Mapping floods from space

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Earth Observation satellites could monitor areas hit by flooding such as in Ireland recently, report Dr Conor Cahalane, Dr Avril Behan and Dr Eugene McGovern

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December 2015 and January 2016 saw extensive flooding along the banks of the River Shannon in the Republic of Ireland, with Limerick, Athlone and Portumna particularly badly affected. The cost involved for infrastructure repair and clean-up could reach ?100m, while the cost to businesses and livelihoods is as yet unknown.

The unpredictability of flooding presents serious problems when attempting to devise management strategies, and accurate, regular mapping and monitoring is therefore vital.

Planning for flood defences, drainage works and possible relocations requires extensive surveying and mapping. Gaining daily access to tens of thousands of properties along the Shannon river catchment for monitoring is not possible in this time frame using conventional ground survey methods, and although aerial platforms can survey large areas quickly and efficiently, flights may be cancelled during bad weather.

However, a space-age alternative exists. A low-cost mapping technology that provides rapid, regular, extensive coverage is the current generation of Earth Observation (EO) satellites.

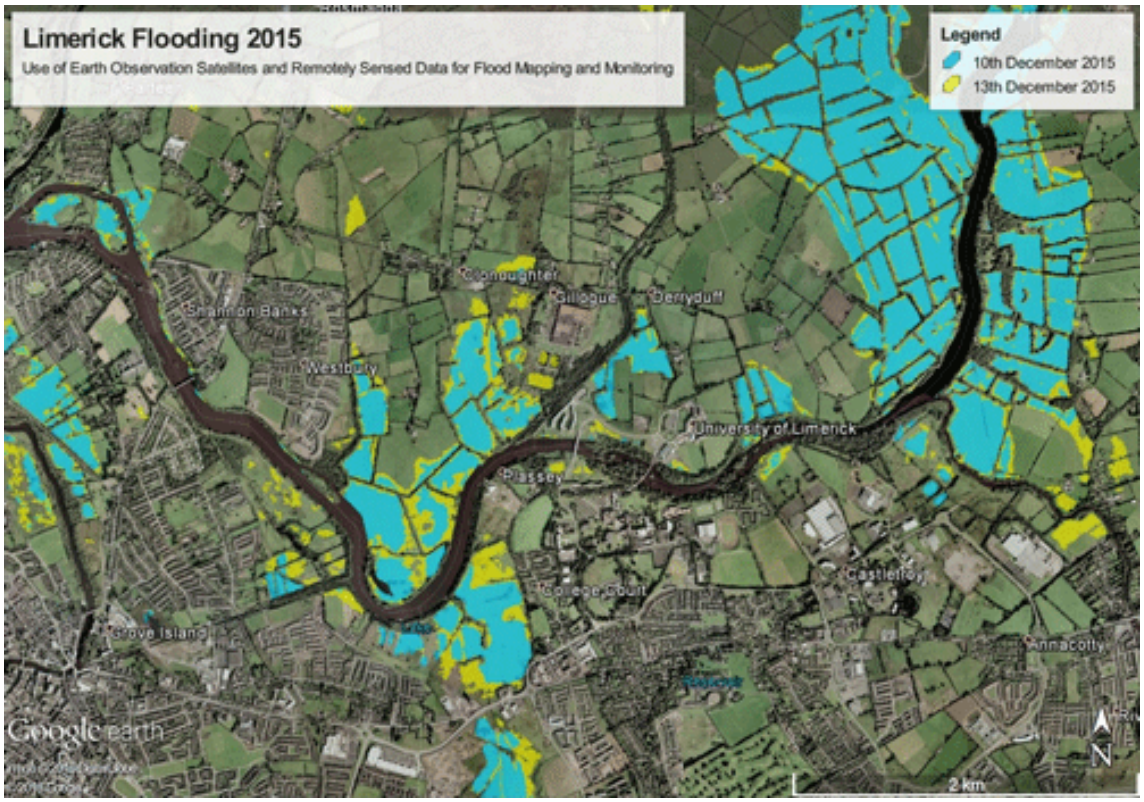


Figure 1: Using Earth Observation satellites for flood mapping

Satellite imagery

EO satellites broadly fall into 2 classes: those that record the sun?s energy reflected from the Earth?s surface, and those that transmit their own energy and measure what comes back. These satellites can survey large strips during each orbit, with some capable of surveying areas the size of Leinster in just a few minutes.

Other satellites, such as the commercially available Worldview 3 , focus on narrower strips, but can therefore provide imagery with a spatial resolution as low as 0.31m2; each pixel therefore represents an area about the size of a box of cornflakes on the ground.

Imagery of the whole island is recorded every 10?15 days by the individual satellites, and geomatics surveyors can generate more frequent updates by using multiple satellites? data. As platforms such as NASA?s Landsat have been operational since the mid-1980s, free archival imagery is also available.

A recent EO development of particular relevance is the ongoing Sentinel project, organised by Copernicus . This is an EU programme aimed at developing European information services from satellite data, implemented by the European Commission and with support from the European Space Agency (ESA).

