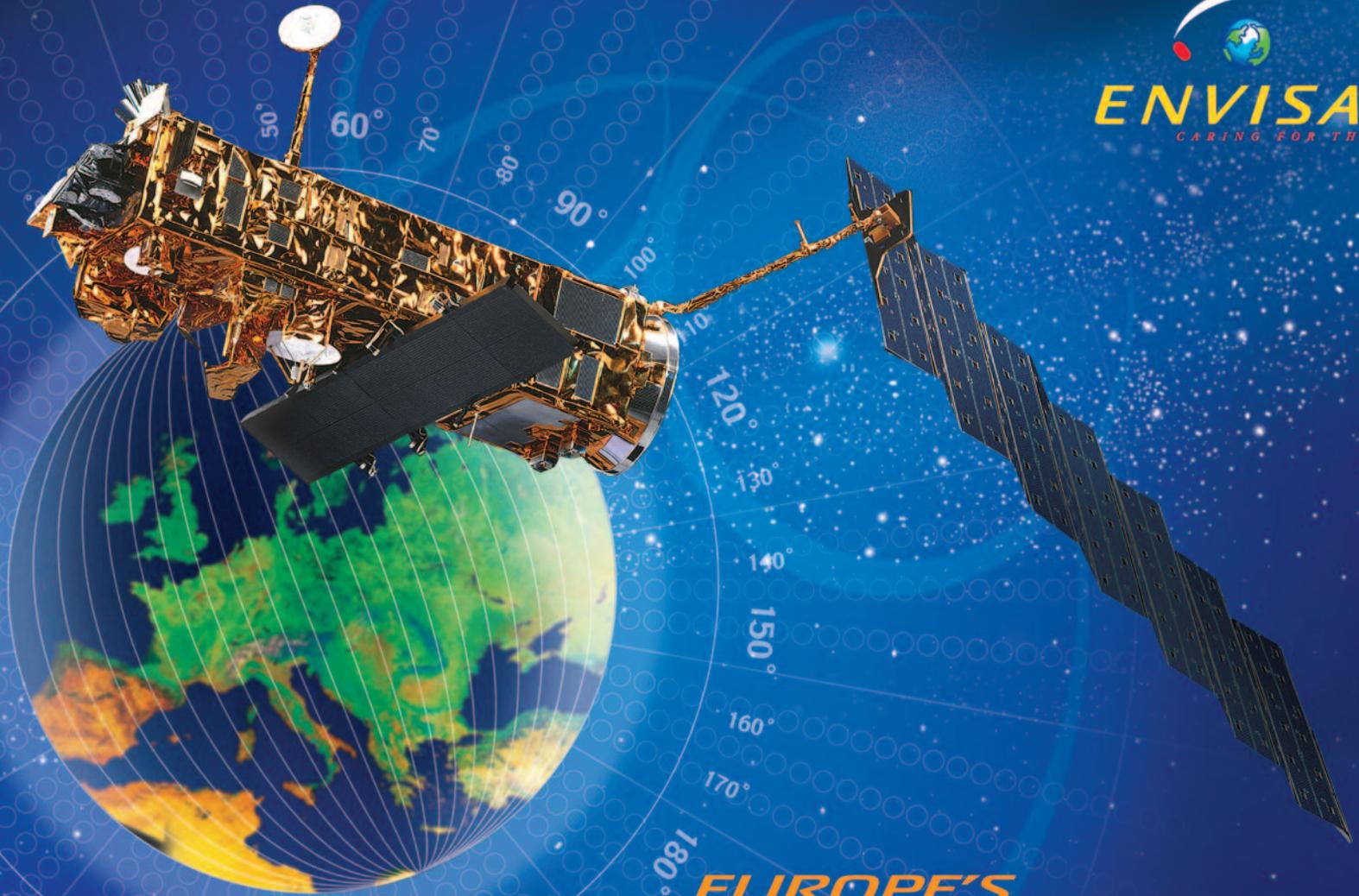




ENVISAT
CARING FOR THE EARTH



EUROPE'S
ENVISAT
ENVIRONMENT SATELLITE



The big questions

Can we slow down global warming?

