

ESA's WIND MISSION

**ADM-AEOLUS**

## ESA'S EARTH OBSERVATION MISSIONS



**METEOSAT** - In 1977 the first of seven Meteosat meteorological satellites was launched to monitor the weather over Europe and Africa. Operational services from ESA's first Earth Observation satellite still continue to this very day.



**ERS-1 and 2** - ERS-1, launched in 1991, was ESA's first remote-sensing satellite in polar orbit and carried a comprehensive payload to measure ocean-surface temperature, waves and winds at sea. ERS-2, which overlapped with ERS-1, was launched in 1995 and added the Global Ozone Monitoring Experiment (GOME) for atmospheric ozone research.



**ENVISAT** - Launched in 2002, Envisat is the largest Earth-observation satellite ever built. It carries 10 sophisticated optical and radar instruments to provide continuous observation of the Earth's oceans, land, ice caps and atmosphere for the study of natural and man-made contributors to climate change and for the study of natural resources.



**MSG (Meteosat Second Generation)** - Following the success of Meteosat, the procurement of four improved second-generation MSG satellites guarantees operational services for the next 15 years. The first MSG was launched in 2002. MSG is a joint project between ESA and EUMETSAT.



**CRYOSAT** - Due for launch in 2005, CryoSat will determine variations in the thickness of the Earth's continental ice sheets and marine ice cover. Its primary objective is to test and quantify the prediction of diminishing polar ice due to global warming.



**METOP (Meteorological Operational)** - MetOp is a series of three satellites dedicated to operational meteorology and forms the space segment of EUMETSAT's Polar System (EPS). The first satellite is due for launch in 2005.



**GOCE (Gravity Field and Steady-State Ocean Circulation Explorer)** - Due for launch in 2006, GOCE will provide the data set required to accurately determine global and regional models of the Earth's gravity field and geoid. It will advance research in areas of ocean circulation, physics of the Earth's interior, geodesy and surveying, and sea-level change.



**ADM-Aeolus (Atmospheric Dynamics Mission)** - Due for launch in 2007, ADM-Aeolus will make novel advances in global wind-profile observation and will provide much-needed information to improve weather forecasting.



**SMOS (Soil Moisture and Ocean Salinity)** - Due for launch in 2007, SMOS will provide global maps of soil moisture and ocean salinity to further our understanding of the Earth's water cycle and contribute to climate, weather and extreme-event forecasting.



**Swarm** - Due for launch at the end of 2009, Swarm is a constellation of three satellites to study the dynamics of the magnetic field to gain new insights into the Earth system by improving our understanding of the Earth's interior and climate.

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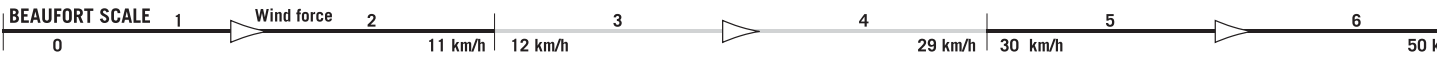


# ADM - AEOLUS ESA'S WIND MISSION

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# ADM-Aeolus: Atmospheric Dynamics Mission



The Beaufort Wind Force Scale.



Courtesy J. Reed

Many aspects of our lives are influenced by the weather. It goes without saying that accurate weather forecasts are important for commercial activities such as farming, fishing, construction and transport, and in general make it easier to plan our daily affairs. In extreme circumstances, knowing what the weather will bring can also help save lives and protect property.

Although weather forecasts have advanced considerably in recent years, meteorologists still urgently need reliable wind-profile data to improve the accuracy of forecasts even further. ESA's wind mission, ADM-Aeolus, aims to demonstrate that measuring global wind-profiles from space, using laser technology, can meet this requirement.

Due for launch in 2007, ADM-Aeolus, commonly referred to as just 'Aeolus', is the fourth Earth Explorer mission to be



The Beaufort scale has been modified to use on land

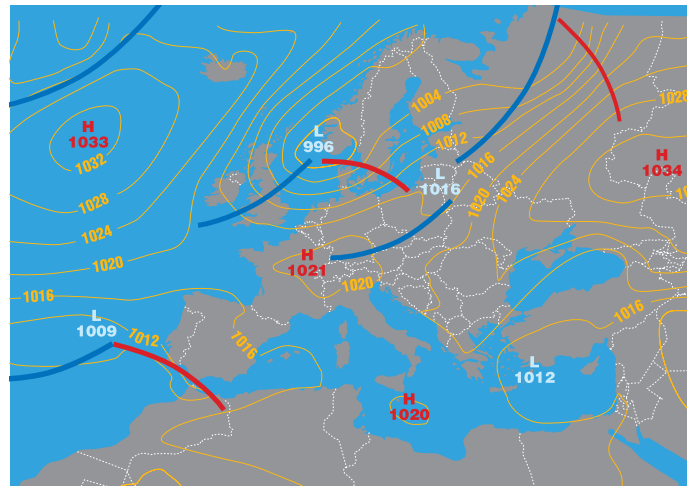


The Beaufort scale was devised by Francis Beaufort, an English naval officer, in 1806. It was originally intended for sailors, who used visual features of the sea to estimate wind strength.

developed within ESA's Living Planet Programme. Aeolus will be the first-ever satellite to directly observe wind profiles from space. Named after Aeolus, who in Greek mythology was appointed 'keeper of the winds' by the Gods, this mission will not only provide the much needed data to improve the quality of weather forecasts, but will also contribute to long-term climate research.

The Aeolus satellite will carry one large instrument - the atmospheric laser Doppler instrument ALADIN, which will probe the lowermost 30 km of the atmosphere from an orbit 400 km above the Earth's surface.

With a lifetime of three years, Aeolus is seen as a mission that will pave the way for future operational meteorological satellites dedicated to measuring the Earth's wind fields.



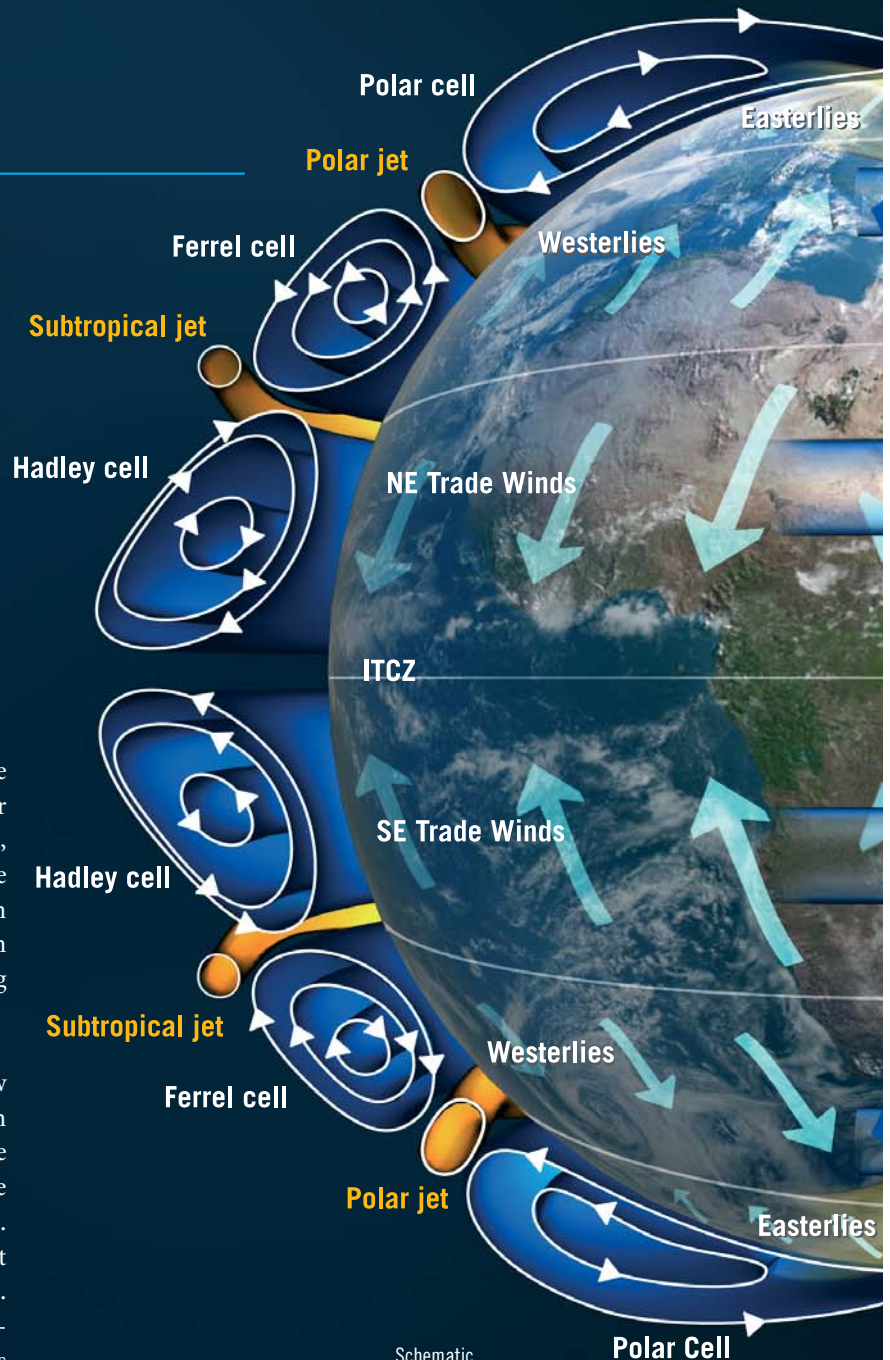
Simplified weather map.



