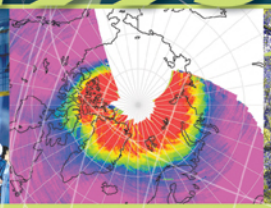
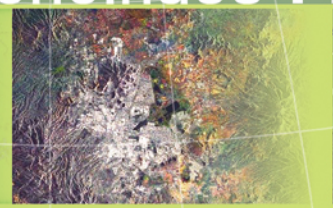
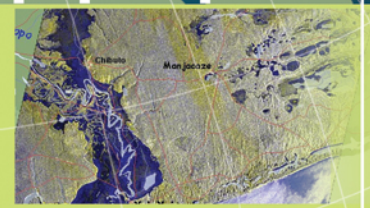
esa

ERS-2
10 Years in Orbit

1995..The mission continues 2005

European Space Agency
Agence spatiale européenne

the Living Planet

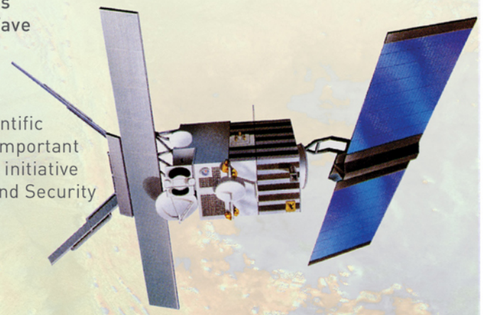
after a decade of ERS-2 earth observation. . .

ERS-2 is a notable European engineering achievement, reaching the milestone of **10 years in orbit on 21 April 2005** with all instruments still working and providing excellent data. Over this 10 year period the satellite has underpinned and supported the development of a unique know-how, a broad range of outstanding Earth Observation science results and a range of operational applications. Together with ERS-1, launched 1991, and Envisat, it has created today's large, widely extended and robust EO community.

The ERS system together with other European and international missions provides long-term uninterrupted observation of many key environmental variables including:

- 15 years of C-band radar imaging of land, oceans and ice, including Glacier, Forest and Subsidence monitoring
- 30 years of C-band scatterometer data and derived Ocean Surface Winds
- 25 years of Stratospheric Ozone observations
- 15 years of high accuracy (0.1K) measurement of Global Sea Surface Temperatures
- 15 years observing Global Ocean Wave and Sea Surface Heights

ERS data products have created and are still the basis for a large number of scientific projects and operational services, with important contributions now for the new European initiative for Global Monitoring for Environment and Security (GMES).



LAUNCHED
21 April 1995

ORBITS
52,000 (first 10 years)

SAR ACQUISITIONS
Over 1 Million Images

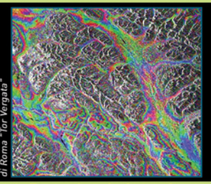
GOME, SCAT, ATSR, RA, Wave Mode
Global and Regional Products

“ More than 3,000 scientists have published over 10,000 scientific papers based on ERS data ”

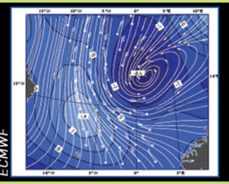
The ERS system, together with other European and international missions, ensures the long-term, uninterrupted, observation of environmental parameters that is crucial to our understanding of the Earth-system. The resultant databases match, by virtue of their continuity, the requirements for distinguishing trends that are influenced by human activity, and those that relate to natural processes.

ERS-2 is in an excellent operational state enabling further years of service:
All instruments are working well
Platform fuel reserves are more than sufficient.
A global network of ground stations continue to acquire the SAR data.
Failure of the on-board data recorders is being off-set by the increasing involvement of foreign ground stations in collecting and distributing low bit rate data in near real time.

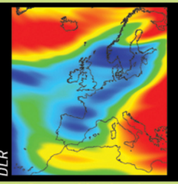
ERS-2 data have an important role to play in the quest to ensure that products from spaceborne systems meet exacting requirements, enabling their use in global and regional monitoring activities. The ability to acquire data from sensors in orbit at the same time and observing the same geophysical parameters, results in a powerful methodology (cross-calibration) that is used to tune instruments and retrieval algorithms. The current ability to compare data from ERS-2 and Envisat, for example, can be extended to involve Earth Explorer Missions such as Cryosat, SMOS and MetOp.



