Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

Annual Report 2010

KNMI round the clock

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Siebe Riedstra

Secretary-General Ministry of Infrastructure and Environment

Dear reader,

It gives me tremendous pleasure to write the foreword for the 2010 KNMI Annual Report. As Secretary-General of the newly formed Ministry of Infrastructure and the Environment, I am justifiably proud of our agency for weather, climate research and seismology in De Bilt. KNMI has until recently been part of the Ministry of Transport, Public Works and Water Management. However, after the Rutte government took office on October 14, 2010, this Ministry was merged with parts of the Ministry of Housing, Spatial Planning and the Environment to create the new Ministry of Infrastructure and the Environment. While creating an organisational structure for this new Ministry is a massive undertaking, made possible by the enthusiastic work of many, the benefits of this restructuring - including for KNMI - are becoming increasingly clear, thanks to the input from the former Ministry of Housing, Spatial Planning and the Environment. What previously would have been called 'overlap' between the two former Ministries has now been given substantive and administrative coherence, with all the inherent advantages.

Beyond the merger of our Ministries, the Rutte Cabinet had another surprise up its sleeve for KNMI, mentioning it by name in the financial section of the coalition agreement with respect to its remit: "The subsidies of the Ministry of Transport, Public Works and Water Management will be reduced. Furthermore, KNMI's current range of duties will be reassessed (possible privatisation)." We fully understand this mandate. After all, it offers opportunities to work in a future-oriented way on an appropriate assignment of national responsibilities with regard to weather, climate research and seismology, laying the ground for the sector to move ahead until at least the year 2020. It's my impression that State Secretary Joop Atsma will submit these plans to the Lower House sometime this summer and that these will then be debated by the Lower House this autumn.

This year's KNMI annual report takes a departure from previous editions. For this report, one day in the year 2010 has been selected at random; one of the 365 days a year KNMI addresses issues related to weather, climate research and seismology in the service of Dutch society. After all, KNMI never stands still. Our institute works around the clock on its core tasks, which are inextricably linked to the safety and security of the Netherlands. As an agency of the Ministry of Infrastructure and the Environment, KNMI serves as a repository of vital meteorological expertise used to warn the Netherlands about extreme weather and, for instance, maintain the safety of Dutch airspace for air travel 24 hours a day. KNMI climatologists work daily on the development of climate scenarios and new insights at both national and international level, thus providing knowledge that is of vital importance to our small, low-lying country, bordering as it does on the sea. Let's not forget the seismologists, who – largely in the Netherlands, but also all round the world – monitor, research and identify seismic activity: natural earthquakes in the province of Limburg, earthquakes attributable to natural gas extraction in the north of the Netherlands and more recently the dramatic earthquake and tsunami event in Japan.

It must not have been hard to find inspiration for this report's theme: 'KNMI round the clock'. I often hear how surprised people are on their first visit to KNMI. Of course, while just about everybody has heard of KNMI, far fewer people are aware of all the work being done and all the resources and facilities it can call on to carry out its core tasks. This is why this annual report presents an hour-by-hour account of a day in the life of KNMI, offering a glimpse into all the tasks it performs - each day, every day.

I hope you enjoy reading it!

Siebe Riedstra
Secretary-General
Ministry of Infrastructure and the Environment

from midnight till 01.00 a.m.

KNMI keeps on going... around the clock

The KNMI offices in De Bilt seem deserted at this hour of the day. The perimeter fencing is locked, and most of the lights in the building are out. The reception area near the main entrance is unmanned, and there is no sign of life in the building corridors. All that can be heard is the hum of a computer tucked away in some corner. It's midnight at KNMI. You can hear a pin drop.

This air of calm is deceiving, however. Located on the third floor is the beating heart of KNMI – the forecasting office. Much like the weather, it is 'on the go' 24 hours a day. This is where KNMI issues its weather forecasts and warnings for the general public, as well as for the aviation and maritime sectors, using high tech displays to constantly monitor meteorological developments all round the world, including extreme wind gusts and lightning storms, black ice, snow fall, volcanic eruptions on Iceland, earthquakes, thick fog, or simply calm, tranquil weather.

At 11 p.m., the five member team working the evening shift makes way for the staff of five braving the night shift. Before taking up their positions, the night shift staff reviews the events of the previous day and look ahead to the coming night and day. Are there any surprises brewing or any other meteorological conditions to note?

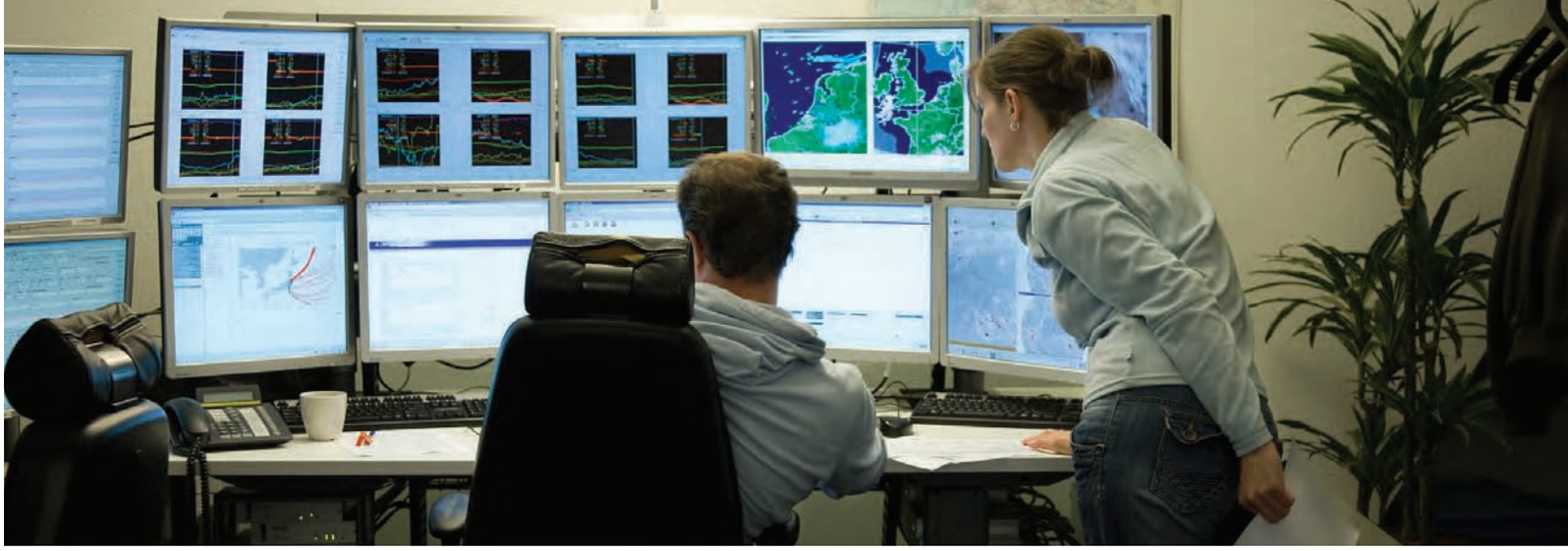
All meteorologists are grouped according to their own niche specialisation into sectors, namely Safety (general weather forecasting and warnings), North Sea (the North Sea and helicopters), Regional (regional airports and ballooning), Mainport Schiphol (Amsterdam Airport Schiphol) and Operator. There is also a space reserved for any additional expertise deployed when ferocious meteorological conditions arise or when disaster response efforts must take the weather into account. This includes, for instance, an incident involving chemical and nuclear substances dispersed in the air.

Spider in the web

In this company the operator can be considered the 'spider in the web'. In the event of an actual crisis, such as the chaos in April 2010 caused by the volcanic ash cloud originating from Iceland, the operator bears responsibility for informing the ministries and embassies, as well as the National Crisis Centre and the traffic control centres of the executive arm of the Ministry of Infrastructure and the Environment (Rijkswaterstaat) and of ANWB, of meteorological conditions and keeping them apprised of developments. The operator eventually also informs KNMI Director-General Frits Brouwer about what is happening. The operator receives on-site support in this task in the form of data from the meteorologists.

North Sea

A little further along, the meteorologist responsible for meteorological forecasting for the North Sea and the surrounding area receives data from the most recent run of the High Resolution Limited Area Model (HIRLAM). This weather model for short-term weather forecasting, developed by KNMI in close cooperation with Denmark, France, Finland, Ireland, Iceland, Norway, Spain and Sweden, can handle runs with a horizontal grid resolution of up to eleven kilometres. As the calculations made involve a relatively small geographical area, it does not take long to compile the necessary data. The results are available more rapidly than those of the long-term forecasts. In other words, the meteorologist receives the HIRLAM calculations quickly, so that any minor changes can be detected immediately and



the forecasts adjusted in a timely manner. The results from the HIRLAM model and other sources serve as the basis for Weather Alerts and Alarms issued by KNMI online or on NOS teletext pages 710 and 713.

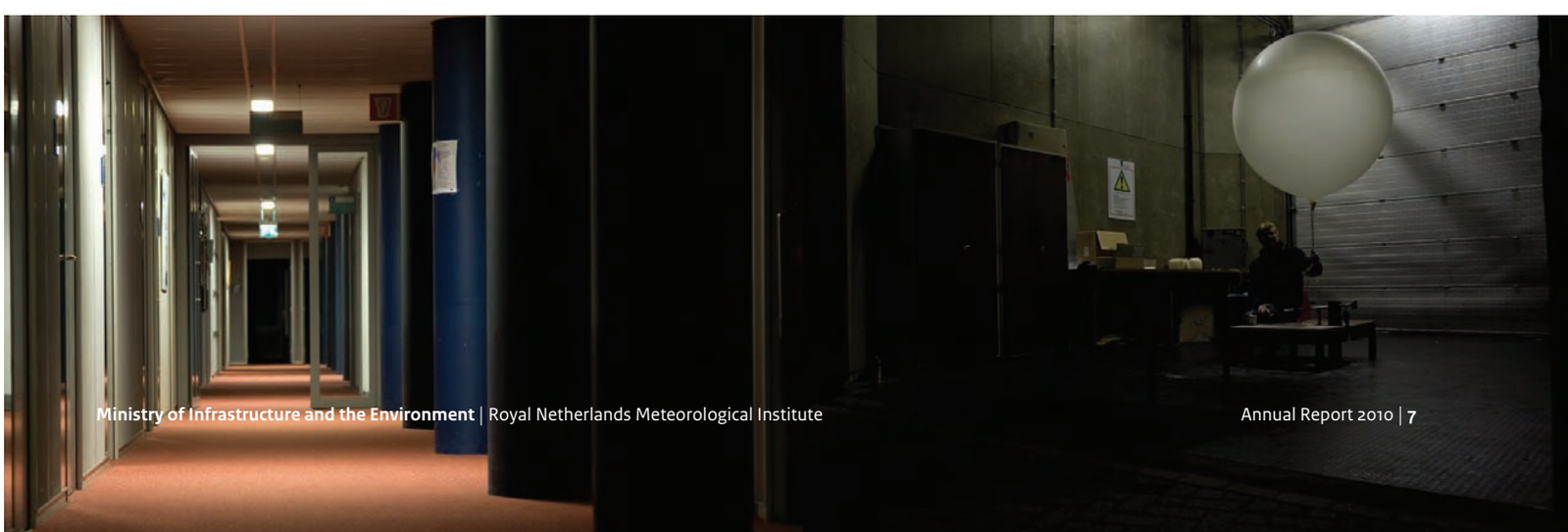
If, for instance, a small scale disturbance develops or intensifies off the Dutch coast, it will greatly impact weather conditions in our country in the hours to follow. This could mean that it will rain harder or that wind gusts will be stronger than previously forecast. HIRLAM also facilitates the close monitoring of such small-scale developments. A new 48 hour forecast is issued four times a day for an area of about 3,000 kilometres around the Netherlands. In addition, six hour forecasts are also issued four times a day. "We pass the data on to the Dutch Coast Guard, as well as to the North Sea regional department of the executive arm of the Ministry of Infrastructure and the Environment (Rijkswaterstaat). We contact these agencies at least four times a day to review the latest developments, which can include information on wind speed, surge – or, in other words, 'how high the water will reach along the coast' – wave action and swell. We only discuss the facts of the situation. Decisions will be taken by the accountable agencies."

Weather balloon

About half past midnight, the operator leaves the team and goes to the weather observation area to release the weather balloon and with it the radiosonde. These helium-filled balloons are released twice a day to gather upper air data to supplement the collected surface data. The results are transmitted to De Bilt by radio. Achieving a height of 20 to 30 kilometres during its one- to two-hour flight, the radiosonde measures temperature, humidity and air pressure. Its position is tracked to determine wind direction and wind speed. The higher the balloon goes the thinner the air becomes. The balloon will expand and eventually explode. The radiosonde, which can only be used once, then returns to the surface by parachute. The finder can keep it, dispose of it as minor chemical waste or even return it to KNMI for further processing. Since 1992, an ozone sensor has accompanied the balloon once or twice a week to measure atmospheric ozone levels.

"These radiosondes are released at nearly every national weather station," explains the operator. "We're talking about a global network of about 500 weather stations." The data generated is absolutely vital to both short-term and multi-day weather forecasting. Ground-level measurements tell you little about air currents at higher altitudes; upper air winds determine the weather for the next few days. This data also benefits the aviation sector. For instance, upper air measurements can be used to determine whether ice accretion will be an issue. Releasing balloons may seem old fashioned, but it continues to yield relevant data. Incidentally, we are working to replace this weather observation method with aircraft based observations.

The day-shift team arrives around 6.30 a.m. and the baton is passed at 7 a.m. The day shift staff will run though the same procedures and perform the same work as the night shift... But slightly different. After all, KNMI never stands still.



from 01.00 till 02.00 a.m.

Maritime observations all over the world

"Hold tight!" The captain of the Emma Maersk looks at his helmsman and sees that he is struggling to remain upright as his ship crashes through the waves. The anemometer indicates strong gales approaching wind force 9. The captain is fully aware of the potential danger. Loaded with 12,000 containers, his ship is easy prey for the storm. He will need every bit of horsepower at his disposal if he is to reach the Port of Rotterdam safely. He calls for his second helmsman and asks, "Has the weather observation data already been sent to KNMI?" He knows that this part of the North Sea is travelled infrequently, which makes the weather observation data vital to, for instance, the shipping forecast. The barometer continues to fall, which does not bode well for the next few hours. The second helmsman is already busy compiling relevant weather observation data. The data sent to KNMI via the ship's satellite link will include wind force and direction, air pressure and temperature.

Throughout the day, more than 4,000 vessels around the world are taking part in the Voluntary Observing Ship (VOS) Scheme, which is a support programme of the World Meteorological Organisation (WMO) implemented in cooperation with the International Maritime Organisation (IMO). They transmit the meteorological data they gather to designated meteorological institutes. This information, along with the data collected by satellite and read from hundreds of data buoys, forms the backbone of efforts to compile surface marine meteorological data. As two-thirds of the Earth is covered by oceans, all relevant information plays a vital role in accurately analysing pressure systems that affect the weather.

150 ships

Participation in this project, which was initiated following the sinking of the Titanic, is laid down in the International Convention for the Safety of Lives at Sea (SOLAS) of 1914. The data was previously recorded in logbooks, but nowadays the data can be transmitted directly to the affiliated weather institute using a satellite link. The data is processed automatically, corrected (if necessary) and then distributed internationally via the Global Telecommunication System (GTS), meaning it can be analysed and utilised all over the world. The data is used in the determination of the current state of the weather and for climate research. The weather observation dataset used for this research goes back many years and is one of the oldest series of meteorological data available.

With about 150 highly active ships currently taking part, the Dutch VOS fleet has in the past year contributed 79,000 weather observation reports of extremely high quality to the international community. We work closely with our colleagues in Germany and the UK to further improve the service we provide to the VOS Scheme. EUMETNET plays a significant role in this work. The meteorological services of 24 European countries have formed an alliance to coordinate their efforts in this regard as part of the purposely designed EUMETNET Surface Marine (E-SURFMAR) programme. The alliance participants are working diligently to automate the VOS Scheme. This will soon result in the generation of additional weather observations of an even higher quality.

The business community

KNMI staff responsible for coordinating this work are known as the Port Meteorological Officers (PMOs). Their primary task is to equip the ships with weather observation equipment, maintain contact with shipping companies and officers, and safeguard the qualitative and quantitative aspects of the weather observations. Foreign meteorological services regularly call upon their services. Intensive international cooperation is required to assist all VOS Scheme ships based in the ports of Rotterdam, Antwerp and Amsterdam. To this end, a special web application was developed in conjunction with a Rotterdam business community that is now used not only in the Netherlands, but also by our colleagues in Germany, France and the UK.

Apart from maintaining a fleet of ships, PMOs also deserve praise for coordinating the placement of the data buoys used to gather surface marine meteorological data. These are made available as part of a pan-European coordinating programme. KNMI developed special software to ensure the quality of observations made on board vessels, which WMO recommends for use anywhere in the world.

Royal honour

Once in Rotterdam, the PMO visits the captain of the Emma Maersk. Fortunately, his ship sustained no damage during the storm. He will soon receive a royal honour for his services to maritime meteorology.

from 02.00 till 03.00 a.m.

Indispensable computing power

The computers run full speed day and night calculating the weather models. Depending on the model's level of detail and the number of days for which the model is being used, the model forecasts are ready anywhere from 1.5 hours to nine hours after the observations are made.

These days, it is almost impossible for meteorologists to make forecasts without the help of weather models. It's no surprise that these models are used intensively. The model to be used depends on the circumstances of each situation. This requires knowledge about the behaviour of the various models and their respective strengths and weaknesses. There are models for long-term forecasts (up to 15 day forecasts) and for very short-term forecasts (same-day and next-day), models with a global scope (ECMWF), and models that focus on the Netherlands (HIRLAM and HARMONIE). At the start of a shift, the meteorologist compares actual data with the results of the models. First the HIRLAM results are compared with the weather observation data from the weather stations, the satellites and radar. Then the ECMWF model is assessed to see if the forecasts can be used.

The reasons for selecting a particular model are reported four times a day. This information enables researchers to make further model improvements. In addition, the researchers can advise the meteorologists on making more effective use of the models to make an even more accurate weather forecasts.

To apply newly developed models, it is essential to explore new approaches to data visualisation, including, for instance, 3D visualisation. It is not always easy to present the tremendous amounts of high-resolution data in simple maps or graphics. Displaying the information as a 3D image makes it possible for the meteorologist to compare the model with actual weather conditions more accurately. Two 3D images are included on pages 41 and 43 of this Annual Report. One is of the ash cloud of April 2010, the other of the circumstances of the Weather Alarm issued on 14 July 2010. Use the 3D glasses enclosed to view these photos to get some idea of the added value of 3D images.

Based on current conditions forecasts are being adjusted all the time. The challenge of the meteorologist is to assess the various models in such a way to maximise the accuracy of the forecast produced. Whether it involves a short-term or longer term forecast, whether it is intended for the aviation sector, a chemical disaster, a storm surge or Weather Alarm.

The data derived from the models are being used by both the meteorologists of KNMI and other customers such as government institutes and weather companies. They use the data generated by the models as input for their own weather forecasts.

ECMWF

ECMWF is a European intergovernmental institute supported by 16 European nations. ECMWF is developing a weather model for both the medium-term and long-term. The ECMWF model is the best and most accurate model in the world, and ECMWF is doing all it can to ensure this stays this way. ECMWF is based in the English town of Reading.

HARMONIE and nowcasting

Nowadays, the very short term forecasts are made using radar and satellite observations that are extrapolated over time. Even more accurate results will be possible in future thanks to the use of detailed models such as HARMONIE. This is particularly important for extreme weather situations. In the future it will be possible to develop model forecasts with a horizontal resolution up to one kilometre. While fairly accurate forecasts are already possible for many weather phenomena, extreme showers and fog situations are still difficult to predict. Extensive research into these phenomena is underway.

High Resolution Limited Area Model (HIRLAM)

KNMI currently uses HIRLAM to make forecasts for Europe up to two days in advance with a horizontal resolution of 11 kilometres. The HIRLAM model was developed by an eleven-nation consortium established about 25 years ago. The intention is to replace HIRLAM in the nearby future with a new model, HARMONIE, which will offer a greater degree of detail and generate data with a horizontal resolution of 2.5 kilometres. The model is being developed by researchers both from the HIRLAM countries and from the ALADIN consortium, which includes another 16 countries across Europe and North Africa.

Grand Limited Area Model Ensemble Prediction System (GLAMEPS)

This ensemble prediction system (see below) is developed and produced by an international consortium as a combination of various weather models, because the computing capacity required for this model exceeds that which any single national meteorological institute can provide. This multi model ensemble is designed for severe weather situations. It is a detailed ensemble prediction system, which reveals any short term uncertainties. This makes it possible to take note of and predict the extremes of severe weather situations. The biggest challenge is to link this model effectively with existing applications and models.

ECMWF deterministic model

In a deterministic model, a single calculation is made for the most likely weather forecast for each grid point (horizontal resolution approximately 16 kilometres). The grid points of this model are situated more closely together than those of the ensemble prediction system model (see below), which yields a more accurate local forecast. Unlike the ensemble prediction system model only single calculations are performed for each grid point. As a result, less information is available on the accuracy of the forecast. By comparing these two models, the uncertainties from the first model can be combined with the greater density of the grid points of the other model. Like the ensemble prediction system, the resolution of the deterministic model has also been improved. In addition, the model's behaviour for winter forecasts has been improved.

ECMWF Ensemble Prediction System (EPS)

The farther in the future the forecast, the greater the uncertainty about its accuracy. The ensemble prediction system makes it possible to make an estimate about this uncertainty. The calculation for the operational ECMWF forecast is repeated 51 times, resulting in what is known as an 'ensemble'. A slight perturbation of the initial conditions is used for each of the 51 calculations in order to simulate the effects of uncertainty in the initial conditions. The greater the distribution of the results within the ensemble, the more uncertain the forecast. In 2010, the resolution of this ECMWF EPS model was increased, improving the long-range forecasts for severe weather.

from 03.00 till 04.00 a.m.

Weather satellites: continuous tracking

The Netherlands is situated on the western edge of the continent. When prevailing winds are westerly, our weather is supplied from over the ocean. In order to issue timely warnings for potentially severe weather in the Netherlands, KNMI requires atmospheric data from above the Atlantic Ocean. Apart from on-the-spot observations from ships, data buoys, islands and aircraft, satellite observations are an invaluable source of data about the Atlantic Ocean and the European continent, which facilitate generating a reliable overview of the current state of the weather (known as 'nowcasting').

Satellite observations are unique in that they are consistent over very large areas and entire continents up to the level of the entire planet, and the resulting data can be made available extremely quickly for processing. For instance, Meteosat satellite observations are available to users in less than 15 minutes. Satellite images can be presented in succession in a time series, which can then be extrapolated into the future (known as 'short-range forecasting'). It also provides information on rapid, small-scale atmospheric developments, such as thunder clouds.

EUMETSAT

Representing the collaborative partnership of European meteorological services established to share operational observations from weather satellites, EUMETSAT currently has four satellites which provide a continuous flow of weather observation data as they orbit around the Earth. While this data is needed for weather forecasts, it can also be used for climate research. In addition, EUMETSAT ensures that a new generation of satellites is developed every 15 to 20 years to replace the previous generation. The development work is carried out under the management of the European Space Agency (ESA), however, the specifications are based on the requirements of the meteorological services. Upper-air observations are becoming increasingly effective in detecting potentially severe weather (i.e. heavy storms, summer storms and heavy blizzards) in particular.