# The Earth's wind systems

Some areas of the Earth receive more heat from the Sun than other areas, leading to differences in air temperature, density and pressure, which in turn, cause the air to move - creating wind. The movement of air constitutes the general circulation of the atmosphere, transporting heat away from equatorial regions towards the poles, and returning cooler air to the tropics.

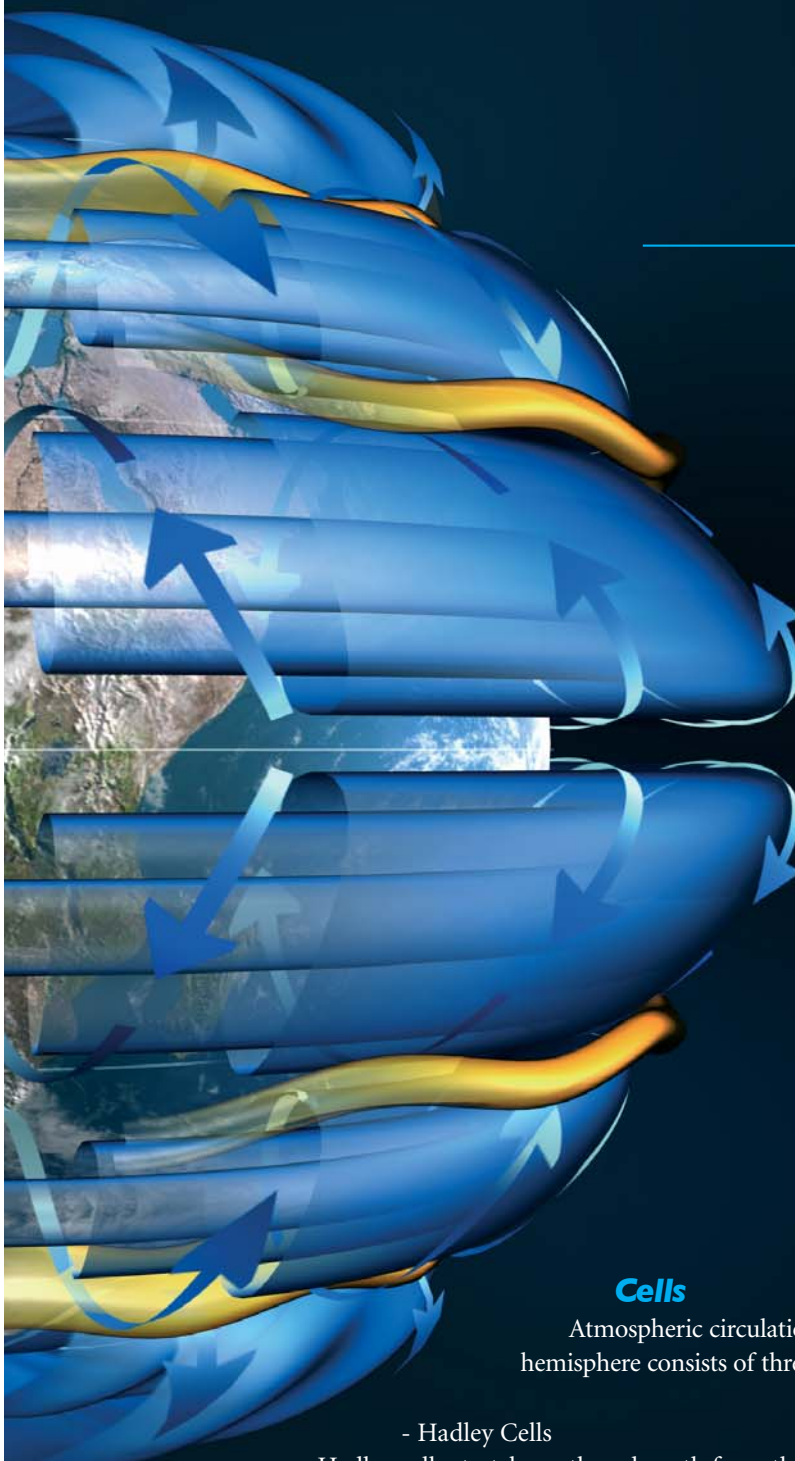
Rising warm air is associated with areas of low surface pressure called cyclones, whilst areas of high surface pressure, known as anticyclones, are associated with subsiding air. These pressure differences are balanced by air motion - or wind. Since the Earth rotates and is spherical, winds do not move directly from high to low pressure areas. Discovered by Gaspard-Gustave de Coriolis (1792-1843), the Coriolis force explains why winds generally blow perpendicular to the direction of the pressure difference. The Coriolis force acts at right angles to the direction of motion, so as to cause deflection to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. The greater the difference in air pressure between the two regions, the stronger the wind will be. This balanced wind will continue to blow until the pressure difference changes. The Coriolis force increases from zero at the Equator to a maximum at the poles, so winds are deflected relatively little at low latitudes, but at higher latitudes the degree of deflection is much larger.



Schematic view of the Earth's wind patterns (vertical scales exaggerated). Atmospheric circulation in each hemisphere consists of three cells - the Hadley, Ferrel and polar cells. High-speed wind fields known as 'jets' are associated with large temperature differences.

## Jet Streams

Jet streams are narrow ribbons of fast moving air found in the upper levels of the atmosphere. These rapid currents reach speeds of up to 500 km/h and are typically thousands of kilometres long and several hundred kilometres wide, but only a few kilometres thick. They mark the boundary between air masses of different temperatures. While their position varies from day to day, jet streams blow from west to east in both hemispheres.



## Cells

Atmospheric circulation in each hemisphere consists of three cells:

### - Hadley Cells

Hadley cells stretch north and south from the Intertropical Convergence Zone (ITCZ) to about 30°. They are characterised by an upward flow near the surface at low latitudes, and a strong downward flow near the surface at higher latitudes. The latitudes where Hadley and Ferrel cells meet are called the Horse Latitudes.

### - Ferrel Cells

Ferrel cells form at mid-latitudes (about 30-60°) balancing the transport from Hadley and polar cells. Jet streams, which are associated with high and low-pressure centres, are superimposed on the Ferrel cells.

### - Polar Cells

Atmospheric circulation cells located in polar regions.

## Did you know?

The windiest place in the world is in Antarctica where winds blow at more than 100 km/h for five months of the year.

The highest wind speed ever recorded was during a storm on 12 April 1934 at the Mount Washington Observatory, New Hampshire, USA (altitude 1918 m), where gusts of wind measured 372 km/h.

The fastest surface wind speed at low altitude was registered on 8 March 1972 at Thule, Greenland, where a peak speed of 333 km/h was recorded.

The Ancient Greeks used to think that wind was the Earth breathing in and out.

Although the word 'monsoon' is now used to describe the extraordinary rainfall that occurs in parts of Asia, monsoon is in fact the name for seasonal winds that blow from the south-west in summer and from the opposite direction in the winter. The word monsoon comes from the Arabic word for season 'mausim'.

The first official hurricane warning was issued in 1847 by William Reid, the British Governor of Barbados.

What the temperature feels like outdoors depends greatly on wind speed. At low temperatures, a rough guide is to take the actual air temperature and then subtract 1°C and the wind speed in metres per second (m/s). For example, an air temperature of 0°C and a wind speed of 6 m/s would feel approximately like -7°C. This effect is called 'wind chill'.

Aircraft often try to catch a ride on the jet stream to save fuel and time. The jet stream is a current of fast moving air found in the upper levels of the atmosphere. At an altitude of 10 km and wind speeds in excess of 450 km/h, planes travelling east from New York to Paris can reduce their flying time by up to an hour.

