

Data Synthesis

Visualising model data as global maps

- New visualisation and data analysis tools, developed in QUEST, enable a broader community of climate impacts researchers to explore the available climate data and display complex data sets easily. A new user interface produced by QUEST allows data originally organised according to global grid squares to be extracted by users on a country-by-country basis (Fig 4).

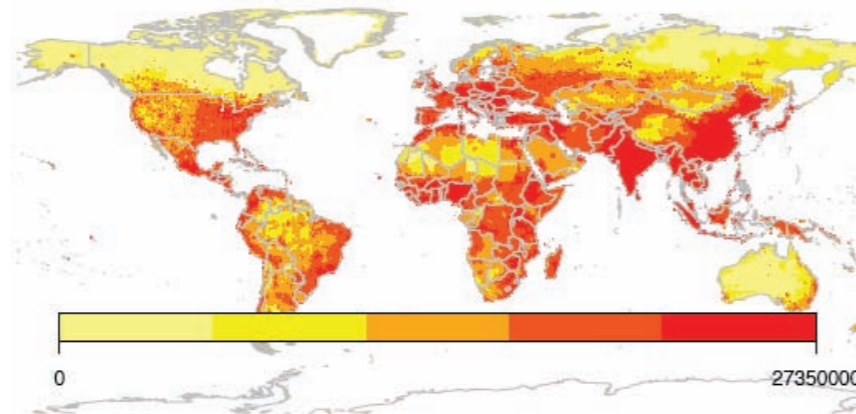


Figure 4: Example of a regional plot of global data produced using QUEST's RWorldMap visualisation tool

- For further information on QUEST's data legacy, visit the QUEST data portal: <http://badc.nerc.ac.uk/data/quest/index.html>

Key links

- Global dust maps: DIRTMAP3 (Maher and Kohfeld 2009), www.lec.lanacs.ac.uk/research/environmental_geosciences/inqua_working_group.php#dirtmap3
- Evolutionary and ecological research: TraitNet, <http://traitnet.ecoinformatics.org>
- Plant functional types: TRY, www.try-db.org/index.php?n=Site.Database
- Model intercomparisons: CMIP5, <http://cmip-pcmdi.llnl.gov/cmip5/>; PMIP, <http://pmip.lscce.ipsl.fr/>; PCMIP, www.igbp.kva.se/page.php?pid=475.
- Intergovernmental Panel on Climate Change fifth assessment report, www.ipcc.ch/index.htm
- Rworldmap: <http://code.google.com/p/rworld/downloads/list>

Publications

A full listing of QUEST research publications is constantly being updated by the QUEST synthesis team at the University of Bristol. Contact quest-info@bristol.ac.uk for more information.

- Bartlein PJ, et al. (2010) Pollen-based continental climate reconstructions at 6 and 21 ka: a global synthesis. *Clim Dyn.* DOI 10.1007/s00382-010-0904-1
- Binney, HA, et al. (2009) The distribution of late-Quaternary woody taxa in northern Eurasia: evidence from a new macrofossil database. *Quaternary Science Reviews* 28(23-24): 2445-2464.
- Cadule P, et al. (2010) Benchmarking coupled climate-carbon models against long-term atmospheric CO₂ measurements, *Global Biogeochem. Cycles*, 24, GB2016, doi:10.1029/2009GB003556.1.
- Harrison, SP and Sanchez Goñi, MF (2010) Global patterns of vegetation response to millennial-scale variability and rapid climate change during the last glacial period, *Quaternary Science Reviews* 29 (21-22): 2957-2980.
- Maher BA, et al. (2010) Global connections between aeolian dust, climate and ocean biogeochemistry at the present day and at the last glacial maximum. *Earth-Science Reviews* 99: 61-97
- Oliver K, et al. (2009) A synthesis of marine sediment core $\delta^{13}\text{C}$ data over the last 150,000 years. *Clim. Past Discuss.* 5: 2497-2554,
- Power MJ, et al. (2008) Changes in fire regimes since the Last Glacial Maximum: an assessment based on a global synthesis and analysis of charcoal data. *Climate Dynamics* 30(7-8): 887-907