Headquartered in Darmstadt (Germany), which is near Frankfurt, and staffed by an international team of about 500, the EUMETSAT organisation is managed by the Council, whose membership consists of the directors-general of the meteorological institutes of the EUMETSAT Member States. The Council meets twice a year on average and is advised by a number of committees, whose membership consists of specialists from the EUMETSAT Member States, which focus on such issues as strategy/policy, technology/science, finance, and data policy. The committee representatives of the Netherlands are specialists from KNMI.

Meteosat Third Generation (MTG)

The geostationary Meteosat satellites represent EUMETSAT's core business. The first Meteosat programme was started in the late 1970s, while the planning and preparation work for the Meteosat Second Generation (MSG) programme began in the mid 1980s. Two years prior to the actual launch of the first MSG in 2002, initial studies were already being conducted into the requirements for a third generation satellite programme, i.e. Meteosat Third Generation (MTG). Although the original plan was to launch the first MTG satellite by around the year 2015, this has been postponed several years due to delays in the launch of the final two of the four MSG satellites. In 2010, the definitive decision to proceed with the MTG programme was taken, representing another key milestone in the history of EUMETSAT.

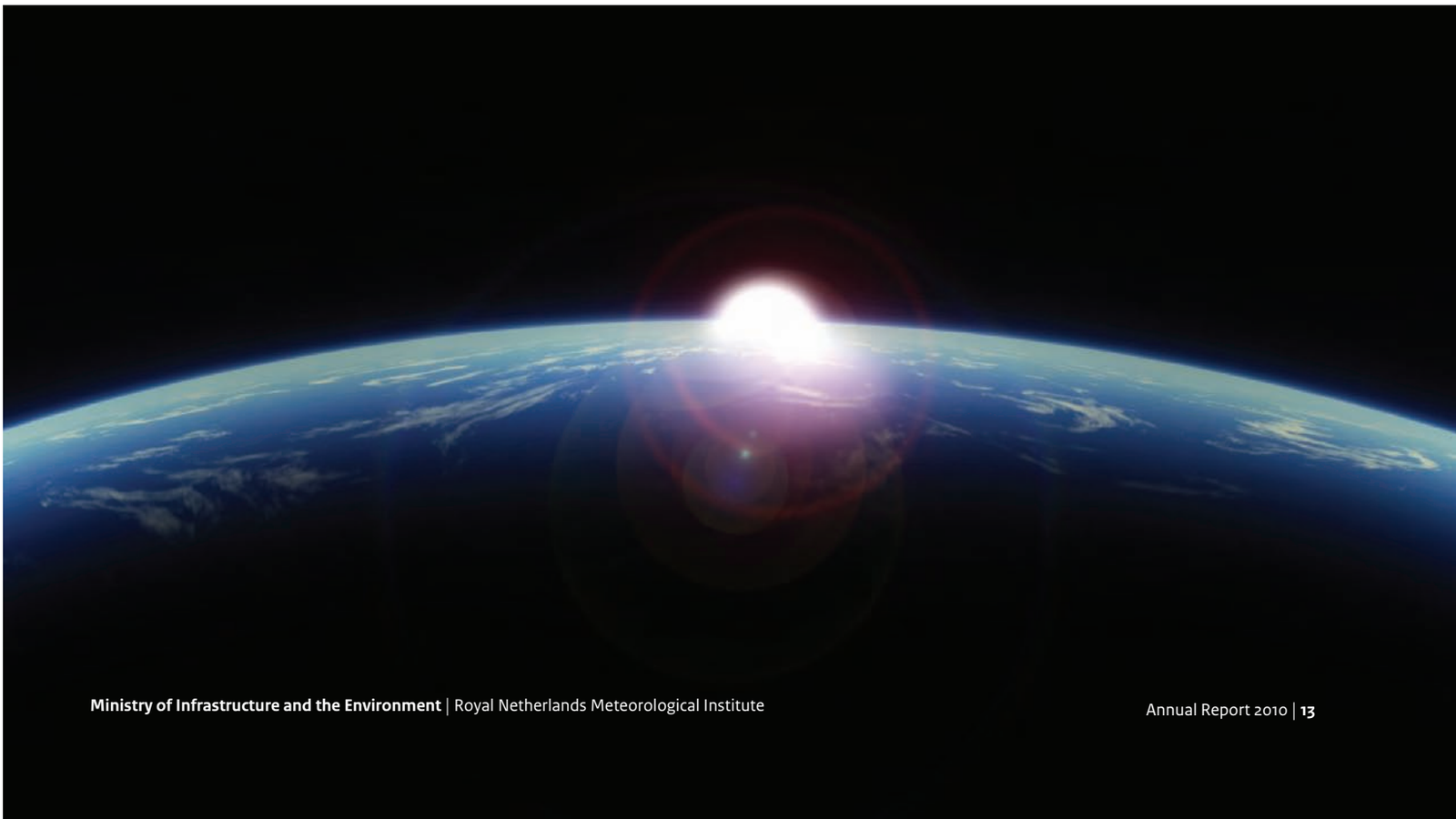
The cumulative costs of the MTG programme will total 2.4 billion euro, of which 4.4% (106 million euro) will be paid by the Netherlands. This contribution ensures that Dutch taxpayers will receive Meteosat data over a period of at least 20 years (2018 - 2037). In addition to improvements to the imaging scanner, the biggest change in the MTG (compared to the MSG) is that the new satellites will carry additional instrumentation. The MTG will include such innovations as a lightning imager to continuously detect lightning discharges in the upper air above Europe, Africa and the Atlantic Ocean. This data will prove highly beneficial both to the general safety-related tasks of KNMI and to the aviation sector. For example, the data can be used to route intercontinental flights across the Atlantic Ocean so as to avoid thunderstorms. MTG satellites will also be equipped with a sounding instrument, which will be used to take half-hourly profile readings of upper air humidity and temperature with a spatial resolution of four kilometres over the Meteosat's entire field of vision. The resulting data will be incorporated directly into the models used to make weather forecasts.

Gebruik EUMETSAT satellieten

The Meteosat satellites currently in operation offer the largest number of spectral channels of all geostationary satellites in the world. The combination of different spectral channels helps to highlight meteorologically relevant atmospheric properties, including ice and water clouds, tropical and arctic air masses, and low, high and semi-transparent clouds. In April and May 2010, one of these combined images provided a clear overview of the distribution of volcanic ash from the Icelandic volcano Eyjafjallajökull. This was the only information to provide a clear picture of the two-dimensional distribution of the volcanic ash. Combining this data with ground weather observations and computer calculations from various KNMI departments facilitate the rapid provision of reliable information to, for instance, Air Traffic Control The Netherlands (LVNL), the Minister of the former Ministry of Transport, Public Works and Water Management, and the National Aerospace Laboratory (NLR).

EUMETSAT manages the MetOp satellites, which travel around the Earth in polar orbit at a height of 800 kilometres, generating information on upper-air temperature and humidity, the composition of the atmosphere, and surface marine winds. KNMI uses this information to improve its weather forecasts. Of course, a weather forecast can still be produced without satellite images, but it will be of a much lower quality.

Longer time series of satellite data (i.e. decades) generate information on climate developments, including temperature and atmospheric composition.



from 04.00 till 05.00 a.m.

Joining forces in the name of safety

The safety meteorologist and the traffic management authorities/organisations are in regular contact, even on days with ordinary weather. However consultations intensify facing severe weather, extreme weather conditions and a potential Weather Alarm. In addition to providing information, the traffic management authorities/organisations can also serve as a source of information for the safety meteorologist. If necessary, the safety meteorologist can call on the Netherlands Traffic Control Centre (VCNL) and/or ANWB to conduct a survey by phone to learn more about traffic conditions or the state of roads, for instance.

The previous night, the traffic management authorities/organisations VCNL, Netherlands Police Agency (KLPD) and ANWB were already notified by means of an Weather Alert about approaching heavy rain and thunderstorms. KNMI issues warnings for severe weather (code yellow) and for extreme weather (code orange), as well as Weather Alarms (code red), and notifies relevant partners of this by e-mail and/or fax. When the Weather Alarm is issued, several partners are engaged to participate in the Weather Alarm team.
In addition to the automatically generated alert, the safety meteorologist will also contact the VCNL control centre and the KLPD incident room by phone to provide further details about the warnings. Both organisations need this information to decide whether to scale up their services.

Today

At the end of the night shift, as dawn breaks, the safety meteorologist studies the 'probability estimate' forms completed by the night shift team, which indicate an 80% to 90% probability that one of the criteria for issuing an Weather Alarm will be exceeded. He will pass this information on to the day shift.

Later in the morning, the VCNL traffic management expert indicates that he will be visiting KNMI to hear about the latest developments. Meanwhile, the safety meteorologist is already hard at work contacting and coordinating all outstanding reports with the other meteorologists for the maritime and aviation sectors. In order to handle all the work, the safety meteorologist decides to call on the crisis meteorologist for support, whose job it is to closely monitor the process leading to a potential Weather Alarm.

Criteria

The safety meteorologist uses various images from weather models to explain to the traffic management expert how he expects the heavy rain and thunderstorms to develop. The frontal systems and the rainbands move across the displays. The colour intensity reflects the seriousness of the situation. This time, the models seem to be unanimous, and it is very likely that the criteria for both lightning storms and severe wind gusts will be exceeded this afternoon and evening. It remains uncertain whether the criterion for precipitation will be met; most of the models estimate 20 50 millimetres of precipitation, concentrated in the western half of the country.

Netherlands Traffic Control Centre (VCNL)

Designed to provide meteorological support to VCNL, the MOVE Project has resulted in the intensification of the collaborative partnership with this organisation. VCNL bears responsibility for operational traffic management

at national level and for the coordination of regional traffic control centres in the event of disruptions on a national scale. Intensified cooperation between VCNL and KNMI has resulted in the more effective embedding of KNMI's activities in the field of weather and traffic. This certainly helps KNMI to perform its tasks for the benefit of society. The MOVE Project is exploring ways to optimise the support that KNMI provides to VCNL. Initially, research explored the ways in which meteorological data and information are used in VCNL's operations and possible improvements. In addition, options for structuring operational meteorological support for the above processes in the most efficient way were also reviewed. One of the project results is that once weather conditions potentially pose a risk to road traffic, a KNMI meteorologist will - at the request of VCNL - join its control centre team. In January and February 2010, a meteorologist visited VCNL control centre seven times.

from 05.00 till 06.00 a.m

Meteorology for safe air travel at Amsterdam Airport Schiphol

It is essential for airline companies to minimise delays, particularly during the initial morning rush hour. Any failure will have a detrimental domino effect on flight schedules for the rest of the day. When less favourable weather conditions necessitate allowing more time for landings and takeoffs, it will no longer be possible to process all scheduled arriving and departing air traffic. This results in delays and even the diversion of aircraft to other airports.

A Mainport Meteorologist staffs the KNMI forecasting office 24 hours a day, preparing the weather forecasts for Amsterdam Airport Schiphol and continuously monitoring the weather conditions there. These forecasts are passed on to the local air traffic control. In the event of extreme weather or unusual weather conditions at or near Amsterdam Airport Schiphol, an additional meteorologist, the Meteorological Advisor Schiphol (MAS), can be deployed. This expert works at the airport. A workplace for the MAS has been set up at Air Traffic Control The Netherlands (LVNL) in the same room where Schiphol Approach, the air traffic control centre for aircraft on approach runs, is located.

Weather conditions determine whether the MAS is deployed. Every evening, seven days a week, the on-duty Mainport Meteorologist working in the KNMI forecasting office will consult the LVNL Approach supervisor at Amsterdam Airport Schiphol to decide whether the MAS needs to be on duty at the traffic control centre starting at 5 a.m. the next morning. This early start is essential, as the day's first arrival peak happens between 7 a.m. and 8.30 a.m. This is when the number of aircraft waiting to use Amsterdam Airport Schiphol is so high that optimal use of its runway capacity is essential if delays are to be avoided. When use of landing capacity is reduced, aircraft may have to fly a hold, divert to other European airports or take off later. They may even have to be cancelled outright.

Also in de course of the day weather conditions may occur which create problems for the aviation and limit the capacity of Mainport Schiphol. These conditions include strong crosswinds blowing over the most commonly used runways, or lightning storms or thundery showers within Dutch flying area, restricting the use of its airspace. When this happens, the air traffic control and the airlines must decide which aircraft can still land and on which runways. In these situations the advice of the on-site KNMI meteorologist is desired.

Late MAS

A meteorologist is on hand daily who can be deployed as the MAS, both for the early shift and later on in the day. Normally, the discussion about the deployment of the 'late' MAS will take place during the morning briefing videoconference between KNMI, LVNL, Amsterdam Airport Schiphol and various departments of KLM. It is a terrific example of cooperation between all the stakeholders. Each has a single vote in determining whether to deploy direct meteorological support at Mainport Schiphol. This MAS represents just one way in which KNMI performs an important operational service for the aviation sector.

Volcanic ash

In April 2010, Europe was confronted with the unprecedented presence of volcanic ash within its air space. The eruption of the Icelandic volcano Eyjafjallajökull

had dramatic consequences for European air traffic (see also ‘Ash cloud brings European air traffic to a standstill’, page 38).

Nowadays, if the presence of volcanic ash within Dutch air space is expected, the MAS is called in immediately, regardless of the weather. The MAS then joins the air traffic control team at Schiphol-Oost. During the shift, the MAS will maintain close contact with air traffic control. Each new report is examined, and air traffic control and other airport stakeholders are informed of any significant change in the forecasts. The maps produced by the Volcanic Ash Advisory Centre (VAAC), which indicate where volcanic ash is expected in Europe and in which concentrations, play a leading role. Local weather observations conducted within Dutch air space are also sometimes used to supplement this information, which includes test flights carried out in cooperation with NLR in order to verify the forecasts. Of course, the MAS will be contacted if there are any questions. Apart from these face-to-face contacts, there are phone briefings and briefings carried out via conference link.

from 06.00 till 07.00 a.m.

Piet Stammes (Senior Researcher Climate Observations) in Japan

Sharing knowledge with our international partners

When it's 6 a.m. in the Netherlands, it's 1 p.m. in Kyoto, Japan: lunchtime. I split the chopsticks supplied in two and open the plastic lunchbox, which has twelve little compartments, each containing a different dish – a surprise. I suspect that everything with a green tint will be fiery (horseradish), so these compartments are the ones I avoid. Unfortunately, I'm not very hungry, possibly because of the breakfast of fish and miso soup that still lies heavy on my stomach. However, I do feel like getting on with my work.

I am in Kyoto for a conference on measuring CO_2 levels by satellite. This key greenhouse gas released into the atmosphere as a result of human activity is difficult to measure from space. This is because it stays in the atmosphere for a long time and is well mixed, which means there is relatively little spatial variation in concentrations. Furthermore, it is difficult to measure the total amount of CO_2 down to the surface, as clouds and aerosols obscure the view. The absolute level of accuracy required is 1%. This is no easy matter! All the same, the Japanese have accepted the challenge, launching last year, on 23 January 2009, the Greenhouse Gas Observing Satellite (GOSAT). The Japanese for this satellite is 'ibuki', which means 'breath'. There are two instruments on board: an imaging tool which takes high quality images (including of the clouds) and a spectrometer which accurately measures the spectra of the gases CO_2, CH_4 and O_2. These spectra are important, as they show how much CO_2 is present.

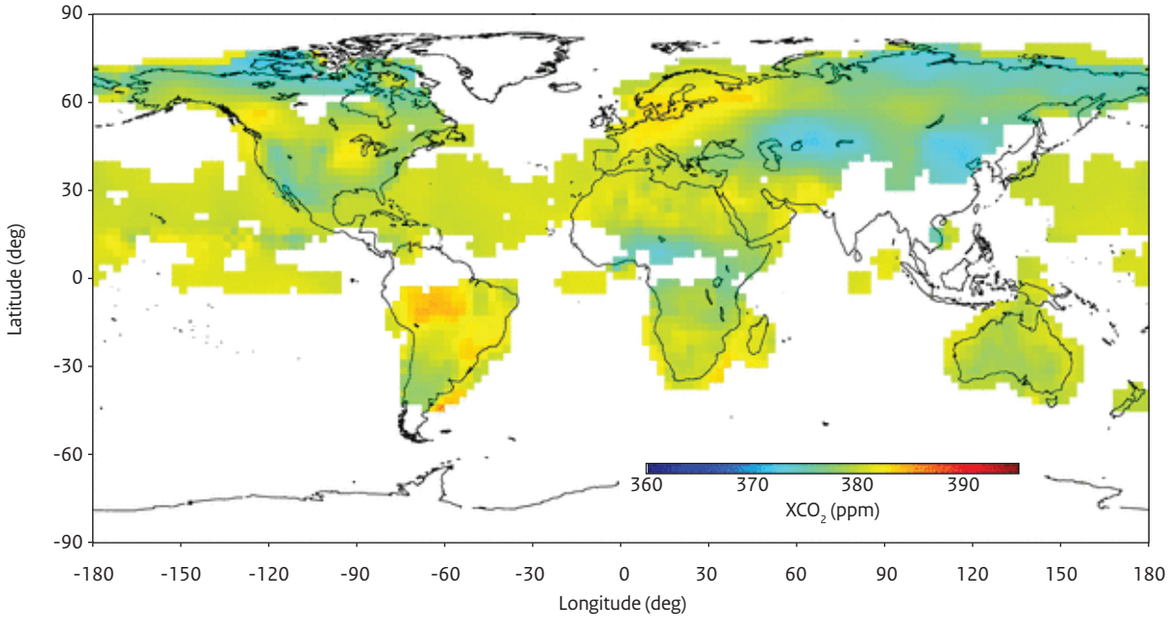
Why is KNMI interested in this information? In short, it aims to stay informed of latest developments in the monitoring of greenhouse gases from space and be able to use the GOSAT data. This work at KNMI is financed by the User Support Department of the Netherlands Space Office (NSO). Postdoctoral researcher Ofelia Vieitez joined the GOSAT Project in February. The project will measure aerosol levels using the oxygen spectrum, including light polarisation, and thus improve the accuracy of the CO_2 measurements.

Accuracy

The conference is being held in Kyoto's international conference centre, where the Kyoto Protocol to reduce greenhouse gases was negotiated in 1997. The building itself is located on the outskirts of the city. As the former imperial capital of Japan, Kyoto is the country's cultural centre, with innumerable temples, palaces, department stores filled with luxury goods, and restaurants. The conference building itself is quite special, though from another time: it resembles the Starship Enterprise made in concrete. Inside, it boasts a magnificent and highly colourful interior. At the rear of the complex, there is a beautiful garden with a large lake. The past and the present meet, bow and shake hands in Kyoto.

The Japanese are very friendly people, but they are sometimes inclined to gloss over mistakes. For me, the conference is important, because we need an indication of the precision of the instrument we are using. My previous contacts with Japanese researchers, which date back to 1990 when we performed research using GOME, are useful when it comes to uncovering further details about GOSAT's calibration. We learn that the polarisation readings are less accurate than we hoped. Although the components had been calibrated, no measurements have been performed on the actual tool now cruising through space. The reason: lack of time and money.

During the conference, all researchers using GOSAT data present their results. The conference concludes with a brief speech by the Japanese head of the GOSAT Project. With his hand on his heart, he promises that he will improve both the quality of and access to the data. It is a 'work in progress'. Measuring CO_2 levels continues to be a challenge - even in Kyoto.



Global distribution of CO_2 (mixing ratio in ppm) in July 2010, measured by GOSAT

from 07.00 till 08.00 a.m.

Construction of new, sustainable computer centre

The forecasting office night shift has come to an end and the meteorologists can call it a day. Following the handover, the day shift gets underway. The working day is also starting for other early bird staff of KNMI. There is also a contractor and a team of construction industry experts walking around. They are busy with the preparations for the work on the new computer centre.

In 2010, KNMI began renovating the existing computer centre as part of the Delta Plan Infrastructure Project. The existing power and cooling infrastructure is no longer adequate. Fortunately, the warehouse on the ground floor is sufficiently large and offers adequate headroom to be converted into a state of the art computer centre. One floor below, there is an nuclear bunker, which dates back to the Cold War. The bunker is no longer used as a shelter, and its location is ideal for storing all the ancillary equipment needed to keep the computer centre cool and provide it with Uninterruptible Power Supply (UPS). The renovation work should be completed by the spring of 2011, in time for the arrival of KNMI's new supercomputer.

Sustainability

A key principle for the construction of the new computer centre is sustainability. Computer equipment uses a lot of energy, which is why sustainability begins with the decision on which computer equipment to buy. However, it doesn't matter how 'green' your equipment is, it still needs power, with this power primarily being released in the form of heat. Conventional cooling by a compressor cooling unit (like the one in a domestic refrigerator) uses a relatively large amount of energy. Simply blowing away hot air means that the air must be supplemented by air from outdoors. This air has to be brought to the right temperature and humidity, which is not efficient either. However, cooling water offers a sustainable solution. The warmed-up cooling water can be cooled again using outside air, known as 'free air cooling'. This works fine in cold weather, but additional cooling is needed in the summer months. This additional cooling is achieved by what is known as a 'geothermal heat pump' (GHP). Cold groundwater from 40 metres underground is pumped up and used for cooling. At about 200 metres from the sources, the warmed-up water is pumped back into the ground. In wintertime, the air coolers have spare capacity, which can be used to cool down the warmed-up groundwater in wintertime: The net effect is that the groundwater temperature has to remain the same. The combination of free air cooling and GHP is revolutionary - at the time of writing you can't get more sustainable than this. The sustainability has to be continually monitored by measuring the energy used by the cooling system and the computers.

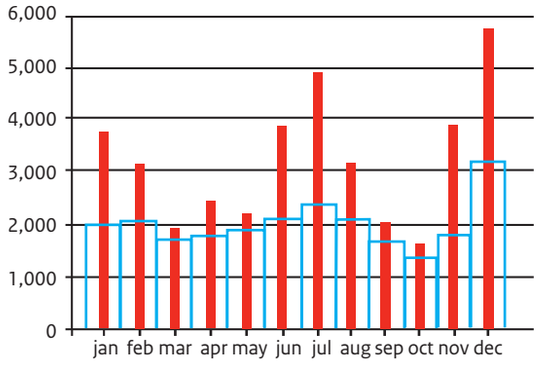
The new computer room requires a new connection to the 10,000 volt power grid using new transformers. Should the power supply fail then some of KNMI computers have to be able to keep going so that weather forecasts and warnings can still be produced at any time. This requires an emergency power supply system that is better than our current one. In fact, a one megawatt diesel generator will be installed. Room has to be found for the heat exchangers for the free air coolers and the geothermal heat pump. All this equipment will be installed in the bunker under the renovated computer room. However, the installation of this equipment does require a hole to be sawed through the 62 centimetre concrete roof. This hole will also be used later on to supply air when the diesel generator is running.

Finally, an archaeologist has to be organised too. Up to the end of the 16th century, the current KNMI site used to house a convent. Who knows what they'll find...

Web statistics

2010 showed a record number of visits to the KNMI website. This trend started early on 8, 9 and 10 January, when a total of over 10 million pages were viewed. On those days a blizzard raged in the northern provinces, so that may explain the interest in the information on the website. The previous monthly record (over 49 million pages viewed in December 2009) was smashed in January by the new record: 61 million page views. Despite this, usage on the above-mentioned days was still far less than the one-day record set on 20 October 2009 during heavy lightning storms, namely over 5.5 million page views.

This one-day record was nearly beaten in July, first of all on 10 and 11 July, when an Weather Alarm was issued for heavy thunderstorms with hail and severe wind gusts, when more than 3.5 million pages were retrieved each day. Just a few days later on July 14, when not only the weather was turbulent (Weather Alarm of heavy thunderstorms with severe wind gusts) – so was the website usage. In just a few hours, 4.8 million page views were counted, which is an extraordinary achievement when you consider that a large number of privately used computers were damaged that day due to the lightning strikes.