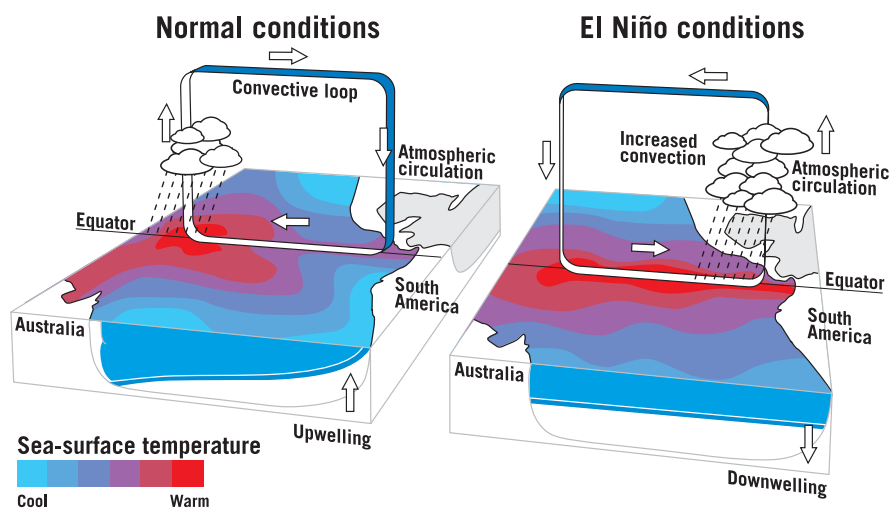
# Why measure the wind from space?

Temperature, pressure, humidity and wind are the basic variables that describe the state of the atmosphere. Accurate global observations on wind speed and direction are currently urgently needed to enhance atmospheric modelling so that operational weather forecasting, as well as the prediction of long-term climate change, can be improved.

Under certain conditions, wind and wind-field data can be derived from temperature fields, which are measured from space by atmospheric sounders using a relationship known as 'geostrophic balance'. However, these relationships are not valid for small horizontal scales (below 3000 km) or large vertical scales (in the order of 10 km). The relationship also breaks down in the tropics where the Coriolis force is weak. Feature-tracking in satellite images of clouds and water vapour can be used to provide wind estimates. However, it is often difficult to assign accurate heights to the observed features, and it is possible for physical processes such as condensation and evaporation to be misinterpreted as wind. Scatterometer data from satellites can also be used to derive information about wind, although this is only possible for surface winds over oceans. All in all, there are large areas of the atmosphere where wind profiles are not regularly observed and this has led to a major deficiency in the Global Observing System.

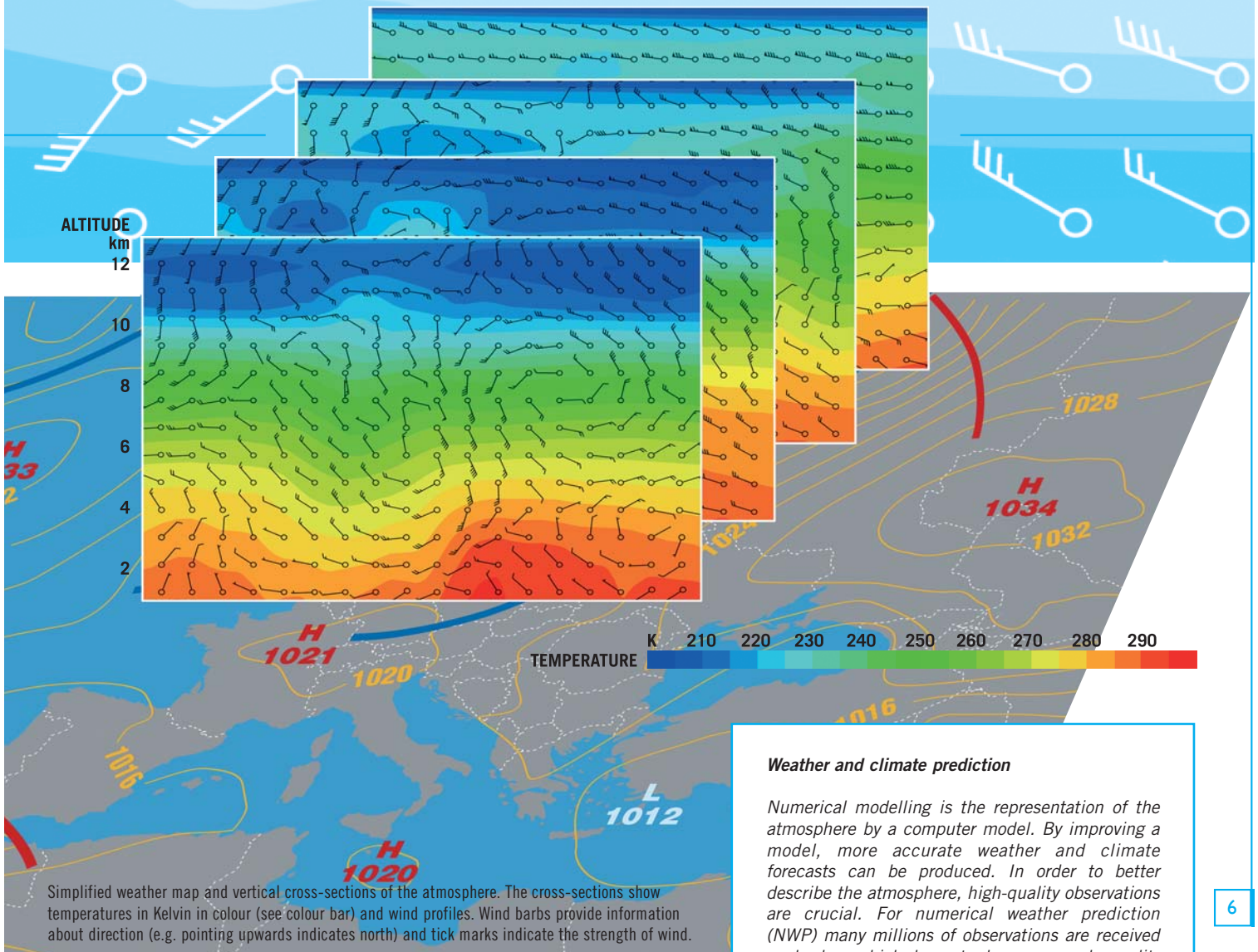


Hurricane Isabel, 2000 km east of the Leeward Islands in the Caribbean on 8 September 2003. The image was taken by the Medium Resolution Imaging Spectrometer (MERIS) on-board Envisat.



El Niño is a disruption of the ocean-atmosphere system in the tropical Pacific. In non-El Niño conditions (left panel), the Trade Winds blow towards the west. These winds lead to warm surface water in the west Pacific. During an El Niño (right panel), the pressure difference weakens and the surface wind changes direction, now blowing from west to east. The result is a rise in sea-surface temperature in the eastern-tropical Pacific.





#### Weather and climate prediction

Numerical modelling is the representation of the atmosphere by a computer model. By improving a model, more accurate weather and climate forecasts can be produced. In order to better describe the atmosphere, high-quality observations are crucial. For numerical weather prediction (NWP) many millions of observations are received each day, which have to be processed, quality controlled, monitored and entered into a model.

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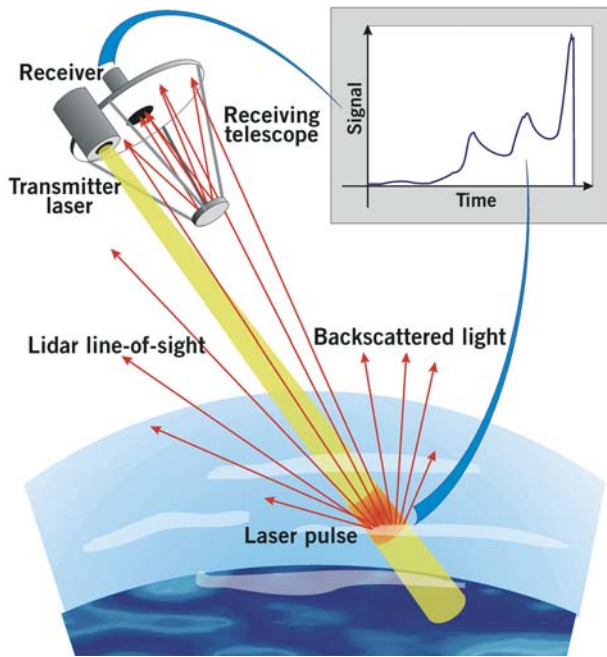
In order to improve numerical weather prediction so that we can benefit from better weather forecasting, there is an urgent need for detailed near-real-time observations of global wind-fields at all scales. This is something meteorologists have been requesting for some years now. Wind and wind profiles need to be measured independently and directly, and, in order to be able to do this globally, these measurements have to be performed from space.



Courtesy J. Varney

Aeolus will be the first space mission to measure wind profiles on a global scale and is expected to result in a breakthrough in weather prediction. The Aeolus wind profiles will find wide application in weather forecasting and climate studies, improving the accuracy of numerical weather forecasting, advancing our understanding of tropical dynamics and processes relevant to climate variability and climate modelling. In particular, a beneficial impact on the prediction of severe storm events is expected. It is envisaged that Aeolus will be the forerunner of a series of similar operational meteorological satellites in the future.