The Intergovernmental Panel on Climate Change (IPCC), a group of 2500 scientists working with the UN, says that mankind is causing global warming. IPCC blames the 'Greenhouse Effect' - certain gases trap heat in the atmosphere and so warm up our planet. The 'Kyoto Protocol' sets targets for reducing the output of these 'greenhouse gases', - an 8% reduction is proposed for Europe by 2012. Today, the challenge is three-fold - first, politicians world-wide must agree the targets; secondly, scientists must monitor greenhouse gases to check that targets are met; and thirdly, we need to better understand the interactions between our planet's atmosphere, oceans and biosphere, so that we can combat global warming together.

How badly damaged is the ozone layer?

Between 25 and 35 km above our heads, a layer of ozone gas permeates the stratosphere. This layer protects us from the barrage of high-energy ultraviolet light from the Sun, which causes sunburn and skin cancer. Certain chemicals - many, like CFCs, produced by mankind - react with ozone, making holes in this vital protective layer. A large hole was first detected over Antarctica in the 80's and a reduction found over the Arctic in the late 90's. The damage is serious: The World Meteorological Organisation says 'the ozone layer is currently in its most vulnerable state'. Even if it suffered no further harm, the ozone layer would need at least 50 years to return to its natural state. So we must monitor and protect it carefully.

What causes El Niño?

El Niño is a huge temperature and sea level change in the Pacific Ocean. A giant pool of warm water moves from west to east, causing rainfall 10-40 times above average in South America, and effects as far afield as Africa. El Niño doesn't come every year, but repeats every few years. Scientists have learned to recognise some of the signs of a forthcoming El Niño event, but they do not yet understand its causes. They are sure, though, that the answer will be found with a better understanding of the global interaction between the oceans' surface and the atmosphere above.



What is happening to the world's forests?

Forests are the lungs of our planet, converting carbon dioxide, the greenhouse gas, into breathable oxygen. In a year, mankind releases 6 gigatonnes of carbon dioxide into the atmosphere - but forests and phytoplankton in the oceans 'clean up' about half of that. However, we are inflicting unprecedented damage on our forests. In a single decade between 1980 and 1990 global forest cover was reduced by 2%, and tropical rainforests by a staggering 8%. Forests are also home to more of the 13 million species on our planet than any other habitat. Without an accurate picture of global forest change, and the most fragile zones, governments cannot protect our environment effectively.

Why are our sea levels rising?

Within a century, some nations may no longer exist. 50 countries are threatened by a sea level rise of 50 cm by 2100, as predicted by the Intergovernmental Panel on Climate Change. Global warming is already raising the high-water mark, but we are not yet sure of the mechanism. Perhaps the icecaps are retreating, releasing part of their vast store of water into the oceans; perhaps other mechanisms are responsible. It may already be too late for some countries. But without global monitoring and detailed scientific analysis we cannot hope to understand why sea levels are rising, nor how the seemingly inexorable process can be stopped.

What are the effects of atmospheric pollution?

Viewed from space, a pall hangs over the eastern USA and parts of Europe. These are just two of the many areas around the world pumping chemicals and dust into our atmosphere. Pollution goes far beyond the spoil tips and poisonous rivers in factory back yards. According to UNEP, 'air pollution and acid rain are now global problems'. The European Environmental Action Programme adds 'Two-thirds of the trees in Europe are suffering from atmospheric pollution'. Asthma is rising dramatically in the industrialised world. It is essential for our children's future that we obtain accurate scientific evidence as a basis for international control of pollution and its effects.

Are natural disasters becoming more frequent?

Catastrophic floods, great storms, mudslides, or avalanches have threatened thousands of people in Europe in the last few years. Many people blame 'global warming' for these natural disasters, and point to unnaturally extreme weather. But climate change is a complex subject, and no one knows for sure whether these natural disasters are actually more common today than in the past. We need more complete information about our climate and the causes of extreme weather. But in the mean time, we can use all the tools at our disposal to monitor the risks of natural disasters, and mitigate their effects when they occur.

