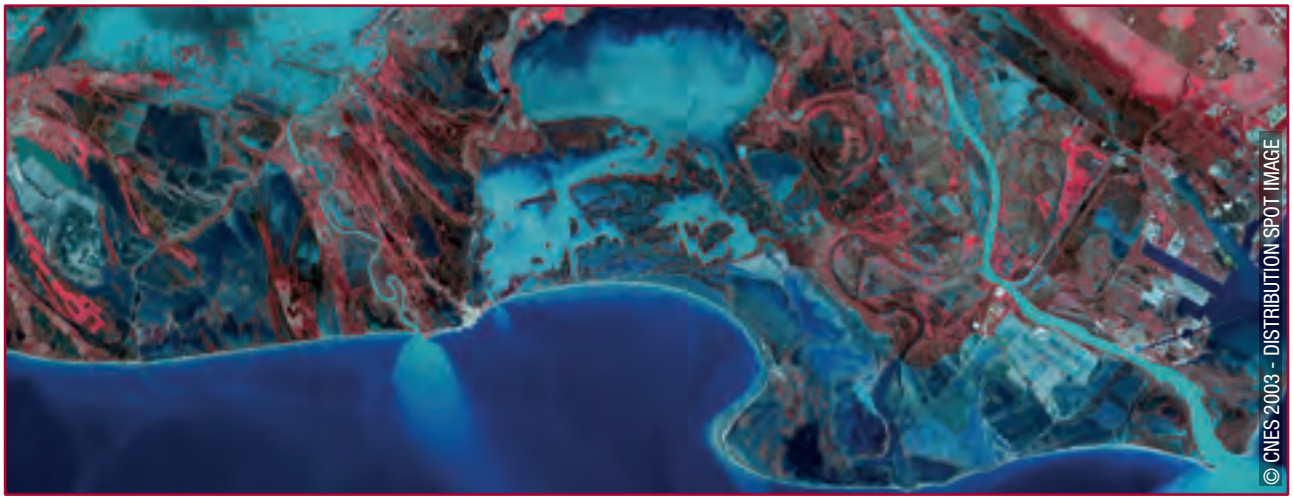
esa

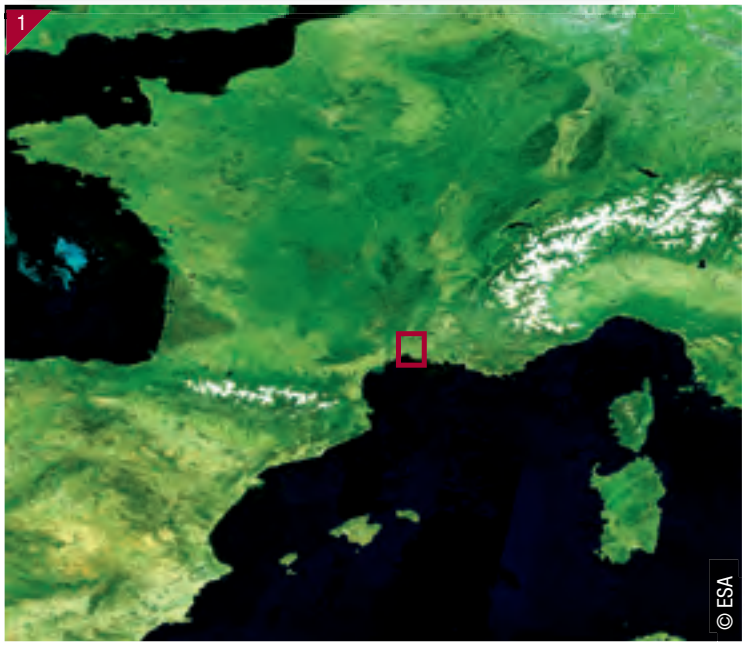
10- Flood monitoring



European Space Agency
Agence spatiale européenne

the Living Planet

THE 2003 FLOODS IN THE SOUTH OF FRANCE



The Rhone, which flows into the Mediterranean, is swollen, in addition to rainfall, by melting Alpine snow and glaciers. When heavy rains fell in autumn 2003, the river's rate of flow increased considerably, causing flooding.