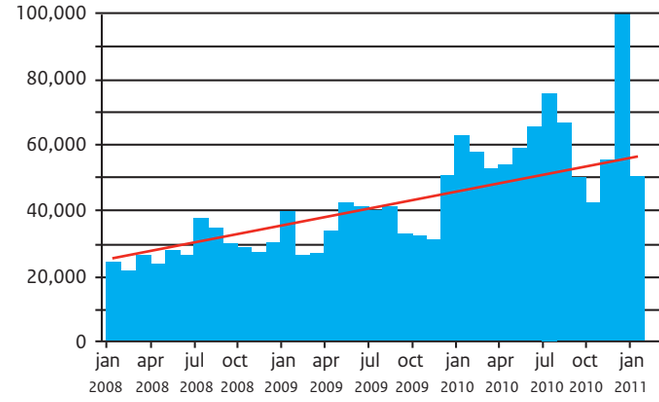
Use of KNMI-webservers (page hits in thousands)

Maximum usage in 1 day
Average daily usage

17 December was busy too, when heavy snow fall caused major problems in the Randstad area in particular, leading to 5.4 million page views. The absolute record was achieved on 19 December, with an exceptionally high peak value of over 5.7 million page views that day.

Monthly record

It will not be a surprise that in 2010 also the records for monthly usage would be beaten several times: the record for January bit the dust in June, which was in turn quickly trumped by the result for July. The major blow in the 'page view wars' was struck in December, when the new monthly record was set at 100 million pages viewed.



Use of KNMI-webservers (page hits in thousands)

Monthly totals
Trend (monthly totals)

Continued popularity of KNMI website

The total number of pages viewed over the entire year 2010 is 725 million, which approximates to 2 million pages a day. This represents an increase of nearly 75% on 2009's figures. Given that only few new large-scale products were launched, it is likely that the Weather Alarms account for most of this increase.

ICT-platform

The usage of the web service is measured in number of pages called up (i.e. viewed). The visitors to the KNMI website are anonymous, making it impossible to convert the number of viewed pages into the number of visitors. Even though utilisation of this website rose again in 2010, the ICT platform continued to perform excellently even during the huge peaks in demand. This means that the KNMI was able to quickly and reliably satisfy the public thirst for information.

from 08.00 till 09.00 a.m.

Seismology: a daily motion

The start of each new working day is still a little bit exciting for the seismologist on duty. He or she was not hauled out of bed during the night by phone, so there was no earthquake during the night that was large enough to cause damage. This could have happened in the Netherlands or anywhere in the world, such as Haiti. All the same, earthquakes could have occurred during the last few hours. This is why each morning starts with a review of the events of the previous evening and night.

The seismograms produced by the Dutch seismic measuring stations are examined for small earthquakes in the Netherlands and surrounding areas. We examine even the smallest tremor. If it is an earthquake we calculate its location and its magnitude. All these earthquakes are entered in a database, so that there is always a good overview of all earthquakes that happened in and around the Netherlands. They might have been in Limburg, Groningen or Drenthe or just across the border in Germany or Belgium.

Once all earthquakes in the Netherlands have been identified and the associated data reviewed and saved, we look further afield, to foreign countries. Have there been any more earthquakes there? Major earthquakes around the world are also detected by the seismic stations we maintain in the Netherlands. In that case, even the subsurface in the Netherlands has moved as the result of an earthquake in Indonesia, Japan or Haiti, for instance. The KNMI does not need to work out the location and magnitude of these earthquakes, but we do add to the knowledge about the subsurface and structure of the Earth by sending our data to the International Seismological Centre and to the European Mediterranean Seismological Centre (EMSC). We also relay our digital seismograms immediately in 'real time' to the ORFEUS data centre (Observatories and Research Facilities for European Seismology). Mainly scientists or anybody else can obtain these seismograms.

Apart from earthquakes, the seismologists also measure infrasound. This sound is inaudible to the human ear as it is made up of frequencies lower than 20 Hz. Such low frequencies are hardly damped by the atmosphere and can travel enormous distances. For example, the eruption of the Icelandic volcano Eyjafjallajökull in April 2010 could clearly be measured using infrasound arrays in the Netherlands, about 2,000 kilometres away.

The result for today is less spectacular: a minor earthquake in Germany is all that has been recorded. It was located in an area just across the border where many earthquakes are induced by mining operations, and in fact this is one of those.

Earthquakes in the Netherlands in 2010

In 2010, 49 earthquakes were recorded whose epicentre was located in the Netherlands. 41 of these were induced quakes in the northern part of the Netherlands. Since 1986 there have been regular earthquakes in the northern Netherlands caused by gas extraction operations. Up to now, the KNMI has recorded 650 of these quakes, most of them in the Groningen gasfield. Only some of these quakes are felt by people: in 2010, the KNMI was only notified of the following:

31 March, Froombosch, magnitude = 2.4
3 May, Spijk, magnitude = 2.3
5 May, Oosternieland, magnitude = 1.6
7 May, Waddenzee, magnitude = 2.5
9 June, Hoogezand, magnitude = 2.0
14 August, Uithuizermeeden, magnitude = 2.5
31 August, Zandeweer, magnitude = 1.4

In the province of Limburg there were eight earthquakes in 2010: near Roermond, Hoensbroek and Voerendaal. None of these were noticed by people, as they occurred much deeper underground than those in the northern Netherlands.

Earthquakes in the news in 2010

Haiti

A violent earthquake close to the surface on 12 January caused great damage in Haiti. The earthquake had a magnitude of 7.0 on the Richter scale and occurred just 10 kilometres below the Earth's surface. The earthquake occurred so close to the surface and so close to the capital city Port-au-Prince that there were many casualties and huge damage was caused. The high number of casualties (more than 100,000) and the great havoc caused led to the earthquake being designated a humanitarian catastrophe. Since Haiti is one of the world's poorest countries, its building regulations are not specified in detail, with the safety of many buildings leaving something to be desired. This could explain why so many houses collapsed.

Chile

On 27 February, a powerful earthquake measuring 8.8 on the Richter scale with epicentre 35 kilometres underground struck Chile. An underwater earthquake can cause a tsunami. To do so, the earthquake has to displace the seafloor vertically, so the column of water above it is displaced too. In addition, the earthquake has to be fairly powerful (magnitude >7.0) in order to displace the entire water column and it must not occur too deep under the seafloor. In this case, all these criteria were met, the result being a tsunami. At various locations along the Chilean coast, 50 to 150 centimetre waves were measured. Both the earthquake itself and the tsunami led to casualties. The earthquake occurred further underground than the one in Haiti and was also located off the coast, which is why there were fewer casualties and less damage. Additionally, in Chile they are better prepared against earthquakes, and buildings there are more resistant to tremors.

Turkey

On 8 March there was an earthquake in eastern Turkey with a magnitude of 6.0. More than 30 aftershocks were recorded in the first six hours after the earthquake, the largest of which had a magnitude of 5.5. This quake resulted in dozens of casualties.

China

A quake on 13 April with a magnitude of 6.9 on the Tibetan plateau in the province of Qinghai, China caused schools, houses and offices to collapse. The Tibetan plateau regularly experiences earthquakes. They rarely result in casualties because the region has a very low population density.

Indonesia

On 25 October there was an earthquake off the coast of the Indonesian island of Sumatra with magnitude 7.7. The earthquake's epicentre was close to the Mentawai islands, which were then badly hit by a tsunami. These islands are located so close to the epicentre that the tsunami reached the islands before the tsunami warning system could warn them about it. The warning issued for the Indian Ocean was withdrawn again two hours later, as there was no longer a risk of the tsunami reaching the more distant locations.

Infrasound incidents in 2010

A gas explosion in Liège (Belgium) on 27 June was recorded by three infrasound arrays in the Netherlands. Special meteorological conditions allowed the sound to be transmitted by the upper atmosphere. The temperature around the stratopause (50 kilometres above the Earth's surface) was more than 20°C, due to Sudden Stratospheric Warming; this atmospheric layer is normally at a temperature of about -10°C during wintertime. This allowed the infrasound to be measured even more strongly.

On 3 February, there were many reports from Friesland about tremors, houses shaking and doors and windows rattling. The infrasound analysis revealed that the source was located on the Vliehors military range on the island of Vlieland, the cause proving to be military bomb exercises. A powerful jet stream (at an altitude of between 6 and 10 kilometres) carried the infrasound to Friesland, leading to the earthquake-like phenomena.

The eruption of the Icelandic volcano Eyjafjallajökull in April and May produced clear readings on the infrasound arrays located about 2,000 kilometres away in the Netherlands. For many weeks, infrasound emanating from Iceland, especially at night, was recorded, because the atmosphere is calmer then than during the day. Although Eyjafjallajökull was closely monitored using all kinds of measurements, this is not the case for many of the world's volcanoes. Research is underway to use infrasound as an early-warning tool for volcanic eruptions.

from 09.00 till 10.00 a.m.

From platforms to airports, from airports to no man's land

Pressure sensors, lightning detection systems, visibility sensors, wind sensors, cloud base meters, temperature sensors, precipitation radar... the Netherlands is full of these, both on land and offshore. They are one of KNMI's most important sources of information. The institute uses all the data gathered by this equipment to fulfil one of its most important tasks: to produce weather forecasts. It's no surprise then that it's essential that all this equipment is maintained both properly and regularly. So, let's take a look behind the scenes with Jan-Willem Schoonderwoerd, who works for the KNMI maintenance crew.

"Basically, we have to be able to rectify any fault and perform preventive maintenance on all the instruments and systems," explains Jan-Willem Schoonderwoerd. "We also have a number of experts who we can call on for more specialised work on precipitation radars, satellite receiving systems and lightning detection systems. If our primary efforts don't rectify the fault then we can ask them for advice. So, if we can't solve it, our experts will."

"With this work, it is inevitable you get the feeling that the technology is getting a bit ahead of us", continues Schoonderwoerd. "Apart from the technology, you have to be interested in meteorology. I can imagine that someone not interested in these things will think twice before applying for a job here."

Partnerships

The hundreds of sensors, measuring systems and two radar systems for which the maintenance crew is responsible are located all over the Netherlands, both on land and off shore (on platforms). "Furthermore KNMI has formed a partnership with the Ministry of Defence. We also carry out all their equipment maintenance work for them, in the same way that we do lots of work for Rijkswaterstaat, the executive arm of the Ministry of Infrastructure and the Environment." For instance, KNMI is responsible for overhauling and calibrating the sensors that this organisation uses in its black-ice detection system. In all fields in recent years, the above equipment has become so much more efficient, which means that faults are becoming more and more the exception. "Therefore nowadays our work is more about technical inspections and preventive maintenance." This includes the checking of the measuring systems in the field and the overhauling and calibration of the sensors and measuring systems in the laboratory.

Safety and security

Schoonderwoerd prefers to be at work on the platforms, even if it is just because of the helicopter flight there and back. "These are not everyday locations – only a few people are granted access to them." This last point even applies to Schoonderwoerd too. For example, prior to every trip to a platform he has to fill in all kinds of questionnaires and watch safety videos. He can't just swan past the customs department just like that either. "I have to go through the full procedure each time. In the same way, permits and risk analyses have to be shown or drawn up as soon as you arrive on the platform. This too is all related to safety and security considerations."

Schoonderwoerd also has to deal with similar rules when he is working on or close to airports. There too he often has a long way to go, figuratively speaking, before doors will open for him. "And even when we've got past the fences, we are still closely monitored by the security guards." This is done using transponders in the cars. "The rules have been made

"There are so many people and organisations that utilise or rely on KNMI data. That's why it has to be accurate! Full stop."

much stricter, every move is closely monitored and everything is checked…" Then, with a broad grin: "It's all because of Alberto Stegeman." Stegeman is the undercover journalist who on several occasions has succeeded in getting into heavily protected locations at Amsterdam Airport Schiphol without too much trouble.

No man's land

Very different is his work in the Groningen area, where a lot of the KNMI equipment is located. Schoonderwoerd calls this area 'No man's land': it's a part of the Netherlands where you can still drive for miles without meeting anyone. "That has its charms too. In this sense, no two days are the same, which I like. From platforms to airports and from airports to no man's land. When I arrive at KNMI in the morning I have no idea what the day will bring - every day is different."
The on-site checks and cleaning and/or maintenance work can easily take two hours to complete. After the work is completed he contacts the KNMI observation system manager. "At De Bilt, they can easily check whether everything is working again as it should. As soon as all the data starts rolling in again, we know everything's OK. They take a quick look at the latest readings with us."

Precise and meticulous

The most important thing with this type of work is to be extremely precise and meticulous. After all, discrepancies in the data can have serious consequences.
Schoonderwoerd: "I can't say that I feel a lot of pressure during my work, but I am very conscious of the fact that I can't afford to make any serious mistakes. There are so many people and organisations that utilise or rely on KNMI data. That's why it has to be accurate! Full stop. It's something we all really understand."

from 10.00 till 11.00 a.m.

To measure is to know

Most of what we know about weather and climate is based on our observations. We monitor the Dutch weather on the ground and in the air using a vast array of instruments. For instance, we have about 50 automatic weather stations spread throughout the land that measure pressure, temperature, humidity, wind, precipitation, radiation, visibility and cloud cover on a minute by minute basis. This data can be displayed directly on the screens in our forecasting office, is supplied to our customers and can be viewed on our website. It is also used in weather models and for climate research.

In order to ensure that the observations are recorded continuously and with the necessary accuracy, the instruments are regularly maintained and even replaced where necessary. KNMI also has a wind tunnel, a calibration lab and a climate chamber for calibrating anemometers, temperature sensors and humidity sensors at its disposal. All observations are checked automatically but are sometimes checked by hand too.

KNMI measuring mast

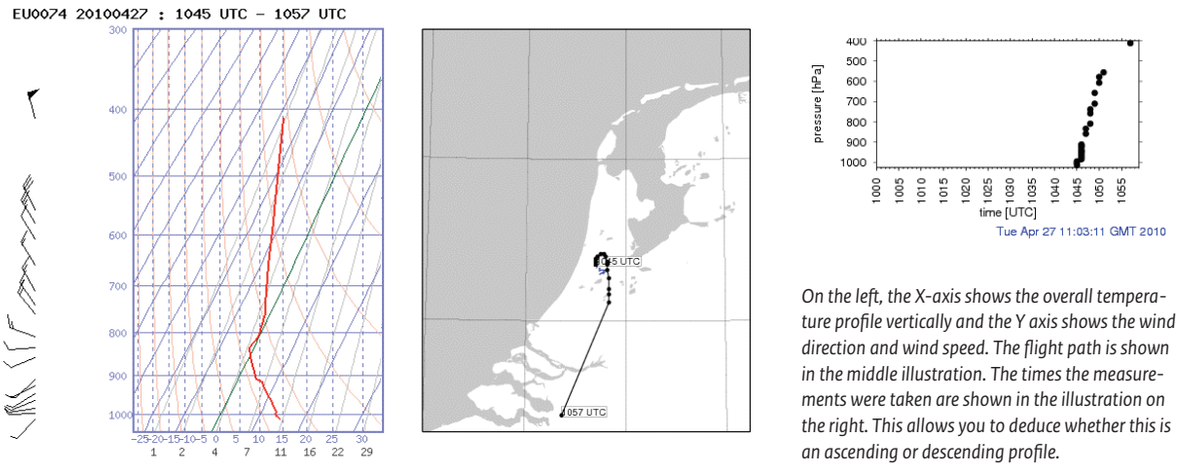
The green heart of the Netherlands, in Cabauw, is the location for KNMI's 213 metre measuring mast which is equipped with advanced measuring instruments and radar systems to map out the atmosphere. Amongst other things, solar and heat radiation and concentrations of greenhouse gases, aerial particles and air pollution are measured. These observations are used to better understand atmospheric processes, allowing weather/climate models to be improved.

Turbulence indicator

It goes without saying that it's safer to fly where there is no turbulence, which is why pilots prefer to avoid powerful, vertical air movements. A computer programme uses information from the radar to report whether any of the clouds of type cumulonimbi and/or towering cumuli clouds caused by this turbulence have been spotted anywhere near an airfield. This system was improved in 2009 and 2010 by the inclusion of a new algorithm that incorporates both radar and satellite observations. In 2011, this modernised system went operational at Maastricht Aachen Airport, Groningen Airport Eelde and Rotterdam The Hague Airport.

Aircraft take observations too

During the flight, and particularly during ascending and descending, aircraft measure wind and temperature to monitor aircraft operations. This information is also useful for input in weather and climate models. Reason enough for KNMI to extend its cooperation with Dutch airline KLM in 2010. This resulted in a project called Business Case AMDAR (Aircraft Meteorological DAta Relay) in which thirty KLM aircraft were equipped with software designed to transmit wind and temperature observations when flying to and from Amsterdam Airport Schiphol. This has given the forecasting office a new profile of the atmosphere preferably every hour, making AMDAR an important source of additional information to the meteorologist. Data on the upper level winds allow for better timing of weather front passages and for quicker observation of changing temperatures in the upper air. This provides a better forecast for the occurrence of black ice, sleet and frozen rain. The high frequency of the AMDAR measurements allows the state of the weather to be monitored and determined more accurately. Obviously the aviation sector benefits also from this work.



On the left, the X-axis shows the overall temperature profile vertically and the Y axis shows the wind direction and wind speed. The flight path is shown in the middle illustration. The times the measurements were taken are shown in the illustration on the right. This allows you to deduce whether this is an ascending or descending profile.

The graph shows what the meteorologist in the forecasting office sees on his display every hour.

Precipitation echoes from the weather radar system Every five minutes, KNMI's two weather radar systems in De Bilt and Den Helder use a narrow pulsed beam of radio waves to scan the atmosphere. Echoes caused by precipitation are detected by the radars and processed into a 3-dimensional image. Apart from precipitation levels, wind speeds and the altitude of showers are measured. The radar provides the best possible estimate of precipitation at a particular place and time. Estimating the latter is not easy, as many factors have to be taken into account when translating high-altitude echoes into precipitation on the ground.
An increasing problem for the radar products is interference caused by newer wireless networks. This happens because these networks use the same frequency of about 5.6 gigahertz. Over the past year, KNMI has been working together with the national radio authority Agentschap Telecom to locate and remove a number of sources of disruption. It is expected that it will take further time and effort to mitigate these interferences completely.
Solar radiation also helps us to make the radar measurements even more accurate. Research carried out by KNMI and the Finnish weather service FMI between 2004 and 2010 mean that this radiation can now be recorded automatically. In this way, differences in the antennae's direction of view and sensitivity of the radar receivers can be corrected for.

Lightning detection system

The lightning detection system consists of seven antennae that pick up electromagnetic crackling disturbances generated by lightning and passes this data on to KNMI. Lightning primarily occurs in strongly convective thunderstorms, which makes this system a useful indicator of extreme weather such as heavy rainfall or hail. The system is used when Weather Alarms or other alerts are issued. An evaluation carried out in 2010 did indicate that the quality of the lightning detection data needs to be improved.

from 11.00 a.m. till noon

Intensive cooperation for disaster response efforts

A disaster can happen 'just like that'. This makes it vitally important to share information quickly and to have the fullest possible cooperation. In its capacity as a meteorological, climatological and seismological knowledge centre, KNMI is designed to provide information and model calculations on the dispersion of dust or smoke in the atmosphere. Over the past few decades, our country has become more vulnerable to industrial environmental disasters, such as fires and/or explosions that release hazardous substances into the air or water. These situations may pose an immediate and major risk to public health and involve potential risks for our environment, food safety and the economy.

There are high-profile examples of disasters with highly damaging consequences such as the accident at the Chernobyl nuclear power station in 1986. In our country, there was a major fire at the petrochemical company Cindu in Uithoorn in 1992 that caused black clouds of smoke to sweep across southeastern Amsterdam towards the IJsselmeer lake. The chemical accidents at CMI in Rotterdam in 1996 and in 2000 at ATF in Drachten, along with a number of other serious incidents involving leaking tank wagons on railway yards, are the most high-profile incidents from recent years.

Organising the response to nuclear and chemical accidents

At the time of the Chernobyl incident, no operational disaster response organisation had been set up, which meant that a lot of improvising was required. Experts from bodies as KNMI, National Institute for Public Health and the Environment (RIVM), the executive arm of the Ministry of Infrastructure and the Environment *(Rijkswaterstaat)* and the Dutch Ministry of Agriculture jointly advised the ministers. This disaster led to the set up of the National Plan for the Relief Effort for Nuclear Accidents (NPK) in 1989. KNMI is responsible for providing the meteorological data needed to make the dispersion calculations for any future clouds of radioactive contamination.

In 2002, the BOT-mi policy support team for environmental incidents was set up. Apart from KNMI, partnership's members are RIVM, NVIC National Poisoning Information Centre, *Waterdienst* (Centre for Water Management), DCMR Environmental Protection Agency Rijnmond, for the agricultural sector the agricultural institute RIKILT Institute for Food Safety and the VWA Food and Consumer Product Safety Authority, and the Ministry of Defence. The Ministry of Infrastructure and the Environment (formerly the Ministry of Public Housing, Spatial Planning and the Environment) performs the overall steering function in order to keep BOT-mi 'in the air'. In practice, we work together with bodies as RIVM and *Rijkswaterstaat* to give us quickly deployable operational partnership that also carries out exercises at RIVM every two months. KNMI's specially instructed and trained crisis meteorologists provide the meteorological expertise within this partnership.

BOT-mi is not deployed or called in during the very first phase of a serious chemical accident; only when the local fire department and other disaster response services need additional specialist knowledge due to the nature and complexity of the accident BOT-mi is called in via the Ministry of Innovation and the Environment. All safety regions have signed a voluntary agreement to this end. BOT-mi is the national body that possesses the best

knowledge and expertise regarding complex chemical accidents. After notification BOT-mi aims to be able to issue its initial recommendations within one hour of being notified of an accid

BOT-mi inzetten in 2010

In April, for the first time in its history, KNMI issued a warning for volcanic ash. In the aeronautical world this is known as a Volcanic Ash SIGMET. Never before has such a warning applied to Dutch airspace. The source was the Icelandic volcano Eyjafjallajökull. When it erupted on 14 July, it blew vast quantities of ash and smoke into the atmosphere. In order to give the aviation sector and the authorities who were looking into potential health risks the best possible information on the ash in the atmosphere, seismologists, aviation meteorologists and researchers from KNMI monitored developments closely. The cloud of volcanic ash had very far-reaching consequences. The ash posed a great risk to air traffic, which is why the airspace over large parts of Europe, including the Netherlands, was closed for some time.

On 21 July, the company Timco Plastics was hit by a major fire. RIVM made dispersion calculations based on the meteorological data provided by KNMI. These were then used to estimate the immediate and longer-term health risks. At the time, the rapidly changing wind direction meant that a complex measuring strategy to detect dioxin levels had to be set up.

Another challenging incident was the major fire at the BOPEC oil terminal on the island of Bonaire in the Leeward Antilles islands. Here too, BOT-mi was called on to provide knowledge and advice. KNMI worked closely with the meteorological service for the Netherlands Antilles and Aruba on Curaçao to be able to issue its forecasts and advices for this BOT-mi operation. Using all the observations available an accurate hindcast analysis was made to be able to perform an optimised deposition survey on the area at risk.

Ministry of Infrastructure and the Environment | Royal Netherlands Meteorological Institute

from noon till 1.00 p.m.

The lessons of Climategate

The hacking of hundreds of e-mails and documents stored on a computer at a British university at the end of 2009 marked the start of the Climategate affair. This case also led to heated discussions in 2010 that were primarily dominated by the climate change sceptics. As far as the sceptics were concerned, the hacked material was proof that climate scientists are conspiring to exaggerate the effect that human actions have on climate change. The sceptics' case was aided by errors in a report by the Intergovernmental Panel on Climate Change (IPCC) that critics uncovered in 2010. All this raised many questions about the quality of the research and about the course of action pursued by some scientists. Hein Haak, the Netherlands' representative of the IPCC, looks back.