Answers from space

Understanding global warming

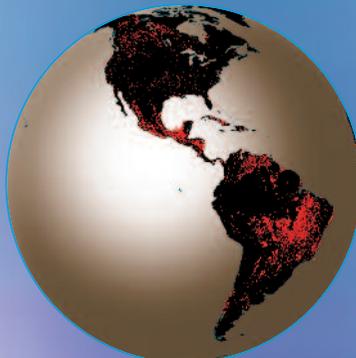
- ESA's satellite ENVISAT carries several instruments that will help unravel the mysteries of global warming. MIPAS and SCIAMACHY create global, three-dimensional maps of greenhouse gases in the atmosphere, like methane and carbon monoxide. AATSR creates the most accurate global picture of sea surface temperature. MERIS measures the 'colour' of the ocean in a wide range of wavelengths, and offers vital insight into global warming by mapping the distribution of phytoplankton, which account for half of the absorption of greenhouse carbon dioxide by our planet's biosphere. The Radar Altimeter contributes by monitoring the smallest changes in sea level, ocean currents and polar ice.

Monitoring the ozone layer

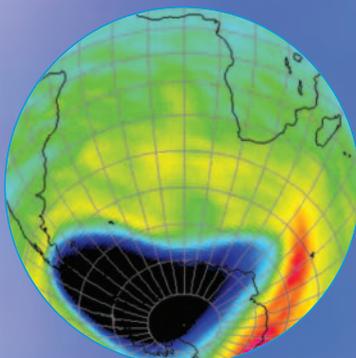
- With its three atmospheric sensors GOMOS, MIPAS and SCIAMACHY, ENVISAT creates a global three-dimensional map of ozone levels in our atmosphere, allowing for better ozone and UV forecasts within hours of data being gathered. ENVISAT is also able to track the trace gases that react with ozone, enabling scientists to obtain a complete picture of the atmospheric chemical reactions that affect the ozone layer. Armed with this detailed view, ENVISAT will contribute to a better understanding of how the ozone layer will repair itself, and how long that process might take.

Exploring El Niño

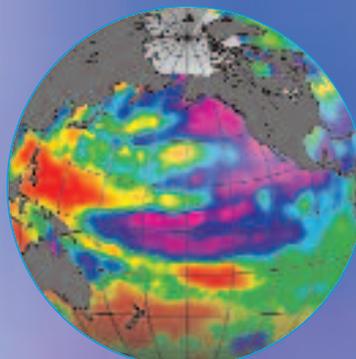
- ENVISAT carries a pair of instruments ideally suited to detecting and mapping the vast plateau created in the Pacific Ocean by an El Niño event. The Radar Altimeter profiles the sea surface to an accuracy of better than 5 cm and precisely measures the up to 50 cm-high plateau. And AATSR, with its accuracy of 0.3°C, can detect the earliest signs of sea surface temperature change which may reach 5°C. MERIS detects changes in ocean colour when El Niño stops the normal up-welling of protein-rich water that is an essential part of the ocean food-cycle. These unique capabilities enable ENVISAT to detect the early warning signs of a developing El Niño event.



Biomass burning



Ozone



El Niño

Forests under the microscope

- Every three days, ENVISAT can tell us how forest cover is changing in threatened areas - and a full global map is a real possibility. The maps of land use produced by combining data from ASAR, AATSR and MERIS distinguish very clearly between forest cover, clear-cut logging, and agricultural land. Such accurate global detective work, with simultaneous radar and optical observations, has never been possible before. AATSR is also able to detect the hot-spots caused by forest fires, while MIPAS and SCIAMACHY can track the trace gases and aerosols which are the unique signature of the large-scale burning of biomass.

Fathoming the oceans

- While we don't need ENVISAT to tell us that sea levels are rising, the data it gathers can offer important insights in how and why this should be happening. Global averages are useful but tell only part of the story. ENVISAT's sensors can map the world's oceans on a local scale. Radar Altimeter data measures precise changes in sea level, and creates accurate topographical maps of the ice sheets at the poles. This data - combined with sea surface temperature measurements from AATSR - gives an incredibly detailed picture of our planet's oceans.

Tracking pollution

- The signature of mankind's industrial activity is all too visible in our atmosphere. Three instruments aboard ENVISAT combine to map that signature on a global scale: MIPAS, GOMOS and SCIAMACHY. Together, these sensors can detect nitrogen oxides produced by burning fossil fuels; sulphur dioxide from dirty industries, which contributes to acid rain; bromine monoxide and CFCs, which damage the ozone layer; and aerosols, fine particles which belch from chimneys and form a climate-altering layer high in the stratosphere. Using maps prepared from ENVISAT data, it will be possible to identify the sources of pollution and its extent, and monitor compliance with environmental standards and protocols.

