

An aerial photograph of a coastline. The top half of the image shows a large body of water with a dark, almost black hue, possibly due to depth or shadows. The bottom half shows a green, forested area with some brown patches, likely a wetland or marsh. The text is overlaid on the water and land.

Space Innovation and Growth Strategy

Leadership in Climate Technologies & Services

Executive Summary

Space Innovation and Growth Strategy (IGS)

Leadership in Climate Technologies & Services – Executive Summary

The IGS Recommendation

IGS Recommendation 6 states that: Government, in partnership with industry and academia, should map out a strategy for the UK to secure world leadership in the technologies and services related to climate-change validation, adaptation and mitigation. This should include verifying international carbon agreements. The UK should ensure that it leverages its world-class research and modelling capabilities in climate change to full economic and social effect and support ESA's contribution to climate change through its recently established ESA Climate Office at Harwell.

Introduction

This strategy has been produced to address the above IGS recommendation. It focuses on the role of satellite observations, climate modelling, the satellite services industry and other information suppliers in the delivery of climate and climate-related services. Such services are required for predicting and anticipating the impact of climate change and for verifying international carbon agreements and other measures aimed at mitigation and adaptation to climate change. The strategy summarised here is driven by the requirement to address user needs (scientific, political and commercial) in order to ensure appropriate returns on investment, for science and policy development and, in commercial terms, for industry and the economy.

Overall, there are five main high-level recommendations plus a number of action points. Once the strategy has been adopted by the various stakeholders, an implementation plan will be required, together with suitable oversight. The main thrusts emerging from the preparation of this strategy have already been adopted within the UK Space Agency's Earth Observation strategy.

This IGS strategy will be owned by the Space Leadership Council, industry (represented by UKspace) and the UK Space Agency, who will coordinate and oversee implementation. Alongside the UKSA will be a network of interested parties undertaking the implementation, including NERC, the Met Office and the satellite and satellite services industries. A variety of delivery mechanisms and initiatives will be employed, including the Satellite Applications Catapult, the Climate and Environmental Monitoring from Space facility (CEMS), the National Space Technology Programme (NSTP), the proposed National Space Applications Programme (NSAP) and collaborations such as the Environmental Science to Services and National Hazard Partnerships (ESSP and NHP respectively).

In order to facilitate realisation of this strategy's ambitions, progress with several of the cross-cutting themes set out in the IGS re-stack is necessary; particularly important areas include market analysis, the introduction of private financial investment capacity, the building of appropriate capacity in the scientific, technological and managerial skills base and the further development of interactions between academia and business.

Collaboration with international partners, and with the rest of Europe in particular, is also a major part of this strategy.





The UK cannot 'go it alone' and without such a strategy to exploit satellite observations and to engage with international efforts, the UK will find it far more difficult to deal with the challenge and threat of climate change and it will also miss the opportunity to develop new business as other nations seek information on how to tackle this global problem.

Vision, Aspirations and Goals

The strategy addresses opportunities to exploit satellite observations which will position the UK to:

- lead the creation, use and sale of credible, trusted climate knowledge covering:
 - climate sciences, research and supporting technologies;
 - climate policy-making and delivery;
 - commercial climate services delivered from world leading businesses;
- develop tools to evaluate climate change policy proposals, monitor policy implementation, provide guidance on extreme weather events and enable informed decision-making;
- establish world leading capabilities and facilities for producing readily available satellite observations and data, including:
 - climate quality datasets with continuity of data, quality assurance, traceability and cross-calibration between different instruments;
 - data sets that can be productively combined with other forms of data and models;

supported by design, production and operation of the necessary satellites, payloads and ground infrastructure;

- become recognised as the leading reference point globally for Earth Observation measurement science and metrology best practice;
- grow its own network of world leading suppliers of integrated Climate Services;
- capture a growing share of the commercial market for Climate and Climate-related Services.

The Scale of the Opportunity

Climate and climate-related services will impinge on many aspects of daily life, bringing direct financial returns to the UK economy as well as substantial indirect value and numerous quality of life benefits to UK citizens. The value to the UK will therefore be realised in many different ways, but investment from industry and business will be swayed by the prospect of immediate commercial transactions and the size of the market for related services. We have attempted therefore to measure the size of the potential commercial market for suppliers of such services. We have also taken into account the public, non-transactional markets for climate data, including in research and policy formulation for example.



