Earth Watching: A Window on Special Events

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History

The Earth Watching project started at the end of 1993, during an emergency in Germany of extensive flooding lasting several days in the Cologne-Bonn area. This event made it evident that during natural disasters, users and government authorities need data more quickly than standard delivery times, in order to gain an immediate broad picture of the extent of the affected areas.

Earth Watching is a joint Eurimage - ESA/ESRIN project. Its primary aim is to demonstrate the benefits of satellite remote sensing technology in emergencies: prediction, assistance or analysis. More generally, its objective is to widen awareness of the potential of remote sensing applications and to promote the use of remote sensing data. It is based on fast and preferential access to sensor planning, image generation and product distribution, and can count on dedicated, even if limited, image processing and interpretation resources. The resulting planning information, images, maps, references, text, etc. are loaded on dedicated Internet pages and can be provided in hardcopy for distribution through newspapers, magazines and television stations. This type of information has made it possible to support activities such as monitoring of threatened or ongoing floods, intervention during disasters, monitoring of pollutants in open waters, detection of ships, detection of fires, and also non-emergency, public-interest applications such as locating archaeological sites.

Earth Watching relies mainly on the remote sensing data directly managed by, or accessible through, ESA and Eurimage. Operations include sensor planning (where applicable), near real-time production, fast transmission, image processing and interpretation, text preparation, and dissemination of results.

Remote sensing data

Since satellites can cover large areas in a single pass, the resulting data from on-board instruments can quickly provide an overview of an emergency event and identify areas under threat or already affected.

Radar sensors, such as the Synthetic Aperture Radar (SAR) on board ESA's ERS-1 and ERS-2 satellites, are excellent tools for obtaining data thanks to their all-weather and day/night capability (data acquisition independent of cloud coverage or Sun illumination). This is particularly important during, for example, flooding, which is normally characterised by cloudy skies.

Optical sensors, like NOAA's AVHRR and the Russian RESURS-O1, with their wide swath and high pass repetition, can be used for detecting medium to large fires. ATSR on board ERS-1 and ERS-2 and EOSAT's Landsat-5, can provide more details on already active fires and burned areas. The optical sensors are excellent for providing multi-channel information which can be combined with radar to identify even more features.

Organisation

The Earth Watching Team activities are normally triggered by external events, e.g. media news or meteorological forecasts (Fig. 1). When starting a new activity, the team first collects as much information as possible. Sources include ESA Public Relations, various press agencies, the Internet and the Eurimage distributor network (about 40 distributors in 32 countries in Europe, North Africa and the Middle East). Data acquisition opportunities are then checked and, if necessary, a special acquisition plan is prepared for ERS-2 (and ERS-1 when active). The information on expected and planned acquisitions from all possible sensors is loaded on the Internet together with links to related news from the media.

The acquisition stations concerned are alerted. At the same time, suitable archive data over the area is searched and priority generation of related products is requested. These products are inserted into the image processing system and prepared for integration with the data being acquired. The resulting multi-temporal image will permit detection of changes.

At the time of data acquisition, the receiving stations involved are asked, depending on their location and processing capability, to either ship the raw data or to locally generate the product and send it to ESRIN by special delivery (or via telecommunication links when feasible). From the receiving station in Fucino (I), it is possible to receive a quick-look of the scene shortly after the pass, and to select and receive a subset of it in full or reduced spatial resolution.

As soon as the new images are received, they are loaded on the Internet where they are accessible through standard World Wide Web browsers. High quality prints of the images are also made available for distribution to newspapers, magazines and television stations.

Normally, quick-look (low resolution) images are available on line two or three hours after the acquisition. Within a few more hours to one day, they are followed by a higher resolution image of the affected area together with a rough interpretation text. This is updated by a multi-temporal image with refined interpretation text in approximately two more days. Finally, within one to two weeks, higher level products (e.g. subsets of the satellite image superimposed on the map) with additional text or photos collected from the Internet, newspapers, etc. are made available on line.

