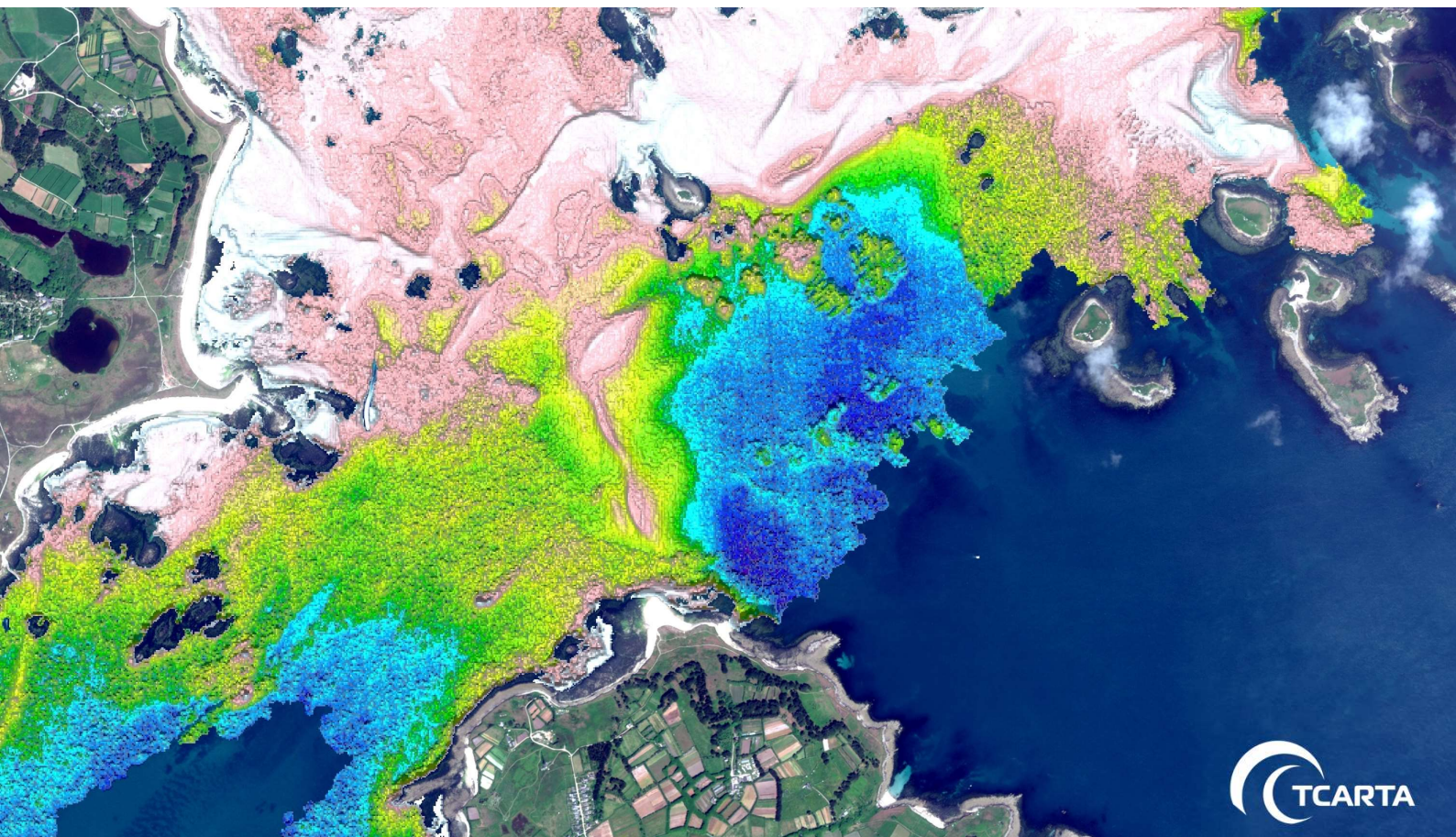


The UK has world-leading Earth Observation capability spanning from research and early mission development, mission build and exploitation of data, and the creation of end-user applications and services. Earth Observation is improving our understanding and helping us tackle the challenges facing our planet including climate change, and it is becoming an increasingly important tool in achieving sustainable development goals.

The UK Earth Observation sector grew at an average rate of 25% per year in the two years to 2017, and Earth Observation-enabled satellite services support industries which create a combined annual turnover of £229 billion. This is a position that has been reached following many decades of positive engagement and collaboration through ESA and other international bodies and through bilateral collaborations with international partners.

Through continued collaboration the UK can rightly and proudly continue to grow the Earth Observation sector, maintaining a broad and deep ecosystem of companies – both big and small – dealing in the entire spectrum of Earth Observation issues from early research and technology development, through manufacture and launch, to the exploitation of Earth Observation data to address a wide spectrum of real-world issues.