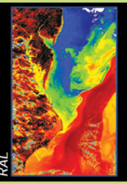
▲ *Preseismic interferogram computed using ERS-2*



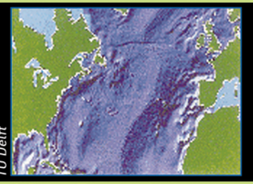
▲ *Ocean Winds for Meteorological Models*



▲ *Ozone Monitoring*



▲ *Sea Surface Temperature*



▲ *Ocean Topography*

▲ *Ground stations involved in SAR data acquisition*

. . . the mission continues

LONGEVITY OF MISSION - excellence of engineering has led to long service so far and underpins the continuing role of the mission

ERS-2 SAR products are still highly valued because of their long-term consistency which is a function of regular and predictable acquisitions in a single operating mode.

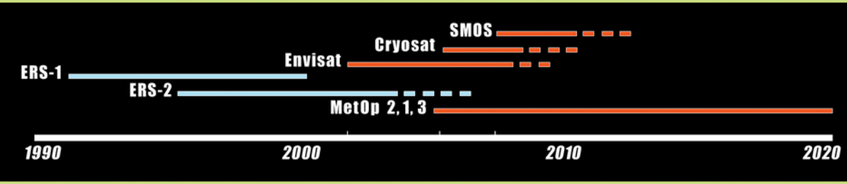
ERS-2 with its well defined products and services has an important role to play in preparation for **GMES**, building on the established customer base through the generation of policy-relevant services. Until the launch of GMES dedicated missions, such as Sentinel, the retention of ERS-2 will provide the necessary additional capacity to maintain the uninterrupted data flow that is critical to the programme.

ERS-2 Wind Scatterometer and **GOME** are unique instruments, not due for replacement until MetOp is launched in 2006. Even then cross-calibration activities will necessitate continued ERS-2 operations during validation.

ERS-2 has an on-going role in fostering and sustaining international relationships. This is driven principally by the network of foreign ground stations receiving SAR data, and increasingly taking low bit rate data as well.

GMES Global Monitoring for Environment and Security

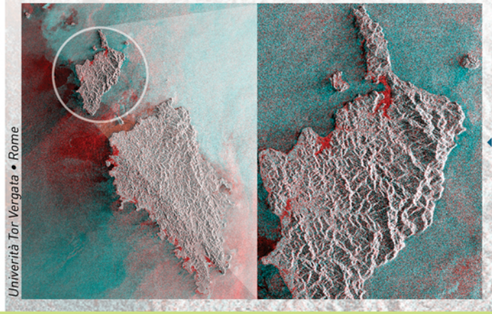
ERS-2 is available now to provide data for GMES



SAR Applications

The **ERS-2 Synthetic Aperture Radar (SAR)** produces all weather, day and night, detailed images of a 100km strip of the Earth's surface. An impressive range of scientific investigations has been carried out in oceanography, glaciology and climate research. Operational systems have been developed for mapping sea ice, oil slick monitoring and ship detection. SAR data are being used for agricultural monitoring, forest mapping, geological exploration and flood mapping, while SAR interferometric measurements of topography and small topographic changes are making major contributions to environmental risk assessment involving earthquakes and land subsidence. The ASAR now operating on Envisat is a step forward in terms of system flexibility and the scientific value of its data sets, however, the demand for ERS-2 SAR data remains relatively unchanged.

> ***"The fixed geometry of the ERS-2 SAR provides a very consistent and reliable product; one which is proving to be highly beneficial for many interferometric applications and operations requiring frequent repeat data sets. The long time series of images means that new ERS-2 acquisitions are especially valuable for the analysis and monitoring of stable targets in urban areas"***
>
> **Professor Fabio Rocca, Politecnico Milano**



Università Tor Vergata • Rome

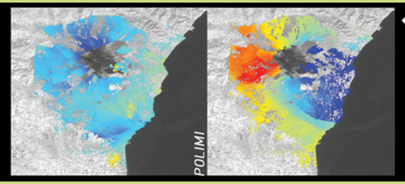
ASIAN TSUNAMI 2004 - Little Nicobar: ***The combination of a pre-tsunami ERS-1 image with a post-tsunami ERS-2 image, shows (in red) changes in low lying areas adjacent to the coast. There is a clear roll for ERS-2 data to contribute to the International Charter 'Space and Major Disasters'***

