Opening Keynote Presentations

Monday 10th May

Prof Jacqueline McGlade
European Environment Agency
Knowledge for action: Building robust links between science and policy

Prof. Berrien Moore III
University of New Hampshire
Faustian Bargains: The Challenge to the Earth System

Scene Setting Keynotes

Greenhouse gases in the Quaternary: constraining sources, sinks, feedbacks and surprises

Eric Wolff[1] and the QUEST DESIRE team

[1]*British Antarctic Survey, Cambridge, UK*
ewwo@bas.ac.uk

Ice cores have supplied us with rich records of the dynamics of CO_2, CH_4 and N_2O during the last 800,000 years. The extraordinary similarity of the CO_2 record to that of Antarctic climate suggests both the importance of the CO_2-climate feedback and the major role of the Southern Ocean. The CH_4 record has a similar long-term pattern overlaid with very rapid changes that coincide with the abrupt Dansgaard-Oeschger signals that pervade northern hemisphere records. In both cases, the detailed timing of change, linked to emerging isotopic data, constrain the possible causes of change, but we are not yet at the stage where Earth System Models can convincingly simulate the greenhouse gas changes even across the major glacial-interglacial terminations. I will discuss recent progress and implications for the feedbacks that might operate in the next few centuries. Finally, I will muse on the dream of modelling the Quaternary based only on the external forcing: to what extent is the Earth System on this timescale deterministic?

Human development within the safe operating space of the Earth system

Johan Rockström[1]

[1]*Stockholm Resilience Centre*
johan.rockstrom@stockholmresilience.su.se

Global environmental change is intimately linked to the ability to attain the UN Millennium Development Goals (MDGs). Already the target to half hunger and poverty by 2015, a target that is very unlikely to be met, may be undermined by inabilities to adapt to unavoidable climate and other interacting environmental changes. Attaining the longer term MDGs, of eradicating hunger and poverty is, for a Planet hosting some nine billion people by 2050, at risk of being out of reach, without transformative changes in (i) bending negative global environmental trends and (ii) building resilience to meet increased turbulence in an era of rapid global change.

This talk presents a recently presented framework, on planetary boundaries, to define, based on earth system science, the safe operating space for humanity in the Anthropocene. A particular focus is set on defining the challenges for a new sustainable agricultural revolution in the world in order to avoid risks of transgressing safe planetary boundaries for many of the key earth system processes that may influence the stability of the current Holocene state of planet Earth.

Keynote Speakers

Tuesday 11th May

A Framework for Process-Oriented Evaluation of Earth System Models

Veronika Eyring[1] and Pierre Friedlingstein

[1]*Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany*
Veronika.Eyring@dlr.de

To determine a safe level of greenhouse gas emissions, physical and biogeochemical feedback processes on various time scales have to be understood and projected with quantified uncertainties. A prerequisite to understanding and improving the representation of climate and biogeochemical feedbacks in state-of-the-art Earth system models (ESMs) is the systematic evaluation of the modeled processes through comparisons with observations. Extensive knowledge and experience has been acquired in a variety of international Model Intercomparison Projects (MIPs) that focus on the evaluation and quantification of processes for most if not all components of an ESM. However, an integrated evaluation to assess the performance of ESMs as a whole has so far been lacking. Only an integrated approach, applying a common strategy across the different Earth system components, will yield a realistic quantitative assessment of our ability to represent the various physical and biogeochemical climate feedbacks involved and will allow to explore the value of weighting multi-model climate projections. In this talk a framework for process-oriented ESM evaluation is presented along with examples for diagnostics and performance metrics that have already been succesfully applied to components of Earth system models.

Towards predicting climate system changes and feedbacks from observations

Gabriele Hegerl[1]

[1]*GeoSciences, University of Edinburgh, UK*
Gabi.Hegerl@ed.ac.uk

Feedbacks involving vegetation and the carbon cycle are dependent on the magnitude of climate change in response to increasing greenhouse gas concentrations, and vegetation is sensitive to regional and seasonal details of that response, and to change in variables other than mean temperature. This talk gives a roadmap towards estimating and predicting these changes from observed climate change:

- The equilibrium climate sensitivity (ECS) determines the overall magnitude of climate change in response to a sustained doubling of carbon dioxide. Evidence for its magnitude is available from observed and recorded changes in the recent and more remote past, and from climate modelling. The ECS, or its relative, transient sensitivity (which is easier to constrain from a transient observed change), provide evidence and predictions for the overall magnitude of climate change in the future.
- The regional pattern of change can be influenced by local and regional forcings, including vegetation and aerosols. Examples of that are given; in addition to examples where the seasonal pattern of temperature change and changes in climate extremes are quite different from changes large-scale mean temperature.
- Ecoystems, agriculture and society will also be strongly influenced by precipitation changes. Precipitation changes in response to CO_2 increases both due to direct

effects of forcing; and in response to warming (thereby being dependent on ECS and global warming predictions). First results on attributing observed precipitation changes to causes are available, but there is some evidence that these are larger than anticipated by models at present. This discrepancy cautions that predictions sensitive to precipitation changes are highly uncertain at present.

