Programme Rationale

"One of the great scientific challenges of the 21st century is to forecast the future of planet Earth. . . . We find ourselves, literally, in uncharted territory, performing an uncontrolled experiment with planet Earth that is terrifying in its scale and complexity"
Sir John Lawton, Chief Executive of the Natural Environment Research Council, 2001.

To address this challenge, in 2003 the Natural Environment Research Council launched a major research programme, "Quantifying and Understanding the Earth System". QUEST has tackled the ambitious scientific challenge of integrating across the interfaces between several research areas: land, atmospheric and marine domains; modelling and observations; palaeoclimate and the contemporary Earth; and the socio-economic and policy contexts of biophysical change. QUEST developed models that link the living and non-living components of Earth, and collated globally important datasets of observational evidence. Together, these are the toolkits for improving our understanding of the interconnected physical, ecological and biogeochemical dimensions of climate change. QUEST's work enables more robust predictions to be made of the likely consequences of different climatic conditions.

QUEST has been a vital focus for UK Earth system research, building up a scientific community that is internationally renowned. Well over 250 scientists from over 50 organisations have been involved in the programme's 18 projects. Wider engagement was achieved through our international working groups, postgraduate summer schools and the first international Earth System Science Conference. So far, QUEST has produced over 300 scientific publications and policy briefings. QUEST has nurtured strong partnerships with UK research organisations, such as the Met Office and the NERC research centres. It has also been influential internationally, through the global change programmes and the IPCC process. QUEST scientists have actively engaged with policy makers including UK government departments and agencies, and the international conventions on climate, biodiversity and pollution. QUEST has engaged in new dialogues with private sector interests in water, insurance and biofuels, and with non-governmental organisations.

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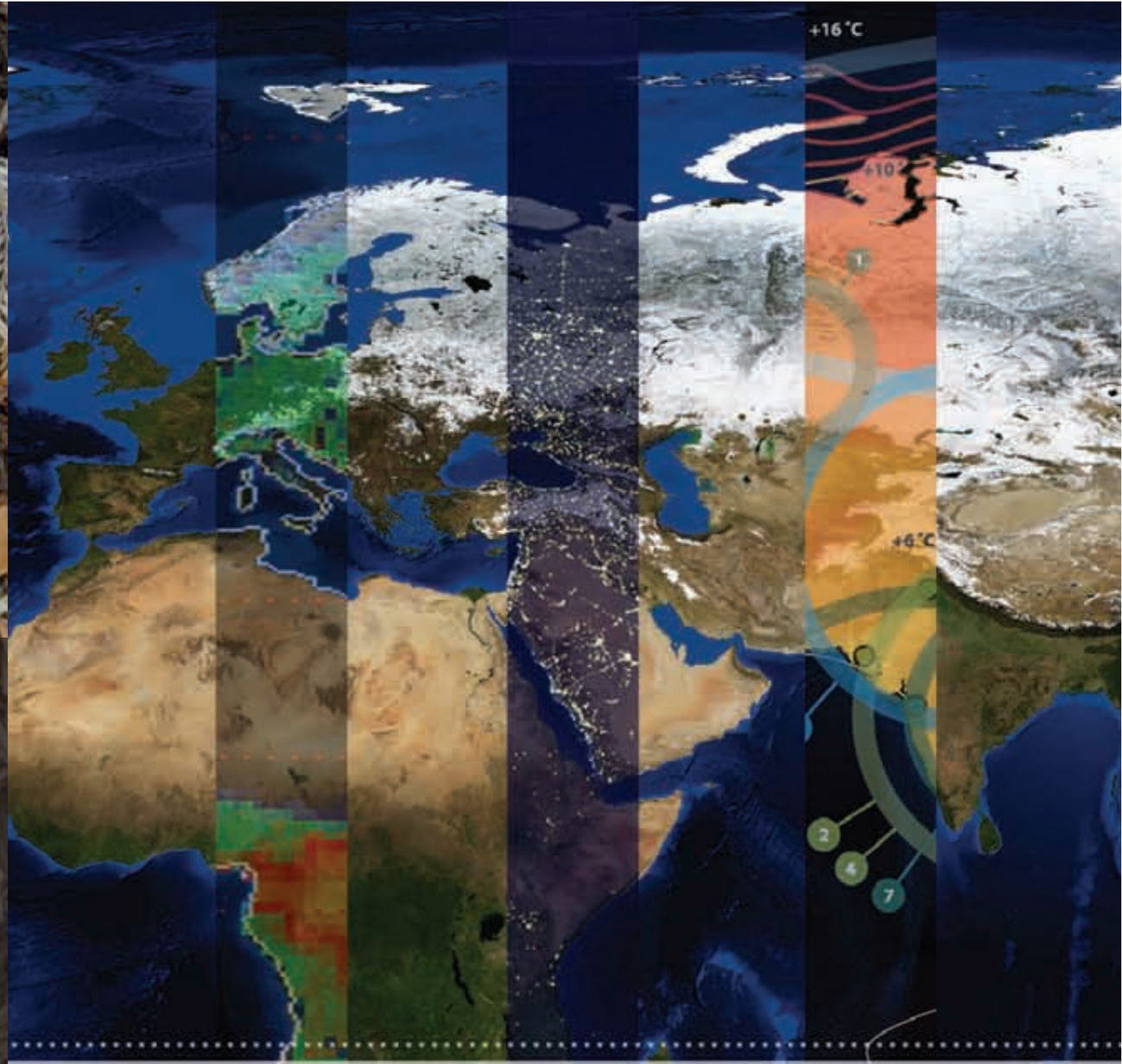
Front page pictures
Main background picture: *R. Stockli, E. Vermote, N. Saleous, R. Simmon and D. Herring (2005). The Blue Marble Next Generation - A true color earth dataset including seasonal dynamics from MODIS. Published by the NASA Earth Observatory*
Inserts, L-R: *1. Isoprene emissions from plants, as estimated by a land surface model by QUEST. Isoprene is significant for the terrestrial carbon cycle, and is particularly important for atmospheric chemistry. 2. Earth's city lights, published by the NASA Earth Observatory. 3. Interactive map of the impacts of a global temperature rise of 4°C, produced by the Met Office and HM Government in 2009, ahead of the Copenhagen climate talks. Impacts on agriculture, sea level rise and water scarcity were provided by QUEST.*