A significant part of the requirement is for what is increasingly being referred to as 'climate services'. Climate services closely parallel the provision of weather services. Weather services are delivered to the government, the public and commerce and are well-understood. They deliver historical data, current observations and prediction of the weather to come in the near future. The main difference in the case of climate services is the timescale for the predictions and for the historical data records. Climate services will also need to draw on information covering a broader range of environmental parameters and require integration of observations from both satellites and in situ sources with information and knowledge from other disciplines. Services supporting provision of information to underpin other policy driven areas, such as carbon trading (carbon markets intelligence), will also be important, as will monitoring of a variety of activities that impact the environment and climate (illegal logging of forests for example).

There is an open market for climate services globally. The (previously unmeasured) global market for commercial weather and climate services, regardless of the source of data underlying the service, is estimated at £26.6bn for 2010/11 and is set to increase to £35.3bn by 2015¹. Of this global figure for 2010/11, £14.3bn (54%) is estimated for weather services and £12.3bn (46%) for climate services. Historical data shows consistent strong market growth and published forecasts project that this will continue. An assessment of the probable use of satellite data indicates that while space accounts for some 24% of this market in its own right, it enables much more of the total value.

The study also suggests that approximately 90% of the measured transactions are undertaken with private sector suppliers (the remaining 10% being attributed to government bodies and charitable organisations). The most significant sectors within this market are Legal and Financial Services (£2.8bn, 10% of transactions), Renewable Energy (£2.4bn, 9%) and News and Publishing (£1.2bn, 5%). It is already clear that several other sectors, including water, energy, food, natural resources and infrastructure development, are important potential users.



The 2009/10 global market for carbon markets intelligence has been valued at £30bn.² It is growing strongly at 12%-15% per annum. This comprises all carbon market activity for which data derived from space systems and delivered as part of wider services is already, or may in the future, be relevant. The market is not waiting for observations from satellites to come on stream; it is already 'making do', but it is waiting on satellite observations to reduce uncertainty and risk and possibly, but

not essentially, cost. This is a particularly significant segment for the UK to develop in the context of the legal and financial services (including insurance and investment) provided by the City of London where there are strong commercial incentives to become early adopters.

There are also 'markets' for the supply of data, measurements and information services, largely within the public sector, which do not involve commercial financial transactions. Typically, such products and services are supplied in support of operational meteorology, academic research, government to government dealings, policy development, aid agency operations and measures undertaken by various entities aimed at disaster risk reduction.

The Public Sector is both a provider and user of climate and data services. Information is frequently provided internally from within the Public Sector to public sector users, for example from the Met Office Hadley Centre and NERC Research Centres such as the Centre for Ecology & Hydrology; these providers also sell to commercial customers, thus contributing to the delivery of the commercialisation and impact targets for these organisations.

¹ Global Weather and Climate Commercial Aftermarket 2010/11, Knowledge Matrix Ltd, December 2011; note that this estimate is based on a broad definition of weather and climate services, covering all transactions, regardless of the source of observational data used.

² Carbon Market: Intelligence: Monitoring Report 2009/10, Knowledge Matrix Ltd, December 2010



Research and policymaking can generate demands for equipment, data and services that are unavailable internally and which are therefore procured from commercial suppliers, providing a significant growth opportunity for EO and information service providers, consultancies and academics.

By continuing to fund the non-commercial, institutional sector, the public sector can enable the commercial sector to underpin the development of broader international business opportunities with considerable export potential.

The scale of these largely institutional data and service supply activities is hard to quantify, but the impact on society is clearly very considerable and no less important than the commercial transactions outlined earlier.

The challenges

The UK's academic and industrial sectors have significant expertise in all aspects of the EO delivery chain, but these capabilities are quite fragmented. One of the main challenges is therefore to develop an end-to-end supply chain capable of developing and delivering climate related information and services efficiently and cost-effectively to end users who are frequently unfamiliar with the power and potential for using data from space. The supply chain is illustrated below.