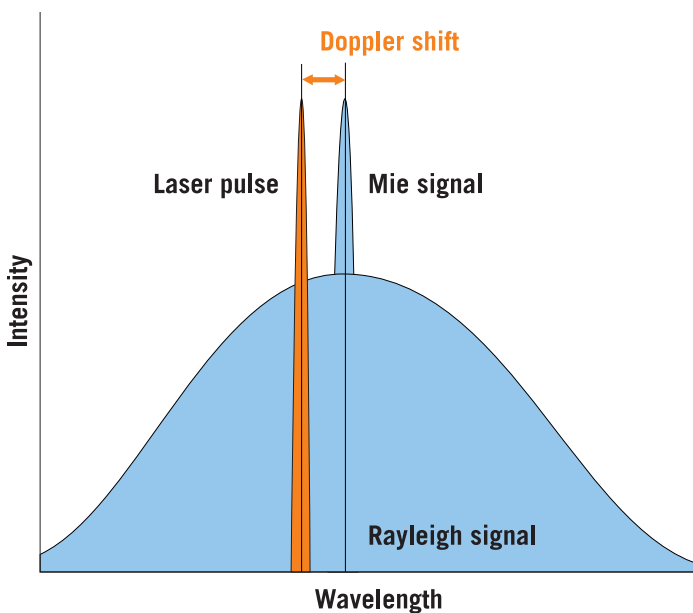
# How ADM-Aeolus works



Schematic view of a space-borne lidar. A short laser pulse is emitted towards the atmosphere where air molecules and particles reflect a small portion of the light pulse back to the lidar. A telescope collects the light and directs it to the receiver. The signal is recorded as a function of time to determine the altitude of the scattering layers.

Being such a dynamic and relatively invisible aspect of the Earth's environment, it is extremely difficult to make global measurements of wind. Studies have shown that the only way to achieve this is to probe the atmosphere from space using a highly sophisticated instrument called a 'Doppler wind lidar', which utilises a phenomenon called 'light scattering' and the Doppler Effect to acquire much-needed data on wind.

A lidar is similar to the more familiar radar, but transmits and receives light instead of radio waves. A lidar works by emitting a short, but powerful, light pulse from a laser through the atmosphere. As the light pulse travels through the air it interacts with molecules of gas, particles of dust and droplets of water. This causes a small amount of the light to be 'scattered' in all directions. Some of this light is scattered back towards the lidar - this is called 'backscattered light'. The lidar's telescope collects the backscattered light, and directs it towards a receiver. The time between sending the light pulse and receiving a signal determines the distance to the 'scatterers' (air molecules, cloud droplets, etc.), and thus the altitude above the surface of the Earth.



The relative motion of air leads to two effects - the centre frequency of the backscattered light is shifted with the wind velocity in the measurement direction, and the random motion of the air molecules leads to a broadening of the frequency width for the backscattered Rayleigh signal.

## Light scattering

Whenever a light beam shines on an object, some fraction of the light changes direction. This phenomenon is called light scattering. The amount of scattering by a particle depends on its size relative to the wavelength of light.

'Rayleigh scattering' (named after the English Nobel prize-winner Lord John Rayleigh) refers to the scattering of light from molecules of air, such as oxygen and nitrogen. Rayleigh scattering is most efficient at scattering light at shorter wavelengths, i.e. blue and violet. This wavelength dependence makes the sky look blue on a clear sunny day.

'Mie scattering' (named after the German physicist Gustav Mie) describes light scattering from particles larger than the wavelength of light. Mie scattering is visible when looking at clouds. Cloud droplets are large enough to scatter all visible wavelengths equally. This means that all of the wavelengths of the sunlight encountering a cloud will be equally scattered - making the cloud appear white.

To measure wind from space, however, another property of scattering has to be used - the Doppler Effect. When scattering particles are moving, the wavelength of the scattered light is shifted by a small amount as a function of speed. The Doppler wind lidar measures this change of wavelength to determine the velocity of the wind in the direction of the light pulse.



### The Doppler Effect

*Have you heard a police car go by recently? Remember how the pitch changes as the vehicle travels towards, and then away from you - first the pitch becomes higher, and then, as it passes it becomes lower. The change in pitch is a result of a shift in the frequency of sound waves. Although first discovered for sound waves by the Austrian mathematician and physicist, Christian Doppler (1803-53), the Doppler Effect holds true for all types of waves including light. The Doppler Effect for light waves is usually described in terms of wavelength rather than frequency and is equivalent to a shift in light colour.*

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Also, the satellite moves much faster than the wind - the satellite travels at a ground speed of about 7200 metres per second whilst the wind speeds being observed are only in the order of a few metres per second. A sophisticated pointing system is required to ensure that the instrument is pointing at a specific angle so that the speed of the satellite can be accounted for.

To realise a space-borne Doppler wind lidar is technically very challenging. The measurements have to be performed from several hundred kilometres above the surface of the Earth; therefore, a powerful laser and a large telescope have to be coupled with a very sensitive receiver. Many measurements have to be averaged in order to achieve accurate wind observations.

Aeolus will orbit the Earth at an altitude of about 400 km. Measurements will be taken orthogonal to the flight direction at an angle of 35° off-nadir. For every 700 laser-pulses, over which time the satellite moves forward 50 km, one wind profile will be obtained. The data will be transmitted to a ground station in Svalbard, Norway once per orbit, i.e. every 90 minutes.

# The instrument

The concept of using a Doppler wind lidar in space to measure wind goes back more than 20 years. However, until recently, studies had found that the measuring techniques would be too complicated and consequently nothing was ever realised. With the benefit of years of research, the technology has now become sufficiently advanced to launch the Aeolus satellite carrying an innovative instrument called ALADIN (Atmospheric Laser Doppler Instrument).

Based on breakthrough technology, ALADIN consists of a powerful laser system to emit short laser pulses down to the atmosphere, a large telescope to collect the backscattered light signal, and a very sensitive receiver to analyse the Doppler shift of the signal from layers at different heights in the atmosphere.

The laser system generates a series of short light pulses in the ultraviolet spectral region at 355 nm, which is invisible to the naked eye and poses no danger for observers on the ground. The ultraviolet region was chosen because the backscatter from atmospheric molecules at this short wavelength is particularly strong, and also because this wavelength can be generated with solid-state lasers, which are amongst the most advanced available.

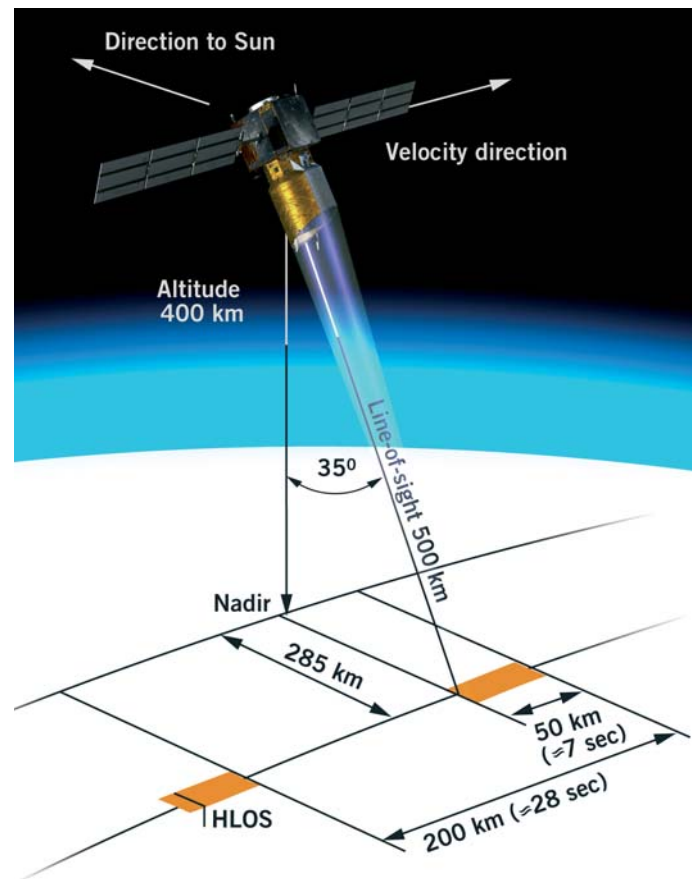
The laser system is actually a complex system of laser sources and amplifiers, which are all packaged closely together. There are two small lasers used to fix the frequency of the emitted pulses, a laser oscillator to generate pulses with the correct temporal characteristics, and two amplifier stages that boost the energy of the light pulses to the required value. The light pulses are generated in the infrared spectral region (1064 nm.). The frequency of the infrared pulses is tripled by a set of two non-linear crystals to reach the ultraviolet (355 nm).

