

Quantifying and Understanding the Earth System (QUEST): Implementation Plan

“Incrementalism is the enemy of innovation.” – Tom Peters

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Introduction and summary

The primary objective of QUEST, as stated in the Science Plan, is to achieve a better qualitative and quantitative understanding of large-scale processes and interactions in the Earth System, especially the interactions among biological, physical and chemical processes in the atmosphere, ocean and land and their implications for human activities. QUEST is designed to build on the UK's already substantial expertise and financial commitments in the component fields of Earth System Science.

QUEST is intended to make the greatest possible use of synergies with existing programmes in the UK and elsewhere. The potential of QUEST lies to a large extent in the possibility of *rapid progress through the removal of cultural and organizational impediments to effective co-operation among institutions and disciplines*. Such co-operation is crucial to success in this field because of its extremely interdisciplinary character.

Following this principle, the implementation of QUEST will be foremost through *multi-institutional collaborative projects* with strong internal co-ordination, based on responses to announcements of opportunity (AOs) in each of the programme's three themes, provisionally entitled: (1) The contemporary carbon cycle and its interactions with climate and atmospheric chemistry; (2) The natural regulation of atmospheric composition on glacial-interglacial and longer time scales; and (3) The implications of global environmental changes for the sustainable use of resources. A strictly limited number of *targeted fellowships* may also be announced if this is considered the best way to enhance the UK science base in specific key areas for QUEST research. QUEST will carry out *focused strategic activities*, in Earth System Modelling, and in global data synthesis (Earth System Atlas). These activities will be financed through grants or contracts, after a consultation process involving the interested parties in the UK and (for the Atlas) an international planning group. The Leader of QUEST will direct a core team which will be responsible for co-ordination and for a range of *integrative activities*, including workshops and brainstorming meetings, international conferences, and an annual “all hands” meeting of QUEST scientists. An effective interface with UK government bodies and other decision makers will be developed to maximize the timely utilization of QUEST research.

Multi-institutional collaborative projects

Collaborative projects will address three themes. The provisional theme titles are: (1) The contemporary carbon cycle and its interactions with climate and atmospheric chemistry; (2) The natural regulation of atmospheric composition on glacial-interglacial and longer time scales; and (3) The implications of global environmental changes for the sustainable use of resources. Each of the themes will form the subject of one or several multi-institutional grants. In each case, QUEST will define a first AO to be agreed and published by NERC, which will specifically call for the formation of community-wide collaborative grant applications. Supplementary calls will allow individual scientists or groups to bid to participate in the collaborations that have been formed in response to the initial calls.

The project proposals will be peer-reviewed and moderated according to the usual procedures of NERC (including significant international participation in all aspects of the process). The panels will broadly represent the relevant scientific communities; there will be a separate moderating panel for each theme because of the diversity of expertise called for in different parts of the programme. In addition to the normal [NERC assessment criteria](#), the criteria for funding collaborative grants will include:

- addressing questions of central importance for the goals of QUEST, as stated in the Science Plan and as expressed in the specific Announcements of Opportunity
- effective engagement of the different disciplines that are required in order to provide an answer to the question addressed;
- effective integration of modelling and empirical/analytical components of the research;
- clear definitions of roles for the different participating groups, and clear justifications for the resources requested for them in terms of fulfilling those roles;
- a well thought-out strategy for integration of results produced by different groups;
- effective use of potential synergies with other UK and international research.

It is expected that cost-effective means will be proposed to ensure effective interdisciplinary communication and synergy, including workshops, research visits and secondments as appropriate.

Each of the three themes is expected to engage a cross-section of the UK environmental research community, including contributions from NERC Centres and from Higher Education Institutions. QUEST will thus play an integrating role across the spectrum of activities and institutions funded by NERC.

Targeted fellowships

Fellowships, especially advanced fellowships set up with agreement from a host institution to provide time-unlimited contracts, provide a unique route to enhance UK expertise in specific areas that are in need of strengthening in cases where this is not appropriately done through the more usual mechanism of funding PDRAs tied to projects. Accordingly, QUEST may issue one or more AOs for a *strictly limited* number of QUEST fellowships and/or advanced fellowships in well-defined subject areas, to be agreed by NERC and advertised and selected as part of the annual NERC fellowship round. The fellows will be subject to the usual evaluation criteria for NERC fellowships, and any individual appointed through this procedure will be expected to play a pivotal role in one or more of the consortia and to significantly enhance the international standing of QUEST.