Joining hands to help

- ENVISAT is able to respond quickly in the wake of a natural disaster. ASAR imagery can be a vital tool for risk and disaster management teams alike, monitoring the extent of flooding, or spotting landslides in remote and inaccessible terrain. ENVISAT's ASAR is able to work day and night, penetrating clouds and bad weather, so it can focus on disaster zones within hours of a catastrophe. With its speedy response, ENVISAT is ideally suited for its role in the constellation of satellites available to the Charter on Space and Major Disasters, which offers relief-teams all over the world rapid access to images and maps from ESA, CNES and Canadian Space Agency satellites.

Users worldwide



Ronald is a coastguard. Using processed ENVISAT ASAR images delivered through a real-time computer network, he spots the oil slick trailing behind a ship illegally flushing its tanks into the

Mediterranean under cover of night, and despatches an aircraft to capture the criminal on film at dawn. In a few hours, the captain and owner can be identified and dealt with.



Erica is a climatologist. Using data derived from ENVISAT's MERIS, AATSR and ASAR instruments, she is able to study the interaction between clouds, rainfall and the ocean surface in unprecedented

detail. Until the launch of first ERS-1 and -2, and now ENVISAT, she had to make do with on-the-spot readings obtained by ships and buoys: today she can monitor entire oceans.



Klaus is an Operational Meteorologist. He's using information from ENVISAT's SCIAMACHY instrument to build new and very accurate computer programs to calculate the amount of ozone in our atmosphere.

Using these models will allow him to make much better forecasts the amount of ozone and the danger from the Sun's UV rays to skiers and sun-worshippers.



Sven is the operations manager of a fleet of coastal tankers. Using ENVISAT ASAR images of the chill oceans around Scandinavia, Russia and northern Canada, he is

able to choose routes for his captains which avoid the heaviest build-ups of pack ice and bergs and the worst waves, making their voyages safer and speedier.



Bruno is a risk assessment expert. Using radar interferometry maps derived from ENVISAT ASAR data, he has identified an area in his city where the ground has started to subside in

recent years. He will target building inspection teams to investigate older buildings in the area, to ensure that they are structurally sound, and guard against sudden and catastrophic collapse.



François is a civil protection officer. Using rapidly-processed images obtained by ENVISAT's ASAR, he is battling severe flooding around the Rhone and Saone rivers. The radar maps,

made by comparing new images with reference data, show exactly how far the flooding has spread, and help him identify the areas of highest risk to deploy his forces.

The billions of bits of data captured and sent Earthward by ENVISAT paint a picture of our planet in unprecedented detail. This data is processed into a variety of products, and distributed to thousands of scientists and engineers, civil servants and elected officials, industrialists and economists. Many are world-leading researchers, attempting to unlock the secrets of our oceans, atmosphere and biosphere. Public bodies and companies are providing day-to-day information to help people in their work and leisure. Regional authorities and international agencies are preparing to battle with natural disasters or monitoring complex activities world-wide. Meteorologists are deriving more accurate weather forecasts for agriculture, business and people deciding whether to take an umbrella on the way to work. Politicians are being briefed with ENVISAT data when dealing with complex issues such as coastal pollution or international treaties on emissions. And the public will soon be able to access a wide variety of the information gathered by ENVISAT through the World Wide Web. Tomorrow you could be watching El Niño, a forest fire or a flowing glacier from your desktop.

Envisat looks at me

Imagine you are standing in the open, on a favourite spot. Look around - perhaps you can see some grass beneath your feet, a nearby clump of trees, and the sea splashing gently onto a shingle beach in the distance. Above, puffy white clouds scud through an otherwise clear sky. Now look up further. You can't see it, but 800 km above your head ENVISAT is streaking across the sky, its ten sensors gathering a hundred million bits of data every second. As ENVISAT looks down at you, **what can it see?**

Altitude 0 to 100 km: GOMOS, MIPAS and SCIAMACHY are building a three-dimensional profile of ozone concentrations in the atmosphere. This also helps to track high-level winds, for better weather forecasts.

Altitude 0 to 20 km: MIPAS and SCIAMACHY are detecting low levels of gases from industry, power generation and agriculture. Although you can't see them, ENVISAT reveals the plumes of pollution from a nearby industrial city.

