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Blue Marble

The magazine of the UK's National Centre for Earth Observation

Measuring our changing planet | Understanding the effects of volcanic ash | Secret origins of Earth Observation | Saving lives at sea

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Credit for cover image: NASA

Welcome to the first edition of Blue Marble, the National Centre for Earth Observation magazine.

Apollo 12 astronaut, Dick Gordon, once noted: "I have often been asked what we discovered when we went to the Moon. My answer to that is… we discovered the Earth."

In addition to its cultural impact, the space age ushered in a whole new era of Earth science. The vantage point of space has allowed us to observe, measure and model environmental phenomena in completely unique and transformative ways.

Here at NCEO, we are pushing the boundaries of what we can understand about the 'blue marble' by exploiting this fantastic resource.

It is an exciting, challenging and at times exhilarating ride and one we wish to share with you within the pages of this new publication. Each edition will feature highlights of our science, its real world impact, the technology we use and the people that do the hard work.

We hope you find this magazine stimulating, thought provoking and informative and would love to hear from you if you have any comments or ideas on how we can improve.

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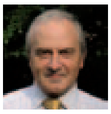
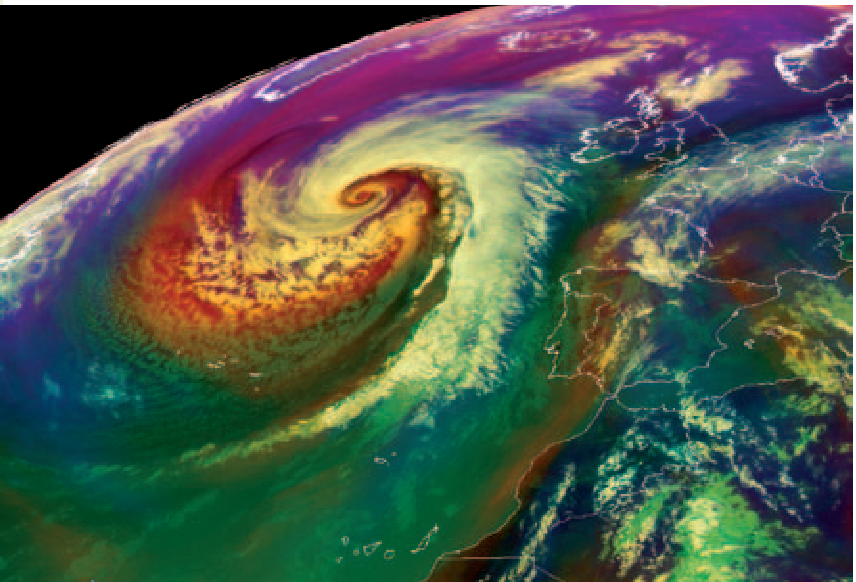
PERSPECTIVE:

Earth Observation from Space

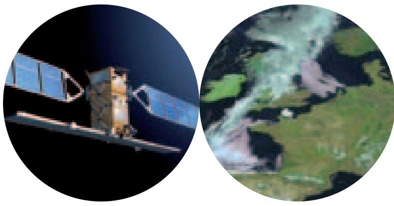


ALAN O'NEILL

Director, NCEO



A large cyclone over the North Atlantic **Credit: EUMETSAT**



Above left: Artist image of Sentinel 1 **Credit: ESA**

Right: A rare (almost) cloud-free view of Europe captured by a European weather satellite **Credit: ESA**

Observations from Earth-orbiting satellites have profoundly increased our understanding of how our planet works as a complex system. This has led to practical benefits that are improving the quality of our lives and helping us to keep our planetary house in order.

Weather forecasting, for example, has been utterly transformed by the now routine provision of measurements from polar-orbiting and geostationary satellites. They continually provide global measurements of temperature, cloud cover, humidity, rainfall rate and so on. These measurements are fed into computer models, providing precise information on the current state of the atmosphere as the starting point for the weather forecast. Satellites are now the most important source of information for such forecasts and there have been marked increases in the skill of forecasting since satellite data became available.

The drive to improve the quality and utility of weather forecasts has been a major stimulus for atmospheric science. This is the reason that weather forecasting models, together with techniques to ingest into them a wide range of measurements (so-called data assimilation techniques), are more advanced in this discipline than in any other area of Earth system science.

The drive for better science to satisfy practical needs will be a recurrent theme during the coming years. As in the case of weather forecasting, the benefits of satellites will emerge strongly when data supply can be guaranteed in the long term. Europe's GMES programme (Global Monitoring for the Environment and Security) has this ambition. GMES is focused on providing sustained measurements not just of the atmosphere but also of the ocean, land, cryosphere and biosphere. Its first Sentinel satellite is scheduled for launch at the end of 2012 and the programme will be a huge boost for science and practical applications.

I am in this business because the science of Earth Observation is challenging, interesting, fun and useful. It is inspirational to be associated with a high technology project to build a satellite, to see it launched at the launch site or even to view the launch remotely in a TV room with hundreds of fellow scientists. Then there is the satisfaction of being part of an international team to interpret the data. Colleagues in the National Centre for Earth Observation have leading roles in many such satellite missions and the articles in this new magazine give a flavour of what NCEO scientists do and why it is important.

MEASURING THE PLANET

The Earth is a dynamic and constantly changing planet, writes Sue Nelson. Monitoring these changes not only informs our understanding of climate, it tells us more about the world we live in.

Satellites play a crucial role – from measuring ice cover, sea levels and gravity field – to determining the amount of moisture in the soil or salt in the oceans.

GOCE (Gravity field and steady-state Ocean Circulation Explorer) was the first European Space Agency (ESA) Earth Explorer mission to be launched in March 2009. It senses tiny variations in the Earth's gravity field and this data is used to construct an idealised surface, or geoid, that shows the shape of oceans without winds or currents. Comparing this geoid with reality reveals how oceans are behaving.

