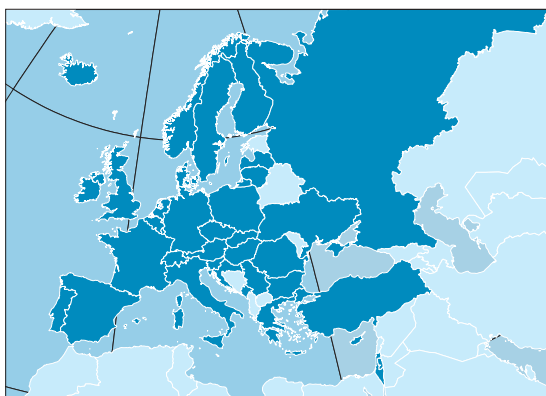


Figure 1. Participating countries in the ECA project (status May 2002).

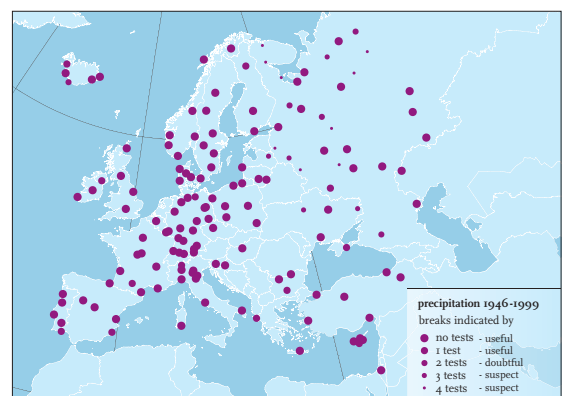


Figure 2. Number of homogeneity tests indicating a break in the series with associated classification for precipitation (period 1946-1999).

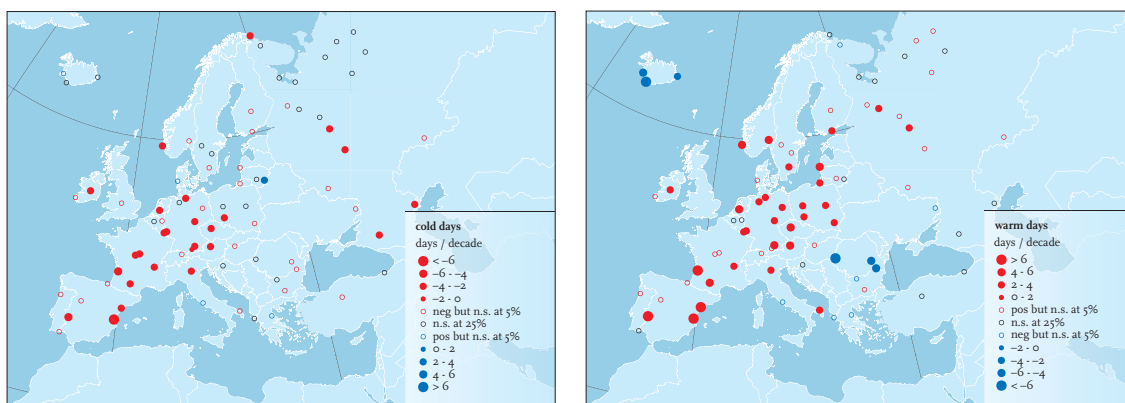


Figure 3. Trends in annual number of cold days and warm days in the 1946-1999 period. Cold days and warm days are defined as days with mean temperature crossing the seasonally varying 10th and 90th percentiles in the 1961-1990 baseline period.

The combination of data collection and dissemination with quality control, homogeneity testing and trend analysis proves to be essential for success

Apart from these deliverables, ECA participants produced a number of papers in peer-reviewed journals describing the analyses in more detail³⁻⁵⁾. ECA is linked to working groups of the Intergovernmental Panel on Climate Change (IPCC), and its results are incorporated in IPCC's Third Assessment Report. For WMO's Commission for Climatology and the Research Programme on Climate Variability and predictability (CLIVAR), ECA maintains a comprehensive list of indices derived from daily surface data and providing insights into changes in climate extremes. There are also links to research and technical projects in the framework of the European Union. Through further matching with WMO requests for long daily station series, the project makes it possible to regard the daily dataset as Europe's contribution to the Global Climate Observing System (GCOS) Surface Network.

Outlook

As a follow-up, the European Climate Assessment & Dataset (ECA&D) project will build upon the unique co-operation of 36 institutions (meteorological services, universities and research centres). The project plans to extend the present dataset with more stations and meteorological elements, broaden the network of participating countries, and intensify the homogeneity analysis of daily series and the analysis of trends in climate extremes. Finally, it will be explored how the indices of extremes can be used by policymakers for impact assessment and the design of adaptation measures. ECA&D will continue the full range of ECA activities, as the combination of data collection and dissemination with quality control, homogeneity testing and trend analysis proves to be essential for success.

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The Netherlands Sciamachy Data Center

Wim Som de Cerff and John van de Vegte

Introduction

The Netherlands Sciamachy Data Center (NL-SCIA-DC) aims at providing access to measurements and data products from GOME and SCIAMACHY, both earth observation instruments mounted on satellites launched in 1995 and 2002 respectively. The NL-SCIA-DC provides data selection, processing and downloading mechanisms to scientists. It is accessible through the NL-SCIA-DC website neonet.knmi.nl. The NL-SCIA-DC has been developed in a joint effort of the Space Research Organisation Netherlands (SRON) and KNMI in the framework of the Netherlands Earth Observation NETWORK (NEONET) program¹.

Objectives

The need for the NL-SCIA-DC stems from the atmospheric researchers in the Netherlands who need faster access to and flexibility in accessing and processing SCIAMACHY and GOME data. The current implementation of the NL-SCIA-DC is an Internet-enabled application developed in Java, which is used by the science community to select, process and download GOME and SCIAMACHY data. It also includes facilities to test new data processing algorithms.