ALADIN is dominated by a large telescope, which measures 1.5 metres in diameter. The telescope is used to collect the backscattered light from the atmosphere and then directs it to the receiver. Although large, the telescope is made of a lightweight ceramic material so that it weighs only 55 kilograms.

The receiver analyses the Doppler shift of the backscattered signal with respect to the frequency of the transmitted laser pulse. Two optical analysers are used to measure, respectively, the Doppler shift of the molecular scattering (Rayleigh) and scattering from aerosols and water droplets (Mie).

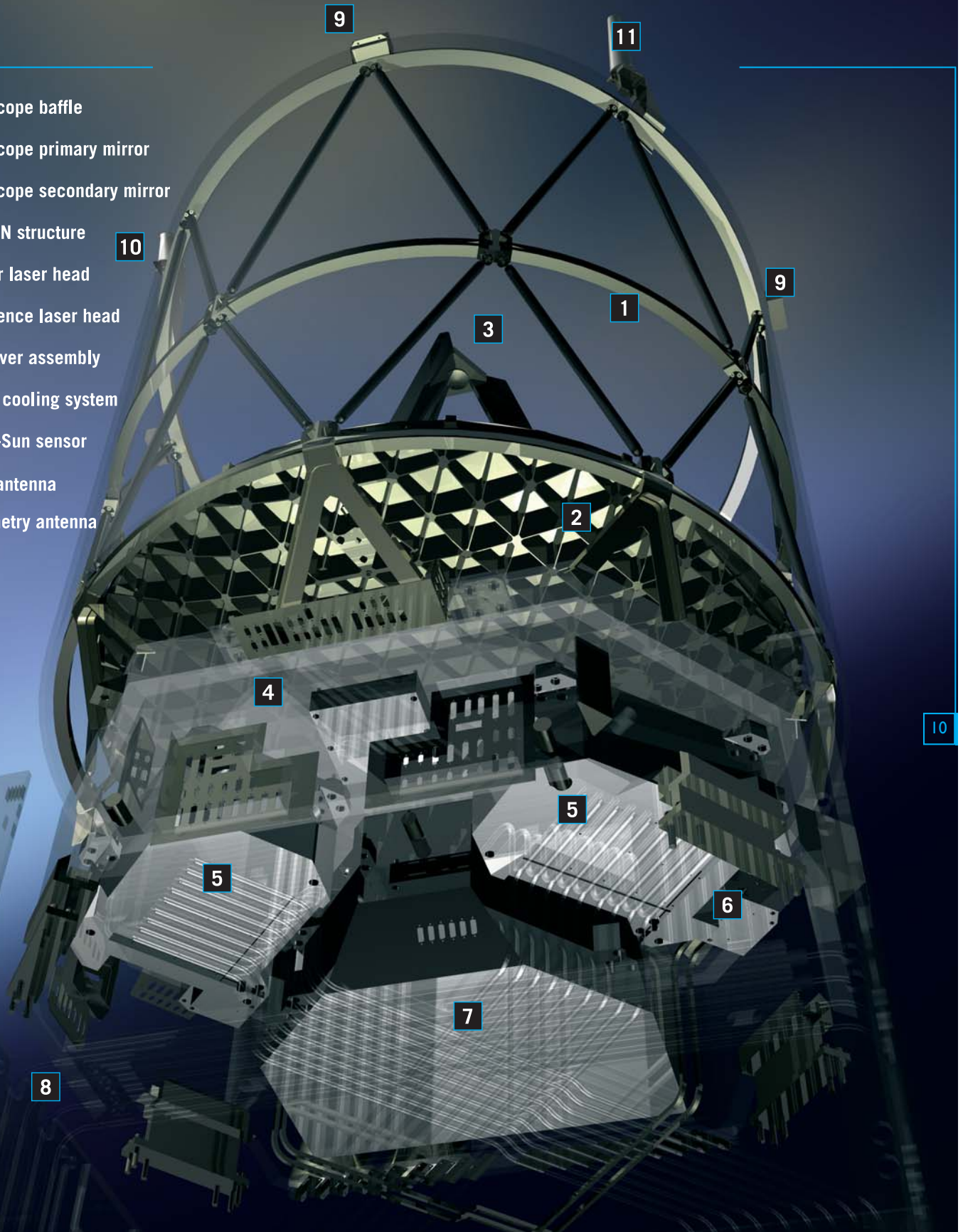
Highly sensitive photo-detectors then transform the light signals into electronic signals, which are amplified and stored on board until they are transmitted to the ground for processing.

The wind profiles are averaged over a distance of 50 km, which corresponds to 700 individual measurements and 7 seconds of measurement time. The wind observations are spaced 200 km apart and correspond to 28 seconds complying with numerical weather prediction and model requirements.



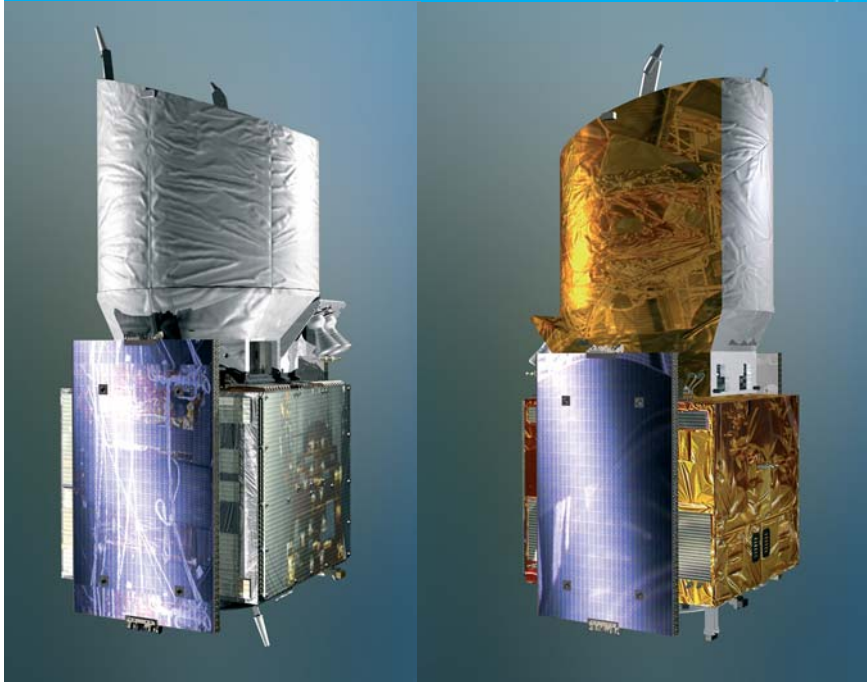
Baseline Aeolus measurement geometry. The wind is observed orthogonal to the satellite ground-track, pointing 35° off-nadir, away from the Sun. Observations cover 50 km along the flight direction, and are spaced 200 km apart. (H)LOS means (horizontal) line of sight.

- 1 Telescope baffle
- 2 Telescope primary mirror
- 3 Telescope secondary mirror
- 4 ALADIN structure
- 5 Power laser head
- 6 Reference laser head
- 7 Receiver assembly
- 8 Laser cooling system
- 9 Earth-Sun sensor
- 10 Data antenna
- 11 Telemetry antenna





# The satellite



The Aeolus satellite in launch configuration with the solar arrays folded up. In the flight direction, the satellite has white covers that protect it from atomic oxygen erosion (left image), while the opposite sides of the satellite are covered with gold-coloured insulation for thermal control (right image).

Although developed specifically for Aeolus, the design of the satellite is based on a heritage of other ESA missions. The aim has been to build a satellite that is relatively simple to operate. This reduces the operating costs throughout its lifetime, and is also important for the future since several Aeolus-type satellites are later envisaged for operational use.

Aeolus will be placed in a polar Sun-synchronous, dusk/dawn orbit, 408 kilometres above the surface of the Earth. This altitude, which is half the height of most other Earth observation missions, is a compromise between observing the best signal and keeping fuel consumption to a minimum. A lower altitude would have considerably increased the fuel required to maintain a steady orbit over the three-year lifetime of the mission.