"The gravity field controls the shape of the sea surface to a huge extent," says Helen Snaith, from the National Oceanography Centre, Southampton. "The surface of the ocean looks flat. But over several thousand kilometres, from the middle of the South Pacific to north of Australia for example, the height of the ocean surface changes by 150-200 metres."

Oceanographers like Snaith are combining GOCE's gravity field data with radar altimetry to determine ocean currents. Snaith displays a map, produced by the University of Newcastle, on her computer screen and points out an area in the middle of the Pacific where the current is affected by islands.

"This is the kind of information that we're really trying to capture using GOCE. We're able to get detail in locations that we've only been able to get before from *in situ* measurements with ships and buoys."

The latest gravity models, based on six months' data, have just been released and will keep scientists like Snaith busy. Meanwhile, two other ESA Earth Explorer satellites address areas of immediate environmental concern.

"The surface of the ocean looks flat. But over several thousand kilometres... the height of the ocean surface changes by 150-200 metres."

Helen Snaith

CryoSat is measuring the thickness of polar ice **Credit: Boffin Media/SAMS**

Above left: GOCE being lowered onto its launcher **Credit: ESA**

CryoSat-2 is measuring the Earth's ice cover while instruments on SMOS (Soil Moisture and Ocean Salinity) are examining the salinity of the oceans and the amount of water in soil.

Soil moisture

Data from SMOS recently showed its potential to improve flood forecasting during the Queensland floods in Australia. Its data helped produce a soil moisture map that can be used to assess how much water an area can take before runoff occurs.

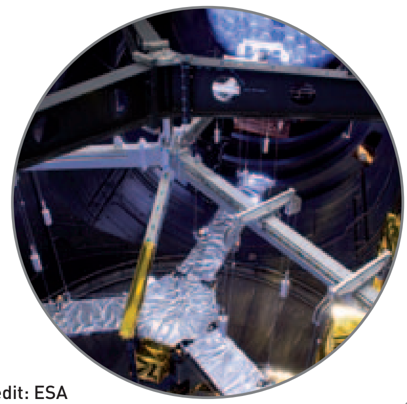
SMOS, launched in November 2009, has been gathering valuable information on soil wetness by measuring microwave radiation emitted from the Earth's surface at a frequency sensitive to moisture variations in the soil. The satellite's Microwave Imaging Radiometer with Aperture Synthesis (MIRAS) instrument simulates a large antenna by using 69 small antennas over three helicopter style arms.

The specific frequency is also sensitive to the amount of salt in oceans. "The density of the ocean is determined by the temperature of the water and the salt content of the water," says Meric Srokosz, also from the National Oceanography Centre. "The density influences currents, so it's important for understanding how the ocean works and how the ocean is related to the atmosphere and therefore to the climate."

But as there are more than 3,000 Argo floats around the world measuring the salinity and temperature of the oceans, why use satellites?

"Even with Argo there's only a buoy every 300-400 kilometres so the sampling is still fairly sparse," explains Srokosz. "The trouble with a ship or a buoy is that you get a measurement at a specific point in time and space. You don't get the coverage globally that you're getting from a satellite. Over two or three days the satellite can map the entire ocean surface."

ESA has released global science data to researchers who are currently comparing it with traditional ship and buoy measurements of salinity, together with computer models of the ocean, to ensure the data's quality. "The achievement is twofold," says Srokosz proudly, whose work is partly funded by NCEO. "We have measured salinity from space for the first time and are able to now start mapping salinity on a global scale."



SMOS being tested **Credit: ESA**

Ice thickness

The CryoSat-2 satellite is also calibrating and testing its data through observations on the ground. Rebuilt and relaunched in April 2010, after a faulty rocket destroyed the first version in 2005, CryoSat-2 is using a radar altimeter to measure the thickness of land and sea ice at the poles of the Earth to centimetre accuracy.

“Since last June we’ve had data almost continuously,” says Seymour Laxon, head of the Centre for Polar Observation and Modelling at University College London (UCL). “We’ve got high hopes that it’s going to be providing us with a higher resolution picture that we can see with current instruments.”

Images taken by the Enivsat satellite ascertains that data correlates to either land or sea ice. In April, scientists from UCL will visit the Arctic to verify that the satellite measurements are correct.

