BELGIUM PIER

KMI

STORMS

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Breathtaking simulations, special effects, projections and up to date information, confronting you with severe storms, tornadoes, hurricanes and floods ... Know everything about their formation and origins as well as the devastating impact on the environment and ecosystem.

English version

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SSAI/NASA, Hal Pierce
NOAA Remote Sensing Division
Mark Dreesen
Luc Daelemans
Wim Dedroog
Piet Henkens
Sylvester Housen
Raymond Lemmens
Jill Peeters, VTM weather forecaster
Theo Smeets
Geert Venken

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STORMS

BELGIUM PIER

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01 [Welcome

"Storms" is an edutainment project, which I have endorsed since the beginning because it embodies everything that I, as a meteorologist at the Royal Meteorological Institute of Belgium (RMI) and a weatherman, wish to convey about what makes the weather, the risks it sometimes entails and how we respond to this at governmental level.

The federal RMI's mission is to alert the population and all the country's governments as accurately and as timely as possible about dangerous weather conditions so people can protect themselves and their possessions. We draw up the daily weather reports as well as sending out specific alerts through the media, the traffic centres and the FPS Home Affairs Crisis Centre, which in turn notifies the local authorities so that protective measures can be taken.

In our federalised country the RMI prides itself on its excellent collaboration with the regional governments in order to achieve the best possible result for the population. This partnership with the regions relates to the water levels of rivers and streams in case of excessive precipitation, to maritime risks such as storms, high water levels along the coast or of the River Scheldt and to keeping the roads free of snow and ice.

Cooperative federalism pays off, guarantees the best results and the population expects nothing less from its authorities. As a result, I am proud to welcome our privileged partner, the Agency for Maritime Services and Coast of the Government of Flanders, as a co-organiser of this exhibition here today. I also would like to thank the Government of Flanders for all the support we obtained from Flemish Ministers Geert Bourgeois and Hilde Crevits.

The RMI's aim is to achieve the highest possible revenue on the taxpayers' money, which it receives by offering a high-quality performance-oriented service. We rely on partnerships for this, between public partners as well as between public and private partners. We would like to thank the owners of Belgium Pier for this initiative in a unique building and the first in Belgium to be exposed to storms. "Storms" allows us to inform the general public in detail about several aspects of dangerous weather conditions. I also want to thank my passionate TV colleague, Jill Peeters, who will unleash her personal experiences with tornadoes and storms on you in her own unique manner, as well as the VTM news service for their contribution to this project

Finally, I wish you all a pleasant and instructive walk and thank you for your trust on behalf of all the parties involved.

Prof. Dr. Ir. David Dehenauw, Engineer
Head of Shipping Forecasts RMI
Weatherman for VTM and VRT-Radio 2

02 [Digicentre

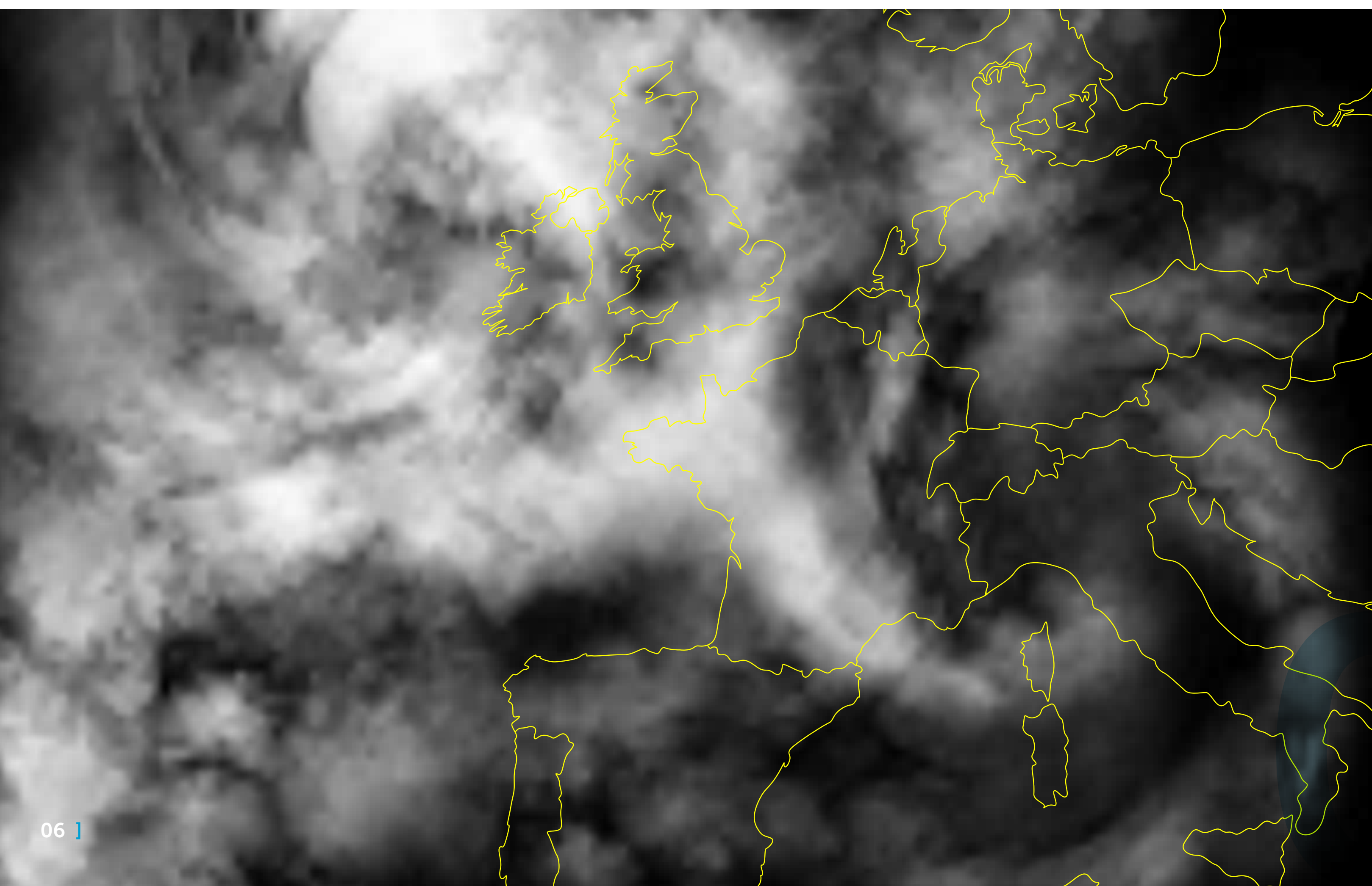
Are you already passionate about meteorology or is it all completely new to you? Test your knowledge in the meteo quiz. Biodiversity, coral reefs, nature and animal species are disappearing every day due to violent natural phenomena. Discover them and see what our planet has to offer.

03 [Weather forecasts

How to make a good weather forecast?

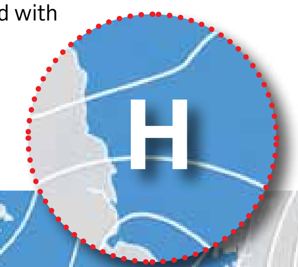
Making a good weather forecast requires one very important thing: you must know precisely what the current atmospheric conditions are like. Thousands of observations on land and over the ocean are useful in this respect. The weather satellites create images that show exactly where the large, spiralling cloud formations are located. These are depressions, where the air pressure is lowest in the centre. The satellite images help to provide a good impression of the location of the depression's core when there are only a few weather stations on the ground. The white cloud banks in the image are weather fronts. That is where the greatest precipitation can be expected; it often rains or snows here for long periods of time.

The appearance of the cloud systems provide meteorologists with an impression of how the atmosphere has been developing. Satellite images allow various time frames to be compared, making the direction in which the storm depression is moving immediately clear. The meteorologist draws the path of the low-pressure area on the weather charts and then calculates the movement over the coming hours or days. This is how weather forecasts are developed bit by bit.



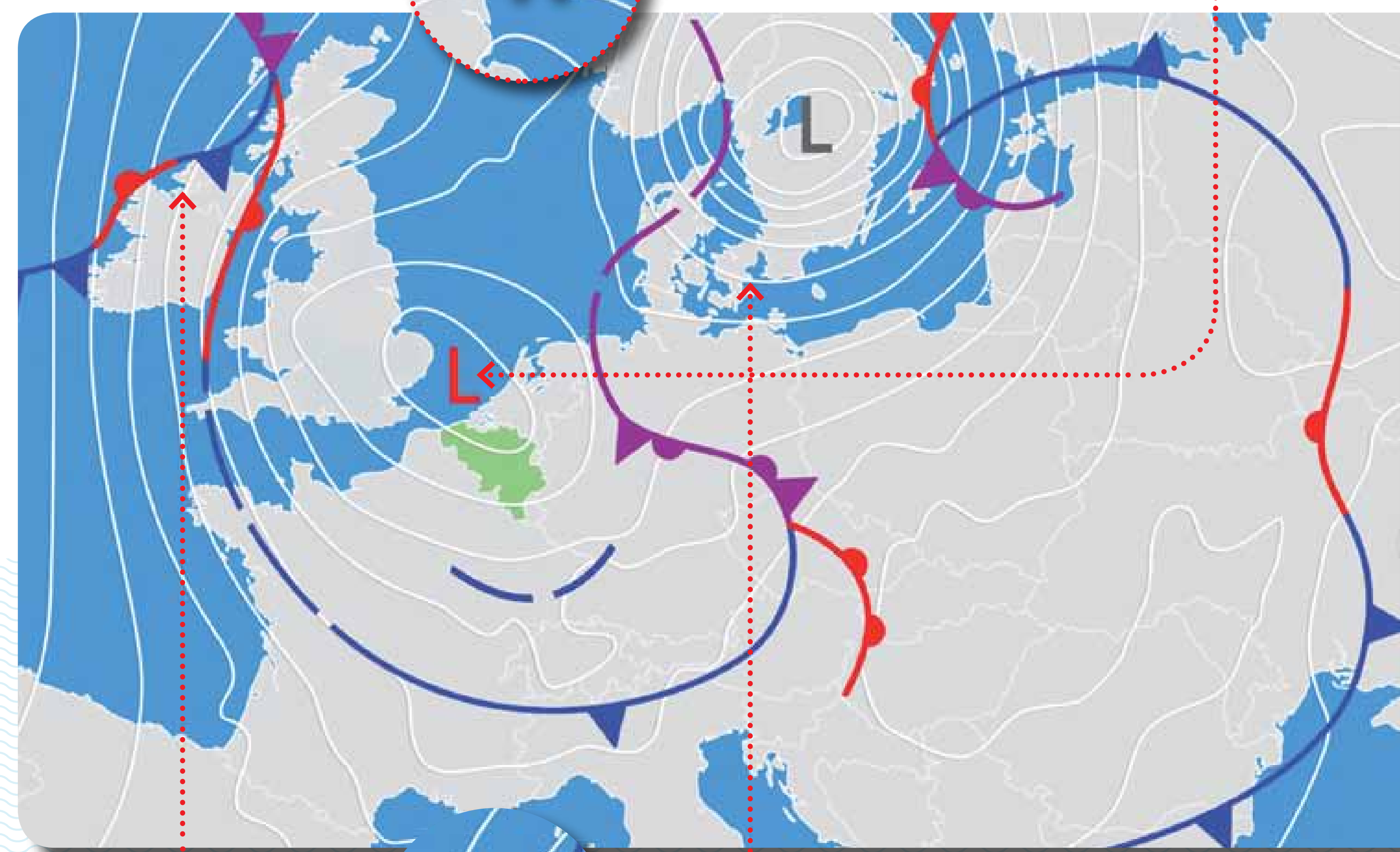
High-pressure area

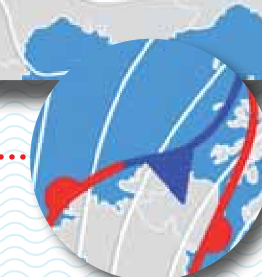
A high-pressure area is represented by the letter H. It shows an area where the air pressure is high. A high-pressure area is normally paired with dry weather.



Low-pressure area

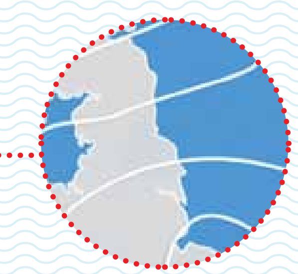
A low-pressure area or depression is represented by the letter L. It indicates an area where the atmospheric pressure is low. Low pressure can mean bad weather.





Fronts

A front is the boundary between warm and cold air. The arrival of a front announces a change in the weather. On weather charts, fronts are indicated by curved lines with triangles on them (for cold fronts) and semi-circles (for warm fronts). The triangles and semi-circles refer to the direction in which the front is moving. A warm front causes temperatures to rise and is often accompanied by rain or snow. Conversely, cold fronts result in lower temperatures, sudden rain showers, thunderstorms and sometimes even hail.



Isobars

Isobars are curved lines on a map that link points of equal pressure with one another.

03

04 [Measuring the weather

Thermometer

Thermometer

A thermometer is used to measure the air temperature. It is made of a glass tube filled with a liquid such as mercury or alcohol. When the air warms up, the liquid expands and the level of the liquid in the tube rises. When the air cools down, the liquid contracts and the level in the tube drops.

Barometer

A barometer measures air pressure. Variations in air pressure indicate a change in the weather. If the pressure drops quickly, this is a sign that bad weather is on its way. If the air pressure rises, this means that we can expect good weather.

Heliograph

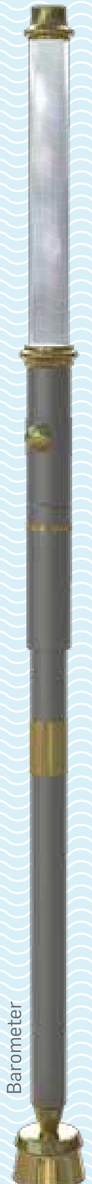
A Campbell-Stokes recorder is a glass orb that catches the sunlight and amplifies it so that the heat is concentrated on a piece of paper. The heat scorches the paper. The length of the burn mark is measured to determine the number of hours of sunshine per day.

Snow gauge

The snow gauge is used to collect snow. Meteorologists use this instrument to measure the amount of snow that has fallen in a particular region.

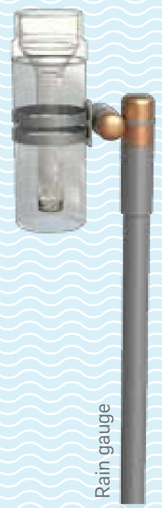
Rain gauge

A rain gauge is a tube marked with measuring lines. This instrument indicates the amount of rain that has fallen in a particular region.

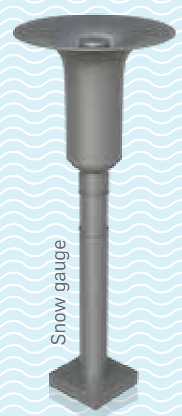


Barometer

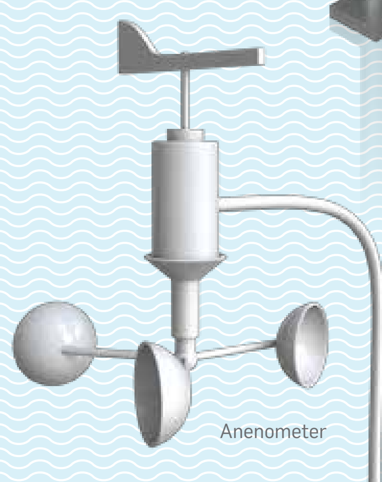
Heliograph



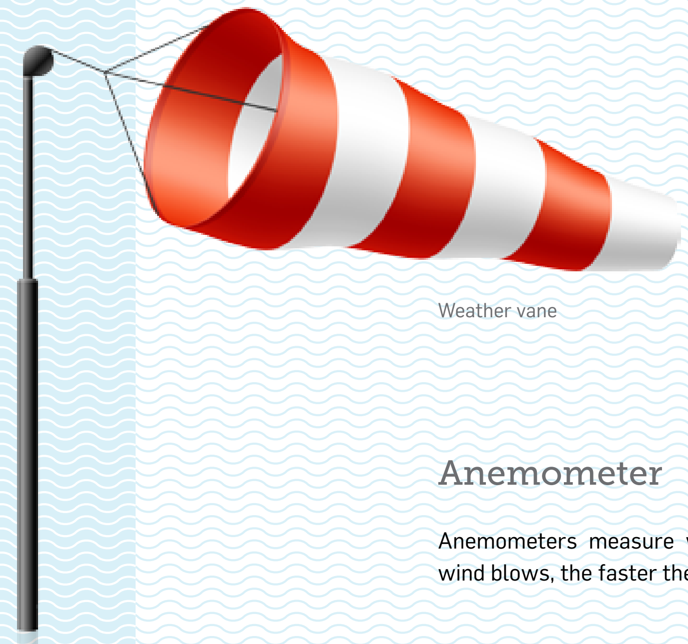
Rain gauge



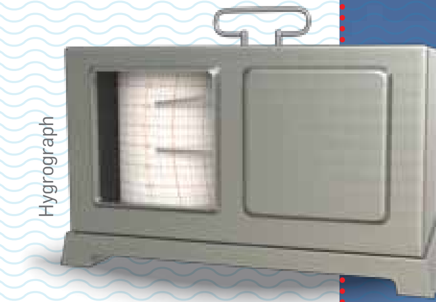
Snow gauge



Anemometer



Weather vane



Hygrograph

Anemometer

Anemometers measure wind speed. The harder the wind blows, the faster the cups spin.

Weather vane

The weather vane shows the direction of the wind. The weather vane helps meteorologists to, among other things, determine the direction in which storm clouds will move.

Hygrograph

The hygrograph measures and records the water vapour levels in the air, i.e. humidity. Some hygrographs use human hair to determine the changes in the amount of humidity. The hairs lengthen in damp weather and contract in dry weather.

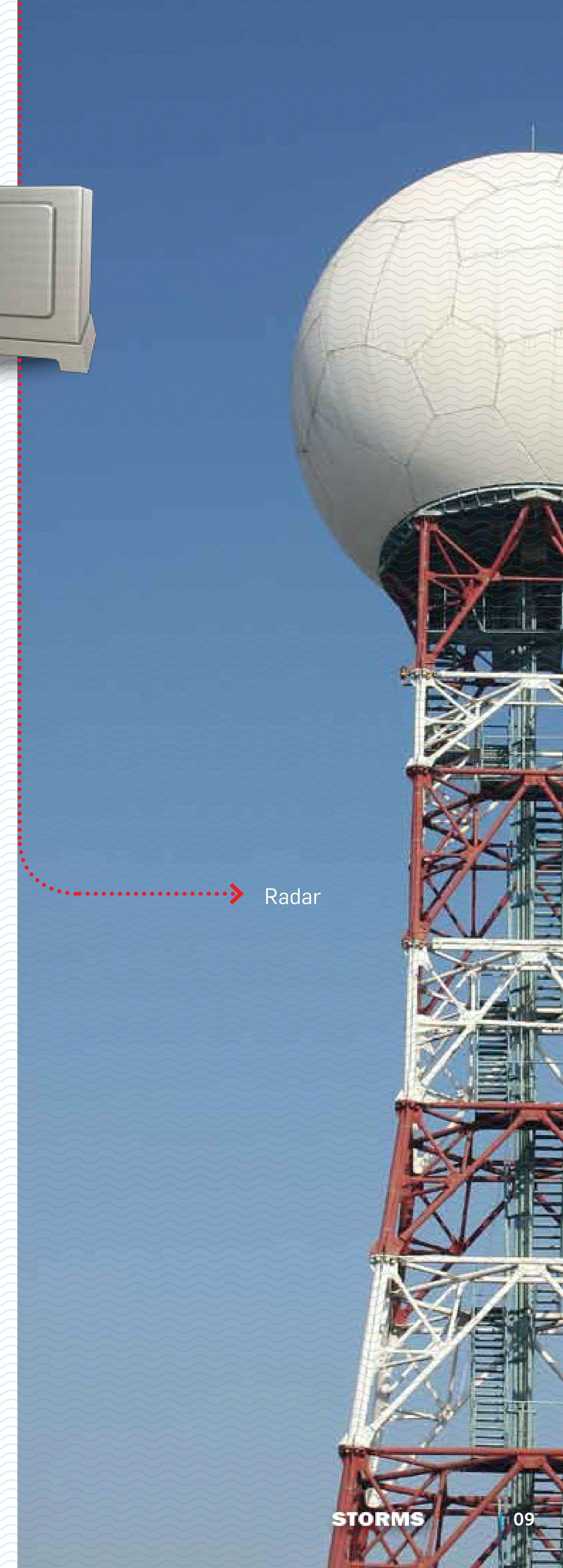
Stevenson screen

The Stevenson screen (or instrument shelter) is a box which is painted white and placed more than 3 feet above the ground. To prevent incorrect measurements, the Stevenson screen has louvered sides through which air can move freely while keeping direct sunlight off the instruments housed in the box. The screen houses various weather instruments which are used to measure the temperature, air pressure and humidity..

Radar

Radar is installed on the ground and helps meteorologists to forecast the type and amount of precipitation. Radar emits radio waves that rebound in various ways, depending on whether they come into contact with rain drops, snow or hail. Meteorologists can also use radar to calculate the wind's speed and direction. This information is useful for following thunderstorms and tornadoes.

04



Radar

Automatic weather station

Some places on earth are very difficult for meteorologists to reach. Weather information on the ocean is collected by shipmasters and weather stations fixed to buoys. In the desert, mountains and polar regions, small weather stations function without the presence of people. The data that these collect is sent via satellite to larger meteorological weather stations for analysis.

Automatic weather station

Weather balloons

Weather balloons are released from the ground. The balloon is filled with a light gas (helium or hydrogen), which causes it to rise up into the atmosphere. It is equipped with a radiosonde, which is a combination of instruments that measure temperature, humidity and air pressure at various heights. The weather balloon's measurements are then sent via a small radio transmitter to a weather station. Given that the balloon drifts with the wind, it can also measure wind speed and direction. Once the balloon reaches a height of approximately 19 miles, it explodes and falls slowly back to earth with the help of a parachute.

