British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

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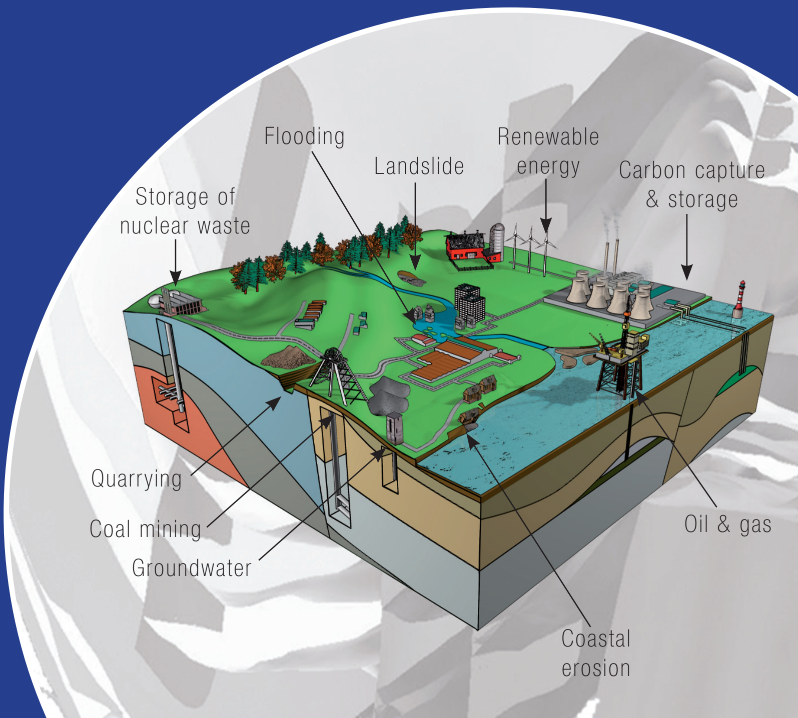
Integrated modelling of natural and human systems — problems and initiatives

H. Kessler, J. Giles, J. Gunnink, A. Hughes, R. V. Moore and D. Peach



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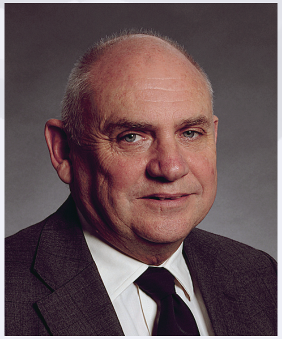

Professor Denis Peach
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Before his appointment as Chief Scientist, Denis spent over nine years as the Manager of the BGS Groundwater Programme, based at Wallingford. He is a hydrogeologist with very broad interests in the area of environment geoscience, including shallow geophysics, hydrogeochemistry, engineering geology and numerical modelling. He has 35 years' experience which includes work for a UK water authority, overseas work in tropical hydrogeological environments and work for international consultants in arid zone hydrogeology. His particular scientific interests have included the development of groundwater modelling in BGS. Denis has a track record of collaborating with several universities and the Centre for Ecology and Hydrology across the disciplines in integrated catchment science. He is an Honorary Professor at the University of Birmingham and has been a Vice President of the Geological Society of London.

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Jeremy Giles is Head of Information Management for the BGS and is responsible for the National Geoscience Data Centre. He has been involved in information management since 1988, though prior to that he was a field geologist making geological maps in Yorkshire and Nottinghamshire.

Abstract

Integrated modelling of natural and human systems — problems and initiatives

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Governments and their executive agencies across the world are facing increasing pressure to make decisions about the management of resources in light of population growth and environmental change. In the UK and the Netherlands, for example, groundwater is becoming a scarce resource for large parts of its most densely populated areas. At the same time river and groundwater flooding resulting from high rainfall events are increasing in scale and frequency and sea level rise is threatening the defences of coastal cities. There is also a need for affordable housing, improved transport infrastructure and waste disposal as well as sources of renewable energy and sustainable food production.

These challenges can only be resolved if solutions are based on sound scientific evidence. Although we have knowledge and understanding of many individual processes in the natural sciences it is clear that a single science discipline is unable to answer the questions and their inter-relationships. Modern science increasingly employs computer models to simulate the natural, economic and human system. Management and planning requires scenario modelling, forecasts and 'predictions'. Although the outputs are often impressive in terms of apparent accuracy and visualisation, they are inherently not suited to simulate the response to feedbacks from other models of the earth system, such as the impact of human actions.