The core of the system is a relational database, called the “control database” (Figure 1). It contains

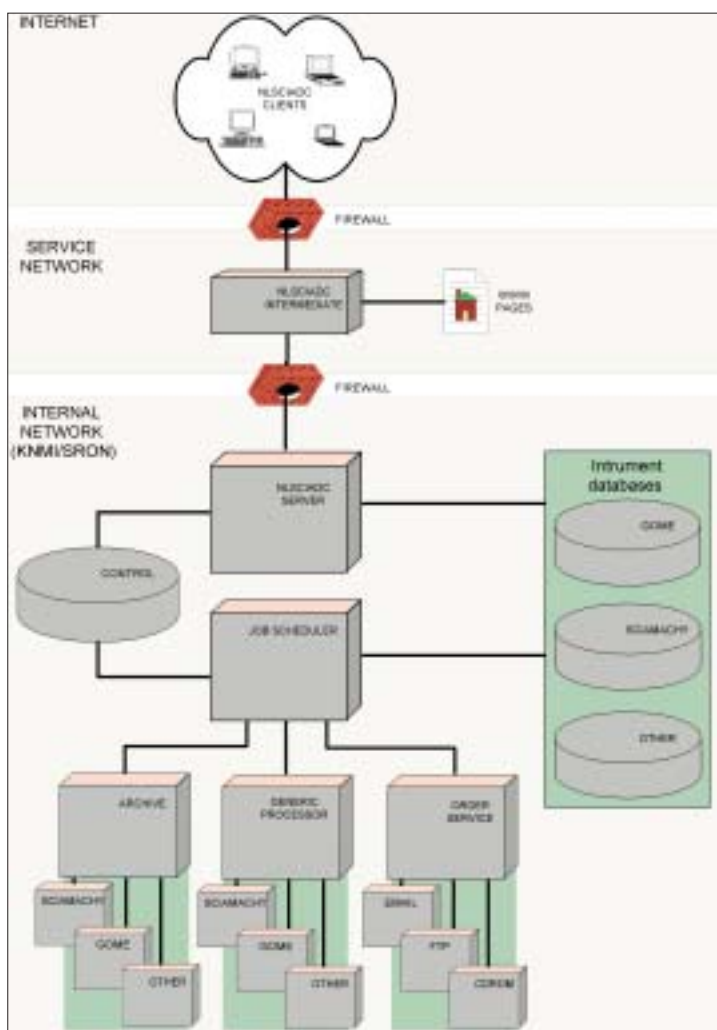


Figure 1. System layout.

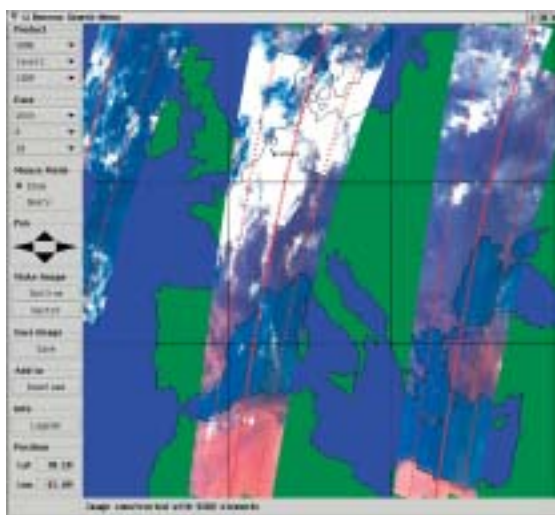


Figure 2. Browse window with visualization of satellite tracks.

The site has registered users from the Dutch and international GOME and SCIAMACHY science community and other research institutes

the user information, instrument data, data processors and their parameters, data processor locations and the locations of other databases, which contain the science data. The control database is used for building the graphical user interface (GUI) of the NL-SCI-DC and for controlling the process and download system. These fields are displayed in the GUI, giving the end-user the possibility to monitor the progress of the various actions.

The GUI is built dynamically from the settings in the control database. This provides the benefit that new processors and new databases can easily be integrated by adding fields in the control database. The development of a dynamic interface takes more time than hard coding of all the options directly in the GUI. However this investment will pay itself back in a more flexible system allowing easier adaptation to new demands, less maintenance and higher availability of the data center.

The data center offers three ways of selection: catalogue, browse and query. The catalogue provides a way of selecting complete data files in a file manager style. The browse selection (Figure 2)

allows for a graphical way of selection: satellite tracks can be displayed on a world map. This allows the user to select an interesting scene and download the corresponding data.

The third way is through a query on the available (meta) data parameters of the data (e.g. ozone value, zenith angle, pixel type).

Results

The NL-SCIA-DC data archive now contains over 2 Terabyte of data, growing daily as the SCIAMACHY mission continues. The data is accessible to the user in the previously described ways.

Outlook

The number of scientists using the NL-SCIA-DC is a measure for the success of the NL-SCIA-DC. Currently the site has registered users from the Dutch and international GOME and SCIAMACHY science community and other research institutes (EUMETSAT, ESA-ESTEC, BIRA, University of Leicester, TNO, RIVM). Furthermore, new research projects have started which will use the NL-SCIA-DC as a basic tool for their research.

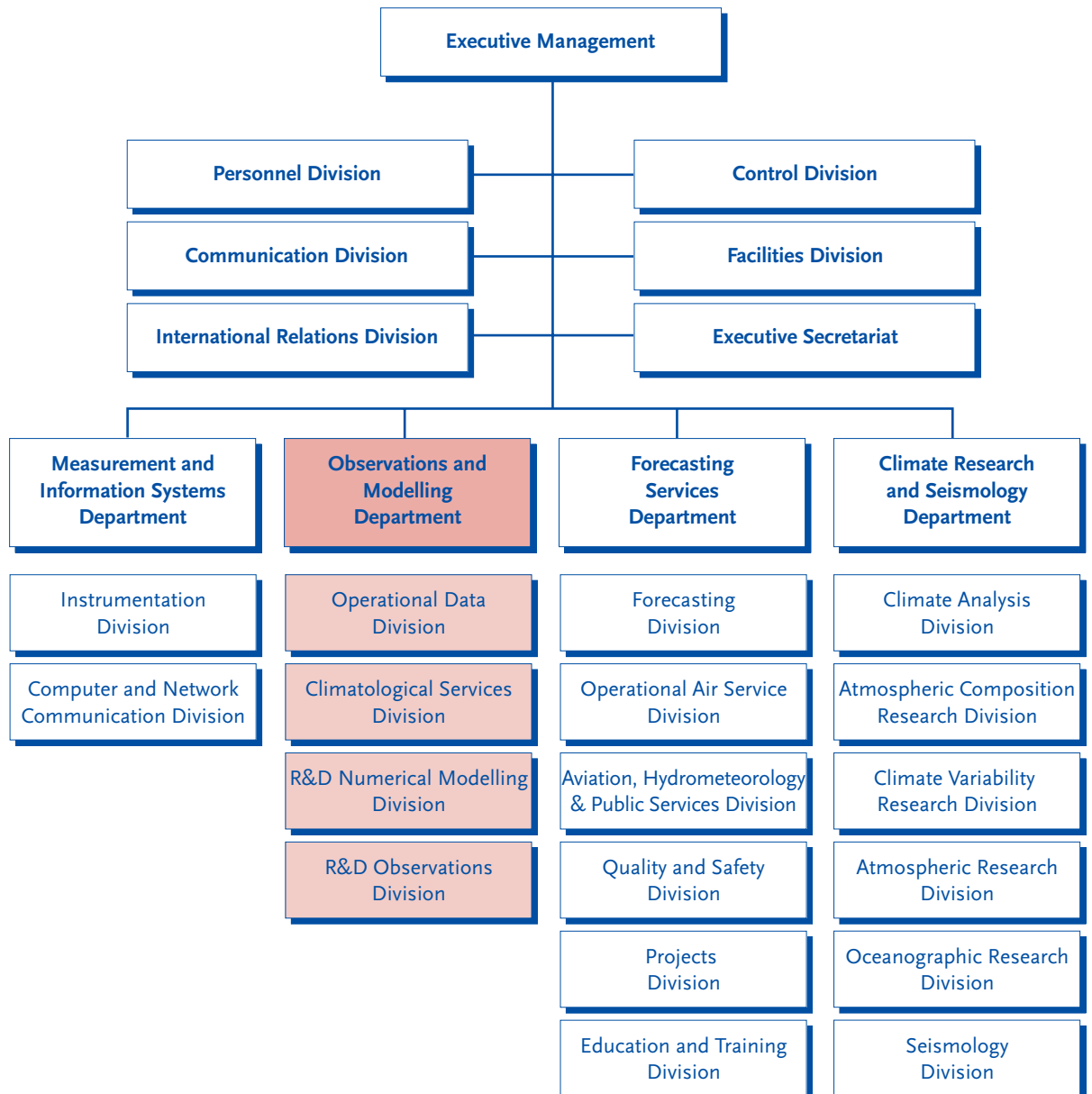
1) Barlag, S.J.M., et al., *The Netherlands Sciamachy Data Center*, Project Report, USP-2, SRON, January 2002.