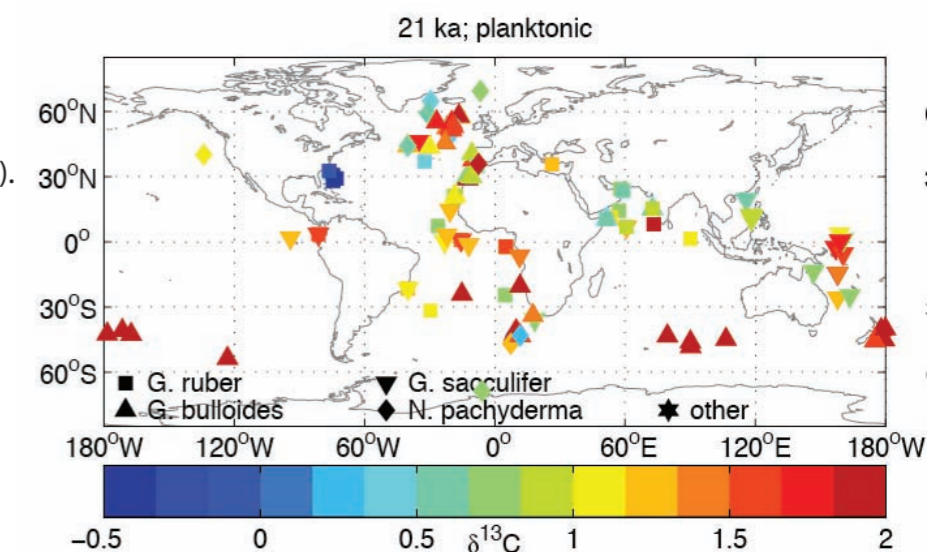


Understanding Earth's dynamic processes requires data sets that are global in scope, with high levels of temporal resolution. However, most of the data available to scientists represent short 'snapshots' in time with limited resolution in space; the resulting shortage of suitable data sets is a major constraint on Earth system research. QUEST has given high priority to data synthesis, data stewardship and data-model comparison.

Activities

- The majority of QUEST's projects brought modelling and observational research expertise together, to ensure that model development captures the key dynamics of Earth system processes with a greater realism and stronger predictive potential.
- QUEST has been instrumental in ensuring that benchmarking and validation of coupled Earth system models, using observational and experimental data, are being given higher visibility and priority, both internationally and in the UK.
- QUEST has collated and standardised a number of global and regional data sets from both the past and present (e.g. Figure 1), and made them accessible for comparison and assessment of model outputs. For example, it has created new datasets of past climates for benchmarking models used in the Intergovernmental Panel on Climate Change (IPCC) reports; it has built new data mapping and comparison tools for carbon cycle and land surface modelling; and, it has contributed scientific support to international model intercomparison projects (see key links overleaf).
- A collective data resource for climate impact specialists was compiled using the outputs of the coupled carbon cycle-climate models from the IPCC, run under different socio-economic development scenarios.
- The development of very high precision instruments for measuring atmospheric O₂, CO₂ and other climate-relevant gases has led to new UK capability in quantifying and monitoring carbon sinks (for more detail, see Carbon Cycle Feedbacks).
- The QUEST Earth System Data Initiative allows for improved sharing of model output and observational data among the Earth system science research community and has contributed new visualisation and data analysis tools.

Figure 1: Global distributions of water-column plankton species at the Last Glacial Maximum (21 kyr before present), based on $\delta^{13}\text{C}$ data in marine sediments (Oliver et al. 2009).



Past climates and landscapes

- New and valuable databases have been created that document the spatial and temporal variability of important Earth system processes including new databases of charcoal distribution (which has given important insights into the role of climate and humans in wildfires); wetlands through time (which provides important constraints for models of methane emissions and concentration); carbon isotopic concentrations in vegetation (which tells us about plant dynamics through time and provides additional constraints on terrestrial vegetation models).