Implications of Global Environmental Change, and Environmental Policies, for Ecosystem Services and Human Well-Being: Energy, Land use, and Climate Stabilization

Jae Edmonds[1]

[1]*JGCRI, Pacific Northwest National Laboratory*
jae@pnl.gov

Human and natural Earth systems are connected through a complex web of interrelationships. Major changes to one system element inevitably affects other parts of the Earth system. Policies to limit anthropogenic climate change will have profound implications for the ways in which humans live and organize both industrial and terrestrial activities. Terrestrial systems provide important carbon storage services, which become increasingly valuable in a climate-constrained world. Taking the value of these services explicitly into account implies important changes in the ways humans use land. In this address we explore those implications for both ideal climate mitigation and under less than ideal circumstances.

Wednesday 12th May

Using Earth System Models to provide more policy-relevant information
Gavin Schmidt[1]

[1]*NASA, Goddard Institute for Space Studies*
gschmidt@giss.nasa.gov

With the addition of atmospheric chemistry, aerosols and other bio-geochemical processes into Earth System Models (ESMs), we can now provide a much more direct assessment of the impact of specific emissions on the key policy areas of climate, air pollution and public health. Furthermore, by assessing the impacts of specific policies on multiple emissions simultaneously and including the atmospheric interactions of these emissions and their byproducts, we can, for the first time, provide coherent and consistent impact assessments for policy-makers. I will discuss the implication of this approach for the importance of methane and the results of sector-based attributions. I will also highlight sectors and regions that provide the best examples of win-win-win scenarios for these three key policy areas.

Ice core records of past climate variability at the glacial-interglacial scale
Valérie Masson-Delmotte[1]z E. Capron[1], K. Pol[1], A. Landais[1]

[1]*Laboratoire des Sciences du Climat et l'Environnement*
valerie.masson@lsce.ipsl.fr

The carbon cycle and the Anthropocene
Michael R. Raupach[1,2]

[1]*Centre for Atmospheric, Weather and Climate Research, CSIRO Marine and Atmospheric Research, Canberra, Australia*
[2]*ESSP Global Carbon Project*
Michael.Raupach@csiro.au

Under the broad title of this talk I will explore three themes:
(1) The carbon cycle as a catalyst for the Anthropocene: Life on earth has created vast stores of detrital carbon, ranging from dead leaves and wood to the fossil carbon in coal, oil and gas. They contain large amounts of usable chemical energy. When the ancestors of modern humans learned to access this energy by mastering fire, they discovered a "new trick" which led to massive evolutionary advantages for the human species. In the technological explosion of the last two centuries, industrial-scale use of exosomatic energy flows from fossil carbon has not only transformed human societies and ecosystems, but also caused exponentially increasing accumulation of the released carbon in atmospheric, land and ocean carbon reservoirs, altering the carbon cycle and other cycles of matter and energy in the earth system.
(2) Changes in the contemporary carbon cycle: For over a century, total anthropogenic CO_2 emissions have increased exponentially with a doubling time of 36 years, and they continue to do so. Land and ocean CO_2 sinks respectively take up 0.3 and 0.25 of all anthropogenic CO_2 emissions, leaving only a CO_2 airborne fraction (AF) of 0.45 to accumulate in the atmosphere. The continuing total CO_2 sink is a massive ecosystem service to the task of emissions mitigation. Although the AF averaged close to 0.45 for the period 1960-2008 (with substantial interannual variability), there has been an increase in the AF over this period at a relative growth

rate of 0.24 ± 0.2 % y^{-1}, with probability P ~ 0.9 of a positive trend. A constant AF would be observed if emissions grow exponentially and there is a linear response of land and ocean CO_2 sinks to atmospheric CO_2 perturbation, idealisations which are met surprisingly well by the real carbon cycle. However, the increase over the last 50 y indicates that CO_2 sinks are ceasing to respond linearly to atmospheric CO_2 and consequently are "losing the race" with emissions which have continued to grow exponentially.

(3) Controlling runaway forcing of the carbon cycle: Human forcing of the carbon cycle, and thence climate, is still uncontrolled. I will characterise the task of sharing emissions reductions (or emissions quotas under a capped cumulative carbon budget), by exploring a rule space for sharing capped emissions. This analysis shows that all but a tiny fraction of the rule space is unviable in practice. The remaining part of the rule space is the part to which negotiations on sharing emissions are necessarily restricted.