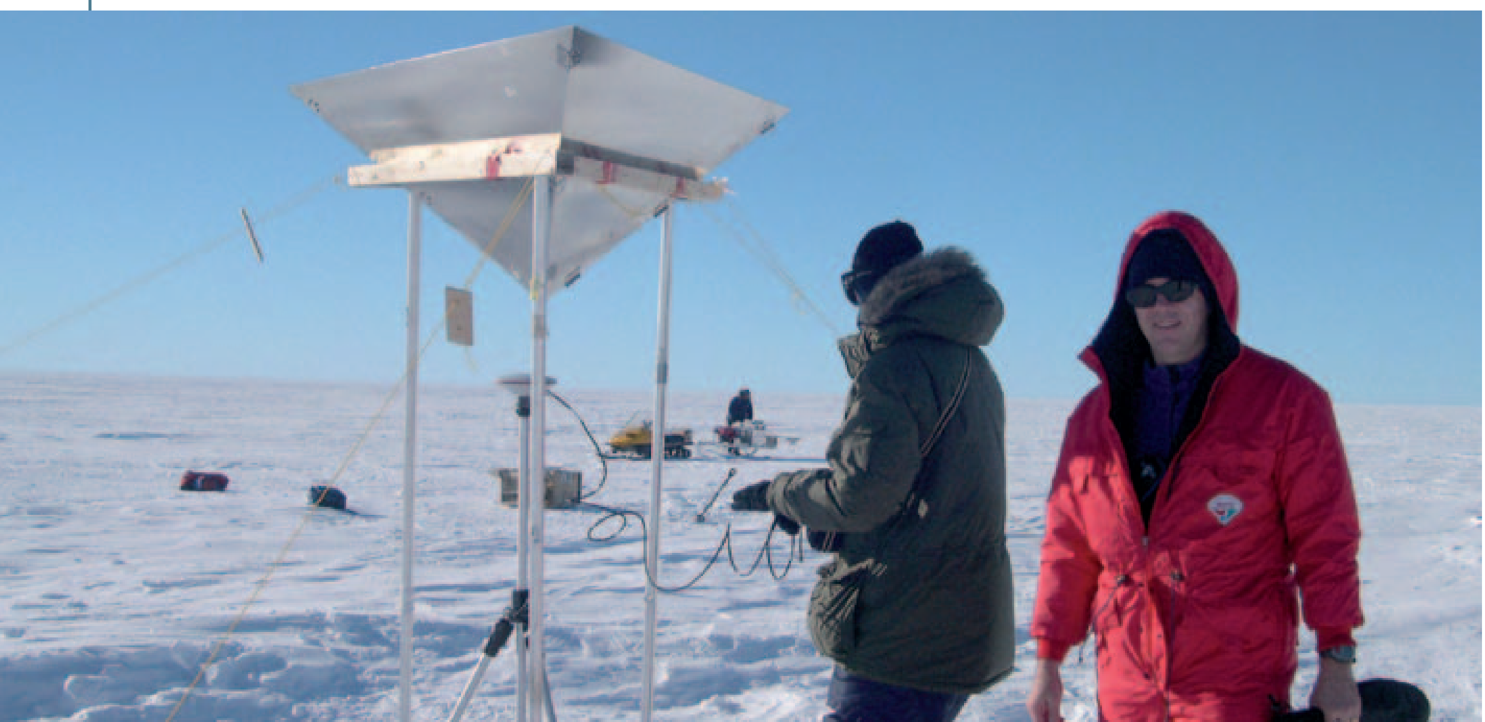
“A critical part of the processing is being able to determine whether you’re making a height measurement over water or ice because that height difference tells us how much ice is sticking up above the water,” explains Laxon. “We calculate that number into thickness using a calculation similar to the idea that nine tenths of the ice is beneath the water.”

CryoSat’s first scientific data has been released to scientists. The information will help determine the impact that climate change is having on the Earth’s ice cover, although early results have already proved useful. “CryoSat has given us the first picture of how Arctic Ocean currents are moving almost right up to the North Pole,” says Laxon.

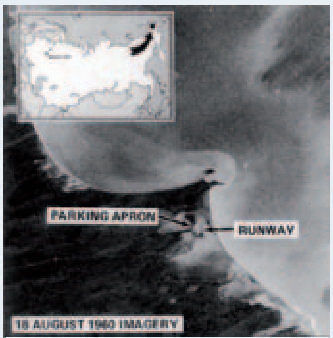
It’s an impressive start.

Above: The successful launch of CryoSat-2 **Credit: ESA**

UK scientists have undertaken Arctic expeditions to verify the data from CryoSat **Credit: Davidson**



OBSERVING
THE BLUE MARBLE



Above: Pictures from the secret Corona project of Soviet rocket and missile installations **Credit: NRO**

Top: Recovery of the Discoverer 14 space capsule **Credit: NRO**

From top-secret spy cameras to the latest hi-tech scientific instruments, Earth Observation has come a long way in the last fifty years. Richard Hollingham explores the origins of satellites that monitor the Earth.

It's August 1960 and a United States military cargo plane circles above the Pacific Ocean. Its rear loading hatch opens to allow a rope, with a hook on the end, to trail behind. This is high altitude fishing: the crew's mission is to snag the hook on the fabric of a parachute attached to the Discoverer 14 space capsule descending from orbit. If they miss, the capsule will hit the ocean and, in all likelihood, sink without trace.

The first two passes fail. By the third, time is running out. Finally, at ten thousand feet, the hook catches on the parachute fabric and the winch operator starts hauling in the rope. Careful not to snare the lines, crew members scramble to the hatch to pull the torn parachute and capsule aboard.

Newsreels described the event as 'dramatic' – a stride towards beating the Soviet Union in the space race. The coverage didn't reveal what was in the recovered capsule. It was part of the secret Corona project to return photographs from orbit and the capsule contained a film camera. Discoverer 14 was the world's first successful spy satellite, designed to take pictures of Soviet rocket and missile installations and return them to Earth.