New attempts are continuously made to simplify image interpretation and to improve the overall service (new filters, layouts, dissemination systems, etc.). In this respect, the Earth Watching Team also cooperates with other research institutes, national entities or value-adding companies. This is also done through special projects.

During 1997, the Earth Watching team was involved in two risk management projects conducted in cooperation with European industry: one related to plains flooding and the other to earthquakes. These projects required Earth Watching to broaden its scope and procedures by incorporating the planning and production sectors of other mission operators for the use of Spot, Radarsat and Indian Remote Sensing satellite data. This increased the probability of obtaining complete data for any single event. In the case of the flooding project, two alert exercises were performed on simulated cases. The first simulated event permitted the identification of bottlenecks and the improvement of the overall system performance. Both simulations demonstrated the adequacy of the structure to provide suitable data in time and confirmed the possibility for adequate data coverage when all available missions are used. In fact, one real flood event was successfully monitored in this way by the same team, outside the project simulations.

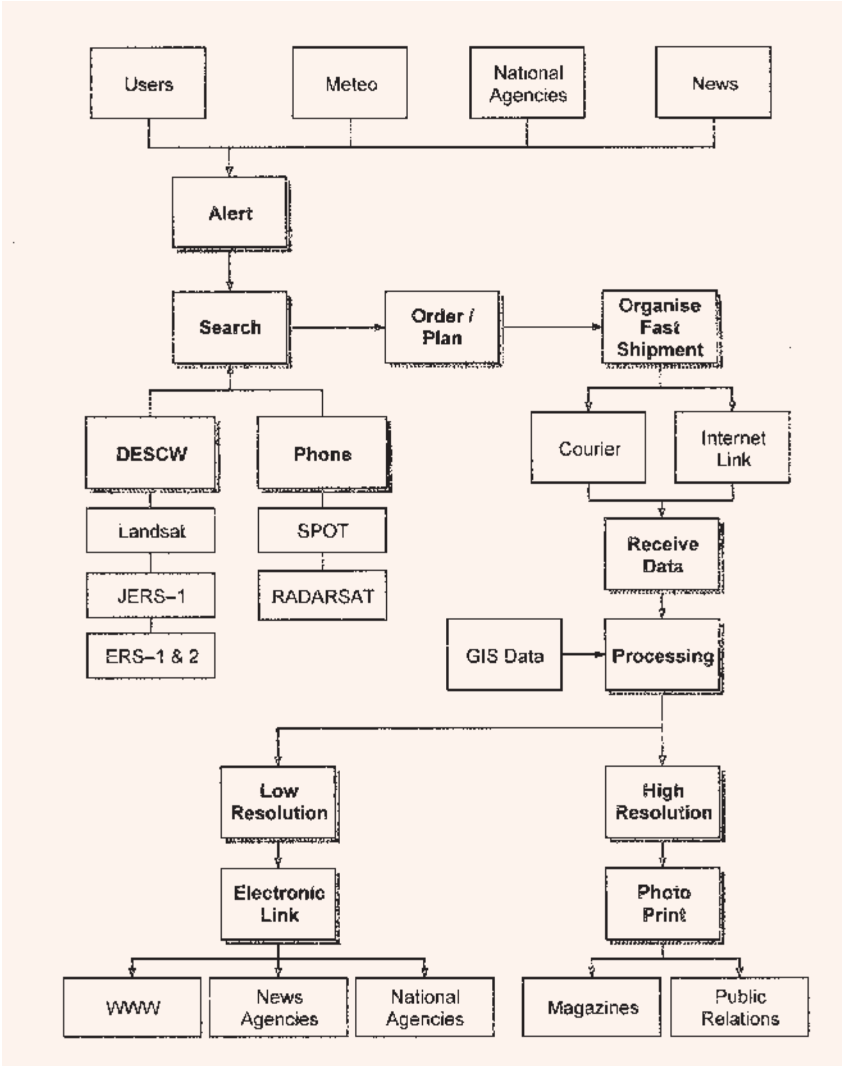


Figure 1. Data acquisition and distribution flow-chart

Conclusion

During these four years of activity, the Earth Watching project has provided support to numerous events, as demonstrated by the examples in this article. The results are available on line*.