Focused strategic activities

Two strategic activities, Earth System Modelling and the Earth System Atlas, are planned. Both are integral to the programme and both will contribute to all of the research areas covered by QUEST. In each case there will be an initial consultation process (including a brainstorming meeting with the interested parties in the UK) to determine the most effective implementation strategy that best utilizes the human and physical resources in the UK in pursuit of the goals of QUEST. The approach adopted for strategic activities differs from that adopted for the main projects because of the central importance of defining standards, assuring consistency, and avoiding duplication of effort.

The QUEST activity in *Earth System Modelling* will develop models of the global climate system including feedbacks due to changes in marine and terrestrial ecosystem processes through biophysical interactions, carbon cycling, and sources and sinks for aerosol precursors and reactive trace gases. The models will also allow representation of land and ocean resource exploitation processes and associated activities such as trade in food and wood products. The activity will develop new “community models” of terrestrial and ocean biosphere processes and their interactions with the physical and chemical environment, and it will incorporate these models as elements in a coupled modelling framework. Observational/experimental “benchmarks” will be developed against which to evaluate terrestrial and ocean biosphere models, both as stand-alone models and as components of coupled models. Community model development will build partly on existing ideas and plans for the Joint UK Land Environment Simulator

(JULES), the international Dynamic Green Ocean Modelling (DGOM) partnership, and nascent UK collaborations in coupled chemistry-climate modelling.

The top (i.e. the most computationally intensive) member of the hierarchy of coupled models will be an Earth System Model based on a version of the Hadley Centre coupled ocean-atmosphere model, which is a world leader in the field and is already extensively used in the NERC community. Models of lower complexity and/or resolution will also be developed, for a variety of applications that will require the ability to perform long simulations or multiple sensitivity experiments. The concept of “traceability” will guide the design of these models. This means that as far as possible, the underlying principles of models at different levels will be the same, and the simplifications made in going down the hierarchy will be explicit. This activity will have a strong “e-science” component, building on recent research (particularly the GENIE project) that has set up grid-based ways of running complex models and a first attempt to set up a traceable hierarchy of Earth System Models.

It is particularly important that the Earth System Modelling activity be conducted according to a well-defined strategy, with due attention to issues of cross-compatibility, modularity and transparency in the development of model code. A detailed strategy will be developed through consultation with the interested parties in the UK. A steering committee will be formed to monitor progress and to ensure that the strategy is in effect. The strategy will be consistent with the recently defined Earth System Science Partnership strategy for Earth System Modelling.

Analytical and modelling activities in Earth System Science rely on the availability of high-quality and properly documented global data sets of environmental variables or (increasingly) descriptors of human population characteristics and activities. Yet access to data and knowledge of the quality of different global data sets is extremely uneven at present. The *Earth System Atlas* has been envisioned by the International Geosphere-Biosphere Programme (IGBP) as a way to overcome the problem. The Atlas is seen by the IGBP as both a key resource for scientists and, potentially, a tool for communication with policy makers and a wider public. It should provide a “one-stop shop” for quality-controlled, peer-reviewed and properly documented global data sets of Earth System variables, including variables describing physical, chemical, biological and socio-economic properties. Such a tool would be exceptionally valuable in ensuring the efficiency and relevance of QUEST science projects, and QUEST is in a position to initiate and play a leadership role in the realization of IGBP’s vision.

QUEST will accordingly play a central role in initiating and implementing the Earth System Atlas, while it is envisaged that the main content of the Atlas will be contributed from other sources. The strategy for implementation of the Atlas will be developed at two levels, international and national. An early meeting of the *ad hoc* international planning group for the Atlas (appointed by the IGBP Task Force on Global Analysis, Integration and Modelling (GAIM) in 2002 on request of the IGBP Scientific Committee) will be convened to decide on key strategic issues, especially as regards potential co-funding from other agencies (possible partners include NASA and NOAA in the USA, and JAMSTEC in Japan) and to make proposals to IGBP regarding the initial membership of the international steering committee and editorial board. A UK brainstorming meeting will then determine the most appropriate and effective way to channel QUEST resources to the Atlas. Both international and UK interests will be involved in making decisions concerning standards for data management, documentation and the user interface.

