→ FAREWELL TO ERS-2

Last 'tango' in space: adding to unique information from previous tandem missions, ESA's ERS-2 was paired up with Envisat for a final campaign in 2010. Data from this final duet are being used to generate 3D models of glaciers and low-lying coastal areas

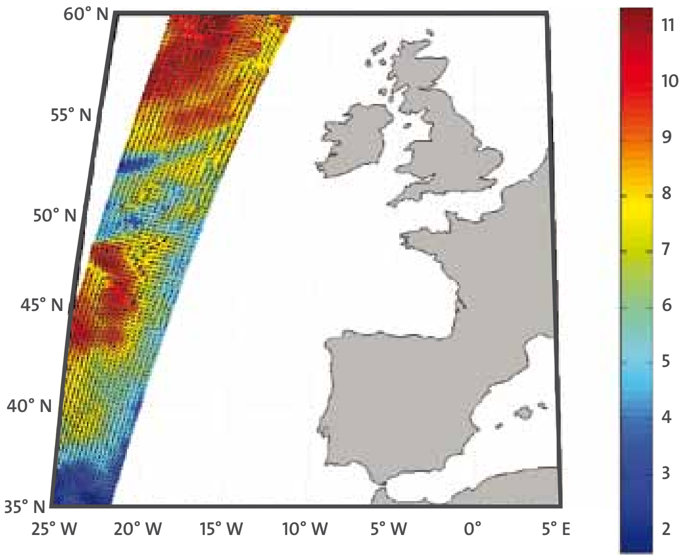
On 5 September the ERS-2 satellite was shut down after 16 years of service. Even in its final months, this sophisticated spacecraft continued to innovatively collect data about Earth's surface and atmosphere.

ERS-2 was launched in 1995, four years after ERS-1, the first European Remote Sensing satellite. With 20 years of continuous measurements, the two missions paved the way for the development of many new Earth observation techniques.

Both satellites carried the same suite of instruments that included the first long-term imaging synthetic aperture radar, a radar altimeter monitoring sea-level change and other powerful instruments to measure ocean-surface temperature and winds at sea.

ERS-2 also carried the first European high-precision instrument to measure atmospheric ozone. It was crucial for observing the evolution of annual ozone depletion over Antarctica.

Although ERS-2 was originally meant to be a three-year mission, it far exceeded its planned lifetime and continued to deliver crucial Earth observation data until the very end.



↑ Some of the last ERS-2 scatterometer data acquired on 3 July 2011. The ERS-2 scatterometer provided information on wind speed and direction at the sea surface. The ASCAT instrument on board MetOp continues the scatterometer measurements initiated by the ERS missions

↑ ERS-2 in the cleanroom at ESTEC, 1994

The ERS-2 'Ice Phase'

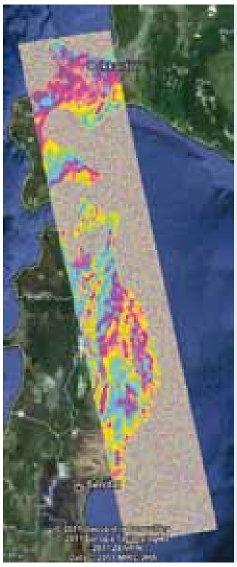
In response to a long-standing request from the cryosphere science community, and to achieve the maximum scientific benefits during the last months of ERS-2 activity, the satellite's orbit was lowered slightly in the spring of 2011. In this new orbit, ERS-2 was able to capture radar images of the same area on the ground every three days, rather than its previous 35-day cycle. The scientific objectives of this mission were to monitor ice-stream dynamics, glaciers, ice caps and post-seismic and volcanic deformation.

This new cycle immediately proved useful to the international community. The three-day repetition provided partial coverage over Japan, which had recently been struck by an earthquake and subsequent tsunami on 11 March 2011. Scientists used ERS-2 radar data to map post-seismic activity, such as aftershocks, further improving our understanding of such tectonic events.

Additionally, radar images acquired during this 'Ice Phase' revealed rapidly changing glacial features in Greenland. Frequent views of the Kangerdlugssuaq glacier showed that its ice stream was advancing steadily at about 35 m per day.