A glossy publication, titled an “Earth Watching Anthology”** has also been prepared and distributed.

* http://earthnet.esrin.esa.it or
http://www.eurimage.it

** A limited number of copies are available for distribution; please contact the ESRIN Helpdesk via e-mail: eohelp@esrin.esa.it or tel. : +39 6 941 80 777

Oil Spills, North Sea, 1996

Each year ships and industries damage the delicate coastal ecosystem in many parts of the world by releasing oil or pollutants into rivers and coastal waters. Offshore environments are also polluted by mineral oil mainly due to tanker accidents, illegal oil discharges by ships and natural seepage. After a tanker accident, the biggest difficulty is to obtain an overall view of the phenomenon, getting a clear idea of the extent of the slick and, if possible, predicting the way it will move. For both natural and man-made oil spills it is necessary to operate a regular monitoring programme.

The Synthetic Aperture Radar (SAR) instrument, which can collect data independently of weather and light conditions, is an excellent tool with which to monitor and detect oil on water surfaces. Oil slicks appear as dark patches on SAR images.

Figure 2 was acquired from ESA's ERS-2 satellite on 18 July 1996 at 11 a.m. (Greenwich time) by the Fucino ground station and by the Tromsø Satellite Station (TSS). The Earth Watching Team discovered some oil slicks in this image during data screening and asked the expert operators of TSS for an interpretation. The overall low grey level in the scene suggests that there is little wind in the area, ranging from about 1 to 7 m/s. This condition is ideal for detecting an oil film. In the image, located northwest of Bergen (Norway), there are two possible oil slicks of roughly 12 x 5 km^2 and 14 x 3 km^2. Both slicks are diffuse and it looks as if the wind has spread them. They are probably several hours old. Conditions for detecting surface dumping features are optimal, and slicks related to almost every oil platform (the very bright points) in the image can be observed. These slicks may be caused by water disposal, drilling fluids or oil. The almost completely black area in the top right of the image is due to low wind conditions.

Operators at the TSS routinely analyse all SAR data received at the station. If an oil slick is discovered, as in this case, a communication is sent to the Norwegian Pollution Control Authority (SFT) by telephone and fax. The SFT surveillance aircraft often operates near the satellite acquisitions and a direct link between the operators of TSS and the pilots is established.

Figure 2. ERS-2 SAR scene acquired on 18 July 1996 showing oils slicks in the North Sea

Fire and Smoke in S-E Asia, 1997

Every year millions of acres of forest and savanna all over the world are destroyed, and animal and plant species disappear as a result of deforestation and fires caused by human activity, with significant effects on the delicate global ecosystem. Using data from satellites, it is possible to quickly obtain a general overview of the situation over large areas of terrain, to monitor the emergency, identify risks, detect fires and, once the fire has been controlled, assess the damage by mapping the extent of the burned areas.

In the summer of 1997, Southeast Asia suffered its worst drought in five decades and, consequently, hundreds of forest fires – many started deliberately as a method of clearing land – began to burn out of control. A cloud of smoke covering an area more than half the size of the continental United States sent air pollution in the affected area well above hazardous levels. In Sarawak, Borneo, the blanket of soot and smoke meant that every man, woman and child was inhaling the equivalent of two and a half cigarettes a day.

Images were produced at ESRIN using data from three ERS-2 sensors: SAR (Synthetic Aperture Radar), ATSR-2 (Along-Track Scanning Radiometer) and, in co-operation with the German Aerospace Research Centre (DLR), GOME (Global Ozone Monitoring Experiment). Those derived from ATSR-2 infrared data (Fig. 3) to detect hot spots were compared to pictures derived from ERS-2 GOME Level-2 products (Fig. 4), which contain the total column amount of the trace gas nitrogen dioxide. The GOME instrument can only measure during daytime; its swath consists of three ground pixels, each one measuring 40 km along-track and 320 km across-track. High values indicated in red can be correlated with the hot spots measured by the ATSR and certainly indicate biomass burning. The map (Fig. 5) shows the locations of individual fires.