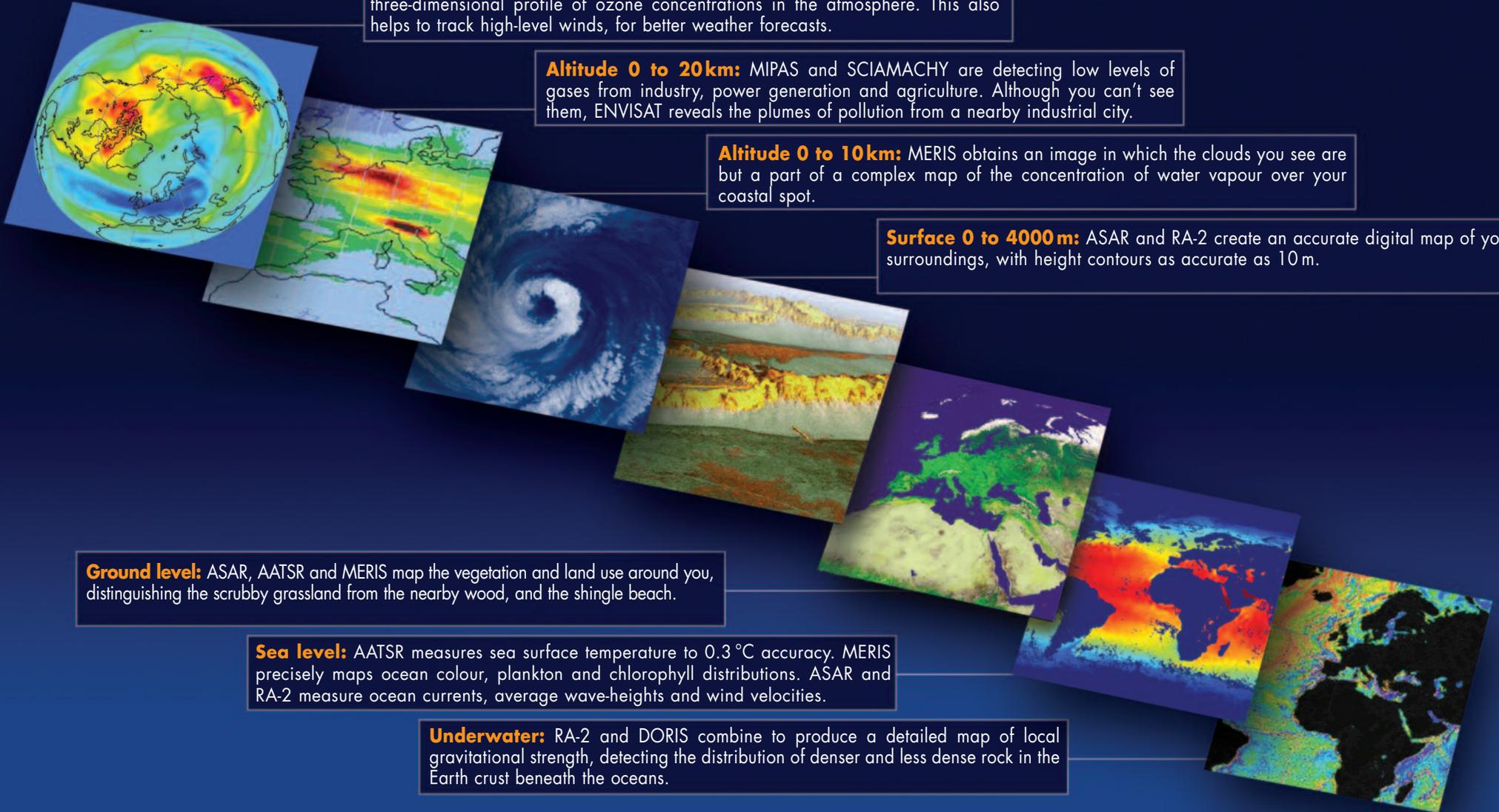
Altitude 0 to 10 km: MERIS obtains an image in which the clouds you see are but a part of a complex map of the concentration of water vapour over your coastal spot.

Surface 0 to 4000 m: ASAR and RA-2 create an accurate digital map of your surroundings, with height contours as accurate as 10 m.

