Story Board 7: Satellite Observations Provide a Global Picture

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Images from satellites are familiar nowadays – ranging from cloud distributions on weather forecasts to high-resolution images of your house in viewers such as Google Earth. For more than 40 years, data from a wide range of satellite sensors have been used to observe the Earth and have improved immensely knowledge of many aspects of the climate system. Some of the major benefits of satellite observation systems include their ability to monitor almost all of the Earth's surface and surrounding atmosphere on a regular basis and in a consistent manner, thereby complementing ground-based observational infrastructure which is relatively sparse, particularly in many oceanic areas, polar regions, high mountain zones, arid desert areas and some developing countries. Satellite observations are also invaluable in contributing time-series data which can be input to models of the global climate system in order to forecast future climate conditions.

Satellite sensor data can contribute to the determination of more than 30 of the ECVs. For some of these, such as cloud properties and upper air temperatures reliable and complete time-series extend back more than 20 years, whilst land-cover mapping from local to global scales has long been one of the major application areas of satellite imagery (Fig. SB7.1). In other cases, such as for soil moisture or biomass, observations exist and work is ongoing to generate long-term, reliable time-series.

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Sea surface temperature has been observed systematically, on a global basis for over 15 years. Global observations at a horizontal resolution of 1 km and an accuracy of approximately ±0.3°C are currently possible. Such information has been crucial for monitoring and providing early warning of major oceanic phenomena such as the El Niño Southern Oscillation (ENSO) in the Pacific Ocean

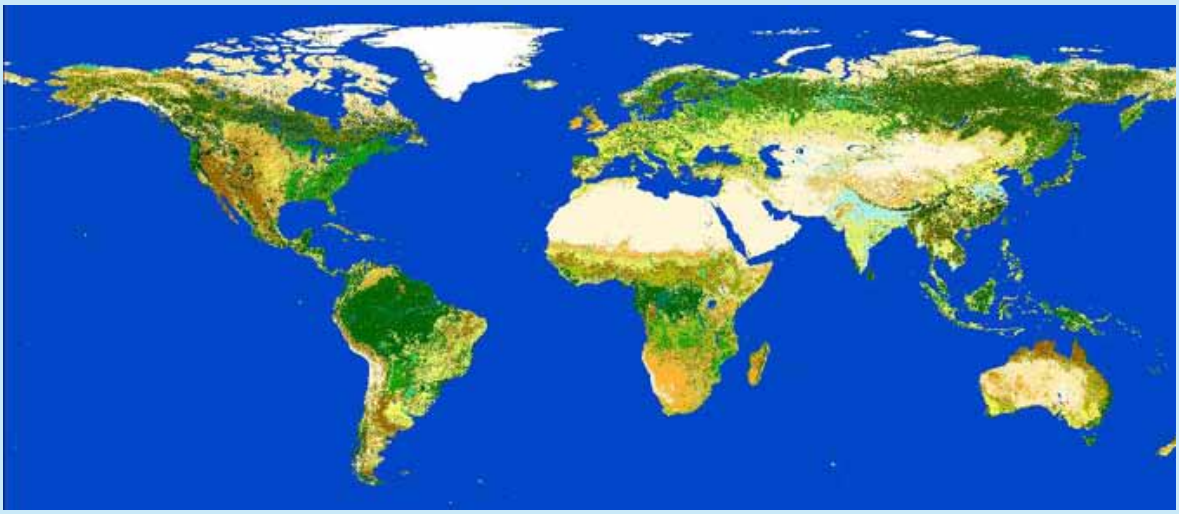

Figure SB7.1. Global land cover derived from data collected in 2009 from Envisat's Medium Resolution Imaging Spectrometer (MERIS) instrument. © ESA and UCLouvain.

(Fig. SB7.2). ENSO, which occurs on an irregular basis every five to eight years sees a significant warming of the ocean surface off the coast of South America and can have major impacts on the global climate, including flooding in parts of South America and severe droughts in parts of southeast Asia.