Like Earth System Modelling, the Earth System Atlas has a strong e-science dimension as it offers a potential application for the NERC data grid. The IGBP blueprint for the Atlas also implies a Knowledge Transfer aspect as it includes the provision of three levels of documentation of the data sets and maps: the top level for scientific users, and two other levels for a wider public (including policy makers) and for school students, respectively. QUEST will propose to develop these aspects as a substantial part of its Knowledge Transfer remit.

Integrative activities

The variety and complexity of integrative activities that will be needed in QUEST has required the recruitment of a dedicated core team directly supervised by the Leader of QUEST. The recruitment process is well advanced, and the intention is for the team to be fully in place by 1 September 2004. The core team will carry out timely interdisciplinary analysis and modelling activities that add value to the programme. It will act as a “rapid response force” in the programme by identifying and addressing emerging topics, and engaging relevant sections of the community in collaborations.

The core team will organize a series of international workshops designed to bring together people from different disciplines and perspectives and thereby help to define research priorities and directions for QUEST. The workshops will be by invitation, engaging the relevant key players in the UK (including scientists leading and involved in the research projects funded under QUEST) and carefully selected international participants. Follow-up activities will be organized in so far as these are necessary to fully realize the workshops’ aims. The core team will also organize UK brainstorming sessions (sometimes with a limited number of non-UK participants) as needed, to facilitate the development of interdisciplinary collaborative grant applications, and to promote more effective information exchange between disciplines; research visits by non-UK scientists to work with the core team in the development of QUEST research; annual science meetings (ASMs) to promote the exchange of information and ideas among different projects and activities funded under QUEST, engaging the principal investigators, co-investigators, postdoctoral research associates and students that are funded through QUEST projects; and international conferences to showcase QUEST activities as well as facilitating information exchange with international activities in Earth System Science.

The Leader and the core team will further be responsible for progress monitoring, facilitation of collaborations, reporting, communications, the effective implementation of strategic activities, and the development of proposals and plans for knowledge transfer and data management. One member of the core team will be a Science and Policy Officer, responsible for developing effective outreach to users of QUEST research through building working relationships with researchers in the science and policy field and with UK policy makers and other stakeholders.

Training

In addition to the excellent opportunities for training of Ph.D. students and PDRAs in the context of multi-institutional collaborative projects, QUEST may organize an annual summer school aimed at senior postgraduate and postdoctoral levels. A blueprint already exists in the form of the successful Earth System Science Summer Schools which have been held at the Universities of Reading and East Anglia during recent years; the last of the present series will take place in September 2004. Discussions with the organizers of these summer schools are planned with a view to the possibility of continuing the series under the aegis of QUEST.

Small Business Research Initiative (SBRI)

A small part of QUEST funds has been set aside for small business participation, and two proposals for funding from this source have already been submitted for the 30 April 2004 SBRI deadline. Small businesses may be involved in QUEST e.g. through the provision of specialist software.

Data management

Data collected or assembled within QUEST, including palaeodata and model outputs, and data synthesized in the context of the Earth System Atlas, will be subject to a data management plan yet to be defined. The data will be maintained as a public resource by NERC after the end of the programme.

Although the detailed roles and responsibilities have yet to be worked out, the following draft policy (which may be modified following discussions with NERC and the wider community of potential data contributors) is intended to apply to data or model outputs *newly acquired* through activities funded by QUEST:

- Data will be lodged with the appropriate data centre *on acquisition*, together with such metadata as are required according to the data management plan.
- Individual PIs or co-investigators *may request* that data they produce (not the metadata) be embargoed for a period of up to *six months* from acquisition, so as to allow them to exploit the data first. Otherwise, and in any case after six months, the data will become available to the QUEST community.
- All data will become public-access *one year* after acquisition.
- Users of the data within *three years* of acquisition will be required to give the named originator(s) of the data the option of inclusion as a co-author on any resulting paper(s).

