Observing the Earth from Space

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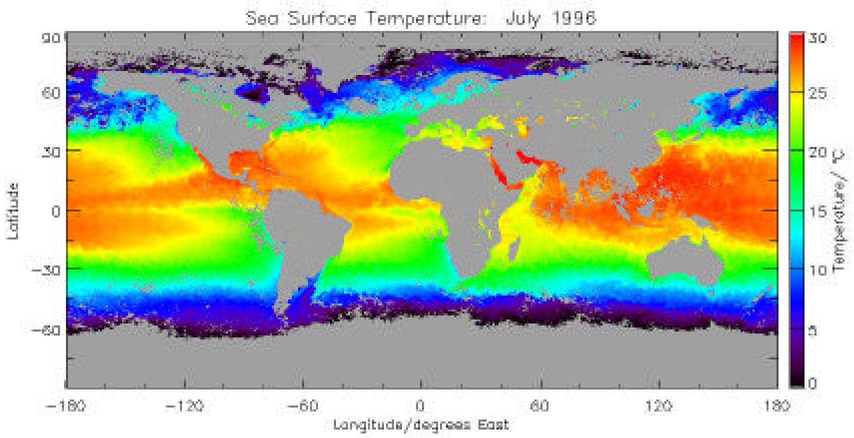
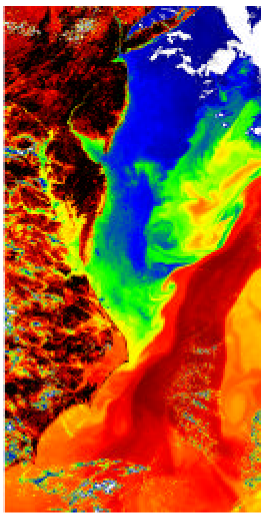
Increasingly, technology is providing an excellent opportunity for scientists to understand the oceans, atmosphere, land and biology that make up the environment in which we live. Using computers and satellites, we can predict the weather fairly accurately up to a few months ahead. We can determine whether winters in Europe are going to be mild or cold, or summers wet or warm. Perhaps more importantly, we can predict whether some of the poorest countries in the world are going to experience drought or flooding, or whether the destruction of rain forests for agriculture is going to have a detrimental effect upon the world's climate. We can ascertain whether industry is going to change the climate irreversibly or if we can provide a solution to climate change. The list of scientific applications of satellite data, and the ways in which society can benefit, is practically endless. In this short summary, I will explore a few applications of satellite data.

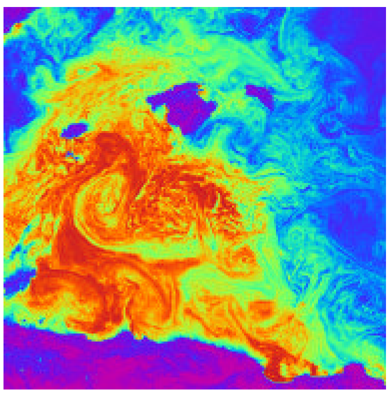
One particular advantage of satellites is that they provide global measurements, as illustrated below in a picture of the Earth's ocean temperature during July 1996. The colours represent different temperatures, from 30 degrees centigrade (red) to about 20 degrees centigrade (green) down to freezing (black).



The satellite instrument that provided the global map above, the British built ATSR instrument, also makes very high-detail measurements, to produce images of the earth. My particular favourites are of the Gulf Stream and a region of the Mediterranean Sea close to the Balearic Islands, shown below. These images give a sense of the dramatic nature of ocean currents.



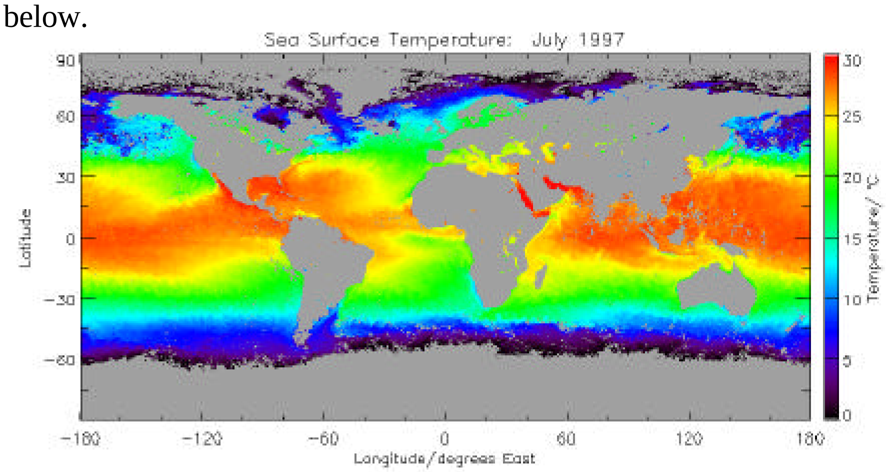
Satellite images of the Gulf Stream (left) and Balearic Islands (below). These images are particularly striking. The dynamical behaviour of the Gulf Stream comes out as a powerful current, bringing warm water towards northern Europe.



At 2 metres per second, the Gulf Stream is the fastest flowing ocean current in the world, whilst the image of currents near the Balearic Islands show wonderful filaments along the so-called "warm core ring", to the South-west of the islands (shown in purple in the centre of the image). There is tremendous detail in this image, which can only be found in satellite observation.

As well as supplying beautiful images, satellites have great scientific advantages. For example, we can measure deforestation, ocean biology (so-called primary production of plankton), oil spills etc. One particular application at the University of Leicester is to explore an important climatic phenomenon known as El Nino. El Nino is supposed to occur about once every 4 years, generally during wintertime. It is a warming of the tropical Pacific ocean, over an area of millions of square kilometres, where the temperature can rise by as much as 5 degrees Centigrade (about 9 degrees Fahrenheit).