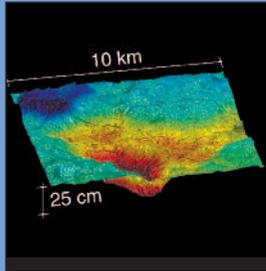
Ground level: ASAR, AATSR and MERIS map the vegetation and land use around you, distinguishing the scrubby grassland from the nearby wood, and the shingle beach.

Sea level: AATSR measures sea surface temperature to 0.3 °C accuracy. MERIS precisely maps ocean colour, plankton and chlorophyll distributions. ASAR and RA-2 measure ocean currents, average wave-heights and wind velocities.

Underwater: RA-2 and DORIS combine to produce a detailed map of local gravitational strength, detecting the distribution of denser and less dense rock in the Earth crust beneath the oceans.



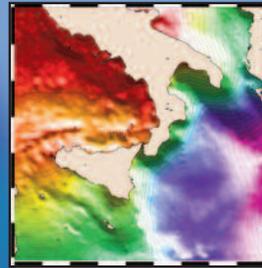
Surprising science



Measuring mm from 800 km

The Advanced Synthetic Aperture Radar aboard ENVISAT can map the Earth's surface to an accuracy of a few tens of metres in a single pass. But combine the images from two orbits, using a technique called interferometry, and

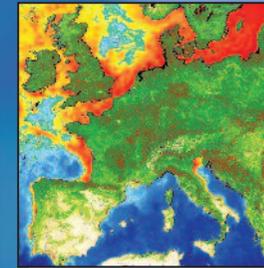
ENVISAT can spot the subsidence of a city street, the bulging of a volcano's slope, or the sagging of a glacier above a buried hot-spot, even if the movement is a mere few centimetres. But amazingly, even more precision is possible: by identifying features like rocks or buildings which are distinctive in each image, interferometry can track millimetric movements from an altitude of 800 km. Experiments in London, Rome and Paris have proved that ground movement of as little as 1 mm/yr can clearly be observed from radar data. This data, readily available anywhere, will be a vital tool for civil protection teams, geologists and civil engineers.



The true shape of the Earth

From its vantage point high above the surface, ENVISAT can 'see' the bottom of the sea. Although none of its sensors - radar, temperature, colour - can penetrate more than a few centimetres

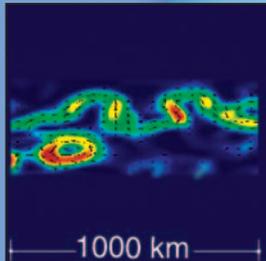
into the ocean, the shape of the sea-bed can still be mapped. ENVISAT carries a sensitive radar altimeter, which determines its exact altitude above the surface of land and sea, and it is also tracked throughout its orbit to an accuracy of a few centimetres in position and speed. Gravity dictates that if there were no wind, waves or currents, the surface of the ocean would reflect, on a compressed scale, the mountains and chasms in the sea-bed below. By combining altimeter data and position data, ENVISAT can extract a global profile of the sea-bed. Similar techniques can map the ice sheets at the poles, and map inland topography. In only 35 days, ENVISAT will be able to help to build a more accurate picture of the true shape of the Earth than centuries of depth soundings, altitude measurements and painstaking cartography.



Monitoring the living Ocean

The seas are alive with tiny single-celled organisms called phytoplankton. These microscopic creatures account for the majority of the biomass in the oceans, and have a greater effect on our planet's climate than any other living thing -

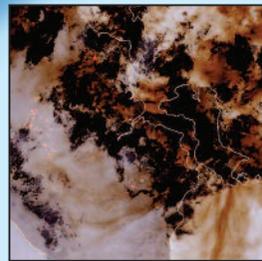
including all the world's forests. It takes a microscope to see a single phytoplankton, but the signs of untold billions can be detected from space. 'Algal blooms' - some of which are the poisonous 'red tides' that make the headlines - occur when a combination of nutrient-rich sea water and ideal temperatures combine to trigger a population explosion among phytoplankton. ENVISAT's MERIS ocean colour instrument can spot the change from blue-green to rust-red or yellow hues as the coloured algae thrive. Such blooms may be indicative of pollution (extra nutrients, as far as the plankton are concerned) or a change in local ocean climate. Either way, they are a key warning sign of environmental change, and must be monitored constantly.