Weather balloons

Meteorological measurement towers

A measurement tower consists of multiple weather instruments that are fixed to a pole at various heights.

Meteorological measurement towers

Satellites

Weather satellites collect data which are then translated into images by computers. Newspapers and television often show satellite images of banks of clouds. By comparing satellite images that have been taken at different times, meteorologists can follow the movements of the clouds, calculate the wind speed and forecast any precipitation. There are two types of satellites, geostationary and polar orbiting. Geostationary satellites rotate along the equator and therefore observe always the same place.

They can immediately collect atmospheric data from anywhere on the earth, with the exception of the North and South poles. The polar orbiting satellites follow a path around the earth and pass close to the North and South poles. Given that they reach a limited height, these satellites can closely observe the ground, sea and lower atmosphere.

Weather satellites

nice weather today!

04

DID YOU KNOW THIS?

Anemometers and rain gauges are the oldest measuring instruments ever to be invented. They were used as far back as 2,000 years ago!

Twice a day, all over the world, over a thousand weather balloons are released into the sky. And, satellites also make around 150,000 observations every day.

February is the transitional month between winter and spring. The weather can be extremely cold, but it can also be extremely mild. We also see some absolute extremes however; on 25 February 1991 the maximum temperature in Meeuwen, in the Kempen region, rose to 70.0 °F, while the minimum temperature in Ostend on 14 February 1929, fell to -2.2 °F.

05 [Water and wind

Water, cloud and precipitation

Water can be found everywhere, in the oceans, lakes, rivers and even underground. The atmosphere is also rich with water, where it takes on the form of an invisible gas, called water vapour. Clouds are gigantic reservoirs harbouring billions of water droplets and ice crystals. They are to a large extent responsible for the weather. Every day, the water that is held in the clouds at various locations around the world leaves the atmosphere, taking different forms, to fall to the earth. We call this precipitation. For humans, precipitation is often a blessing and a source of wonder, but it can also cause a great deal of damage and disrupt our daily existence.

How is a cloud formed?

The sun's heat changes the water in the rivers, lakes, seas and oceans into vapour, which rises into the atmosphere. The air is cooler higher up in the atmosphere, which causes the water vapour to change into small droplets.

Wind

We can't see it, but we can feel it around us - waving flags, blowing our hair around and filling boats' sails. Wind occurs simply because warm air is lighter than cold air. Warm air moves like a giant Ferris wheel and rises, which allows cold air to take over the vacated space near the ground. When the cold air becomes warmer, it also decreases in weight and begins to rise. In the meantime, the warm air above begins to cool, becomes heavier and sinks. This large, circular interaction between warm and cold air generates the wind. The principal air flows that stream over the earth's surface are called prevailing winds. These winds are constant - they generally blow with the same force and never change direction. They are the result of the exchange of large warm and cold air streams between the warm and cold regions on the earth.

Suddenly spring?

A "Chinook" is a warm, dry local wind that blows from the Rocky Mountains to the North American Great Plains. Chinooks are responsible for a sudden and extreme increase in temperature. On 22 January 1943, a Chinook blew over the Black Hills in South Dakota. The temperature shot up from -4.0 °F to 44.6 °F in just 2 minutes!

Types of precipitation

Precipitation depends on two things: the type of cloud from which the water droplets or ice crystals originate and the temperature of the air layers through which these must pass on their way to the ground. The primary forms of precipitation are listed below.

DID YOU KNOW THIS?

The longest days of the year are in June. The Uccle weather station records an average of 198 hours of sunshine in June. In 1987 it only shone for 97 hours, but in 1976 residents enjoyed 306 hours of sunshine. Between 15 and 22 June 1977, the sun shone for a mere 15 minutes.

types of precipitation

Drizzle

Diameter of less than 0.02 inch

Clouds that produce drizzles almost touch the ground. The tiny drops of water that fall as drizzle result in very little water on the ground.

Rain

Average diameter of 0.08 inch

Rain falls mainly from nimbostratus clouds, which are thick grey clouds that cover the entire sky.

Freezing rain

Diameter varies

Freezing rain is formed when rain drops fall through a cold layer, which drops their temperature below zero, but they still remain liquid. They freeze when they land on the ground.

Ice pellets

Diameter of less than 0.2 inch

Ice pellets forms when water droplets go through a thin layer of warm air followed by a layer of cold air. The cold air freezes the water droplets. These small kernels of ice are called hail.

Snow

Diameter from 0.2 - 1.0 inch

In the winter, ice crystals fall to the ground as snow as long as they meet any hot air and their temperature remains permanently below zero.

05

Local winds

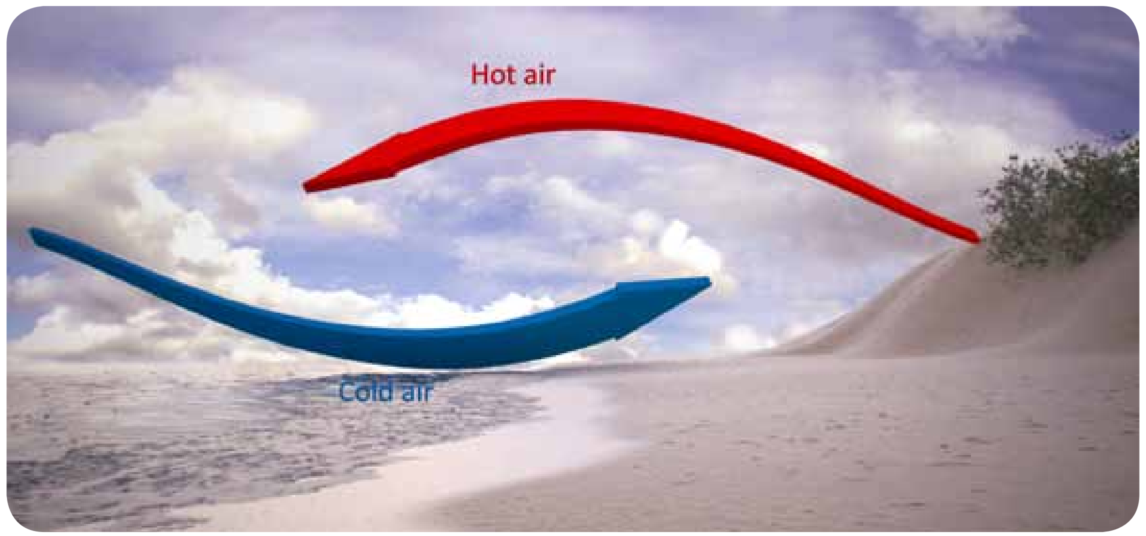
Sea breeze

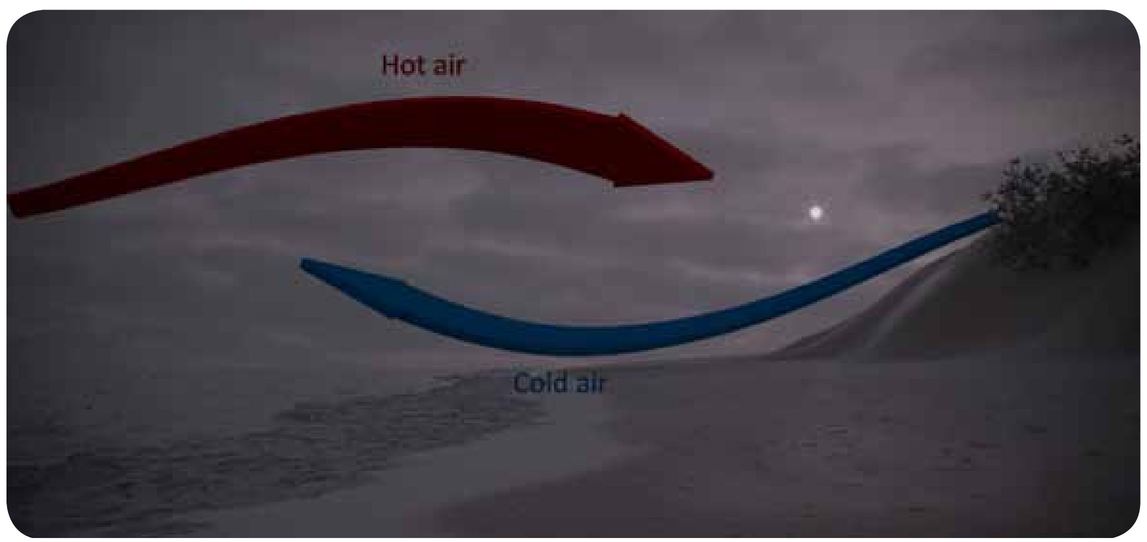
Unlike prevailing winds, local winds blow over small areas and they often change direction. The wind from the coast is a good example of how a local wind works. During the day, the land warms faster than the sea. The warm air above the land rises and the colder air above the sea moves inland to fill in the vacant space. This causes a sea breeze.

Land breeze

At night, when the temperature is lower, the opposite of a sea breeze occurs. The land cools off faster than the sea. While the warmer air above the sea rises, the vacated space is taken over by the cooler air from the land. The wind's direction changes and a land breeze occurs.

Sea breeze day





Land breeze night

06 [The Beaufort scale

Thanks to the Beaufort Scale, we can calculate the wind's force. This method of measurement was devised by the British sailor Francis Beaufort in 1805. In this period, the scale was used to estimate the force of the wind without using instruments. Admiral Beaufort developed his scale by observing the effects of the wind on the ship's sails. A number of years later, the Beaufort Scale would also be used to measure the force of wind on land.

nmph: nautic miles per hour

Scale: 0
Wind speed: less than 1.08 nmph
Description: calm
Effect: chimney smoke rises vertically

Scale: 1
Wind speed: 1.08 - 2.70 nmph
Description: light air
Effect: smoke indicates wind direction

Scale: 2
Wind speed: 2.70 - 5.94 nmph
Description: light breeze
Effect: wind vanes move; wind felt on face

Scale: 3
Wind speed: 5.94 - 10.26 nmph
Description: gentle breeze
Effect: light flags wave; leaves and twigs moving

Scale: 4
Wind speed: 10.26 - 15.66 nmph
Description: moderate breeze
Effect: dust and loose paper raised; small branches begin to move

Scale: 5
Wind speed: 15.66 - 21.06 nmph
Description: fresh breeze
Effect: waving tree branches

Scale: 6
Wind speed: 21.06 - 27.00 nmph
Description: strong breeze
Effect: umbrella use becomes difficult; large branches in motion; wind makes whistling sound

Scale: 7
Wind speed: 27.00 - 32.94 nmph
Description: high, wind, moderate gale, neargale
Effect: effort needed to walk against the wind; whole trees in motion

Scale: 8
Wind speed: 32.94 - 38.88 nmph
Description: gale, fresh gale
Effect: some twigs broken from trees

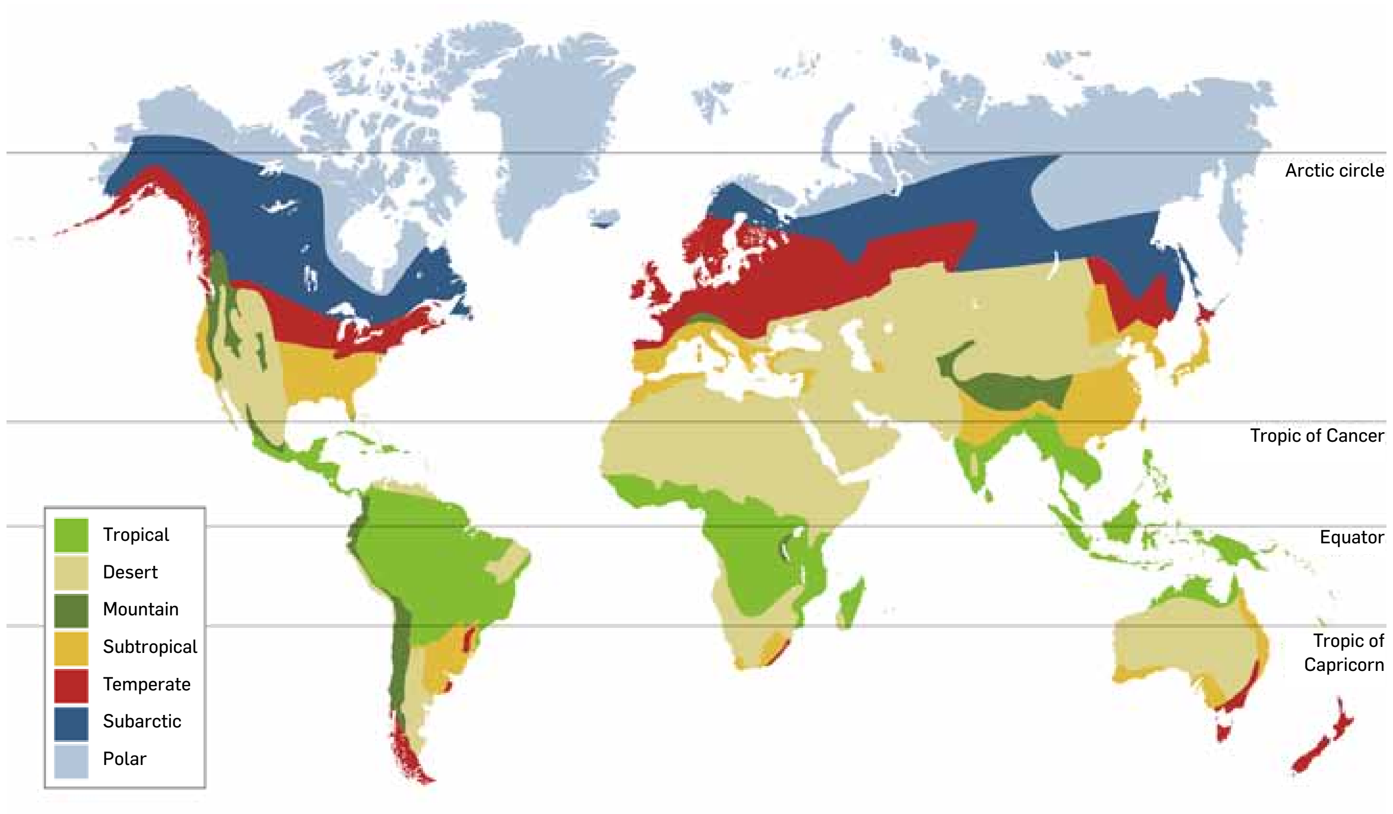
Scale: 9
Wind speed: 38.88 - 46.98 nmph
Description: strong gale
Effect: tiles detach from roofs, some branches break off trees

Scale: 10
Wind speed: 46.98 - 54.54 nmph
Description: storm, whole gale
Effect: considerable damage to housing, uprooted trees (rare)

Scale: 11
Wind speed: 54.54 - 64.79 nmph
Description: violent storm
Effect: serious damage to housing (very rare)

Scale: 12
Wind speed: more than 64.79 nmph
Description: hurricane
Effect: destroyed houses and landscape

07 [Climate



Climate types

Tropical climate
Very warm climate around the equator. Little variation in temperature and heavy rainfall

Subtropical climate
Climate characterised by mild winters, hot summers and regular rainfall.

Desert climate
Climate characterised by little rain or snow and almost no flora. Strong variations in temperature between night and day

Mountain climate
Climate typical of mountainous regions. Temperatures fall and vegetation becomes sparser as altitude increases.

Temperate climate
Climate characterised by variable weather and four clearly distinguishable seasons.

Subarctic climate
Climate characterised by long cold winters and short cool summers.

Polar climate
Very cold climate in which the ground is often frozen and where temperatures are rarely above 50 °F.

Winds

Many types of wind blow in every part of the world. These can be gentle, warm, cold, dry, moist or dusty. Below are the names of several types of wind:

1 Chinook
A warm westerly wind that blows in the Rocky Mountains of North America. The wind can make the temperature rise 39.6 °F in just 15 minutes and quickly melts the snow.

2 Chocolatero
A warm, moderate, northerly wind that blows in the region around the Gulf of Mexico. This wind gets its name from the chocolate-coloured sand that it carries with it.

3 The Barber
This name is given to snow storms during the winter in North America that come from the north in the Gulf of St. Lawrence. It is a powerful ocean storm with drizzle and rain that can freeze anything at any moment, including hair and beards, which is why it is called the Barber.

4 Mistral
This is a powerful northerly wind that can blow nearly the whole year long in central France. Mistrals in the winter are sometimes powerful enough to affect trains travelling through the Rhone Delta region.

5 Sirocco
A warm, dry, dusty wind that primarily blows north from the Sahara Desert towards the Mediterranean in the spring. When the Sirocco crosses the sea, it becomes moist and causes mist and rain in Malta, Sicily and southern Italy.

6 Föhn
A warm, dry southerly wind that primarily blows during the spring and summer in the Swiss Valais region and the German Bavaria. The powerful gusts of wind blow down from the mountains and provide good weather and higher temperatures. The wind is so warm that it can melt snow faster than the sun!

7 Monsoon
This wind changes direction with the seasons and primarily blows in southern Asia. The summer monsoon blows from the south-west over the Indian Ocean and into Asia. This moist wind can cause extremely severe rainfall in India and the surrounding areas. The winter monsoon is the exact opposite: a dry wind from the north-west that blows from the Asian continent towards the Indian Ocean.

8 Buran
A strong north-easterly wind that blows across Siberia and other parts of Russia and Central Asia. The Buran moves at a speed of more than 34 mph with powerful gusts that often limit visibility. During the summer, it is called the Black Buran because of all the dust that it carries with it. During the winter, it is usually called the White Buran because of all the snow that is blown about by the wind. In Canada and the northern United States, winds like this are called "blizzards".

08 [Clouds

Levels of clouds

The highest clouds in the sky (at a height of 3.7 miles or more) are cirrus, cirrostratus and cirrocumulus clouds. At the middle level (between 1.2 and 3.7 miles high) are altostratus and altocumulus clouds. The clouds on the lowest level (1.2 miles and lower) are stratus, nimbostratus, stratocumulus, cumulus and cumulonimbus clouds. The tops of these low-hanging clouds, like the nimbostratus, cumulus and cumulonimbus, can reach up into the higher levels.

Types of clouds

Cirrus
Cirrus clouds are thin and fine and look like thin locks of white hair blowing in the wind. They are associated with good weather. Cirrus clouds appear in the sky before cirrostratus and cirrocumulus clouds.

Altocumulus
Altocumulus clouds look like little, swollen grey or white rolls in successive rows. They generally do not herald rain, unless they appear together with altostratus clouds.

Stratus
Stratus clouds are low-hanging, grey clouds with an even basis. They are associated with gloomy weather and sometimes form banks of mist along the ground. Stratus clouds can be associated with drizzle, light rain, ice crystals or snowflakes.

Nimbostratus
Nimbostratus clouds are thick and dark grey in colour. They form a layer that covers the entire sky and completely blocks out the sun. They often have a frayed base and bring rain that can last for hours, or even the whole day.

Cirrostratus
Cirrostratus clouds form a transparent, white veil that partially or fully covers the sky. These often create a halo around the sun. Cirrostratus clouds indicate that precipitation may fall within 12 hours.

Stratocumulus
Stratocumulus clouds look like massive, swollen grey or white rolls. They rarely bring precipitation, but if this is the case, it's only a drizzle. When stratocumulus clouds are spread out across the sky, blue sky can be seen here and there between the clouds. They often evolve into nimbostratus clouds if their normally wavy base becomes even.

Cirrocumulus
Cirrocumulus clouds look like little, white cotton balls all clustered together. They give the sky a wrinkled appearance. They often appear together with cirrostratus clouds.

Altostratus
Altostratus clouds form a veil over the sky that is thicker and greyer than the veil formed by cirrostratus clouds. They can partially or fully cover the sky and the sun sometimes shines through. Altostratus clouds are a sign that it will rain soon.

Cumulus
Cumulus clouds are lovely and white and look like cotton. Spread out across a blue sky, these indicate good weather. However, if the tops of these clouds begin to grow, they evolve into cumulonimbus. These are the clouds that cause rain. Showers are always local and limited in time, unlike a rain belt (with nimbostratus clouds), which covers a larger area and lasts longer.

Cumulonimbus
Cumulonimbus clouds have a dark, threatening base and rise extremely high up into the sky. These clouds are true factories for the production of thunderstorms, severe rains, snow showers, hail, strong squalls and tornadoes. Cumulonimbus clouds are full of air streams that are constantly rising and descending. In 1959, a pilot used his ejector seat in an emergency and was shot up into a cumulonimbus cloud. The powerful winds threw him through the air for an hour before he was able to escape the cloud and land on the ground.


Cirrus


Stratocumulus


Altocumulus


Cirrocumulus


Stratus


Altostratus


Nimbostratus


Cumulus


Cirrostratus


Cumulonimbus

09 [Dew, fog and mist

Dew and fog

Meandering white blankets of fog and mist cover the land in a mysterious beauty. Fog and mist appear on the earth's surface and are in fact clouds that form very close to the ground or water. Just like clouds, fog and mist are composed of tiny water droplets that float through the air. At sea and on lakes and rivers, large fogbanks can create a real danger for both professional and amateur sailors. On land, fog reduces visibility on roads and bridges, making travelling by car more dangerous and complicated.

Condensation

Air contains water in the form of an invisible gas called water vapour. The amount of water vapour in the air changes with the temperature. Warm air can contain more water vapour than cold air. If cold air cools and can no longer contain the water vapour, it has reached its dew point. At this exact moment, the water vapour is transformed into visible water droplets in the form of dew, fog or mist. This process is called condensation.

Dew

Dew is formed when the air close to the ground cools off to the dew point and condenses. This usually occurs at the end of a calm, clear night. When the water vapour comes into contact with cold blades of grass or other objects on the ground, it condenses into glistening dewdrops.

DID YOU KNOW THIS?

Coastal regions are among the regions in which fog and mist are the most prevalent. With an average of 206 days of fog a year, Argentia, Newfoundland (Canada) is one of the foggiest places on earth.

Fog and mist banks

Mist and fog appear when water vapour in the air condenses close to the ground. Mist is nothing more than a cloud on the ground. The cloud created by the fog can reduce visibility down to between just a few feet and 0.6 miles. If the water droplets from which the fog is created are farther apart, then the fog is called mist. Visibility is reduced to somewhere between 0.6 and 3.1 miles.