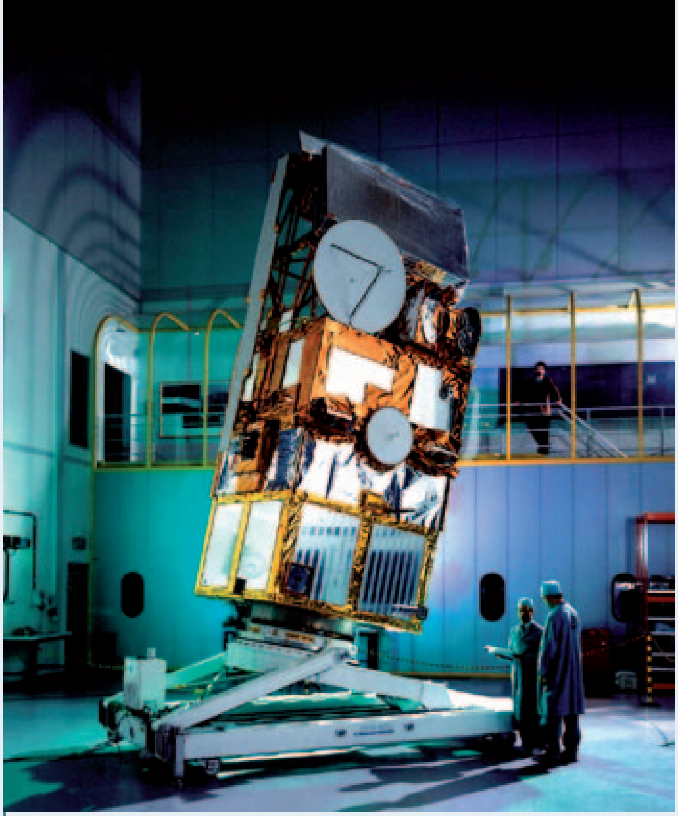
This wasn't the first time the Earth had been photographed from space. As far back as 1946, American scientists successfully flew a film camera on a captured German V2 rocket. An early attempt to transmit TV pictures from space was made in 1959 when NASA's Explorer 6 beamed back a few distorted images. But the clarity of the Discoverer 14 pictures made them remarkable. These early military missions proved what could be seen from orbit and revealed the potential of Earth Observation.

Above the clouds

The Cold War wasn't the only reason for developing Earth Observation satellites. Descriptions and pictures captured by the first astronauts revealed just how much weather you can see from space. During his first mission in 1962, John Glenn reported clouds over the Canary Islands and massive dust storms across the Sahara Desert. Space offered a much bigger picture of the weather than balloons, or observations on the ground, could possibly provide.

The first weather research satellite, Nimbus 1, was launched by the United States in 1964. Two years later, ESSA-1 became the first operational weather satellite. But in weather forecasting using satellites really came into its own with the launch of the first geostationary satellites. These satellites, in orbits that match the Earth's rotation so that they appear constantly stationed over the same area, enabled forecasters to track weather patterns as they developed. Europe's first geostationary satellite, Meteosat 1, was launched in 1977.

By the time Apollo astronauts took pictures of the Earth from the Moon, the fragility of our small blue-green planet was beginning to become apparent. The next generation of Earth Observation satellites was designed to investigate the environment and changing land use. Although the military would continue to use spy satellites, scientists were now developing satellites to study and monitor the Earth.



ERS-1 under test **Credit: ESA**

European success

Encouraged by the success of the European weather satellite programme, ESA started to develop a broader programme of monitoring the Earth from space with the launch in 1991 of the European Remote Sensing satellite (ERS-1). It was equipped with a comprehensive set of radars and sensors to collect information about the Earth's land, oceans and ice caps. One of its key imaging instruments, the Along Track Scanning Radiometer (ATSR), was designed and developed in the UK by a consortium of research institutes.

In 1995 ERS-1 was followed by ERS-2, which was fitted with the same instruments as its predecessor, as well as an ultraviolet spectrometer to monitor the ozone layer. In 2002, Envisat – the largest and most ambitious Earth Observation spacecraft ever built – joined the two satellites. Around the size of a double-decker bus, the £1.4 billion satellite was designed to make comprehensive measurements of the Earth's atmosphere and surface. The programme was led from the UK.

There are now 20 years of continuous measurements available from the satellites with results from ERS-1 (operational until 2000), and both ERS-2 and Envisat still going strong. For the first time, satellites are helping to reveal long-term trends in our atmosphere, on land and in the oceans. Long-term continuity of these measurements is being

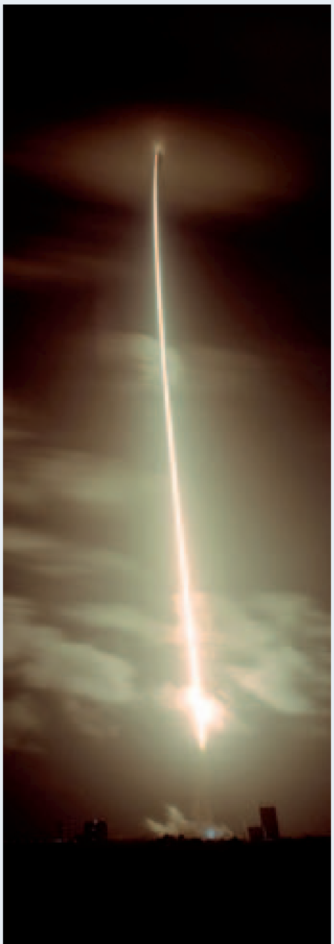
The famous 'Earthrise' picture taken by the crew of Apollo 8
Credit: NASA

assured through the GMES (Global Monitoring for Environment and Security) Space Component Programme being developed by ESA and the European Commission.

Alongside results from smaller satellites like the Disaster Monitoring Constellation (built by SSTL in the UK), ESA's Proba-1 (fitted with a UK-built camera) and ESA's new science satellites such as GOCE, SMOS and CryoSat, satellites have transformed the understanding of our planet.

With so much data now available, the skill is being able to use that information to interpret and predict how the environment and climate are changing. That's the challenge for scientists at NCEO who use data from more than fifty satellites. It's certainly different but not necessarily easier than trying to hook a falling parachute.