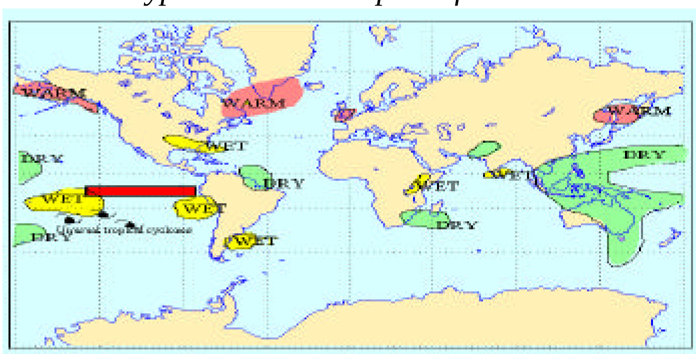
To picture El Nino, it is useful to compare with the ocean in a normal year. For example, the map for 1996 shown earlier has a colder patch of water (coloured green) off the coast of Peru (the East Pacific), along the equator. This is the East Pacific Cold Tongue. During El Nino, this cold water does not appear, as is shown below.



This map shows the 1997 El Nino, the largest and most dramatic event of its kind ever measured. Compare this with the map for 1996, especially around the East Pacific region, to see that the temperature has warmed by several degrees centigrade over a very large area, corresponding to about 10 megawatts of power!

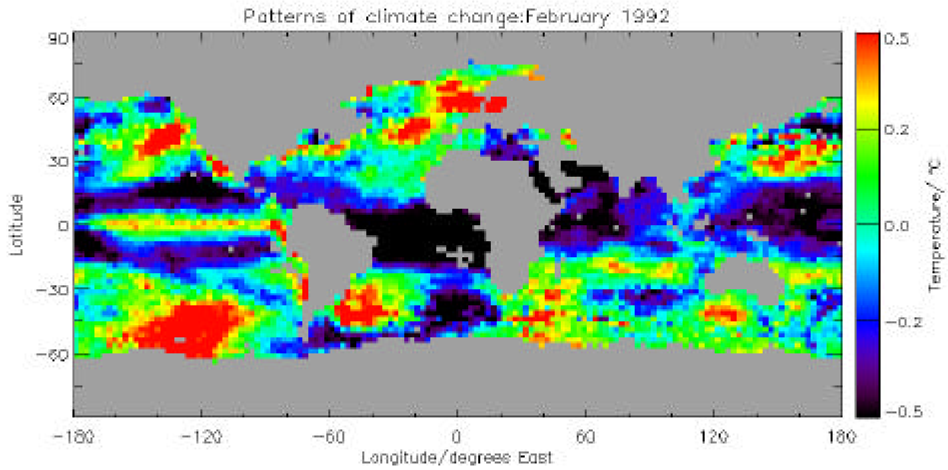
El Nino can have catastrophic climatic consequences, giving rise to flooding, droughts etc., as illustrated in the picture below.

Typical climatic impact of El Nino



It is important to be able to predict when El Nino is going to occur, how powerful it is likely to be and what the consequences are. This is where satellites can help, providing important observations for scientists exploring El Nino and its climatic impact.

In addition to El Nino, satellites can help detect and understand global warming and climatic change. Climate change occurs because of natural processes, such as ice ages. Perhaps of much more serious concern are the changes due to industrial activity. The generation of greenhouse gases such as carbon dioxide by industry appears to have had an immense impact upon climate in the last 100 years. Since the industrial revolution, the climate has warmed faster than at any time since the last ice age. The actual amount of warming and its cause are ambiguous. Is it a natural change or is it due to pollution? What is the magnitude of warming and what regions of the globe are changing most? These are some of the outstanding questions that satellite data can help answer. Again looking at surface temperature, we can identify for the first time where the globe is likely to change most. The picture below shows a recent result obtained at Leicester using satellite data. Here, regions that are warmer (red) or colder (blue) than average are indicated for February 1992.



It is hard to make out the continents, but you should be able to see Spain and Northern Europe. Most importantly, in the North-east Atlantic, we find that the ocean is warmer than average (red), whilst the North–west Atlantic is colder than average (blue). This gives rise to warm wet weather over northern Europe and very cold dry conditions over Greenland and Iceland, a dramatic reversal of what we expect our wintertime climate to look like. In addition, this warm-cold temperature contrast indicates that the normal pressure patterns in the atmosphere have changed, so that, looking at this picture, scientists would expect particularly strong winds towards Britain during early 1992. Indeed, this is precisely what we have experienced in recent years – warm, mild winters, high rainfall and strong winds, giving rise to lots of wintertime flooding and little snow (in the South and midlands anyway).

It is very surprising that these features come out in the satellite data, especially as previously they were evident mainly in computer models. For the first time, we may be seeing real patterns of climate change due to industrial activity!

Thus, satellite data provide a wealth of information about our climate – much more than I could illustrate in this short summary. If you want further information, please contact me by e-mail or telephone:– spl5@le.ac.uk; tel: 0116 2525239. There are numerous web sites as well, although one must be careful, since often the information has not been reviewed and may or may not be of high quality. For example, try:

http://www.noaa.gov/	a very comprehensive site, written in a “public understanding of science” style.
http://www.elnino.noaa.gov/	discussion of El Nino, written in an uncomplicated way
http://www.atsr.rl.ac.uk/	images of the Earth from the ATSR instrument
http://www.ipcc.ch/	official reports from the Intergovernmental Panel on Climate Change, providing comprehensive summaries on climate change. The reports are slightly technical.