MONITORING LAND SURFACE MOVEMENT

There have been remarkably accurate results using the long sequence of ERS-1 and ERS-2 SAR measurements for measuring land surface deformations. From repeated SAR observations it is possible to select ground targets which maintain their coherence for a long period of time. Once these so called, Permanent Scatterers are identified, it is possible to measure their motion along the ERS-2 line of sight. Moreover, by combining ascending and descending passes, it is possible to separate vertical from horizontal motion to centrimetric precision.

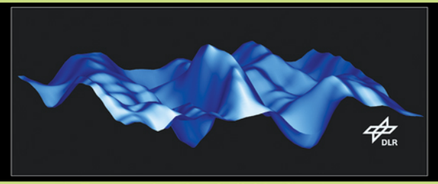
OCEAN WAVE HEIGHTS

The SAR Wave Mode imagettes taken every 200km along track are an important source of ocean wave information, including significant wave height, mean wavelength and propagation direction. Data are used in the assimilation of numerical ocean wave forecasts, and also to check whether the observed extreme waves are within the standard wave statistics currently used for marine design.



POLIMI

The Etna Volcano with colour overlay of surface movements detected using the 12 year time series of ERS-1 and ERS-2 data. The left image shows vertical velocities from -3cm/yr to +3cm /yr (from red to blue). The right image shows horizontal velocities from -2cm/yr to +2cm/yr. These results are making an important contribution to tectonic studies, revealing how the Eastern flank of Etna is moving off the Sicilian coast.



DLR

Topography of an individual wave of 25m height in the South Atlantic

Wind Scatterometer Applications

The **Wind Scatterometer** works by firing a trio of high-frequency radar beams down to the Earth's surface and recording the characteristics of the backscatter returned to the satellite. Wind-driven ripples on the ocean surface modify the radar backscatter and as the energy in these ripples increases with wind velocity, the scatterometer is able to measure wind speed and direction across the water surface. It is practically unaffected by heavy rain, and so can return useful wind data from extreme weather events such as hurricanes and tornadoes. In this way ERS-2 is helping to preserve life and minimise damage to property. The data are used operationally within routine weather forecasting assimilation algorithms, and this is the only scatterometer of this type currently in orbit.

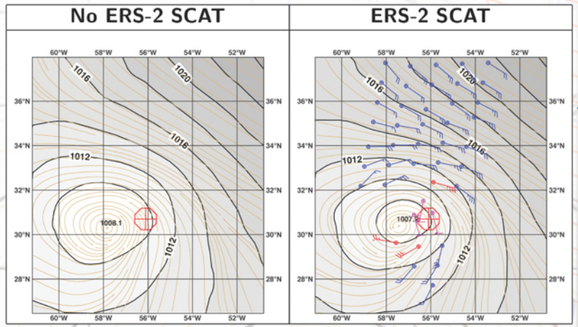
> ***"For the first time ERS-2 results are available for nowcasting, which is a whole new application for the satellite. You want observations of current weather on your desk immediately, otherwise you are already getting behind the actual facts"***
>
> **Ad Stoffelen of the Royal Dutch Meteorological Institute KNMI**

WEATHER NOWCASTING

After the loss of the on-board ERS-2 tape recorders, ESA has more than tripled the data acquisition rate, allowing data coverage in the North Atlantic and adjacent seas within 30 minutes. This is unprecedented for scatterometer winds, available nominally in about 150 minutes, and for the first time has allowed the use of scatterometer winds for weather nowcasting. At KNMI, a procedure has been developed to provide unique on-the-fly scatterometer winds, i.e., swath overlaps are taken out, and incomplete Wind-Vector-Cells are combined for completion. KNMI produces easily available real-time ERS-2 scatterometer wind products.