Satellite Derived Bathymetry 2-metre resolution depth map of the Scilly Isles. Kindly reproduced with permission of TCarta





Space Cluster, Harwell Campus Oxford.
Harwell 2017 © 21AT, Earth-i Ltd. All rights reserved

The UK Space Agency (UKSA) is responsible for strategic decisions on the UK civil space programme and provides a clear, single voice for UK space ambitions. UKSA is the policy lead for satellite Earth Observation and works closely with the UK community to continually develop our world leading capability. UKSA represents the UK community, within ESA and CEOS, and fosters bilateral relationships to ensure it is at the forefront to developments within the sector. This international collaboration is a vital part of the UK Earth Observation landscape.

The UK's vision by 2040 is to maximise the potential of Earth Observation – for economy, science and society – by providing the quality-assured data required to underpin mass market and business applications, cutting-edge science, and the development of effective and efficient policy and operational decision making.

We are committed to utilising collaboration in Earth Observation and climate science to tackle the challenges facing our planet.

The UK is a major investor in ESA's Earth Observation programmes. Since the creation of ESA's Envelope Programme the UK has taken significant roles in early mission development, building the Earth Explorers, managing and calibrating the missions and developing data handling and processing expertise for exploitation of the mission outputs.

Within the Earth Watch element UKSA has proposed the TURTHS mission developed by the National Physical Laboratory. TRUTHS (Traceable Radiometry Underpinning Terrestrial-& Helio-Studies) would establish the first elements of a space-based climate and calibration observatory to help provide society with trustable evidence, facilitating a timely and economically and socially sustainable international mitigation and adaptation strategy.

The UK is also a leading funder of the Investing in Industrial Innovation (InCubed) programme, which aims to help European industry commercialise innovative new Earth Observation technologies and services, and compete in the global market.

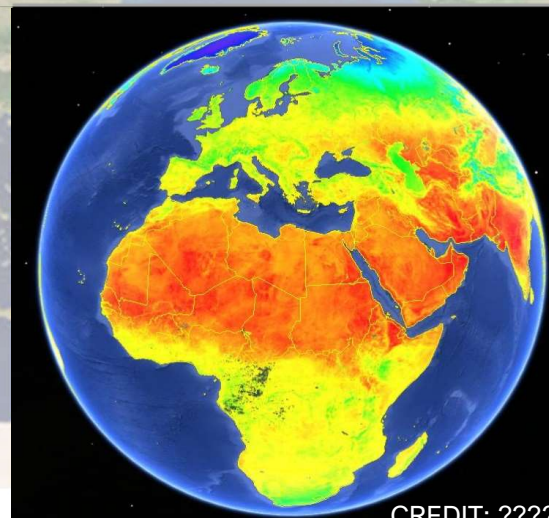
The UK has made significant science and financial contributions to the development of the Copernicus programme through ESA, the EU and EUMETSAT.



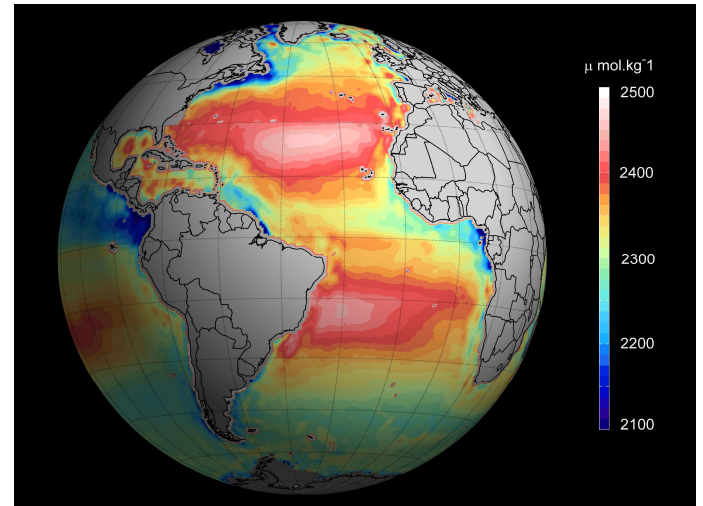
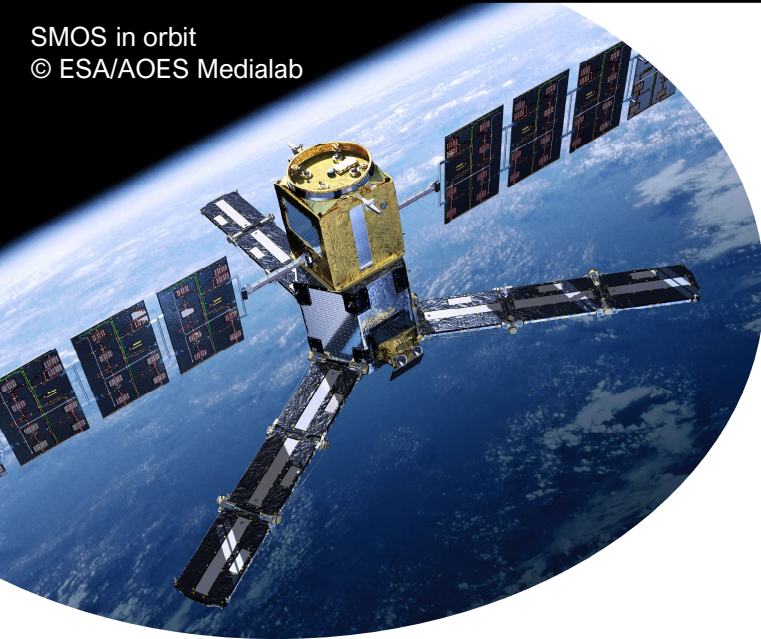
The UK is the lead funder of ESA's Climate Change Initiative which is managed from the ESA site at Harwell (UK) ECSAT. With UK science leading or contributing to all the 13 of the first phase of Essential Climate Variables, these algorithms have directly led to Climate Change Service.