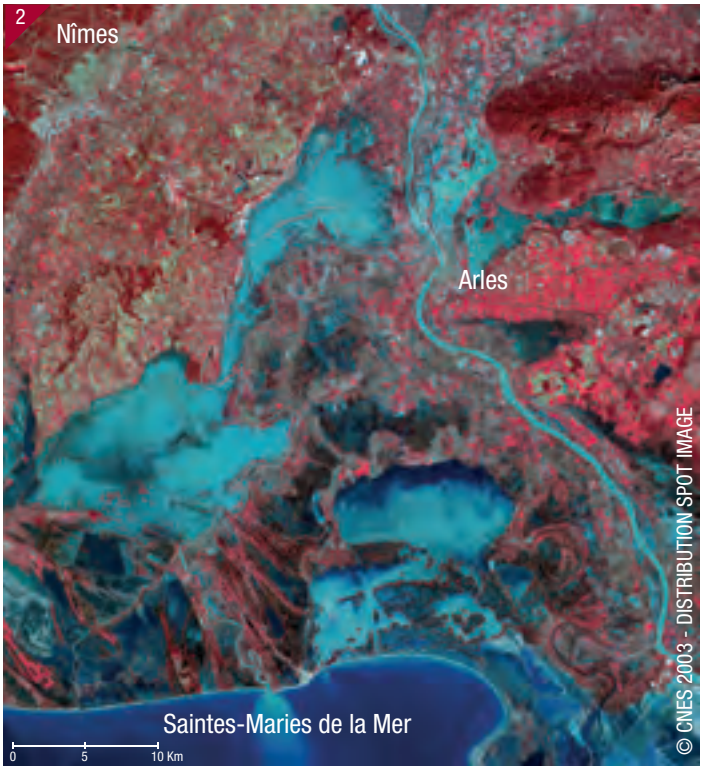


Image of a flooded Camargue (France) taken by SPOT 5 in December 2003.

In December 2003, very heavy rains led to flooding in the south of France. The waters of the Rhone flooded thousands of square kilometres and the town of Arles found itself under water for several weeks.

Usually, water infiltrates the soil and flows down into underground water tables.
But when the soil ceases to absorb excess water, serious flooding can result. This is the case in areas where human construction (roads, car parks, housing development, industrial and commercial zones, etc) increase the extent of impermeable areas.

All the water runs off, converging directly at streams and rivers, causing their levels to rise rapidly. Even agriculture can aggravate this problem, for example as a result of bare fields which form hard impermeable crusts in the summer which the water cannot easily drain through. Forests, by contrast, are very effective at absorbing the additional volumes of water that storms produce in a short space of time. The damp soil swells with water, retaining it like a sponge.

Today, floods are having serious consequences as human construction spreads out ever further, often in areas close to water courses.

Flooding occurs when rivers receive more water than their bed is able to contain. It is almost always very heavy rains which are the cause of such flooding. When violent storms occur, water levels can rise very quickly, spelling danger to human life.

4

Arles submerged by flooding (7th December 2003). Although the natural phenomenon of such sudden and heavy rainfall is nothing new, infrastructures put in place by humans exacerbate the consequences.

5

Laboratory-processed satellite image of the flooding in the area around Arles.

ASSISTING PREVENTION AND EMERGENCY RESPONSE

Important information is obtained by analysing and processing satellite images in specialised laboratories. Here, for example, one can clearly see the rate at which water levels have fallen in the area affected by flooding and the areas in which the flood waters have remained present the longest (north of Arles).

Emergency response in a flooded neighbourhood.