QUEST is NERC's programme for Earth System Science http://www.nerc.ac.uk/research/programmes/quest/



QUEST

Quantifying and Understanding the Earth System

NATURAL ENVIRONMENT RESEARCH COUNCIL

Quantifying and Understanding the Earth System

QUEST Research Highlights

How important are living processes and feedbacks for 21st century climate change?

Living organisms play a vitally important role in Earth's climate, through a set of interlinked physical, chemical and biological processes. Ecosystems and the ocean are important sinks for about 60% of carbon dioxide emissions. The biosphere is also a source of atmospheric constituents that affect climate directly and indirectly. These sources and sinks are affected by climate change. For example, warming causes reduced ocean carbon uptake and carbon loss from soils. QUEST has developed new tools for assessing Earth system processes and complex climate feedbacks.


Photo:NASA


Federico Stevanni FreeDigitalPhotos.net

- New UK capability for high-precision oxygen and trace gas measurement and monitoring allows more robust identification of the land and marine sinks for CO_2. Data assimilation "toolkits" have been developed, reducing uncertainty in predictions of land carbon sources and sinks. QUEST science was embedded in the Global Carbon Project 's authoritative assessment of the global CO_2 budget and trends.
- QUEST has been instrumental in promoting validation of Earth system models with observational data in the UK and internationally, and in synthesising datasets for this purpose. For example, new remote sensing techniques enable plant and plankton functional types to be determined from satellite observations, so dynamic ecosystem models can be validated.

What are the natural controls on atmospheric composition?

Human-induced climate change is taking place in the context of large natural variability in atmospheric composition and climate, especially on long time scales (ice ages and beyond). Changes in the Earth's orbit (responsible for the alternation of ice ages and warm periods) and slower changes in the geography of ice sheets, oceans and continents, affect all parts of the Earth system. Understanding these past changes has enormous, still largely untapped potential to inform contemporary climate change science.

- Unique global data sets have been assembled, mainly from cores through ice, terrestrial and marine sediments, including charcoal counts (fire), pollen assemblages (vegetation composition), wetlands, and land and marine climate variables. These provide snapshots of the Earth and its climate throughout the last million years.
- Methane, a major greenhouse gas, has varied considerably in the past. QUEST research shows that rapid, climate-driven changes in natural sources (wetlands), rather than sinks, appear to be the cause.
- Climatic changes had a strong effect on natural fires over the past 20,000 years, until suppressed on a large scale by recent human activity.
- The causes of glacial-interglacial CO_2 change is an abiding problem in Earth system science. Using data synthesis, and developing models of different complexity QUEST has improved understanding of the ocean mechanisms involved.
- Analysis of past climate events, including a warm period 55 million years ago that witnessed substantial increases in CO_2, has confirmed that large and rapid increases in atmospheric CO_2 can happen, and have severe consequences for marine biology.
- With the Met Office, QUEST is using ensemble model simulations and observational data to reduce uncertainty in "climate sensitivity", one of the most important quantities for climate change prediction.