What is the difference between a fogbow and a rainbow?

In a rainbow, the sunlight is refracted in the raindrops into the separate colours of the spectrum. It now appears that the size of the rain drop is important in determining whether a specific colour will be brighter or fainter. Droplets of 0.08 inches bring the red and violet colours strongly out to the fore, while the blue is barely discernible.

If the droplets are only 1/125th untill 1/50th of a inch in diameter, then the red colour is nearly absent from the rainbow. Even smaller droplets, e.g. 1/500th of a inch in diameter, create a practically white bow without any appreciable colouring. The water droplets forming fog can contain these sizes, which creates a fogbow, which is a practically colourless reflection of the light.

10 [Tornadoes

Cumulonimbus clouds
All tornadoes are born from thunderstorm clouds, known as cumulonimbus clouds.

De condensation funnel
The condensation funnel is the most important part of the tornado. It behaves like a gigantic vacuum.

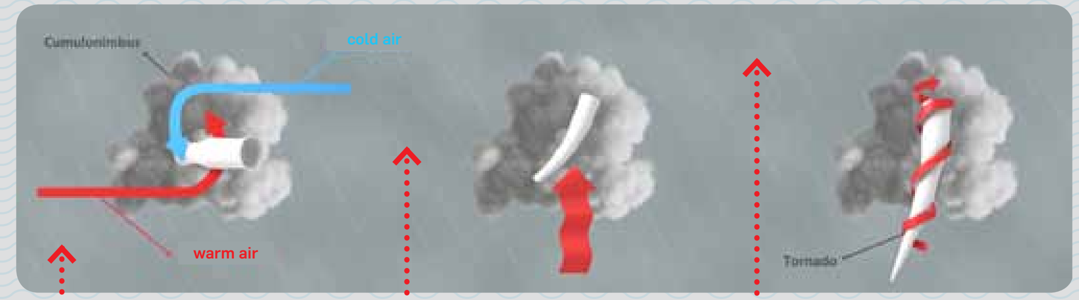
The dust cloud
The dust cloud is the part of the tornado that touches the ground. It is made up of debris that is picked up and carried along by the tornado.

Devastating twisters

They smash windows into shards, uproot trees and pull the roofs off houses. They can throw cars and trains - and humans and animals as well - into the air! Tornadoes are the most dangerous meteorological phenomenon on earth. With their massive funnels, which come down out of cumulonimbus clouds, the tornadoes vacuum up everything in their path. Their severe, swirling winds sound like the roar of a jet plane. Accompanied by thunderstorms, rain and often hail, tornadoes can rage across a landscape in a matter of minutes, and leave a large swath of horrific destruction in their wake.

How do tornadoes form?

Luckily, not every cumulonimbus cloud produces a tornado! All the right weather conditions must be present to bring about this powerful storm.



Fast-moving cold air high in the atmosphere passes over slow-flowing warm air closer to the ground. Both of these air streams begin to rotate around a horizontal axis, one around the other until they form a gigantic tube within the cumulonimbus cloud.

Warm surface air moves up towards the cloud and pushes against the tube of rotating air, which causes it to move into a fully vertical position.

The funnel shape that is formed at the base of the cloud creates a vacuum that continues to suck up warm surface air at an increasingly faster pace. The funnel is pulled downwards and becomes longer until it reaches the ground and becomes a tornado.

Tornado tragedy

The most destructive tornado ever was the Tri-State Tornado. On 18 March 1925, it travelled over more than 220 miles of the USA, through the states of Missouri, Illinois and Indiana. The Tri-State Tornado killed nearly 700 people.

Raging out of control

Tornadoes are difficult to forecast and impossible to stop. Considering that a warning is only issued a few minutes before the tornado passes through the region for which the warning was issued, many people are unprepared for it. The basement of a house, a small bedroom or a bathroom can provide shelter when a tornado hits. When someone is caught outside, he or she can seek protection in a ditch or any random hollow in the ground.

US

The United States of America are the region most affected by tornadoes. There are nearly a thousand tornadoes every year! The American Great Plains, which cover many states including Texas, Oklahoma, Kansas and Nebraska, provide the best tornado brewing conditions. In this region, warm moist air from the Gulf of Mexico in the south meets the cold northerly air from Canada.

DID YOU KNOW THIS?

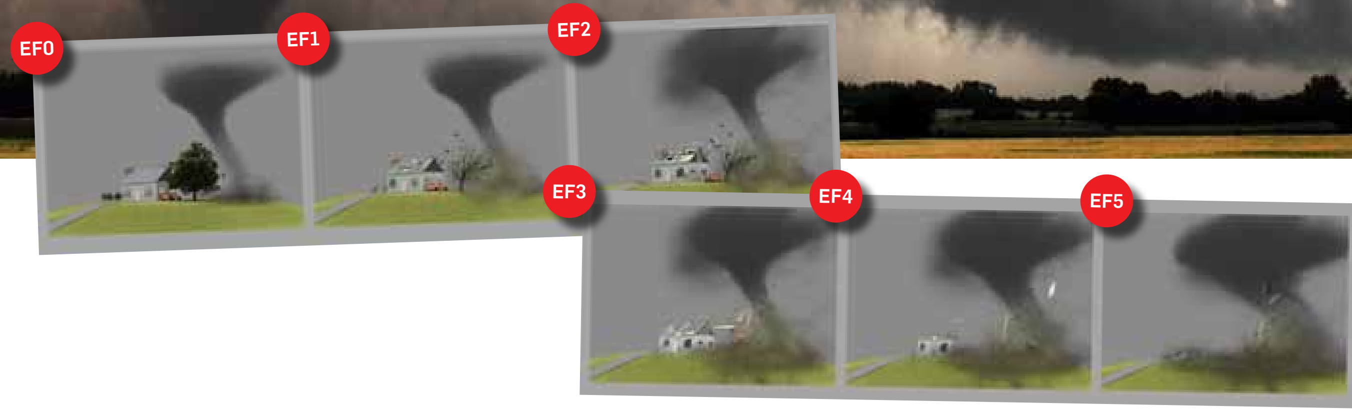
Oostmalle 1967
The tornado completely destroyed 117 homes and damaged approximately 500 others.

A deep sleep
In 1981, a tornado lifted a baby from its pushchair to a height of 16.4 yard in the air. The twister then gently deposited the baby on the ground some 100 yards from the pushchair. The baby slept through it all!

The enhanced Fujita scale

Since 2007, the EF scale is officially used in the U.S.

Tornadoes can cause destruction and even death when they move through a region. Luckily, not all tornadoes are equally intense. One tornado can crush a house, while the other can't do more than bend TV antennas! Tornadoes can be categorised by the amount of damage that they cause. The way in which tornadoes are classified is called the Fujita scale, named after the tornado expert Theodore Fujita.



EF0
Wind speed: 65 - 85 nmph
Effect: bent TV antennas, damaged chimneys and traffic signs, broken tree limbs

EF1
Wind speed: 86 - 110 nmph
Effect: shingles blown off roofs, windows broken, caravans overturned, small trees uprooted

EF2
Wind speed: 11 - 135 nmph
Effect: caravans destroyed, large trees uprooted, small cars moved, wooden building destroyed

EF3
Wind speed: 136 - 165 nmph
Effect: the roofs and some of the walls on homes collapse; heavy cars are picked up and thrown over distances

EF4
Wind speed: 166 - 200 nmph
Effect: houses destroyed, cars, lorries and train cars are lifted into the air, objects weighing a couple hundred kilograms are blown away

EF5
Wind speed: > 200 nmph
Effect: houses are ripped from their foundations and carried over considerable distances, buildings constructed of reinforced concrete are damaged, cars are thrown through the air

David Dehenauw

...why do most of the major tornadoes occur in the United States?

Tornadoes often occur during heavy thunder storms and most of the very big thunder storms occur in the United States. They are caused by the arrival of large volumes of hot moist, air coming up from the Gulf of Mexico that collides with cold arctic air coming down from Canada and from almost as far north as the Polar regions.
The place where these two fronts meet is where major storms occur. On the ground you often have a south or south easterly wind, but a few kilometres up in the air you often have strong westerly and north westerly winds. The perfect conditions for a tornado.

In Belgium we don't have such major contrasts in temperature because the air from the North blows in from the sea and is heated in part by the sea water.
So, we don't get the cold air from the North. Belgium is also in a more northern location, so we don't get all the hot air from the South. Which means that we don't have the big contrasts in temperatures between the hot and cold are that are prevalent in the United States.

We also have no mountains like the Rocky Mountains, which means we don't have big changes in the winds due to differences in height. This is why there are more tornadoes in the United States and why they are more violent than here at home.

In Belgium we record approximately five tornadoes per year, but there are also some cases of tornadoes that we don't even know exist. You can only see that there has been a tornado in fact because of the damage they cause. If there's a tornado somewhere in the Ardennes for instance, we are often unaware of its passage.
We do have tornadoes in Flanders though. In the past 50 years we have only experienced one very serious tornado and that was on 25 June 1967 in Oostmalle. It caused extensive damage and a lot of serious injuries.

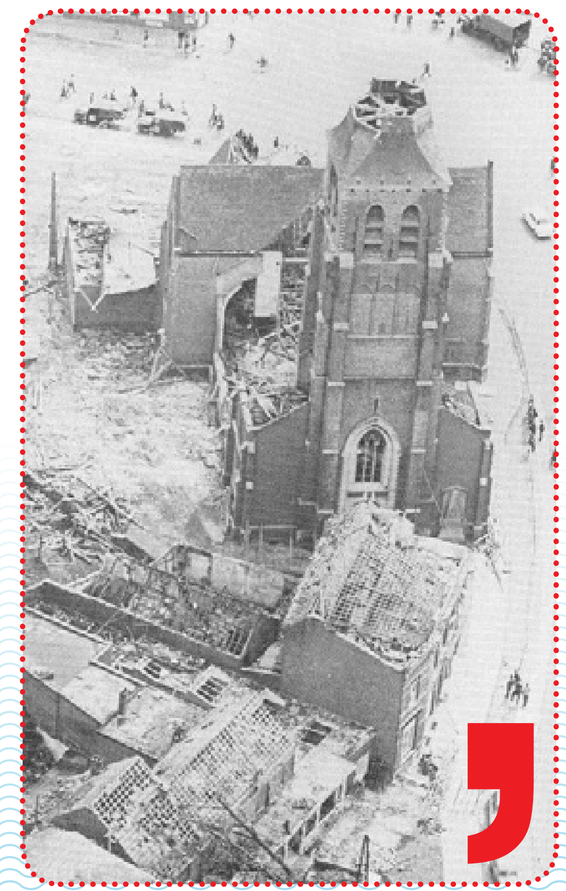
What is the difference between a tornado and a water spout?

Well what happens in the main is that if sea water is sufficiently warm in the late summer or in early springtime and if there are a number of major downpours and storms we see, quite often actually, waterspouts along our coast.

They are the little brothers of tornadoes. They usually cause less damage, but they can be dangerous out at sea.

They are caused by a collision between hot and cold air at sea. Two types of air meet and create a major downpour. Because they are not the result of a change in the wind at altitude, they cause a lot less damage, but we need to watch out for them nevertheless.

Aerial photograph of Oostmalle after the tornado on 25 June. The tornado completely destroyed 117 homes and damaged approximately 500 others.



300° tornado simulator

Last June 11 Tim Samaras an two colleagues did the near impossible - they chased down a tornado and placed a probe with video cameras directly in its path. Beginning at precisely 2.23 p.m. the team caught images that have - in a breakthrough - made it possible to calculate wind speeds close the ground, where tornadoes rip through human lives.

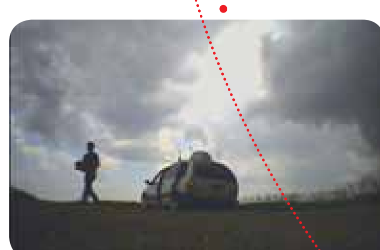
Even after his team found the tornado and drove along a dirt road in Iowa to a place they were fairly certain lay in its path. Samaras remained unsure of where exactly he would leave the probe. He stood watching the tornado boil toward him, then, at the last second, he jogged over (right), hefted the 80-pound probe, and shifted it 40 feet to the north. Samaras guessed right : the eye passed just 10 feet from the probe, giving the cameras the closest ever view op the fierce winds turning just off the ground around a tornado's center.
Wind speeds within tornadoes are so difficult to measure directly that scientists must rate tornadoes by the damage they cause. The one Samaras caught plucked up a steel bridge and threw it down in a twisted heap, severe damage earned in an F3 rating, with estimated maximum wind speeds of 137 to 179 nmph. Scientists can measure wind speeds with mobile Doppler radar, but only from distance. Samaras's cameras looked into a part of the tornado long hidden from scientists using Doppler: the bottom 33 feet. Winds at this level flatten houses and hurl cars. Understanding these winds - the tornado's strongest and most erratic - may enable engineers to design better tornado-resistant structures. 43,600 frames, 300° view.

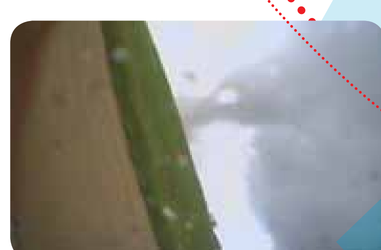
Moments after Samaras places pressure sensors and the team drives away (left top), rain starts falling and the tornado cuts like a scythe across a cornfield. Suddenly the tornado strikes thecameras: Cornstalks, rocks, sticks, leaves, and dirt fill the air. As it pushes past the probe, the tornado rolls a piece of farm equipment, snaps trees, and scours a field to bare soil.

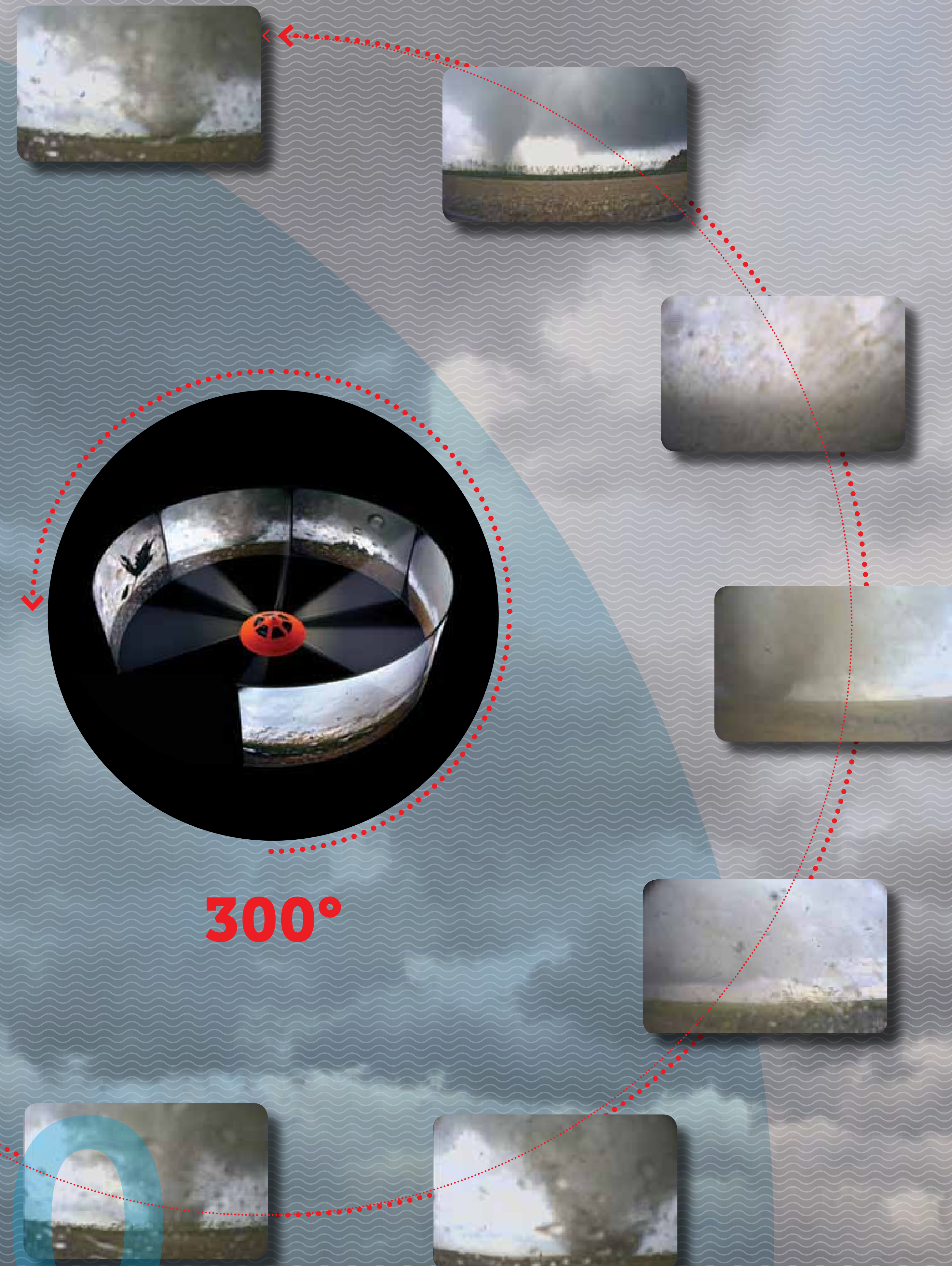
Each image like this stick (above left), contains two superimposed pictures recorded milliseconds apart (above right)—a characteristic of video photography that anabled Samaras to estimate the velocities of objects picked up by the tornado. He matched the position of the stick to a spot where he stood while placing the probe (below) and then used measurements of his body to figure the stick's size and distance traveled. Knowing that the two pictures were taken 16.6 milliseconds apart, he calculated a speed of 62 nmph. That's remarkably fast, given the stick's location just inches off the ground. Similarly, he found that a maple leaf (not shown) a few feet off the ground was traveling at 108 nmph. Combining many such estimates will make it possible to create detailed pictures of wind speeds – and grasp what is happening inside tornadoes where they meet the ground.

Distance/time = velocity
❯ 1.72 feet / 0.0166 seconds
= 104 feet per second
= 62 nautic miles per hour

43,600 pictures in a viewing angle of 300 degrees







11 [Lighting and thunder

Lightning

Lightning is a fascinating yet at the same time dangerous phenomenon. There are enormously strong energy currents in the lightning bolt, which is often no more than a few centimetres thick. Normal lightning already releases an electric current of 10,000 to 20,000 amperes, and some severe storms can release at least 10 times that. The discharge is extremely short, averaging no longer than 1/100th to 1/5th of a second, but the storm can discharge several times one after the other via this same bolt of lightning. We see this as a flickering of the lightning bolt in which the charge is discharged multiple times per second.

Speed and safety

The temperature in the bolt of lightning can reach values up to 54,000 degrees Farenheit. The air is so quickly displaced that the horizontally transmitted pressure wave is responsible for the audible part of this phenomenon, the thunder.

The sound

Sound travels through the air at approximately 370 yards per second, while the light from the lightning reaches our eyes at 186,450 miles per second. The time difference between the lightning strike and the audible rumble that follows it allows for a rough approximation of how far the storm is from a certain location. Every second of difference represents a distance of 370 yards. If it takes 5 seconds for the thunder's rumble to be heard, then the storm is approximately 1 mile away. If the distance becomes even shorter than this, then it is time to take precautionary measures. Unplug all electric appliances from the sockets and make sure that you are not at the highest point if you are out in the open. Do not shelter under tall trees or close to metal objects, such as a bicycle. You are, however, perfectly safe enclosed in a car.

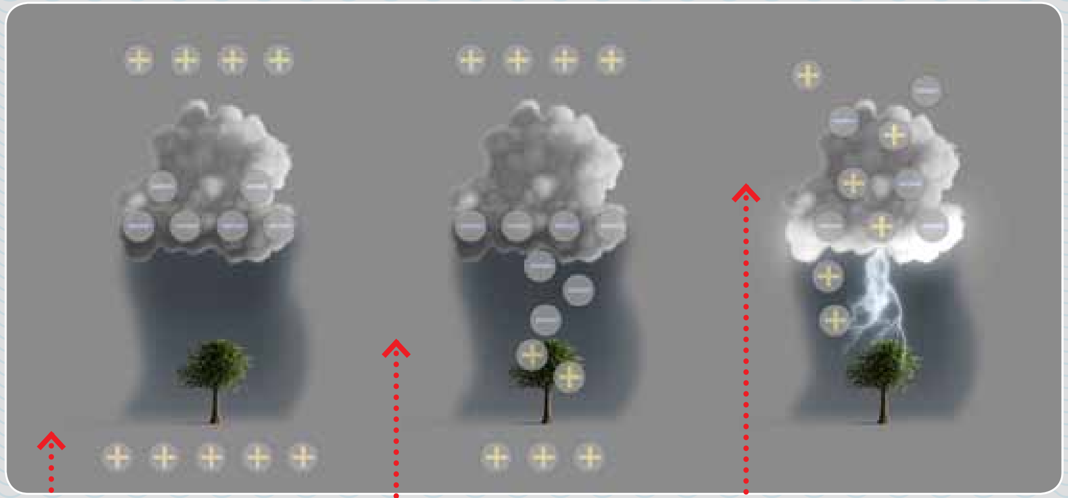
When lightning strikes

When a storm breaks out, it is important to find shelter immediately in a building or in a car with closed windows. If that is not possible, because for example you are in an open field (festival), crouch down on your toes with your feet as close together as possible. This way, if lightning hits you, it will cover as short a distance as possible through your body. Do not run towards trees, podiums or tents. And do not forget that some storms can generate very strong gusts of wind.

The power of the released electricity is strong enough to cause serious injury and even to kill. Although the danger is great, you will be surprised to learn that four out of five people who are hit by lightning survive this violent force of nature!

How lightning occurs...

The winds that arise in a cumulonimbus cloud cause disruptions within the cloud. The rain drops and ice crystals in the cloud begin to rub against each other and collide, which creates small electric particles. These particles contain either positive or negative energy and are attracted to each other. This power of attraction between contradictory charges causes the particles to move towards each other, which results in lightning. The following illustration shows how the lightning moves from a cloud to the ground.