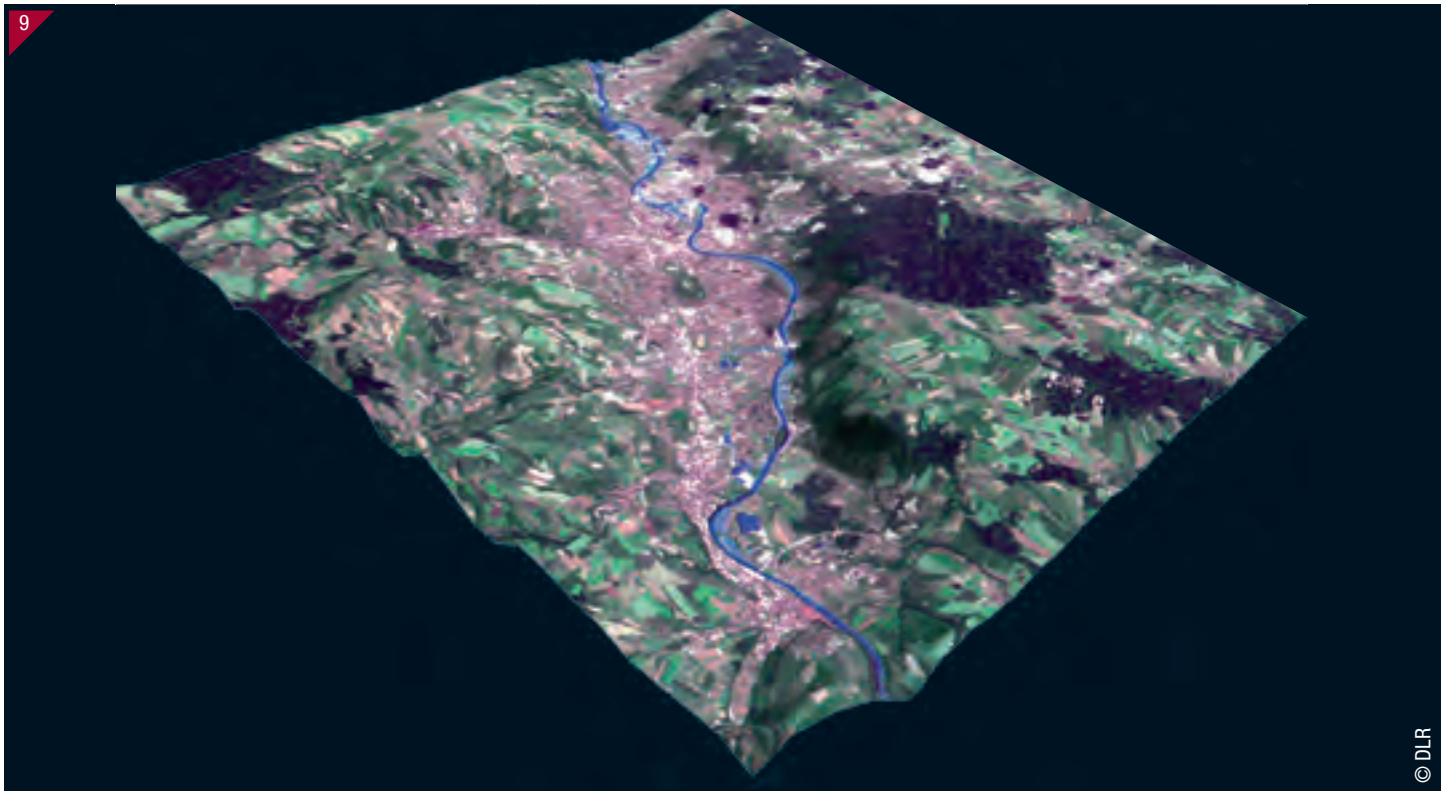
Damage caused by flooding can be very substantial, affecting homes, the workplace and schools. Roads and railways can become impassable, while agricultural land and livestock can also be affected.
Sewage systems can themselves become flooded with the risk of drinking water contamination. Energy and communications networks can also sustain damage.

With satellites it is possible to identify both flooded areas and those which are prone to flooding. That information is essential when organising and directing the emergency response. Using very large-scale views from the SPOT satellite, it is possible to determine which routes should be used by emergency services to evacuate people from the disaster area or to come and provide assistance.

Satellites provide the data required to produce detailed maps highlighting areas prone to flooding.
Such data can also be used as a means of assessing what equipment and work are required to limit the effects of such disasters in the future.
If the flooding persists over a long period, emergency services also have to help those in the disaster zone cope with their precarious situation, possibly for several weeks, while their own working conditions are made difficult by the flooding.

Flooded neighbourhood to the north of Arles, France. Satellite imagery makes it possible to see which access routes are still passable.