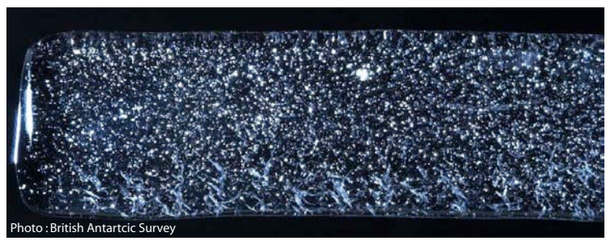


Photo :British Antartcic Survey

The QUEST Earth System Model

The QUEST Earth System Model (QESM) is a new national capability that will integrate fully with the Met Office Hadley Centre model, putting it at the forefront of models being used for the IPCC. QESM includes new detailed representations of ocean, atmosphere and land processes. By coupling these elements, the interactions and feedbacks between climate, the biosphere and atmospheric chemistry can be explored.

Ocean
By incorporating the specific ecological functions of marine organisms at a greater complexity than ever before, we can better understand their role in global climatic change.

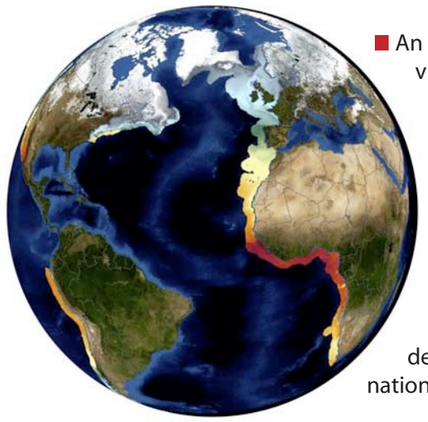
Land
Improved representation of vegetation dynamics and fire allows QESM to address more complex questions regarding ecosystem shifts and changes in carbon than many global models.

Atmosphere
With better representations of atmospheric aerosols from biological and other sources it is possible to model their affect on clouds, atmospheric chemistry and climate.

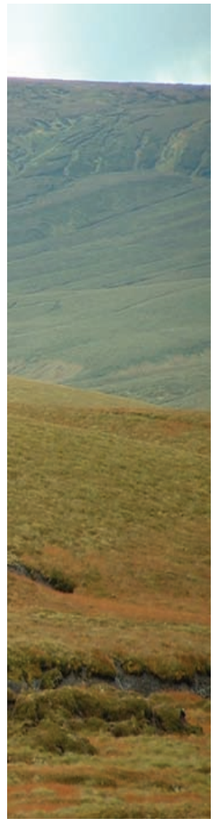
How much climate change is dangerous, and how much can be avoided by managing the biosphere?

A major challenge in Earth System Science has been to obtain a more comprehensive assessment of the impacts of climate change on human systems. QUEST has addressed global scale impacts, and explored how much mitigation is realistic through 'real world' policies and projects for management of land ecosystems.

- QUEST has provided a comprehensive investigation of how risks change as temperatures increase, across a range of sectors including agriculture, fisheries, water resources, biodiversity, and human health. By looking at multiple risks, impact "hot spots" can be identified. The UK Government used this analysis in their 4°C impacts map.



- An innovative vulnerability analysis shows how climate change will affect global fisheries resources and how this risk is highest in fishery dependent nations.
- QUEST's risk analysis methodology for climate change has been used in over 50 studies in various contexts since publication.
- QUEST explored the complex interactions between the economy, land availability and the environment to assess the mitigation potential of forestry and bioenergy. Detailed national forest carbon balances and mitigation potential informed UNFCCC discussions. The methodologies have been used by the EU and the Forestry Commission.
- Forest conservation and management projects established by QUEST will be certified under the Kyoto Joint Implementation mechanism. Novel methodologies and indicators were developed for assessing social and environmental impacts and benefits.
- A joint QUEST-Environment Agency study suggests that more than half of UK upland peat environments will be vulnerable to change by 2050, affecting carbon storage, water quality and flooding.



Quantifying Earth system processes and feedbacks for better informed asessments of alternative futures of the global environment