Are we to conclude that climate scientists 'were caught with their trousers down' by the Climategate debacle and by the errors found in the IPCC report?
"There's some truth in that, especially given our initial successes three years previously." Haak is referring to the events of December 2007, when the IPCC and Al Gore were jointly awarded the Nobel Prize for Peace. "Those past events just make our perceived fall even greater. If it was the case that for a long time the climate change critics were being completely overlooked, suddenly everyone was listening to them. At KNMI, we felt this too."

In what way?
"Let's start with the discussions within KNMI. Many researchers were of the opinion that KNMI should intervene in the rapidly developing and heated public debate. I discussed this question many times with departmental heads. How should we deal with this? What action should we take? These were questions that were extensively discussed by our Management Team too. In the end, we decided to keep a close eye on the debate, to listen very closely, but not to intervene or go on the defensive. It was an approach where KNMI isolated itself somewhat but that allowed it to emerge unscathed at the end of it. Universities for example were ready to take action and intervene, for instance through write-in campaigns."

How do you look back on the climate debate in 2010?
"As KNMI, we have come through it unscathed. In any case, I don't feel that we have been harmed by it. One reason for this is that we took the signals society was sending out very seriously indeed. Not for nothing do we stay in contact with those who put forward critical views in the climate debate. This means we hear other views and stay on our toes. It also helps improve the IPCC's transparency to bring in critical points of view. Particularly the open discussion with the climate sceptics improves transparency, something that was very necessary. We are talking here about a complex debate that plays out across many different levels: some scientific, some economic, some moral. Transparency is a pre-requisite for this. This forces us to state clearly why certain choices were made and prevents us from being attacked afterwards. This is a lesson that we definitely learned in 2010."

To what extent were the attacks against you personally?
"Let me put it another way. They showed me that with these sorts of debates it's very much about trying to influence public opinion. I saw it as my main challenge in that sort of climate to 'stick to my own trade' and also to guide my fellow researchers at KNMI through this process. For instance, I advised at all times that we should keep out of the political debate. KNMI's 'playing field' is that of scientific

Hein Haak

Director Climate & Seismology

"KNMI's 'playing field' is that of scientific matters - knowledge is what we do best. On the political playing field, our views and opinions are not relevant."

matters - knowledge is what we do best. On the political playing field, our views and our opinions are not relevant."

Surely that must be difficult. After all, a scientist does have feelings and opinions...

"Absolutely. It is essential to recognise this too. A scientific researcher is not a machine. What's more, scientists must place themselves at the centre of society. After all, this is where society's questions will be asked from. On the other hand, I do believe that a scientist has to be able to clearly separate facts and information that are based on scientific research from his own personal opinion about them. A scientist who is unable to separate these two areas will only add confusion to the debate."

In a previous interview, you let slip that it is 'business as usual' again at the IPCC. Is this really the case?

"At the current time, the 'production process' for the fifth assessment report is well underway. In that sense, it is business as usual. However, what I have noticed is that everyone who was or is involved is aware more than ever that 'we' are standing right in the spotlight and that nothing like Climategate must ever happen again. This is absolutely clear to all stakeholders."

from 1.00 till 2.00 p.m.

NMDC: Sharing knowledge yields better results

What is the precise effect of air pollution on the climate and on our health? What effect does climate have on nature? For years now, various parties have been jointly working on such complex social issues. In order to encourage and structuralise a more integrated approach and in order to prevent fragmentation of the research results, NMDC (National Model and Data Centre) was set up in 2010.

NMDC officially opened its doors in mid-April 2010. It's a strategic alliance between KNMI, Netherlands Organisation for Applied Scientific Research (TNO), National Institute for Public Health and the Environment (RIVM), Netherlands Environmental Assessment Agency (PBL), Deltares and Alterra. The increasing complexity of (social) issues and the growing need for efficient research played an important part in the decision to set up this partnership. The various partners meet up almost once a week. This time the meeting was held at KNMI.

Common interests

The NMDC harmonises and integrates models for applied and strategic research in the field of environment and sustainability. In doing so, it helps to ensure that our environment is organised as safe and sustainable as possible. The start-up phase of NMDC (NMDC 1.0, 2010 - mid-2012) aims to encourage cooperation between model developers and model users and to enhance and standardise the model infrastructure (tools and instruments). The NMDC achieves improved interoperability between the various models, improves standardisation and the exchangeability of data and provides more efficient use of computer capacity. In short, it's all about common interests and the need to share knowledge.

More efficient and simpler

This approach allows the partners to focus even more effectively on environmental challenges in our society . In addition, it will be easier to secure and disclose project and research results in such a way that other users can utilise them too, both within the organisation itself and in external organizations. This new way of working ties in with the spirit of the age, in which government is becoming smaller and smarter. Another benefit is that it strengthens the Netherlands' international profile as a country of knowledge and innovation.

A virtual organisation

The NMDC's focus is primarily aimed on the (natural) environment and spacial planning. In these areas, the partners contribute people, knowledge and (IT-)resources. They collectively share the risks and run NMDC as a virtual organisation. The different projects that NMDC is involved in can be divided into three categories: learning projects, innovation projects and improvement studies. All in all, 165 people are involved.

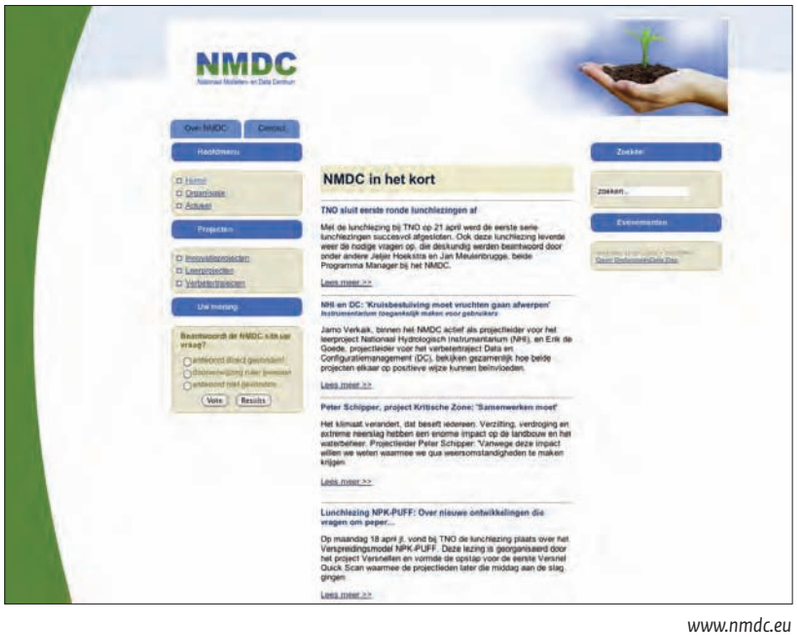
Add-a-diamond

One of the most noteworthy learning projects at NMDC relates to the further optimisation of the Eulerian chemical transport model Lotos-Euros. This model is used to calculate the (current) concentrations and/or depositions from dust emission and weather data. Amongst other things, the model can calculate the air quality in the bottom 3.5 kilometres of the atmosphere above Europe. This may relate to levels of ozone, fine particles or heavy metals, for instance. RIVM is the project manager for this project.

Secretary-General Siebe Riedstra and directors and projectleaders from the six diferent institutes after signing the foundingagreement of the NMDC

Visualisation and user interfaces

A noteworthy improvement study is known as 'Visualisation and user interfaces', in which KNMI is playing a leading role. One of the main reasons for this project is that visualisation is a very prominent - and perhaps the most important - tool for analysing and presenting (combined) data. An important ultimate goal for this project is to make 'accessible 2D and 3D visualisation tools available via the Internet.'



www.nmdc.eu

Proof of concept

At the current time, NMDC is still in phase 1.0, known as the 'proof of concept' phase. By mid-2012, when the 'operational phase' NMDC 2.0 starts, continuity must have been assured and the partnership must be able to support itself financially. Currently, NMDC is still 'leaning' for much of its budget on financial contributions from the programme for improvement of the national government (VRD). As to whether these objectives can be achieved cannot yet be said with 100% certainty but if they aren't, it won't be the partners' fault. "There is great commitment and enthusiasm on the part of the participants to let NMDC 'flourish', including in the years after 2011 too," explains Marcel Molendijk. At NMDC Molendijk - who works at KNMI in the product and process innovation department - is Programme Manager Infrastructure.

from 2.00 till 3.00 p.m.

KNMI and the market for weather information

Weather information and weather forecasts have now become big business and cover a wide range of commercial products. All kinds of weather-related applications are available via the Internet and on mobile phones. Weather apps, weather alerts by text message, customised weather information for companies - all these products have increased the demand for detailed and/or local weather forecasts. KNMI is collaborating with the commercial weather bureaus in order to place this expanding weather market on a sound footing.

There are two main aspects to this cooperation: data provision and sharing knowledge. The KNMI Act defines the dividing line between the two sectors (public and private). KNMI only gives general weather forecasts, gathers meteorological data and warns for any dangerous weather conditions. The way in which this works in relation to Weather Alarms is set out later in this annual report. The meteorological business community focuses on commercially attractive weather products for which there is market demand.

Data provision

In order to be able to make these commercial weather products, the weather (information) providers receive all kinds of data from KNMI, including radar images, weather models, and observations from weather stations and satellite data. Since late 2009, KNMI has been providing this data almost free of charge. These days, customers only need to pay the cost of the actual provision of the data, whereas licence fees used to be charged for this. This move has improved the accessibility of meteorological data in the Netherlands. In doing so, KNMI is complying with the national guidelines designed to make government data as accessible as possible. KNMI is an international trendsetter in this respect. In 2010, KNMI set down its terms and conditions for the provision of data in a series of Service Level Agreements (SLA). These agreements were drawn up in close consultation with meteorological companies.

Sharing knowledge

KNMI regularly organises lectures, symposia and workshops, in order to encourage the sharing of knowledge between meteorologists working in the business community and KNMI. In 2010, the first symposium aimed at the weather professional was held. In early autumn, 66 persons drawn from the ranks of KNMI, the Ministry of Defence and the business community took part in a workshop entitled 'Winter Weather'. The aim of this workshop was to shift meteorologists' focus from the ups and downs of summer weather to winter-related conditions and issues, such as mist in the autumn and winter, the way in which models behave during wintry conditions and the phenomenon that it seems that black ice can form even when the temperature in the atmosphere is below zero. This workshop received a rating of 4.3 out of 5. Other workshops received great praise as well, receiving positive reviews, including: "We are so pleased that we could be there!", "Great idea!" and "We definitely want to attend other courses".

Mutual expectations

The semi-annual weather providers' consultation meeting attended by KNMI and representatives of the meteorological business community ensures improved coordination. It provides a platform for all parties for the exchange of technical requirements, as well as for the answering of practical questions. The public tasks and duties of KNMI are sometimes a subject for discussion, in favour of the ambitions of the weather providers. It's no surprise then

that the somewhat vague dividing line between public sector duties and private sector interests creates a certain tension. This is why discussions on this issue started in 2010 between the commercial weather bureaus and the Ministry of Infrastructure and the Environment, which were organised by the OVW, the Ministry's consultative body.

MeteoVista

MeteoVista is one of the meteorological information providers that obtains data from KNMI, is consulted on potential Weather Alarms and attends the providers' consultation meetings. According to Johnny Willemsen of MeteoVista, the cooperation with KNMI is going well, although MeteoVista would prefer KNMI to issue fewer general weather forecasts and instead leave this to 'the market'. He is very pleased with the new structure that it is in place for the Weather Alarm, as they are now consulted and asked for their input. He feels that the providers' consultation meetings are useful too. "These are opportunities where we can agree arrangements with KNMI and other weather providers and state our ideas and wishes for the coming months."

Jos Broeke, a native of Zeeland with a passion for weather

Appearing four times a day on the radio and continuously every working day on the TV channel Omroep Zeeland, weatherman Jos Broeke is a regional celebrity. He is often ranked number one in Omroep Zeeland's ratings. And you can see (and hear) why: Jos knows more than anyone else about the vagaries of Zeeland weather and is fascinating to hear on the subject. He was already fascinated by the weather as a child and this passion has stayed with him. He joined KNMI at a young age where he manned the important observation post in Vlissingen as a meteorological observer, Vlissingen being the gateway to the Dutch weather, as they say. Since the 1990s this work has been handled by automated equipment, which is why Jos decided to start up his own business, as he had already amassed a great deal of knowledge and experience. He worked for the radio probe and weather ship service for eleven years, his most enjoyable working years, he feels.

These days, Jos works from home as a full-time weatherman for the regional TV station. He's a one-man weather business in Ritthem, working from 6 a.m. to 9 p.m. The midday hours are reserved for recording TV programmes on location. It takes up the most time but is the most enjoyable part of his work. The weatherman is welcomed with open arms everywhere and "you're always meeting new people and seeing new places". The rich history of Zeeland has provided plenty of material for a long-running series of interesting programmes.

Jos is very pleased with the 'free data' policy of KNMI. This means that all Dutch observational and model-based data is made available free of charge and without any licensing fees. This allows him to make full use of the weather data on the KNMI site, even though he would prefer to get some figures even more quickly. His day invariably begins with taking a look at the observations and model calculations and the discussions regarding them. He is also very interested in the climate data. If there is some way to do this, he will relate historical information to current topics. Omroep Zeeland is one of the few stations to broadcast KNMI's wind and storm forecasts in full every half an hour, politely quoting its source each time.

from 3.00 till 4.00 p.m.

KNMI's financial core

When you think about KNMI, finance & control probably isn't the first thing that springs to mind. However, the Project Agency does play a decisive role in the institute's affairs. Project Controller Annemarie Koot, leading light at this body, which is KNMI's financial core: "KNMI is a research institute and wants to undertake as much relevant research as possible.

In many organisations, the controller is not someone you envy. They are often seen as someone who asks awkward questions or gives you unpleasant news. In order to ensure that she is not seen in this way, in recent years Annemarie Koot has built a bridge between the scientists/researchers on the one hand and the Project Agency on the other.

Advice and support

This office, which employs a total of six people (from l. to r. on the photo: Annemarie Koot, Alexandra Remmerde-Karydaki and Jeroen Sassen; not on the photo: Elisa Bos, Immie Das and Milene Kempenaars), keeps tabs on a major share of the external funds (read: subsidies) that KNMI's project leaders use to finance their research. Consider for instance the funds that the European Union (EU) provides: if they want these funds KNMI's project leaders must submit an official application for them. One of the Project Agency's jobs is to advise and assist the project leaders with this process. "For instance, we draw up budgets and calculate whether projects are financially feasible in practice," explains Annemarie Koot. If a 'funder' then approve the application, the contractual negotiations can begin. Here too, Annemarie and 'her people' have an important role to play. She checks the financial arrangements made and then steers the document to the in-house lawyer, who checks that everything is OK from a legal point of view. "In short, it boils down to the fact that our expertise means that we have a good idea of what funders can offer us and what conditions they could attach to this. We then look to see whether this would fit in with our financial framework and with the guidelines issued by KNMI's management team. These areas in particular are where we can offer added value."

Obtaining support

The question is whether scientists/researchers see this in the same way. They are not a natural match with financial people. This is why in recent years the Project Agency has been working hard on improving mutual understanding. For instance, the last few years the Project Agency has worked on putting its employees more on the scientists' wavelength when it comes to work and ideas. Annemarie: "Scientists are people who are highly educated. Our strategy has led to greater cooperation, reciprocity and support. This is extremely important. Without reciprocity and support you cannot apply for funding. Demolishing boundaries is precisely what creates opportunities. These days, project leaders have a much better overview of all the possibilities, whereas we have a much better understanding of the matters that they are concerned with and feel are important." After all, project control is not about keeping tabs on the project from outside - it's about internal project control.

Opportunities and risks

Apart from its advisory work, the Agency looks at potential opportunities, as well as at the associated risks and threats (risk management). "After all, our decisions and choices must fit in with the management of KNMI's operations." In addition, this department checks that the employees' (personnel) costs are covered and that ongoing projects remain within the financial budget. Should there be cost overruns then talks will have to be held with the responsible project leaders.

Reserves are needed

Those who 'conjure' with figures would prefer to see plus

Annemarie Koot

Senior Project Controller of the Project Agency

"You would prefer to see plus signs."

signs. "However," explains Annemarie Koot, "KNMI is not out for profit – we are driven by research. This means we need to bring in enough money to be able to carry out relevant research. The maxim here is to 'break even' i.e. to cover our costs. However, this doesn't mean that we don't have to make a profit sometimes too. After all, planning and realisation never match each other perfectly. In other words, we need to maintain reserves."

Serving society

"KNMI is charismatic," continues Annemarie Koot. "This institute has a very positive image, both nationally and internationally. It is a privilege to be working for an institute such as this and this feeling has only intensified in recent years. The enthusiasm of the people who work here is almost limitless. At, it's not about higher turnover, profit and shareholder interests but about serving society. This is what drives KNMI's scientists. I have learned to greatly appreciate this social involvement. In the same way, I'm so pleased that in our own way we number freaks can help KNMI to achieve this."

from 4.00 till 5.00 p.m.

Ash cloud brings European air traffic to a standstill

In mid-April 2010, large areas of European airspace were 'locked up' for days on end as a result of the volcanic eruption of 14 April under the Icelandic glacier Eyjafjallajökull. Daan Vogelezang, team leader at the forecasting office, and Piet Stammes, senior researcher Climate Observations, look back at this unprecedented phenomenon together.

It is Sunday 18 April. Daan Vogelezang's mobile phone rings. A crisis meeting has been convened at Air Traffic Control The Netherlands (LVNL) at Amsterdam Airport Schiphol. He is asked to attend along with his immediate superior Fons van Loy, head of the KNMI forecasting office and who is representing KNMI in the crisis response team that has been set up. A little later they are joined by Wouter Knap, in charge of observations in Cabauw, and Piet Stammes. The crisis team needs assistance from the forecasting office and the research department. A particularly urgent question at the present time is: where is the volcanic ash cloud right now? Vogelezang: "That very same afternoon our meteorologists were able to map this out using satellite images and other information."

Test flight

However, more needs to be done: in order to verify that the images mapped out are really accurate, it is decided to carry out a test flight using a specially equipped Cessna Citation airplane provided by the NLR (National Aerospace Laboratory). Vogelezang and Knap are joining this observation flight. It's on a very important mission, as the Dutch aviation authorities will use KNMI's calculations to decide whether to reopen Dutch airspace to commercial air traffic. Once in the air, the pilot agrees to fly through the ash cloud. Vogelezang: "It was the first and probably the last time that I chose an aircraft's flight path."

The ash cloud is located at a very low altitude over the Netherlands, no more than 3 kilometres above it, and currently resembles thick smog. The ash cloud was already three to four days old. Stammes: "At that time the ash particles were of minute size, a few thousandths of a millimetre across. The 'boulders' had already dropped out above Iceland." Vogelezang: "Nevertheless it was risky to fly through it, even though personally I wasn't concerned. In fact, more than anything else it was very exciting... all the air traffic had been grounded but we were up in the air. It was a situation I won't forget easily."

"Whether you're talking about meteorologists, heads of air traffic control or researchers, no one had any experience with such a phenomenon," explains Stammes. "This means that we had to gather a lot of information in just a couple of days, using only the operational measuring instruments we already had." These tools include the satellite instrument OMI (Ozone Monitoring Instrument) used to measure ash and sulphur dioxide (SO_2) levels. A lot of essential information is also obtained from Cabauw's surface-based observations. The equipment used includes the UV Lidar, which uses a laser to measure the altitude of the ash layer. The balloon with ozone sensor will give us some answers too. This sensor is sent up once or twice a week with the weather balloon that is itself launched twice daily from KNMI's observation area in De Bilt. Measurements from this sensor reveal that there is less ozone in the layer of air that contains ash. This may mean that ash particles are breaking down ozone molecules.

Stammes: "All this data and the images were quickly made available to the operational process, including via a hastily created website. I also provided an explanation with each

Piet Stammes I Daan Vogelezang

Senior researcher Climate Observations/ Team leader forecasting office

"At that time you could feel the sense of urgency at KNMI. We all knew that something extraordinary was going on. As soon as the airspace was closed, everyone understood the massive impact this would have."

of these images. What does the colour red signify? How serious is it? How are the two related?"

Madhouse

Stammes describes this period, which started on Friday 16 April, as a madhouse. That Friday was when the ash cloud drifted over our country and turned the air an ominously dark colour, a colour that Stammes had never seen before. "I drove straight to De Bilt to have a meeting with colleagues. That Thursday we had already observed ash on our satellite images, namely in the air between Iceland and Norway. However, at that time it was not yet clear whether this cloud would reach the Netherlands." By the way, at that time the airspace had already been closed. This had already been done the night before.

Vogelezang: "At that time, you could feel the sense of urgency at KNMI. We all knew that something extraordinary was going on. As soon as the airspace was closed, everyone understood the massive impact that this event would have, and we really set to work in-house. KNMI was fully staffed that weekend, including by volunteers. History was in the making, and everyone wanted to be there."

Stammes was on standby the whole weekend too. He provided explanations for the different satellite images to the forecasting office's personnel. "It was all pretty unheard of. Normally, the researchers rarely 'cross the bridge' to the forecasting office. In addition, many people from the aviation sector in particular wanted to know what was going on, what still needed to be done, how dangerous it was and when the airspace could be opened up again. All these queries ended up at their natural home – KNMI's forecasting office. But KNMI couldn't answer them." Vogelezang: "It's true that our measurements provide valuable input for the making of policy, but we are not policymakers ourselves and would never enter that sphere. In fact, this option was never debated either. All we did was provide information. As to what people did with this information, that was out of our hands. That was and is as clear as day."

3D photos of volcanic ash and Extreme Weather Warnings

It was a huge challenge to find out precisely where and at what altitude the ash cloud was located, and, perhaps even more important, to forecast where the ash particles might go next. In order to understand this, weather researchers developed a model that releases 50 ash particles each minute at a particular altitude above the Icelandic volcano Eyjafjallajökull.

These particles were then moved through the atmosphere using the wind data from the HIRLAM model. Since the particles have weight, they do not always remain at the same altitude but instead descend at different speeds, depending on their size (this process is called 'sedimentation'). In the case of precipitation, the particles are washed out, this process is known as wet deposition. In this way, the distribution of the ash particles for the next 48 hours could be calculated. The model can determine the distribution of as many as 1 million ash particles.