THE 2002 FLOODING IN GERMANY



Measurements carried out by satellites are used to reconstruct relief maps of whole regions, in this case the Elbe valley and the city of Dresden.

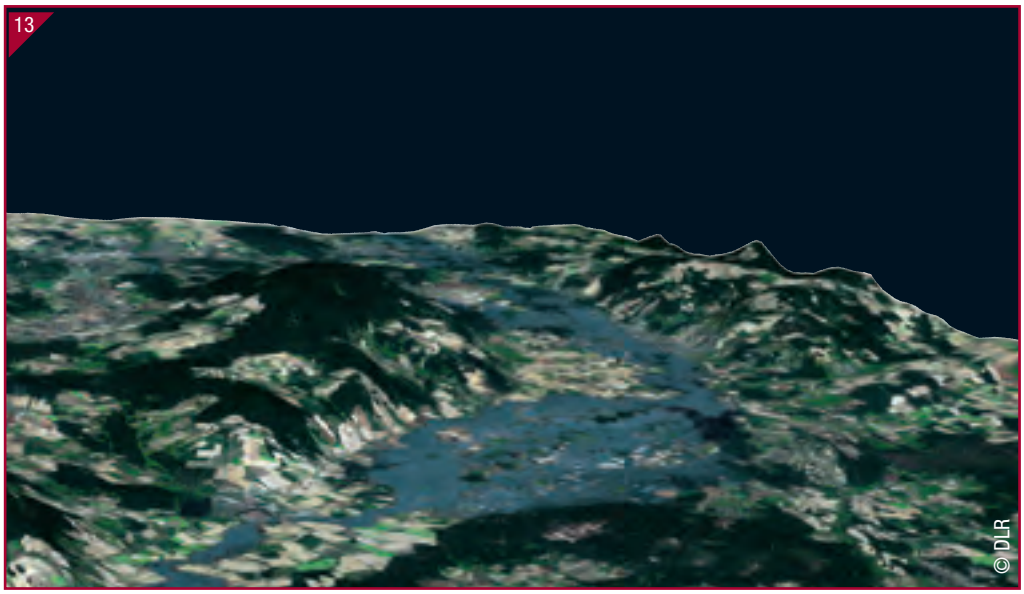
In this satellite image, the flooded areas around Dresden in September 2002 are indicated in blue.

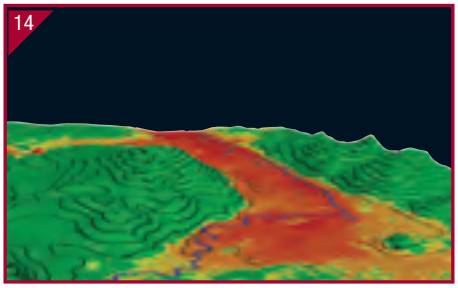
Three-dimensional views allow regions to be represented with greater realism so as to facilitate understanding and analysis of a flood's consequences. They also make it easier to visualise the situation on the ground.

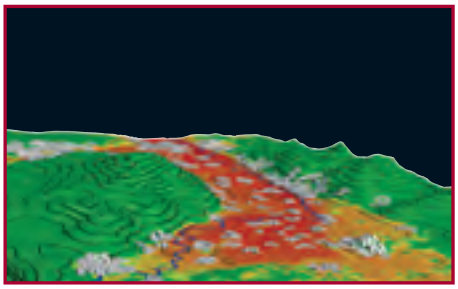
Dresden. Aerial views of the flooded city centre in September 2002.

How do satellites work?