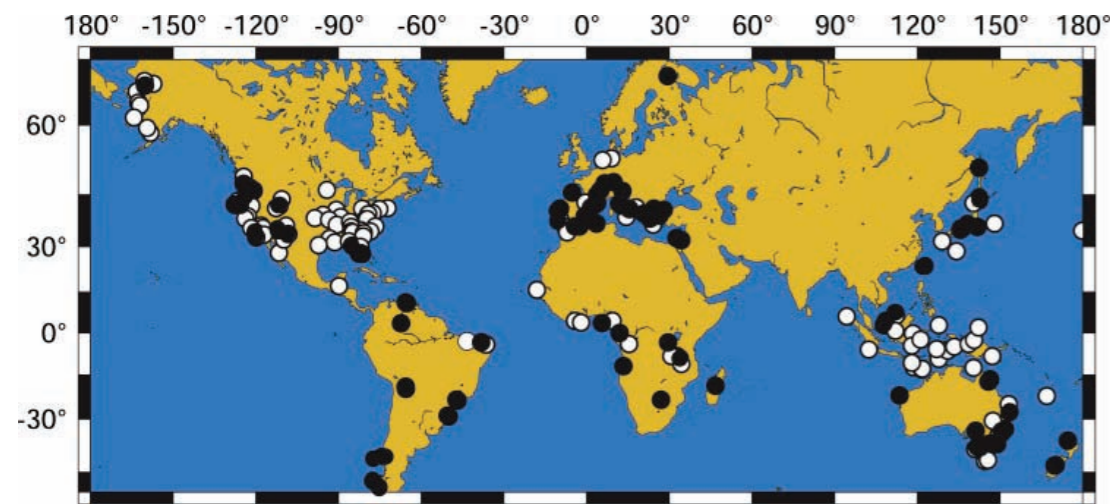
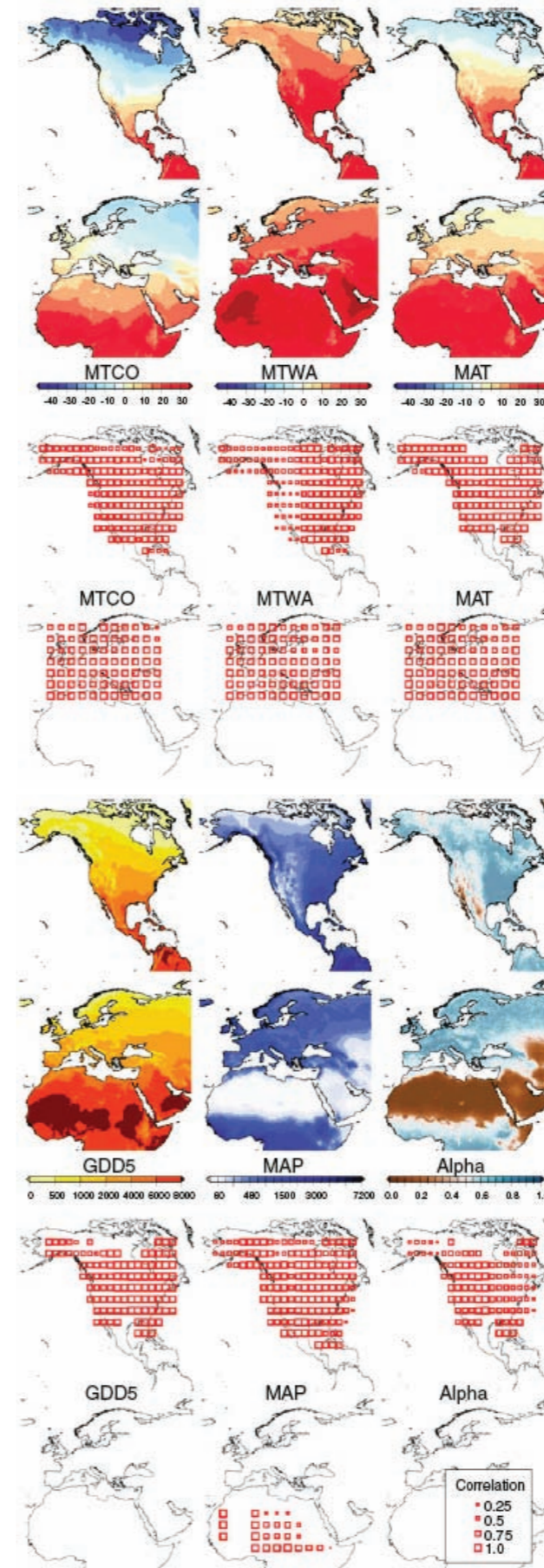