Appendices

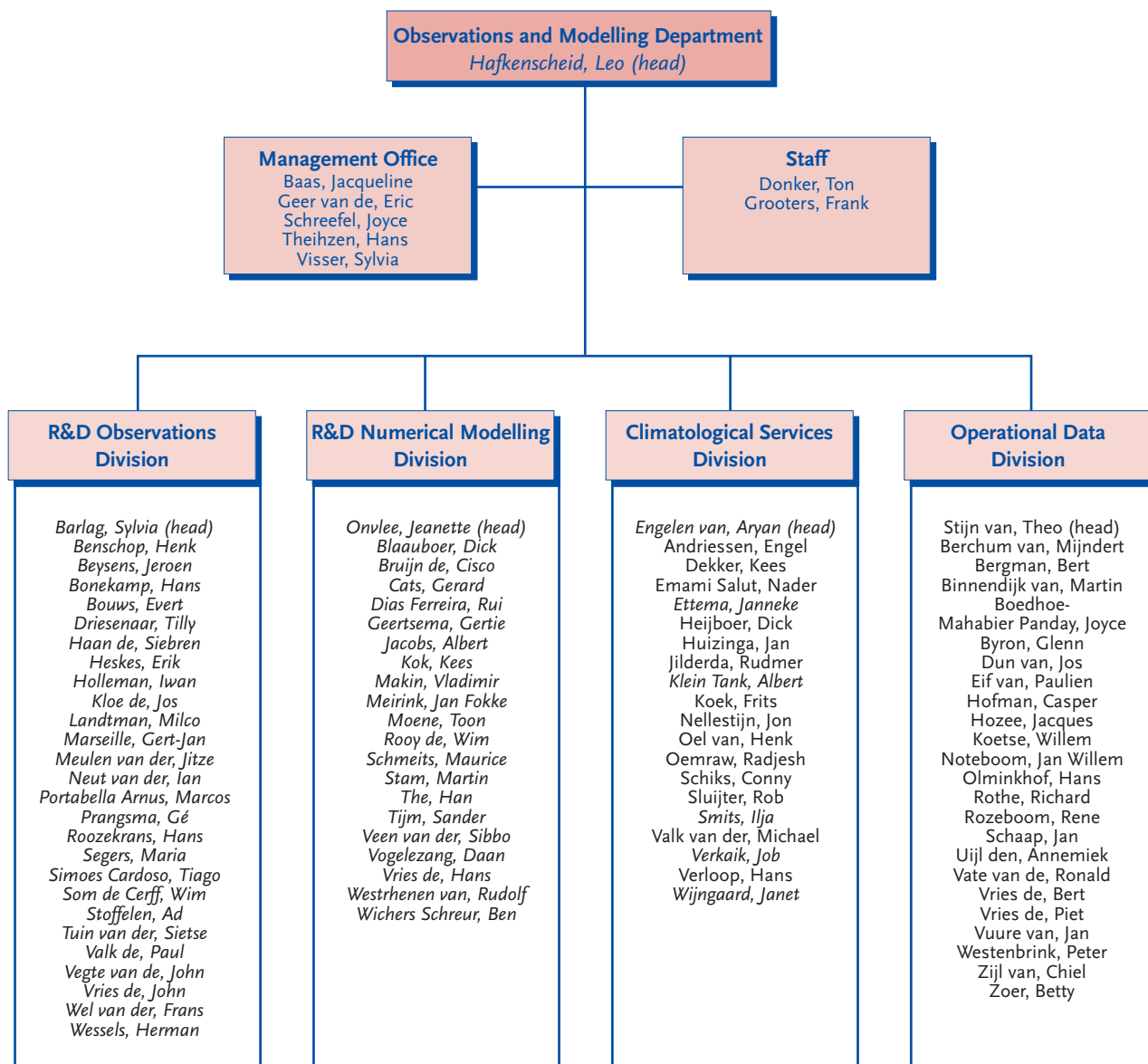


Organisational charts

KNMI



Observations and Modelling Department
(R&D personnel in italics)



Publications

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2001

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- Klein Tank, A.M.G., Data quality checking techniques, Presentation and teacher at NOAA/WMO Workshop on enhancing caribbean climate data collection and processing capability. University of the West Indies, Mona, Jamaica.
- Klein Tank, A.M.G., European Climate Assessment, Presentation at NORDKLIM- 'Nordic co-operation within climate activities' workshop, Helsinki, Finland.
- Klein Tank, A.M.G., Present and future climate, Presentation at Annual meeting of the National Union for Water management history, De Bilt, the Netherlands.
- Klein Tank, A.M.G., European Climate Assessment, Presentation for hydrologists of the Institute for water education UNESCO-IHE, De Bilt, the Netherlands.
- Klein Tank, A., and J. Wijngaard, Changes in European temperature and precipitation extremes. Poster at Climate Conference 2001, Utrecht, the Netherlands.
- Klein Tank, A.M.G., European Climate Assessment / ECSN Climate Dataset, Presentation at Management Committee meeting of COST-719, Funchal, Madeira.
- Klein Tank, A.M.G., European climate assessment & EUMETNET/ECSN climate dataset, Scientific lecture at the WMO Commission for Climatology (CCL) 13th session, Geneva, Switzerland.
- Kok, C.J., Cursus kansverwachtingen voor operationeel meteorologen (Course on probability forecasting for Dutch operational forecasters), De Bilt, The Netherlands. (in Dutch)