Positive charges collect at the top of the storm cloud, which negative charges collect at the base. Positive charges collect on the ground under the cloud.

The negative charges in the cloud are attracted to the positive charges on the ground. As they move towards each other, they create invisible sparks.

When both invisible sparks touch each other, they create a path over which the positive charges from the ground move up into the cloud. This upward movement creates the visible lightning bolt.

11

12 [Hurricanes

Cyclones

These are called “hurricanes” in North America and the Caribbean region. Residents of Southeast Asia call them “typhoons”. They are called “willy-willies” in Australia and “cyclones” in the Indian Ocean region. Whatever you call them, these storms are a nightmare for anyone living in a tropical region. Tropical cyclones (or hurricanes) can stretch themselves out over large portions of the ocean, and sometime reach the coastline. Their clouds roll forward in giant tornado-like formations and cause extremely strong winds and heavy rainfall. In just seven to nine days, these tropical giants can travel thousands of kilometres, during which they pose a threat to both ships and the people living in coastal regions.

Since 1979, meteorologists from the World Meteorological Organization (WMO) have been giving the hurricanes names. Each year they create an alphabetical list with alternating female and male names in English, Spanish and French. Every time a hurricane is “born”, it is given a name from the official list. The first hurricane of the year is given a name beginning with the letter A, the second gets a name beginning with the letter B and so on.

The birth of a hurricane

With the sun’s aid, the warm, moist air above the ocean’s surface begins to rise. A group of storm clouds begins to form. Within the core of the largest storm cloud, an invisible “chimney” begins to develop. The air at the base of the chimney is sucked up and rises up in a spiralling pattern.

When the air approaches the top, the water vapour condenses and forms clouds that begin to spin in a whirlwind-like pattern. This movement of the rising air close to the eye of the storm behaves like a giant vacuum cleaner. As long as the ocean’s warmth continues to feed the chimney, the air will continue to be sucked up.

The winds

The winds that sweep across the surface of the ocean move the hurricane along at a speed of approximately 13.5 nmph.

Warm water

A hurricane can only develop if the ocean is warmed to a temperature of at least 80.6 °F. This is therefore impossible in the North Sea. Storms can nevertheless reach 12 on the Beaufort Scale, which qualifies as a “hurricane”. They then tend to be “depressions with hurricane force”, the strength of which is not comparable to an actual hurricane, which is always tropical in origin.

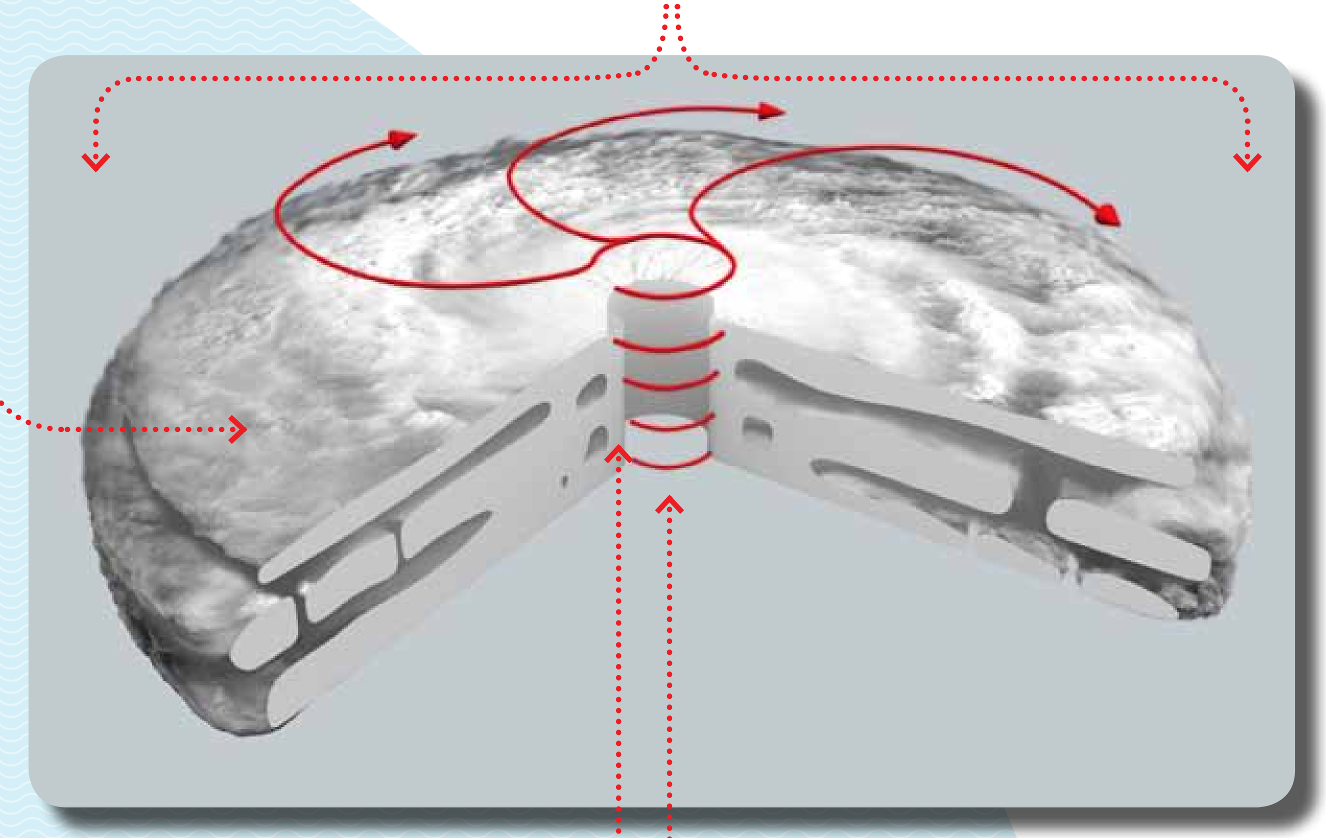
12

The storm cloud

The clouds whirl around the eye.

The diameter

The diameter of the tropical cyclone can reach as much as 620 miles. It can cover an area the size of France, for instance.



The eyewall

The eyewall, which surrounds the eye, consists of a layer of thick clouds. This is the most dangerous part of the hurricane, with winds that can reach speeds of 135 nmph.

The eye

The eye is a calm zone in the hurricane. The wind here is weak, the sky is often clear and there is little rain. The diameter of the eye can vary widely, but is on average 19 miles wide.

13 [Ship disasters

Horizon Hunter

On 26 January 2010, a Horizon Lines ship was travelling from Los Angeles to Guam but had to make an unscheduled stop in Honolulu. Various containers were teetering at an angle over the side of the ship after the ship was hit by a storm in the Pacific Ocean. The storm dragged six containers overboard. Many of the containers were leaning over the side of the ship. Luckily, no one was injured. The waves were approximately 9.8 yards high and the wind was racing at 43 nautic miles per hour. The damaged containers contained foodstuffs, cleaning agents and cars.

Company	Horizon Lines
Capacity	2824 TEUs
Type	Container ship
Route	Los Angeles – Guam
Body of water	Pacific Ocean
Location of sunken ship	1,200 miles to the east of Hawaii
Wind speed	9 Bft
Wave height	9.8 yards
Type of storm	Pacific storm

MS Riverdance

On 31 January 2008, the MS Riverdance was hit by a wave while travelling from Heysham to Warrenpoint. The wave caused the load to shift and the ship ran ashore in Blackpool. The ship listed to an angle of 60 degrees. Attempts to bring the ship back under control failed, so the ship sat stuck on its side for all of 2008. The crew and passengers were evacuated by helicopters and lifeboats. Two of them were suffering from mild hypothermia and were taken to hospital. The wind speed that day was between 32 to 70 nautic miles per hour.

Company	Mashala Shipping Co.
Commissioned	1977
Type	Ferry
Length of the ship	127.2 yard
Crew members	19
Route	Heysham - Warrenpoint
Location of sunken ship	N 53°52'23" W 3°03'09"
Wind speed	32 - 70 nmph

MV Maassluis

The MV Maassluis was an oil tanker for the Nedlloyd shipping company. On 15 February 1989, the ship went missing in severe storms close to the port of Skikda in Algeria. Two sailors who were working on the anchor fell overboard and survived the accident. The other 27 crew members died. When the wind reached 10 Beaufort, the ship was pulled from its anchors and crashed into a pier at the port. The captain and first mate tried to start the engines so that they could sail away from the pier. The waves had a height of between 9.8 and 13.1 yards. This was the worst disaster for a Dutch ship since World War II.

Company	Nedlloyd Bulk BV
Commissioned	1982
Type	Oil tanker
Length of the ship	188.4 yards
Crew members	29
Location	Port of Skikda
Wind speed	10 Bft
Wave height	9.8 - 13.1 yards

New Lucky VII

On 5 April 2011, the ship New Lucky VII went missing in the East China Sea. The ship, with 17 crew members aboard, was travelling from Papua New Guinea to China with a cargo of wood when a severe storm hit the ship. When contact with the ship was lost, the decision to launch a search-and-rescue operation was made. An airplane discovered a lifeboat with nine survivors, and a bit further along, another lifeboat with two people in it. The 11 crew members were still in good health. The airplane also saw several oil slicks close to the sinking ship. Six crew members were still missing.

Company	Franbo Lines Corp (Taiwan)
Commissioned	1982
Type	Cargo ship
Route	Papua New Guinea - China
Length of the ship	103 yards
Weight	4,078 long tons
Location	N 35°59' W 120°31'
Crew members	17

Autumn storm in Black Sea region

On 11 November 2007, four cargo ships sunk in the Black Sea because of a severe storm with 6.6-yards high waves and a wind speed of 49 nmph. Three sailors died and at least 23 were missing. The sunken tanker, Volgoneft 139, was broken in two and lost 1.970 long tons of the 3.940 long tons of fuel oil in the Black Sea. The other ships were carrying sulphur and steel. Six other ships ran aground on sandbanks and two tankers were damaged. This was a severe environmental disaster.

4 sunken ships	Volgoneff 139, Volgonosk, Nahichevan, Kavel
Location	Kerch Strait
Wave height	6.6 yards
Type of storm	winter storm

Heinrich Behrmann

The German cargo ship Heinrich Behrmann ran aground on the beach in front of the Blankenberge Casino on Friday morning, 9 November 2001. The ship was experiencing a technical problem in the steering gear. A severe storm pushed the ship towards the beach. It was feared that the ship would break open during the salvage. The ship was carrying a cargo of 80 containers filled with chemicals.

Company	Behrmann Heino
Construction year	1975
Type	Cargo ship
Length of the ship	92 yards
Crew members	29
Route	Ireland - Zeebrugge
Ship beached	4 days

14 [Herald of free enterprise

What kind of ship was the Herald of Free Enterprise?

The Herald of Free Enterprise was a British roll-on-roll-off car ferry that, on 6 March soon after leaving the port of Zeebrugge for Dover, capsized. 193 people lost their lives in this disaster.

Fate

At 7.05 p.m., just after the ship set sail at 7 p.m., it capsized in around 980 yards of water just off the Belgian coast. At the time there were 80 crew on board and the ship was carrying about 600 passengers, 81 cars, 3 coaches and 47 lorries.

An analysis of the disaster revealed that this was an accident in which a combination of latent and active human errors at a specific point in time paved the way for an accident.

Latent errors: design of the ship, lack of a warning system, unclear task allocation for the crew, haste in order to travel at the scheduled time.
Active errors: leaving the bow door open, not emptying the ballast tanks and alcohol consumption among officers during active service.

The roll-on-roll-off type of ship was at a disadvantage from the word go, due to the big car decks that ran the full length and breadth of the ship in order to load and unload speedily. As soon as this type of ship takes on water, the water rolling back and forth across the surface causes a loss of stability and finally capsize. Water also flooded the deck during the disaster that hit the MS Estonia in 1994, in that instance probably due to the lack of a bow door.

Intervention

The contingency plan was declared by the governor of West Flanders at the time, Olivier Vanneste, and together with the speedy and efficient handling by the Belgian emergency services including army divers and the Civil Protection, the excellent medical assistance provided by the Belgian Red Cross, the number of deaths was limited to 193. A number of shrimp fishermen were the first to reach the site of the disaster and also helped the situation and several crew members intervened to ensure a speedy and effective evacuation which saved lives.

Most of the victims were British and they died of exhaustion in the ice cold water (35.6 to 37.4 °F). Three bodies were never found: a baby and two British soldiers.

Company	Schichau Unterweser AG
Commissioned	1987
Type	British roll-on-roll-off car ferry
Maximum snelheid	23 nmph
Length of the ship	144.3 yards
Crew members	80
Route	Zeebrugge - Dover
Location of sunken ship	980 yards from the port of Zeebrugge

15 [Coastal Tram

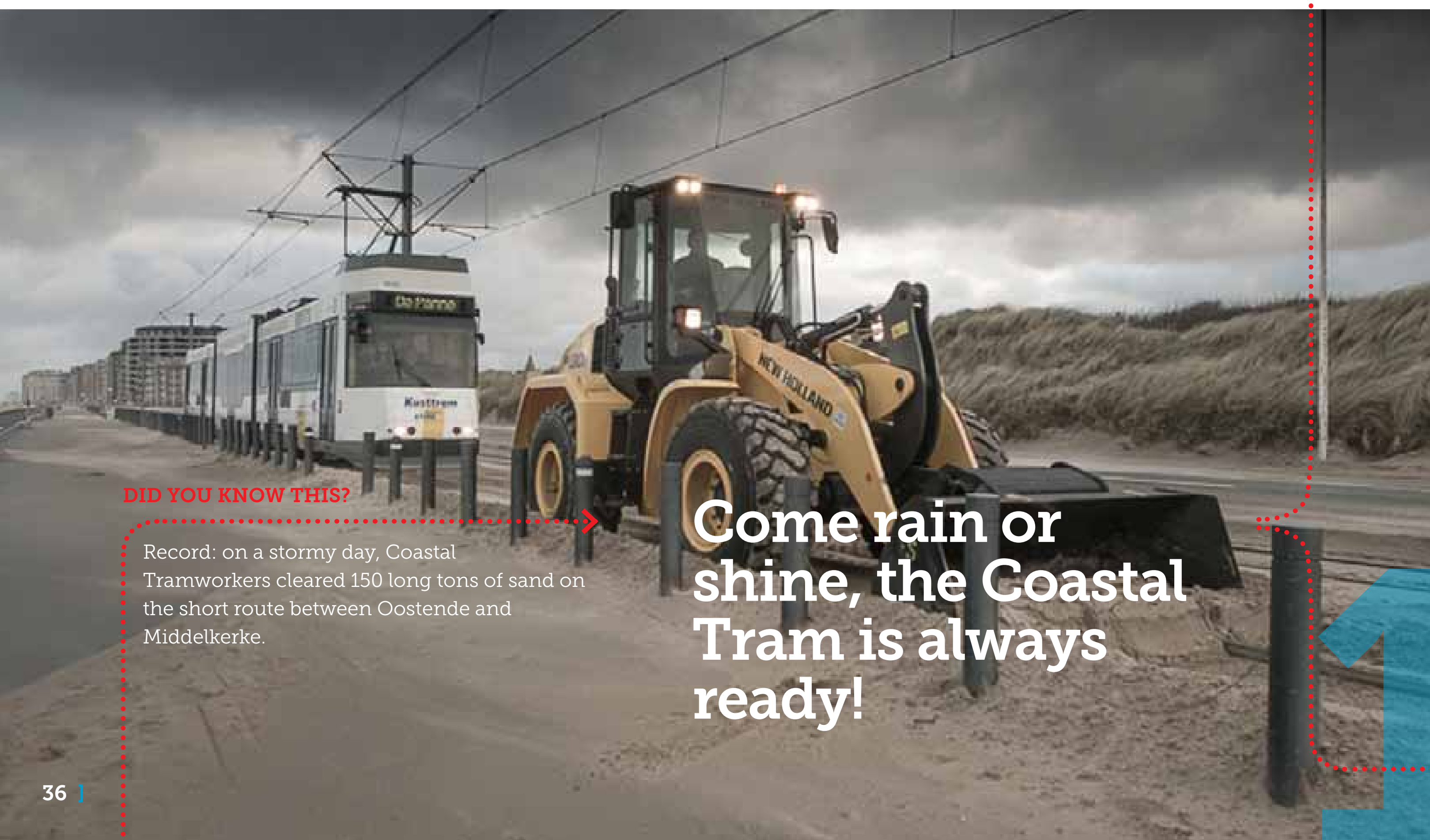
A seaside icon

There is only one way to discover the Flemish sea-sideand that is on board the Coastal Tram, enjoying a front row seat. Are you planning a relaxing day trip to the seaside some time soon? You will be happy to know that you can rely on the Coastal Tram, regular as clockwork,to take you to exciting sights and attractions, unmissable events and delightful little shops. With 68 stops between De Panne and Knokke, the Coastal Tram continues to serve as your faithful transport partner, and that includes eco-friendly rides to work.

Our seaside and the Coastal Tramare inextricably linked, sharing a longstanding history of mutually rein-forced growth. Especially as the Coastal Tramalso used to carry goods and building materials back in the old days. This prompted busy economic activities along the tram's course, as a result of which the number ofho-tels, restaurants and private homes mushroomed ac-cordingly.

Looking back on 125 years of history, the Coastal Tram is confidently chugging into the future as the most ap-propriate, not to mention greenest remedy againsttraf-fic congestion and parking stress.

Relive the history of the Coastal Tram and its close ties to Blankenberge. Come rain or come shine, the Coastal Tram will safely take you to your destination.



DID YOU KNOW THIS?

Record: on a stormy day, Coastal Tramworkers cleared 150 long tons of sand on the short route between Oostende and Middelkerke.

Come rain or shine, the Coastal Tram is always ready!

The Coastal Tram takes travellers safely to their destination any time of day. De Lijn always works with might and main to keep the tracks clear.

Sand can pile up over a considerable distance by as much as half a yard in height.

Sand starts building up as from 4 on the Beaufort scale, especially with wind coming in from the west, the south-westor the north.

A sand"hoover"is used to clear the tracks from sand and leaves. The build-up of sand may cause the tram to get stuck or even get derailed. Leaves act to make the tracks more slippery, which in turn makes for a longer stopping distance.

In the fight against sand, a pilot project got un-derway in October 2012 in which De Lijn is a partner. Alongside the Kustbaan (Coastal Road) between Middelkerke and Oost-ende, a 330-yard length retaining wall was put in place with high concreteedging slabs.

De Lijn's twosand hoovers not only scramble if there is a storm. They are sent out to keep the tracks and switches neat and tidy. They also clean the track drainers that drain off the rain water.

16 [Sea King Search & Rescue

History of the Sea King

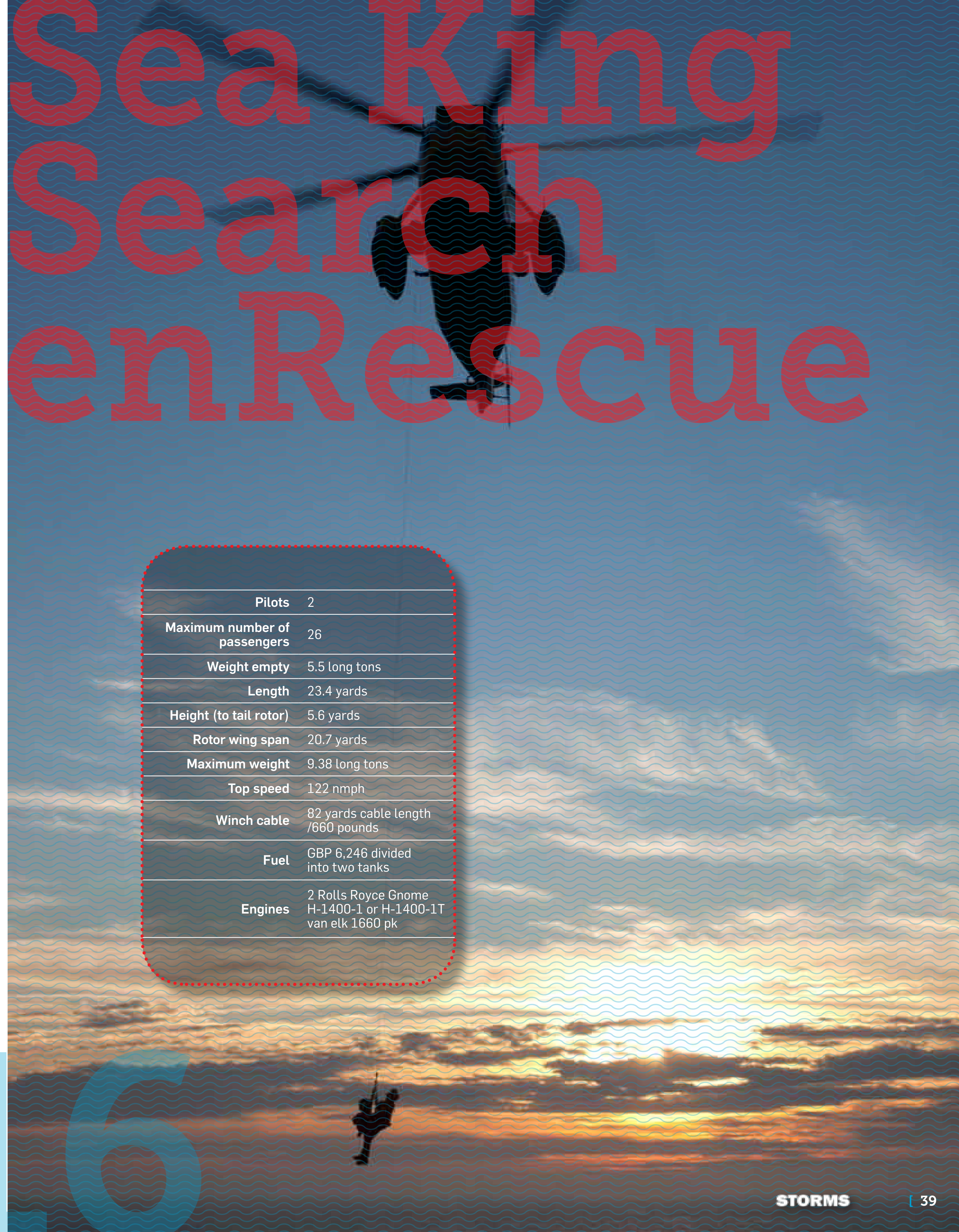
In 1957 the US Navy asked the Sikorsky company to design a twin-engine helicopter to be used against submarines and at the same time be able to carry sensors and weapons. On 11 March 1959 the XHSS-2 made its first trial flight. The American navy was so impressed by the helicopter that in 1961 all other helicopters were replaced by the brand new SH-3A. Because of its double role whereby it carried weapons and sensors, the SH-3 was soon nicknamed Sea King. A further 15 military and civil variants were built based on the SH-3A. One of the most famous is the VH-3, the American presidential helicopter, the Marine One.