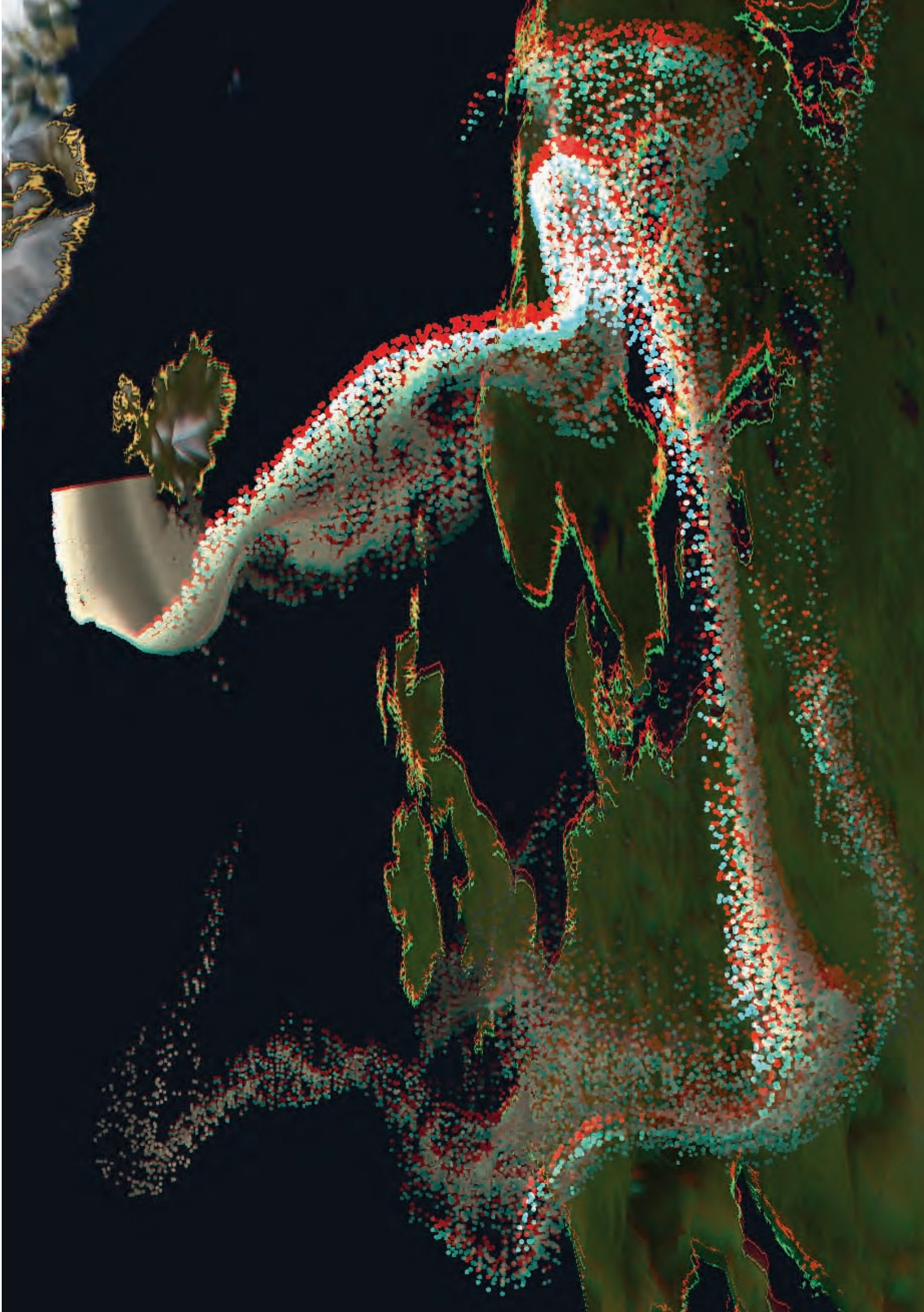
This distribution of the ash particles can then be visualised using the Weather 3D eXplorer application recently developed by the 3D visualisation team. This application allows you to view model data in 3D and virtual reality (VR), and in this case the distribution of the ash particles. This creates a much more accurate view and analysis of complex weather structures. The Weather 3D eXplorer compared the ash particle model and the special MSG satellite images for volcanic ash. It turned out that the method of using HIRLAM to calculate ash particle distribution developed by KNMI provides a reasonably accurate forecast for up to 48 hours ahead.

Even though we cannot provide the same quality on paper as we can with a 3D display, we would like to give you an impression of this technology. On the next two pages, you will find two 3D photos that you can view using the enclosed 3D glasses.

Explanation of the 3D photo on page 41

This is a 3D image of the model calculations for Saturday 17 April 2010, 2 a.m. GMT for the distribution of the ash particles emanating from the Icelandic volcano Eyjafjallajökull. The direction of view is from the southeast to the northwest. The background shows Europe, Iceland and Greenland. The ash particles are shown in various shades of white and grey, depending on their different altitudes in the atmosphere.

Director-General Frits Brouwer with Halldór Pétursson and Árni Snorrason, director of the Icelandic Meteorological Office, on Friday 16 April at Amsterdam Airport Schiphol. Snorrason and Pétursson were in the Netherlands for the HIRLAM council meeting. The TV news programme NOS Journaal took the opportunity to interview the Icelandic experts in 'the KNMI's weather tower at Amsterdam Airport Schiphol'.



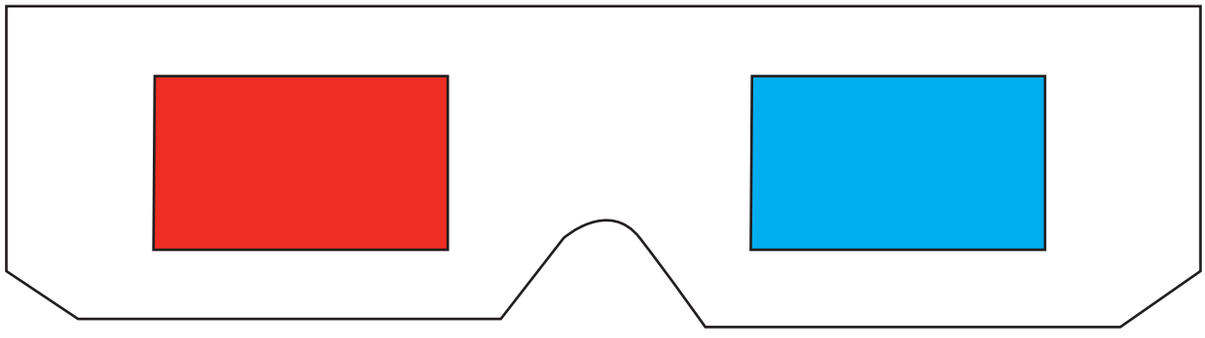
Damage caused by the storm to the camping site near Vethuizen

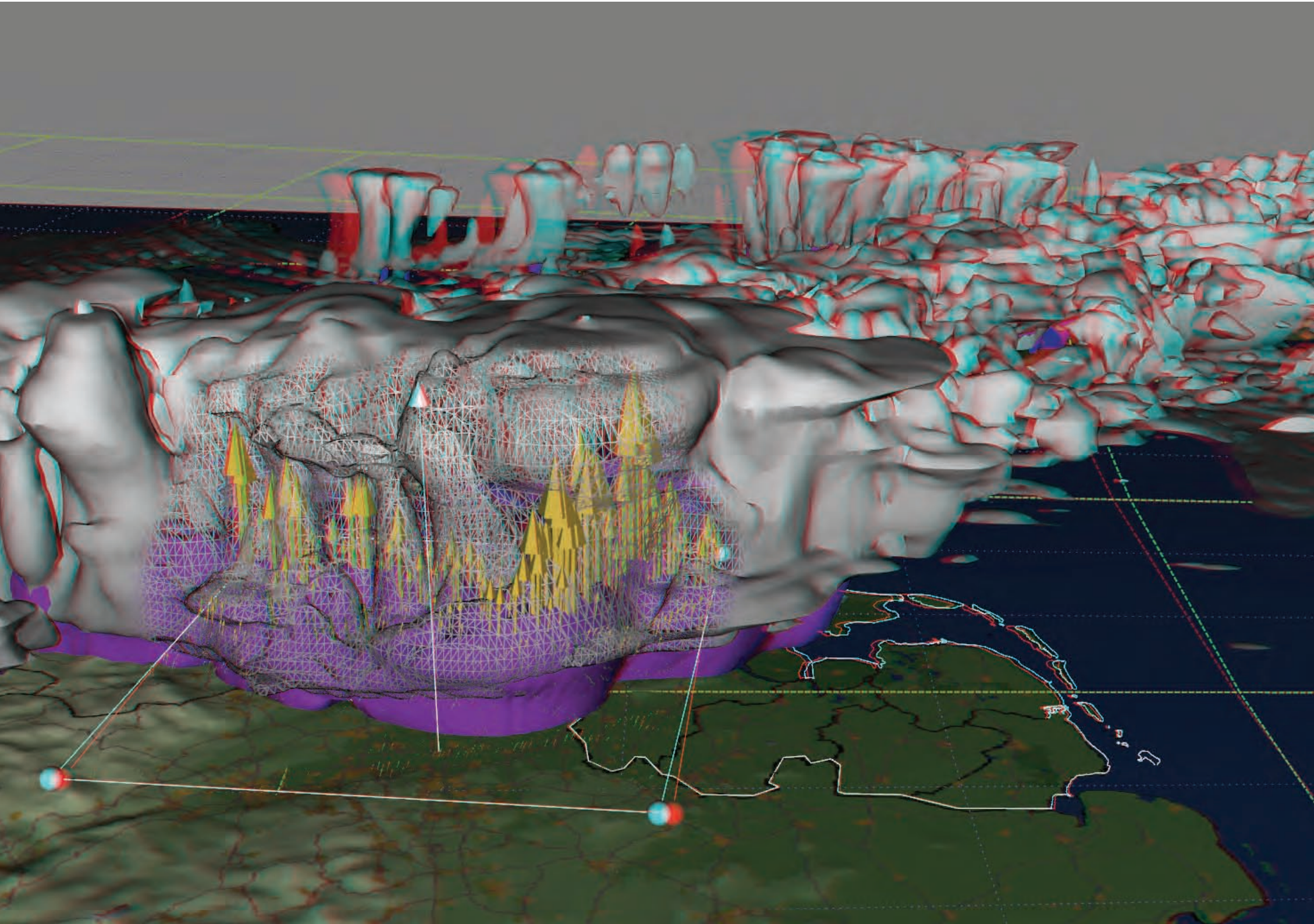
Explanation of the 3D photo on page 43

This 3D photo shows the model scenario on 14 July 2010 at 5 p.m. GMT (7 p.m. in the Netherlands). The direction of view is from east to west. The background image shows the north and east of the Netherlands. The grey columns are the ice and water clouds, with the tops of the mushrooms representing the 'overshooting tops' of showers shooting through the tropopause. Under these clouds, we see the estimated location of the rain in purple, with the arc-shaped segment above the Achterhoek region corresponding closely to the precipitation actually observed at the time of the fall winds ('downbursts') close to Vethuizen. The yellow arrows symbolise the rising atmospheric movements in the vicinity of Vethuizen, with part of the cloud cover being made transparent.

Tips to maximise viewing the 3D photos

- Put the glasses on with the red film in front of the left eye and the cyan film in front of the right eye;
- Hold the image about 40 centimetres from your eyes;
- Give your eyes (and brain) time to get used to the 3D image;
- View the whole image by just letting your eyes glide over it;
- It may occur that you do not see a 3D image at all, possibly due to colour blindness;
- Be aware that 3D photos can cause dizziness.





from 5.00 till 6.00 p.m.

Weather Alarm in sight

The safety meteorologist at KNMI forecasting office is on the edge of his seat. The warning for extreme weather 'This afternoon and this evening, heavy rain and thunderstorms are expected' has been in place for the whole country since 2.09 a.m. this morning. Heavy thunderstorms had been forecasted ever since yesterday, Tuesday 13 July. On Tuesday, the warnings were still mild (code yellow: warning of dangerous weather) but were raised to code orange (Weather Alert) last night at 2.09 a.m. Would the Weather Alert be upgraded to an official Weather Alarm?

Since yesterday 8.30 pm the Team of Experts has been keeping a close eye on developments in the weather. The Team of Experts consists of the Head of the forecasting office, the crisis coordinator and a weather model specialist. Also meteorological opinions from various meteorological information providers, namely Infoplaza, Luchtmacht Meteorologische Groep (LMG), MeteoVista and Piet Paulusma Meteoservice BV are used. These parties have shared their opinions of the weather developments with the Team of Experts using the KNMI webtool. The general opinion is as followed: "We must expect showers to develop in the warm air before the frontal system"

At 10 a.m. this morning, the Team of Experts passed the baton to the Weather Alarm team, the team that makes the final decision to issue the Weather Alarm based on the expected social impact of the weather. The members of the Weather Warning team include representatives from various social parties such as the Netherlands Police Agency (KLPD), Netherlands Traffic Control Centre (VCNL) and the national government's Crisis Coordination Centre. In total, the Weather Alarm team has three meetings by phone, in which it becomes clear that severe wind gusts may occur with possible downbursts and whirlwinds. France and Belgium are already experiencing heavy rain and thunderstorms.

A crisis meteorologist has now been called in so that all the additional work relating to the extreme weather can be carried out. For example, many calls come in from fire brigades, police forces, municipalities and safety regions who want to know whether certain events can go ahead. In addition, the meteorological information providers and government partners are continually kept up-to-date.

5.25 p.m.

At 5.25 p.m., at the request of the Weather Alarm team, the KNMI safety meteorologist issues an Weather Alarm for the provinces of Zuid-Limburg, Brabant and Gelderland. The Weather Alarm reads:

> Weather Alarm for the southeast and east: heavy rain and thunderstorms, severe gusts. Heavy rain and thunderstorms over the south and southeast of the country will move northeast this evening. These storms may include hail and severe gusts that may reach 75 100 km/h and 100 to 120 km/h in the northeast. In addition, a lot of precipitation could fall in a small area in a short time period.

The Weather Alarm is issued because the Weather Alarm criteria for lightning and severe gusts are exceeded and because the social impact is expected to be significant. The Weather Alarm criterion for lightning storms is: more than 500 discharges in a five-minute period, possibly with hail; and for gusts: faster than 100 km/h. This criterion applies for an area of at least 50 square kilometres. The safety meteorologist and his fellow meteorologists monitor the developments in the weather as closely as possible. Various model runs

are examined, wind measurements are viewed, lightning discharges monitored and temperature forecasts analysed. Where necessary, researchers are consulted for further interpretation and analysis of weather developments.

5.45 p.m.
The meteorologists in the KNMI's forecasting office now hear and see the impact of the Weather Alarm issued themselves. The Dutch storm damage trail starts in Maastricht and follows a route along the eastern border of the country to the north. Much damage and inconvenience has been caused in the south and east of the country: trees blown over in Zuid Limburg, blocked motorways and obstructed train travel, power outages in Nijmegen and Deurne, damaged farms in Gelderland.

There are two locations in the country where the storms have hit especially hard: in Vethuizen in the province of Gelderland and Neerkant near Limburg. Subsequent research reveals that in Vethuizen a downburst of wind travelling at 130 km/h lifted up a group of twenty caravans and then dumped them again in a pool, killing one person and wounding at least four very seriously. In the same area, six high tension masts were blown over.

Press briefing: A link to society and communities

He had only just been properly installed as the KNMI press spokesman when our country was hit by the worst storm in decades, on 25 January 1990 to be precise. That day, seventeen people lost their lives. Dutch society was completely disrupted. Since that day, Harry Geurts's specialist field has gone through 'tumultuous' changes. "Nowadays, you only have to open your mouth and it's a major news story everywhere. This adds a new and very important dimension to my work. That is communication. It's what I've always dreamed of."

On the evening of 24 January 1990, KNMI, speaking through Harry Geurts, their brand new press spokesman, warned that at least a force 10 wind was on the way. However, this dramatic notification was not enough to prevent a disaster. The news even talked about a hurricane that was racing across the Netherlands. Many people were unable to either comprehend or understand this, a subsequent assessment by the COT crisis research team revealed. COT is now known as the Institute for Safety and Crisis Management. The consequences of this particular 25th January was so far-reaching because the wind revealed its most savage side precisely during the evening rush hour. For a short time it was impossible to reach Amsterdam Airport Schiphol, road and rail traffic were completely disrupted by uprooted trees, overhead power cables that had been brought down and by damage to railway crossings. Thousands of travellers were left stranded in the major cities and were forced to spend the night there.

"At that time there was no such thing as an Weather Alarm, and communication was much less well organised than is the case these days," says Geurts, looking back. "It was a massive challenge to make information public in the best way possible and to put the information flows 'back on the right track'. It was an incredible baptism of fire."

Geurts still thinks about that day often. “The very next day I took my PR exams at the Jaarbeurs conference centre in Utrecht. I can still see myself arriving there… half of the Netherlands had spent the night there and was walking round with sleeping bags under their arms. So, I turned up to take my exams… and yes, I passed them too…”

“These days, my job is a bit easier,” continues Geurts. “There are clearly defined and structured arrangements in place, with there being almost no end to the ways in which we can communicate.”

Social media

All the same, this new era, which includes a huge increase in the range of public and commercial media available, brings with it its own very different issues and dimensions. Just consider for instance the unstoppable advances made by social media such as Twitter and Facebook, which hurl information into and around the world at record speed. This is all happening so fast that you can scarcely keep up with it, let alone keep it in check.

Geurts wouldn’t go so far as to call these developments inconvenient. ‘Challenging’ is more the word he would use. “I can still remember the days when we used to send faxes to get some information printed in the newspapers. And see what it’s like now… you only have to open your mouth and it’s a major news story. And not just locally - everywhere! This adds a new and very important dimension to my work. That is communication. It’s what I’ve always dreamed of. It is almost impossible to exert any kind of control on social media channels – this is now a fact of life. There’s nothing you can do about it and there’s no point getting annoyed about it. Today’s world is one huge communication source, on all levels.”

Objective and factual

Geurts’s motto is that communications should always be as objective and factual as possible. “Then or then you can expect that or that response. However, not even KNMI can tell what the impact of this will be. What we can do is say how hard the wind will blow and that in that case it may be that trees will be blown over. It’s not up to us to say what action people should take. That’s a job for other bodies such as our traffic partners ANWB, VCNL and the VID traffic information service. They can advise motorists at what times it would be better to stay at home, for instance.”

14 July 2010, downbursts and gustnados

One day that was literally and figuratively stormy was 14 July 2010. On that day, the southeast and east of our country in particular were hit by heavy thunderstorms and fall winds, the latter known as ‘downbursts’ in meteorological circles. On the edge of the storm structures there were even whirling structures known as ‘gustnados’. This led to an Weather Alarm for the east and southeast of our country. “The days before that 14th were when the weather was already showing its worst side,” remembers Geurts. Not for nothing was KNMI already issuing a code orange and a code red on those days. “The storm clouds had already been gathering above our heads for a couple of days - literally - generating many stories in the media. This implies that everything that you communicate will be interpreted on a grand scale. This shows that more than ever these days, we have to take the greatest care with our communications.”

“On such days I keep in close contact with our safety meteorologist, the man who is in charge of the forecasting office,” continues Geurts. “It’s down to me to communicate his message to the media in understandable language. He continually updates me on the latest developments. Based on this information, I decide whether to update the press and other media again. I have my regular contacts there and am on a first-name basis with them. If an Weather Alarm is issued we keep in very close contact with the press agencies such as ANP and Novum and with websites such as NU.nl. The major players in the Dutch broadcasting system, both public and commercial and radio and TV, are brought up to date immediately, after which the news is spread further.”

Despite our nuanced (‘these are forecasts, not certainties’), objective and factual communication, sometimes the media broadcasts it to the public with errors or in a less nuanced way. “In that case, I immediately get in touch with their editorial office and try to get them to understand that their story is factually incorrect. In the end, what they publish or do not publish, and how they do it, is their responsibility. I can’t force them to do anything but I can inform them that some of their statements are incorrect.”

In order to avoid this where possible, Geurts keeps as close an eye as possible on what the media reports. “It’s the initial contact, the very first communication that we send out, more than anything else that sets the tone. That’s why it has to be perfect. Luckily, most journalists share this view. They also know that we never try to give them rubbish - our information is to be taken seriously.”

Ambivalence is trumps

“A day on which KNMI issues a Weather Alarm is a particularly intensive and exciting one,” continues Geurts. “First of all there is the excitement of the forecast. We have certain expectations but of course the atmosphere has to play ball and ensure that our timing is correct. In short, it’s the fine

Harry Geurts

Press officer

"It's the initial contact, the very first communication that we send out, that sets the tone. That's why it has to be absolutely right."

detail that can make or break a forecast. Apart from that, you have your own concerns: what is the best way for me to communicate this? And there's something else too: on the one hand, you hope that the forecasts are right, as if they aren't, KNMI may be inundated with complaints. 'Yes, but you lot said that…' On the other hand, you hope that the weather won't turn out as bad as all that, because if it does, you know what the consequences of that could be. So you're very ambivalent."

Be single-minded but set intelligence to maximum

Back to 14 July 2010. "That day, the Weather Alarm was only in force for the eastern and southeastern part of the country. It was up to us to make this very clear to everybody. This implies that you always have to be thinking about the communication method and that you have to monitor developments closely. You mustn't think for a second: 'not right now'. You have to stay focussed, professional and calm, and ensure that all communications to the outside world are 100% accurate. In short: be single-minded but set intelligence to maximum."

from 6.00 till 7.00 p.m.

EUMETNET: making progress together

While the meteorologists and press spokesperson have their hands full with the Weather Alarm and storms are raging across the Netherlands, elsewhere at KNMI a videoconference is underway. The chairman of the European Taskforce on Climate Change Services, Dr. Arie Kattenberg, is meeting with his colleagues from the EUMETNET countries to discuss the organisation of a joint approach to climate change services. All affiliated countries feel that they need these services but are not always in agreement on the precise content. This is of great political significance for the Netherlands, for instance in respect of future water management policy. After all, it seems logical that KNMI's cross-border climate scenarios should dovetail with those of the neighbouring countries. However, this is far from certain, as each country carries out its own research on climate change on a national level.

So, why has Arie Kattenberg convened this meeting? Well, the meeting of the EUMETNET General Assembly held on 18-19 May 2010 in The Hague unanimously passed a resolution to set up an 'ad hoc' taskforce. The directors of the National Meteorological Services (NMS) recognised that this development was in all countries' interests. As a result, they each agreed to appoint an expert to develop this idea further. This decision was supported by the directors of EUMETSAT and ECMWF.

Twenty-nine European National Meteorological Services have joined forces in the Network of European Meteorological Services (EUMETNET). This organisation sets up pan-European (infrastructure) programmes in such fields as observation systems, weather models for local and regional forecasts, warning systems for dangerous weather, and climate issues. This includes programmes - such as the carrying out of observations in the North Atlantic Ocean - which one country cannot afford to carry out on its own. Other areas include the harmonisation of observations and methods, to ensure that comparative studies use the same basis. In 2009, EUMETNET became an Economic Interest Grouping (EIG), an official organisation. Its members are the National Meteorological Services.

KNMI's Director-General, Frits Brouwer, is chairman of the EUMETNET General Assembly. Note that EUMETNET is not the only alliance of National Meteorological Services - others are EUMETSAT and ECMWF, which are intergovernmental organisations. It is EUMETSAT's mission to build up, launch, maintain and operate the European network of operational meteorological satellites, and also to collaborate with ESA. Within ECMWF 30 countries work together to develop and operate computer-generated medium-term forecasts using meteorological models that cover the entire planet. Together with the NMSs, EUMETNET, EUMETSAT and ECMWF make up EMI, the European Meteorological Infrastructure. The EMI is the contribution of the wider European Union to the WMO World Meteorological Organisation.

National hub

KNMI is internationally active in meteorology, because the Netherlands is very dependent on long-term international cooperation. In fact, KNMI is a national hub in an international meteorological network. Society is becoming increasingly vulnerable to weather. Increasingly detailed forecasts are needed both to help ensure our short-term and long-term safety and to ensure favourable conditions for business development. In the Netherlands almost all

weather comes from abroad. It's no surprise then that data from the whole of Europe is needed to produce a two-day weather forecast, and from almost the entire planet for a five-day forecast. The most efficient and effective approach is to collaborate with fellow-NMS to be able to use and share knowledge, information and weather data.

Vulcanic ash

Frits Brouwer invited the members of the EUMETNET General Assembly in The Hague to attend the meeting in May 2010. It almost all went wrong. Amsterdam Airport Schiphol's closure due to the volcanic ash cloud on Monday 17 May threatened to 'derail' the semi-annual meeting. However, Frits was able to use his first-hand knowledge to assure the directors, their advisors, the deputy representative from Turkey and the invited experts that the airspace would be opened up in time.