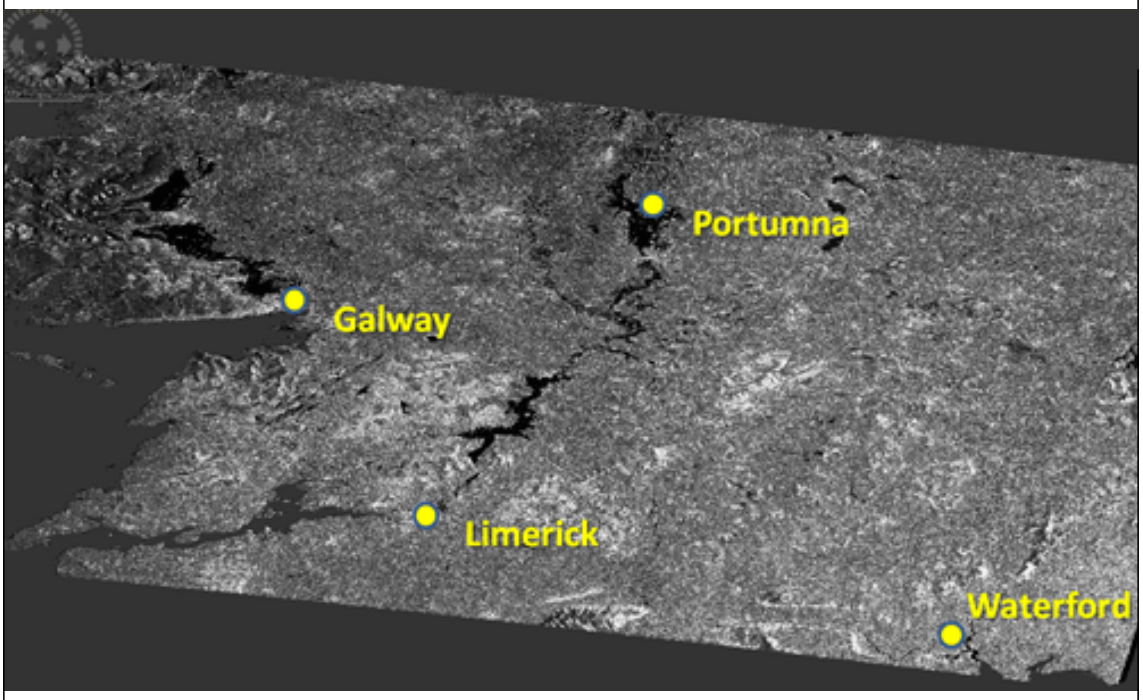
Preliminary market estimates are that for every ?1 invested in Copernicus by a member state, ?7?10 is returned in economic value. Sentinel-1a successfully entered orbit in April 2014, Sentinel-2a in July 2015, while Sentinel-1b is undergoing calibration and commissioning following its April 2016 launch.

Sentinel-1a is particularly suited for mapping cloudy western European countries such as Ireland and the UK. Unlike the optical systems that rely on sunlight and cloud-free days, Sentinel-1a is a synthetic aperture radar (SAR) satellite, meaning that it emits its own energy capable of penetrating cloud cover.

The resulting SAR imagery cannot be compared with the more familiar aerial orthophotography, as rather than colour photographs the resulting imagery is a measure of how much energy is scattered back to the sensor (see image, top). But these SAR images can be used for terrain mapping, classifying land cover, monitoring urban subsidence or deformation, flood mapping, tracking oil slicks and so on. Sentinel-2a is a multispectral satellite, which, although capable of producing colour imagery similar to aerial orthophotography (see image, above right), can also record information that the human eye cannot see, such as thermal or near-infrared energy.

Multispectral satellites can be used for mapping, land cover classification, urban planning, flood monitoring, assessing water quality, precision agriculture, forestry, mapping the sea bed and so on. Each Sentinel satellite produces around 1.7TB of free data each day.

Figure 2: An SAR image of parts of Munster/Connaught and the Shannon River. Strong returns are bright, whereas weak returns, such as water, are dark.



Figure

3: A true-colour satellite image of Limerick, which required cloud-free conditions

Irish flooding

In early December 2015, NASA?s Landsat 8 took some multispectral images, but the inundated regions in north Munster were completely obscured by cloud cover, and it was not until 24 December that a gap in the clouds coincided with another overpass by the satellite, which was then able to record flooding patterns. SAR satellites such as Sentinel-1a are therefore essential to penetrate cloud.

By measuring the strength of the energy that returns to the satellite, SAR assists with the automatic identification of water and delineation of flood boundaries to measure the flood extents.

This data can also be combined with pre-event colour imagery to help with visualisation and ? because a single satellite is rarely sufficient for monitoring major flood events ? geomatics surveyors can incorporate data from multiple satellites. Data from 2 SAR satellites on 10 and 13 December was combined to delineate flooded areas in Limerick, as shown in the main image.

The Copernicus Emergency Services programme can provide regular, localised geospatial data derived from multiple satellites, free of charge to all involved in crisis management. Mapping for the 2015 event from 8 December is freely available for specific locations in Ireland (activation code EMSR149), with satellite-derived polygons provided on a daily basis.

Similar activations were in place for Cumbria (EMSR147) throughout December 2015 and activations were set in place for other locations in England (EMSR150) as conditions worsened at the year?s end and into 2016.

Future events?

Government agencies and businesses should be conscious of the potential of satellite-derived spatial data for providing rapid, up-to-date mapping. If used properly, it can enable a changing situation to be closely monitored and then mitigation measures developed. Archival satellite imagery can be used for assessing performance during the management of past events, planning flood defences or redefining flood plains for county development plans, enabling effective use of public funding.

Other applications such as coastal defence, seabed mapping, precision agriculture, forestry, geology, fishery protection, climate monitoring, urban deformation monitoring and biodiversity protection can all benefit from satellite imagery as well.

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Further information

- Images: figure 1 ? GoogleEarth; figures 2 and 3 (flood polygons) ? Copernicus
- The authors are members of the Society of Chartered Surveyors Ireland Geomatics

Division
Working Group on Remote Sensing and Earth Observation. This is an updated version of an article that first appeared in the *Surveyors journal* (vol. 6, no. 1, Spring 2016)

- Related competencies include Environmental assessment , Remote sensing and photogrammetry , Spatial data capture and presentation (advanced mapping)
- This feature is taken from the RICS *Land journal* (October/November 2016)