Now in the second phase of CCI, the UK is also leading or contributing to new ECVs, in the areas of Water Vapour, Salinity, Biomass, Land Surface Temperature, Ice Sheets (Antarctica), Ocean Colour, and Sea Surface Temperature. The UK leads on the Data Portal, exploiting the world leading JASMIN facility, and on the Climate Modelers User Group which is led by the Hadley Centre.

There is a significant overlap between UK leading teams in CCI (SST, LST, Biomass) and on the UK leads on algorithms for the European operational / Earth Explorer satellites (such as Sentinel-3 and Biomass)



SMOS in orbit
© ESA/AOES Medialab

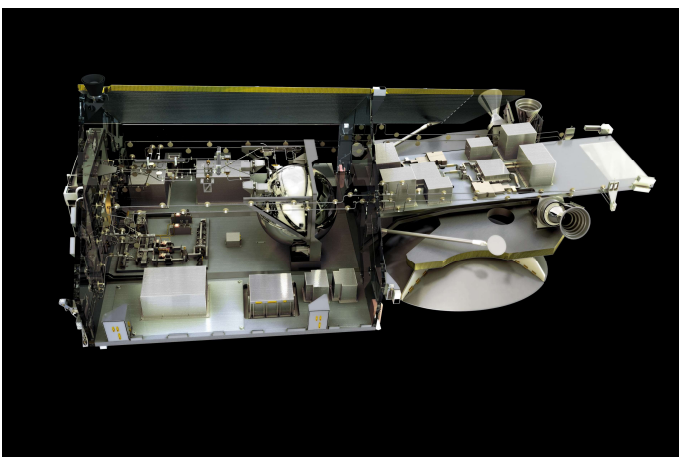


Ocean alkalinity © Ifremer/ESA/CNES

SMOS (Soil moisture and ocean salinity) is ESA's water mission making global observations of soil moisture over land and salinity over oceans, two crucial components of the water cycle.

Two Principal Investigators on SMOS are drawn from UK academia (the National Oceanography Centre at the University of Southampton and the Earth and Planetary Remote Sensing Laboratory at De Montfort University in Leicester).

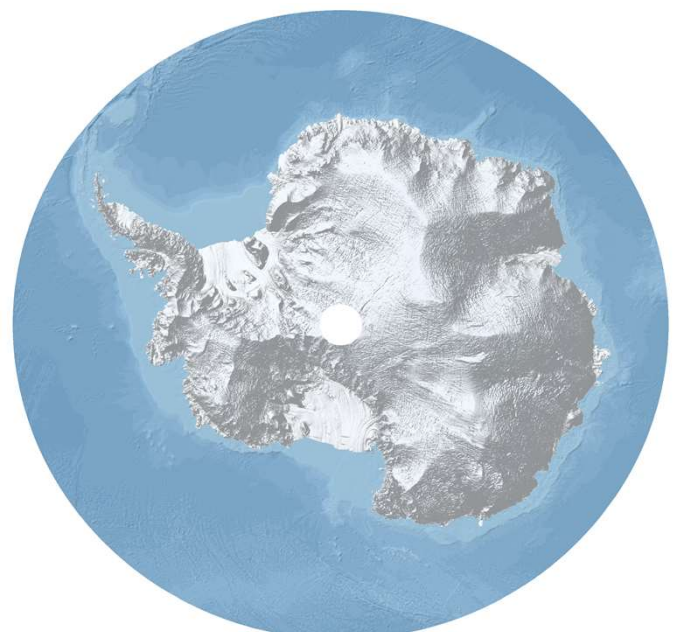
UK industry has also made important contributions with SCISYS UK Ltd responsible for the design and implementation of the satellite's main instrument control and data handling software and for a simulator used to support instrument commissioning. ComDev developed the X-band filter and Chelton Antennas was involved in the manufacture of the antennas.