The final images were also compared to those taken by sister satellite ERS-1 in 1992, showing that the Kangerdlugssuaq ice stream's calving front had retreated by at least 5 km in the past 19 years.

"Now that ERS-2 is retired, no other flying or planned satellite is able to accurately detect the grounding line location of ice streams," says Marcus Engdahl, scientific coordinator of the ERS-2 Ice Phase. "This makes the data gathered by ERS-2 during its final months all the more valuable to scientists."

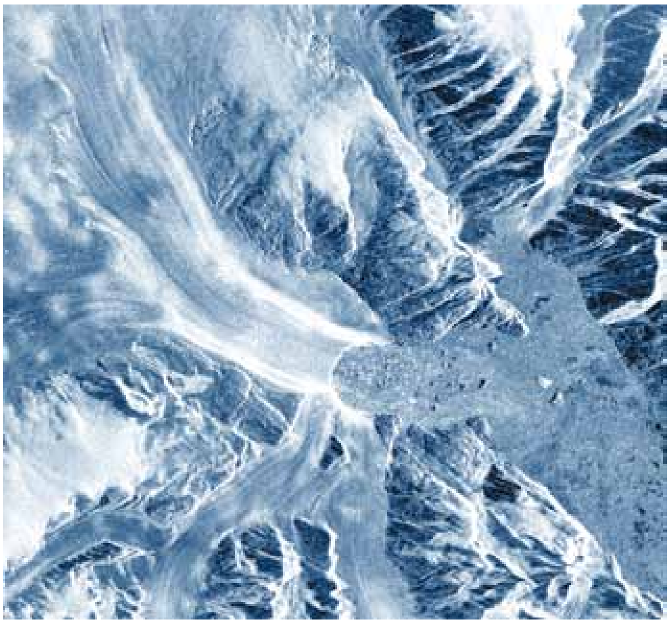


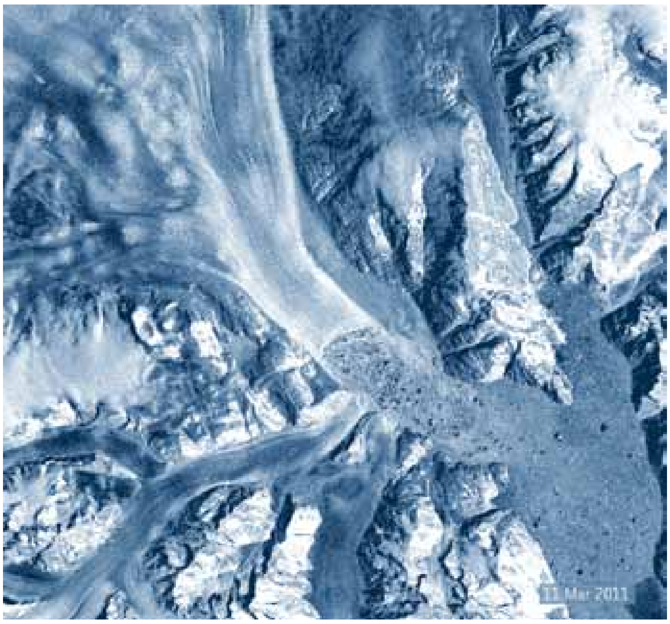
← ERS-2 SAR interferogram over the northern part of Honshu Island, Japan, in March 2011. The three-day ERS-2 revisiting time during the ice phase in Spring 2011 allowed for almost continuous monitoring and the extracting of the co-seismic deformation field with the post-seismic deformation filtered out

Mission complete

The ERS-2 satellite travelled 3.8 billion km in 16 years, providing data for thousands of scientists and projects. After orbiting nearly 85 000 times around Earth, the risk that the satellite could lose power at any time was high. To avoid it ending up as a piece of space debris, ESA decided to bring it down to a lower orbit while there was still enough fuel to do so. The lower orbit reduces the risk of collision with other satellites or space debris. With Earth's gravitational pull, the satellite is expected to burn up in the atmosphere in about 15 years.