Tracking the world's largest river

Silently, a river thirty times greater than all the others on Earth put together runs through our oceans. This huge current system has a powerful effect on our climate: without it, Britain would be like Spitzbergen, and Paris

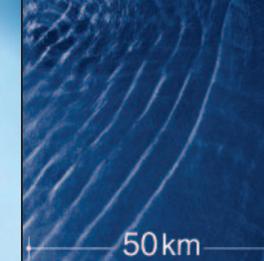
as chill as Hudson Bay. The Gulf Stream is just the most famous part of a global circulating current which connects the Atlantic, Indian and Pacific Oceans, taking a hundred years to complete a circuit. ENVISAT will watch this invisible river, its instruments detecting the changes in ocean surface temperature and velocity caused by the flow of warmer water along the surface, and the eddies swirling in the main flow's slipstream. It's vitally important to monitor this global current, because of its enormous influence on both weather and climate. ENVISAT will help us understand this global current much better than we do today.



Biomass burning

The giant forest fires which struck south-east Asia in 1997/98 covered the region in a pall of smoke and made headlines. But every year, many times as much forest burns globally, in a multitude of separate incidents,

pumping nitrogen dioxide, fine ash, and a wide variety of trace chemicals into the atmosphere. These fires, some natural, some man-made, devastate vast tracts of forest, many in remote areas, rarely travelled by people who might raise the alarm. ENVISAT is able to detect fires using AATSR's 'hot-spot' detection capability, which can track the tell-tale infra-red signature of the flames, and monitor the effects of the smoke particles floating in the highest layers of the atmosphere. The amount of chemicals produced when organic matter burns can be measured by SCIAMACHY. Soon, ENVISAT will become a global 'fire-watcher', summoning fire-crews to damp down the raging blazes.



Waves inside the Ocean

Beneath the turbulent ocean surface there are no still calm depths, but swells with heights of up to 50 m and wavelengths of anything from a few hundred metres to tens of kilometres.

These internal waves occur at the boundary between layers of water with different properties, and they can be very powerful, preventing the operation of drilling platforms, or disturbing submarine communications. Although the waves are far out of sight, they leave a tell-tale signature at the surface, which can be spotted using the Advanced Synthetic Aperture Radar aboard ENVISAT. The interaction between the deep waves and the surface currents affects the roughness of the smaller waves on the surface, which is undetectable to the eye, but significant to the radio waves of ASAR. Investigating these and other dynamic features in the world's oceans is a vital task for ENVISAT.

The European Space Agency's Earth Observer: ENVISAT satellite.

ENVISAT is the most powerful tool for monitoring the state of our planet and impact of our activities on our world that has ever been created. Producing enough digital data to fill the hard drives of 500 desktop PCs every day, Envisat views the Earth with unprecedented detail and richness. The truck-sized satellite carries 10 instruments, powered by a 70 m² solar array generating 6 kW of electricity. ENVISAT's unique capability is driven not only by the selection of instruments. The ability to combine data from different sources into highly-sophisticated products - often digital images or 'maps' - reveals views of the world that have never before been possible. And the long lifetime of ENVISAT, coupled with the legacy of compatible data from ESA's ERS-1 and-2 satellites, will enable scientists to create FOUR-dimensional pictures, showing the evolution of complex environmental phenomenon through timescales of over ten years.

Advanced Synthetic Aperture Radar

ASAR

Uses radar beam to map the surface of the planet below, with several different modes that allow broad views or detailed snapshots. Able to map the shape of the land, profile waves and ice, monitor land use and types of vegetation, and measure some of the properties of the surface.

Medium Resolution Imaging Spectrometer

MERIS

Takes images of the surface and clouds in sunlight which capture visible light and some of the infrared part of the spectrum. Able to determine the exact 'colour' of oceans and coastal zones, which reflects biological activity and other processes; monitor clouds and detect invisible water vapour in the atmosphere; and identify plants at various stages of their growth. Measures chlorophyll levels, allowing calculation of the amount of vegetable biomass.

Radar Altimeter 2 and Microwave Radiometer

RA-2
and MWR

Measures the satellite's height above the surface to an accuracy of 4.5 cm (in 800 km). When combined with exact orbital tracking data from DORIS, RA-2 measurements yield a profile of the sea or ice surface below. Further signal processing on the ground gives data on wave conditions and wind speeds in mid-oceans. MWR measures amount of water vapour in atmosphere to correct RA-2 radar signals for best accuracy.