- Makin, V.K. and V.N. Kudryavtsev, Impact of long waves on sea drag, presentation Eur.Geophys.Soc. General Assembly, Nice, France.
- Makin, V.K., Wind-over-waves coupling theory - a revision, Presentation Wind-Over-Waves Coupling Conference, Cambridge, England.
- Onvlee, J.R.A., Mogelijkheden van downscaling toepassingen voor Rijkswaterstaat (Possibilities of downscaling applications for Rijkswaterstaat), Presentation in workshop on downscaling, De Bilt, The Netherlands. (in Dutch)
- Onvlee, J.R.A., Recente ontwikkelingen in de operationele wind- en golfverwachtingen van het KNMI (Recent developments in the operational wind and wave forecast systems at KNMI), Presentation for Meeting of Waves Group of Council for Physical- and Oceanographic Research of the North Sea, Delft, The Netherlands. (in Dutch)
- Onvlee, J.R.A., Volgens verwachting ... Modellen voor weer en klimaat op het KNMI (As predicted ... Models for weather and climate at KNMI), presentation for Department of Transport, Public Works and Water Management, De Bilt, The Netherlands. (in Dutch)
- Rooy, W.C. de, Performance of the modified CBR scheme, Hirlam All Staff Meeting, Reykjavik, Iceland.
- Rooy, W.C. de, High resolution physical post-processing, Management Committee meeting of COST-719, Funchal, Madeira.
- Roozkrans, J.N., Introduction to CLOUDMAP2 project, products and applications, CLOUDMAP2 User Workshop, Antalya, Turkey.
- Smits, A., Statistiek koppelt kansen aan wind extremen (Statistics relate probabilities to wind extremes), Presentation 4th HYDRA workshop, De Bilt, the Netherlands. (in Dutch)
- Smits, A., Elementaire statistiek en extreme waarden analyse (Elementary statistics and extreme statistics), Workshop Probability Forecasting, De Bilt, the Netherlands, Series of 5 workshops held between September 2000 and February 2003. (in Dutch)
- Tijm, A.B.C., Het nieuwe Hirlam (The new HIRLAM), presentation in meeting with service providers, De Bilt, The Netherlands. (in Dutch)
- Tijm, A.B.C., organization of Workshop mesoscale meteorology, De Bilt, The Netherlands.
- Tijm, A.B.C., Downscaling Hirlam wind, Presentation 4th HYDRA workshop, De Bilt, The Netherlands. (in Dutch)
- Tijm, A.B.C., Case studies: a way to develop metrics for extreme events?, Presentation for EUMETNET/SRNWP Verification workshop, De Bilt, The Netherlands.
- Veen, S.H. van der, MetClock cloud initialisation in HIRLAM, Hirlam All Staff Meeting, Reykjavik, Iceland.
- Verkaik, J.W., Wind, Short course for the Steel Building Engineering Association, Utrecht, The Netherlands. (in Dutch)
- Verkaik, J.W., Local wind speed estimation. Presentation for a selected research group at the Energy research Centre of the Netherlands (ECN), Petten, The Netherlands.
- Verkaik, J.W., Nieuwe Wieringa methode bepaalt wind op plaatsen zonder meetpunt of model gridpunt (New Wieringa method estimates wind at sites without observation or model grid point), Presentation 4th HYDRA workshop, De Bilt, the Netherlands. (in Dutch)
- Wel, F.J.M. van der, Dissemination of climatological data by means of the Internet, EGS Conference, Nice, France.
- Wichers Schreur, B., Introductie HIRLAM-22 (Introduction of HIRLAM-22), Congres Netherlands Society for Professional Meteorologists (NVBM), Wageningen, The Netherlands. (in Dutch).
- Wijngaard, J.B., European Climate Assessment, European Environment Agency (EEA) expert meeting on Climate Change Indicators, Copenhagen, Denmark.

2002

- Barlag, S.J.M., Meerjaren plan toegepast meteorologisch onderzoek 2002-2006 (Long-term research programme applied meteorology, 2002-2006), Presentation to meteorological service providers, De Bilt, The Netherlands. (in Dutch)
- Blaauboer, D., EUMETNET PWS-GTS, Presentation for EUMETNET/ProgramBoard on observations (PB-OBS), Paris, France.
- Bruijn, E.I.F. de, Experiments with ECMWF physics in the HIRLAM framework, Poster presentation for Eur. Geophys. Soc. General Assembly, Nice, France.

- Engelen, A.F.V. van, Climate of Europe, an assessment based on your contributions of high resolution datasets, Presentation XIIIth session of WMO Regional Association VI, Geneva, Switzerland.
- Engelen, A.F.V. van, The new Climate atlas of the Netherlands, and Progress in the European Climate Dataset and the European Climate Assessment, Presentation at European Climate Support Network (ECSN) Advisory Committee (EAC) meeting, Hohen Peissenberg, Germany.
- Engelen, A.F.V. van, Presentatie van de klimaatatlas van Nederland, normaalperiode 1971-2000 (Presentation of the Climate Atlas of the Netherlands, Normal Period 1971-2000), KNMI, De Bilt, the Netherlands. (in Dutch)
- Engelen, A.F.V. van, KNMI's contribution to the project Generating Climate Monitoring Products (GCMP), Presentation Expert meeting of the European Climate Support Network (ECSN) GCMP project, Hamburg, Germany.
- Ettema, J., Bestaat er een fysieke bovengrens aan de 10-meter wind? (Does a physical limit exist to the 10-meter wind speed?), Presentation 5th HYDRA Workshop, De Bilt, The Netherlands. (in Dutch)
- Geertsema, G.T., On the usage of the Ensemble system, Presentation for EU-Ensemble project meeting, Ispra, Italy.
- Geertsema, G.T., Veiligheidstaak van het KNMI: Verspreiding luchtverontreiniging (Safety task of KNMI: Dispersion of Air pollution), Presentation for Department of Transport, Public Works and Water Management, De Bilt, The Netherlands. (in Dutch)
- Haan, S. de, and H. van der Marel, The influence on GPS estimates of NWP derived mapping functions, EGS Conference, Nice, France.
- Holleman, I., Waarnemen van weer en wind (Observing weather and wind), invited lecture series for 1st-year students, Eindhoven University, The Netherlands. (in Dutch)
- Holleman, I., Wind Profiling by Doppler Weather Radar, Presentation COST-720 workshop on Atmospheric Profiling, L'Aquila, Italy.
- Holleman, I., High Quality Velocity Data Using Dual-PRF, Presentation ERAD-II conference, Delft, The Netherlands.
- Holleman, I., and L. Delobbe, Radar-based Hail Detection: case study using volumic data from two radars in Belgium and The Netherlands, Poster Presentation ERAD-II Conference, Delft, The Netherlands.
- Jacobs, A.J.M., Wind prognoses op kleine ruimtelijke schalen (Wind prognoses at small spatial scales), Presentation for Directie Kennis Rijkswaterstaat, De Bilt, The Netherlands. (in Dutch)
- Jacobs, A.J.M., Wind prognoses op kleine ruimtelijke schalen, Downscaling Methodiek (Wind prognoses at small spatial scales, the downscaling method), Presentation for meeting KNMI with traffic control and Coast Guard center, De Bilt, The Netherlands. (in Dutch)
- Jilderda, R., An analysis of yearly rainfall amounts in the context of a possible ground-water table rise in the coastal area of the Netherlands, Presentation European Conference on Applied Climatology, Brussels, Belgium.
- Jilderda, R., International co-operation in the field of water related matters, Presentation at the meeting of the Netherlands Union United Nations, Utrecht, The Netherlands.
- Klein Tank, A.M.G., Zijn de extremen van het klimaat van Europa veranderd? (Did the extremes of European climate change?), KNMI Colloquium, De Bilt, the Netherlands. (in Dutch)
- Klein Tank, A.M.G., Global/European Analysis of Extremes – recent trends –, IPCC Workshop on Changes in Extreme Weather and Climate Events, Beijing, China.
- Klein Tank, A.M.G., Identifying natural hazards in climate databases, ISDR/WMO/UNDP Workshop on Linking Disaster and Climate Databases, Geneva, Switzerland.
- Klein Tank, A.M.G., Weergegevens worden voor eeuwen op het KNMI bewaard; waarom? (Weather data are stored at KNMI for centuries; why?) National week for Science and Technology, De Bilt, the Netherlands.
- Klein Tank, A.M.G., Climatological extremes, Presentation European Conference on Applied Climatology, Brussels, Belgium.
- Kok, C.J., Cursus kansverwachtingen voor operationeel meteorologen (Course on probability forecasting for Dutch operational forecasters), De Bilt, The Netherlands. (in Dutch)
- Makin, V.K. and V.N. Kudryavtsev, New parameterization of the sea drag, presentation Eur.Geophys.Soc. General Assembly, Nice, France.
- Makin, V.K. and V.N. Kudryavtsev, On impact of short waves on wind growth of long waves, presentation Eur.Geophys.Soc. General assembly, Nice, France.
- Meulen, J.P. van der, Surface Measurements and Automation of Observations, CIMO-XII, Bratislava, Slovakia.