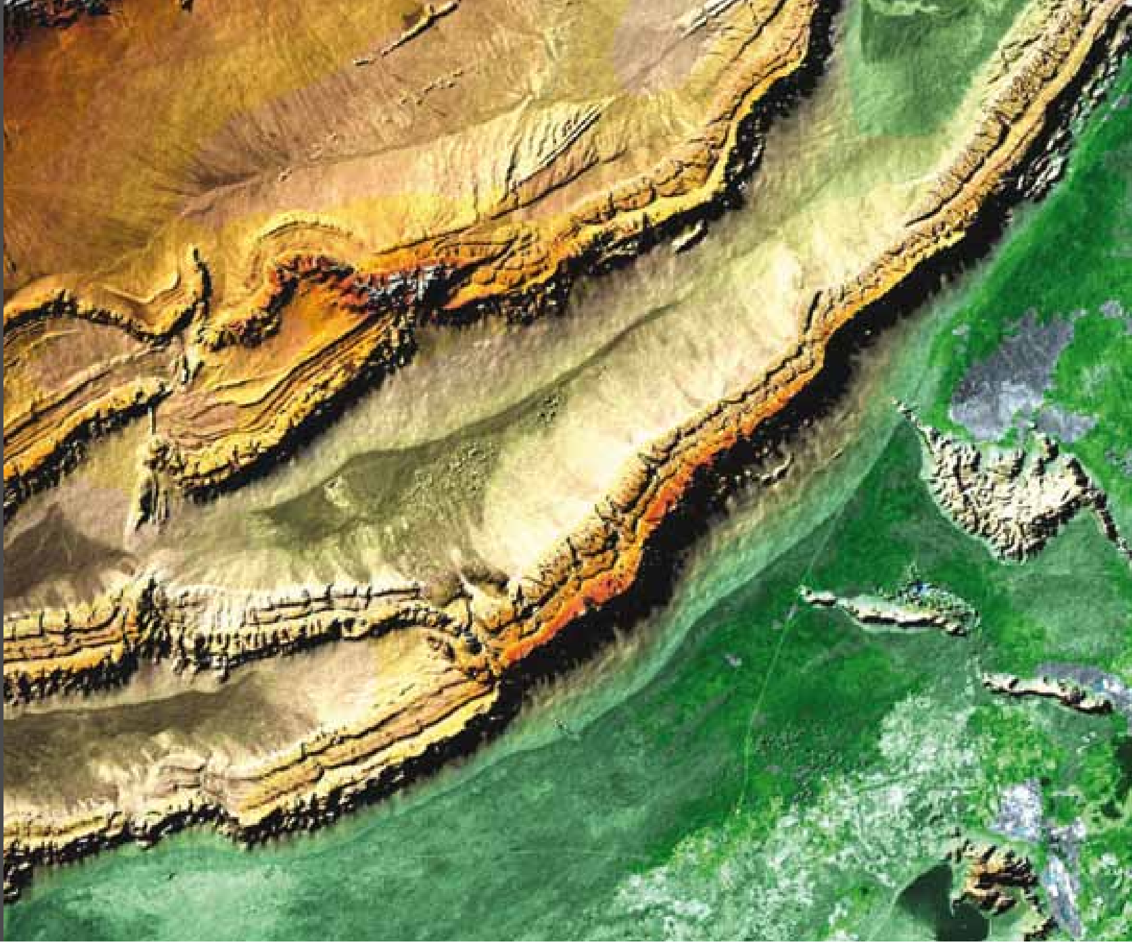
The first in a series of thruster firings to lower ERS-2 from its initial 785 km orbit began on 6 July. The burns each