Inside the CryoSat-2 satellite © ESA/AOES Medialab

CryoSat, ESA's ice mission, was proposed and the science led from the UK. It is dedicated to measuring the thickness of polar sea ice and is the only mission capable of systematically charting the ice sheet's contribution to global sea-level rises.

The UK also developed important hardware for the satellite: Marotta UK Limited supplied high-performance fluid components for space applications, SCISYS UK Ltd developed the onboard application software responsible for controlling the satellite's orbit and altitude and for managing communications with the ground segment, ABSL provided CryoSat-2's battery, and ComDev produced the mission's Siral Duplexer.



Antartica in 3D © CPOM

Aeolus - ESA's wind mission – and the first satellite to measure wind speeds across the entire Earth from its surface to the high stratosphere has benefited hugely from the involvement of UK industry with Airbus UK priming the mission and leading AIT.

Teledyne e2v contributed a key detector on the Atmospheric Laser Doppler Instrument (ALADIN) to measure the altitude of aerosols in the atmosphere and the wind speed at each altitude.

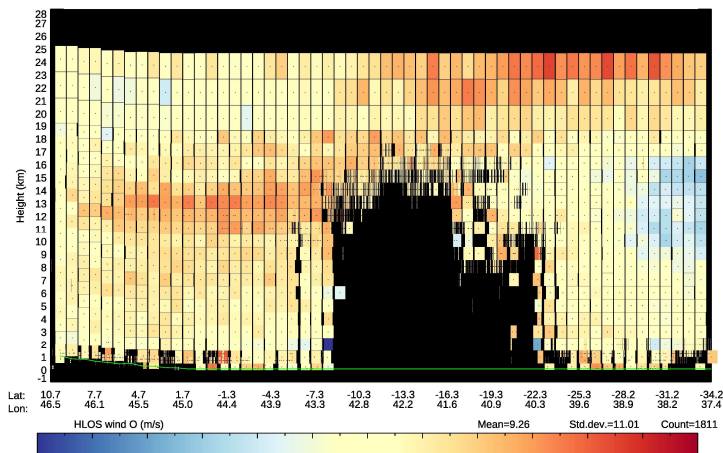
Scisys developed the satellite's onboard software and provided a bespoke operational simulator, SSTL provided electronics for onboard instruments, and battery and propulsion equipment were provided by ABSL and AMPAC respectively.



ESA's Earth Explorer satellites © ESA-P. Carril, 2012

EarthCARE (Earth Clouds, Aerosols and Radiation Explorer), ESA's cloud and aerosol mission, developed in co-operation with JAXA, will collect global simultaneous observations of cloud and aerosol profiles together with solar and thermal radiation to include these parameters in numerical weather and climate models.

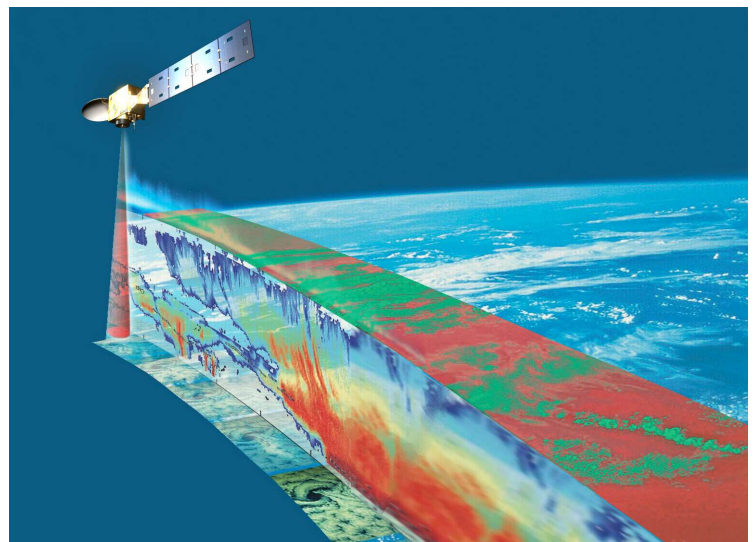
It is scheduled for launch in 2022 with key elements of the project being built in the UK. SSTL is supplying the Multi-Spectral Imager, the control unit for which is being developed by TAS UK who will also supply the Broadband Radiometer instrument.