Proba image of Venice
Credit: ESA



The launch of Envisat in 2002
Credit: NASA

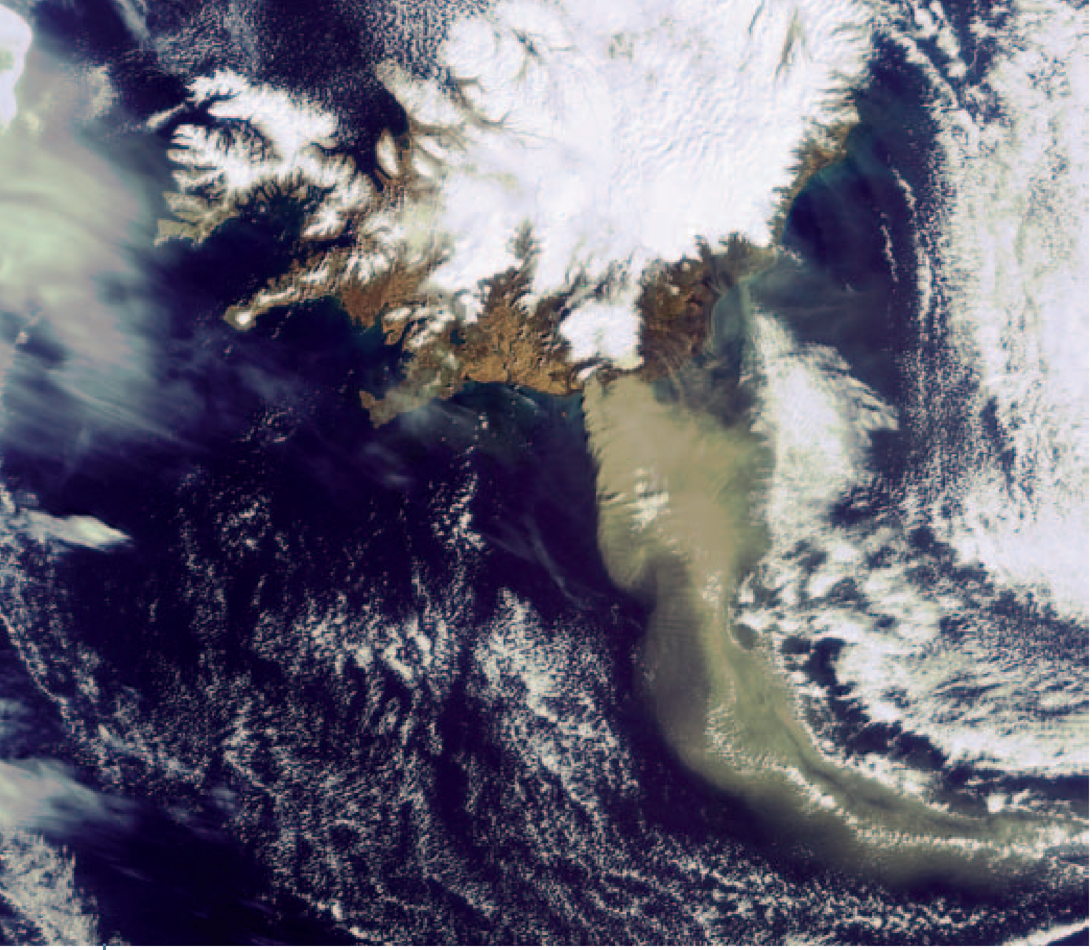
Lasting legacy

While it's easy to get excited by the latest results from a particular satellite, the true value of data often only becomes apparent over time. The long-term global data sets from Earth Observation satellites, for example, are vital if we are to understand and monitor global change. This is where the Natural Environment Research Council (NERC) Earth Observation Data Centre and British Atmospheric Data Centre come in. Between them they hold more than 500 terabytes of data in tens of millions of files, all made available to hundreds of scientists every year.

"Any work that goes into collecting or analysing data is wasted if you don't keep it," says Victoria Bennett, from the Earth Observation Data Centre. "The point of preserving that data is so that it can be reused. You can even derive something that the satellite wasn't originally designed to do."

In a world of rapidly changing technology, the practicalities of preserving this mountain of information involves such things as standardising measurements and ensuring the format will last through new generations of software. And it's not just the raw satellite data that's important.

"Scientists within NCEO take satellite measurements and using their calculations and computer models get new results and generate new datasets," says Bennett. "We have to make sure these don't get lost because they will be useful to other scientists who might, for instance, feed them into models to get a better understanding of how the Earth system is behaving."



Envisat image of the ash cloud spreading south east from Iceland **Credit: ESA**

The eruption of the Eyjafjallajökull volcano led to the closure of airspace across Europe **Credit: iStock**

SIFTING THROUGH THE ASHES

"There was a lack of knowledge about the optical properties of ash, so it was difficult to provide an accurate measurement from space."

Don Grainger

Fiona Hatton reports on what's been learnt from last year's volcanic eruption in Iceland.

In April 2010 Europe's airspace shut down for almost a week – grounding planes, stranding passengers and costing the economy millions of pounds.

The cause was the previously dormant Eyjafjallajökull volcano in southern Iceland. When it erupted the volcano emitted more than one billion watts of energy – enough to power 40,000 cars – and discharged more than six tonnes of lava per second.

The resulting ash cloud was at the heart of the chaos. Spreading thousands of kilometres through the Earth's atmosphere, it left its mark as far afield as Spain and Portugal. One year on, by studying the event, a variety of research is producing a better understanding of the eruption and others like it.

Although millions of people viewed the eruption in terms of transportation problems, scientists and researchers across the globe saw an opportunity to analyse the volcano and its eruption. Geologists and volcanologists studied lava and magma at its source and collected ash samples. Hundreds of kilometres above the ground, a raft of Earth Observation (EO) satellites were called into action.

Measuring ash

At the University of Oxford, two very different types of monitoring were taking place: one with satellite data and one ground-based – both providing important optical data that could improve the way EO responds to volcanic eruptions.

When the volcano erupted, Don Grainger from the Atmospheric, Oceanic and Planetary Physics department quickly set to work with his team. Focusing on sulphur dioxide and the emitted ash, they processed data from satellites Envisat and MetOp, and measured atmospheric profiles using lidar. But the team soon realised their research wouldn't be easy.