The SAR image (Fig. 6) shows an area in the Tanjung Puting National Park, which with its more than 3000 km^2 of rare wildlife and flora, is the largest and most diverse protected example of the extensive coastal tropical swamp forest which used to cover much of southern Borneo. The multi-temporal image combines data from two different dates to make a colour composite image in which colours indicate changes between the two acquisitions. Green shows the healthy vegetation, while the areas appearing in magenta tones are most probably the ones affected by the deforestation caused by the fires.

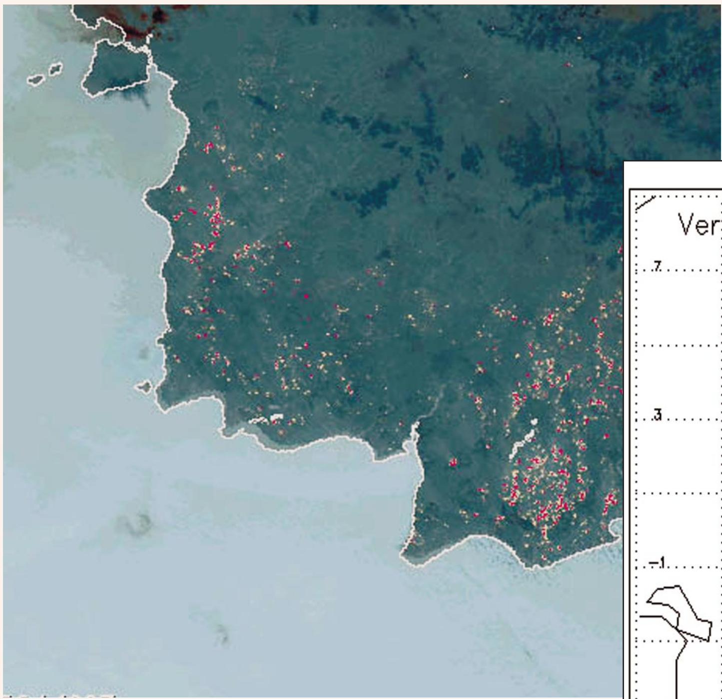


Figure 3. ATSR colour composite image, 1 km resolution, from 15 September 1997. The coastline has been added in white. All pixels indicating a temperature above 39°C have been rendered as red spots. Cold clouds appear in black and warm areas (over 32°C) in yellow