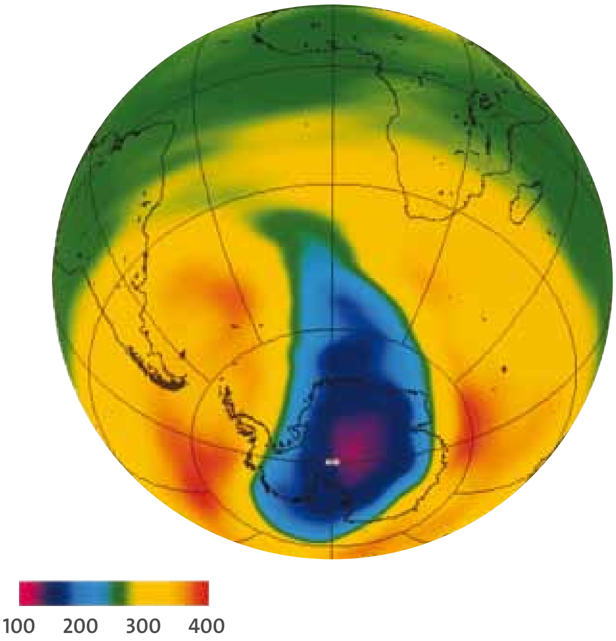


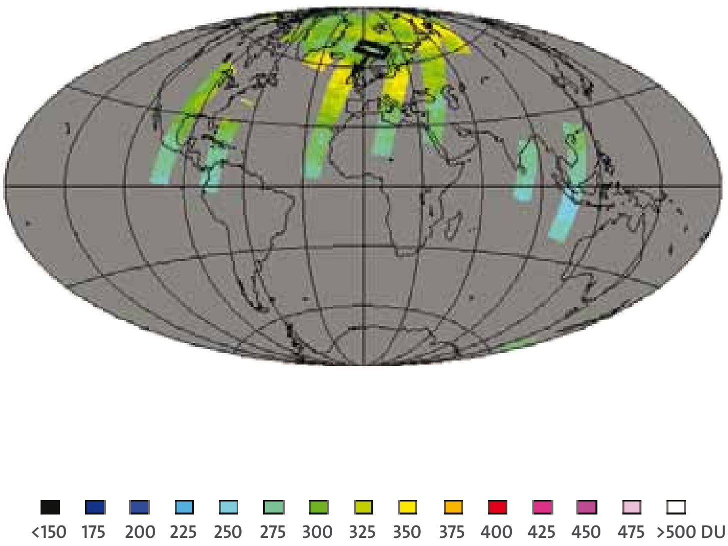
↑ ↗

Two ERS images of the Kangerdlugssuaq glacier in eastern Greenland, left in 1992 and right in 2011, show that the ice stream's calving front has retreated by 5 km in the past 19 years. Thinning in the ice stream and surrounding ice sheet is also evident



→ Varied elevations of Bachu and the nearby Tian Shan mountains in western China, in an image developed using data from the two ERS satellites. The ERS missions pioneered the technique of processing satellite radar data into digital elevation models, 3D relief maps to study changes in the terrain





↑ ERS-2 carried an instrument called GOME that helped to monitor the ozone layer around Earth. This is a GOME ozone measurement from October 1996, showing the opening of the ozone hole during austral spring (image produced from GOME-derived data from KNMI, pre-processed by DLR/Univ. Bremen)

↑ Last Global Ozone Monitoring Experiment map, acquired on 4 July 2011. The GOME instrument aboard ERS-2 was one of the longest serving ozone monitors in the world, with its success leading to a string of similar satellite sensors like GOME-2 on MetOp or SCIAMACHY on Envisat (KNMI) lasted about 300 seconds, and were commanded by the mission control team at ESA's European Space Operations Centre in Germany. Engineers closely monitored the manoeuvres via ESA's ground stations in Kourou, French Guiana, and in Malindi, Kenya.

Once the satellite had been lowered to about 570 km, ERS-2 entered the final 'passivation' phase in late August 2011 aimed at ensuring that all energy sources and pressurised systems were depleted or rendered safe. This primarily comprised of exhausting the fuel, disconnecting the batteries and switching the transmitters off.