"There was a lack of knowledge about the optical properties of ash, so it was difficult to provide an accurate measurement from space," says Grainger. "We needed good calibration data from the lab."

This is because volcanic ash is a complex mix of rock mineral types and this mix can vary with each eruption. Satellite retrieval of ash particle size depends on prior knowledge of the ash's optical properties. Without lab data, retrievals are nothing more than an educated guess. "If you're looking from space to make a measurement, you need to have a better idea of what you're looking at," he explains.

Grainger carried out his own preliminary measurements at the Natural Environment Research Council's (NERC's) Molecular Spectroscopy Facility and used the results to quantify the amount of ash emitted by the volcano.

His team's work on data from MetOp's IASI (Infrared Atmospheric Sounding Interferometer) instrument led to a fast scheme to identify and retrieve the amount of sulphur dioxide in volcanic plumes.

It also forms a key component of a major project led by the National Centre for Atmospheric Science (NCAS) to improve predicting volcanic plume dispersal. Bringing together EO scientists, observers and atmospheric modellers, the NERC-funded project combines satellite data with both ground-based and airborne remote sensing data from radars and lidars.

"By bringing together these technologies we aim to assist the Met Office in providing predictions of volcanic ash for the aviation industry," says NCAS Professor Stephen Mobbs.

Studying dust

And what about ground-based research that was already taking place – not only at the volcano itself, but closer to home? In fact, research was underway just around the corner from Grainger and his team on the roof of a university building in Oxford.

Professor of Earth Sciences, David Pyle, specialises in the gas aerosol and ash emissions from active volcanoes – in particular what happens to fine particles in volcanic plumes. Pyle and his team usually study South American volcanoes but, when he heard of the ash cloud coming his way from Iceland, it was an opportunity too good to miss. "It's quite rare to collect samples before they reach the ground," admits Pyle.

Hearing the ash had reached the UK, Pyle and post-doc student Melanie Witt fitted a pumping system, normally used in the field, onto the roof of their department building.

Filters separated different sized particles – some around 10 microns in size, small enough to inhale. Others were much larger, accounting for the significant amount of ash dust people found on their cars and windows across the UK.

Even now, a year on, Pyle is still sorting through the results but initial findings show that both relatively large particles, and clumps of fine particles, fell out from the ash cloud over great distances from the volcano. These new observations will change computer models of how ash clumps form and fall out of volcanic ash clouds.

Pyle's research will be invaluable to the Earth Observation community. With better information about the composition of the ash cloud, satellite data and imagery will be much easier to interpret and act on.

"We need a library of optical properties to do the best job," says Pyle. "If we can work out the profile of the ash falling on Oxford, we can be much better prepared next time."

STORMY WEATHER

The noise is deafening and 80 mph winds will lift you off your feet into the sea, hundreds of miles from land, if the waves haven't knocked you down first. This is the dangerous reality of working on board an oil rig during a storm.

Only last year, for instance, a tropical storm left a rig listing at a 45-degree angle off the coast of China. In 2007, in the Gulf of Mexico, the impact of a hurricane was even worse when massive waves knocked a platform onto its side and left 19 people dead.

Although storm systems can usually be forecast several days in advance or more, this is not the problem. "It's more the uncertainty in the path the storm is going to follow, the speed it's going to move, and the intensity of the storm," explains Robin Stephens, senior adviser in oceanography and meteorology for BMT ARGOSS, a company that uses Earth Observation satellite data to advise offshore industries.

Stephens works closely with scientists at the University of Reading, in a collaboration that could lead to improved forecasts and potentially save lives.

"Storms are generated by contrasts of temperature in the atmosphere, for example warm ocean temperatures on one side and cold land on the other," says Keith Haines, the BMT Professor of Marine Informatics at the University of Reading and leader of the NCEO climate theme. "But you can also get storms developed locally due to convection. So in the Tropics that could be due to very warm sea temperatures and unstable air. These local tropical storms sometimes merge and become rotating Hurricane systems on much larger scales.

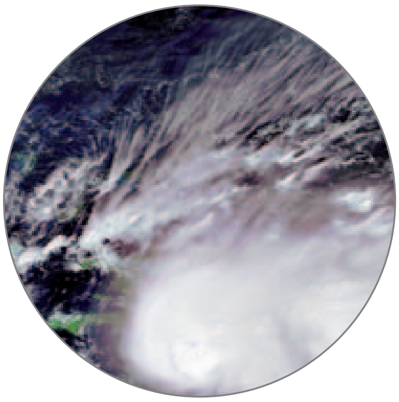
"Storms at sea can be even more intense than those over land," he adds, "which is why the shipping and oil industries are interested. Water is much more dense than air so when large waves hit a ship or a rig, that has a huge impact."

In some cases, even a storm 'no show' causes problems. "The health and safety procedure is to abandon platforms in advance of a storm occurring," says Stephens. "So if you falsely forecast that a hurricane is going to impact a particular area, you have the huge expense of de-manning."

There are also design issues. Knowing the maximum height of waves, for instance, helps set deck elevations on a rig. "In European waters, extreme storms are associated with severe Atlantic depressions. In other areas such as the Gulf of Mexico and parts of South East Asia, worst case conditions will be associated with intense tropical revolving storms. The real challenge," Stephens says, "comes in relatively benign areas on the fringe of normal tropical storm tracks where a single 'freak storm' could completely change the basis of engineering design. This happened with cyclone Gonu in the northern Arabian Sea in July 2007."

Left: Industry, academia and Earth Observation satellites are working together to help improve storm forecasts for offshore structures such as oil platforms **Credit: Shell**

Below: Envisat tracked tropical storm Noel across the Caribbean Sea in 2007 **Credit: ESA**



Offshore structures such as wind turbines, oil production platforms and ships all need reliable and accurate information about ocean circulation, storms and weather, both for engineering design and operational planning. Emergency responses to oil spills, for instance, also rely on good environmental data.