- Meulen, J.P. van der, Present Weather - Science, Exploratory actions on automatic present weather observations, EUMETNET PB-OBS 7th Meeting, Paris, France.
- Onvlee, J.R.A., Mesoschaal weersverwachtingen met het HIRLAM model (Mesoscale weather forecasts with the HIRLAM model), Presentation for Hoofddirectie Rijkswaterstaat, De Bilt, The Netherlands. (in Dutch)
- Onvlee, J.R.A., Het weer voor de komende dagen: Verleden, heden en toekomst van numerieke weersmodellen (The weather outlook for the coming days: past, present and future of numerical weather prediction models), Presentation for fluid physics group of Twente Technical University, De Bilt, The Netherlands. (in Dutch)
- Onvlee, J.R.A., HIRLAM en downscaling toepassingen voor de luchtvaart (HIRLAM and downscaling applications in aviation), Technical User Consultation meeting with aviation representatives, De Bilt, The Netherlands. (in Dutch)
- Onvlee, J.R.A., Projection of the Elbe 2002 event on the Rhine-Meuse catchment area, presentation in Meeting of European Working Group on Limited Area Modelling (EWGLAM), De Bilt, The Netherlands. (in Dutch)
- Onvlee, J.R.A., The weather outlook for the coming days: past, present and future of numerical weather prediction models, Presentation at Leiden University, Leiden, The Netherlands.
- Onvlee, J.R.A., Het weer voor de komende dagen: Hoe waarnemingen en weersmodellen worden gebruikt om weersverwachtingen te maken (The weather outlook for the coming days: how are observations and weather models used to create weather forecasts), Presentation for national week for science and technology, De Bilt, The Netherlands. (in Dutch)
- Roozekrans, J.N., Gebruik MSG in de operationele meteorologie en klimatologie (On the use of MSG in operational meteorology and climatology), Presentation at Technet meeting, Delft, The Netherlands. (in Dutch)
- Roozekrans, J.N., Satelliet waarnemingen van zeeoppervlakte temperatuur bij het KNMI (Satellite observations of sea surface temperature at KNMI), Presentation Meeting with meteorological service providers, De Bilt, The Netherlands. (in Dutch)
- Schmeits, M.J., Kansverwachtingen voor onweer met behulp van model output statistics (MOS) (Probability forecasts for thunderstorms using model output statistics), mini-symposium Netherlands Society for Professional Meteorologists (NVBM), Wageningen, the Netherlands. (in Dutch)
- Smits, A., Elementaire statistiek en extreme waarden analyse (Elementary statistics and extreme statistics), Workshop Probability Forecasting, De Bilt, the Netherlands, Series of 5 workshops held between September 2000 and February 2003. (in Dutch)
- Smits, A., Statistiek koppelt kansen aan wind extremen: opties in de analyse van stormmaxima (Statistics relate probabilities to wind extremes: options in the analysis of storm maxima), Presentation 5th HYDRA workshop, De Bilt, The Netherlands. (in Dutch)
- Smits, A., Recent trends in storm activity over the Netherlands, Presentation European Conference on Applied Climatology, Brussels, Belgium.
- Som de Cerff, W.J., The Netherlands Sciamachy Data Center, Presentation at the UNIDART Workshop, Langen, Germany.
- Stoffelen, A., Satellietmetingen en het weer (Satellite observations and the weather), Lectures for the NVWS circles, The Netherlands WeTeN Foundation, various locations. (in Dutch)
- Tijm, A.B.C., Workshop on mesoscale meteorology, De Bilt, The Netherlands.
- Tijm, A.B.C., Course on Hirlam for meteorologists in training, De Bilt, The Netherlands.
- Tijm, A.B.C., Status of Kain Fritsch Rasch Kristjansson and HIRLAM-22km experiences, Hirlam All Staff Meeting, Copenhagen, Denmark.
- Veen, S.H. van der, MetClock cloud initialization in HIRLAM, EU-project CLOUDMAP meeting, De Bilt, The Netherlands.
- Veen, S.H. van der, Meteosat cloud initialization in a high resolution limited area model, Presentation at EUMETSAT Conference, Dublin, Ireland.
- Verkaik, J.W., Wind, Short course for the Steel Building Engineering Association, Utrecht, The Netherlands. (in Dutch)
- Verkaik, J.W., Het HYDRA project: verleden, heden en toekomst; en Interpolatie met het twee lagen model: vooruitgang en obstakels (The HYDRA project: past, present and future; and Interpolation using the two-layer model: progress and obstacles), Presentations 5th HYDRA workshop, De Bilt, The Netherlands. (in Dutch)