In 1969 the British company Westland become the first foreign company to be able to build the Sea King under license. The helicopter was also built under license later on in Japan (by Mitsubishi) and in Italy (by Agusta). The United Kingdom, Germany, Belgium and Norway purchased the Sea King.

In 1990 Sikorsky stopped production after having built 1100 helicopters. The United Kingdom, Italy and Japan continued to produce the helicopter. The Italian and Japanese Sea Kings were only purchased by the countries where they were produced, while the United Kingdom continued to export the helicopter to all different countries.

The situation today

At the current point in time, the British RAF and the Belgian Air Force still make intensive use of the Sea King as a Search and Rescue helicopter. But the days of this helicopter are almost counted and better helicopters such as the EH-101 and the NH-90 are taking their place. The Belgian RS-01 (Rescue 01) flew its last flight on 17 December 2008, in the company of another Sea King and an Alouette III, between its home base in Koksijde and the esplanade of the Cinquantenaire in Brussels. After 33 years of service (first deployed on 19 December 1975) it has now been put out to pasture as a show piece in the Royal Army and Military History Museum next to the Cinquantenaire.



Sea King Search enRescue

Pilots	2
Maximum number of passengers	26
Weight empty	5.5 long tons
Length	23.4 yards
Height (to tail rotor)	5.6 yards
Rotor wing span	20.7 yards
Maximum weight	9.38 long tons
Top speed	122 nmph
Winch cable	82 yards cable length /660 pounds
Fuel	GBP 6,246 divided into two tanks
Engines	2 Rolls Royce Gnome H-1400-1 or H-1400-1T van elk 1660 pk

17 [Coastal division

Coastal division

Climate change, sea level rise, extremely long spells of rain, very high water levels, increase in really stormy weather, all are images of today's reality which we cannot neglect any longer.

What would Flanders coast look like if a very heavy storm occurs together with a storm tide that exceeds the one of 1953? The threat is real. The Flemish government cannot and does not want to wait to prepare the coast for the worst.

Coastal defence, what's that?

The main force of the sea is hidden in the relocation of a huge water mass. This is encouraged by currents, tides and wind. The moving water mass can destroy dunes and wear away, lower and deepen the beaches and the sea bottom.

At Flanders coast we have three types of coastal defence: natural, hard and soft coastal defence.

Natural coastal defence

Dunes and beaches along the sandy coast of Flanders constitute the natural defence of the lower-lying polders, cities and towns against flooding. However, dunes can lose their coherence. Sand is blown away. In case of a storm the dune foot will lose sand to the sea. A multitude of holiday makers leave deep and transverse ruts in the dune massifs, damage the vegetation and thus weaken the dunes. Osier hedges serve to fix the sand blown up by the wind.

Marram grass and other plantings are used to fix the sand grains. Beautifully laid out paths, wooden stairs and fences are provided to lead the numerous holiday makers and walkers on their way. With these interventions the Coastal Division tries to limit access to and damage of dunes with a coastal defence function.
The almost straight line of the coastal strip of Flanders is the work of human hands. Tidal inlets have been closed off and the coastline has been fixed with artificial coastal defences.

Hard coastal defence

Over half of Flanders coast is protected against the sea with one or several man-made reinforcements. Groynes extend until beyond the low-water mark and are up to 330 yards long. They break tidal currents, which cause beach erosion. They run perpendicular to the coast and are usually constructed using blocks of bluestone or concrete. At the end of the 19th century, dune areas were transformed to entirely new residential areas, which have evolved into our seaside resorts.

The new patrimony was protected from the violence of the sea by building seawalls, which were complemented with walking paths and became popular early coastal tourism destinations. These seawalls were reinforced and extended later on. In the last decades of the 20th century the Coastal Division did not build any new seawalls. The hard constructions were maintained and embellished into promenades. Seawalls thus got a coastal defence function as well as a recreational function.

Soft coastal defence

To achieve safe coastal defences the Coastal Division especially takes into account the natural dynamism of the coast with the natural interaction between the beach, currents, waves and wind. In case of a storm great water depth results in larger and higher waves. A wide beach with a gradually decreasing water depth reduces the strongest storm waves to mere ripples. Soft coastal defence focuses on the construction of safe beaches.

Foreshore nourishment concerns the nourishment of the beach that continues underwater up to the sea bottom with sand. In case of beach or dune foot nourishment the sand is brought to the beach and the dune foot and pushed under the slope of the dune. In case of dune nourishment the dune volume is increased with sand so that it can offer more resistance during storm waves. Beach nourishment, the process of rainbowing or raising the dry beach with sea sand, results in a coast that can grow along with the sea.

The Coastal Safety Master Plan

Flanders has 42 miles of coastline. Along this relatively short coastline there are 4 coastal cities and 6 coastal municipalities. Here we find the commercial ports of Zeebrugge and Oostende with industrial areas in the hinterland and the recreational marinas of Nieuwpoort, Oostende, Blankenberge and Zeebrugge, which have a significant economic value to the region. There are also a number of valuable scenic areas, such as Westhoek, IJzermonding and Zwin.

The coastal region is a densely populated and frequently visited region, a mix of significant economic values, recreational values and ecological values.
However, the coast is very vulnerable considering the likelihood of a storm flood and the risk of flooding.

Since 2007 research has been conducted on how to protect Flanders coast against very heavy storms and thus ensure coastal safety until at least 2050. All current defences against the violence of the sea have been checked against international standards. All flood risks for the entire coast have been calculated and all risk areas have been mapped. Measures and possible alternative interventions have been studied for those areas.

All required interventions have been discussed with the towns and cities in question. They have declared themselves in agreement with the **coastal safety master plan**.

Interventions are required on a third of the entire coastline so as to protect the coast and the hinterland against sea flooding.
Proposed measures include sand supply for all weak dunes and seaside resorts and hard constructions in the weakest seaside resorts. The ports have been provided with storm walls around the docks or a storm surge barrier in the mouth of the port.

The **coastal safety master plan** subprojects are gradually being implemented by order of the Coastal Division of the Flemish government since 2011 so as to quickly arrive at a **strong** and a **safecoast**.

Further information on www.afdelingkust.be
& www.kustveiligheid.be

To predict stormy weather and storm tide and to immediately issue warnings it is necessary to have access to all possible data related to wind force and wind direction, water level, wave height, current and so on. All these data with regard to the part of the North Sea located off the Flemish coast are collected by the Flemish Government.

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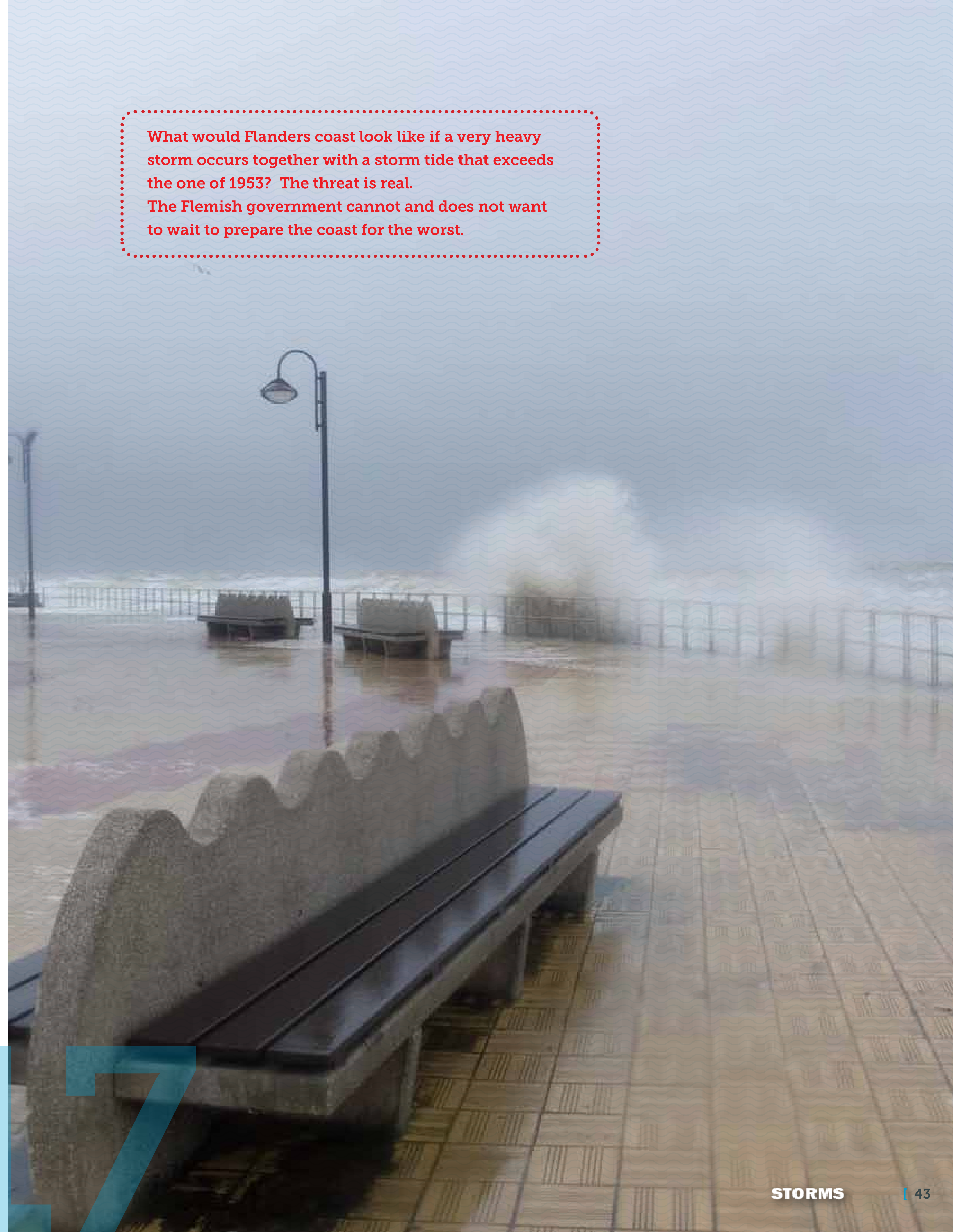


What would Flanders coast look like if a very heavy storm occurs together with a storm tide that exceeds the one of 1953? The threat is real.
The Flemish government cannot and does not want to wait to prepare the coast for the worst.

VlaamseBanken Monitoring Network

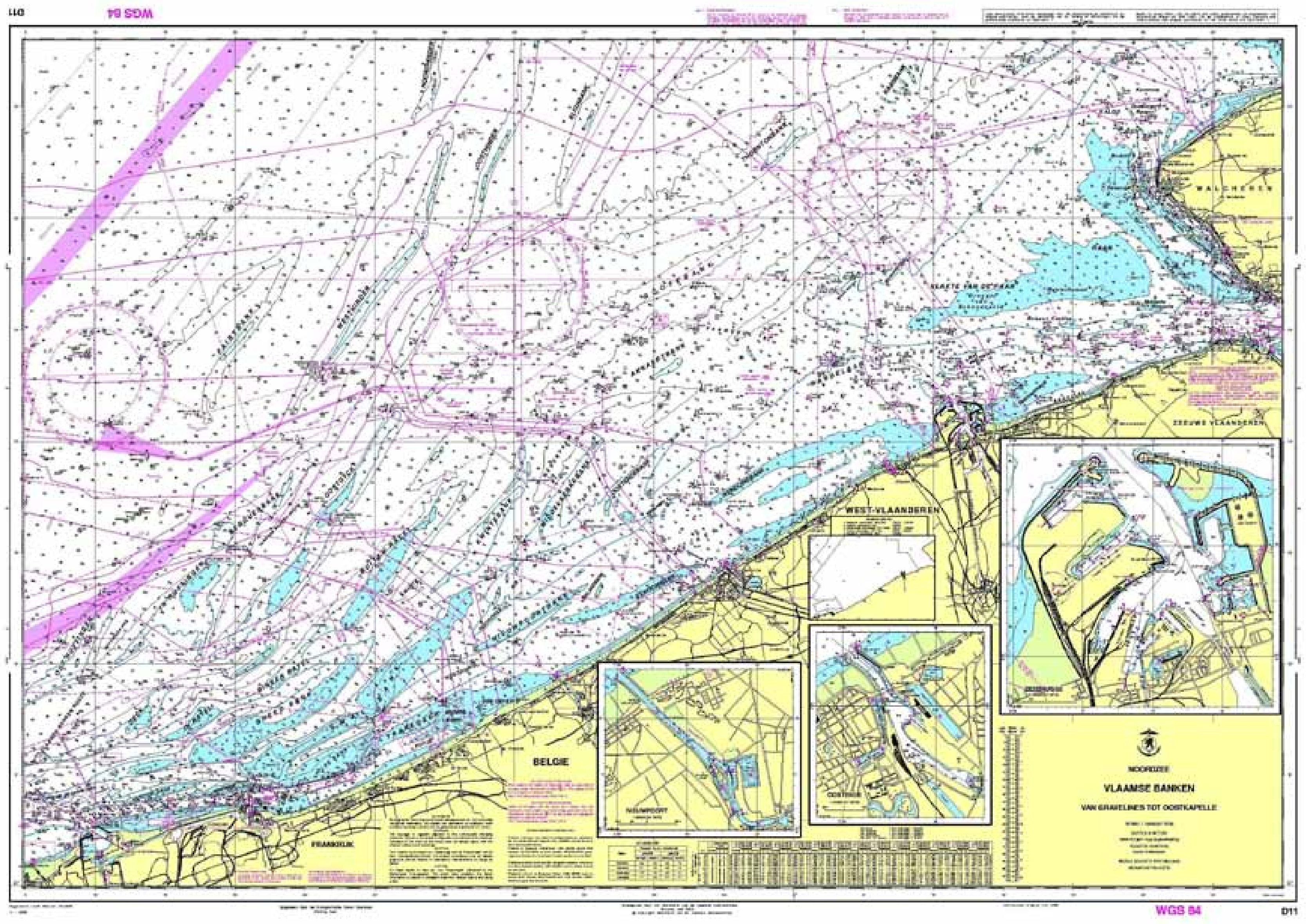
The development of the VlaamseBanken Monitoring Network started in 1976 within the scope of the expansion of the port of Zeebrugge. A network of wave measuring buoys was constructed at sea on the Belgian Continental Shelf and a meteorological station was established on land. During the execution of the hydraulic works the construction team required information about the current hydrometeorological conditions and forecasts for the subsequent days. For that purpose daily meteorological reports were drawn up.

In 1984 a total of 5 permanent measuring poles were installed in the channels to Zeebrugge and the Western Scheldt. In 1993 a measurement and beacon platform was installed on Westhinder Bank. This Westhinder bank measuring pole plays an important role in the safety of shipping traffic in one of the busiest shipping routes in the world. At a later stage a platform on Oostdyck Bank was added to the network.

The measuring devices and sensors on the platforms collect important information on the wind, the water level and the waves.

1989 saw the launch of the Westerscheldemond Hydrometeorological System. The network of measuring buoys, the meteorological station and the network of measuring poles were aligned and integrated into the measuring system. The system was given the name VlaamseBanken Monitoring Network. It is managed and maintained by Flanders Hydrography, a team of the Coastal Division. This division is an entity of the Agency for Maritime and Coastal Services (MDK) of the Flemish Government.

All information gained is processed into immediately operationally useful data in a data centre in Oostende. The central database contains data on water levels, waves, currents, wind, air pressure and water and air temperature. The data are exchanged on a national and international level.



Oceanographic Meteorological Station

The meteorological station in Knokke-Heist has evolved into a full meteorological station. Forecasters have access to real-time data of the entire VlaamseBanken Monitoring Network and the linked monitoring networks of the Dutch Department of Public Works.
Since 2008 the Oceanographic Meteorological Station (OMS) of the Flanders Hydrography team is housed in the port of Oostende.

The meteorologists make very accurate local hydrometeorological forecasts at the station. Four times a day they draw up a Marine Meteorological Forecast with predictions about wave swell, tides, wind direction, wind force and visibility at sea. The hydrometeorological forecasts are valid for the channels running off Flanders coast and for the various work areas of the Coastal Division.

The meteorological forecasts are sent by fax or e-mail to various professional users from e.g. the shipping industry, the Flemish ports, the Flemish maritime government services, the authorities and companies working on and along Flanders coast. The forecasts are also communicated to the Storm Tide Warning Service.

The maritime and coastal weather forecast drawn up at the OMS based mainly on the data of the VlaamseBanken Monitoring Network is not only important for safe shipping traffic at sea, but also for protecting Flanders against storm tides and flooding.

Further information on
www.vlaamsehydrografie.be
>> meetnet Vlaamse Banken

Different types of storm tide warnings

Preliminary warning
As soon as a storm tide risk is predicted with great certainty off FlandersCoast, the Storm Tide Warning Service issues a warning by phone. This warning acts as a signal for all warned bodies to prepare themselves for the startup of their own procedures and tasks.

Increased alertness
If the probable level of the next high tide in Oostende exceeds TAW +5.40 m without reaching TAW +5.60 m, a warning will be sent by e-mail or text.

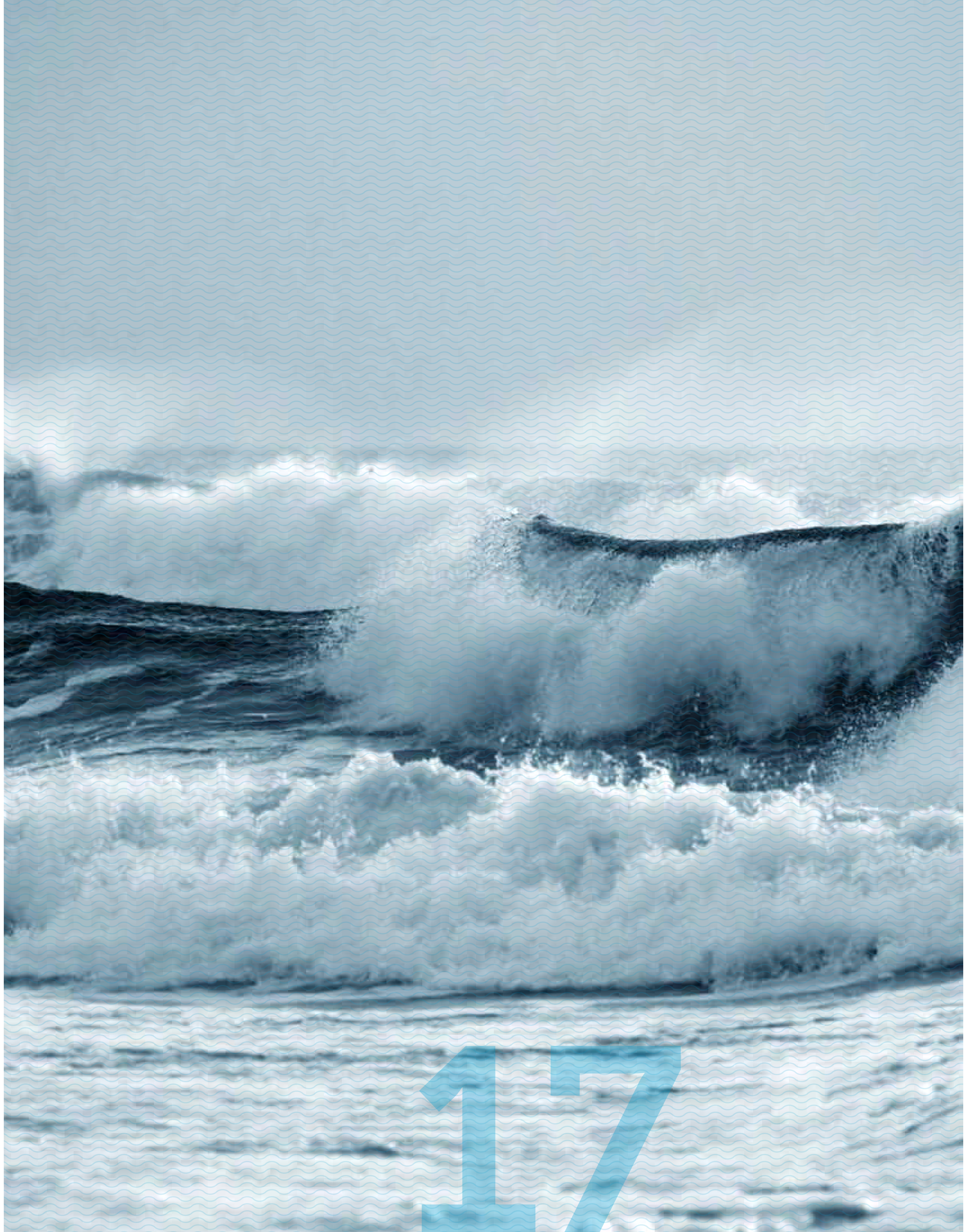
Coastal storm tide
If the expected level of the next high tide in Oostende exceeds TAW +5.60 m without reaching TAW +5.90 m, the water level for a Coastal Storm Tideis reached. The Storm Tide Warning Service then draws up a storm warning that indicates the time of the expected high tide in Oostende and the expected high tide level in Oostende. This warning results in a security increase with the bodies receiving it.