Aeolus wind measurements, Cyclone Idai, March 2019 © ECMWF-M. Rennie

Strong UK contribution to the Earth Explorer programme is continuing:

- ESA's forest mission is **Biomass** which will launch in 2022. It is being primed in the UK by Airbus Defence and Space.
- **FLEX** is ESA's plant health mission and will launch in 2023. TAS UK is leading on the Assembly, Integration and Testing of the satellite which will be the first ESA mission to pass through National Satellite Testing Facility at the Harwell space campus in Oxfordshire.
- UK science and industry is involved in both candidate missions under consideration for EE9.



EarthCARE © ESA – AOES Medialab

UKSA is committed to creating many new jobs in space over the next ten years. We therefore also need a new generation with the right skills and enthusiasm to fill the Earth Observation jobs that will be created in the UK.

Space inspires old and young in a way few other things can. For example, Tim Peake's Principia mission reached 1.6 million young people with science, technology, engineering and maths, using space to change the way they look at their world.

The EO team have capitalised on that and have a variety of projects aimed to bring EO topics into everyday life and through hosting careers events.



This year we have funded a project led by experts at the University of Edinburgh and the Plymouth Marine Laboratory to develop innovative teaching tools to bring the science of Earth Observation to life in the classroom.

The EO-Pi project provides introductory educational materials to support the development of lesson plans in UK schools. These include some basics on Earth Observation science and the opportunity to test those ideas using computational and physical experiments, and to explore real Earth Observation data. This material is delivered using Raspberry Pi units and online tools allowing students to collect and analyse real life Earth Observation data to produce models and images.



Scientists from [@PlymouthMarine](#) showed Y8 students how to explore ocean colour using drones and satellites on a project with [@EdinburghUni](#) & funded by [@spacegovuk](#). Thanks to [@VMartinezPML](#) [@cursedquark](#) [@rjbrewin](#) for the insight [#SecchiDisc](#) [#EOschoolUK](#) [#WomenInSTEM](#)



We have also supported The Triathlon Trust to partner with Ideas Foundation and Venture Thinking to deliver the 'View from Space to Earth' project, bringing primary schools an engaging day of bike-run activity linked with the theme of Earth Observation. It's a fun event designed to inspire children to get more active and work together towards a shared goal, whilst learning about the exciting topic of Earth Observation.

Children attend an assembly to watch a briefing video setting their challenge, featuring Team GB Paralympian and Triathlon Trust ambassador [Lauren Steadman](#) and glaciologist Dr Anna Hogg from the [Centre for Polar Observation and Modelling](#). All equipment required to participate, including bikes mounted on turbo trainers to make them static, is provided and the physical activity is non-competitive, fully inclusive and suitable for children of all abilities.



We have also supported outreach to higher education students. Students have experienced Earth Observation careers as part of UKSA's Space Placement in Industry programme which supports the provision of paid work placements across the sector. SPIN is a competitive process which offers small grants up to a maximum of £3,000 for each award for projects that can be carried out by an undergraduate or postgraduate student in a relevant discipline over a period of 8 or more weeks in the summer. The scheme has been very successful in securing these students continued employment: around 30% have secured posts within the company they were placed with and around 70% have secured employment across the sector more generally.

UKSA relies on successful collaborations with a range of delivery partners to develop and implement our vision for EO. A few, but by no means all, are described in the pages below.

Space for Smarter Government Programme

Enabling the public sector to save money, innovate and make more effective policy decisions by using space technology and data