- Verkaik, J. W., Wind Data for the Assessment of the Dutch Wind Climate, European Conference on Applied Climatology, Brussels, Belgium.
- Wel, F.J.M. van der, Results of the ECSN project ECD, Presentation UNIDART Workshop, Langen, Germany.
- Wel, F.J.M. van der, and S. Agersten, Accessing European Climate Data through the Internet - the ECD Project, Presentation EGS Conference, Nice, France.
- Wel, F.J.M. van der, COST-719: the use of GIS in meteorology and climatology, Presentation EGS Conference, Nice France.
- Wel, F.J.M. van der, Results of the ECSN project ECD, Presentation and demonstration KODAC Symposium, De Bilt, The Netherlands
- Wel, F.J.M. van der, The EUMETNET/ECSN Climate Data Set, Presentation European Conference on Applied Climatology, Brussels, Belgium.
- Wichers Schreur, B., Hirlam-22, Presentation at formal introduction of Hirlam-22, De Bilt, The Netherlands. (in Dutch)

Web pages

www.knmi.nl/onderzk/applied/wm/en/wm_rdindex.html

Meteorological research at KNMI / Applied research at KNMI

Observations

www.knmi.nl/onderzk/applied/ob/en/ob_radaridx.html

Development of new radar products

www.knmi.nl/onderzk/applied/sd/en/sd_sst.html

Impact of NOAA Sea Surface Temperatures (SST) in HIRLAM

www.knmi.nl/scatterometer

KNMI scatterometer web site

www.knmi.nl/scatterometer/qscat_prod/qscat_app.cgi

Quikscat products

www.knmi.nl/onderzk/applied/sd/en/sd_dwl.html

Doppler Wind Lidar in Space

www.knmi.nl/onderzk/applied/sd/en/sd_gps.html

Obtaining vertical atmospheric profiles by observing the occultation of GPS-satellites

www.knmi.nl/onderzk/applied/sd/en/sd_metclock.html

MetClock: a cloud analysis system based on Meteosat images

www.knmi.nl/onderzk/applied/turbowin/turbowin.html

TURBO-WIN: data collection software for Voluntary Observing Ships

www.knmi.nl/samenw/cloudmap2/

CLOUDMAP2 project website, Derivation of cloud parameters from satellites

www.knmi.nl/samenw/cost716/

COST716 project website, Exploitation of Ground Based GPS for Climate and NWP

www.knmi.nl/samenw/cost719/

COST719 project website, The use of Geographical Information Systems in Climatology and Meteorology

Modelling

hirlam.knmi.nl/

HIRLAM project website

www.knmi.nl/~tjrm/H11IR.html

Pseudo satellite images made with HIRLAM (Dutch only)

www.knmi.nl/~jacobs/en/downscaling.htm

Downscaling: general description, validation and experimental products

www.knmi.nl/onderzk/applied/mm/en/wi-p-sms.html

Downscaling: methodology

www.knmi.nl/~jacobs/en/aviation.htm

Short-term predictions for applications in aviation meteorology

www.knmi.nl/onderzk/applied/am/en/am_ktb.html

Metcast short term cloud prediction model

www.knmi.nl/onderzk/applied/am/nl/am_dispers.html

Atmospheric dispersion modelling (Dutch only)

www.knmi.nl/~jwdv/WAQUA/General.html

WAQUA storm surge model

www.knmi.nl/onderzk/applied/mm/en/nedwam.html

NEDWAM wave model for North Sea

www.knmi.nl/onderzk/applied/mm/en/nedw-obs_act/tsa_epl.html

Presentation of NEDWAM spectra versus observations for location Europlatform (EPL)

www.knmi.nl/onderzk/applied/stat/en/stat_index.html

Statistical postprocessing

Climatology

www.knmi.nl/voorkd/index_eng.html

Climatological services: Information on past weather (climatological data)

www.knmi.nl/samenw/hydra/

HYDRA wind climate of the Netherlands project website

www.knmi.nl/samenw/eca/

European Climate Assessment & Dataset (ECA&D) project website

www.knmi.nl/onderzk/hisklim/index-en.html

Historical Climate (HISKLIM) programme website

Data infrastructure

neonet.knmi.nl/

Netherlands Atmospheric Data Center

neonet.knmi.nl/neoaf/

The Netherlands SCIAMACHY Data Center

www.knmi.nl/samenw/codex/

The code explorer CODEX

<http://www.knmi.nl/onderzk/applied/datagrid/projectinfo.html>

DataGRID

Membership of committees

Barlag, S.J.M.

Working Group Remote Sensing of the Atmosphere (ROAT), Chairman
EUMETSAT Science and Technology Group, Delegate Netherlands
EUMETSAT Operations Working Group, Chairman
EUMETSAT Ocean and Sea Ice - Satellite Application Facility (OSI-SAF) Steering Group, KNMI Representative
GPS Receiver for Satellite Soundings - Satellite Application Facility (GRAS-SAF) Steering Group, EUMETSAT Science and Technology Group Representative
EUMETNET Programme Board for Observations, Member
Coordination of Sciences and Technology (COST716) Management Committee, Member (Chairman of Working Group 3)

Blaauboer, D.

WMO Commission for Basic Systems (CBS), Expert Team on Migration to Table Driven Code Forms, Member
European Working Group on Meteorological Work Stations (EGOWS), Member
EUMETNET Programme Present Weather Systems – Global Telecommunication System, Responsible Member
European Conference on Applied Meteorology (ECAM), International Scientific Planning Committee, Member

Bouws, E.

Co-ordination Group on Composite Observing System for the North Atlantic (COSNA), Member
National Oceanographic Data Commission (NODC), Member.

Cats, G.J.

International HIRLAM-5 project, System Manager
EUMETNET Short-Range Numerical Weather Prediction Programme, KNMI Representative

Donker, A.W.

ECMWF Advisory Committee on Data Policy, Member
ECOMET Working Group, Member
Informal Conference of the Directors of the Western European Weather Services (ICWED), Working Group on International Data Exchange, Member
EUMETSAT Working Group of licensing agents, Member

Dijk, W.C.M. van

WMO Intergovernmental Oceanographic Commission/European Group on Ocean Stations (IOC/EGOS), Member
International Civil Aviation Organisation (ICAO), Member

Engelen, A.F.V. van

WMO Commission for Climatology (CCI), Principal Delegate Netherlands
WMO CCI, Expert Team on Rescue, Preservation and Digitisation of Climate Records, Member
WMO Regional Association VI Working Group on Climate Related Matters, Observations and Data management, Member, Rapporteur
European Conference on Applied Climatology (ECAC), International Scientific Planning Committee, Member
EUMETNET/ECSN Advisory Committee, Member
EUMETNET/ECSN Programme European Climate Dataset (ECD), Responsible Member
EUMETNET/ECSN Programme European Climate Assessment (ECA), Responsible Member
EUMETNET/ECSN Programme Generating Climate Monitoring Products (GCMP), Advisory team, Core Member

National Commission of the International Hydrological Programme/Hydrological Research and Water Programme (IHP/HRWP), KNMI Representative
National Hydrological Platform (NHP), Member

Ettema, J.