Dangerous coastal storm tide
If the expected level of the next high tide in Oostende reaches TAW +5.90 m, the water level for a Dangerous Coastal Storm Tide is reached. The Storm Tide Warning Service then draws up a storm warning that indicates the time of the expected high tide in Oostende and the expected high tide level in Oostende. This warning also results in a security increase with the receivers.

Accelerated procedure
If a storm comes up suddenly due to unexpected circumstances and a warning can only be given when the high water level in Oostende has almost been reached, there may be insufficient time to follow the standard procedure. The number of services and persons to be warned may be limited. The Coastal Division then sends direct urgent warnings by phone.

Legend:
TAW: The Belgian reference level
"De Tweede Algemene Waterpassing"
NAP: The Normal Amsterdam water level
"Normaal Amsterdams Peil"

Further information on
www.vlaamsehydrografie.be
>> stormvloedwaarschuwing



The maritime and coastal weather forecast

The KMI-team of marine meteorologists at the Oceanographic Meteorological Station (OMS) in Oostende exclusively concern themselves with the weather in the coastal region and at sea and with its impact on maritime phenomena such as wave height and tides. They are entirely familiar with the coastal and maritime climate, a requirement in order to make successful predictions, as the weather computers do not always allow to work very precisely. Every day the OMS team prepares several bulletins, which are made available. On working days this is at 8 a.m., 12 noon, 3.30 p.m. and 8 p.m.

Apart from the theoretical astronomical tide, the forecasts include the actual tidal situations for several locations at the coast and at sea, taking into account the current weather situation. Other predictions include the significant and maximum wave height, the wave period and the swell. The OMS team divides the wind information for the coast and at sea in three to six hour periods. The general weather outlook is predicted up to five days in advance with as much specification as possible in the short term.

Apart from the specific users who are sent the weather forecasts by fax or e-mail, everyone can monitor the weather situation at sea. The forecasts can be found on the website of the Agency for Maritime and Coastal Services (www.agentschapmdk.be) under the Nice Weather at the Coast icon.

The coastal weather forecast, including tidal and wave predictions, is also freely available on the website of the Coastal Division (www.afdelingkust.be) or of its team Flanders Hydrography (www.vlaamsehydrografie.be).

Things are very simple for the general public:the specific coastal and maritime weather forecast can be found directly on www.kustweerbericht.be. It is available free of charge in 4 languages.

Since 2012, anyone has been able to read the coastal weather forecast on a mobile site that is accessible to smartphone and can be reached quickly with a unique QR label. A storm tide warning always takes precedence on the smartphone version.

Timeline of floods

The copious amounts of precipitation from the previous weeks, together with the thawing snow in the Ardennes, caused severe floods in the southern part of the country. Dinant and Namur were ghost towns and some of the rivers reached their highest level ever.

28.02.1910

14.05.1906

A severe hail storm caused intense rain showers in the Leuven area. We estimate that the amount of precipitation that fell was at least 7.9 inches in 3 hours and 15 minutes. Floods resulted in significant local damage, particularly in Bertem.

15.12.1925

Today is the first day of one of the most disastrous periods in our climatological history: the melting of the thick layer of snow that has been lying on the ground since November, accompanied by heavy rains. This will lead to serious flooding in the Meuse valleys and those of its tributaries in early January.

07.01.1926

The extremely copious amount of rain since 19 December, together with the melt water from all the snow that had accumulated since late November 1925, meant that the Meuse and its tributaries were at exceptionally high levels. This was without doubt one of the three most catastrophic floods of the century in the Meuse Valley.

09.07.1952

During a flash flood of the Soor in Jalhay in the High Fens as a result of a thunderstorm, 6 workers (5 Italians and 1 Belgian) were carried away and died.

29.05.1956

In the region around Verviers, four people were killed in floods resulting from severe thunderstorms.

30.01.1961

To the south of the Sambre and Meuse rivers, half of the stations recorded over 1.6 inches of rain. Copious amounts of rain and the quickly melting snow caused a sudden rise in the water levels in this region, followed by general flooding that was particularly severe in the Sambre and Meuse valleys.

01.1995

An extremely high water level and heavy flooding of the Meuse in Belgium and the Netherlands due to exceptionally heavy rainfall. The total precipitation recorded in Uccle for January was 5.65 inches, the record of a century for January.

12.1993

The flooding at the end of December is among the most catastrophic in our recent history. The highest totals occurred in the Ardennes: 14.7 inches in Sugny (Vresse-sur-Semois), 15.7 inches in Libramont, 16.5 inches in Arlon, 17.2 inches in Dohan (Bouillon), etc.

13.09.1998

This was an exceptional day because of the copious amounts of precipitation, particularly in the provinces of East Flanders, Antwerp, Flemish Brabant, Limburg and Liège. On the 14th, amounts of more than 1.6 inches were registered in various places. The waterways were swollen and there was flooding in many places. The floods caused damage to crops in various municipalities.

13-14.11.2010

Heavy rainfall in Belgium and the south of the Netherlands. Five people drowned and the widow of one of the victims committed suicide. An elderly man in the province of Antwerp was trapped and died of hypothermia. There were also floods near Brussels, and an advance alarm for high waters on the Meuse. There was a great deal of flooding in Limburg as streams burst their banks.

Flood of 1953

The North Sea flood of 1953 (also known as the Disaster of 1953) was initially named the Sint-Ignatius flood. It came during the night from 31 January to 1 February 1953. Spring tide and a Nor'wester (north-westerly storm) drove the water in the trench-like North Sea up to record heights.

In the Netherlands, a large part of the province of Zeeland, West-Brabant and the Islands of South Holland were flooded. More than 1,800 people drowned, as well as many animals, and 100,000 people lost their homes and possessions. Floods also occurred in England, Belgium and Germany, resulting in hundreds of victims. Many lost their lives in shipwrecks at sea. The storm caused snow to fall in a 2.2-yards thick layer in the Ardennes.The Disaster of 1953 caused, in addition to the extremely high loss of human lives, a great deal of damage to livestock, buildings and infrastructure.

How the disaster in the Netherlands happened

On the evening of Saturday 31 January 1953 there was a strong north westerly storm. At around midnight it was low tide on the south west coast of the Netherlands. Which meant that on the morning of Sunday 1 February between 4 and 6 a.m. it would be high tide.

On Saturday morning, the Storm Signal Service reported the arrival of a "very heavy north westerly storm" to the subscribers to its service. During low tide on that Saturday evening, the water level was as high as it usually is at high tide. It was also the spring tide, which meant that the water level would rise even more. In the general weather forecast a warning was issued for that Saturday evening announcing a 'dangerous high tide". Unfortunately, this warning was not heard or was misunderstood by a lot of people in the area where the disaster struck. Early Sunday morning the water level reached NAP (the Normal Amsterdam water level, "Normaal Amsterdams Peil") + 4.5 metres. A record. Between 4 and 6 a.m. sea walls broke everywhere. The north and east banks of the Oosterschelde (Stavenisse, Ouwerkerk, Nieuwerkerk), the Grevelingen (Oude-Tonge en Nieuwe-Tonge) and the Hollandisch Diep (Schuring and 's-Gravendeel) were hit particularly hard.

In some places on the Goeree-Overflakkee the water flowed into the polders with such a force that villages such as Oude and Nieuwe Tonge were under up to three metres of water in a matter of just half an hour. Elsewhere the flooding was more gradual and/or the water level was not so high.

What happened in Belgium?

In the Scheldt region, the storm had created 20 breaches and caused a hundred cases of subsidence. In around 20 districts fields and houses were under water for more than two months. In 15 other districts (Melsele, Kallo, Berendrecht, Zwijndrecht, Zandvliet, etc.) the water did not fully recede until more than six months later, because the repairs to the breached sea walls were very difficult and took a long time. Belgium mourned 22 victims. The damage to the coast was estimated at 450 million Belgian Francs (GBP 941,603). There were about 37 important breaches in the sea walls in total between Koksijde and Knokke (15 in Knokke-Heist alone). The roads, drains, electricity, water pipes, were seriously damaged after the storm. Private individuals suffered from flooded cellars, damage to hotels and sea wall constructions, silted up meadows, lost personal belongings, damaged clothing and tools, etc.

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Testimonies

You couldn't recognise Donato

"We ran upstairs because our son, Donato (20 months old), was asleep up there. I took him out of his little bed and brought him over to the edge of the bed with me. I was seven months pregnant with our second child at the time. A little while later, the floor of the attic gave way and Donato and I fell into the icy water. I was continuously getting hit with rubble and pieces of wood, and eventually I lost my hold on Donato. I found him, though. When I saw the crib for our unborn child drift by, I thought of Moses in his reed basket. I grabbed Donato and threw him on top of it, but the crib sank immediately, and I lost him again for a moment. After that, I swam with Donato to the port dyke. I wanted to climb up the dike, but slid back down three times. I was so stiff from the cold that I couldn't walk anymore, so I began to crawl down an entire street. When I reached the Krakeel's house on Bolwerk, Johan Krakeel took Donato from me and wanted to put him in the basement. He thought that my son was dead. He was completely stiff and foaming at the mouth. His little head was battered right down to his skull. I didn't want to leave Donato behind. After much insistence, Johan brought him upstairs as well. I followed behind them, going up the stairs on my knees. Luckily Janny Eckhart was upstairs; she worked for the Red Cross. She helped Donato first until he came back around. The first word out of his mouth was 'mama'."

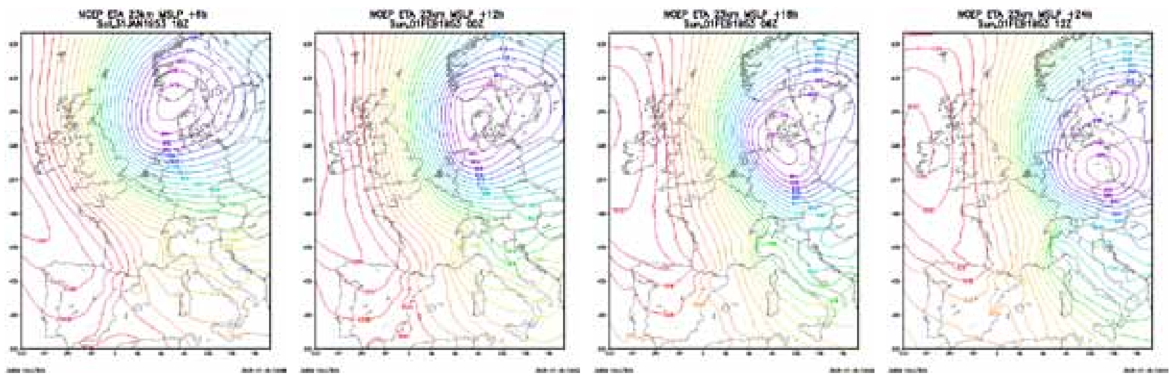
J.P.M. de Spirit-Leijdekker
Prinsenbeek
©PZC 02-01-03

Mother trapped in rubble

"As soon as they were warned that the water was flooding over the dikes, they went home. "As soon as they were warned that the water was flooding over the dikes, they went home. In the meantime, my mother got the rest of the kids dressed and waited for my father to come get them. But the dike broke right next to our house and the water swept them all away. My youngest brother ended up under the rubble. He had just turned 7 on 30 January. My oldest brother wound up in a tree and was rescued later. My sister landed next to a wall a bit further down by the neighbours across the road, and she managed to hold on to that. But the water kept rising. She was eight. My mother landed in a ditch close to my oldest brother. She got stuck under the rubble and couldn't get away. We found out later that she died of hypothermia."

Ria Daalman, Zwolle
©PZC 24-01-03

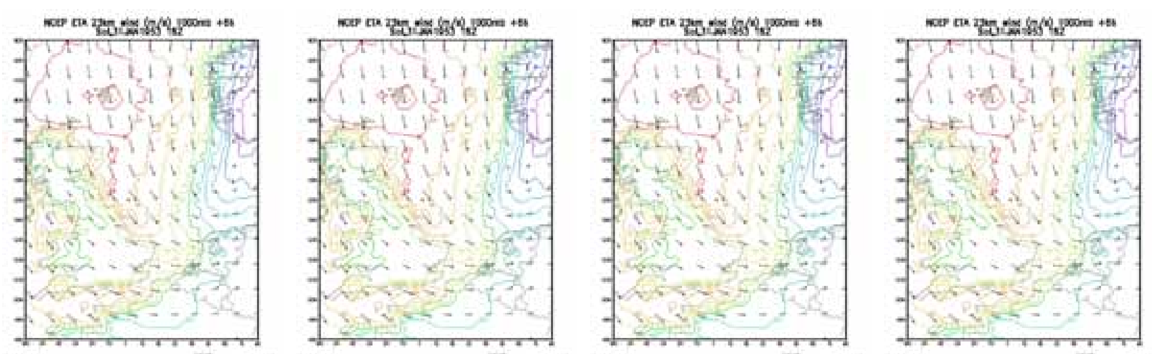
Weather chart showing the progress of the storm



At around 1 a.m. local time, the heart of the storm depression was above Denmark and the strong north to north westerly wind was blowing over the western part of the North Sea pushing an enormous mass of water towards the Belgian and Dutch coasts.

The storm lasted a very long time and at 7 a.m. the wind changed, and at around midday it blew just as fiercely over the North Sea and the Low Lands.

Weather chart key:
The black lines are the isobars or the lines of constant atmospheric pressure, the isobars in a circle shape indicate the heart of the storm depression. The coloured lines indicated the expected volume of rainfall.



Although the wind force was very strong (10-11 Bft at sea and 9-10 Bft on the Flemish and Dutch coast) this was not the most violent storm of the century. The fact that it was the most destructive is due to the duration of the storm and the wind direction. This meant that an enormous amount of water was shifted to our coast. Another factor that played a very important role was the tide.

Characteristics

Core pressure	970 hPa
Above sea	11 Bft
At the coast	10 Bft
Highest gusts	66 nmph in Belgium
	78 nmph in the Netherlands

18

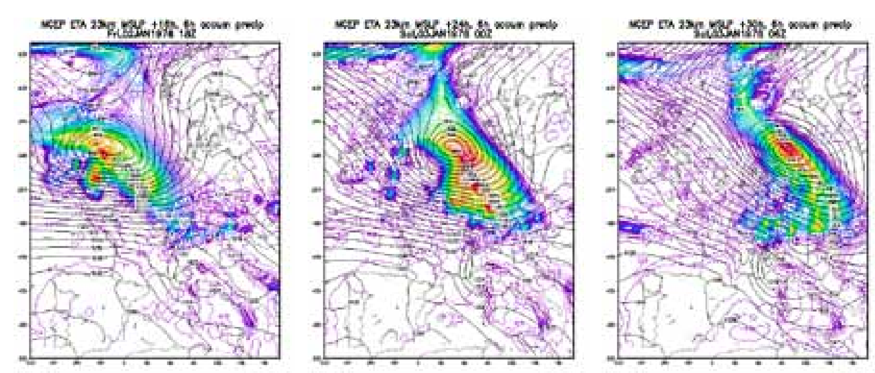
19 [Belgian greatest storms

Storm in 1976

There were problems caused by the extremely high water levels, especially in Zeeland and the basin behind it. For example, in Stavenisse, on the banks of the then still open Eastern Scheldt, flood boards had to be used to prevent the low-lying village from flooding. The dyke cut-off here was at 3.50 metres above NAP, which was well above spring tide level.
Because the extremely high water level and the storm, the dykes in Walem and Ruisbroek broke. This caused massive flooding in the province of Antwerp. After this disastrous flood, the Sigma Plan was created in Flanders, the aim of which was to secure the basins of the Sea Scheldt from storm floods from the North Sea.

There were at least 60 deaths throughout the entire region hit by the storm:

- the United Kingdom: 24 dead
- the Federal Republic of Germany: 12 dead
- North Sea: at least 10 dead
- Sweden: 4 dead
- Ireland: 4 dead
- the Netherlands: 2 dead
- Belgium: 2 dead
- Other countries: 2 dead



Characteristics

Gusts of wind up to	81 nmph (Ostend)
Wind force	11 Bft
Water level	+3,50 m NAP (Belgium)
	+4,06 m NAP (Vlissingen)
Wave height	1.42 yards

Storm in 1990

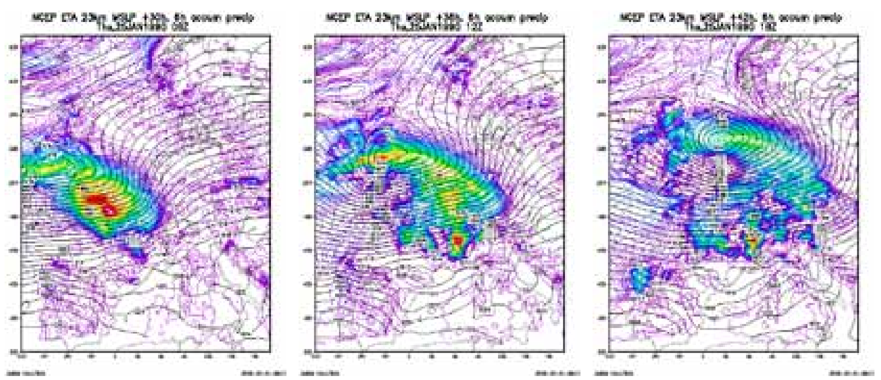
On 25 January 1990, an extremely severe storm raged across Ireland, Great Britain, France, the Netherlands, Germany, Belgium and Denmark. The storm was called Hurricane Daria in several places, including Germany and France. According to estimates, 97 people were killed by the storm. The highest wind speeds, of 103 nmph, were reached near Belfast in Northern Ireland. The worst hit was Great Britain, where thirty-nine people were killed. At least 17 people were killed in the Netherlands and 11 in Belgium.

The wind speeds in Belgium reached up to 84 nmph. Eleven people died, and approximately forty were injured. The roof of an airplane factory near Charleroi collapsed. The airport in Liège was closed. Approximately

12 flights were at Brussels Airport in Zaventem, but it remained open. A fallen electricity pylon blocked the motorway between Brussels and Ostend. No ferries left Ostend.

Characteristics

Wind force	11 Bft
Water level	+3,90 m NAP
Squalls	103 nmph (N-Ireland)
	54 nmph (Belgium)
Wave height	4.2 yards (Scheur)



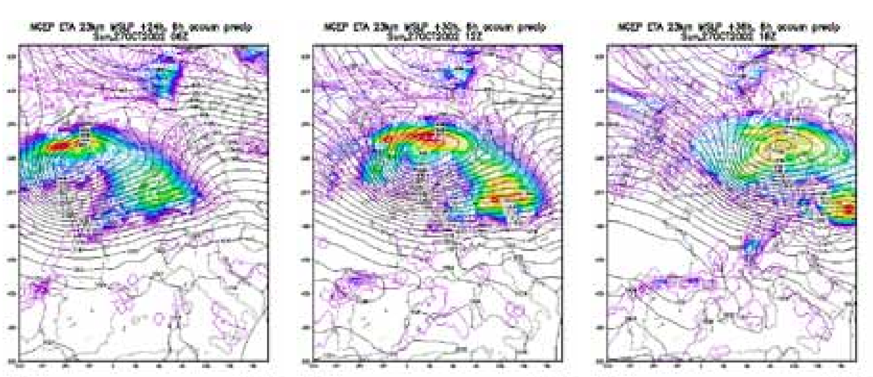
Weather chart keyt:
The black lines are the isobars or the lines of constant atmospheric pressure, the isobars in a circle shape indicate the heart of the storm depression. The coloured lines indicated the expected volume of rainfall.

Storm in 2002

The most violent storm in years hit Western Europe and caused 29 deaths. The storm winds reached speeds of 70 to 85 nmph and the wind continued to increase in strength as the day went on. The first damage was reported at around 9.30 a.m. A (small) tree was uprooted and fell on the E19. The team working the week shift were called in to clear up the mess. This was the start of three long days... Reports of damage kept coming in. A 12 Bft wind force was recorded at the coast which is equal to a hurricane force wind! And a 10 Bft wind force was recorded at the meteorological station at the Deurne airfield.

Characteristics

Wind force	12 Bft
Wind speed	55 nmph
Squalls	80 nmph
Water level	+2,55 m NAP



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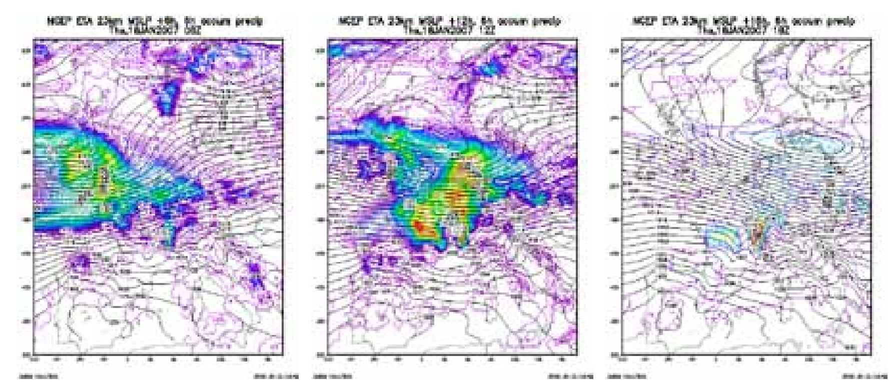
Storm of 18 januari 2007

Kyrill was the name of a low pressure area that had developed into a European storm. Although this storm didn't satisfy the definition of a hurricane, it was however named Hurricane Kyrill. The Netherlands, Germany, Belgium and Great Britain were affected. The low pressure area originated near Newfoundland on 15 January 2007. This is where the extremely cold air from the northern United States of America came into contact with the much warmer subtropical air from southern latitudes. The depression developed strongly due to the jet stream. The depression then moved over the southern part of the North Sea towards the Baltic Sea. The storm reached Poland during the night of the 18th to the 19th of January. The depression than moved on towards northern Russia. A total of 47 people were killed throughout Europe as a consequence of the storm.

The wind speed along practically the entire coast was 10 Beaufort. An hourly average of 51 nmph was measured in Vlissingen, the storm indeed being at its most severe in Zeeland. The hardest squalls were measured in Wilhelminadorp, at a speed of 72 nmph. Further inland, wind speeds decreased, but dangerous gusts of wind were still present. For example, a gust of wind was measured at 67 nmph in Herwijnen.