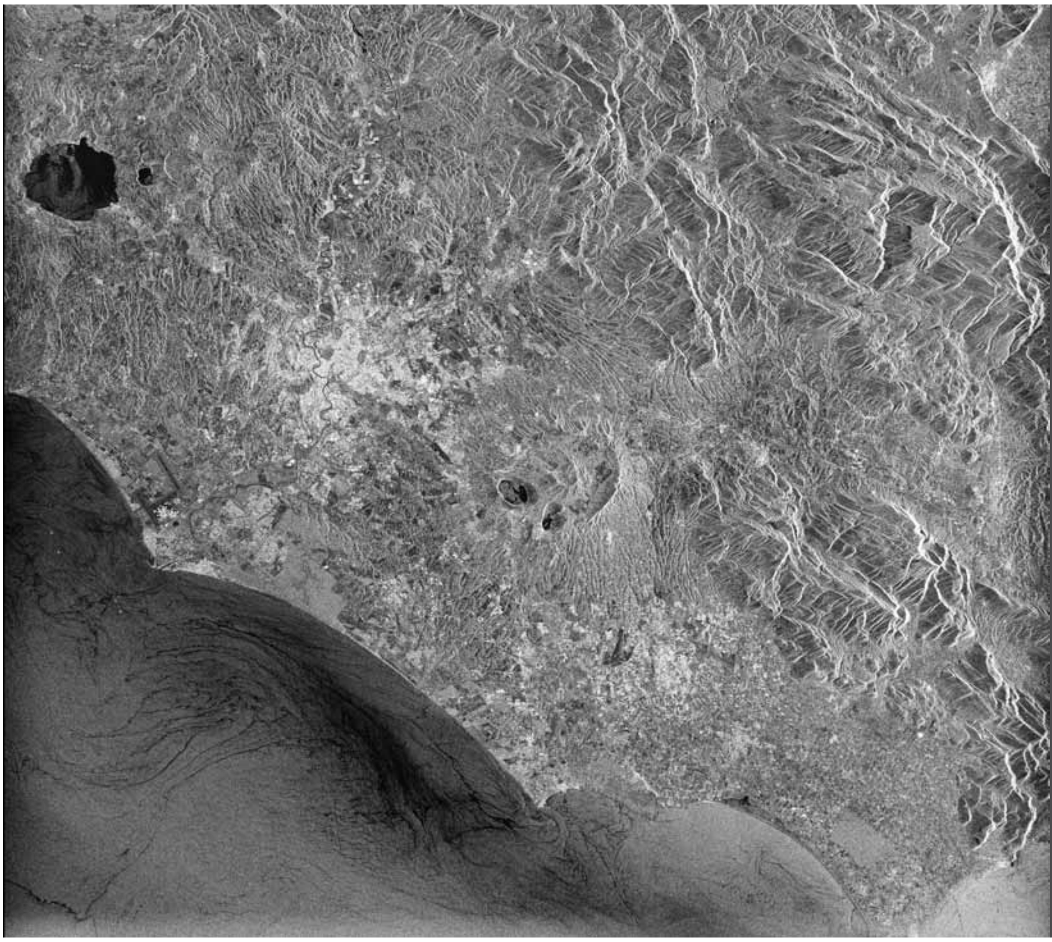
Unlike a car, ERS-2 has no convenient gauge that indicates when fuel is running low. So to exhaust the remaining fuel, controllers conducted a series of thruster firings that alternately raised and lowered the spacecraft altitude slightly. Doing this, controllers could monitor the fuel depletion by judging if the thrust had become uneven or intermittent.

The firings occurred while the satellite was tracked by ESA's ESTRACK ground stations in Kiruna (Sweden), Maspalomas (Canary Islands) and Kourou. Additional tracking support was provided by the Japan Aerospace Exploration Agency station in Katsuura, and the Svalbard station operated by Norway's Kongsberg Satellite Services.

"ERS-2 deorbiting [was] conducted in compliance with ESA's space debris mitigation guidelines. This indicates the strong commitment by the Agency to reduce space debris, which can threaten current and future robotic and human missions," says Heiner Klinkrad, Head of ESA's Space Debris Office.

The veteran satellite was finally shut down on 5 September, but the end of flight operations does not mean the end of the mission's usefulness. Twenty years of data acquired by both ERS missions will continue to be used by scientists for their Earth observation and climate change studies for years to come. The missions have also paved the way for imaging radar and interferometry technologies, which are now being implemented in several current and future satellites.

"We will continue exploiting data gathered by ERS-2, especially the radar imagery," said Volker Liebig, ESA's Director for Earth Observation Programmes. "Combining this rich scientific heritage with new data delivered by improved radar instruments on the GMES Sentinel-1 mission will generate strong synergies as we work to understand our planet's climate." ■



← Last ERS-2 image over Rome, acquired using the Synthetic Aperture Radar on 4 July 2011