Netherlands Standardization Institute (NEN) Working Group on Wind Climatology for Built-up Areas, Member

Grooters, A.T.F.

WMO Intergovernmental Oceanographic Commission/Data Relay and Platform Location System (IOC/ARGOS), Joint Tariff Agreement (JTA), Member
WMO Intergovernmental Oceanographic Commission/Data Buoy Cooperation Panel (IOC/DBCP), Member
WMO Aircraft Meteorological Data Relay (AMDAR) Panel, Chairman
WMO, Commission for Basic Systems (CBS), Expert Team on Observational Data Requirements and Redesign of the GOS, Member
WMO Aircraft to Satellite Data Relay (ASDAR) subgroup, Member
EUMETSAT Council, Advisor
EUMETSAT Working Group on Policy (WGP), Member
ESA, Program Board for Earth Observation, Head of delegation
ESA, Task force on Data Policy, Member
EUMETNET Composite Observing System (EUCOS) Programme, Advisory Committee, Member
EUMETNET Aircraft Meteorological Data Relay (E-AMDAR) Programme, Technical Advisory Group, Chairman
European Commission on Global Monitoring for Environment and Security (GMES), Steering Committee, Delegate

Haftkenscheid, L.M.

EUMETSAT Policy Advisory Committee, Member
EUMETNET, Program Board on Observations (PB_Obs), Chairman
EUMETNET Composite Observing System (EUCOS) Programme, Advisory Committee, Member

Jilderda, R.

WMO, Regional Association VI Working Group on Hydrology, Delegate Netherlands
National Commission of the International Hydrological Programme/Hydrological Research and Water Programme (IHP/HRWP), KNMI Representative
Study Group on the Hydrology of the Hupselse Beek catchment area, KNMI Representative
Study Group Urban Water in the Netherlands, KNMI Representative

Klein Tank, A.M.G.

WMO, Commission for Climatology (CCL), Delegate Netherlands
WMO CCL, Implementation/Coordination Team on Data Sets and on Climate System Monitoring, Member

Kok, C.J.

ECMWF, Ensemble Prediction System (EPS) expert meetings, KNMI Representative

Kruizinga, S.

ECMWF, Technical Advisory Committee, Chairman and KNMI Representative (until 2001).

Makin, V.K.

European Geophysical Society (EGS) Conference, Session on Air-sea Interaction, Chairman

Meulen, J.P. van der

WMO, Commission for Basic Systems (CBS), Open Programme Area Group Expert Team on Automatic

Weather Station (OPAG ET/AWS), Member
ESA Data Operations Scientific and Technical Advisory Group (DOSTAG), Member
EUMETNET, Program Board on Observations, Member

Moene, A.R.

ECMWF Technical Advisory Committee (TAC), KNMI Representative

Onvlee, J.R.A.

HIRLAM Advisory Committee, Vice-chairman
Steering Group Numerical Weather Prediction SAF, KNMI Representative
COST Technical Committee for Meteorology, Netherlands Representative
Waves Group of Council for Physical and Oceanographic Research of the North Sea, Chairman

Roozekrans, J.N.

EUMETSAT Satellite Data Users Conference, Scientific Programme Committee, Member

Stijn, Th.L. van

WMO, Commission for Basic Systems (CBS), Delegate Netherlands

Stoffelen, A.C.M.

ESA/EUMETSAT Advanced Scatterometer (ASCAT) Science Advisory Group, Member
ESA Atmospheric Dynamics Mission – Aeolus Advisory Group, Member
NASA Ocean Vector Wind Science Team, Member

Tuin, S. van der

EUMETSAT Administrative and Financial Group, Delegate Netherlands

Valk, J.P.J.M.M. de

Working Group Remote Sensing of the Atmosphere (ROAT), Member
EUMETSAT Science Working Group, Member

Verkaik, J.W.

Working group on Wind Technology of the Royal Institution of Engineers in the Netherlands (KIVI),
Member

Vries, J.W. de

ECMWF Member State Computing Representatives committee, KNMI Representative

Wichers Schreur, B.

EUMETNET Short-Range Numerical Weather Prediction Programme, Responsible Member for
Verification

Topics of user-driven research

Government: Water management

Coastal safety against flooding

- Wind climate and air-sea interaction description for hydraulic boundary conditions
- Improved storm surge and wave forecasting

Coastal zone management

- Appropriate wind input for high-resolution coastal hydrodynamical models
- Detailed wind and wave forecasts for coastal zone and IJsselmeer
- Improved wave forecasting methods

River floods

- Improved observations and modelling of precipitation in Rhine and Meuse basins
- Use of uncertainty information in support of crisis management
- Study Projection of Elbe 2002 flood onto Rhine and Meuse river basins
- Incorporation of meteorological information in High water Information System of Rijkswaterstaat

Regional water management (water boards)

- Improved description of precipitation on scale of water board regions
- Assessment of return frequencies of extreme precipitation and drought
- Specific weather information and warnings in situations of flooding or drought
- Use of uncertainty information in support of crisis management

Government: Air pollution dispersion in case of nuclear or chemical accidents

- Development and performance assessment of national dispersion model PUFF
- Regular training exercises with national crisis authorities and fire departments
- Selection of suitable chemical dispersion model

Government: Road transport safety

- Weather forecasts (icing, fog) for Traffic Information Center
- Ad-hoc advice, e.g. concerning High Speed (Rail) Link

Aviation

- Local wind behaviour at and close to runways, and impact of building activities
- Adaptations in observational network required by building activities and runway extensions at airports
- Use and quality assessment of aircraft observations
- Improved forecasts of severe weather relevant to aviation: gusts, hail, severe convection, poor visibility
- Feasibility studies on a second national airport at sea
- Use of uncertainty information in support of decision making by airport and airline authorities.