The Assembly may be characterised as a 'pressure cooker'. In just a day and a half, over 50 papers are discussed, with the experts providing comments where necessary. Accordingly, the chairman has to have a special knack for keeping everything in equilibrium. This all the more so because the directors have wildly differing opinions on a whole variety of items. Usually it's best to call for a short break, as lobbying can then be carried out during a coffee break, after which the resolution can be decided on, often under pressure from the chairman. Europe is undergoing rapid change. Standing still means going backwards quickly. Note that in meteorology, unlike other specialist fields, you get left behind if you don't take part. As the sixth largest financial contributor in Europe, making it the largest of the small contributing countries, the Netherlands feels it's imperative to remain involved in this regard. The resolution passed in the meeting to create a new, considerably more efficient working structure is a major achievement. After all, the increasing number of members is making it more difficult to take decisions. A number of proposals for which KNMI staff have provided input are approved. Examples are: a vision of the future for meteorological observations in Europe up to 2020; the joint invitation (via EUMETNET) of tenders for automatic weather stations on ships; a mandate to set up the European taskforce Climate Change Services, and a roadmap for regional forecast models.

There was a lot of discussion regarding the consequences of the volcanic eruption. The directors were of the opinion that a coordinated response to the European Union, to airline companies and to other stakeholders can only be achieved by 'speaking with a single voice' via EUMETNET. Both VAAC London (Volcanic Ash Advisory Centre) and the individual countries were complemented about the very effective action they had taken after the volcanic eruption. The Netherlands's decisive action had even led to it getting its airspace opened one day earlier than the other European countries did.

Cooperation is essential

On 18 May, the Secretary-General of the Ministry of Transport, Public Works and Water Management, Siebe Riedstra, invited his foreign guests to attend a reception at the Johan de Witthuis residence. In his speech, he expressed his pride that KNMI is part of the Ministry. He believes that international cooperation is essential, both to tackle the challenges posed by climate change and to deal with such problems as dangerous weather and volcanic ash. He is convinced that EUMETNET has an important role to play in these efforts.

So, in 1.5 days of hard working many resolutions were passed (although Frits Brouwer would have liked more to have been taken). During the next six months, many people will be working hard to implement these resolutions in detail and to making European cooperation a bit closer and more efficient.

Speech of Secretary-Generaal Siebe Riedstra to the members of the EUMETNET General Assembly

from 7.00 till 8.00 p.m.

Increasing demand for climate knowledge

The Dutch government, knowledge institutions and companies are working hard on climate adaptation, this meaning adjusting to the consequences of climate change. This is leading to a sharp increase in the demand for information on climate and climate change. We define 'climate services' as the active provision of historic and future climate information to a broad range of users: policymakers such as the Ministry of Infrastructure and the Environment, impact researchers and adaptation researchers working for knowledge institutions, companies, NGOs etc.

Off the peg versus tailor made

Wherever possible, KNMI tries to provide answers to climate information queries using standard or 'off the peg' products such as climate scenarios. The advantage of this is that a large group of users can make use of the same product. This aids comparability and the consistency of results between various users and is cost-effective. In 2010, we worked on the climate atlas for the period 1981-2010 and on the next generation of climate scenarios.

However, not everyone needs the same climate information or uses the same timescale (see table on next page). This is why KNMI also provides tailor-made advice and/or data. In 2010, for example, information was provided to the Delta Commission regarding the determination of future river drainage for the Rhine and Maas rivers; we carried out research for GasTerra/NAM on the extent to which the likelihood of extremely cold winters is diminishing; and we generated the climate datasets needed by Alterra for impact research into plant yields.

When it comes to both off the peg and tailor made products, we make use of our extensive knowledge in the field of climate research, made possible by a top-notch knowledge infrastructure on an international scale. Thorough knowledge of the climate system, climate models and techniques to prepare the information for use in impact studies play a vitally important role in the development of these products.

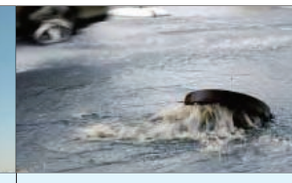
KNMI keeps in regular contact with users through workshops, presentations and consultations. In this way, we gain a better understanding of the ways in which climate data/information is used in the various sectors. This means we can give more effective advice and potentially help users to apply the data too. In March and April 2010, two workshops for users of climate information were organised. These workshops focussed on users' wishes relating to the new KNMI climate scenarios that will be published in 2013. The fact that large numbers of various types of users attended showed that the users want this too.

International cooperation

Up to now, climate services have primarily been organised at a national level and there has been little cross-border sharing of services. Although climate change is a global phenomenon, the effects are primarily felt locally. Despite this, the various European countries experience many of the same problems with climate service provision, and user needs do not vary greatly. In the Netherlands, much has been done in relative terms in recent years regarding climate service provision, but we are certainly not the only country active in this field. This is why we can learn a lot from each other's methods and insights. Various international initiatives have now been set up (EUMETNET, WMO, ECLISE, EURO4M, CLIK'EU, ENES) where such cooperation is being worked on or where this is planned. KNMI is actively involved in these initiatives.

Delta programme based on KNMI climate scenarios

In September 2010, Delta Programme Commissioner Wim Kuijken presented the first Delta Programme. The aim of the Delta Programme is to protect our country now and in the future against high water levels and to secure fresh water supplies. The Delta Programme was drawn up using a large amount of Dutch common sense and advocates taking a safe and flexible approach. The programme is based on measurements and the KNMI climate scenarios from 2006. These scenarios will be re-evaluated in 2013. Over the past century, the sea level has risen, the land has subsided and it has got warmer. According to the KNMI climate scenarios, this trend will continue. When planning the layout of our country, we must take into account the fact that heavier showers will occur. Summers may get drier too, which could endanger freshwater supply. The Delta Programme contains measures to ensure the safety of our delta in the short term and to put the preparations for the future on a firm footing.

			
	Energy	**Sewerage**	**Coastal protection**
Desired data	windspeed	precipitation-extremes	sealevel, windspeed and direction
Desired time resolution	day-month-year	5-6 minutes	year
Desired time horizon	2015-2020	2050-2100	2050-2200

User needs differ greatly when it comes to climate data

The Climate Effect Indicator compiles data and information on climate and its effects in the Netherlands. The Indicator helps users to find information on climate impact and adaptation studies produced by various research institutes. KNMI is responsible for the klimaat (climate) section.

from 8.00 till 9.00 p.m.

Meteorology in the Caribbean Netherlands

It is now 8 p.m. in the European part of the Kingdom of the Netherlands. The lightning storm removed the stuffiness in the air, and a cloudy but pleasant evening has begun. However, starting on the great-looking date '10-10-10' onwards, the Netherlands will be enriched by three islands in the Caribbean region referred to as the Caribbean Netherlands, also known as the BES islands, consisting of Bonaire, Sint Eustatius and Saba. The three islands have the status of 'special municipalities'. From this date onwards, KNMI will be responsible for the meteorology and seismology on these islands. Aruba, Curaçao and Sint Maarten will become autonomous countries. There is already a close cooperation with the MDNA&A, the Meteorological Service for the Netherlands Antilles and Aruba, but this will change now that KNMI has assumed responsibility for the BES islands. There has been much travelling between the Netherlands and the Antilles, but part of the meetings can be conducted by phone. Local time there is now 2 p.m.

The six Antillean island are divided into two groups. The Windward Islands, also known as the 'sss islands', are located to the east of Puerto Rico. The Leeward Islands are called the 'ABC islands' and are located off the coast of Venezuela. The two groups of islands lie about 1,000 kilometres from each other, which means that the Caribbean Netherlands does too.

The accession of the BES islands to the European Netherlands adds more than just a rich culture. The islands have much to offer in a meteorological and seismological sense too. The islands enjoy a tropical climate and some areas are covered by rainforest. They display all the characteristics of a humid tropical climate. It is known that hurricanes pass through every year, the hurricane season lasting from June to end-November. Hurricanes can cause very great devastation, which is why an early warning system is imperative. The knowledge centre in this field is the National Hurricane Centre in Miami, which is part of the United States' National Weather Service.

The BES islands' own natural scenery adds major new phenomena too. Saba consists of a dormant volcano with four lava domes. The slopes incline steeply down to a rocky coast by the sea. The Mount Scenery volcano is 877 metres high, which makes it the highest point of the Netherlands and in the entire Kingdom of the Netherlands. Sint Eustatius has a dormant volcano known as The Quill, which name is an anglicisation of the original Dutch name 'De Kuil' ('The Pit'). Bonaire is famous for having one of the most beautiful underwater nature reserves in the world, which makes it a location much loved by scuba divers.

Safety

In its capacity as National Meteorological Service, KNMI has always worked closely with the former MDNA&A meteorological service of the Netherlands Antilles and Aruba. The latest developments are shared with each other to benefit the population's safety and welfare and to assist with socio-economic planning. Example: on Friday 2 July, after years of being out of action, Sint Maarten's weather radar, now modernized, was officially declared operational again in a ceremony attended by the Minister for Transport, Public Works and Water Management Camiel Eurlings and the Antillean Minister for Traffic and Transport Patrick Illidge. The weather radar system, which had now been

upgraded with the latest technology, is an important acquisition for making accurate weather forecasts for the Windward Islands and for the regional aviation sector. Furthermore, this weather radar is an essential component of the radar network in the northeastern Caribbean region that is an early warning system for tropical storms and hurricanes in this region.

In order to maintain continuity and quality of - and knowledge about - the weather forecasts for the Caribbean Netherlands, KNMI has asked the legal successor to the MDNA&A, namely the MDC (Meteorological Department Curaçao), to work closely with KNMI to continue to provide its service for the BES islands. The risk of hurricanes means that very specific knowledge is needed of the region and its culture, making international cooperation between the meteorological services in the Caribbean region of paramount importance. This is why MDC is also a member of the National Hurricane Centre in Miami and the World Meteorological Organization (WMO). In addition to hurricane forecasts, MDC provides weather forecasts for the aviation sector on the BES islands. In order to continually innovate and improve the quality of MDC's meteorological service, KNMI and the Curaçao weather service will continue to assist each other in matters of knowledge and research. A cooperation agreement has been signed to this end, which also sets out the cooperation on seismological matters. In 2006, three seismometers were installed on Sint-Maarten, Sint Eustatius and Saba in order to provide improved data on the islands' volcanoes and earthquakes. This seismic activity is monitored by KNMI, in the same way as is done with the Dutch measuring stations, in real time. A volcano monitoring system is to be installed on Saba in 2012 to monitor Mount Scenery.

The new countries within the Kingdom of the Netherlands will continue to cooperate. Sint Maarten and Aruba have signed bilateral agreements with MDC to continue the meteorological service performed until further notice. The cooperation used to bear the name Netherlands Antilles and Aruba but will now be registered with the WMO under the new name of Curaçao and Sint Maarten. Aruba has not yet reached a decision on this matter.

from 9.00 till 10.00 p.m.

Research never stops

Calm is once again descending in the KNMI building. For many researchers, this is the perfect time to work on their articles. You need quiet surroundings and a calm mind to be able to put your research and results down on paper properly. Here and there you can still see lights burning. The official language is now English; some of the researchers do not come from the Netherlands. To name just a few of their nationalities at random: Italy, China, England, Swaziland and Germany.

The research carried out at KNMI always relates to issues and problems faced by society. This may vary from new climate scenarios for the future to improving the models used to make weather forecasts to an analysis of the earthquakes in Groningen. The results of the research are used in turn at KNMI and are published in specialist journals. KNMI works closely with universities both at home and abroad. Some KNMI staff spend a small part of their time as professors at universities and several research projects are undertaken at KNMI.

In its role as a scientific institute, KNMI issues many publications each year. The year 2010 was no exception: several hundred dissertations, articles, presentations and scientific reports were published. Three examples are mentioned in this annual report. All publications can also be found in the database on KNMI's website.

Mxolisi Shongwe's doctorate

Improving understanding and forecasting of climate extremes

Cold, heat, drought, floods: climate extremes have a major impact on society, both in Europe and Africa, especially if they last a couple of months or more. How well can we predict climate extremes?

Mxolisi Shongwe from Swaziland has carried out research at KNMI on a number of specific events: extreme cold springs in Europe; the warm autumn in 2006; and the altered probability of drought and floods in the south and east of Africa. He obtained his doctorate on 20 January 2010 at the Utrecht University on his research on the subject of seasonal climate extremes: mechanisms, predictability and response to global warming.

The effects of climate change in Africa appear to depend greatly on the region and the season. According to current predictions, the region by the Kalahari desert in southern Africa will get even drier if global warming continues. Mxolisi Shongwe also found a shortening of the rainy season in and around his native country of Swaziland, with the same amount of rain falling in a shorter period of time. Further north, in Tanzania and Kenya, it was the exact opposite, with greater average rainfall being predicted, a reduced likelihood of drought in the future and a greater likelihood of very high levels of precipitation. However, the capriciousness of the African climate means that most of these trends will not be properly discernible until the second half of the 21st century.

In Europe, the autumn of 2006 was exceptionally warm. A careful analysis of the source of this warmth revealed that it was a combination of different types of weather, with much southerly wind and water from the Atlantic Ocean that was much warmer than usual. The southerly wind cannot be predicted a couple of months in advance, but the warmer water can be, so there is some hope that we will be able to predict whether these types of climate extremes are more likely. This is especially true for cold extremes in springtime in Eastern Europe. These appear to depend greatly on the volume of snow that fell in the winter: a cold spring is

much more likely if there is still a thick layer of snow on the ground at winter's end.

Wilco Hazeleger extraordinary professor at Wageningen

Linking KNMI's knowledge to the university's focus on applied solutions

On 1 June 2010, Wilco Hazeleger, head of the KNMI's Global Climate division, was appointed extraordinary professor of Climate Dynamics at Wageningen University. In this position, he works closely with the departments of Meteorology and Air Quality and Earth System Science.

Hazeleger defines his professorship in terms of 'achieving' and 'conveying', and as a step that both the university and KNMI will benefit from. He expects that he will be able to convey his (and KNMI's) knowledge on large-scale meteorology and oceanography, as well, of course, as their expertise regarding climate models. In turn, the University of Wageningen can contribute much knowledge of small-scale processes and of the non-physical aspects of Earth system processes.
Another aspect that attracts Hazeleger is the applied nature of his professorship, which at Wageningen has traditionally been in the field of water and agriculture. "Linking knowledge to practical applications: that's what it's all about," says Hazeleger.

Bram Bregman, extraordinary professor at Nijmegen

Interaction between climate knowledge and climate policy

On 15 November 2010, Bram Bregman, one of KNMI's strategic advisors, was appointed extraordinary professor in Climate and Sustainability at Radboud University Nijmegen. This position primarily focuses on the interaction between climate knowledge and climate policy.

Bregman is no stranger to Radboud. Some years ago, together with Prof. Wim van der Zande, he set up the 'Chemistry and physics of the atmosphere' course of lectures at Radboud. The course certainly turns out to satisfy a great need and attracts many students. Great pressure of work meant that he had to pass the baton to another but he intended to formalise the cooperation. This has now been achieved, with this appointment to the faculty of Natural Sciences, Mathematics and Information Science. Apart from the above-mentioned course set up, Bregman will also focus on making the link between scientific climate knowledge and climate policy understandable, by concentrating on the relevant problems, successes and challenges. The first step is to be the launching of a new course of lectures in the spring of 2011.

Radboud is no stranger to KNMI either and participates in a wide range of climate research programmes. Radboud collaborates with KNMI on the research programme Knowledge for Climate, and with various universities and institutes such as RIVM and PBL on impact studies.


Mxolisi Shongwe

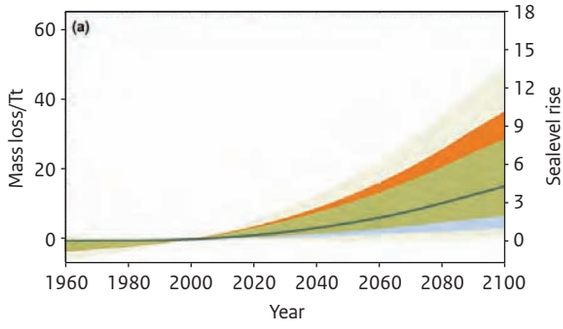

Wilco Hazeleger


Bram Bregman

Publications

Global sea level rise in the 21st century

The Greenland ice cap contains enough water to raise sea levels all over the world by seven metres. Over the past few decades, the volume of ice in Greenland has decreased. This is due to melting and crumbling away of ice. KNMI researchers, using an ice model that describes both processes, and working with colleagues from Utrecht University, have calculated how much Greenland could contribute to sea level rise during the 21st century. To this end, the model was fed with a range of scenarios relating to temperature and precipitation in the 21st century. The calculations show that Greenland could raise global sea levels by between one centimetre and 14 centimetres by the end of the 21st century. This range of values is due to uncertainties regarding future emissions of greenhouse gases, their effect on climate and on the crumbling of the ice floes, and uncertainties in the ice model.



This graph contains projections for Greenland's contribution to the raising of global sea levels in the 21st century. The orange, dark green and blue bands show the range of results from the various climate models, for three scenarios of future greenhouse gas emissions (blue: low emission levels; dark green: moderate emission levels; and orange: high emission levels). The light green band indicates the range of uncertainties in the ice model.

Graversen, R.G., S. Drijfhout, W. Hazeleger, R. van de Wal, R. Bintanja and M. Helsen, Greenland's contribution to global sea level rise by the end of the 21st century, Clim. Dyn., 2010, doi:10.1007/s00382-010-0918-8.

Infrasound measures changes in the stratosphere

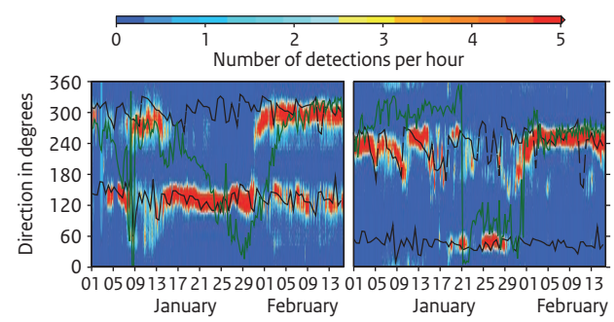
Infrasound generated by ocean waves can indicate a dramatic change in the stratosphere as the result of sudden warming. This is because instruments that measure inaudible infrasound as part of the checks performed under the nuclear-test-ban treaty also show temperature variations of up to 50 degrees Celsius and variable winds at great altitudes. This means that apart from tracing nuclear bomb tests, this remote sensing technique can be used for climate research.

Ocean waves in the Atlantic and Pacific Oceans continuously generate infrasound called 'microbaroms'. This inaudible sound travels over distances of thousands of kilometres, and the signals can be detected all over the world using infrasound arrays. Wind and temperature in the atmosphere (at altitudes of between ten and 50 kilometres) play a decisive role in the transmission of this sound. Measurements taken in January 2009 revealed a drastic change in the direction from where the infrasound came. Infrasound arrays set up in Greenland (IS18) and Alaska (IS53) suddenly started registering infrasound emanating from the Atlantic Ocean instead of the Pacific Ocean. This appeared to be related to a 'Sudden Stratospheric Warming', whereby the temperature in the stratosphere - at about 20 kilometres above the Earth - rose several dozen degrees Celsius in just a few days. At the same time, the wind speed dropped or changed direction.

In the article, KNMI researchers Läslo Evers and Peter Siegmund show how passive measurements of infrasound at the Earth's surface can be used to monitor changes in the stratosphere. This work is necessary because observations of the upper stratosphere are scarce.

The graphics show which direction the infrasound observed emanating from ocean waves came from in January and the first half of February 2009. A direction of 0 degrees means that the source was located north of the measurement device, with 90 degrees meaning it was located east of the device. The left-hand section of the graph shows the results for the IS18 array on Greenland, the right-hand section shows the results for the IS53 array in Alaska.

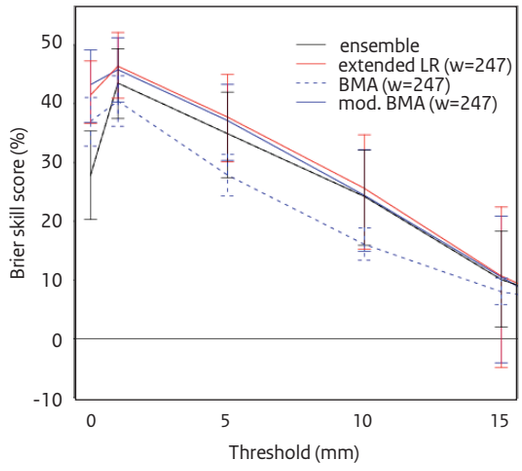
Evers, L.G. and P. Siegmund, The infrasonic signature of the 2009 major Sudden Stratospheric Warming, Geophys. Res. Lett., 2009, 36, doi:10.1029/2009GL041323.



A better way to forecast probability

These days, most probability forecasting techniques involve ensemble prediction systems (EPS). These systems consist of a large number of weather model forecasts (known as 'ensemble members'), each of which starts from a different (somewhat perturbed) initial state, and whose model physics often differ too. When the various model forecasts within the ensemble start to diverge, the atmosphere becomes less predictable and thus the forecast more uncertain. By taking the percentage of ensemble members that predict more than one millimetre of precipitation, for instance, an estimate of the probability of more than one millimetre of precipitation may be made. However, these probabilities are usually not 'reliable'. 'Reliable' in this context means that the x% probability of an event occurring will actually lead to the event occurring in x% of the cases, for any value of x.

In this article, KNMI researchers Maurice Schmeits and Kees Kok compare the raw ECMWF-EPS precipitation probabilities with two statistical techniques: Bayesian model averaging (BMA) and extended logistic regression (LR). The raw EPS precipitation probabilities all proved to be reasonably 'reliable', whereas BMS generally produced very unreliable probability forecasts. The researchers have identified what was wrong with this method and have improved it. The improved BMA method turned out to perform about as well as the extended LR method, with both methods being able to further improve EPS probability forecasts.



The above graph shows verification in terms of the Brier skill score (%) as a function of the precipitation amount for which the probability forecasts were made (precipitation threshold). The higher the Brier skill score (BSS), the more accurate the probability forecasts are. A perfect system will have a BSS of 100%, whereas a system that is no better than climatology will have a BSS of 0%. It is encouraging to see that the improved BMA method (blue line) and the extended LR method (red line) achieve more accurate probability forecasts than does the EPS (black line). It can also be seen that the Brier skill score is lower for higher precipitation thresholds, as it is harder to forecast high amounts of precipitation.

M.J. and C.J. Kok, A comparison between raw ensemble output, (modified) Bayesian model averaging and extended logistic regression using ECMWF ensemble precipitation reforecasts, Mon. Wea. Rev., 2010, 138, 11, 4199-4211, doi:10.1175/2010MWR3285.1.

from 10.00 till 11.00 p.m.

The Ozone Monitoring Instrument (OMI): Vital data

The Dutch-Finnish OMI satellite instrument has been in space for over six years now. KNMI supplied the principal investigator for the OMI project and is responsible for such matters as the day to day management, the quality of the raw measurement data and several data products. The day-to-day management work consists of KNMI sending commands to the NASA Goddard Space Flight Centre (GSFC) in Washington DC.

NASA-GSFC relays these commands to the satellite the same day at 10 p.m. our time. These commands tell the instrument which measurements to take the following day. The OMI instrument is in fine working order and can supply high quality data for many years to come. We need to further extend the dataset that we already have, as this would allow us to derive trends in gases such as ozone and nitrogen dioxide. Apart from using the OMI data to discover trends, each year a number of events occur that allow OMI to supply unique data. Two of these events occurring in 2010 were the eruption of the Icelandic volcano Eyjafjallajökull and the forest fires in Russia.