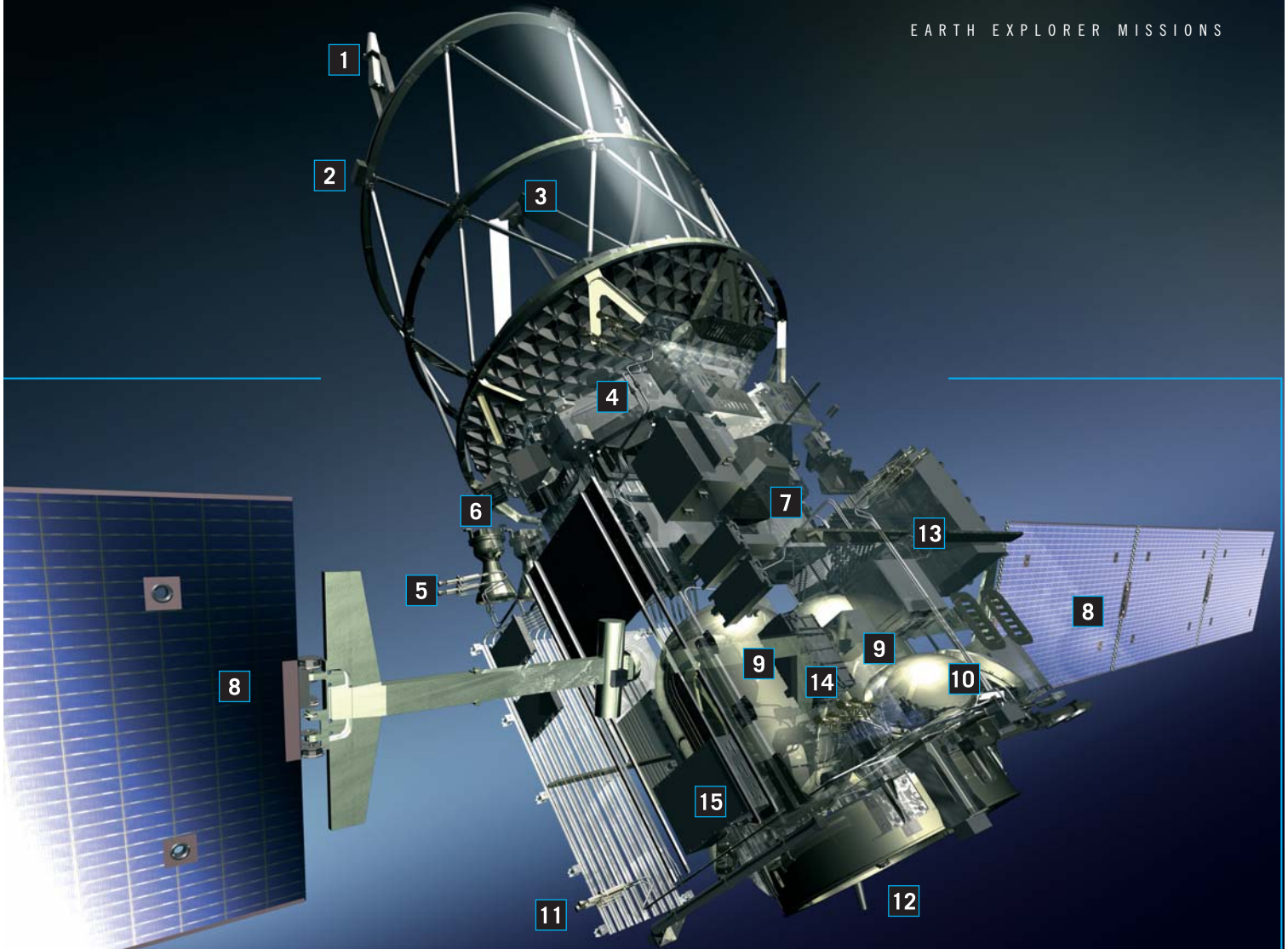
The dusk/dawn orbit (where the satellite crosses the Equator at 06.00 and 18.00 hours local time) will provide maximum illumination from the Sun, as well as a stable thermal environment. Observations of the wind will be performed on the night-side of the satellite to avoid the solar background. However, when orbiting over the hemisphere experiencing winter, the satellite will enter the Earth's shadow for up to

20 minutes per orbit. This means that the satellite will undergo huge temperature changes as it passes from day into night. With this in mind, the thermal design has had to be particularly robust.

Aeolus carries a state-of-the-art high-precision pointing system to point the ALADIN instrument towards the Earth's atmosphere. In order to obtain accurate wind profiles the pointing system has to be extremely stable and has had to meet very demanding technical requirements.

Keeping the ALADIN laser system cool has posed a new problem in space technology. However, this has been resolved by engineering a large radiator on the dark side of the spacecraft which radiates the excess heat back into space. The radiator is connected to the laser system via a number of heat pipes.

Once every orbit the measurement data will be sent to a ground station in Svalbard, Norway. For a polar-orbiting satellite a ground-station at high latitudes is ideal for fast data delivery, although any satellite receiving station with a dish more than 2.4 metres in diameter could be used if data were required more urgently than within 3 hours.



**1** Data antenna (X-band)

**2** Coarse Earth-Sun sensor

**3** ALADIN telescope

**4** ALADIN structure

**5** Orbit control thrusters

**6** Star-tracker

**7** Inertial measurement unit

**8** GaAs solar arrays

**9** Hydrazine fuel tanks

**10** Reaction wheels

**11** Laser cooling system

**12** Telemetry antenna (S-band)

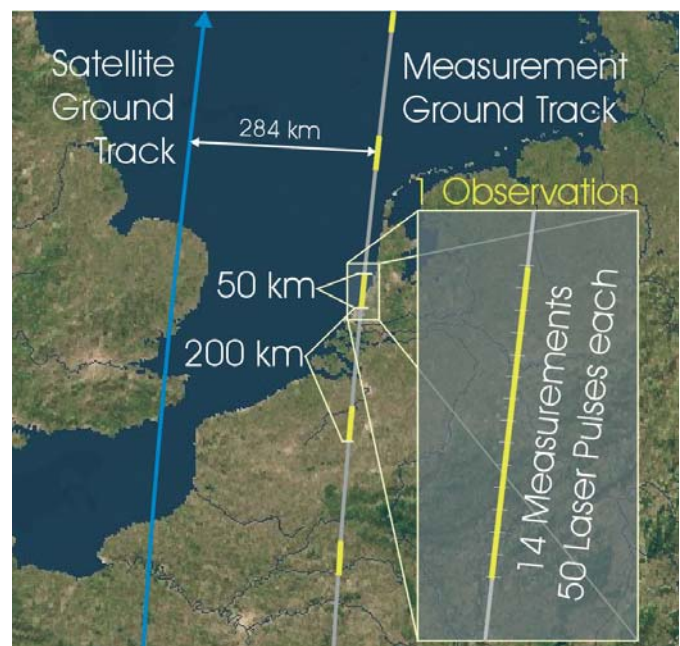
**13** Power control and distribution unit

**14** Li-Ion battery

**15** ALADIN control and data management

**12**

Ground pattern of wind observations covering a 150-second flight segment. One 50 km-long wind observation, divided into individual measurements of 3.5 km, is indicated. The measurement corresponds to 50 laser pulses, while one observation corresponds to 700 laser pulses.



The data are transmitted from the receiving station to the processing station, where the measurement signals that ALADIN has made are translated into wind profiles. These processed data are then sent to various meteorological offices to be used in weather forecasts. The ground processing-system is geared to provide rapid data processing and delivery as fast as possible.

The complete satellite is small and light enough to fit on a number of small launchers, such as Rocket, Vega or Dnepr. The launch cost is, therefore, comparatively low.

# Getting ready for a wind of change



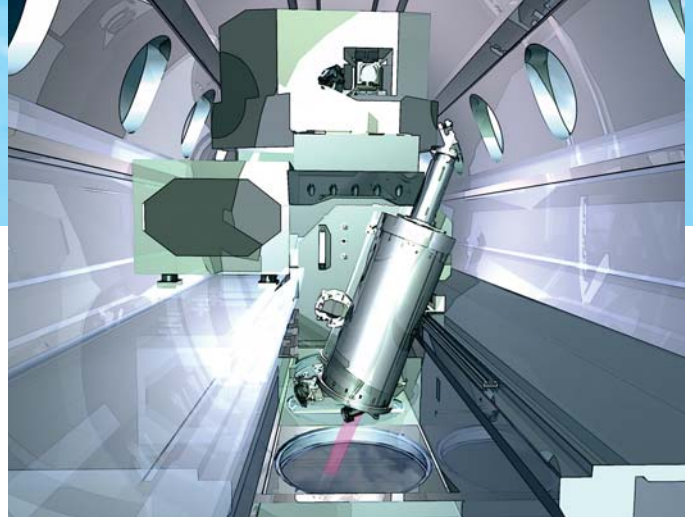
The Falcon research aircraft from DLR used for Aeolus campaigns.

Soon after their development in 1961, lasers were used for making various measurements of the atmosphere. In the 1970's, Doppler wind lidars using infrared laser sources were developed for ground-based measurements. Even by then, the importance of global measurements of wind profiles had been recognised.