Geological Survey Organisations (GSO) are increasingly employing advances in Information Technology to visualise and improve their understanding of geological systems. Instead of 2 dimensional paper maps and reports many GSOs now produce 3 dimensional geological framework models and groundwater flow models as their standard output. Additionally the British Geological Survey and the Geological Survey of the Netherlands have developed standard routines to link geological data to groundwater models,

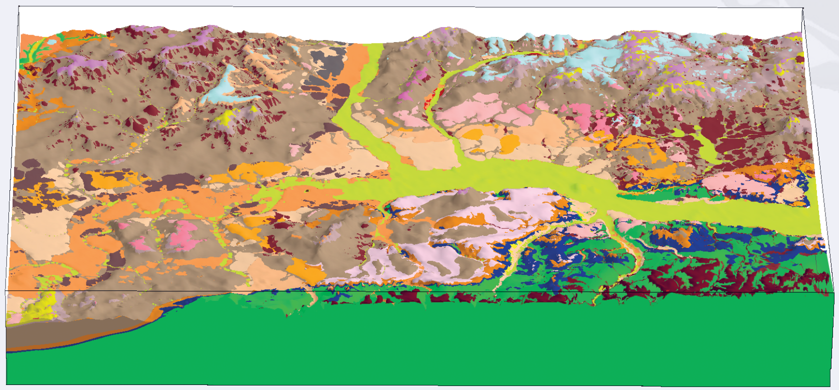
but these models are only aimed at solving one specific part of the earth's system, e.g. the flow of groundwater to an abstraction borehole or the availability of water for irrigation.

Particular problems arise when model data from two or more disciplines are incompatible in terms of data formats, scientific concepts or language. Other barriers include the cultural segregation within and between science disciplines as well as impediments to data exchange due to ownership and copyright restrictions. OpenMI and GeoSciML are initiatives that are trying to overcome these barriers by building international communities that share vocabularies and data formats. This paper will give examples of the successful merging of geological and hydrological models from the UK and the Netherlands and will introduce the vision of an open Environmental Modelling Platform which aims to link data, knowledge and concepts seamlessly to numerical process models. Last but not least there is an urgent need to create a Subsurface Management System akin to a Geographic Information System in which all results of subsurface modelling can be visualised and analysed in an integrated manner.

An open environmental modelling platform

Our platform for participation

Both the NERC Strategy and Living with Environmental Change (LWEC) are encouraging environmental science communities to work more closely with each other to model and understand the environment and to make predictions upon which policy can be developed. To do this the NERC and LWEC need to change behaviours within the environmental science community



London 3D model.

and one driver for this would be the creation of an open environmental modelling platform developed by the community as a true platform for participation. The BGS Strategy 'Applied Geoscience for our changing Earth' embraces the culture of collaboration and includes the development of such a modelling platform as a major initiative, together with crosscutting projects that would be used as test-beds for the validation of the platform and exemplars for the development of process models that would use the platform.

Various parts of the environmental science community are building modelling platforms to meet the specific requirements of their own communities and projects. For example the British Geological Survey has been developing GSI3D to enable the systematic production of geological framework models. This application is being used by a multinational geoscience community as evidenced by the attendees and speakers at the 2nd International Conference held in September 2008. BGS now needs to add parameters to the modelled 3D volumes to enrich the models and improve our understanding of processes in order to make decisions about our changing environment. Furthermore we have to better understand the purpose and limitations of these models and begin to communicate their uncertainty. It is becoming clear that to do so we need work with other environmental science communities who are, or have developed independent modelling systems. Another example might be the Joint UK Land Environment Simulator (JULES), being developed for community use by the Centre for Ecology and Hydrology (CEH) and the Met Office. At the same time for instance, to understand groundwater, as a sustainable natural resource, we need to create linkages between the 3D geological models and the groundwater models such as the ZOOM family of groundwater models. In turn we need to integrate with hydrological and meteorological models and understand predicted changes in precipitation over time. There are many other scenarios, including other variables, like ecology, socio-economics, and so on that will require linkage to these types of environmental predictive models. These models will be required for the science community and then for practitioners in governments and their regulatory agencies to provide the decision making capability to enable us to live with environmental change.

Currently all the communities' modelling systems have a number of common issues:

- They tend to be 'discipline based' supporting only one sphere of the environmental science community thereby not facilitating a Whole Earth Systems approach, urgently needed to tackle todays environmental challenges
- Little consideration is given at the design stage to interfacing with other science

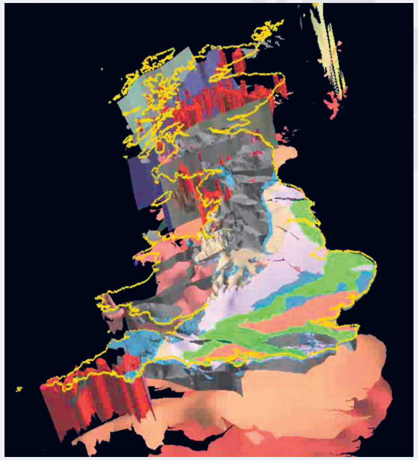
communities, including socio-economic sciences
- If there is a need to interface with other parts of the environmental science community the modelling platforms may need significant redesign or complex interchange formats have to be considered;
- Often large parts of the software code produced is proprietary; and
- Environmental Data Centres find it difficult to provide web services that meet the needs of a broad breadth of the environmental modelling community.