Vulcano

The Icelandic volcano Eyjafjallajökull began erupting on 20 March 2010 and continued until 23 May. Iceland is home to many active volcanoes, so eruptions are not in themselves unusual. What made the Eyjafjallajökull eruption special was that on 14 and 15 April a huge cloud of ash was released that the wind carried straight towards Europe. Since volcanic ash can damage aircraft engines it was decided to ground all air traffic for a few days. OMI can measure both the volcanic ash and the sulphur dioxide emissions. OMI measurements made it much easier to monitor the ash cloud and to estimate the ash concentrations. A major benefit was that OMI data were available just three hours after measurement. OMI data is also supplied to the aviation sector automatically. In order to be even better prepared for the next time there is an eruption, these days OMI data is available just 20 minutes after being recorded. This improvement is the result of cooperation between KNMI, FMI (Finnish Meteorological Institute) and NASA.

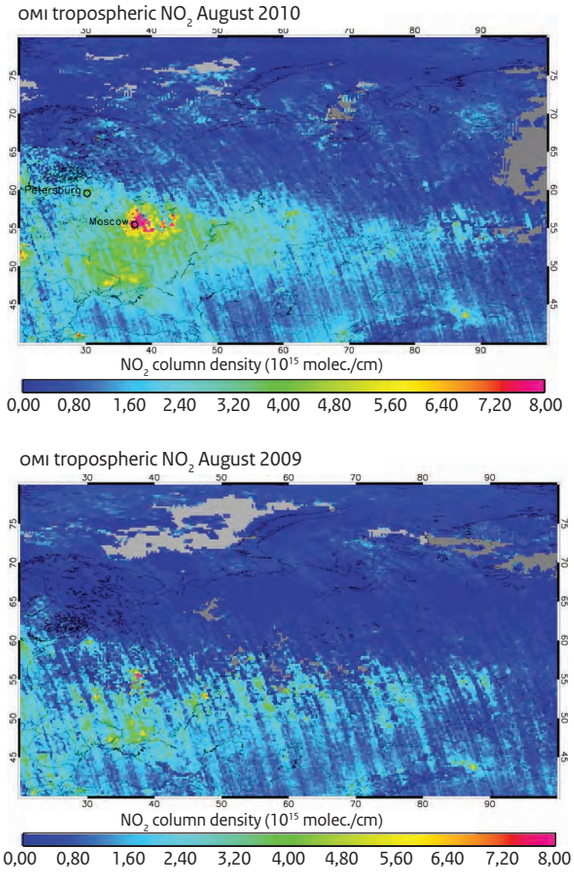
Forest fires

In 2010, the region around Moscow experienced an extremely hot and dry summer. In July and August there were more forest fires than usual, which caused a great deal of air pollution over a wide area. A suffocating layer of smoke hung above the city of Moscow and its ten million inhabitants for days, with high levels of dust particles known as 'aerosols' even being detected in Finland, more than a thousand kilometres from the fires. In July and August, in the Netherlands the wind came predominantly from the west, which is why the smoke could not reach us from Russia. We use OMI to measure the nitrogen dioxide levels released by forest fires. In summertime, nitrogen dioxide decomposes quickly, which is why high concentrations are a good indication of the location and intensity of fires. OMI measurements of the smoke also revealed that the smoke reached higher altitudes than was the case in previous years where Russia experienced a large number of fires. Quite apart from the large-scale air pollution, the drought and the fires affected the grain harvest in Russia and thus global food prices too.

TROPOMI

In the Netherlands and at KNMI, people are working hard on a successor of OMI, to be called TROPOMI (TROPospheric Ozone Monitoring Instrument). KNMI has provided the principle scientist for this programme. This instrument

was developed in partnership with ESA and is scheduled for launch in late 2014. TROPOMI will not only continue the OMI measurements but will also incorporate important improvements that allow for more accurate measuring and also mean that the greenhouse gas methane and the gas carbon dioxide can be measured. The TROPOMI development programme is part of the European GMES (Global Monitoring of the Environment and Security) programme.



Average nitrogen dioxide concentration for the period 1-9 August 2010 and 2009. The yellow and red areas around Moscow indicate the locations of the forest fires

The EOS Aura satellite, with OMI and other instruments on board. All instruments are completely wrapped up in a type of golden paper that protects them from the heat

from 11.00 p.m. till midnight

On volcanic ash, the coalition agreement and the political arena

A white Christmas, a (new style) Weather Alarm, a good few codes orange (Weather Alert) and the coldest year in years - 15 years to be precise. In short, from a meteorological point of view, 2010 was anything but a dull year for KNMI. All the same, Director-General Frits Brouwer recalls two other issues that dominated 2010: the Icelandic ash cloud that brought European air traffic to a complete standstill in April, where KNMI played an important role, and the coalition agreement of the new government that mentioned KNMI by name.

It may have only been two short sentences, but - when first read by KNMI employees - they certainly gave no reason to jump for joy: "The subsidies of the Ministry of Transport, Public Works and Water Management will be reduced. Furthermore, KNMI's current range of duties will be reassessed (possible privatisation)."

All the same, Director-General Frits Brouwer was pleasantly surprised that 'his' institute was explicitly mentioned in the financial section of the coalition agreement. "Whichever way you look at it, it implies that KNMI is an important agency! The negotiators of the different political parties have been discussing us, and that's just as it should be. After all, KNMI performs very important work in many different fields, both nationally and internationally. Just think of Weather Alarms, climate change and earthquakes."

Scary?

"And oh well, the fact that it says that our role is being reviewed, didn't and doesn't surprise me," adds Brouwer. "It may sound scary, but our role would have been reviewed even if the above statement hadn't been made. The Kingdom simply has to make savings, a total of 18 billion euro of them. You don't achieve such cost savings just by improving efficiency. In other words, activities in all government departments will have to be reviewed."

However, one thing that did surprise Brouwer is the section where the sentence was taken from, which was discussing subsidies. Brouwer: "Subsidies that this Ministry, the Ministry of Infrastructure and the Environment, grants to third parties. However, KNMI does not award any subsidies and does not receive any from the Ministry either. As part of the Ministry, we only receive the so-called 'Agency contribution' for providing a range of products and services once our Programme Council has approved them [Note that KNMI's customers are represented on this committee - Ed.]." The fact that KNMI cannot bring this up for discussion is something that Brouwer calls 'a fact of life'. "The House of Parliament accepted the coalition agreement, including its subsidy requirement! The elaboration will show us exactly what this signifies for us."

New procedure for Weather Alarms

An important role in this elaboration has been reserved for CDA Party (Christian Democrats) member Joop Atsma, 'our new State Secretary' and 'an old friend of KNMI'. It was Atsma who at the end of 2007 whilst a Member of Parliament started the public debate about Weather Alarms. In the Dutch daily newspaper Algemeen Dagblad at that time, he commented that "too often KNMI issues incorrect Weather Alarms that have had needlessly detrimental consequences for society." Brouwer: "There was truth in what he said, but we had been issuing Weather Alarms for almost ten years, and a process was already underway at KNMI to modernise the whole procedure. However, his criticism certainly meant that Atsma helped to introduce a new Weather Alarm procedure at KNMI, which made its debut

Frits Brouwer

Director-General KNMI

"In short, the volcanic ash crisis showed that when things get critical, it's KNMI that can make the difference. And that's something I'm really proud of!"

on 1 February 2010, and it is a procedure moreover that really proved its worth in 2010."

Political overtones

By way of this detour, Brouwer returns to the subject of 'the quote' in the coalition agreement. In addition to the previously mentioned benefit ('we make a difference'), he feels that this statement has provided another benefit too. "Somehow, KNMI has to cut costs. This quote means that the whole process has gained a political dimension now - it is no longer just about balancing the books... This means we can now conduct a fundamental discussion at a political level about the role that national meteorology should play in the Netherlands. What approach should we take? A proper response to this issue requires more things to be taken into account than just a cost-cutting campaign."

No sacred cows

"For example, it is now possible to bring the international dimension into the debate," continues Brouwer, "as well as such issues as safety, the contribution that meteorology makes to innovation that in turn benefits the Dutch economic growth, and environmental issues – these must all be considered too now. Basically, there are no sacred cows any more. You may find this scary or feel vulnerable as this debate could result in any one of a number of outcomes. However, I prefer to take the opposite view: I believe that it offers us a whole host of opportunities! In addition, we

have faith a) in ourselves and b) in the people who in the end must take the decisions. In short, I have complete faith that the political outcome will be both appropriate and consistent with existing policy. After all, we can debate roles, as long as the outcomes will be laid down for a longer period of time - I would say for at least ten years."

Pride

A word about politics. One major political development in 2010 was the major gains made by the Party for Freedom (PVV) during the elections to the Dutch Lower House. These gains ultimately led to a government that members of political parties could accept in a way that gave considerable power to the PVV, which had more than once expressed scepticism about such issues as climate change. Brouwer, down-to-earth as ever, "This same political movement really cares about the Netherlands. It is also proud of its national accomplishments. I believe that a fantastic knowledge-based institute such as KNMI is something to be proud of. Just imagine for instance that the Netherlands became dependent on another country's meteorological office. I don't think that the PVV wants to see that happen!"

The very pinnacle

KNMI experienced the very pinnacle of achievement in mid-April 2010 when large areas of European airspace were closed for days due to the ash cloud emitted by the volcanic eruption under the Eyjafjallajökull glacier in Iceland on 14 April (see also: Ash cloud brings European air traffic to a standstill, page 38). "KNMI really showed its worth during this time and (further) raised its profile, even though this was naturally the last thing on our minds. At times like that, you take the action that benefits society, not that which benefits your own profile."

"During this particular period, all kinds of people cooperated very closely with each other," continues Brouwer. Researchers, operational forecasters, technicians... all the 'blood groups' that KNMI can call on in-house flowed together. During a time of great pressure of work, this produced solutions that would probably have taken longer to arrive at if we had just kept to the standard procedures. It was a very special time. Furthermore, there was particularly good cooperation with external stakeholders such as LVNL (Air Traffic Control The Netherlands) and NLR (National Aerospace Laboratory). The result was that we here at KNMI really helped to ensure that our airspace was one of the first to be opened up again. This saved a lot of money. The Netherlands also showed other countries that we are an innovative country that can find solutions quickly. Then Minister, Camiel Eurlings, subsequently thanked us for this. What more can you ask for?"

The difference

"It was a time when we had to stand up and be counted - and we were! Just imagine how things would have gone if there had been no institute like KNMI. Would we very quickly have been able to bring together researchers from a university and - staying with this example – the staff of a foreign meteorological service so that they could advise the Minister? I very much doubt it! In short, the volcanic ash crisis showed that when things get critical, it's KNMI that can make the difference. And that's something I'm really proud of!"

Staff

The number of staff declined in 2010. This is due to the austerity package introduced by the Balkenende IV government. Apart from the outflow of employees there have been measures designed to restrict recruitment. This situation will continue in the years to come, thanks to the new cabinet's austerity package. The average age will rise further too, due to the limited inflow of new employees.

The rate of absence due to illness has risen a full percentage point compared to 2009. This is largely due to the accumulation of cases of serious medical complaints unrelated to working conditions.

2010	Men	%	Women	%	Total
Number of staff	345	75.5 %	112	24.5 %	457
Average age	47.9		42.4		46.6
Number of part-timers	55	15.9 %	71	63,4 %	126
Average working hours	35.15 uur		28.56 uur		
Rate of absence					4.13%

2009	Men	%	Women	%	Total
Number of staff	371	76.5%	114	23.5%	485
Average age	46.6		40,9		45.3
Number of part-timers	57	15.4%	65	57%	122
Average working hours	34.85 uur		28.27 uur		
Rate of absence					3.12%

The year 2010 in brief

January

Signing the first employment contract at SWO, KNMI's scientific research foundation

Weather forecasts now include wind chill factor

On frosty days, and especially on mild or hard frost days, the wind makes you feel colder. This is why in January KNMI started reporting the wind chill factor as well as the air temperature.

Amateur weather enthusiasts help KNMI with its research of urban climate

In (large) cities it is usually warmer than in the countryside. This difference in temperature is often as much as several degrees, and is usually called the 'urban effect' or the 'urban heat island'. In this month, KNMI launched a research project on the urban effect in Dutch cities. This project uses data from 150 amateur weather enthusiasts from all corners of the country.

First appointment at SWO, KNMI's scientific research foundation

SWO has welcomed the first member of staff to its ranks. On 14 January, Frits Brouwer, in his capacity as chairman of the SWO, signed the first employment contract. Sébastien Berthier from France then added his signature, making him the foundation's first employee. The foundation was set up some time ago but has now been reactivated as part of the central government reform programme VRD. This programme aims at creating a smaller but smarter government.

Weather and Infra pass their joint quality audit with flying colours

Both the Weather and Infra sectors now possess a quality management system (KMS) that has been awarded ISO 9001 certification. On Thursday 21 and Friday 22 January, they both underwent - and passed - the annual audit performed by DNV (Det Norske Veritas), an independent foundation active in risk management. For the first time a joint audit was performed, which was intended to intensify cooperation. This time, the main focus was on the customer-supplier relationship.

Febuary

Updated warnings

Updated warnings and the KNMI website

Starting on 1 February, the weather alerts have been regionalised for each province, with a three-phase system being deployed: severe weather warning, Weather Alert and Weather Alarm. These three phases are presented on the KNMI website using the colours yellow, orange and red, respectively. In addition, KNMI issues wind and storm warnings especially for shipping.

State of the Climate 2009

Minister Jacqueline Cramer of the Ministry of Housing, Spatial Planning and the Environment received the first copy of the brochure Staat van het Klimaat 2009 (State of the Climate 2009). This brochure published by the PCCC, the Platform Communication on Climate Change - which the KNMI participates in - provides a summary of relevant developments in the field of climate, climate change, climate research and climate policy for the previous year. Possibly the most important climate-related event in 2009 was the climate conference in Copenhagen.

Delta Programme Commissioner Wim Kuijken starts work, Delta Act submitted to Dutch Lower House

The submission of the Delta Act on water safety, 'high water' protection and freshwater provision by State Secretary Tineke Huizinga to the Lower House on 1 February has enshrined in law the Delta Programme, the Delta Fund and the role of the Delta Programme Commissioner. This means the Netherlands' new water safety policy is now on a sound legal footing.

Delta Commissioner Wim Kuijken

Fall of the government

The government fell in the evening of 19 February. The PvdA party withdrew, with the remaining ministers and state secretaries from the CDA and Christian Union parties forming a caretaker government. State Secretary Tineke Huizinga, who bore the political responsibility for KNMI, was sworn in as the new Minister of Housing, Spatial Planning and the Environment on 23 February. Her portfolio as State Secretary for Transport, Public Works and Water Management was handed to Minister Camiel Eurlings.

March

KMI visits KNMI

A delegation from Belgium's Royal Meteorological Institute (KMI) led by its director Henri Malcorps visited KNMI on 17 March. The visit was primarily intended to intensify the existing cooperation between the two

institutes. Topics discussed included KMI's installation of the KNMI Brewer spectrometer on Antarctica, cooperation on the SAFIR lightning detection systems, and the joint development of climate scenarios for the Netherlands and Flanders.

World Meteorological Organisation celebrates 60th birthday

On Tuesday 23 March, the World Meteorological Organisation (WMO) in Geneva celebrated its 60th birthday. WMO is a specialist United Nations organisation that promotes international cooperation and scientific research on the weather and climate. On this day, the KNMI building in De Bilt was one of those to fly the flag of WMO. The KNMI's Director-General represents the Netherlands at WMO.

April

Eruption of the Eyjafjallajökull vulcano

Eyjafjallajökull

The eruption of the Eyjafjallajökull volcano on 14 April and a northwesterly wind spread a cloud of volcanic ash in the air right across Europe. This brought air traffic to a standstill for the first time in Dutch aviation history. There was a huge demand for information from the London Volcanic Ash Advisory Centre and from KNMI that was needed to take decisions regarding the resumption of air traffic. As an innovative weather service we were able – in close consultation with organisations such as LVNL (Air Traffic Control The Netherlands) – to develop and provide new products for the aviation sector within just a couple of days. For instance, lidar measurements taken by the measuring mast in Cabauw were combined with satellite images to produce charts showing the distribution of the volcanic dust above the Netherlands.

Volcanic dust and infrasound from Eyjafjallajökull eruption measured in De Bilt and Cabauw

In April, for the first time in history, volcanic ash was recorded in De Bilt with the aid of a special ozone balloon. The ash was also visible on the lidar equipment at the KNMI measuring mast in Cabauw. A lidar is a special type of radar that looks upward. Furthermore, infrasound from the eruptions was measured by very sensitive barometers known as microbarometers. Infrasound is inaudible to the human ear as the frequencies are below 20 hertz. Such low frequencies are hardly damped by the atmosphere, allowing them to travel huge distances.

KNMI directs new European climate research programme EURO4M

In its capacity as an international data centre, KNMI is directing EURO4M (European Reanalysis and Observations for Monitoring) project, a large-scale research project into extremes in European weather and climate. In a programme to be undertaken jointly with research institutes in eight countries, observations from weather stations and satellites will be combined to provide an even more detailed map of climate change in Europe. The European Union needs this data to help it make policy decisions.

Oil spill in the Gulf of Mexico

Oil slick in the Gulf of Mexico

The oil spill in the Gulf of Mexico has caused a great deal of damage and has had unprecedented ecological consequences. KNMI has helped with the disaster response efforts. At the request of the American NOAA (National Oceanic and Atmospheric Administration), KNMI provided satellite wind data for the disaster area. This wind data was needed to help determine where the wind is driving the oil slick to. This allowed the efforts to combat the oil slick to be concentrated in the most effective location.

Institutes pool data and computing power in the National Model and Data Centre

Six Dutch government departments and science institutes (RIVM, PBL, TNO, Deltares, Alterra and KNMI) will now link up their computer models and data in a National Model and Data Centre. Linking up models and data from these institutes provides a more complete and more detailed picture of trends and developments in the field of the (natural) environment and living environment. NMDC officially started work on 20 April. NMDC is part of the current trend for a smaller but smarter government that works together in partnership with the market.

MeteoSwiss visits KNMI

Gerhard Mueller (Director Climate) and Peter Binder (Director Weather) of the Swiss national meteorological office MeteoSwiss visited KNMI on 7 and 8 April, specifically to talk about their experiences with KNMI as an agency of the Ministry of Infrastructure and the Environment (known at that time as the Ministry of Transport, Public Works and Water Management) and about the relationships that KNMI has in the aviation

meteorology sector. MeteoSwiss is currently going through the same sorts of changes that KNMI has been through in recent years.

Lower House hearing on climate research and IPCC

On 19 April, the Dutch Lower House held a hearing on climate research and IPCC. Members of Parliament listened the whole day to stakeholders talk about the set-up and organisation of IPCC, about possible errors made, and about the content of the Fourth Assessment Report (AR4). They listened to journalists, contributing authors and lead authors, expert reviewers and others. KNMI's Hein Haak, Rob van Dorland and Bart van den Hurk spoke at the hearing.

May

KNMI demonstrates air quality at World's Fair in Shanghai

The KNMI presence in the Dutch pavilion at the Shanghai World's Fair that took place between 1 May and 31 October 2010 included an air quality measurement station. It is the first meteorological pavilion in the history of the World Expo. Visitors could view the most recent satellite observations of nitrogen dioxide levels in the troposphere – the bottom ten kilometres of the atmosphere - on a huge screen. China's wild economic growth in its densely populated and industrialised regions make air pollution a problem that requires urgent action.

Frits Brouwer showing the signed agreement of the partnership of EUMETNET

EUMETNET Assembly meets in The Hague on 18 and 19 May

In its role as chairperson, KNMI had invited the EUMETNET Assembly to meet in The Hague. EUMETNET is the partnership of the European meteorological services. There was much discussion about the consequences of the volcanic eruption. Furthermore, important agreements were reached about issues as a roadmap for international observations, the provision of climate services, and the involvement with European programmes such as SES (aviation meteorology) and GMES (Global Monitoring for Environment and Security = European Earth observation programme).

Changes to the KNMI Council

In spring 2010, the composition of the KNMI Board was changed. Former chairman Prof. C.J.E. Schuurmans handed the chairmanship over to Prof. N.D. van Egmond. Mr Van Egmond is Professor of Geosciences at Utrecht University and a former director of the Milieu- en Natuurplanbureau (MNP), which is currently known as the Netherlands Environmental Assessment Agency. Also present was new member Prof. M.A. Herber. Mr Herber is Professor of Earth Sciences at the University of Groningen and had previously worked for over thirty years at Shell/NAM. Mr Herber is the Council Member who succeeds Prof. S. Cloetingh, who stood down last year.

June

Wilco Hazeleger, extraordinary professor at Wageningen University

1 June 2010, Wilco Hazeleger, head of the KNMI's Global Climate department, was appointed extraordinary professor of Climate Dynamics at Wageningen University. In this position, he will work closely with the departments Meteorology and Air Quality and Earth System Science. Hazeleger defines his professorship in terms of 'achieving' and 'conveying', as a step that both the university and KNMI will benefit from. He expects that he will be able to convey his (and KNMI's) knowledge on large-scale meteorology and oceanography, as well as the expertise relating to climate models. In turn, the University of Wageningen can provide much knowledge of small-scale processes and of the non-physical aspects of Earth system processes.

NERIES project completed; NERA project started

The four-year EC project NERIES reached a successful conclusion in 2010. NERIES's chief goal - the integration of the many existing seismological infrastructures - was achieved. NERIES put together the concept for the European Observational Plate Observatory (EPOS), which formed the cornerstone for the preparatory phase for EPOS, which commenced operations on 1 November 2010. The successor project to NERIES, NERA, commenced work on 1 November 2010 too, and will run until the end of 2014. NERA, which stands for the Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation, brings together seismologists and civil engineers who are specialists in earthquake-resistant buildings so that the relevant engineering infrastructures in Europe can be integrated with the seismological infrastructures too. All projects need to make multidisciplinary data accessible to a broadly based group of researchers as efficiently as possible. KNMI and ORFEUS (Seismology department) manage both NERIES and NERA.

Book on Weathermen in Wartime published

During World War II, KNMI was forced to shut down its meteorological service in De Bilt and at Amsterdam Airport Schiphol. Only research and observations were permitted to continue at the Netherlands Meteorological Institute, the German occupier having stolen the K of *Koninklijk* (Royal). Public service weather forecasting was halted in other countries too. Former KNMI employee Tjitse Langerveld dived into the archives and came up with a unique book about Weathermen in Wartime. This book received its official presentation on 4 May 2010.

July

Camiel Eurling and Patrick Illidge at the radar on Sint Maarten

Updated weather radar on Sint Maarten up and running

After years of being out of operation, the weather radar on Sint Maarten has been fully operational again since July. The radar officially went 'online' again in the presence of the caretaker Minister for Transport, Public Works and Water Management Camiel Eurlings and the Antillean Minister for Traffic and Transport Patrick Illidge. The weather radar system, which has now been upgraded with the latest technology, is an important acquisition for MDNA&A (Meteorological Service for the Netherlands Antilles and Aruba), as it can now make even more accurate weather forecasts for the Windward Islands and the regional aviation sector.

CESAR consortium: cooperation on air quality measurements

Directors of nine Dutch knowledge institutes (RIVM, TU Delft, TNO, ECN, Wageningen University, Utrecht University, Alterra, ESA and KNMI) have signed an agreement to increase cooperation in the field of climate and air quality measurements. The central site of this CESAR consortium (Cabauw Experimental Site for Atmospheric Research) is the KNMI measuring mast in Cabauw. The 213 metre mast is used to measure the state of the atmosphere (including clouds, fine dust, temperature and humidity) at various altitudes.

Damage caused by the storm to the camping site near Vethuizen

Fall winds during the 14 July storms

The chief cause of the damage during the storms of 14 July, which primarily affected the southeast and east of our country, was fall winds. The campsite near Vethuizen, where two were killed and at least four wounded, was probably hit by strong fall winds, known as 'downbursts' in meteorological circles. The edge of the storm structures also featured whirling structures known as 'gustnados'.