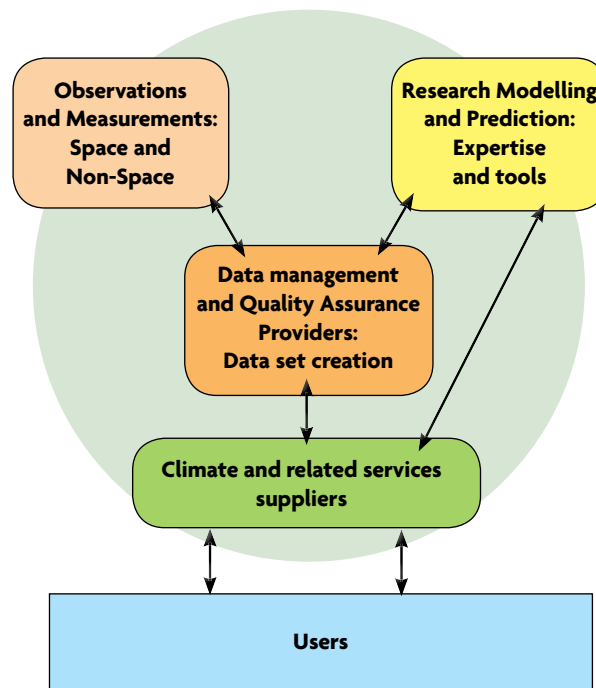


Figure 1: The Supply Chain for Climate and Related Services

There are also challenges in ensuring the continuity and quality assurance of essential satellite observations, with extracting traceable measurement information, with integrating such information with in-situ terrestrial data and in managing the UK's contributions and positioning in the relevant international and global collaborations.

Overcoming the challenges in the development of new services should be one of the Satellite Applications Catapult's primary objectives, bringing together participants and linking them to funding opportunities from the Research Councils, the TSB, ESA and the EC (including the Horizon 2020 programme in particular).

An objective for the UKSA and its partners should be to align the programmes from these sources to support the strategy and manage the UK's interaction with relevant international and global collaborative endeavours.

Recommendations

1. The UK should act quickly to develop operational climate-related information services using satellite (and other) observations and measurement data.
2. The UK should establish a seamless supply chain for these services.

To take a leading role in the actions needed to underpin the above the UK should:

3. Initiate work nationally aimed at ensuring the integrity of satellite observations, measurement data and derived information products;
4. Work with other stakeholders internationally to ensure the continuity and evolution of required satellite observations;
5. Play a leading role internationally to link UK national activities to the efforts of European (and other international) partners and programmes.

The recommendations are reproduced in greater detail in the final section of this document.

Actions


To implement the above recommendations, and thereby realise the strategy's vision, ambitions and goals, the UK needs to initiate the following actions without delay:

1. **Carry out detailed market studies and pilot at least two climate services** as full operational demonstrations. One should be with the re-insurance industry, to include application to flood prediction and mitigation. The second should be with carbon market stakeholders, to include application to agricultural and natural resource monitoring and management, to include forest monitoring in particular. This work should be completed by March 2014.
2. **Establish an interconnected UK ground segment infrastructure** and use it to develop and demonstrate suitable information products.
3. **Use the Climate and Environmental Monitoring from Space facility (CEMS) to process and merge data streams into climate quality and other required data sets.** It should also provide improved access to data and data sets. This development of the services to be undertaken by CEMS should be completed by 2015.
4. **Develop appropriate metrology procedures and standards**, through the NPL Centre for Carbon Measurement (NPL|CCM) using the UK National Measurement System, QA4EO and other initiatives and, working with NCEO, Met Office, CEMS and others, demonstrate and disseminate metrology best practice in earth observation and climate applications.
5. **Task the Satellite Applications Catapult with facilitating a UK supply chain providing Earth Observation products for climate related services with the desired seamless connectivity.**

In the medium to long term the UK Space Agency and its UK partners should:

6. **Provide funding and, working with others, ensure that the essential satellite observations needed for the provision of climate services are sustained.**
7. **Engage fully in relevant science, research and modelling;** the Agency should continue to a) support relevant ESA programmes including: EOEP, CCI and Jason, building on the commitment made at the 2012 ESA Ministerial, b) ensure that the UK stays at the leading edge of related technology development c) ensure that mechanisms are in place to enable appropriate training and support for scientists, engineers and others required to deliver climate services.



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8. **With its partners, UKSA should develop a mechanism which enables UK scientists to work with ESA and others to define and develop concepts for long term science missions.**
 9. **Identify priorities for GMES and ensure that as far as possible they are funded.**
 10. **Coordinate activities, technology development and training** in order to a) align research with exploitation and with technology roadmaps and b) ensure that UK companies, universities and other organisations can take advantage of current and future mission opportunities.
 11. **Take the global lead in tackling the migration of Earth Observation research missions to longer term operational programmes.** This should include identifying new funding lines for sustaining and 'operationalising' key data streams from research-led missions.
 12. **Retain the UK's lead for ESA's Climate Modelling User Group (CMUG),** to maintain strong UK influence in the programme and ensure that climate quality data sets are generated to support the UK's planned climate services activities.