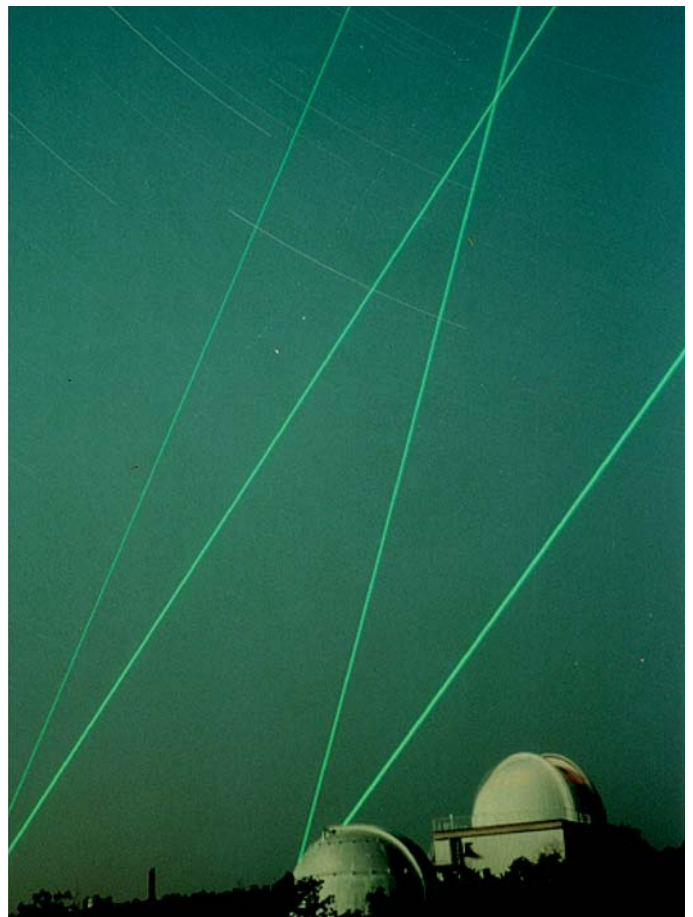
Doppler wind lidars continued to be improved and eventually led to the development of direct detection lidars from the ground that operate in the ultraviolet spectrum using molecular backscattering as well as aerosol scattering. This was important because it meant that wind profiles could now be measured in clear air, which is essential for monitoring the wind globally.

In 1999, ESA organised a measurement campaign with various ground-based direct detection Doppler wind lidars to establish the performance of these newly developed instruments. The campaign, called VALID-II, was performed in an atmospheric observatory in Haute Provence, France. Here, data from the wind lidars were compared with wind profiles that had been compiled using conventional sensors such as anemometers and balloon sondes. The VALID-II campaign confirmed that it was feasible to develop a direct-detection Doppler lidar for taking measurements of the wind from space.

After the success of the VALID-II campaign, a direct-detection lidar for measuring wind from space was engineered for full performance testing in a laboratory. This process leads to the prototype models, which is an essential step in the development of the flight model.



The ALADIN Airborne Demonstrator mounted in the Falcon research aircraft. Wind-profiling measurements are to be taken from the upper atmosphere in order to simulate the geometry of the observations that will be made by Aeolus.



Lasers pointing at the sky during the 1999 VALID campaign in southern France.



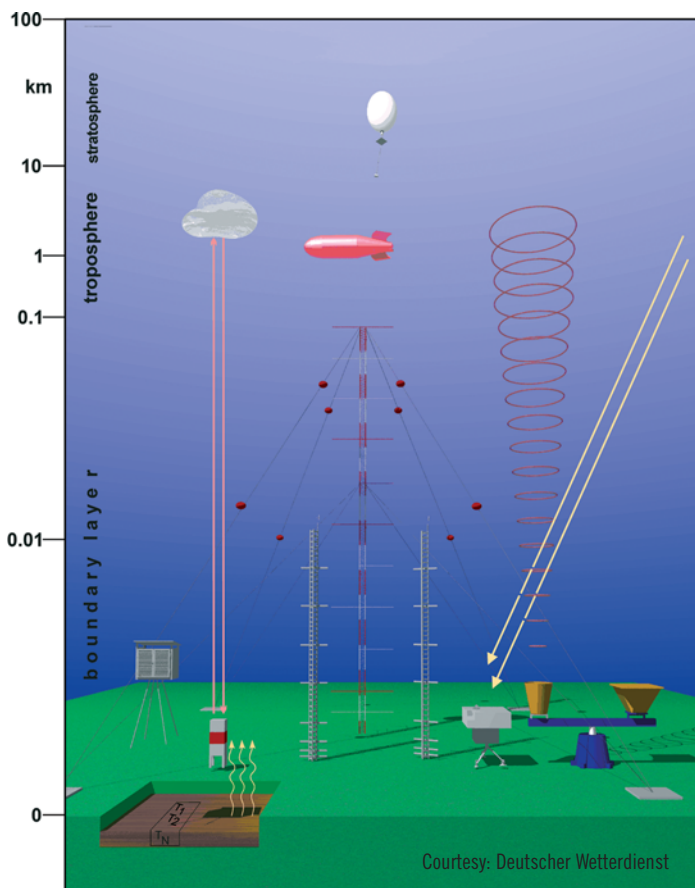


Courtesy: V. Quaschnig

An anemometer measures wind speed. The wind drives a shaft with 3 half-shells. A tachometer measures the rotational speed - this is proportional to the wind speed.



A radiosonde.



Courtesy: Deutscher Wetterdienst

In the Lindenberg Column, vertical profiles of wind temperature, water vapour and liquid water are measured for validating observations from other instruments.

These prototype models will be used to build a fully functional direct-detection Doppler lidar that is representative of the space-borne ALADIN lidar. This demonstrator has to be able to perform wind measurements using the same geometry as it would use in space. However, for testing it must also be capable of taking measurements from an aircraft. The ALADIN Airborne Demonstrator is currently under construction and due to be ready in 2005. A first ground-based measurement campaign will compare wind measurements between the demonstrator and those from conventional wind measurement techniques and other Doppler wind lidars. The campaign will be carried out at the Meteorological Observatory in Lindenberg, Germany.

Following the ground-based campaign, the ALADIN demonstrator will be integrated into a research aircraft from the German Aerospace Centre (DLR) to perform airborne measurements. In addition, an existing Doppler wind lidar will also be installed in the aircraft to make measurements. The wind observations from these two airborne Doppler lidars will be complemented with ground-based data from the Lindenberg site.

A number of airborne campaigns are to be carried out prior to launch to sample different meteorological conditions. These ground-based and airborne measurement campaigns are important to ensure that the data that will be eventually received from the Aeolus mission will be as accurate and meaningful as possible.

# ADM-Aeolus overview

The Atmospheric Dynamics Mission Aeolus will provide global observations of wind profiles from space to improve the quality of weather forecasts, and to advance our understanding of atmospheric dynamics and climate processes. By demonstrating new laser technology, Aeolus is seen as a pre-operational mission paving the way for future meteorological satellites to measure the Earth's wind.

ADM-Aeolus was selected in 1999 as an Earth Explorer Core mission as part of ESA's Living Planet Programme.

## Mission Objectives

- To measure global wind profiles up to an altitude of 30 km
- To measure wind to an accuracy of 1m/s in the planetary boundary layer (up to an altitude of 2 km)
- To measure wind to an accuracy of 2 m/s in the free troposphere (up to an altitude of 16 km)
- To determine the average wind velocity over 50 km tracks.
- To measure 120 wind profiles per hour.

## Mission Details

Launch: 2007

Duration: 3 years (plus 3-month commissioning phase)

## Mission Orbit

Sun-synchronous, dusk/dawn orbit

Inclination: 97°

Altitude: 408 km

## Configuration

Total dry mass of 1100 kg, comprising:

- platform 650 kg (plus 116-266 kg propellant)
- payload 450 kg

Dimensions (launch configuration):

- height 4.6 m, length 1.9 m, width 2.0m.

## Payload

- Atmospheric Laser Doppler Instrument ALADIN - a Direct Detection Doppler Wind Lidar operating in the near UV (355 nm)
- Transmitter: diode laser pumped Nd:YAG laser, frequency tripled to 355 nm 150 mJ pulse energy, 100 Hz pulse repetition frequency in bursts of 10 s (including warm-up time) with a 28 s repeat period, single frequency (line-width less than 30 MHz), tuneable over 10 GHz spectral range.
- Receiver: 1.5 m diameter SiC telescope, Mie channel (aerosol and water droplets) with Fizeau spectrometer, Rayleigh channel (molecular scattering) using dual edge étalon spectrometer signal detection applying two charge coupled devices with on-chip signal averaging for noise reduction.

## Attitude Control

- Pointing knowledge (after in-flight calibration): 30  $\mu$ rad.
- Sensors: coarse Earth Sun sensor, magnetometer for coarse pointing control, star tracker, inertial measurement unit, GPS for fine pointing control.
- Actuators: reaction wheels, magnetotorquers, thrusters.

## Power

- Average power demand 1400 W.
- GaAs Solar Array with 2200 W end-of-life power.
- Energy storage in 84 Ah Li-ion battery.