Satellite images highlight areas prone to flooding



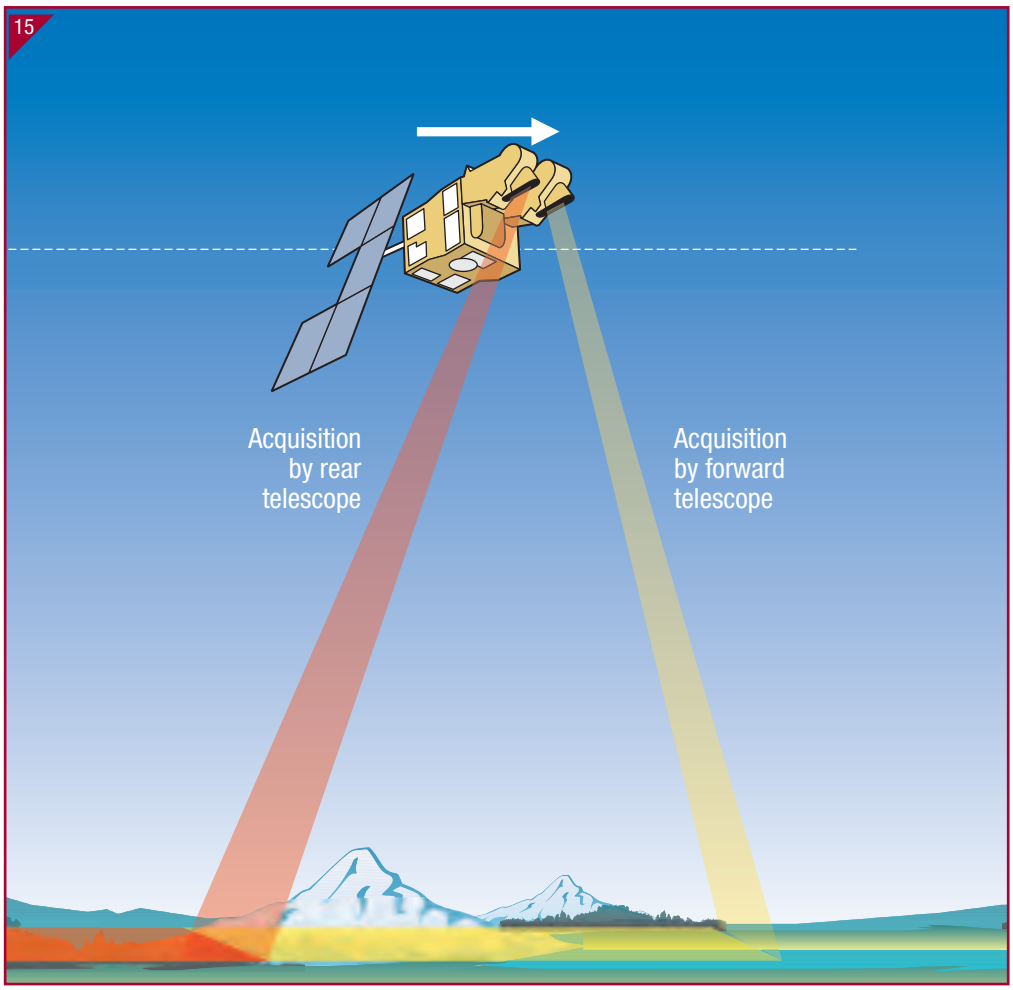




Flood-prone area around the town of Wittenberg.

Relief maps are produced using two images, each from a slightly different viewpoint, thus replicating how the human eye works. From these satellite views, it is possible to produce computer-generated images containing information on various infrastructures and thus to identify equipment in at-risk areas.

How are satellite measurements used to produce three-dimensional images?



To produce a three-dimensional image, an object must be observed from two different angles. A relief image is a combination of two such views, from slightly different angles, of the same object.

It is possible for a single satellite to produce such 3D images: for example, SPOT has two sensors, one forward- and one rear-pointing. At a few minutes' interval, each of these captures an image of the same zone viewed from a different angle. These are then pieced together to reproduce relief.

Information for teachers

The "Information for teachers" sheets are designed to offer assistance with the preparation of classes and complement the worksheets handed out to pupils. They contain useful information for the presentation of the subject, additional information relating to the satellite images, and a list of websites dealing with the subjects concerned.

Worksheet 10: Flood monitoring

Worksheet 10 discusses risks and natural disasters around the world, taking as an example the floods caused by the Rhône (2003) and Elbe (2002) rivers. The worksheet considers the fragility and vulnerability of human societies with respect to the forces of nature, brought more or less under control.

This worksheet can be used to:
- locate and identify certain at-risk regions in Western Europe;
- distinguish the different natural risks for human societies;
- evaluate the role humans play in the consequences of natural disasters;
- apply concepts such as variables, risks, disaster, vulnerability, etc.