Commercial meteorological service providers and broadcasters

- New types of observational and model products
- Use and improvement of operational weather forecast products
- Use of probabilistic forecast information

Energy

- Detailed wind field information for wind energy production forecasts
- Radiation and cloud predictions for solar energy production forecasts and for climate control systems in greenhouses

Meteorological research community

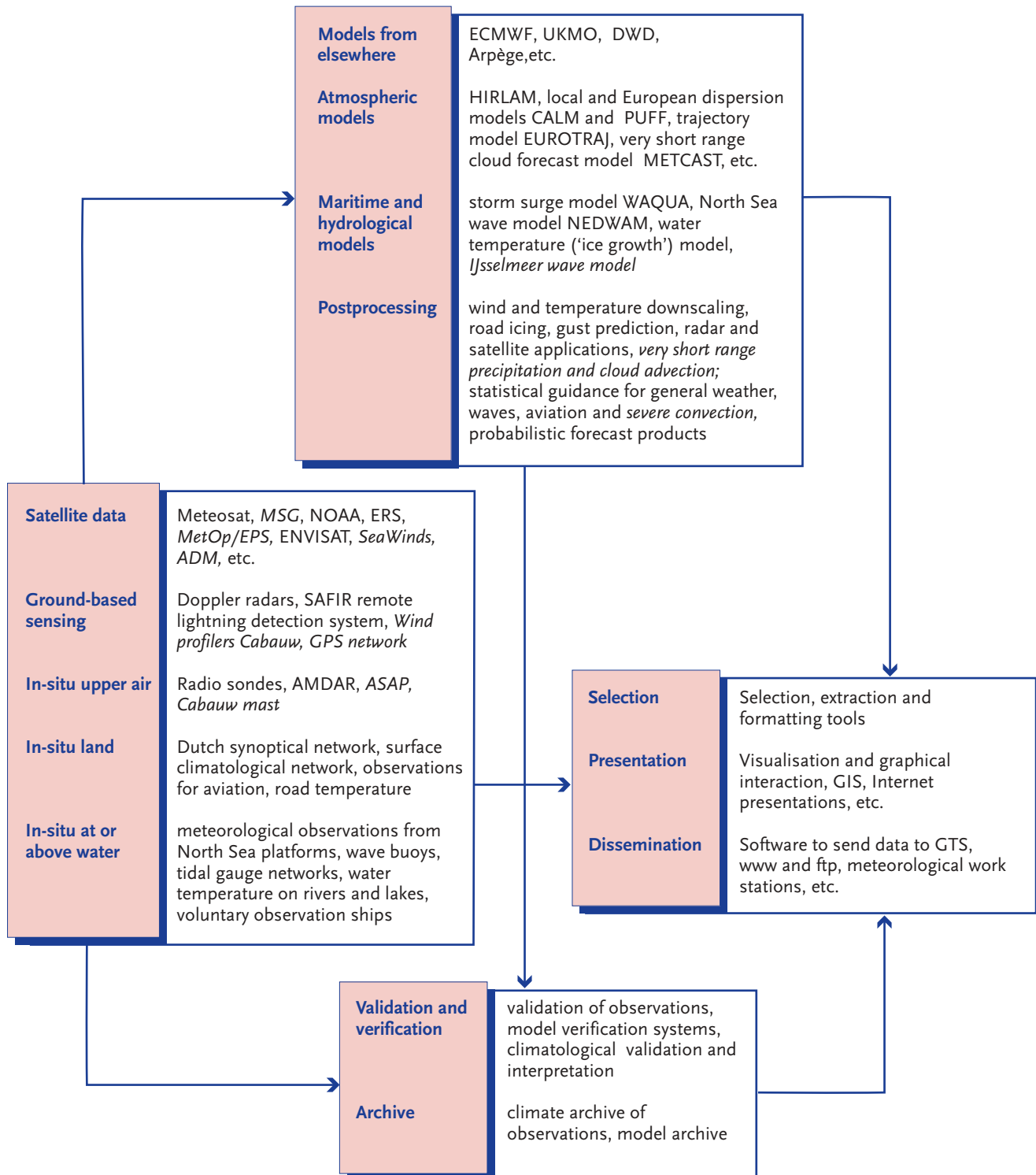
- Development of new (remote sensing) observation techniques
- Improved interpretation and use of (remote sensing) observations
- Development of a European Composite Observing System
- Development and quality assessment of limited area numerical weather prediction models of mesoscale resolution and higher
- Development and quality assessment of other forecasting techniques
- Suitable tools for data handling and data exchange

Climate research community

- Construction of, and provision of access to, European climate dataset of daily observations

Overview of operational systems and applications

KNMI's meteorological R&D activities aim primarily at improving the quality, availability and accessibility of operational meteorological observations and model data. Below, an overview is given of the main systems and applications involved. Pre-operational systems and applications are given in *italics*.



Acronyms

AAS	Amsterdam Airport Schiphol
AMDAR	Aircraft Meteorological Data Relay
AUTOTAF	Automated Terminal Area Forecast
AUTOTREND	Automated guidance for short-term aviation forecasts
AWS	Automatic Weather Station
CLIVAR	Research programme on Climate Variability and predictability
COST	Coordination of Science and Technology (EU programme)
DWD	Deutscher Wetterdienst (German weather service)
ECA	European Climate Assessment (EUMETNET programme)
ECMWF	European Center for Medium-range Weather Forecasts
ECSN	European Climate Support Network (EUMETNET programme)
EPS	Ensemble Prediction System
ESA	European Space Agency
ESTEC	European Space Research & Technology Centre
EUCOS	Eumetnet Composite Observing System (EUMETNET programme)
EUMETNET	European Meteorological Network (cooperative network)
EUMETSAT	European Meteorological Satellite Organisation
EUROTRAJ	KNMI trajectory model
GCOS	Global Climate Observing System
GIS	Geographical Information System
GPS	Global Positioning System
GTS	Global Telecommunication System (meteorology)
HDF	Hierarchical Data Format
HIRLAM	High Resolution Limited Area Model
HISKLIM	Historical Climate (KNMI programme)
HYDRA	Hydraulisch Randvoorwaarden (Hydraulic Boundary Conditions; project)
ICAO	International Civil Aviation Organisation
IPCC	Intergovernmental Panel on Climate Change
KNMI	Koninklijk Nederlands Meteorologisch Instituut (Royal Netherlands Meteorological Institute)
METAR	Meteorological Aviation Routine weather reports
MOS	Model Output Statistics
MSG	Meteosat Second Generation (satellite)
NASA	National Aeronautics and Space Administration
NEDWAM	Nederlands Wave Model (operational ocean wave model)
NEONET	Netherlands Earth Observation NETwork
NL-SCIA-DC	The Netherlands Sciamachy Data Center
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
PBL	Planetary Boundary-Layer
PUFF	KNMI national dispersion model
RMI	Royal Meteorological Institute of Belgium
SAF	Satellite Application Facility
SRON	Space Research Organisation Netherlands
SST	Sea Surface Temperature
TURBO-WIN	Software package for marine meteorological observers
UKMO	Met Office UK
UNIDART	Uniform Data Request Interface (EUMETNET programme)
VOS	Voluntary Observing Ship
WAQUA	Water Quality model (operational storm surge model)
WMO	World Meteorological Organisation
WMO-CBS	Commission for Basic Systems of WMO
WMO-CCI	Commission for Climatology of WMO

Colophon

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