It will be necessary to assign responsibilities and timescales for the above where this is not already explicitly stated. Further detail associated with these actions is given below in conjunction with expanded text on the recommendations.

Process and acknowledgements

This strategy has been formulated by a core team from the three organisations sponsoring IGS Recommendation 6 (NERC, the Met Office and UKspace), supported by a Task Group comprising, from time to time, representatives from industry, commerce, academia, UKSA, NCEO, NPL|CCM, CEMS, Defra, and DECC.

The principal authors of this document are:

Richard Brook (UKspace), Stewart Turner (Met Office) and Andrea Sharpe (NERC)

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Recommendations in full

Recommendation 1 – Development of climate-related information services

UK industry, supported by academia and government, should take prompt action to develop new climate related information services utilising satellite observations to address the commercial component of the rapidly growing £40Bn-£45Bn global market for climate related information services; it should ensure that it is first to market with new services and should aim to lead the world in the provision of such value adding services.

The significance of the opportunity

The real value in the climate related information produced from satellite observations and data lies in demonstrating and monitoring changes in the environment and in supporting policy development and decision making. Such information can also be used to examine adherence to directives and agreements that are designed to limit damaging impacts of human activity.

There is emerging global demand for on-going information services, professionally delivered to governments, public bodies and commercial enterprises for such purposes. This is where the value to the UK in terms of political influence and commercial return on investment (growth and jobs for the UK) lies and the UK can usefully build on its existing activities by incorporating Earth Observation data more extensively.

The UK is well-placed to develop and deliver climate services. For example, the Met Office is providing some major climate services to a range of customers and is working with NERC and others to develop a strong national framework for climate services in the coming years. The UK also has a number of smaller specialist businesses and larger consultancies that can capitalise on these opportunities, provided they are supplied with reliable data from observations and sufficient understanding of the significance of the data.

The global market in terms of commercial transactions from provision of climate related information services has been sized at around £40Bn-£45Bn pa. If these recommendations are accepted and the actions taken, the UK should aim for a 10% share of this market by 2030.

Priorities for the UK

It is already clear that several sectors, including water, energy, food, natural resources and infrastructure development, are important potential users of climate related services. Another particularly significant segment for the UK to develop is associated with legal and financial services (including insurance, re-insurance and investment). This sector is a significant user in its own right and it also serves the many of the other potential user communities above. It has a world leading presence in the City of London and strong commercial incentives to become an early adopter.

Further detailed analysis to identify priority target uses within these sectors is needed to strengthen the underlying evidence base and the case for commercial investment.

Actions for the UK

- 1 In conjunction with existing operational activities, carry out detailed market studies in new areas of application and pilot at least two new climate services as full operational demonstrations. One should be with the re-insurance industry, to include application to flood prediction and mitigation. The second should be with carbon market stakeholders, to include application to agricultural and natural resource monitoring and management, to include forest monitoring in particular. This work should be facilitated by the Satellite Applications Catapult and be completed by March 2014.





Recommendation 2 - Facilitating a seamless supply chain

The Satellite Applications Catapult should be tasked by its governing board with facilitating a seamless UK supply chain providing Earth Observation products for climate related services, from obtaining satellite observations and in-situ data through to new research and the delivery of information services on a professional basis, in volume, to end users.

The importance of a seamless supply chain

The end-to-end supply chain, from scientific researchers through to end users who may have no knowledge of space, encompasses a wide range of expertise, skills and knowledge. The UK is very good in most of the key areas of activity but its areas of expertise do not function as a seamless supply chain and, in particular, the connectivity between the satellite community, modellers, researchers and the end users of climate related information services is very underdeveloped.

In order to reap the commercial and political rewards from the supply of services, against competition from elsewhere also aiming to lead in this domain, it is essential that barriers to the smooth exploitation of research and knowledge and to the delivery of professional services are removed. This includes poor connectivity in the supply chain. Without better connectivity, the UK will be unable to lead the delivery of information services to national and international clients or to deliver the commensurate returns to the UK economy and value to the UK's stakeholders.

Developing the role of the Catapult and the Harwell Space Cluster

The Harwell Space Cluster, comprising the Satellite Applications Catapult, ESA Harwell, the demonstration and other facilities initially developed by ISIC, elements of the interconnected UK ground segment infrastructure, RAL Space and planned high speed networks to other sites, is ideally placed to serve as a focal point for supply chain facilitation. The Satellite Applications Catapult in particular is in an excellent position to facilitate much of the required connectivity through outreach and collaborative working.