## Telemetry and Command

- Telecommand uplink 2030 MHz (S-band), 2 kbps.
- Telemetry downlink 2205 MHz (S-band), 8 kbps.
- Telemetry ground station Kiruna, Sweden.
- Measurement data downlink: 8040 MHz (X-band), 10 Mbps.
- Data ground-station: Svalbard.

## Ground Infrastructure

- Command & Control Centre: European Space Operations Centre (ESA-ESOC), Germany.
- Data processing: European Space Research Institute (ESA-ESRIN), Italy.
- Wind profile retrieval: European Centre for Medium-Range Weather Forecasts (ECMWF), UK.
- Data ground processing to be completed within 5 minutes after reception at processing station.



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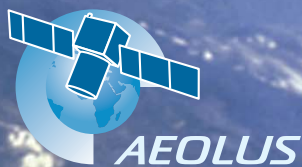
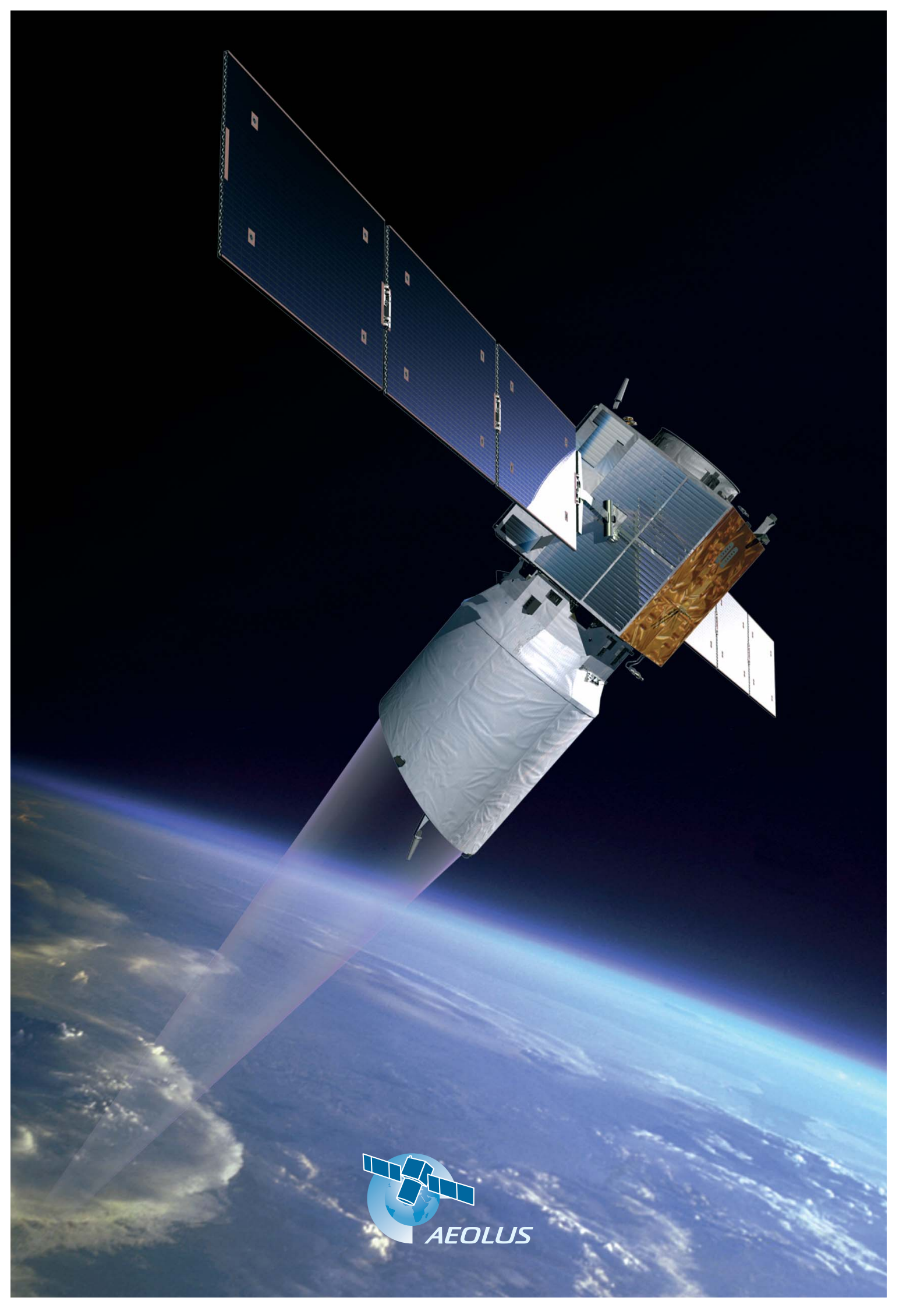
The SvalSat data receiving station in Svalbard. Due to its location in the Arctic, measurement data from Aeolus is received every orbit, i.e. every 90 minutes.

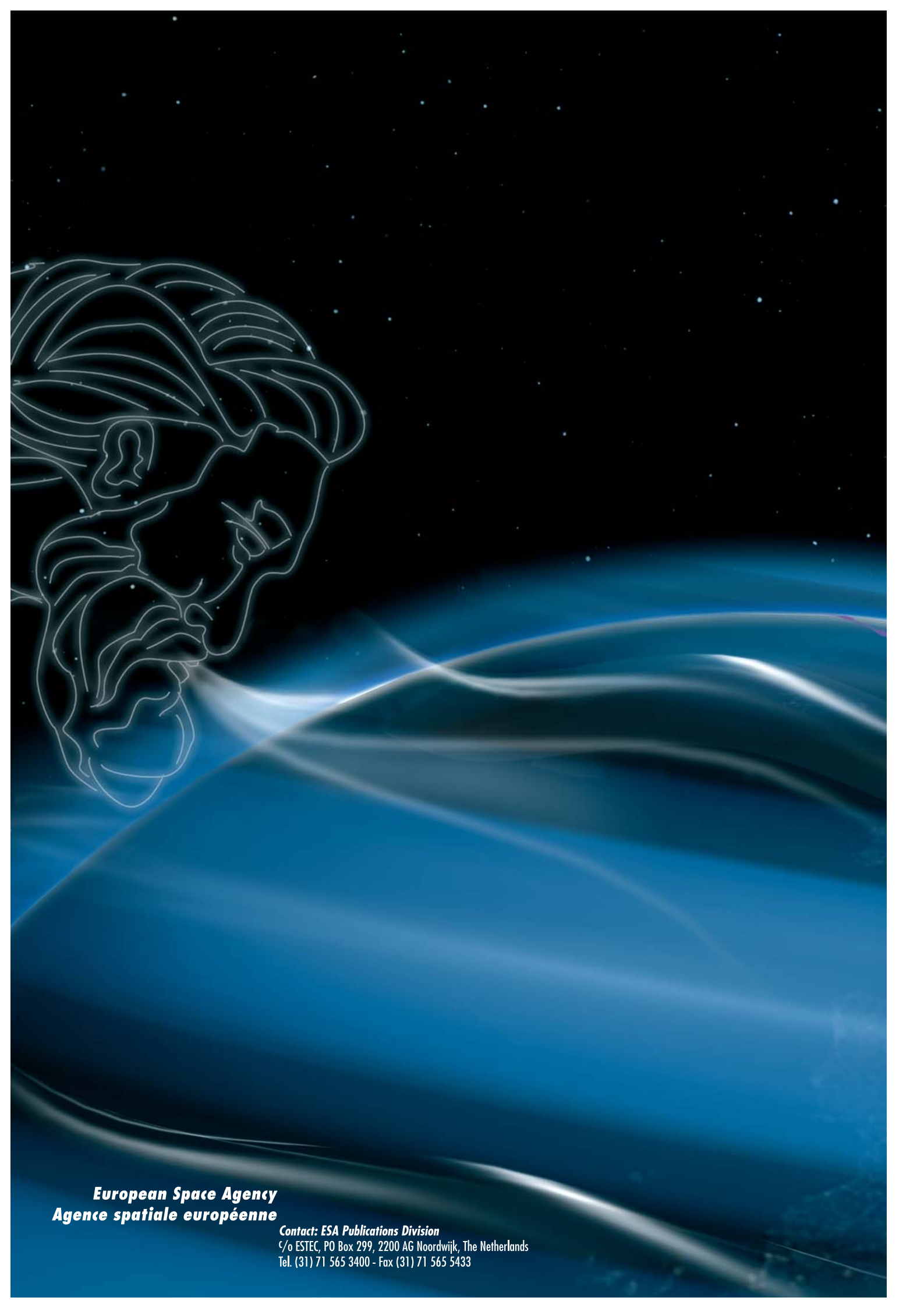
## Launch Vehicle

To be decided - Aeolus is compatible with many small launchers, such as Rocket, Dnepr and Vega.

## Platform and Payload Prime Contractor

EADS Astrium





**European Space Agency**  
**Agence spatiale européenne**

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