August

Satellite instrument OMI monitors forest fires in central Russia

The extent of the smoke from the forest fires that wreaked havoc in central Russia from July to September was mapped out by KNMI researchers using satellite images from the Dutch-Finnish satellite instrument OMI. Apart from smoke, forest fires generate nitrogen oxides and other poisonous gases. The nitrogen dioxide released is measured by the OMI satellite. In summertime, nitrogen dioxide decomposes quickly, which is why high concentrations are a good indication of the location and intensity of the fires. OMI measurements of the smoke also established that the smoke reached higher altitudes than was the case in previous years when Russia experienced a large number of fires.

September

Recieving the book 'Werk aan Delta'

First Delta Programme presented

Director-General Water Annemieke Nijhof officially took delivery of the first Delta Programme on 22 September. Delta Programme Commissioner Wim Kuijken handed Nijhof the first copy of the book 'Working on the Delta Programme. Investing in a safe and attractive Netherlands, both now and tomorrow.' The Delta Programme contains measures to ensure the safety of our delta in the short term and to put the preparations for the future on a sound footing. The KNMI scenarios have an important role to play here.

October

KNMI responsible for weather forecasts for the BES islands

Bonaire, Sint Eustatius and Saba joined the Dutch state system on 10 October, which means that from that date KNMI has been responsible for the meteorology and seismology for these three BES islands. In order to ensure that the weather forecasts for the Caribbean islands continue to be of top quality, Meteo Curaçao will cooperate with KNMI and continue to provide its service for the BES islands, as it previously did as MDNA&A (Meteorological Service of the Netherlands Antilles and Aruba).

KNMI takes second prize in Strategy Award competition

KNMI placed second in the Strategy Award competition organised by the VSB, the Dutch Strategic Management Society. KNMI won this award for its effective strategic work during the eruption of the Icelandic volcano last April. First price went to Raet (IT service provider for personnel and payroll records); third prize went

Minister of Infrastructure and the Environment Melanie Schultz

State Secretary Joop Atsma

November

De Bos Altas of The Netherlands - Land of Water

State Secretary Joop Atsma visiting the KNMI

December

to the online investors' bank BinckBank. On 12 October, Director Weather Service Remco den Besten accepted this second prize on behalf of KNMI.

New ministry, Minister and State Secretary

On Thursday 14 October, Queen Beatrix swore in the members of the new cabinet. Melanie Schultz van Haegen is the new Minister for Infrastructure and the Environment and Joop Atsma is State Secretary of the ministry and thus bears the political responsibility for KNMI. The new ministry is a combination of the former Ministry of Transport, Public Works and Water Management and part of the former Ministry of Public Housing, Spatial Planning and the Environment.

KNMI gets new computer centre

The KNMI's current computer room at De Bilt no longer satisfies power and cooling standards. The new computer centre is part of the KNMI Delta Plan Infrastructure and will be built in the old supply room. Construction started in late October and is expected to be completed by May 2011. Sustainability is a major requirement. This is why a geothermal heat pump system was chosen that stores heat and cold in the soil, in combination with coolers on the building's roof that utilise the open air.

Maritime sector will be warned earlier about wind gusts in the coastal areas

Starting on 1 November, wind gusts will be mentioned if the wind speed in gusts is more than 10 knots (5 metres/second) above the average wind speed. The criterion for mentioning wind gusts used to be one and a half times the average wind speed. In doing so, KNMI is fulfilling the wishes of the executive arm of the Ministry of Infrastructure and the Environment (Rijkswaterstaat) and others who want to further improve safety on the water.

The Bos Atlas of the Netherlands - Land of Water

Our country's culture has been enriched by the publication of a new atlas, the *Bosatlas van Nederland Waterland* (Bos Atlas of the Netherlands - Land of Water). The key theme of the new atlas is the many-sided relationship that the Netherlands has with water. More than forty government bodies, knowledge institutions (including KNMI) and companies collaborated on this compendium, which is also designed for use in the educational sector. HRH the Prince of Orange wrote the foreword. The atlas was published in early November.

Familiarisation visit by State Secretary Joop Atsma

On 22 November, State Secretary Joop Atsma paid a visit to KNMI in De Bilt. It was his first introduction to KNMI, for which he assumed responsibility when he was appointed as State Secretary of the Ministry of Infrastructure and the Environment. The State Secretary met the KNMI's management team, meteorologists and researchers and dropped by the forecasting office.

Bram Bregman, extraordinary professor at Nijmegen

15 November, Bram Bregman, strategic advisor at KNMI, was appointed extraordinary professor in Climate and Sustainability at Radboud University Nijmegen. This position primarily focuses on the interaction between climate knowledge and climate policy.

HIRLAM-B to commence in January 2011. KNMI's Jeanette Onvlee once again programme manager research

The research programme for the High Resolution Limited Area Model (HIRLAM) weather model will continue until at least 2015. The national weather institutes of ten European countries - including KNMI - have signed a Memorandum of Understanding to extend this partnership by a further five years. HIRLAM is a European weather model for short-term weather forecasts. With the accession of Lithuania, the number of members and participating countries has been increased to ten. Also in this second programme, KNMI will take the lead in the new HIRLAM research programme.

Alliance between KNMI and RIVM in the field of ICT

RIVM (National Institute of Public Health and Environmental Protection) and KNMI will study ways in which they can cooperate on ICT matters. Friday 3 December, Wouter Nieuwenhuizen (KNMI) and Niek Parlevliet (RIVM) signed a declaration of intent for this study on behalf of their respective institutes. Reasons for future cooperation include efficiency gains within government, reducing the volume of outsourcing and eliminating the duplication of work. The new computer centre that is currently being built will intensify this cooperation.

2010: coldest and warmest year

The average annual temperature in De Bilt ended up being 9.1°C. This made 2010 the first year since 1996 that ended significantly below the long-term average of 10.1°C. In 2010 it was cold in large parts of Europe. However, when averaged out across the entire world, the past year was one of the three warmest since 1850.

Snow-rich winter was coldest in fourteen years

In De Bilt, the winter of 2010 had an average temperature of 1.1°C, compared to a long-term average of 3.4°C, making it the coldest since 1996. During the previous century, the winter would have been at about that same temperature about one year in six. The warming-up of the Netherlands in recent decades has reduced the likelihood of such a winter to about once every fifteen years. Averaged out across the country, we had 42 days of snow cover. The long-term average is 13 days of snow cover. Some small areas in the northeast of the country even recorded 55 days of snow. That many days of snow cover has not been recorded for more than 30 years, since the winter of 1979 in fact. On 6 January heavy snow during the evening rush hour in the Haarlem-Amsterdam region resulted in hours of road and rail traffic delays.

Coolest May since 1991

For the first 19 days of May, the temperature was far below the long-term average. A persistent northerly flow that brought in cold air was responsible for the low temperatures. There was little time for sunshine either. On some days, the maximum temperature was just 8°C, whereas 17°C is normal for that time of year.

Summer: first warm and sunny, then wet and gloomy

The first half of the summer was warm and sunny. July in particular stood out, with an average temperature of 19.9°C compared to the usual 17.4°C, this month ending as the fifth warmest July month since 1901. The towns of Arcen and Ell in the province of Limburg even recorded temperatures above 35°C on three separate days. During August the weather was unsettled and very wet. An average of 170 millimetres of precipitation fell across the country, compared to the usual 62 millimetres. This made it the second wettest harvest month since 1906. The wettest August month was that of 2006, with 185 millimetres.

Downburst

On 14 July, an intensive, elongated storm line that arose in Belgium moved northwards across our country. Southeast of a line connecting Tilburg, Arnhem and Emmen, this led to intense wind gusts that caused damage. The damage was especially serious in the neighbourhood of Vethuizen (Gelderland): at one camping site, caravans were blown into the water and two people were killed. Five high tension line towers were blown over and a number of residences and farms were very badly damaged. KNMI carried out extensive field research into the pattern of damage. It also calculated the state of the atmosphere at the time of the storm. Vethuizen had been hit by a 'downburst'. The downburst (fall wind) was accompanied by a small, partially downward oriented zone that contained a storm with high wind speeds. It may be that at the edges of the downburst, at the Earth's surface, whirlwinds were created that accelerated the wind even more. The research revealed that the extreme wind gusts may have reached 180-200 km/h locally.

Two cases of flooding

Around the date of 26 August, an almost completely still frontal zone caused heavy rainfall. Over a broad strip of our country, between 80 and 130 millimetres of rainfall was recorded. The KNMI precipitation station in Lievelde recorded 138 millimetres in just 24 hours. This is the third highest total 24 hour rainfall ever recorded in our country. It led to flooding on a wide scale. On average, our country suffers regional flooding once very two years. However, we have to go back to September and October 1998 to find two cases where the scale of the flooding was similar to that of 26 August. On 13 November, heavy local flooding occurred in Zuid-Limburg, following 90 to 100 millimetres of rainfall.

Coldest December since 1969

In December, the average temperature in De Bilt was -1.1°C compared to the usual +3.7°C. We have to go back more than 40 years if we want to find an even colder December month, to December 1969, which had an average temperature of -1.4°C. In this month, most of the precipitation fell as snow. This meant that for almost the entire month, large areas were covered by snow. The heaviest snowfall of 5 to 20 centimetres of snow was recorded in the Randstad area and in Zeeland on Friday 17 December. The snowfall caused extensive traffic delays. Most of the country experienced a white Christmas. In De Bilt, it was the eighth white Christmas since 1901.

Precipitation

The national average of precipitation in 2010 was 801 millimetres, a figure very similar to the long-term average of 847 millimetres. The wettest KNMI station was Rotterdam with 907 millimetres, and the driest Ell (Limburg) with 708 millimetres. De Bilt recorded 825 millimetres against the usual 833 millimetres.

Sunshine

Over the whole country, we enjoyed an average 1,772 hours of sunshine compared to the usual 1,639 hours. As usual, the coastal provinces received the most sunshine. Of the KNMI stations, Stavoren was the front runner with 1,900 hours of sunshine. The sun shone the least in the southeast of the country, Maastricht seeing just 1,626 hours of sunshine. De Bilt recorded 1,752 hours of sunshine compared to the average 1,602 hours.

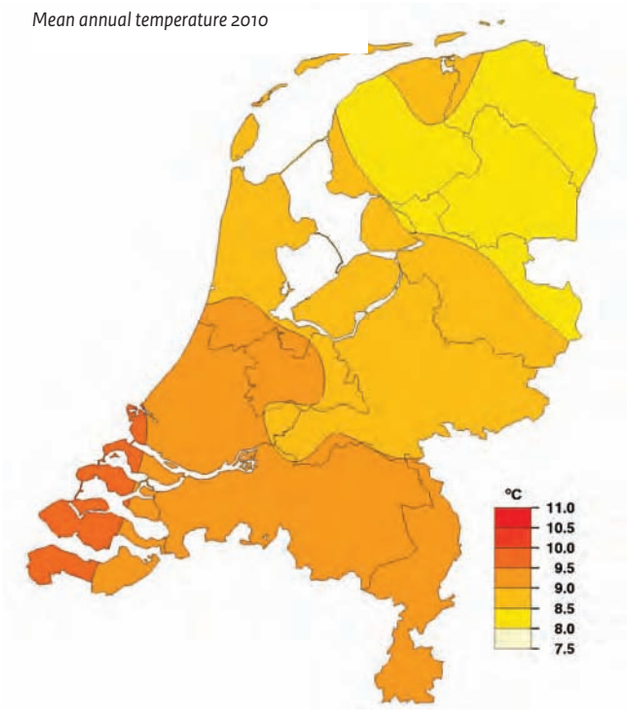
Four Weather Alarms and 15 code oranges

The first Weather Alarm in 2010 was issued on 9 and 10 January for blizzards, which are rare in the Netherlands. The north of the country experienced severe problems caused by persistent snowfall and snowdrifts. In the summer, one Weather Alarm on 10 July was followed closely by another, on 14 July. Both were for heavy thunderstorms with extreme wind gusts. The Weather Alarm of 14 July in particular was for weather that left a trail of destruction in the east and southeast of the country. The last Weather Alarm of 2010 was issued on 17 December for heavy snowfall concentrated in the Randstad area. Traffic and public transport for the cities of Amsterdam, Rotterdam and Utrecht was brought to a complete standstill.

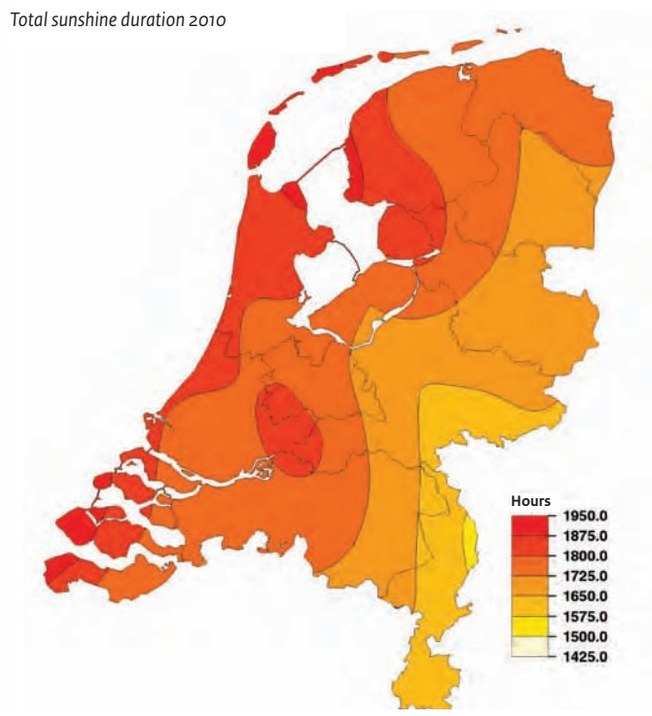
	Normal	2010	
Freezing days	8	29	Maximum temperature below 0.0°C
Cold days	58	88	Minimum temperature below 0.0°C
Warm days	85	90	Maximum temperature of at least 20.0°C
Summery days	26	27	Maximum temperature of at least 25.0°C
Tropical days	4	3	Maximum temperature of at least 30.0°C

	Monthly average temperature (°C) De Bilt		Total sunshine duration (hours) De Bilt		Monthly precipitation amount (mm) De Bilt	
	Normal	2010	Normal	2010	Normal	2010
Jan	3.1	-0.5	62.3	72.2	69.6	41.2
Feb	3.3	1.6	85.7	52.8	55.8	77.0
Mar	6.2	6.4	121.6	144.5	66.8	54.6
Apr	9.2	9.7	173.6	246.1	42.3	30.8
May	13.1	10.5	207.2	190.1	61.9	66.0
Jun	15.6	16.4	193.9	281.0	65.6	18.2
Jul	17.9	19.9	206.0	256.0	81.1	77.2
Aug	17.5	16.8	187.7	163.0	72.9	155.3
Sep	14.5	13.6	138.3	140.6	78.1	90.3
Oct	10.7	10.4	112.9	111.6	82.8	88.2
Nov	6.7	5.8	63.0	51.8	79.8	83.4
Dec	3.7	-1.1	49.3	42.5	75.8	42.3
Total	**10.1**	**9.1**	**1601.5**	**1752.2**	**832.5**	**824.5**

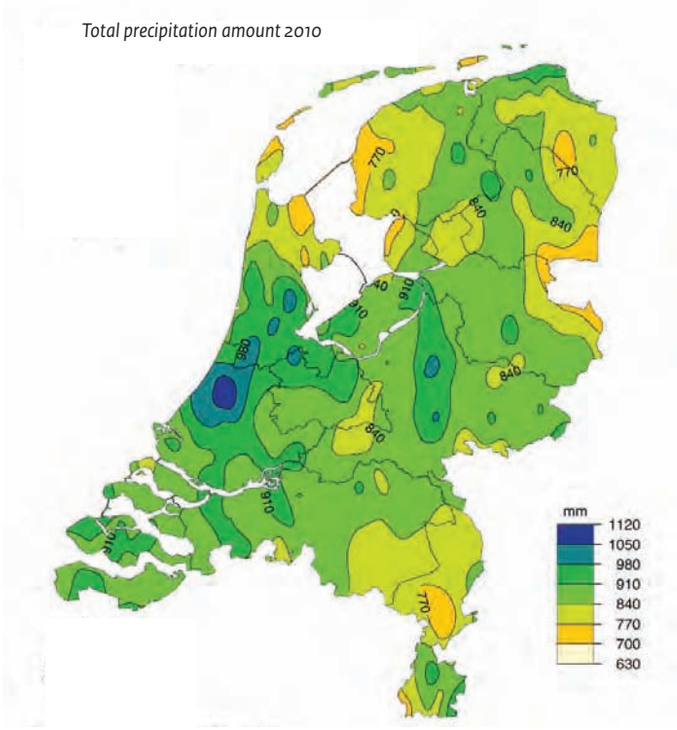
Mean annual temperature 2010



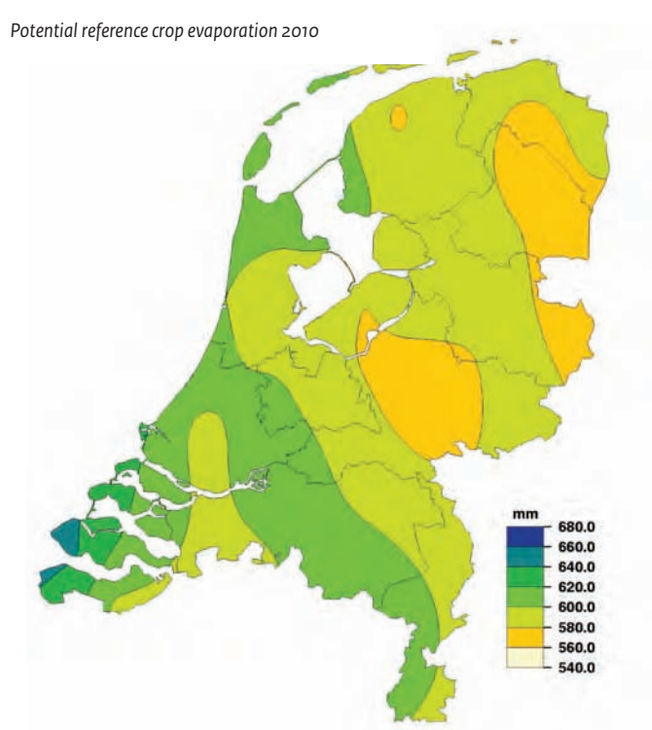
Total sunshine duration 2010



Total precipitation amount 2010



Potential reference crop evaporation 2010



Finances

There was a significant increase in investment in 2010, which was primarily used for centralised data storage systems and the new computer centre. This explains the increase in value of the tangible assets item and the proportionate increase in accounts payable, as loans were taken out with the Ministry of Finance for these investments.

The funds received from the Ministry (i.e. 'Agency Contribution') for Earth observation, the Delta Infrastructure Plan and NMDC exceeded the expenditure in these areas. This led to an increase in the liquid funds item. The accounts payable item increased too, as the funds as yet unspent in this context were incorporated into the accounts payable item.

The income from the Ministry increased, despite the austerity measures implemented by the Balkenende IV government. This is primarily due to higher income from the provision of Earth observation services.

Results

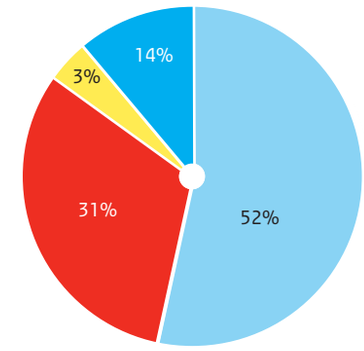
Normally, the result achieved for a financial year equals the difference between the Equity item at the start and end of the financial year. However, this is not the case this time, due to a systematic change in the way in which assets are valued. This change has not been included in the Results but has instead been added directly to Equity. This is why the Equity item has increased even though a financial loss was incurred.

Balance sheet *)		
Assets	31 dec 2010	31 dec 2009
Fixed assets	8,643	5,561
Work in progress	1,277	1,698
Accounts receivable	5,356	6,883
Liquid funds	19,350	8,021
Totaal assets	**34,626**	**22,163**
Liabilities	31 dec 2010	31 dec 2009
Equity	1,911	1,391
Results 2010	-109	-100
Equalisation account	0	0
Provision	1,109	1,791
Accounts payable	31,717	19,081
Total liabilities	**34,626**	**22,163**

Profit and loss account *)		
Income	2010	2009
Agency contribution	38,089	36,818
Third-party revenue	19,765	19,616
Interest received	1	3
Release of provisions	225	222
Extraordinary revenue	0	91
Total income	**58,080**	**56,750**
Expenditure	2010	2009
Staff	34,326	34,419
Material		
- Outsourcing	1,543	981
- Maintenance and operation	3,255	4,578
- Rent and lease	3,258	3,296
- Contributions	10,944	9,006
- Remaining	2,675	2,553
Interest	152	140
Depreciation	2,036	1,813
Donation reserves	0	64
Extraordinary xpenses	0	0
Total expenses	**58,189**	**56,850**

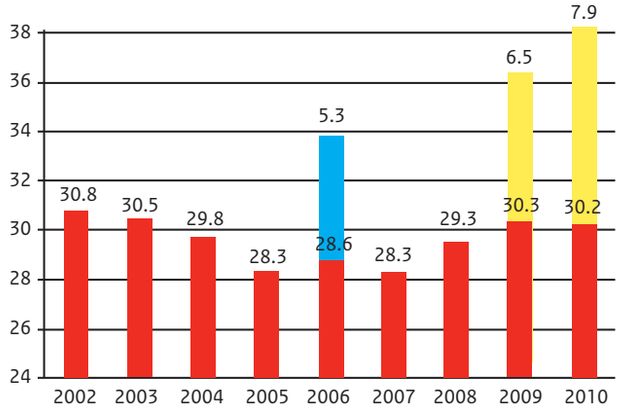
*) *Amounts in euro 1.000*

Costs per product group *)		
Product group	2010	2009
Weather	30,310	31,059
Climate	17,954	17,257
Seismology	1,998	1,973
Earth observation	7,909	6,497
Donation reserves		64
Extraordinary expenses	18	
Total costs	**58,189**	**56,850**



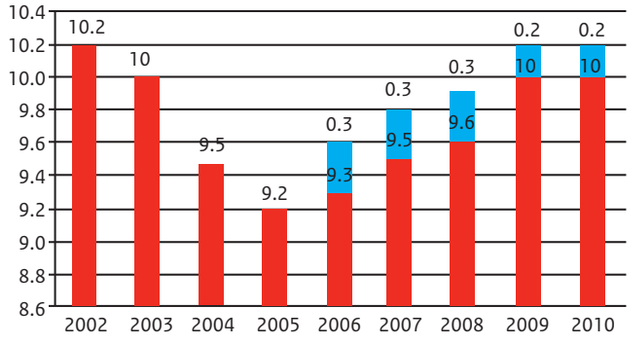
Total productgroup costs

Weather
Climate
Seismology
Earth observation



Agency contribution in millions EUR

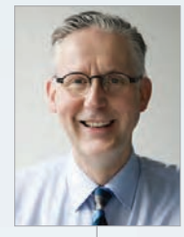
Regular
Incidental
Earth observation



Aviation income in millions EUR

Aviation
North Sea

Management Team KNMI



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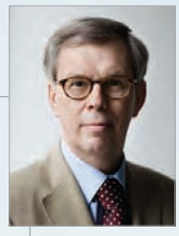

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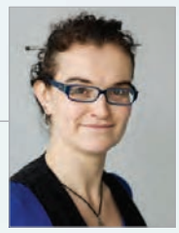

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