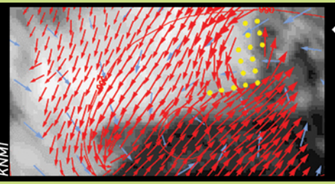
IMPROVING HURRICANE PREDICTION

Hurricane Kate was a category 3 Atlantic event, active between 25 September and 7 October 2003. Kate was captured twice by ERS-2 on 5 October, at 12.00 UTC and 14.00 UTC. When the scatterometer data are not assimilated, a positional error, relative to subsequent analysis, of 200km, is observed. Not only does the positional error improve when scatterometer data are used, but the vortex is shown with increased intensity which more closely matched the real situation.



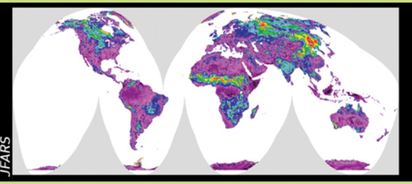
ECMWF

HURRICANE KATE
The ECMWF analysis at 12.00 UTC 5 October 2005, with and without Scatterometer data. Shown are: isobars (in black), wind streamlines (cream) and assimilated scatterometer winds (blue barbs). The observed hurricane centre is indicated by the red cross wire.



KNMI

On 23 April 2004 around midnight and west of Ireland, a complex low was developing. The red arrows show real-time ERS scatterometer wind speeds up to 15 m/s and a cyclonic wind direction. There is a significant improvement on the 3 hour forecast (blue arrows) which shows only one cyclonic centre and no shear line.



JFARS

SCATTEROMETER OVER THE LAND
Seasonal Variation of Vegetation Response

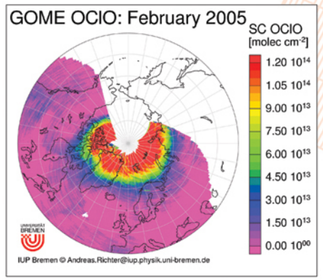
GOME Applications

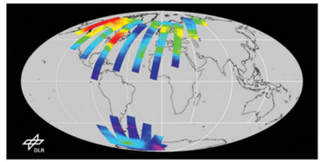
GOME has provided the first European trace gas measurements from space and has been a significant breakthrough for atmospheric remote sensing and the study of the physics and the chemistry of the atmosphere. As an instrument it is working as well today as it was at launch. GOME continues to provide data on stratospheric ozone, its primary objective, and key gases that control ozone, such as NO2, OClO and BrO. A secondary objective was to retrieve tropospheric trace gases such as NO2, SO2, HCHO, H2O and cloud and aerosol parameters. GOME continues to meet these goals very successfully. GOME data are downlinked to ground stations around the World. This enables observations of the **"ozone holes"** at high latitude in both hemispheres. These measurements can be used to determine the rate at which the atmosphere is recovering following the Montreal Protocol that initiated action to reduce ozone depleting substances in the atmosphere.

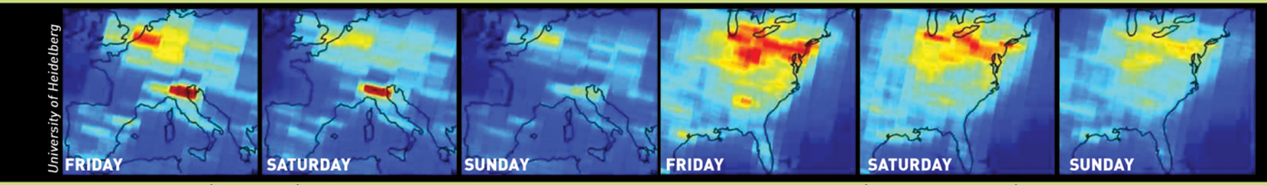
> **"GOME is providing evidence for changes in circulation patterns in the statosphere and is helping to answer the question: Are these natural changes or a response of the Earth Atmosphere system to climate chemistry interactions ?"**
>
> **Professor John Burrows, IUP/IFE University of Bremen**

GOME data are available on a near real time basis and can be used to monitor events when low levels of ozone lead to a significant increase in the risk from the Sun's UV radiation

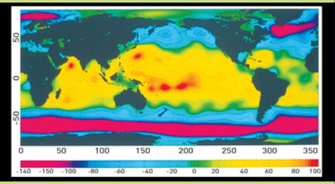
GOME provides measurements of gases that control ozone as well as details of the structure of the atmosphere, such as in this example, where the polar vortex has been initiated