Characteristics

Wind speed	10 Bft
Squalls	72 nmph
	121 nmph in Switzerland
Atmospheric pressure	964.2 hPa
Water level	+3,31 m NAP
Precipitation	up to 2.36 inches in 36 hours



The highest wind speeds during the storm were measured in Switzerland, however. A squall near the Aletsch Glacier was measured at 121 nmph. The lowest atmospheric pressure measured in the eye of the low pressure area was 964.2 hPa.

Storm of 9 november 2007

This storm made history because of the extremely high water levels along the coast. The water levels measured on Friday in the Hook of Holland were the highest on record since 1953. On 9 November, measurements peaked at 3,16 m above NAP.

Wind gusts of 54 nmph were recorded in various locations along the coast.The storm that moved through our country caused damage in places. For instance, ten people were evacuated from the Antwerp district of Merksem after a wall of a house collapsed and the roof of the adjacent building caved in. The house disintegrated under the weight. The premises are currently unliveable. The residents of the destroyed house went to stay with family, and no one was hurt.

The wind speed during this Nor'wester measured over land peaked at 49 nmph, as measured at Deurne airport and reported by weatherman Eddy De Mey.

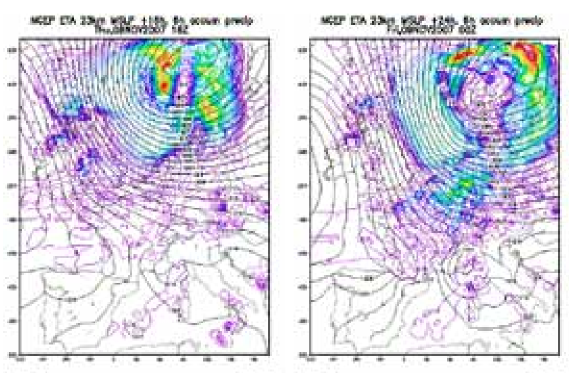
Of the other official measuring points, Koksijde was at number two with 43 nmph. Peaks between 32 and 40 nmph were recorded over the rest of Belgium. A full-blown 9-Beaufort Nor'wester raged for some time over the North Sea, with peaks of up to 56 nmph.

"The fact that the precipitation fell in the form of rain showers makes a big difference in terms of amounts, which varied between 0.08 and 0.71 inches. The weather image of the night was in line with the forecast on the Thursday. The various computer models were, in this case, congruent," says De Mey.

The severe storm that raged over the North Sea on Thursday night forced various oil groups to shut down their platforms along the Norwegian coastline. People were also on the lookout for squalls in the United Kingdom, the Netherlands and Germany. The British Secretary of State for Environment made preparations for severe floods which might affect the western part of England. British Prime Minister Gordon Brown also convened a crisis meeting. The heaviest squalls swept along the coast of Scotland, reaching speeds of up to 86 nmph. The severe weather conditions forced various petroleum groups to close their platforms off the coast of Norway.

Characteristics

Water level	+3,16 m NAP
Wind speed	54 nmph



Storm Pukkelpop 2011

Total chaos, even though thunderstorms had been forecast. At around 5 p.m. yesterday, those of us here in the editorial office could see with our own eyes how the storm was raging in Groot-Bijgaarden. Even then, we wondered what would happen if the same thunderstorm were to move over to the Pukkelpop festival grounds. But no one would have guessed that the consequences would be so catastrophic. There isn't a meteorologist out there, apparently, who could have forecast what would break out over the festival grounds. The severe storms on that Thursday evening were caused by the friction between air masses under the influence of winds from different directions.

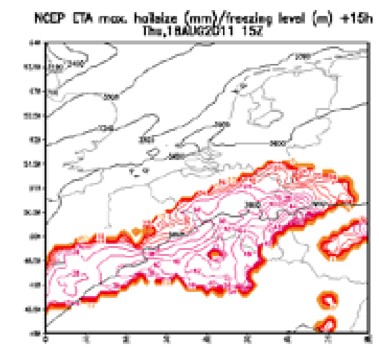
The ill-fated weather came from France. A south-western high-altitude air current (above 2,190 yards) brought very unstable air from the Bay of Biscay, which resulted in a thermal low. This moved over our country, but collided here with a north-eastern, cooler air current above Flanders. Above the regions of the Sambre and Meuse rivers, a sort of "forced" rising movement of the air occurred: the warm southern air slid over the cooler northern air. The result: thunderstorm clouds 8.1 to 8.7 miles high, with heavy rains, hail and lightning, as well as very strong squalls locally.

The south-western high altitude air current determined the direction in which the clouds moved, and thus, one after the other, East Flanders, Brussels, Brabant, Antwerp and Limburg were hit.

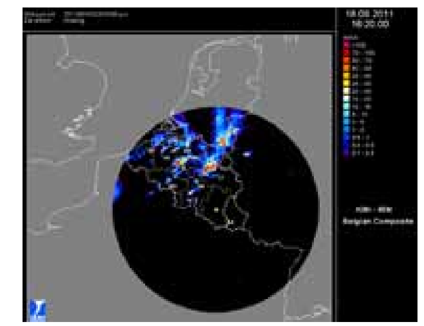
The strongest squalls were recorded at the measuring stations in Diepenbeek (45 nmph) and Beauvechain (43 nmph). The Royal Meteorological Institute of Belgium noted that the winds could even be much stronger locally. The type of thunderstorm that besieged us yesterday can cause katabatic winds, which are comparable to the movements of a weak tornado.

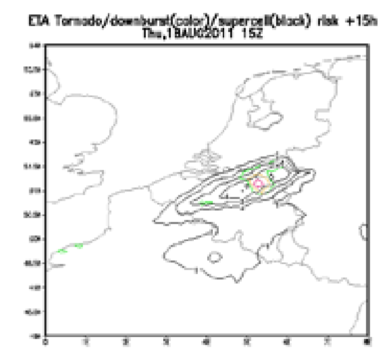
The amounts of precipitation were highly variable. The largest amounts were recorded in Bertem. During a short but heavy shower, 1 bushel fell per 1.2 square yard, which is normally what falls in a month's time. The Hasselt fire department said on Friday that a comparable amount fell on and around the Pukkelpop festival grounds.

19



Weather chart 1


Weather chart 2



Weather chart 3

Caption weather chart:
Weather chart 1: Anticipated diameter of the hailstones particularly in the Centre, the South and the East were expected in the late afternoon.
Weather chart 2: The rainfall image at the time of the drama, the biggest downpours above Hasselt.
Weather chart 3: The weather chart with the big chance (coloured lines) of whirlwinds or katabatic winds in the Centre and the East of the country (especially in Limburg) in the late afternoon/early evening. The black lines indicate the great probability of super cells forming or very violent storm cells forming.

20 [WWF - Biodiversity

Mankind and the climate

Throughout the history of the earth the climate has undergone changes. But never has there been such an increase in the volume of greenhouse gases (mainly CO_2) in the atmosphere and in the average global temperature as we are seeing today. The median global temperature has risen by 1.33 °F since 1850. That is an exceptionally fast increase. Since the end of the last ice age, so for more than 10,000 years, the global temperature has remained relatively stable.

The majority of scientists agree that the current increase in the earth's temperature is the result of the increase in greenhouse gases (mainly CO_2) in the atmosphere due to human activity. The industrial revolution at the end of the 18th century and the invention of the combustion engine in 1867 heralded an era in which people started burning fossil fuels, such as coal, petrol, diesel, heating fuel and natural gas, on a large scale. This process releases large quantities of CO_2 into the atmosphere.

Scientists have established a critical limit, which involves maintaining the increase in global temperatures below 3.6 °F in order to limit climate change.

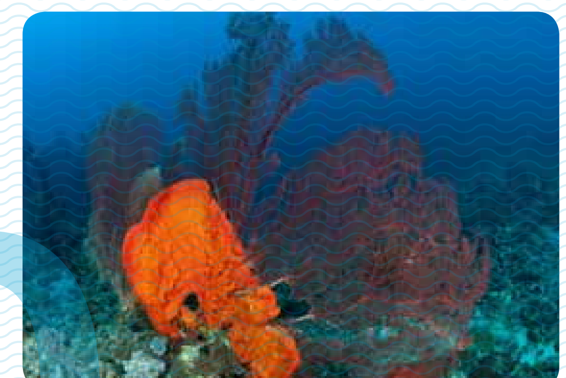
What are the consequences?

The climate is changing. We are already experiencing the consequences of this, both here at home and elsewhere. The severity of these consequences can vary by location. But one thing is for sure: the vulnerable populations in developing countries will have to pay the heaviest price.

Consequences of climate change:

- Extreme signs of climate changes: such as serious storms, droughts, abundant rainfall, etc. are occurring with greater frequency;
- The seasons have become extremely unstable: which affects agriculture and our flora and fauna among others;
- Sea levels: are rising which is a threat for millions of people who live close to the coast;
- Glaciers are melting everywhere: and that endangers the water supply for a lot of people.

Biodiversity today is suffering tremendously: pollution, deforestation, loss of habitat, over-fishing, etc. The survival of a wide range of different species is also becoming a serious problem because of climate change.



Extreme weather phenomena

Heat waves, heavy rainfall, flooding, extreme droughts, storms, etc. These extreme weather phenomena indicate that climate change is an extremely hot topic today.

Weather phenomena may appear as serious fluctuations that are the result of natural condition such as El Niño for instance.

However, there are some pronounced trends that are clearly due to climate change:

- In many regions we are seeing and increase in rainfall (the East Coast of the American continent, Northern Europe and North and Central Asia);
- while rainfall in the Sahel, Southern Africa, parts of South Asia and the Mediterranean Basin is decreasing;
- periods of heavy rainfall are increasing, even in places where there is a decrease in the total amount of rainfall.

Scientists predict that:

- Extreme weather phenomena (periods of heavy rain resulting in flooding, storms, heat waves, etc.) will occur more frequently;
- maximum intensity of wind speeds and rainfall during storms will increase.

Of all the consequences of climate change, extreme weather conditions will probably have the greatest impact on the wellbeing of human beings. People living in the Southern Hemisphere, who are already the most vulnerable, will be hit the hardest by extreme drought, storms, etc.

DID YOU KNOW THIS?

The Great Barier Reef is the largest living thing on the planet. Corals are marine animals living in compact colonies of many identical individual 'polyps'.
© Jürgen Freund / WWF-Canon

DID YOU KNOW THIS?

Coral reefs are home to 25% of all marine life. They are the nurseries of approximately one quarter of all the fish in the sea.

Coral reefs

One quarter of all marine life in the world lives in coral reefs. The Great Barrier Reef is the biggest living organism on our planet. It is the only living organism that is visible from space. Coral reefs are not just good for fish. 450 million people depend on coral reefs for food, jobs and protection from the sea. Some drugs against cancer and AIDS inhibitors come from coral. The coral triangle provides income for more than 100 million people.

Tourism around the Great Barrier Reef accounts for 4.5 million dollars in revenues each year but climate change, pollution and over-fishing are damaging the reefs. One quarter of the world's coral reefs have been damaged beyond repair.

A maroon clownfish.
© Cat Holloway / WWF-Canon

A young Green Sea Turtle. 6 of the world's 7 marine turtle species live in the Coral Triangle. All marine turtles are endangered.
© Jürgen Freund / WWF-Canon

Coral reefs are extremely important for biodiversity. They also break the power of the waves during storms, hurricanes, typhoons, and even tsunamis by helping to prevent coastal erosion and flooding.

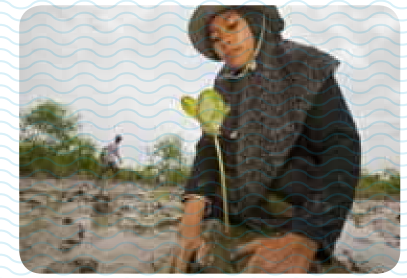
Major threats to coral reefs are destructive fishing practices, overfishing, pollution, climate change...
© Jürgen Freund / WWF-Canon

Mangroves

Mangroves thrive in places where the land and the sea meet. They provide a safe haven where fish and other sea life can grow to maturity. Mangroves protect people and nature against storms and tsunamis. They help the climate by acting as a storehouse for oxygen. They provide homes, jobs and a source of food for millions of people. But development, fish farms and pollution have serious consequences for the mangroves. Half of the mangrove forests in the world have already been destroyed.

DID YOU KNOW THIS?

These mangroves are battered by the sea, but are important in protecting the coast from storms and erosion.
© naturepl.com /Tim Laman / WWF



Fisherman and volunteers from the Mangrove Action Project planting mangrove seedlings in abandonned shrimp ponds in Sumatra. Dykes have been opened to restore natural tidal flow to the ponds.
© naturepl.com /Tim Laman / WWF

Fiddler crabs among the spike-like finger roots of mangrove trees. Mangroves are extremely productive ecosystems and are home to a wide variety of marine and terrestrial life.
© naturepl.com /Tim Laman / WWF

A mangrove reforested area in the Philippines.
© Jürgen Freund / WWF-Canon

20

The animals tell their story

Bengal Tiger

Here in the Ganges Delta, everything is huge. I am a Bengal Tiger and I like criss-crossing this region made up of water and land. This is my territory, my natural habitat. I like living alone and need a lot of room in order to hunt my prey. On the menu are deer, wild boar, apes and lizards. I can find my way blindfold through the mangrove forests with their roots that plunge into the salty water. But I am still a bit nervous. The landscape is changing. Sea levels are rising due to climate change and islands in this big delta are disappearing. 10,000 kilometres of land threatens to disappear under the water.

Dolphin

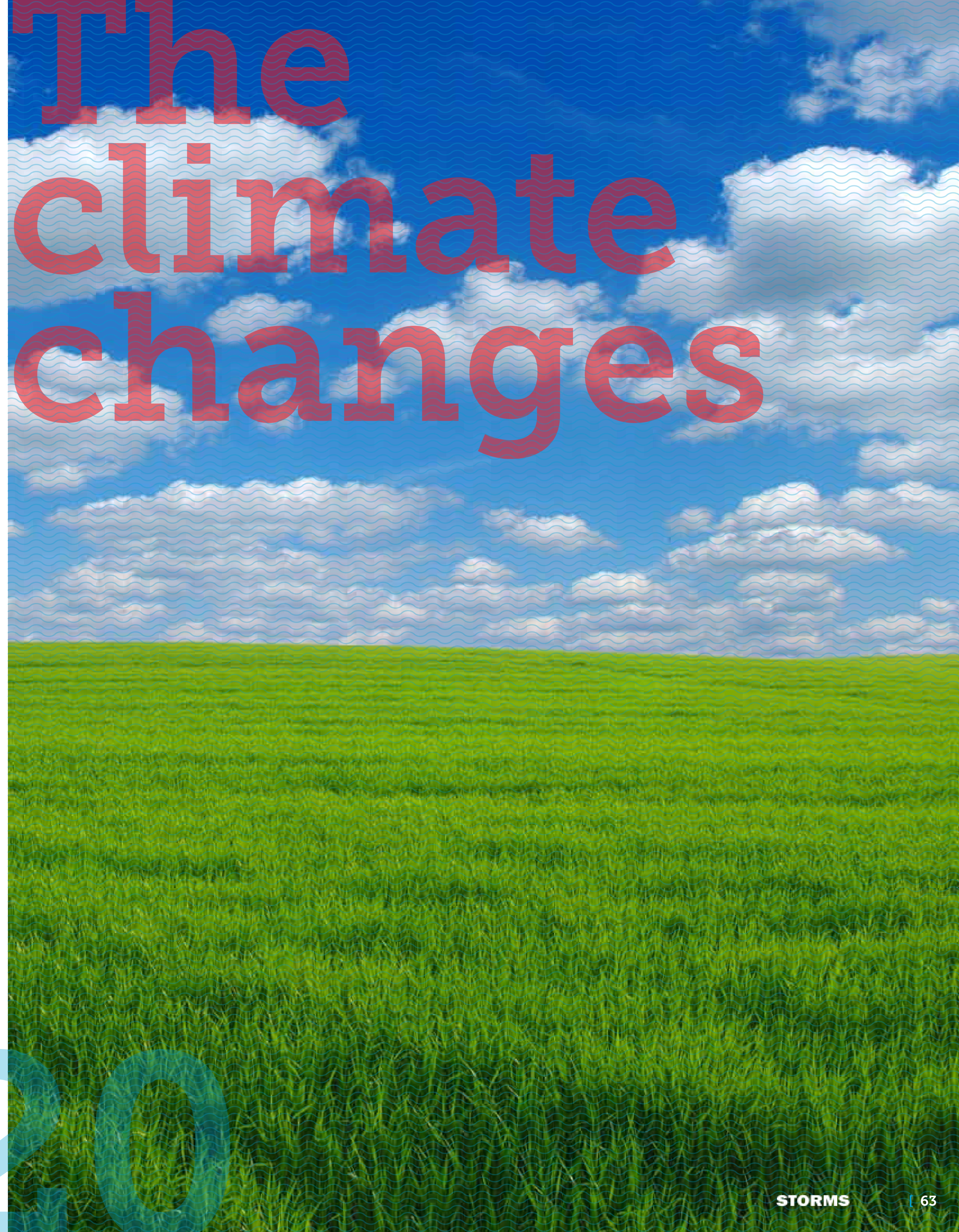
This is my world. The Indian Ocean between Africa and Madagascar, along the coral reef with all the shoals of colourful fish. I live in a fairytale. But alas, alack the coral is sick and as a dolphin I am the first to witness this phenomenon. I see them turning pale and slowly dying. You may not know it, but coral is actually made up of animals that live in colonies and this is what form the reefs. But they are vulnerable and they need water at a constant temperature. This is why the increase in temperature that is announced for this century is fatal for them. The coral reefs that are so important for marine life risk dying and becoming extinct. What will happen then?

Hawksbill Sea Turtle

I am a Hawksbill Sea Turtle. Look at my shell; you'll see that the plates fit together perfectly like the tiles on a roof. I feel completely at home in the clear waters of the Caribbean Sea and I only come on land to lay my eggs. I eat sponges that live in the coral reefs. But the whole of the marine world today is being disrupted because of climate change. Look at how the coral is turning pale. The rise in the temperature of the water will be fatal for them. And what about the cyclones, the violent tropical storms that are becoming increasingly violent and that devastate the fauna and flora in the water?

Crow

No, I'm not going to tell you that crows are threatened with extinction. You will find me everywhere, in the countryside and in towns. We are birds that can lead a rural life or live alongside urban sparrows. I can adapt to the most extreme circumstances. I have heard that climate change is responsible for a lot that is going on and that Europe, depending on the region, will suffer from the consequences on the water cycle. In the south there is a clear drop in rainfall and we are seeing more drought conditions appearing. In the north, the centre and the east of Europe, the number of heavy rain showers is growing and with them an increased risk of flooding, resulting in a lot of damage.



The climate changes

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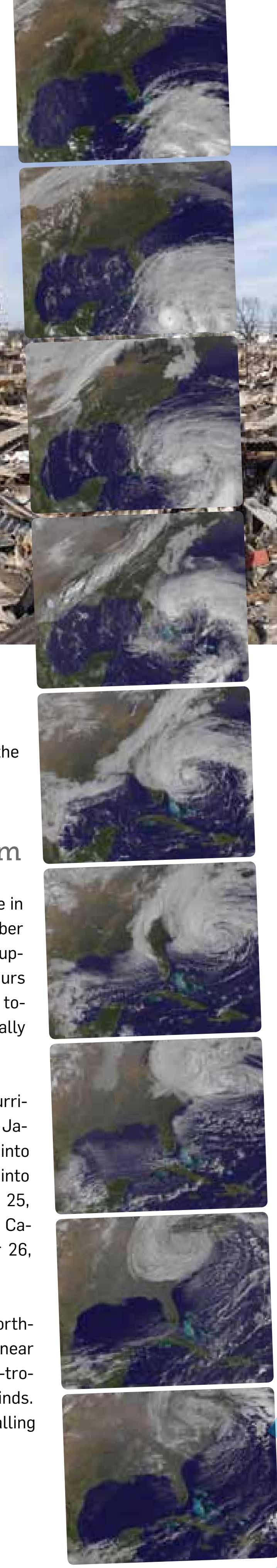


21 [Superstorm Sandy

Intro

Hurricane Sandy was a hurricane that devastated portions of the Caribbean, the Mid-Atlantic and Northeastern United States, and Eastern Canada in late October 2012. Sandy, the eighteenth named storm and tenth hurricane of the 2012 Atlantic hurricane season, was a Category 2 storm at its peak intensity.
While it was a Category 1 storm off the coast of the Northeastern United States, the storm became the

largest Atlantic hurricane on record. Sandy is estimated in early calculations to have caused damage of at least $20. Preliminary estimates of losses that include business interruption surpass $50 billion, which would make it the second-costliest Atlantic hurricane behind only Hurricane Katrina.

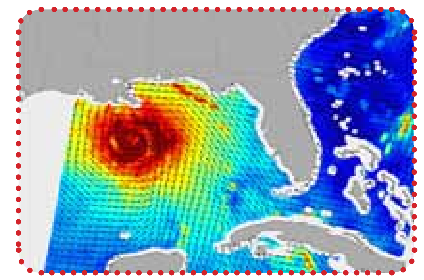
At least 209 people were killed along the path of the storm in seven countries.

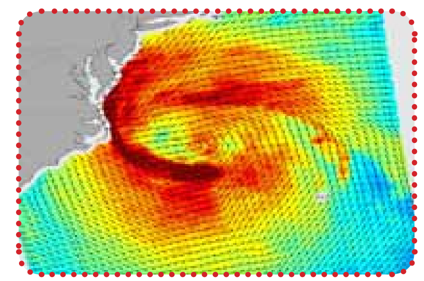
Animation of the storm

Sandy developed from a tropical wave in the western Caribbean Sea on October 22, quickly strengthened and was upgraded to Tropical Storm Sandy six hours later. Sandy moved slowly northward toward the Greater Antilles and gradually intensified.