"We're providing information and advice," says Haines, "and through our close connections with BMT ARGOSS, we help them interpret and make better use of the available ocean and meteorological information."

This is where satellites play a crucial role in obtaining information of moving storms at sea. "Satellites can see storms in the cloud structures and wind speed has a signature on the surface of the ocean," explains Haines. "It affects the wave patterns on the ocean surface and they can be detected by radar, even through heavy clouds. That's led to an enormous improvement in storm forecasts especially in remote ocean areas."

Altimeters on the Jason and Envisat satellites track ocean currents and Envisat also measures sea surface temperatures. The ESA's forthcoming Sentinel missions will also add further information about the world's oceans.

Scientists like Haines use the data to improve our understanding of the processes involved in storms and help organisations such as the Environment Agency and the Flood Risk Management Research Consortium improve forecasts.

"It's not only the marine industries that are affected," he stresses. "When storms hit landfall they have a big effect on manmade structures and on the coastline, moving huge amounts of sediment and causing coastal erosion. Some of the largest impacts of climate change may be through changes in extreme events like storms."

Stephens has never been on a rig during a tropical storm but he has witnessed Atlantic storms from a drilling platform. "As an oceanographer it's a real fascination," he admits. "It's a privilege to see these huge waves that you only consider statistically from a desk. But in the past few years we've seen a significant increase in the number of storms and magnitude of storms in some regions and this has caused serious concern in the oil and gas industry. Whether that's fully attributable to climate change, or more short-term atmospheric variability, is still an area of strong discussion."

FEATURED INSTRUMENT: CompAQS

Text by Paul Ireson

"Air quality continues to be a serious health issue worldwide with significant industrialisation in some regions further exacerbating impacts on climate, vegetation, health and the human respiratory system."

Roland Leigh, University of Leicester

What is it?

CompAQS (Compact Air Quality Spectrometer) is a spectrometer sensitive to light in the visible range. A spectrometer is an instrument that measures properties of light over a specific portion of the electromagnetic spectrum.

CompAQS is much smaller and lighter than current instruments. The demonstration model is around 18x18x25cm and weighs under 10kg. It has been developed over the past four years at the University of Leicester's Space Research Centre, in association with Surrey Satellite Technology Limited and Astrium UK, with funding largely provided by the Centre for Earth Observation Instrumentation.

What does CompAQS do?

It measures the concentration of various gases and aerosols in the atmosphere, notably nitrogen dioxide (NO2), with a very high degree of precision. CompAQS' ability to resolve detail down to 1km from a satellite orbiting the Earth puts it in a class of its own.

Why is it useful?

CompAQS is designed to measure air quality, especially in urban areas, accurately and in great detail. When data from multiple devices is combined, a 3D picture of the atmosphere can be produced. The size and weight of CompAQS means that it is relatively cheap and easy to get into orbit, whether on a dedicated satellite or 'piggybacked' on a launcher alongside another satellite.

NO2 is a particularly useful 'marker' for studying air quality – it is produced by transport and from industrial combustion processes. It persists in the atmosphere for long enough that its source can be traced but not so long that it becomes mixed in the atmosphere.

What's next?

Two ground-based instruments are currently being installed as part of CityScan, an atmospheric monitoring system developed at the University of Leicester. This will provide a real-time 3D picture of air quality over an area 25km squared. Data from CityScan will also be used by an ESA-funded project, iTRAQ, which integrates space borne and ground-based remote sensing data to provide urban management services.

In 2012 the system will be moved to London as part of the Clean Air for London campaign, where it will monitor air quality during the London Olympics. The Environment Agency is also exploring the use of CityScan to study emissions from aircraft as they take off from London's airports.

CompAQS technology will be used to monitor pollution during the 2012 Olympics **Credit: London 2012**

PROFILE

Chris Merchant is Reader in Earth Observation at the University of Edinburgh's School of GeoSciences and science leader for the European Space Agency's Climate Change Initiative on Sea Surface Temperature.

Why do we need Earth Observation satellites?

It's clear that humans are having an impact on all aspects of the environment. Think about how incredibly important the relatively limited temperature observations from past centuries are to us for understanding climate change. The global scale observations being made now by Earth Observation will be just as important in 100-200 years time.

How do satellites take sea surface temperatures?

Remarkably accurately, given they are orbiting 600km above the Earth! Sensors collect infrared radiation emanating from the surface, the atmosphere and clouds. We identify the areas that are giving us a cloud-free view of the sea and look at the amount of infrared radiation at different wavelengths. From that we can remove the atmosphere's contribution and infer the sea surface temperature beneath.

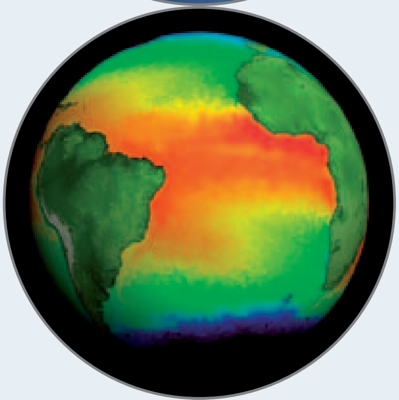
Older instruments gave sea surface temperatures to within 0.6 of a degree. The Along Track Scanning Radiometers (ATSRs) – Earth-observing instruments flying on the ERS-1, ERS-2 and Envisat satellites – were a big step forward. With these sensors, and by applying more sophisticated techniques, our observations are often more accurate than many *in situ* observations in the water. This makes these observations much more useful to climate science. And by using accurate ATSR measurements to improve results from other instruments they benefit weather forecasting too, since the atmosphere can respond to quite subtle variations in sea surface temperature.