Global Ozone Monitoring by Occultation of Stars

GOMOS

Tracks stars and monitors their light spectra as they set through the Earth's atmosphere. Able to build vertical profiles of water vapour and ozone through the atmosphere from altitudes of 20-100 km. Produces as much data as a network of 360 separate ground stations.

MIPAS

Michelson Interferometer for Passive Atmospheric Sounding

Observes the atmosphere in middle infrared range, mapping the profiles of a series of different trace gases. Able to map industrial pollutants, and greenhouse gases to shed new light on atmospheric chemistry.

Advanced Along-Track Scanning Radiometer

AATSR

Scans land ocean surface at several infrared and visible frequencies to accurately measure temperature. Able to measure sea surface temperature to an accuracy of 0.3 °C. Detects hot spots from forest fires. Maps extent of vegetation in different regions.

Doppler Orbitography and Radiopositioning Integrated by Satellite

DORIS
and Laser
Retro-reflector

Measures exact orbital position of satellite to an accuracy of 4.5 cm, and orbital speed to an accuracy of 0.4 mm/s. Works with radar altimeter to produce maps of ocean surface and derive gravitational field maps of sea bed and elevation maps of land. Laser reflector allows ground-based laser ranging of satellite to calibrate DORIS and RA-2.

SCanning Imaging Absorption spectroMeter for Atmospheric CHartography

SCIAMACHY

Maps atmosphere over a very wide wavelength range, which allows detection of trace gases, ozone and related gases, clouds and dust particles throughout the atmosphere. Gives total amounts of gases, and profiles in the atmosphere. Versatile instrument which will enable investigation of many different facets of atmospheric chemistry, including the effects of forest fires, industrial pollution, arctic haze, dust storms and volcanic eruptions.



Envisat fast facts

Size

- Envisat is the size of an articulated truck
- 10m x 4m x 4m with solar panel and ASAR stowed
- 25m x 7m x 10m with solar panel and ASAR deployed

Weight

- 8200 kg at launch
- Includes 300 kg hydrazine fuel for orbit control thrusters

Power

- Solar array generates 6.6 kW of electricity after five years in orbit

Orbit

- Orbits Earth every 100 minutes at altitude 800 km
- Global coverage every 3 days (for most instruments)
- Exact repeat coverage every 35 days

Lifetime

- 5 years design life
- Both ESA's previous Earth Observation Satellites ERS-1 and 2 significantly exceeded their design lifetimes

Instruments

- Ten instruments observing Earth
- In wavelengths from 0.2 micrometer to 10 cm

Data gathering

- Envisat will collect 1 Petabyte (10^{15} bytes) of data over its lifetime
- Enough to fill the hard disk drives of a million desktop PCs.

Datalinks

- 2 x100 Mbit/s links via European Data Relay Satellite
- 2 x100 Mbit/s direct downlinks to ground receiving stations
- Each link 2000 times faster than a standard computer modem

Data storage

- 160 Gbits total data storage on board
- Enough for 1.6 million square kilometres of SAR imagery plus one complete orbit of data from all the other sensors

Construction

- Satellite built by consortium of 50 companies led by Astrium
- Ground Segment built by consortium of 20 companies led by Alcatel Space Industries

Launcher

- Ariane-5 launch vehicle from Europe's Spaceport, Guyana Space Centre.

Cost

- 2 billion Euro over 15 years
- Works out at 7 Euro per citizen for ESA member nations or about 1 cup of coffee each a year

Participating states

- Austria, Belgium, Canada, Denmark, France, Finland, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom

ENVISAT is a programme of the European Space Agency (ESA). The 15 countries of (ESA) are working together and pooling their resources to open up pathways in space exploration and the development of advanced technologies for the nations of Europe. Canada is also taking part in some programmes.

<http://www.esa.int>



ILLUSTRATIONS: AWI Germany; CLS France; DEOS Netherlands; DLR Germany; Polimi Italy; JRC Italy (EC); KNMI Netherlands; NERSC Norway; RAL UK; Scripps USA; U. Bremen Germany; U. Hamburg Germany