Initiatives such as GeoSciML and OpenMI, try to bridge the gap between the different modelling communities by creating common standards on data formats and ontology's as well as publishing input/output (i/o) formats of different modelling software.
The platform would be:
- Open;
- Interdisciplinary;
- Designed with interoperability at its core;
- Standards based, building on the OGC ISO standards and others;
- Community owned and built;
- Free to use; and
- Enable environmental data centres to provide appropriate web services.

Industry experience suggests that there are real advantages to open platforms. IBM was spending large sums unsuccessfully competing with the emerging Linux operating system. In 1998 they decided that they would support Linux and invest in the development.

'IBM spend about $100 million per year supporting Linux development. If the Linux community puts in $1 Billion of effort, and even half of that is useful to IBM customers, the company gets $500 million of software development for an investment of $100 million. 'Linux gives us a viable platform uniquely tailored to our needs for 20% of the cost of a propriety operating system,' says Joel Caley (IBM VP).

IBM engaged with the community at two levels, firstly by showing leadership, and secondly by doing the less glamorous activities in the Linux workflow such as promoting standards and producing documentation. In this way they gain community buy-in. The NERC could adopt this model by leading the community and encouraging the developers within NERC to do some of the less glamorous activities essential to a successful platform.



A 3D model of the UK.

Useful links

British Geological Survey (BGS)	www.bgs.ac.uk/
BGS Strategy	www.bgs.ac.uk/about/strategy2009-2014.html
Centre for Ecology and Hydrology (CEH)	www.ceh.ac.uk/products/publications/HealthandWealthoftheEnvironment.html
DAEM Project WIKI	http://daem.wikidot.com/
GSI3D	http://en.wikipedia.org/wiki/GSI3D
Natural Environment Research Council (NERC)	www.nerc.ac.uk/
NERC Strategy	www.nerc.ac.uk/about/strategy/ngscience.asp
Netherlands Geological Survey	www.en.geologicalsurvey.nl/
OpenMI	www.openmi.org/reloaded/
ZOOM Groundwater Models	www.oomodels.info/pmwiki/pmwiki.php/Main/OOModelsHome

BGS's recent experience with OneGeology suggests that such community engagement is possible and by so doing the activity becomes a focus of funding. By its formal launch in at the International Geological Congress in Oslo in September 2008 OneGeology has attracted major funding from both the EU eContentPlus Programme and the USA National Science Foundation.

The BGS is keen to progress this idea with a nine month international scoping study commencing in April 2009. The results of the scoping study would be:
- Build community engagement;
- Articulate the vision and objectives of the open environmental modelling platform;
- Identify any existing parallel initiatives developing around the world and seek to engage with them;
- Identify appropriate international standards under which the platform should develop;
- Recommend leadership framework under which the development would be steered; and
- Identify components that need accelerated development to create a 'critical mass' that others can build upon.

What is the British Geological Survey?

Founded in 1835, the British Geological Survey (BGS) is the world's oldest national geological survey and the United Kingdom's premier centre for earth science information and expertise.

As a public sector organisation BGS is responsible for advising the UK government on all aspects of geoscience as well as providing impartial geological advice to industry, academia and the public. The BGS is part of the Natural Environment Research Council (NERC), which is the UK's main agency for funding and managing research, training, and knowledge exchange in the environmental sciences. The NERC reports to the UK government's Department for Innovation, Universities & Skills which works closely with the Department for Business, Enterprise and Regulatory Reform.

We also undertake an extensive programme of overseas research, surveying and monitoring, including major institutional strengthening programmes in the developing world.

Our annual budget is in the region of £52m, about 60% of which comes from NERC's Science Budget, with the remainder coming from commissioned research from the public and private sectors. Further details may be found in our Annual Report.

What does the British Geological Survey Do?

The British Geological Survey (BGS) is the nation's principal supplier of objective, impartial and up-to-date geological expertise and information for decision making for governmental, commercial and individual users.

The BGS carries out research in strategically important areas including energy and natural resources, vulnerability to environmental change and hazards, and Earth System Science, often in collaboration with the national and international scientific academic community. In this way BGS maintains and develops understanding of earth sciences to improve policy-making, enhance national wealth and reduce risk.

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