Risks and natural disasters in the world

Each year nearly 250 million people are affected by one or more natural calamities. Although the most vulnerable are the populations in developing countries, which are located in the tropical belt and are subject to natural disasters, wealthy countries are not exempt. Over the past 35 years, 3 million people have died worldwide in a natural disaster. Of these, 97% lived in developing countries, in Asia and Africa in particular. Insufficient infrastructure, the absence of prevention systems, and inadequate emergency services are among the different factors that help underscore the strong correlation that exists between poverty and the impact of natural disasters.

Since the early 70s, the CRED (Center for Research on the Epidemiology of Disasters) has surveyed nearly 7,000 disasters, not counting epidemics. Natural disasters are much more common, more deadly, and most costly than technology-related catastrophes. Munich Re, a German reinsurance company, has estimated that in 2004, without including the costs of the tsunami in South and Southeast Asia, natural disasters had cost approximately 40 billion dollars, making it the most expensive year in insurance history. This cost could have been still higher had the value of the property destroyed during the catastrophes been greater in the developing countries. In fact, property in these countries is almost always valued very low and is under-insured. By contrast, the losses sustained as a result of these disasters always make up a major share of the GDP of the affected countries.

In Western Europe, such risks remain fairly moderate, though they are present all the same. Dramatic flooding took place recently in the fluvial plain and humid regions in Europe, notably in the Somme, Gard, and Bouches-du-Rhône regions of France and in the Elbe river valley in Eastern Germany. Seismic risks are also present, and several mini earthquakes have shaken the Vosges, Alps, and even Brittany. There is continuing volcanic activity in the south of Italy and the Chaîne des Puys region in Auvergne, France is not entirely risk-free. In 2004, 641 natural disasters were recorded around the world (Source: Munich Re 2004 report). The percentages by disaster type are as follows: storms (41%), floods (24%), earthquakes (13%) and other (16%). The geographical distribution is very uneven across continents: Africa (7.5%), Europe (19%), Americas (26%), Asia (39%) and Oceania (8.5%). The major disaster of the year was the tsunami in South and Southeast Asia on December 26, 2004 which caused an estimated 300,000 deaths.

The satellite images

Cover page

Cover image: The Rhône Delta in France (SPOT 5 image, 2003)

The flooded areas to the west of Lake Vaccarès appear in blue in this image taken using the near infrared band. As a result, vegetation is shown in red (see Worksheet N°11, "Colours in satellite imagery", for information on infrared images).
To the right of the picture, it is possible to distinguish the industrial facilities at Fos sur Mer.

Core content

Image 1: France (Envisat/MERIS image, 2004)

This image shows the Camargue and Rhône delta, as well as the snow-capped mountainous regions of the Pyrenees and Alps, which constitute one of the water reserves that contribute to the risk of flooding.

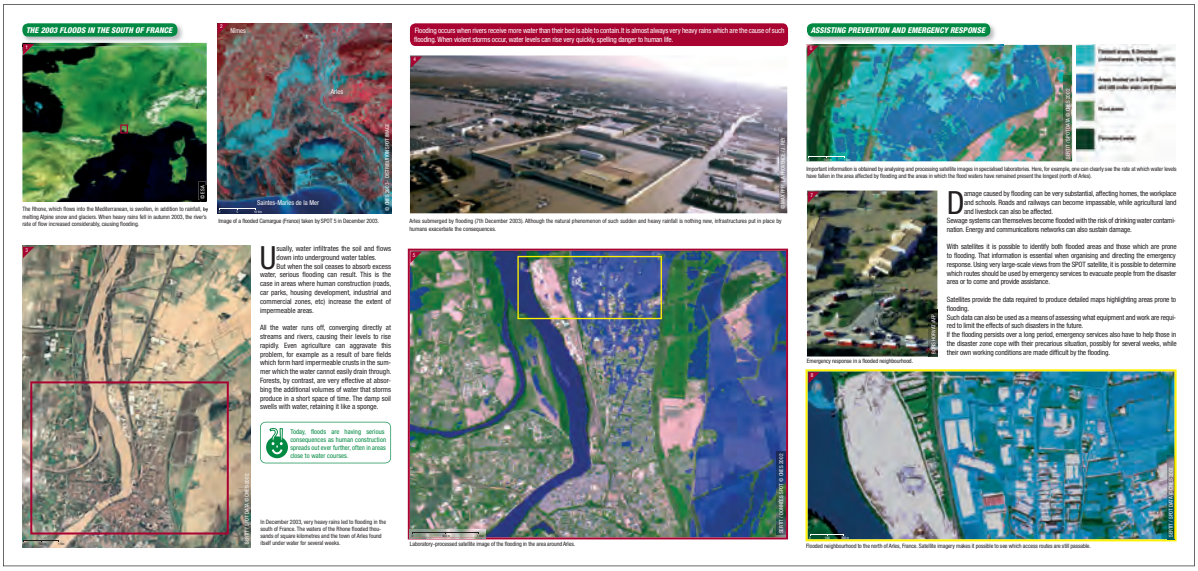
Image 2: The Rhône Delta in France (SPOT 5 image, 2003)