Although satellite observations are an invaluable source of information on the climate system there are significant challenges in working with the data. Data often comes from multiple satellite sensors; the sensors degrade over time; and satellites have a finite lifetime (5 to 10 years). In order to ensure high-quality and reliable observations the satellite data need to be carefully validated using *in situ* measurements and continuous calibration and quality control has to be carried out. It has taken some time for satellite-derived data products to become embedded in operational monitoring programmes. One of the most successful to date has been meteorology.

Recognising the valuable role that satellite data play in improving understanding of the climate the GCOS secretariat has published specific requirements with regard to the use of satellite-based products for climate observation. In support of this, the ESA conceived a Climate Change Initiative (CCI) which focuses on providing reliable, long-term satellite data sets for a number of the ECVs to assist climate change studies. Data from the many instruments on board ESA's flagship Earth-observation satellite *ENVISAT* have been used as part of the CCI. *ENVISAT* ceased operations in April 2012 and there is now pressure to launch the follow-up Sentinel series of satellites as soon as possible. Furthermore, the Global Monitoring for Environment and Security (GMES) programme, a joint initiative between the European Commission and the ESA contributes to the Global Earth Observing System of Systems (GEOSS) whose aim is to provide satellite-derived information on a range of key global issues including climate change. Figure SB7.3, which shows monthly mean CO_2 concentrations for August 2010, was generated as part of the GMES Monitoring Atmospheric Composition and Climate (MACC) project.

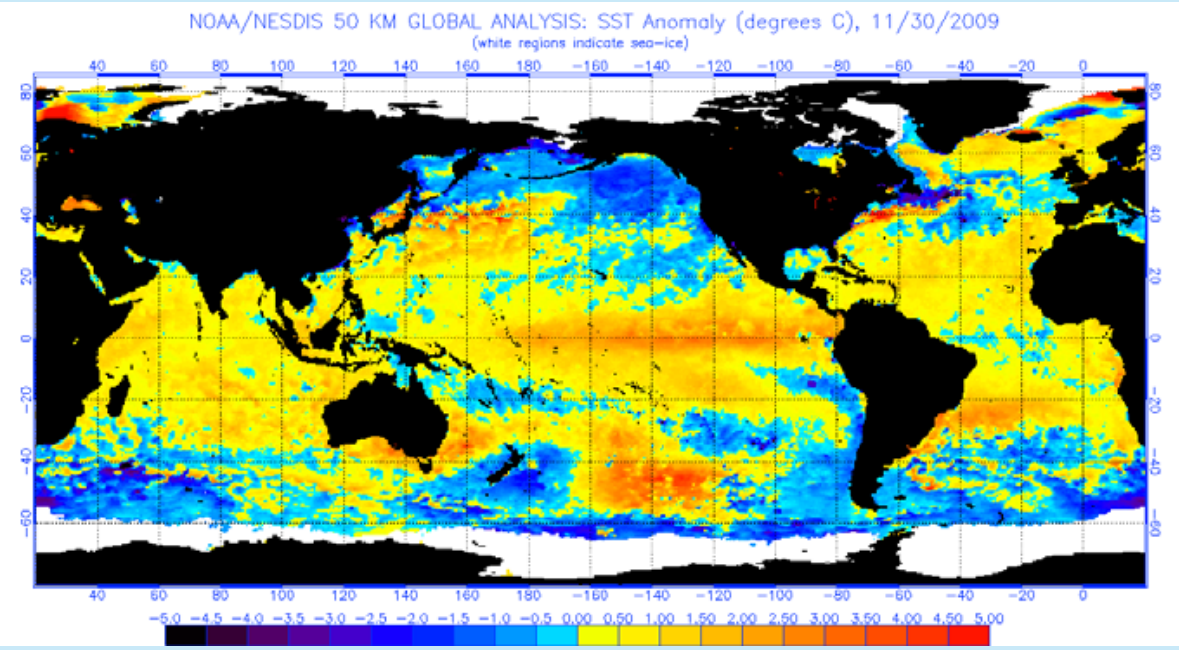

Figure SB7.2. Sea surface temperature anomalies based on satellite measurements for 30 November 2009 show that the El Niño event saw ocean temperatures more than 2°C above normal (orange) in the Eastern Pacific. Image © NOAA Satellite and Information Service.)