Figure 2: Pollen sites covering the last glacial, used for a global assessment of vegetation response to climate change. Black circles show sites with high temporal resolution. (Harrison and Goñi 2010).

Contemporary data

- QUEST has been instrumental in initiating the global-scale TRY database of vascular plant traits. This synthesis of existing data sets covers a variety of biomes, geographic areas, and traits. Information about 64,000 plant species is now available to researchers.
- Climate impacts researchers use climate model output as the input data for their own models. QUEST compiled outputs from multiple global climate models used for the IPCC to provide a ready-made resource for studying impacts. These standard runs included the IPCC SRES scenarios of future greenhouse gas emissions, and also a set of “prescribed warming” scenarios, where global average temperatures reach up to 7°C by 2100.

- QUEST has also improved pollen and plant macro-fossil databases, advancing their geographical coverage to help increase our understanding of climate-vegetation interactions as well as providing additional constraints on terrestrial vegetation models (Figure 2). A new synthesis of marine, pollen and ice core records of the last few interglacial periods has been compiled; it indicates that different biosphere-climate mechanisms operated during warm periods. This has already stimulated new hypotheses about processes and feedbacks, and presents a huge challenge to current climate models.
- This work has built upon successes from efforts worldwide and demonstrates that the contribution of the palaeoscience community is vital in the ongoing debate on climate change.



Data-model comparison

- The ability to reproduce regional patterns seen in palaeoclimatic data syntheses is a crucial measure of confidence in the ability of climate models to simulate climates radically different from the present day's. QUEST has contributed to the development of new methodologies and an international framework for the community of researchers working at the interface between models and data.
- The shortage of global data sets on key Earth system variables has meant the scientific evaluation of palaeoclimate model simulations has tended to lack quantitative rigour. However, thanks to QUEST, “palaeo benchmarking” is now possible, using data sets such as biomass burning and pollen records (Fig. 3). These reconstruction methods have been shown to be effective predictors of vegetation patterns when confronted with modern observed climate.
- QUEST has developed strong international collaborations, developing a series of benchmarks for terrestrial carbon cycle modelling.
- QUEST supported the launch of the international Land-Atmosphere Modelling and Benchmarking project (iLAMB), setting up universally accepted benchmarks for modelling land surface processes in the context of both numerical weather prediction and climate and Earth system modelling.
- An early version of the QUEST Earth System Model was compared with data from the Mount Pinatubo eruption (1991) to test the capacity of the model to simulate biosphere-carbon interactions.

Data stewardship and archives

- QUEST data produced by the research projects is being archived at NERC's British Atmospheric Data Centre (BADC), and will soon be available to all NERC researchers and those registered as users with BADC. As a highly international endeavour, QUEST has also linked with many other data providers and collaborative data synthesis initiatives worldwide.
- The QUEST Earth System Data Initiative (QESDI) provides an accessible portal to many synthesis data sets of value to the wider Earth system research community.

Figure 3: Benchmarking data sets of past climate from pollen and other palaeo proxy records for IPCC models. Upper panels show CRU climatology for a range of climatic variables (i.e. coldest month temp). Lower panels show the strong correlations generally found for the pollen-based regional reconstructions. (Bartlein et al. 2010)