This image is the same as the one on the front cover, except that it shows a wider expanse of the Camargue. The flooded areas to the south and east of Nîmes and north of Arles are particularly visible. Between Nîmes and Arles, the roads have been cut off.

Images 3, 5, 6 and 8: Flooding in the Arles region

These four satellite images of the Arles region were taken by the SPOT 5 satellite and were processed by SERTIT, France's remote sensing and data processing service. SERTIT has a rapid-response cartography department, which processes satellite data and images in order to rapidly produce maps and images for emergency rescue services.

These images highlight the extent and scale of the damage affecting the devastated area and can immediately be used by those whose job it is to respond. SERTIT also produces series of maps showing the evolution of a disaster over time. It also intervenes outside Europe, providing, for example, satellite images of the earthquakes that struck Boumerdes in Algeria and Bam in Iran and of the south-east Asian tsunami in December 2004.



Page 5 - Flooding of the Elbe in September 2002

Images 9 and 10 : Dresden and the surrounding area (DLR, 2002)

The two satellite images shown here were also processed by SERTIT.

Aerial photographs also have their uses but obviously to obtain each series of shots, a specific plane or helicopter flight has to be scheduled. Orbiting satellites, on the other hand, fly with great regularity over every region of the world and have differing fields of view and spatial resolutions, which makes them adapted to every situation. They are often equipped with radar instruments which can also supply information at night or in overcast conditions. This is also the case with satellites that can capture data in the infrared. Satellites are also a particularly useful tool for crisis monitoring and management.

The flooding of the Elbe was particularly devastating: in places the level of the river rose by more than 9 metres. 9 people died and more than 20,000 inhabitants of Dresden were evacuated.
At the time, more than 740 kilometres of roads and 180 bridges were damaged or destroyed in the various countries affected by the floods.

Page 6 – "How do satellites work?"

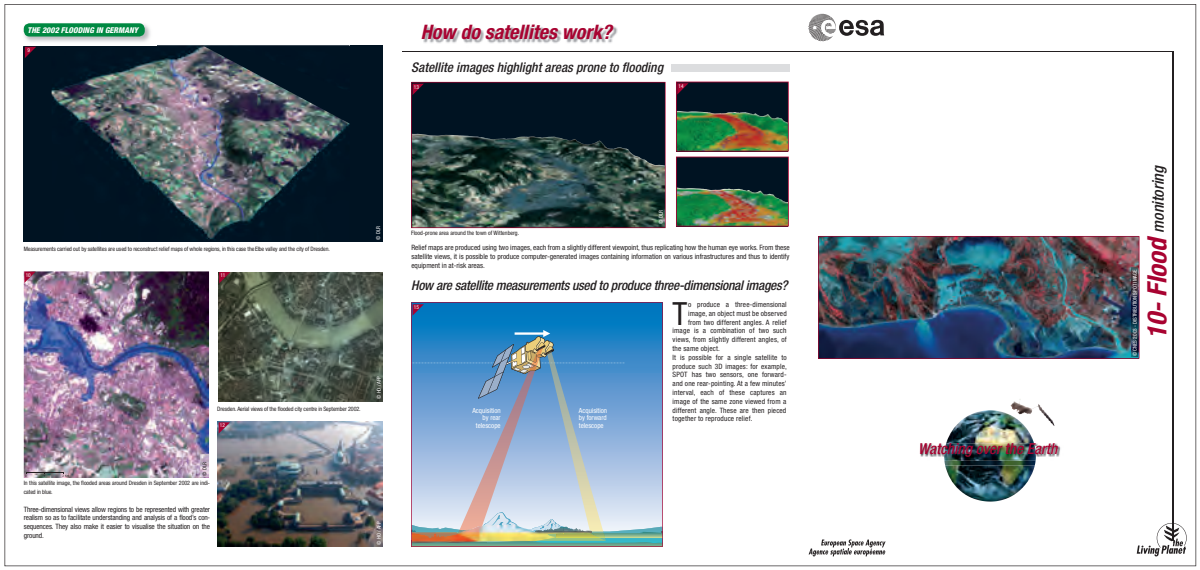
Images N°13, 14 : Easily flooded zone around Wittenberg