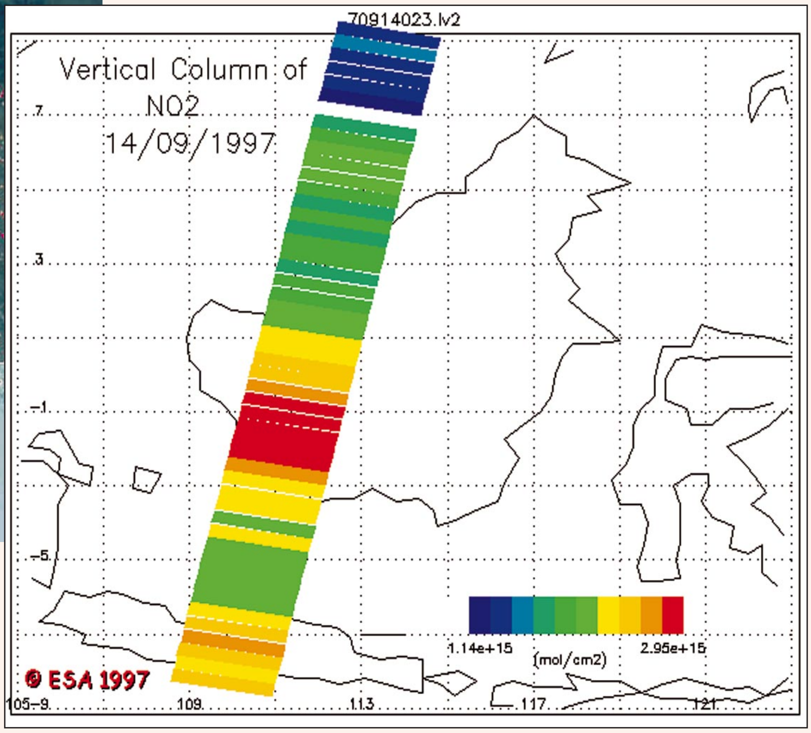


Figure 4. GOME data from 14 September 1997. More images are available on the Earth Watching WWW site

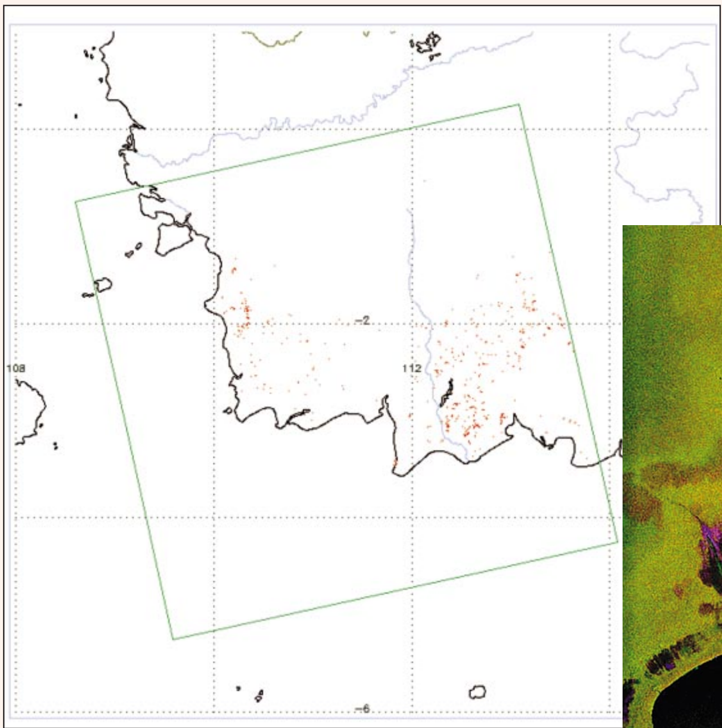


Figure 5. Map showing the locations of individual fires

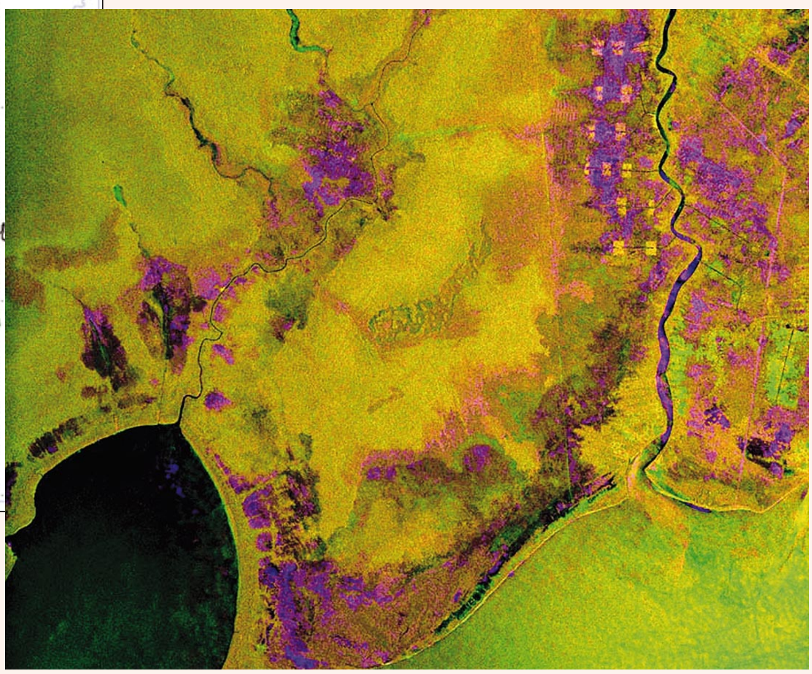


Figure 6. ERS-2 SAR multi-temporal image, combining data from 22 October 1996 and 7 October 1997