Actions for the UK

- 1 The Satellite Applications Catapult should develop a programme for achieving the desired connectivity and for facilitating the development and demonstration of pilot services at operational level, ensuring that existing UK assets and skills are fully utilised.
- 2 An interconnected UK ground segment infrastructure, incorporating existing assets, should be established and used to develop and demonstrate suitable information products.
- 3 The Climate and Environmental Monitoring from Space facility (CEMS) should be used to process and merge data streams into climate quality and other required data sets. It should also provide improved access to data and data sets. This development of the services to be undertaken by CEMS should be completed by 2015.
- 4 The UK Space Agency should ensure that the UK stays at the leading edge of related technology development; coordinating activities, technology development and appropriate training to ensure that organisations are able to take advantage of upcoming opportunities from current and future missions.
- 5 The UK Space Agency and its UK partners should remain fully engaged in relevant science, research and modelling. The Agency should continue to a) support relevant ESA programmes including: EOEP, CCI and Jason, building on the commitment made at the 2012 ESA Ministerial, b) ensure that the UK stays at the leading edge of related technology development and c) ensure that mechanisms are in place to enable appropriate training and support for scientists, engineers and others to deliver climate services.

Recommendation 3 – Assuring the integrity of observations, data and products

The UK Government, industry and researchers should build and strengthen the UK as the leading authority for the creation of climate quality datasets, rigorous integrity checking of data and for the application of best metrology practices to the calibration of observations and characterising the uncertainty of information products derived from satellite instrumentation.

The importance of data integrity

The level of confidence that can be placed in the accuracy and meaning of observations and data is crucial. Uncertainties in the measurements obtained from observations are compounded in the climate modelling process to broaden the spread of predicted outcomes, lessening the confidence that can be placed in such predictions and hampering understanding, in scientific terms, of how the Earth's climate works.

The problem is further compounded by the diversity of satellite instrumentation and systems, many of which were produced originally for a variety of different scientific research programmes, and from which data sets spanning extended time domains have to be assembled.

The uncertainties in the accuracy of measurements obtained from satellite observations can in some cases be as great as 50% or even 100%. The impact shows up in the divergence of modelling predictions from measurements made subsequently in the field; a good example is the much faster than expected seasonal reduction in sea ice thickness and extent in the Arctic in the last few years. Good metrological practice applied to the calibration of instrumentation and the validation of data, against ground truth or by other means, can reduce the uncertainties in the data currently used by develop climate models by as much as an order of magnitude.

An opportunity which the UK should seize

Ensuring the validity and integrity of observations, data and products is an area in which the UK aspires to lead. The UK has world leading competence in this domain. There is an opportunity to fill a gap in the European and global infrastructure for observation and data management and, as a result of the in depth understanding of the observations and data sets obtained from such activities, the UK will be in an excellent position to derive maximum benefit from exploitation of the data for research, advisory and commercial purposes.

Actions for the UK

- 1 Building on and strengthening the UK's position as a world-leading authority in the generation of climate quality data sets, the NPL Centre for Carbon Measurement, working with partners (for example NCEO and Met Office), should develop and disseminate methodologies for applying metrology best practice for earth observation and climate applications. This will provide a robust underpinning for the development of data handling tools by CEMS. It will ensure that these tools and resultant data are fit for purpose and that derived information is consistent with QA4EO principles³ and can be trusted. Funding from the UK National Measurement System, ESA and other national and international initiatives should be sought to establish the UK as the global centre for assessing quality of EO and climate data.

³ See <http://QA4EO.org>





Recommendation 4 – Ensuring the continuity and evolution of satellite observations

The UK Government must work with researchers, industry and international partners to ensure long term identification, development, sustainability availability of climate quality data sets, participating in European policy development, programme implementation and broader global initiatives.

Continuity is crucial

Continuity, evolution and access to these data sets is fundamental to the strategy – without it there will not be a proper basis for credible climate prediction, well-informed decision support or confidence to invest in commercial climate services. The UK is well placed both academically and industrially through its instrumentation capability and user knowledge to play a key role in helping to ensure the continuity and evolution of observations. The UK cannot achieve this alone and should participate fully in development of the observing infrastructure (particularly with ESA, EUMETSAT and the EU) whilst also recognising the objectives of the Global Climate Observing System initiative (GCOS).