On October 24, Sandy became a hurricane, made landfall near Kingston, Jamaica, a few hours later, re-emerged into the Caribbean Sea and strengthened into a Category 2 hurricane. On October 25, Sandy hit Cuba, then weakened to a Category 1 hurricane. Early on October 26, Sandy moved through the Bahamas.

Early on October 29, Sandy curved north-northwest and then moved ashore near Atlantic City, New Jersey as a “post-tropical cyclone” with hurricane-force winds. Shortly after, media outlets were calling the storm “Superstorm Sandy”.





Rain

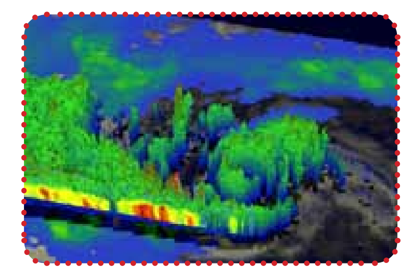
This TRMM rainfall analysis indicates that the heaviest rainfall totals of greater than 10.2 inches were over the open waters of the Atlantic Ocean. Rainfall totals of over 7.1 inches are also shown over land in many areas near the Atlantic coast from New Jersey to South Carolina.

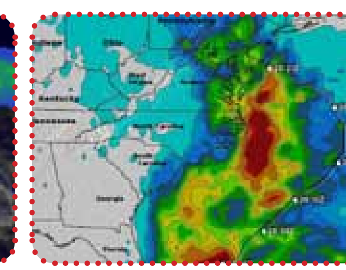
Hurricane Sandy’s track over the Atlantic Ocean is shown overlaid on this analysis in white.

Comparing Sandy and Katrina

The scenes of devastation and wreckage that Hurricanes Sandy and Katrina left behind were tragically similar. Both storms flooded major cities, cut electric power to millions, and tore apart densely populated coastlines. But from a meteorological perspective, the storms were very different.

“Katrina was a textbook tropical cyclone, with a compact, symmetrical wind field that whipped around a circular low-pressure center. Like most tropical cyclones, Katrina was a warm-core storm that drew its energy from the warm waters of the tropical Atlantic Ocean.”
“ Sandy had similar characteristics while it was blowing through the tropics. But as the storm moved northward, it merged with a weather system arriving from the west and started transitioning into an extra-tropical cyclone.”





Sandy was still a hurricane after landfall

On Oct. 29, 2012 at 11 p.m, the center of Hurricane Sandy was just 9.3 miles southwest of Philadelphia, Penn., near 39.8 North and 75.4 West.

Sandy was still a hurricane with maximum sustained winds near 65 nmph and moving northwest at 16.2 nmph. The hurricane-force-winds extended 93 miles east of the center of circulation. Tropical-storm-force winds, however, went much further, as far as 485 miles.

Hurricane Sandy changes coastline in New Jersey

On October 29, 2012, lives were changed forever along the shores of New Jersey, New York, Connecticut. The landscape of the East Coast was also changed, though no geologist would ever use the word “forever” when referring to the shape of a barrier island.

Result

In Jamaica, winds left 70% of residents without electricity, blew roofs off buildings, killed one, and caused about $55.23 million in damage. In Haiti, Sandy’s outer bands brought flooding that killed at least 54, caused food shortages, and left about 200,000 homeless. In the Dominican Republic, two died. In Puerto Rico, one man was swept away by a swollen river. In Cuba, there was extensive coastal flooding and wind damage inland, destroying some 15,000 homes, killing 11, and causing $2 billion in damage. In The Bahamas, two died amid an estimated $300 million in damage.

In the United States, Hurricane Sandy affected at least 24 states, from Florida to Maine and west to Michigan and Wisconsin, with particularly severe damage in New Jersey and New York. Its storm surge hit New York City on October 29, flooding streets, tunnels and subway lines and cutting power in and around the city.

21

David Dehenauw wrestled with superstorm Sandy

Sandy is going down in History, even though it is only a Category 1 storm.

On Monday, 29 October at 1.12 p.m., Dr Dehenauw, a meteorologist at the Royal Meteorological Institute in Brussels informed the media about his forecast. After the facts, it became clear that his analysis had been right on the mark. Outstanding observation!

Date: Mon, 29 Oct 2012 13:12:48 +0100

David Dehenauw
So what makes it so special?

Its size

This is quite possibly the large hurricane/storm in the history of the US. In other words, what is relevant is not so much where it made landfall but rather the extent of the surface in which its consequences were felt. It may reach the coast in New Jersey/Delaware tonight/early tomorrow our time, and it is possible that it will no longer be a hurricane but a storm. (It will reach colder waters as it crosses the Gulf Stream.) Because of its size, a large wind field will be born which will cause considerable rises in water levels along the coast.

Its location

The area of the US with the heaviest cloud cover, it is also the northernmost location for hurricanes. This is where warm damp hurricane air can collide with cold air from the north. (See time item further down in e-mail.)

Spring tide

It is spring tide on the US eastern coast, which means that the high tide levels are already higher anyway (without wind). The onshore wind causes a huge surge of water (a storm surge) of water towards the coast, particularly to the north of the hurricane's centre (where the wind is blowing inshore; to the south, it is blowing offshore). A storm surge of 3.3-4.4 yards is expected, waves included.
Since the hurricane is expected to hit land in NJ/Delaware, the areas most vulnerable to storm surges are in the north, with NYC as a prime target. The wind won't be directly responsible for most problems: the floods will. This is not uncommon with hurricanes, but it will definitely be the case here.

Time

It is late in the year for hurricanes, which means that the early winter phenomena can get considerably stronger the closer they are to hurricanes:

- The hurricane itself, which carries warm damp air with it.
- A cold front in the east of the US, which separates the cold air to the west of the eastern coast from warmer air. This cold front moves eastwards and will collide with the hurricane's warm damp air. This will make the temperature difference at short distance increase sharply and reinforce the storm.
- Arctic air coming from the north (Canada) and the contrast in temperature will in turn contribute to the hurricane. This temperature contrast creates a powerful jet stream which keeps up the storm's considerable strength in spite of the fact that it reaches colder waters and then land (and therefore loses its hurricane status).

This temperature gradient also activates precipitation:

- Up to 11.8 inches rain in certain areas.
  (In Belgium, on average 34.5 inches fall in a whole year.)
- Up to 1.1 yard snow in the Appalachian Mountains (West-Virginia, Kentucky, etc.)

Local variations are possible.

Perfect Storm

This is reminiscent of what is known in meteorological circles as "Perfect Storm", a storm that took place around Halloween in 1991, when Hurricane Grace was absorbed into other reinforcing weather systems in the same area.

This caused a wave at sea (not on the coast!) some 32.8 yards in height as measured by a buoy. The film of the same name starring George Clooney in 2000 is based on these facts (including the wave that can be seen in the movie and that capsizes the boat). However, "Perfect Storm" did not hit land in the US.

Its trajectory

After moving northwards, it suddenly took a westward course inland instead of continuing in a northeasterly direction as would be customary along the coast and then proceeding to the Atlantic Ocean. This is due to an area of high pressure above eastern Canada at high altitude blocking its progress and easterly winds at altitudes between 0.93 and 3.11 miles blowing the hurricane inland. This is a very rare occurrence, but it means that 1/3 of the US will be affected by the storm.

Sandy was still a hurricane after landfall.

21

22 [Flooding in 1993-1994

Introduction

1993 - 12,000 people had to be evacuated in Limburg because the Meuse River burst its banks. The cause was the enormous amount of rainfall in the days preceding the flood.

The dykes along the river were also not sufficiently maintained. The government had made budget cuts and the dykes were suffering from erosion, cave-ins and muskrats. Some of the dykes also just appeared to be far too low. The river was also curtailed years before the flood, which also meant that the river had a lower water capacity.

The Meuse rose to at least 8.7 yards above the NAP. This was more than three yards higher than usual. The Meuse flooded over its banks, but two days later, the river burst its banks throughout all of Limburg. Approximately 20% of the province was under water and 12,000 people had to be evacuated. Many livestock, which could not be saved in time, were killed. The flood caused over 50 million euros worth of damage.

Schutters Gr'vorst houden de kerk droog

Uit het DvNL van maandag 27-12-1993

Monday, 20 December 1993

Water level: +46,50 m NAP

The Meuse River burst its banks in Wallonia.

Tuesday, 21 December 1993

Water level: +47,25 m NAP

A level 3 alert of the contingency plan was declared. At around midnight, the police began using megaphones to wake up the residents of Kotem, Boorsem, Stokkem and Uikhoven. These areas had to be evacuated.

Wednesday, 22 December 1993

Water level: +47,32 m NAP

A man falls off his bike and drowns. The bridge over the Meuse in Maaseik is closed to all traffic. A few of the dykes appear to be collapsing.

Thursday, 23 December 1993

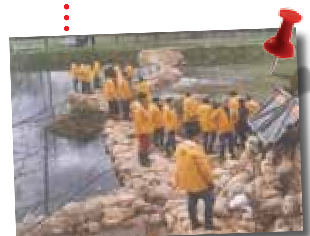
Water level +46,90 m NAP

Hundreds of calves drown in their stalls. Many other municipalities are evacuated.

Friday, 24 December 1993

Water level: +46,75 m NAP

A Sea King helicopter helps to once more repair the dyke at the Molenveld. The helicopter dropped 1,48 long tons sandbags at crucial places along the dyke. The evening mass was even cancelled in Leut and Meeswijk. The disaster tourists impaired the transport of the sandbags.



Saturday, 25 December 1993

Water level: +46,50 m NAP

Because the water level had sufficiently decreased, the evacuated residents could return home in the morning. A paper on the church door in Meeswijk and Leut stated "No evening mass or high mass at Christmas".

Sunday, 26 December 1993

Water level +46,10 m NAP

The water was 26.4 inches high in Herbricht. It had reached a height of 41.3 inches in Meeswijk. The water was 42.3 inches high in Stokkem. It left behind a massive layer of sludge across the entire Maasland region. Farmlands were either washed away or swamped with slurry, and fences were lying on the ground. Various roads were no longer accessible because the asphalt had been washed away in the flood.

Monday, 27 December 1993

Water level: +45,65 m NAP

After nearly a week, the level 3 alert of the contingency plan finally ended on Monday, 27 December 1993. The coordination cell remained active until all the danger was gone. Many families began the big clean up. The damage costs ran into the hundreds of millions.

Friday, 7 January 1994

Water level: +45,90 m NAP

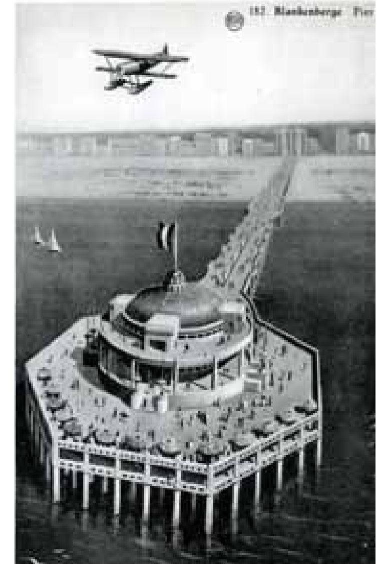
The water level rose again, to 5.9 inches higher than on New Year's Day. The Meuse once again burst its banks in various places. The dykes in Visserweert were once again too low, and once more dozens of hectares of farmland were flooded. On Monday, 10 January 1994, the water level dropped to +44,30 m NAP.

23 [Pier in the storm

What is a pier?

Pier structures are unique pavilions on the sea with a very characteristic architecture. They dominate the coastlines of the world. These sea monuments are are the favourite prey of the forces of nature. Piers were originally constructed as moorling sites for passenger ships. During this pier experience you'll become acquainted with (all) the pleasure piers of the world.

There are three types of piers.
The first type is cargo and passenger piers. They serve to facilitate the unloading of ships and allow passengers to board ships. This was one of the first types of piers to be built. In England, this was the Ryde Pier. This pier was the first of its kind, making it much more comfortable for passengers to board vessels. This pier was transformed through the years into a leisure pier, which we can consider to be the second type. This was circa 1814. A leisure pier gives visitors the opportunity to walk out over the water and thus truly experience the sea. This was naturally a privilege reserved for the upper classes during the late 19th century, and visitors were required to pay for access. But a leisure pier has a naturally strong tourist draw and these structures ultimately became the place par excellence for entertainment on the coast. The golden years dawned in the early 20th century and lasted until just before the First World War. But a pier also allowed fishermen to get closer, to actually go fishing in the sea without having to use a boat. As a result, we also come across a great many hobby fishermen on a pier every day.



Pier Blankenberge

It was John Hendrey, a Londoner, who first propositioned the city of Blankenberge in 1873 to build a pier at de Kerkstraat. The proposal was ignored by the municipal council. In 1881 and 1883, other proposals were made and rejected.

Engineer Casse, architect E. Hellemans and contractor Monnoyer developed a fourth proposal in 1888. In 1889, they received the go-ahead from the city council and established the "Société Anonyme du Pier de Blankenberghe" (the Blankenberge Pier PLC). Work on the pier started in February 1894, and the first visitors were already walking along the pier by Sunday, 12 August 1894.

The Pier, in art nouveau style, quickly became a familiar sight and a real tourist attraction along the Belgian coast.

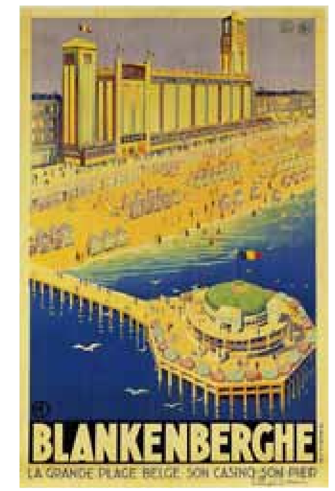
On 15 October 1914, the Pier was set on fire by the German occupying forces for strategic reasons. Nothing was left of this once glorious showpiece but a smouldering skeleton.

1933 - 2005

After the First World War, the skeleton of the Pier became an eyesore on the Blankenberge beach. The city council went in search of a solution and sold the Pier to the previous company. In 1930, the city made the decision to build a new pier itself. It was designed by Jules Soete (Blankenberge), assisted by G. Mangel, a professor from Ghent, and A. Bouquet, and Engineering Architect from Ghent.

The unveiling of the new Pier took place on 9 July 1933. Until 1937, the Pier was part of the amusement park Luna Staar. From 1938 to 1940, the concession came into the hands of G. Mathonet and L. Van Bladel, but the Second World War seriously cut back this concession. The Pier remained undamaged during the Second World War, although the order to destroy the Pier was given. Sergeant Karl Hein Keselberg was responsible for saving it. He ignored a direct order. In 1994, the German sergeant was honoured by the city of Blankenberge for his fortunate disobedience.

After the war, the Pier was renamed Aquarama and after 1955, and up to 1999, the building was part of the Meli amusement park (now known as Plopsa-land) in Adinkerke.



During the 1980s, the Pier once more came under threat. As it happens, concrete rot was found in the Pier's construction. A massive renovation was needed, but the large work could only commence in 1999. After the massive renovation and modernisation of the Pier, the next concession was sold in 2003 to Traincity. This model train city was rather short-lived and closed its doors in 2005.

24 [Cinema
VTM's weather forecasterJill Peeters

Survive in a storm

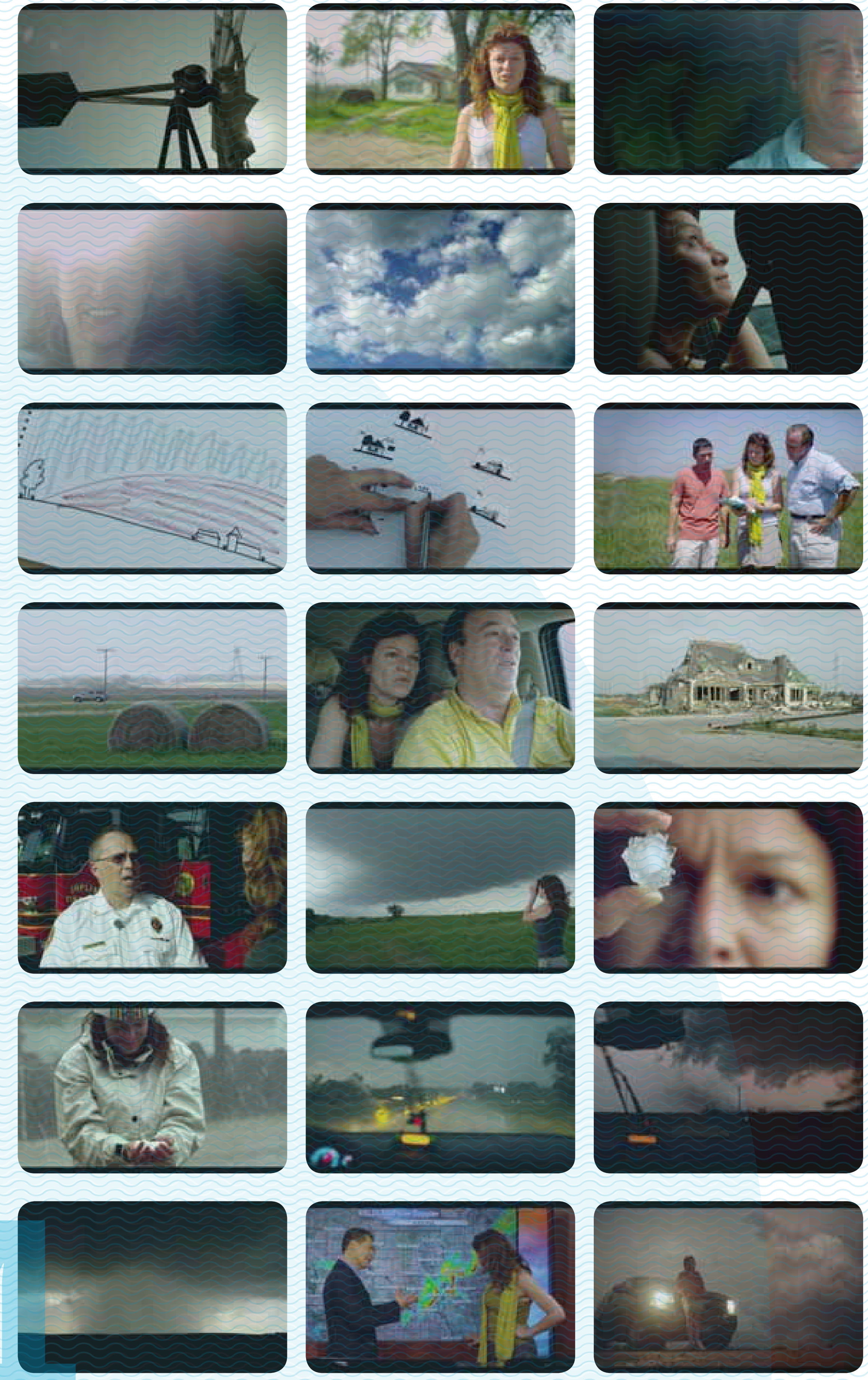
On 18 August 2011, the worst storm imaginable - known as a supercell to meteorologists - directly hit the field where the Pukkelpop music festival was being held. Devastating wind, rain and hail left desolation in their wake. Five young people lost their lives and 140 others were injured, and for thousands of those who went to Pukkelpop, no storm will ever be the same again. Meteorologists can nevertheless predict the likelihood of a heavy storm. But can they also give its precise location?

Weather presenter Jill Peeters went to Tornado Alley in the United States, the place where supercells and tornadoes occur the most frequently. So "Pukkelpop weather" is by no means rare there. Jill went over right in the middle of the tornado season to "hunt" along with the best storm chasers.

She looked at how precisely she could forecast the location and time of a storm or supercell, and when measures needed to be taken. What can we learn from people who are confronted almost daily with heavy storm conditions? When do you sound the alarm? Who can and must take action? How often can you evacuate a whole group of people because of the weather?

Jill had the weather data of the day the Pukkelpop disaster took place analysed by Jeff Piotrowski, the best storm chaser in the world. She also consulted Jay Trobec, Tornado Alley's most famous weatherman, who has to issue warnings to the audience almost every day. In Joplin, Jill was impressed by the impact of nature's forces. In 2011, fate struck: an EF 5 tornado (the most violent type of storm) left behind a trail of destruction 1 mile wide and 22 miles long. A hundred and sixty-one people died, but if the authorities had not taken measures in time, the number of fatalities would have been ten times as high. Chief Randall of the Fire Department knows exactly when people need to be evacuated or when an event has to be cancelled. Over leven in de storm is a documentary written and presented by Jill Peeters.

Jill Peeters (38) has been a weather presenter for VTM for many years. She was nominated best European female weather presenter (EMS, 2008) and best European female climatologist (EU, 2009). She has three daughters and is passionate about the weather and the climate.



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As for the "Storms" experience, it is an entertaining and educational interactive exhibition that ties in closely with this unique location on the sea. "Storms" is an adventure-filled experience for the young and the not-so-young in which every sense is stimulated!

BELGIUM PIER

Thanks for your visit!

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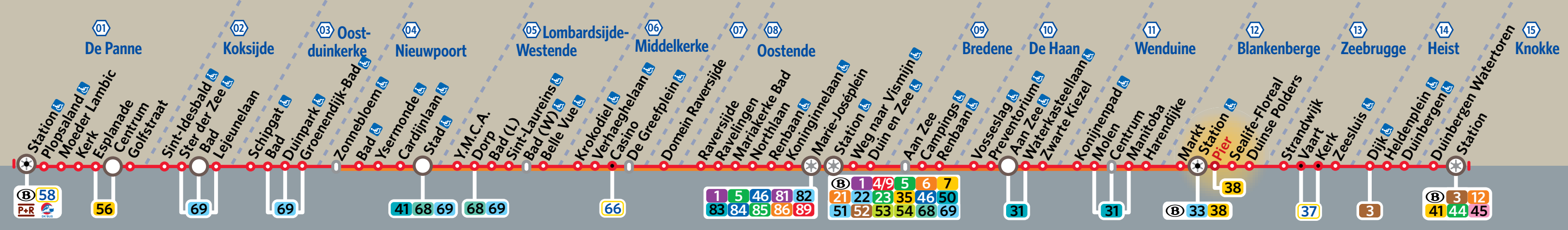

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