Briefing Statement

Work Package 5 – Coupled Modelling

GREENCYCLESII MC-ITN

A major uncertainty in how future emissions of greenhouse gases such as CO_2 will affect climate is the extent to which natural systems will buffer or accelerate the growth in atmospheric carbon. Vegetation, soils, and the oceans are major reservoirs of carbon, but are subject to the effects of climate, and so may lead to feedbacks on climate change. Our work aimed to improve our understanding of the dynamics of this climate-carbon connection over a diverse range of timescales, with a focus on the use of Earth system models of differing complexities. Through a combination of model development, testing, and simulations we have significantly advanced our knowledge of both how the natural system behaves and how we can model it. This will lead to improvements in our ability to foresee the impact of policy decisions on the future evolution of the Earth system.

In particular, we have shown that permafrost thaw may have been a key cause of the initial rise in atmospheric CO_2 during the period of deglaciation following the last ice age. This is important because an understanding of the controls on atmospheric CO_2 during this time is so far lacking, and yet it is a key period with which we can understand the response of the Earth system to perturbations of similar magnitude to those currently occurring as a result of anthropogenic activities. Our model simulations provide important constraints on how much CO_2 and methane may be released from current permafrost as warming continues at high latitudes. This release will likely cause a significant acceleration of future climate change.

In other work, we greatly refined our understanding of the strength and timescale dependency of the climate-carbon feedback through the application of a sophisticated model of the Earth system. It was found that there is strong dependency of the strength of this feedback on timescale, with a maximum response on centennial timescales. This finding provides an extremely useful constraint on the climate-carbon cycle feedback that will be of interest to many future studies.

Biofuels represent a potentially useful mechanism for providing energy without burning fossil fuels. However, an unwanted side product is the emission of nitrous oxide, a powerful greenhouse gas resulting from fertilizer application. We have studied the trade-off between saved carbon emissions and extra nitrous oxide, finding that up to 60% of nitrous oxide emissions by 2050 may result from growing bioenergy crops. It is strongly recommended to careful evaluate mechanisms for limiting nitrous oxide emissions through improved agricultural management.

Methane is also an important greenhouse gas, whose concentrations have started growing again after a hiatus. Controls on methane concentrations are poorly understood, and earlier variations provide a means to increase our understanding. Of particular interest, the last interglacial period saw increased temperatures at high latitudes compared with the preindustrial state, but ice core data suggest methane concentrations were not elevated. We have investigated this problem using a combination of land surface emissions modelling and atmospheric chemistry modelling to determine the atmospheric sink strength. It was found that while emissions were indeed likely higher during the last interglacial, the rate at which atmospheric methane is destroyed was also higher, leading to no absolute change. These findings potentially solve an important question concerning past atmospheres with significant relevance for our understanding of the evolution of the future greenhouse effect.

This briefing statement is intended for use by Policy Makers and Journalists – if you have any questions or would like further information on the points raised above then please use contact the GCII Project Co-ordinator.

Email: gc2@geog.cam.ac.uk
Website: www.greencycles.org