There are pressing priorities for action (for example, the current GMES data policy expires in 2013 and funding for satellites, ground systems and operations for the long term is not assured). In the event that current and planned programmes do not address current gaps in the capability to make climate related observations, the ability to model climate change will remain incomplete, constrained in its usefulness and scientifically open to challenge. If the EU GMES programme is truncated, there will be a failure to develop and operationalise European climate services and progress will become dependent on the US, losing Europe both scientific and political credibility, as well as commercial revenues and jobs.

Actions for the UK

- 1 The UK Space Agency should address the need for continued funding to sustain the satellite observations needed to enable the provision of essential climate services. It should contribute to efforts to secure the necessary climate data by supporting relevant ESA programmes e.g. EOEP, MetOp-SG, CCI and Jason and also the EU GMES programme.
- 2 Defra should work with stakeholders to identify the priority GMES activities and, as policy lead, ensure that as far as possible these are funded.
- 3 The UK Government should take a lead globally in tackling the migration of research missions to longer term sustained programmes, by identifying new funding lines for ‘operationalising’ key data streams from research-led missions.

Recommendation 5 - The relationship with Europe

In addition to pursuing a UK national strategy and a set of UK national initiatives, the UK Space Agency with wider government, industry and academia must co-ordinate its efforts with, and engage with, European and other international partners to deliver key aspects of the strategy, through ESA, EU and other programmes and initiatives.

The importance of international programmes and infrastructure

The provision of the satellite infrastructure needed to obtain and disseminate continuing observations and space-based data requires investment beyond the capacity of a single nation to provide.

Furthermore, standardisation of data formats and inter-comparison of calibration procedures can only be achieved through international collaboration.

The WMO and other UN Agencies are currently developing a Global Framework for Climate Services (GFCS), and the UK has been playing a central role in its development. The vision of the GFCS is to enable society to better manage the risks and opportunities arising from climate variability and change, especially for those who are most vulnerable to such risks.

The EU component of GMES is designed to operationalise the observation infrastructure into the future and provide European data to underpin Europe's contribution to global climate change related endeavours. Europe has a world leading track record of commercialising space technology and capability but without its own infrastructure for data provision it will be virtually impossible to extend this achievement into the realm of climate related information services.

UK participation in ESA and EU programmes

Engagement with Europe and support for European collaborative programmes such as ESA's EOEP, CCI, Jason and MetOp-SG, as well as EUMETSAT operational programmes, together with the EU's Horizon 2020 and the GMES programmes (the latter in both ESA and the EU) will enable the UK to exert maximum political influence and leadership.

Together with the UK's national space technology (NSTP) and space applications (NSAP) programmes, these collaborations with Europe will enable the UK to stay at the forefront of research and technology development, ensure the existence and operationalisation of the observations infrastructure and provide opportunities for the creation of associated services.

Actions for the UK

- 1 The UK Space Agency should increase its contribution to the ESA CCI programme, building on the commitment made at the 2012 ESA Ministerial to ensure that the UK's aspirations of parity with Germany in this programme are met.
- 2 The UK should retain its lead for ESA's CMUG to ensure that climate quality data sets are generated in support of the UK's planned climate services activities.
- 3 Provide a mechanism to facilitate and enable UK scientists to work with ESA and others to define and develop long term science missions.

This international engagement is essential to delivery of the strategy. The UK cannot 'go it alone' and without such a strategy the challenge and threat of climate change will be far more difficult to deal with.





Glossary

CCI	Climate Change Initiative
CCM	Centre for Carbon Measurement
CEMS	Climate and Environmental Monitoring from Space
CMUG	Climate Monitoring User Group
Defra	Department for Environment, Food and Rural Affairs
DECC	Department for Energy and Climate Change
EC	European Commission
EO	Earth Observation
EOEP	Earth Observation Envelope Programme
ESA	European Space Agency
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GCOS	Global Climate Observing System
GMES	Global Monitoring for Environment and Security
IGS	Innovation & Growth Strategy
ISIC	International Space Innovation Centre
MetOp-SG	Meteorological Operational satellites Second Generation
NCEO	National Centre for Earth Observation
NERC	Natural Environment Research Council
NPL	National Physical Laboratory
NPL CCM	National Physical Laboratory Centre for Carbon Measurement
NSAP	National Space Applications Programme
NSTP	National Space Technology Programme
RAL	Rutherford Appleton Laboratory
QA4EO	Quality Assurance for Earth Observation
TSB	Technology Strategy Board
UKSA	UK Space Agency