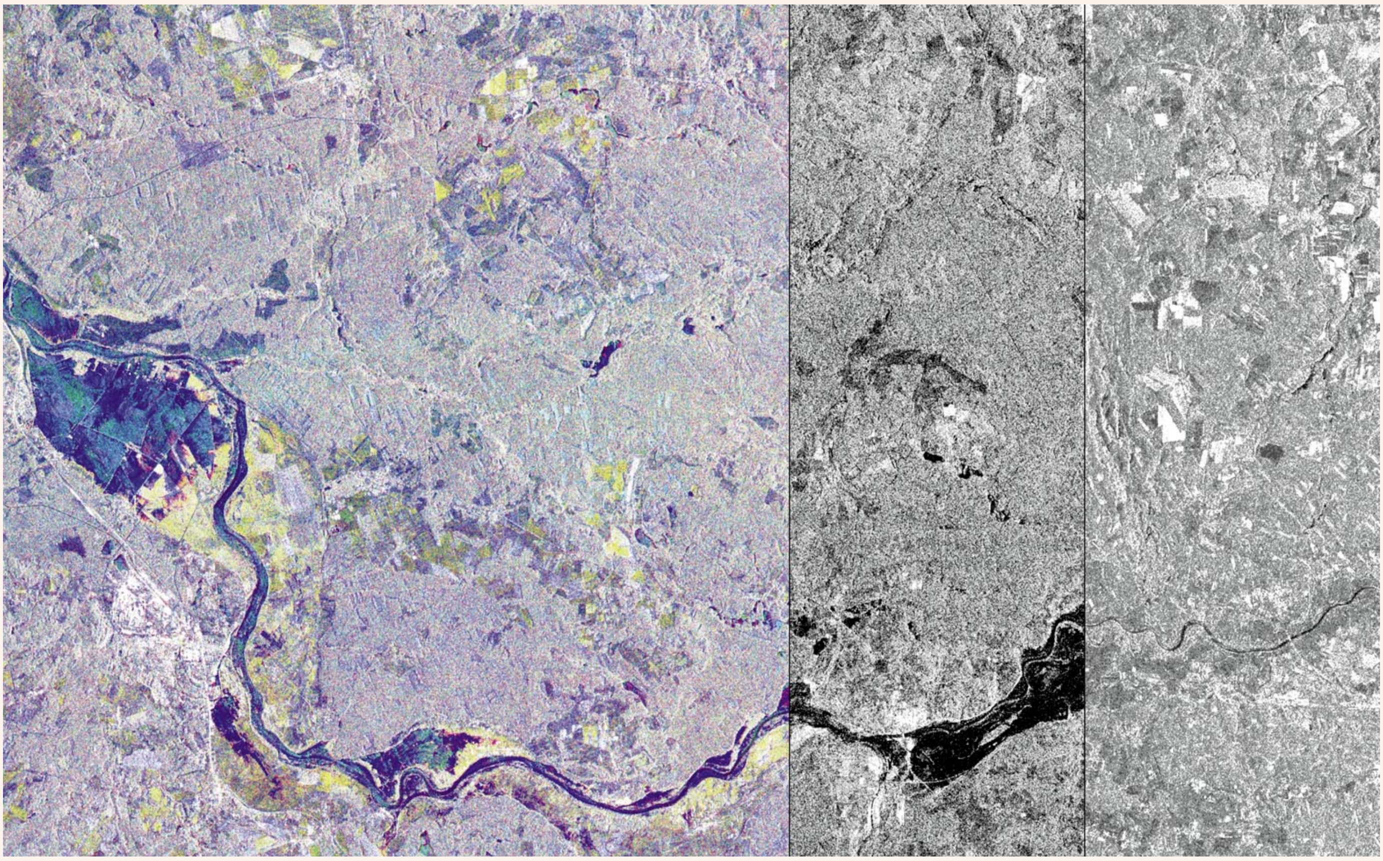
Flooding around the Oder River, Poland-Germany (1997) and in Béziers, France (1996)