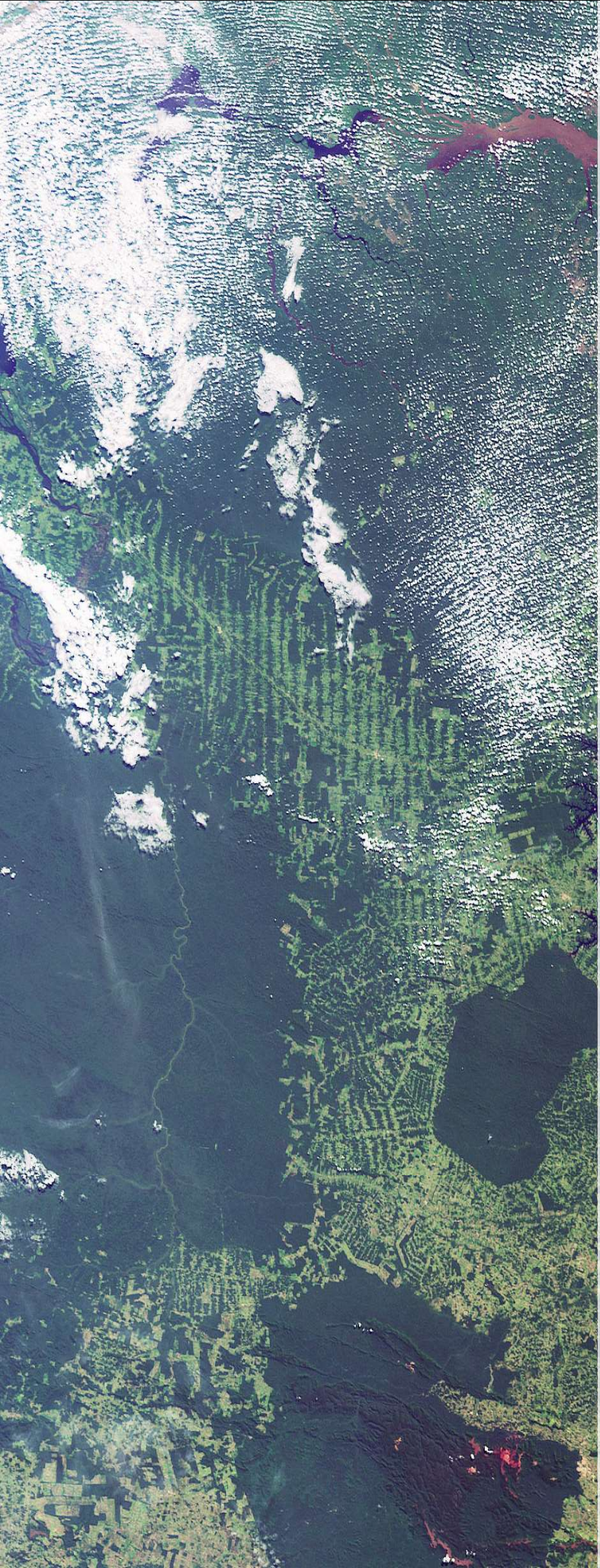
The Space for Smarter Government Programme (SSGP) is a strategic, national, programme established in 2014, led and funded by the UK Space Agency. It is delivered in collaboration with the Satellite Applications Catapult to drive the uptake and use of space products, data and services across government departments.

The programme aims to increase the public sector's use of space as an enabling technology to stimulate innovation and growth whilst at same time making government more efficient and 'smarter'. A major success of the programme is that the Department of Environment (Defra) have now set up their own EO Centre of Excellence and all major policies and programmes now consider what benefits EO can bring from the outset.

Recent SSGP projects making use of EO data have:

- Investigated the feasibility of using satellite imagery and Machine Learning to identify barriers to widespread roll out of Electric Vehicle charging infrastructure via automated identification and measurement of the features of public and on-street locations;
- Demonstrated a cost and time effective procedure utilising satellite-derived data to aid in the management of interventions to structures forming UK Critical National Infrastructure.
- Quantified maritime traffic to give a more realistic representation of vessel movements in congested maritime environments in order to improve safety and secure cost savings.





Earth Observation has been a key component of a significant number of projects within the Agency's **International Partnership Programme (IPP)**. IPP is a five-year, £152 million programme which uses the UK space sector's research and innovation strength to deliver a sustainable economic or societal benefit to emerging and developing economies around the world.

IPP is part of and is funded from the Department for Business, Energy and Industrial Strategy's Global Challenges Research Fund (GCRF): a £1.5 billion fund announced by the UK Government, which supports cutting-edge research and innovation on global issues affecting developing countries. It harnesses the expertise of the UK's world-leading researchers, focusing on:

- funding challenge-led disciplinary and interdisciplinary research;
- strengthening capability for research, innovation and knowledge exchange in the UK and developing countries through partnership with excellent UK research and researchers;
- providing an agile response to emergencies where there is an urgent research or on-the-ground need.

The GCRF forms part of the UK's Official Development Assistance (ODA) commitment, which is monitored by the Organisation for Economic Cooperation and Development (OECD). ODA-funded activity focuses on outcomes that promote long-term sustainable growth of countries on the OECD Development Assistance Committee (DAC) list and is administered with the promotion of the economic development and welfare of developing countries as its main objective. IPP is fully ODA compliant, being delivered in alignment with UK aid strategy and the United Nations' (UN) Sustainable Development Goals (SDGs).

IPP contributes to the continued strength of the UK's space sector, building on the unique strengths that the sector can offer through services and technology to help with aid effort. The projects within IPP span a variety of themes, including reducing deforestation, disaster response, land-use monitoring, reducing maritime problems and renewable energy.