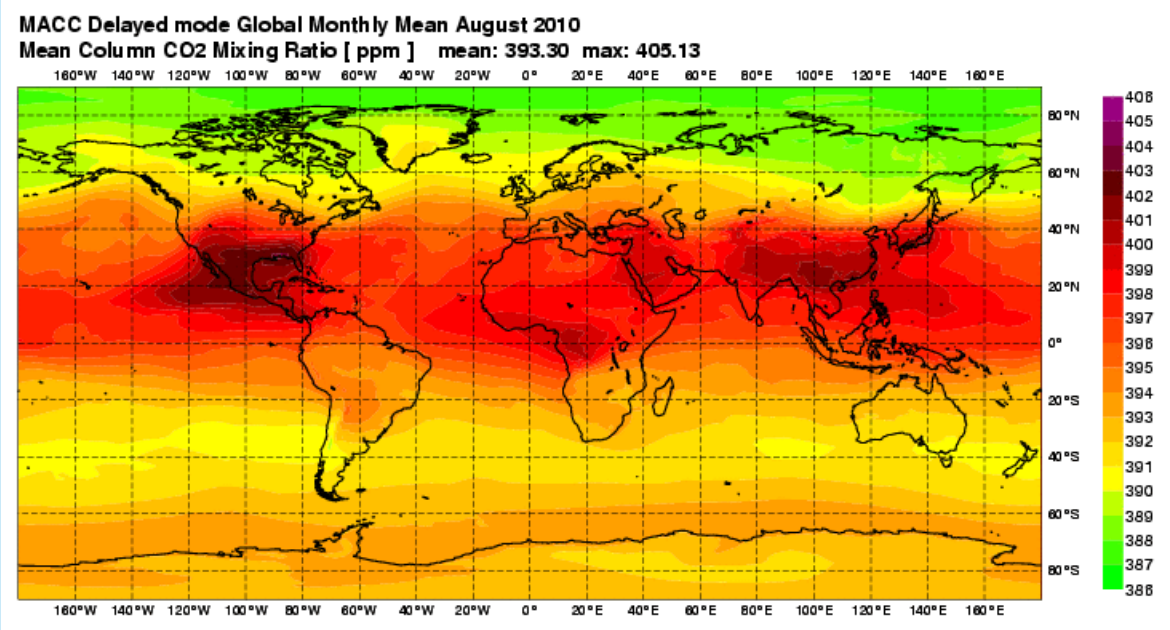

Figure SB7.3. Global mean monthly carbon dioxide concentration for August 2010 calculated from a combination of satellite and *in situ* measurements.

In Ireland there is limited use of satellite data for systematic monitoring of climate variables. The perception is that satellite data are expensive, difficult to interpret and more uncertain than ground-based systems. Nonetheless, some niche applications have developed. Imagery and data from the *Meteosat* satellites are used in weather forecasting by Met Éireann. The Marine Institute uses ocean colour data as part of its Harmful Algal Bloom service and high-resolution images from satellites including *Landsat* and *SPOT* are used in the production of land-cover maps such as CORINE. Ireland's participation in the EC/ESA GMES and ESA's Earth Observation programme offers the potential to increase expertise in remote-sensing data use and analysis along with the number of people working in the field. This will enhance use of remote-sensing products for climate studies.

Satellite remote sensing will never fully replace *in situ* observing systems, some of which have been in place for over 150 years. However, they offer a vital complement to these measurements and fill the gaps in areas where *in situ* sensors are not deployed or would be prohibitively expensive to install. New and improved satellite-based sensors are constantly being developed and deployed and will provide ever more detailed, frequent and reliable information regarding the state of our planet for decades to come.

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Further Information

ESA's Climate Change Initiative*:* http://www.esa-cci.org/

ESA's GlobCover project: http://ionia1.esrin.esa.int/

Information on the GMES programme: http://www.gmes.info/

GCOS (2010) *Systematic Observation Requirements for Satellite-based Products for Climate. Supplemental details to the satellite-based component of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC – 2011 Update,* Report No. 154, http://www.wmo.int/pages/prog/gcos/index.php?name=Publications