Closing Keynote Presentations

Thursday 13th May

Providing seamless seasonal to centennial projections for health impacts of climate change

Andy Morse

School of Environmental Sciences, University of Liverpool
A.P.Morse@liverpool.ac.uk

The integration of dynamic disease models with seasonal lead time ensemble prediction systems has been developed over the last 10 years especially through the EC funded FP5 DEMETER and FP6 ENSEMBLES projects, particularly for malaria. In ENSEMBLES, the Liverpool Malaria Model (LMM) was extended to run over multi-decadal scales driven by Regional Climate Models (RCM) outputs produced for FP6 AMMA project. At seasonal scales the LMM shows skill for some regions, in Africa, with a lead time of 4 to 6 months, including areas with epidemic malaria transmission. This paper will introduce a framework for the seamless use of models including the LMM. The knowledge of integrating disease and climate models has been transferred to projections of disease for Europe. In the ERA-NET ENHanCE project an RCM driven blue tongue model has been developed for what is an economically important disease for ruminants especially sheep.
Forthcoming work in FP7 QWeCI will be discussed, here a seamless ensemble prediction system ranging across days to decades is being constructed to use with disease models for Africa. Further the paper will look towards the future use of ESMs with dynamic 'landscapes' within in the seamless approaches outlined above. Finally, even perfect models will have no use, unless the community and policy makers are involved in developing their integration within decision support systems.

What Went on When it Got Warm? Exploring Exogenous and Anthropogenic Climate Drivers in the Rise and Demise of Rome

Carole L. Crumley[1]

[1]*Stockholm Resilience Centre*
crumley@unc.edu

The history of Earth, a complex adaptive system that includes humans, must have as its starting point the understanding of ancient landscapes: they expose initial conditions and identify limiting factors that constrain subsequent forms the system can take. The rich European archaeological and historiographic record, in combination with well-studied biophysical features of the region, offers a remarkable laboratory in which to begin this global effort. The European case, one of three initiated by the Integrated History and Future of People and Earth (IHOPE) project, will collate information for the period 1000BCE-1000CE throughout Europe, linking research on earlier times (e.g., the Neolithic and Bronze Age), subsequent periods (the Medieval warm period, the Little Ice Age), modern studies of climate, environment, and society, and other regions (e.g., Eurasia, the Near East, teleconnections with the Americas). This integrated history will be used to produce dynamic models for future climate change in Western Europe.

Responding to the challenges of Climate Change: going beyond dangerous

Kevin Anderson[1,2]

[1]*Director of the Tyndall Centre for Climate Change Research*
[2]*Joint appointment: University of East Anglia (cross faculty Chair) and University of Manchester (School of Mechanical, Aerospace & Civil Engineering)*
Kevin.Anderson@manchester.ac.uk

The Copenhagen Accord reiterates the international community's commitment to *"hold the increase in global temperature below 2 degrees Celsius"*. Similarly, the EU maintains it *'must ensure global average temperature increases do not exceed 2°C'* and the UK's Low Carbon Transition Plan, states that "*to avoid the most dangerous impacts of climate change, average global temperatures must rise no more than 2°C"*. Despite such unequivocal statements the accompanying policies or absence of policies demonstrate a pivotal disjuncture between high-level aspirations with regards to 2°C and the policy reality. In part this reflects the continued dominance of 'end point' targets rather than scientifically-credible emission budgets and pathways, but even within the UK, where the policy-community and legislation aligns more closely with the science of climate change, the disjuncture nevertheless remains.

In recent years increasing numbers of national and global emissions scenarios have been developed, each with differing carbon budgets and hence with different temperature impacts. Coordinating national with global analyses is evidently a prerequisite of understanding the scale and rate of mitigation and adaptation accompanying differing levels of climate change. However, as it stands, such coordination is rare with little more than perfunctory correlation between national emission pathways and the quantitative scale of the challenge at a global level. By disaggregating selected global emission pathways into Annex 1 and non-Annex 1 nations, this presentation outlines a much-improved understanding of the extent of the mitigation challenge specifically and the adaptation challenge more generally.

This analysis offers a stark and unremitting assessment of climate change. There is now little to no chance of maintaining the global mean surface temperature at below 2°C, despite both repeated high-level statements to the contrary and the conclusions of more orthodox analysis (Committee on Climate Change, Stern, ADAM, AVOID, etc). Moreover, the impacts associated with 2°C have been revised upwards, sufficiently so that 2°C now more appropriately represents the threshold between '*dangerous* and *extremely dangerous* climate change'. Consequently and with tentative signs of global emissions returning to their earlier levels of growth, 2010 represents a political tipping point. The science of climate change allied with the emission scenarios for Annex1 and non-Annex 1 nations outlined in this paper suggests a very different mitigation and adaptation challenge from that we are collectively prepared to countenance. Whilst the implications of this are profound for policy they also raise fundamental questions about the framing of climate change research.