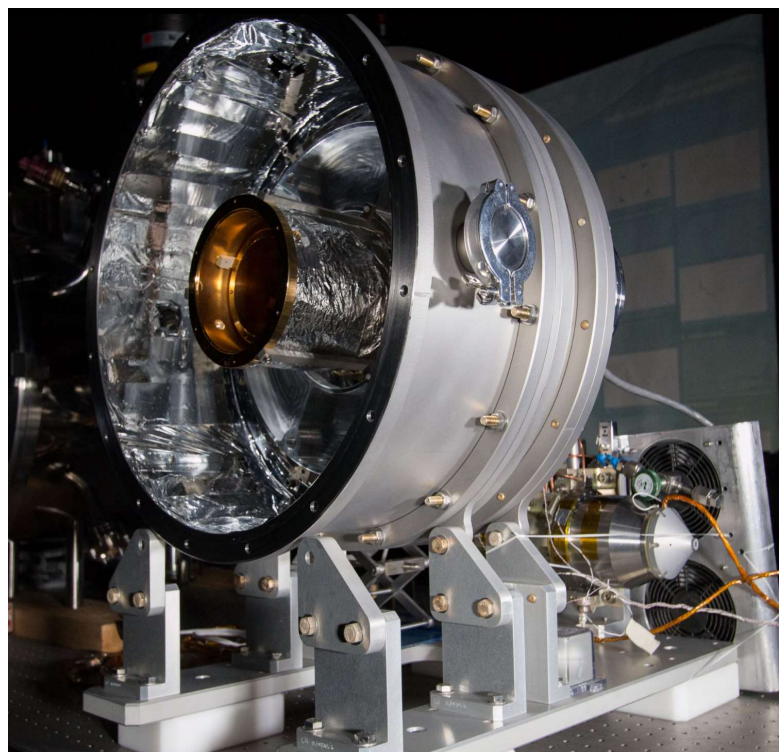
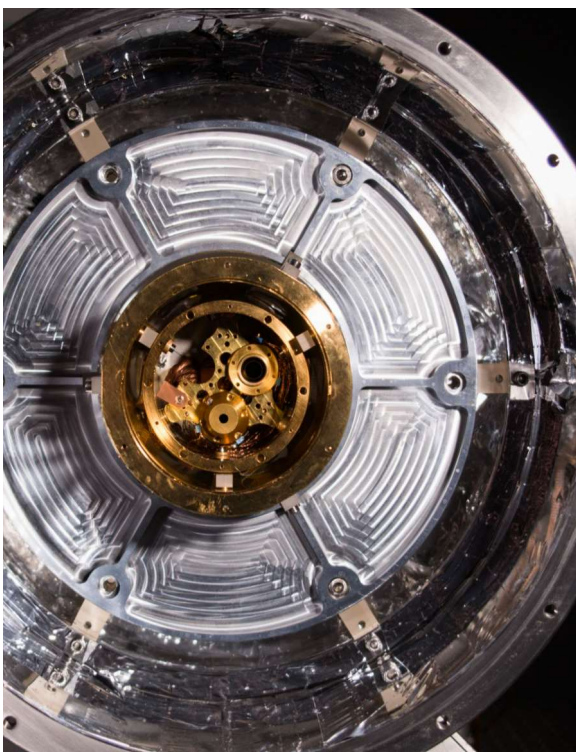
33 projects have been commissioned to date run by a large variety of organisations across industry, academia and non-profit entities. UK and international organisations are involved in the project consortiums.

The Centre for Earth Observation Instrumentation (CEOI) is a collaboration hosted by University of Leicester in partnership with Airbus, QinetiQ, University of Leicester, and RAL Space/the Science and Technology Facilities Council.



CEOI aims to be the driving force in the UK for the development and delivery of world class instrumentation for national and international EO missions for science, operational and commercial needs. The CEOI vision is to develop and strengthen UK expertise and capabilities in EO instruments. The CEOI run competitions for grants to develop new ideas in EO technology and oversee the selected projects, so as to position UK teams to win leading roles in future space programmes.

CEOI is funded by the UK Space Agency with all projects requiring matched funding from the project partners. Since its launch in 2007 CEOI has supported the development of a range of technologies which have played an important part in the use of EO to better understand our planet.



Case Study: CEOI support in the development of the UK-led TRUTHS mission

The images above show a flight representative engineering model of Cryogenic Solar Absolute Radiometer (CSAR). CSAR lies at the heart of the novel in-flight calibration system of the UK led mission proposal called TRUTHS (www.npl.co.uk/TRUTHS) which aims to establish a climate and calibration observatory in space capable of improving the accuracy of Earth observation data by a factor of ten. CSAR operates at -220 °C cooled by a space cooler and measures variance in incoming solar radiation, to assess any impact of natural variation on climate. CEOI funding has supported the development of CSAR and other elements of the proposed mission.

Working collaboratively in the UK

SPACE CLIMATE

Space4Climate is a public-private-academic partnership working collaboratively to ensure a seamless supply chain for climate data from space. UKSA chairs the partnership.

Space4Climate supports the UK's world-leading climate community to deliver, sustain and make use of climate information from space, enabling it to be integrated "as standard" in a variety of climate services for global economic and societal benefit.

This is done by coordinating activities, expertise and resources across our partners to:

- **Expand market uptake domestically and internationally**, raising the profile of UK expertise, products and services, identifying climate services user requirements and facilitating and brokering new market growth opportunities.
- **Sustain and grow the network**, expanding our community by developing and maintaining lists of UK providers, and building community capacity by providing training and alerts to funding sources.
- **Support delivery of a seamless supply chain**, by identifying new requirements and barriers to provision and sustainability, and working together to address these.