One of the primary problems during flood emergencies is to obtain an overall view of the extent of the affected area and to predict likely developments. Aerial observation is often impossible due to prohibitive weather conditions and can be very time-consuming and expensive. However, the ERS-1 and ERS-2 satellites' Synthetic Aperture Radar (SAR) instruments can collect data independently of weather and light conditions. The data can provide the required assessment of the damaged area and produce detailed maps for both hazard assessment and input to hydrological models used for planning preventive measures.

To highlight the flooded areas, a multi-temporal technique is normally used. Black and white radar images of the same area are taken on different dates and assigned to the red, green and blue colour channels in a colour image. The resulting multi-temporal image clearly reveals the change in the Earth's surface through colour: the hue and intensity of the colours indicate the date and degree of change.

The technique is illustrated in Figure 7, which reveals flooding around the Oder River on 5 and 6 August 1997 at the Polish-German border. On the far right, the normal summer situation shows the narrow, shallow river presenting a weak radar reflection. Alongside is part of an image from 6 August showing the black reflection from the flood waters. The multi-temporal image brings out the changes between the two dates. Areas flooded on both dates are dark blue, while those flooded on only the 5th or 6th are magenta and green, respectively.

Figure 7. Multi-temporal ERS-1and 2 SAR image of the Oder River flooding on 5 and 6 August 1997 at the Polish-German border



On the night of 29 January 1996, a fierce flood descended on the small southern French town of Béziers. Four lives were lost and more than six hundred people evacuated. From the Loire to the Ardennes, 2700 towns and villages were devastated. The Earth Watching Team loaded the images to the Web within days of the flooding.

ERS-1 passed over at 23:00 local time on 28 January 1996, during heavy rainfall (more than 200 mm in 24 hrs); ERS-2 crossed the area at the same time a day later. In Figure 8, the bright white areas are the city of Béziers and towards the bottom left, the city of Narbonne. Due to very wet soil conditions on both dates, the prevailing colour in the coastal plain is greenish-cyan, except for the hills of Montagne de la Clape, which are covered with Mediterranean shrubs and pines. The reddish zones and spots in the lower parts of the plain were flooded during both January acquisitions. This flooding came from the River Aude, north and east of Narbonne. The worst damage occurred along the Orb River, crossing the city of Béziers. The green-yellowish area above Béziers indicates that it was flooded on the 28th from the arrival of the water that had fallen in the mountains to the north. The huge bluish-magenta area below Béziers and in other parts of the scene, as well as the reddish parts in the lowlands, reflect the situation of the flooded surface on the 29th. The large oblong area of a faint bluish colour appearing close to Narbonne still needs to be fully explained. It might indicate land hit by heavy rainfall immediately before and during the acquisition, leaving behind water-soaked terrain.

When integrated into a Geographical Information System (GIS) with other data on flooding mechanisms, this type of image is of great benefit for estimating, in 'near real-time', the extent and dynamics of the flood, as well as for the validation of hydrological models for assessing flood risks.