These three-dimensional images of the Wittenberg region were created by the Germany space agency, the DLR .
Such 3D images give a more realistic representation of the true lie of the land. They allow more precise assessment and expert analysis, which is more tailored to the situation and thus helps with management of the response. They also help with the setting up of prevention programmes and with making changes designed to lessen the impact of such disasters.

Images N°15 : 3-D images from Spot 5

The SPOT satellite carries on board the HRS (High Resolution Stereoscopic) instrument. Two cameras view at a fixed 20° angle, one pointing forwards and the other back, with a 90 second gap between the two shots of the same area, thus making it possible to obtain stereo views of the terrain.

Using these data, it is possible to generate 3D views and especially Digital Elevation Models (DEMs) of the terrain precise to within ten metres, which are used in many different areas including cartography, civil and military aeronautical databases or when setting up telephone networks. Each stereo view covers a wide area of up to 600 by 120 km.



Online resources

www.esa.int	ESA (European Space Agency) website
www.esa.int/SPECIALS/ESRIN_SITE/index.html	ESRIN (European Space Research Institute) website ESRIN is ESA's centre for Earth observation
www.esa.int/eo	ESA Earth observation website
earth.esa.int/earthimages	Gallery of ESA satellite imagery
www.esa.int/education	ESA educational website
www.eduspace.esa.int	Earth observation educational website (EDUSPACE)
www.cnes.fr	CNES (Centre National d'Etudes Spatiales) website Presentation of the French national space agency's missions and activities
www.cnes-edu.fr	CNES educational website
www.spotimage.fr	SPOT IMAGE gallery

NATURAL DISASTERS

ec.europa.eu/research/leaflets/index_en.html	European Commission: research in action - disasters/Floods
ec.europa.eu/environment/water/flood_risk/index.htm	EU action aimed at combating and managing flooding
www.cred.be	Website of the Centre for Research on the Epidemiology of Disasters (CRED), Université Catholique de Louvain, Belgium
www.disasterscharter.org	Website of the International Charter "Space and Major Disasters"

IMAGE PROCESSING

sertit.u-strasbg.fr/english/en_welcome.htm	SERTIT website: France-based remote sensing and image processing service
www.dlr.de	German space agency, DLR (Deutsches Zentrum für Luft- und Raumfahrt) website

Satellite images

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Illustrations	Philippe Bouillon - Illustratek
Translations (ESA)	Colin McKinney / Anthony Blend
Production	Europimages - Aliette Cremer

Worksheet N° 10 – Flood Monitoring

Once you have read and carefully examined the worksheet, please answer the following questions :

1 – What natural phenomena cause flooding?

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2 – What human activities aggravate natural factors?

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3 – Why are human-made structures particularly vulnerable to flooding?

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4 – How are satellite images useful during floods?

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5 – How can satellite images be used to prevent floods?

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6 – Look at the page discussing flooding in Germany in 2002. What similarities do you see between the satellite images and the aerial photographs? What additional information can be found in the satellite images?

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7 – What kind of satellite image is especially helpful for monitoring a valley or a region that may flood? Why?

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8 – Give a rough description of how a satellite produces a three-dimensional image. What similarity is there with the way human vision works?

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