Contact: s4c@the-iaea.org | [@Space4Climate](https://twitter.com/Space4Climate) | www.the-iaea.org/space4climate

UK IMPROVES CONFIDENCE IN CLIMATE DATA AND SERVICES THROUGH RIGOROUS METROLOGY

Satellite observations of Earth, that are essential for climate monitoring, require robust validation.



SPACE CLIMATE

NPL

SATELLITE DATA HELPS MONITOR CARBON RELEASED BY FIRES

Model that uses satellite data to monitor areas burned by fires, is used by organisations around the world for fire and land management.



SPACE CLIMATE

UCL National Centre for Earth Observation

OBSERVING THE URBAN THERMAL ENVIRONMENT FROM SPACE

Land surface temperature climate data provides insight into the changing landscapes of the urban environment.



SPACE CLIMATE

UNIVERSITY OF LEICESTER National Centre for Earth Observation

OCEAN ATLAS OF BIOLOGICAL RESPONSE TO CHANGING EL NIÑO

The atlas provides key climate impact information to improve prediction of possible risks and opportunities for fisheries-dependent societies.



SPACE CLIMATE

Enhanced productivity Reduced productivity National Centre for Earth Observation PML Plymouth Marine Laboratory

UKSA is an active member of the Committee on Earth Observation Satellites (CEOS) which ensures international coordination of civil space-based EO programs and promotes exchange of data to optimize societal benefit and inform decision making for securing a prosperous and sustainable future for humankind. The Agency also supports Defra and UK work within the Group on Earth Observations (GEO), a global partnership of governments and organisations that envisions “a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations”.

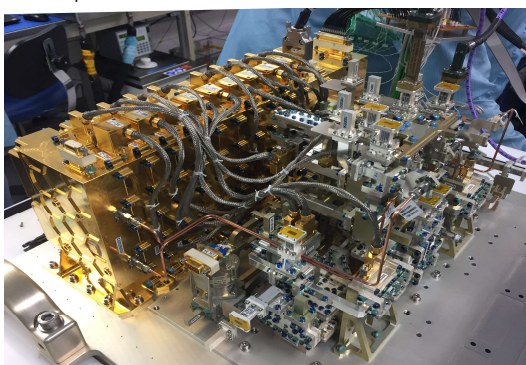
Alongside our contribution to the international coordination of EO, the Agency works to cultivate cooperation and collaboration by securing bilateral agreements in areas of mutual interest with other space agencies and governments, both in Europe and further afield, including, for example Algeria; Argentina; Australia; China; France; Greece; India; Indonesia; Italy; Japan; Kazakhstan; Mexico; Nigeria; Peru; Russia; South Africa; United Arab Emirates; United States of America. These agreements provide important opportunities for the UK EO community to develop new capabilities and contribute to significant missions.

Case Study: UK-France collaboration in EO

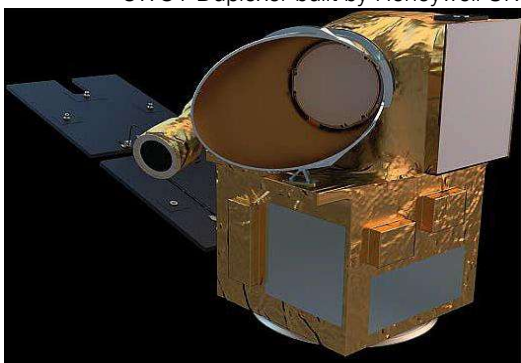
Following a bilateral agreement, signed during a French Presidential visit to the UK in 2014, UKSA and CNES have collaborated successfully on three important weather and climate missions:



MetOp Second Generation © ESA-P. Carril 2012



SWOT Duplexer built by Honeywell UK



Artist impression of MicroCarb satellite © Airbus DS

1. **IASI-NG** is a key instrument for the second generation MetOp satellites. With £8.5m of financial support provided by UKSA, Leonardo UK have developed cutting edge infrared sensors, often described as the eyes of the instrument, key to its improved weather forecasting capability.
2. **SWOT** is a NASA-led mission to make the first global survey of the world's surface waters and oceans. UKSA provided funding for Honeywell UK to develop and build a duplexer for the mission, a vital component to route radar signals around the satellite at a power of 1,500W – a level never seen in this kind of device. UKSA is also supporting UK scientists to be involved in the calibration of the mission for Estuarine environments.
3. **MicroCarb** is a CNES-led mission to monitor carbon fluxes. As a mission partner the UK is undertaking a suite of activities including the Assembly Integration and Testing (AIT), the batteries, and ground segment, as well as being part of the mission science preparation and essential calibration and validation.