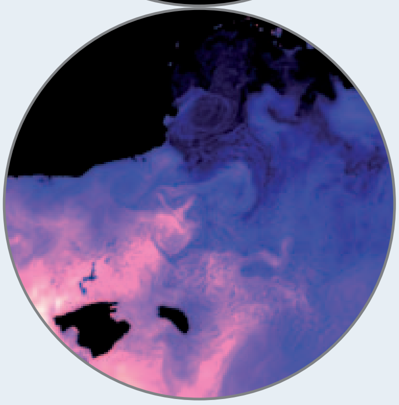
What stage are you at with the Climate Change Initiative on Sea Surface Temperature project?

We started last August, building on work over several years where we cut our teeth working on the ATSRs and developed new techniques. NCEO funding has been a crucial part of that. We're now transferring our knowledge onto US sensors, working with partners around Europe to create a more comprehensive, but still accurate, picture of the ocean surface. In this phase, we will prove that concept and create a valuable new climate data record.

What do you enjoy most about your job?

It's the innovation – where you find a problem you need to solve and then have to work out how to do that – that's the creative bit.





Top: Artist image of ERS-2 and Envisat working in tandem **Credit: ESA**

Middle: A false colour image of sea surface temperature captured by Envisat's Advanced Along Track Scanning Radiometer **Credit: ESA**

Bottom: Envisat image of the waters around the Balearic Islands showing differences in surface water temperatures **Credit: ESA**

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

NCEO is one of the Natural Environment Research Council's research and collaborative centres. Its mission is to unlock the full potential of Earth Observation to monitor, diagnose and predict climate and environmental change.

NCEO involves more than 100 scientists from 26 universities and research establishments. By working together, they help ensure that the UK's investments in satellite observations are fully realised.

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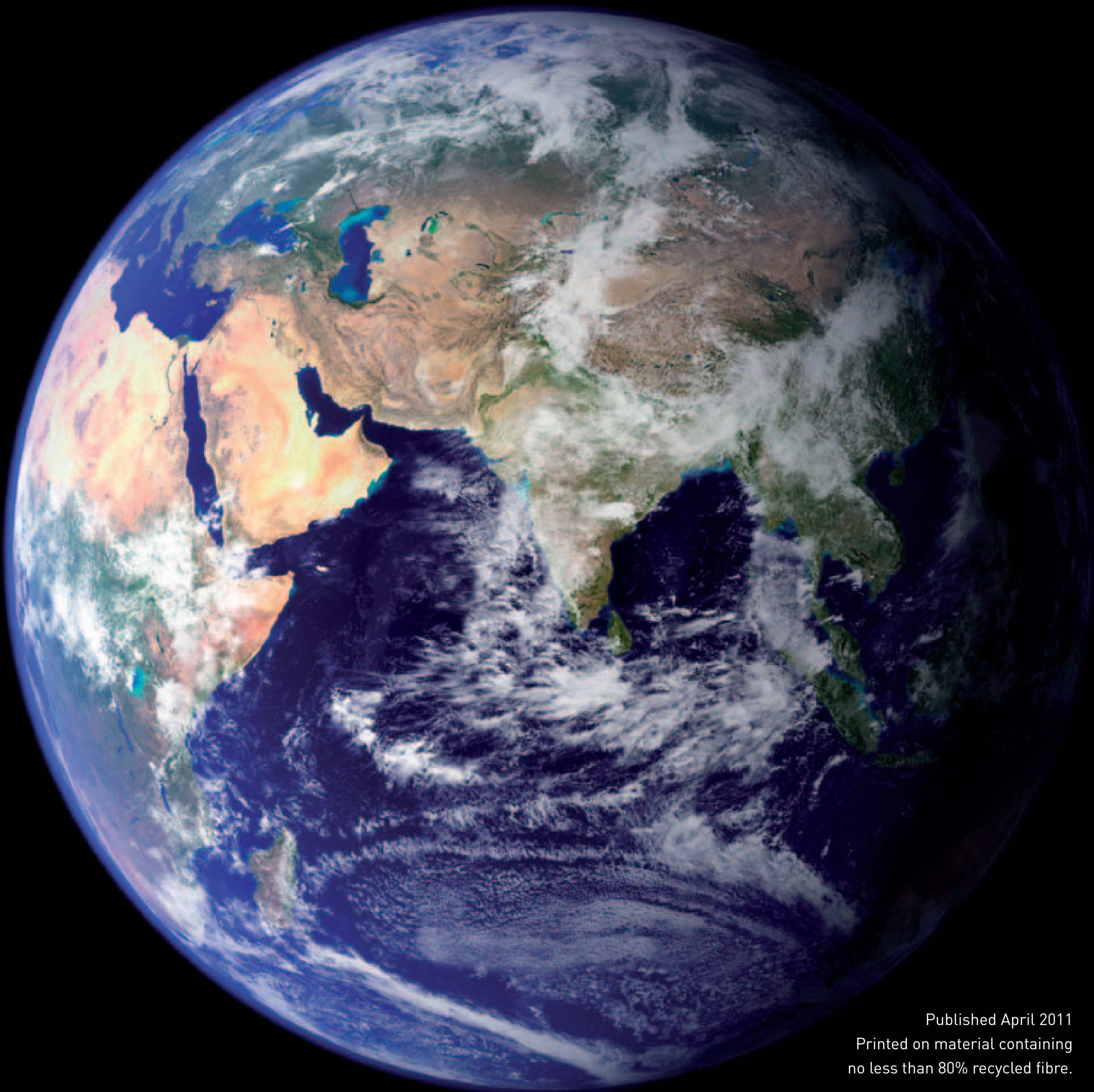

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