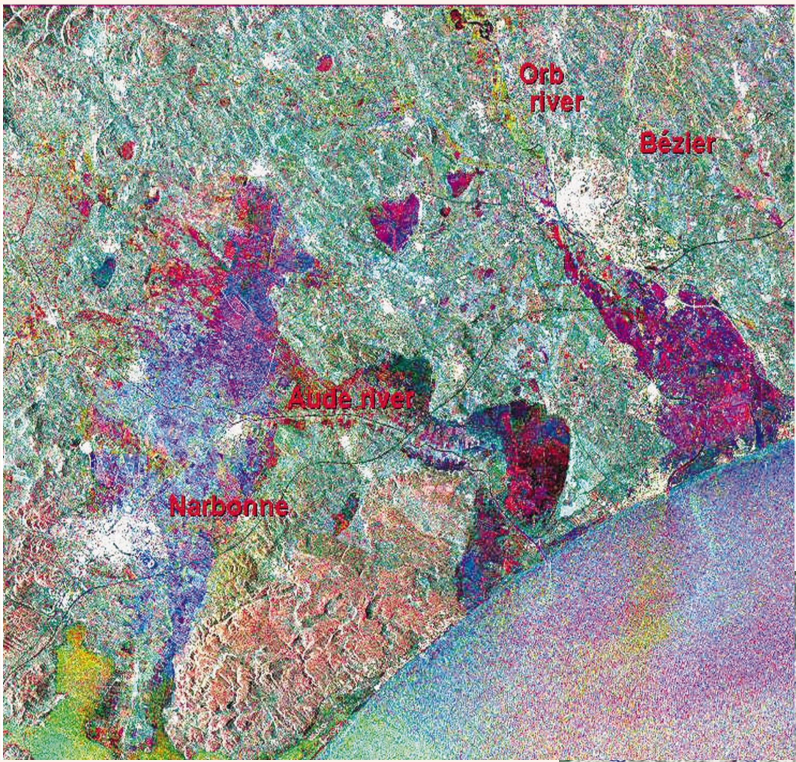


Figure 8. Red: ERS-2 SAR, 7 August 1995
Blue: ERS-1 SAR, 28 January 1996
Green: ERS-2 SAR, 29 January 1996

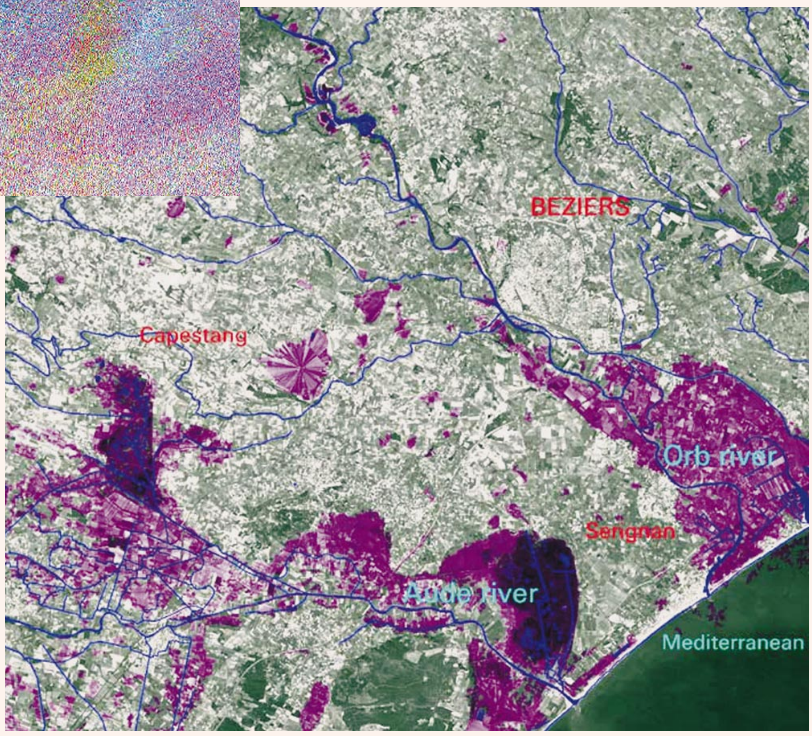


Figure 9. Here the flooded areas have been extracted from the multi-temporal SAR and superimposed on a SPOT panchromatic image (10 metre-resolution) by Laboratoire Commun de Télédétection CEMAGREF