Any data sets that QUEST activities may create specifically for the Earth System Atlas will also be lodged at an appropriate data centre, but subject to different rules because the Atlas is meant as a form of publication and is intended to be subject to the International Council for Science (ICSU) policy on free and open access to published data. Thus, data in the Earth System Atlas will by definition be freely available *as soon as it is published*.

Governance and outreach

The Leader of QUEST reports to the NERC Chief Executive. The Leader will periodically make presentations to the NERC Science and Innovation Strategy Board (SISB), on request from SISB, and will act on suggestions from SISB regarding the general scientific direction and implementation of QUEST. The programme will also be subject to a mid-term review by SISB. The NERC Superintending Officer for QUEST is Dr. Phil Newton. The Programme Administrator at NERC is Dr. Gina Adams.

The Leader will give high priority to establishing effective mechanisms of liaison with the scientific and user community. Mechanisms will be developed to facilitate timely communication with the NERC Research Centres and Collaborative Centres, and other key players in NERC-funded programmes. A first meeting with NERC Centre Directors is planned for June 2004 to discuss this and other aspects of the implementation of QUEST.

In addition, it is anticipated that two independent advisory bodies will be constituted, as follows:

(1) An international **Advisory Board**, which will consist of internationally recognized leading scientists with broad interests in Earth System Science. The main purpose of the Board will be to advise the Leader on the overall scientific direction and priorities of the programme. The group of people invited to form this Board will include some scientists with national-level responsibilities for research programmes in other countries, and some individuals with roles in international organizations involved in climate and global change research and assessment. It is suggested that the Board will visit twice during the duration of the programme, but that they will also be consulted individually on specific matters.

(2) A **UK Stakeholder Group**, which will comprise representatives of the most important governmental and non-governmental potential users of QUEST research. This group will meet formally once a year but individual members will be consulted more frequently. The role of the stakeholder group will be to help formulate policy relevant questions and provide feedback on the usefulness and accessibility of QUEST products for the user community. The composition of the group will be formed with advice from NERC. The Science and Policy Officer will convene and regularly meet with the stakeholder group. This role is envisaged as a further contribution to the Knowledge Transfer activities of QUEST.

ANNEX: Synopsis of planning for AOs and meetings (as of 06/06/04)

06/04	First AO: Core Collaborations for Theme 1
06/04	UK brainstorming: biospheric trace gas emissions (08/06/04)
06/04	Workshop: Wetlands and the global CH ₄ cycle (14-16/06/04)
06/04	Meeting with NERC Centre Directors
08/04	UK brainstorming: Earth System Atlas
10/04	<i>Deadline for responses to first AO</i>
10/04	Stakeholder Group meeting
10/04	UK brainstorming: Earth System Modelling strategy
11/04	Workshop: Global Change and Sustainable Development
11/04	UK brainstorming: Global impacts analysis
12/04	Second AO: Core Collaborations for Theme 2
12/04	Moderating Panel (First AO)
03/05	<i>Deadline for responses to second AO</i>
04/05	Joint workshop with IGBP Fast Track Initiative: Fire modelling
05/05	Joint workshop with NSF-TERACC and DIVERSITAS: Biodiversity processes and modelling
06/05	Third AO: Core Collaborations for Theme 3
06/05	Supplementary AO for Theme 1
06/05	Moderating Panel (Second AO)
09/05	<i>Deadline for responses to third AO</i>
09/05	<i>Deadline for responses to supplementary AO for Theme 1</i>
09/05	First International Conference
09/05	First Annual Science Meeting
09/05	International Advisory Board visit
10/05	Stakeholder Group meeting
12/05	Supplementary AO for Theme 2
12/05	Moderating Panels (Third AO, Supplementary AO for Theme 1)
03/06	<i>Deadline for responses to supplementary AO for Theme 2</i>
06/06	Supplementary AO for Theme 3
06/06	Moderating Panel (Supplementary AO for Theme 2)
09/06	<i>Deadline for responses to supplementary AO for Theme 3</i>
09/06	Second Annual Science Meeting
10/06	Stakeholder Group meeting
12/06	Moderating Panel (Supplementary AO for Theme 3)
09/07	Third Annual Science Meeting
09/07	International Advisory Board visit
10/07	Stakeholder Group meeting
09/08	Second International Conference
09/08	Fourth Annual Science Meeting
10/08	Stakeholder Group meeting
07/09	Finale event