Six years mean (1996-2001) of global tropospheric N20 measurements over the weekend for Europe (first three pictures) and the US East Coast (last three pictures). The reduced amount of pollution on Sunday is particularly noticeable



Ocean Topography

ATSR Applications

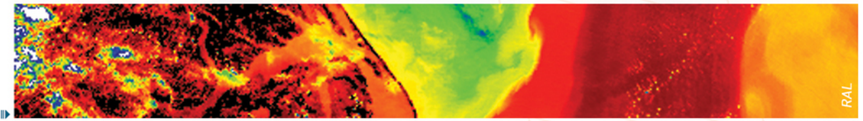
SEA SURFACE TEMPERATURE

Sea Surface Temperature (SST) is a relatively stable geophysical parameter, which is closely related to the available heat content of the Earth's climate system and is a useful indicator of climate change. However, the rates of change in global mean SST that can be attributed to genuine climate change, as opposed to natural variability, are expected to be small; rates of change are typically measured in tenths of a degree per decade. The ATSR sensor was designed for this and has achieved the required accuracy.

ATSR image of the Gulf Stream off the US coast. Warmer Gulf Stream is red, with colder waters to the north shown in blue and green. The importance of monitoring the Gulf Stream is universally recognised in the context of climate change

The **Along-Track Scanning Radiometer (ATSR)**, incorporating the innovative dual-angle view concept, has been producing high-quality global sea-surface temperature (SST) products to 0.1 Kelvin since ERS-1 launch in 1991. The ATSR instruments on ERS-1/2 and Envisat have provided SST data of unprecedented accuracy and consistency, meeting the demanding requirements of climate research. ATSR data are also used for monitoring atmospheric aerosol and over the land for fire detection. The difference in ERS-2 and Envisat overpass times of 30 minutes is providing opportunities for investigating diurnal variations in land surface temperature (LST) and soil moisture; important parameters for predicting vegetation development.

> **"Simultaneous operation of ERS-2 and Envisat provides excellent and important opportunities to cross-calibrate and cross-validate the data from the two sensors. This is particularly important for the climate record, where inter-sensor calibration helps guarantee the quality of the data"**
>
> **Professor David Llewellyn-Jones, University of Leicester**

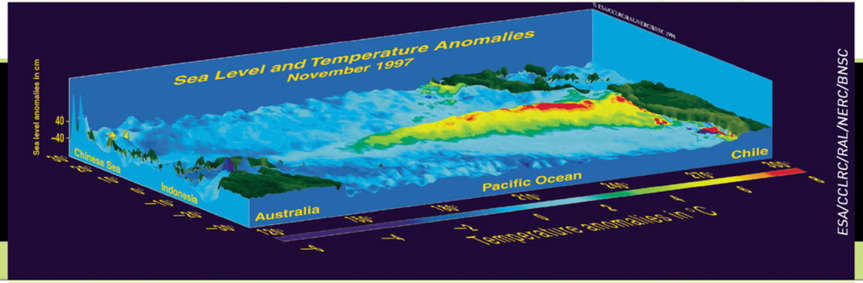


RA Applications

EL NIÑO

El Niño is a phenomenon of the ocean-atmosphere system in the tropical Pacific affecting the weather around the globe. It is characterised by changes in sea level and sea surface temperature, which are able to be monitored by the combined use of the RA and ATSR.

This 3D diagram shows the state of the Pacific Ocean in November 1997, when El Niño reached its maximum. Sea level anomalies based on RA measurements are shown vertically, ranging from -40cm to +40 cm. Colours indicate sea surface anomalies ranging from -6° C (in blue) to 8°C (in red). The correlation between temperature and sea level anomalies is clearly demonstrated.



> *ERS-2 has given us more than we ever dreamed of. From space we can now observe the chemical impact of human activities in the atmosphere, such as biomass burning from land clearing in the tropics, the photo chemical smog from urban centres, the NO2 emissions from ship traffic, surface ozone depletion at polar sunrise, and even 'the weekend effect' when people pollute less than on weekdays. GOME has been a pioneer instrument. Such instruments are of great value for international negotiations on air quality and climate*
>
> Professor Paul Crutzen, Nobel Prize Winner

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