Inspiration material from 2014

Long-term Holocene increases in atmospheric CO2 and CH4 concentrations: natural or anthropogenic? (Mats Rundgren)

- In 2003 William Ruddiman, a respected palaeoclimatologist, published a paper in which he argued that the increasing atmospheric CO2 and CH4 concentrations recorded over the past 8000 and 5000 years, respectively, were caused by human land use. The rise in carbon dioxide was suggested to result from early agriculture and deforestation in Eurasia, and the methane increase was attributed to rice irrigation. According to Ruddiman, the high greenhouse gas concentrations in the late Holocene relative to earlier interglacials has prevented ice accumulation in northeastern Canada and postponed the transition into the next glacial period. This 'outrageous' hypothesis has become highly debated within the scientific community. This project should present and discuss the evidence and arguments put forward by Ruddiman and the contra-evidence and arguments that challenge his hypothesis. References to start with:

I

Stable isotope composition of CH4 in ice cores spanning the last glacial and the Holocene: what does it reveal about the relative importance of different, natural and anthropogenic, methane sources? (Mats Rundgren)

- Ice core records spanning several glacial-interglacial cycles show that atmospheric CH4 levels are tightly coupled to orbitally-controlled insolation variations. A strong climatic influence on atmospheric methane concentrations is also indicated on centennial timescales for the last glacial-interglacial transition. In contrast, the Holocene methane record is more difficult to directly relate to climate-related processes and, at least during recent centuries, anthropogenic processes are likely to have been important. One way to better understand the relative importance of different, natural and anthropogenic, processes for the observed CH4 changes is to analyse the stable carbon (δ13C of CH4) and hydrogen (δD of CH4) isotope compositions of methane preserved in ice cores. Because the isotopic composition of different methane sources, e.g. wetlands, soils, lakes, biomass burning, fossil fuels and marine clathrates, is relatively well known, CH4 isotope and concentration records can be used as input in model calculations to estimate the relative contribution of these processes. A number of recent studies adopting this approach have provided interesting information about carbon cycle dynamics during the last glacial, the last glacial-interglacial transition and the Holocene (both before and during the recent period of strong anthropogenic influence).

II

Present and future impacts of anthropogenic CO2 increase on ocean chemistry and marine ecosystems (Mats Rundgren)

- Ocean CO2 uptake in response to the anthropogenic increase in atmospheric CO2 concentrations over the past decades has been larger than the ocean buffering capacity, resulting in an ocean pH decrease. Since 1800 A.D., ocean pH has decreased from 8.16 to 8.05. A further drop to around 7.8 is estimated by the end of the century (*Feely et al.* 2009), and within a few hundred years ocean pH may reach levels not experienced in the last 20 million years or more. Because many marine organisms, both planktonic and benthic, are known to be sensitive to changes in pH, human CO2 emissions are likely to have important consequences for marine ecosystems. For example, experiments in artificially acidified waters show that organisms with carbonate shells have difficulties maintaining their shells at lower than present pH. In addition to this pH effect, ocean CO2 uptake results in changes in the chemistry of the oceans that reduce their ability to absorb additional atmospheric CO2. This project should describe and discuss the likely effects of the anthropogenic CO2 increase on ocean chemistry and marine ecosystems, both at present and in the future.

III

Has ancient DNA helped understanding of animal ecology during the Quaternary? (Richard Bradshaw)

- Recovery and sequencing of ancient DNA from extinct and surviving fauna have altered understanding of the combined effect of climate change and human impact on population dynamics and ecology. In this project you will assess the strengths and limitations of this new analytical technique, including the issues of contamination. You will review selected studies to highlight how they have contributed to our knowledge of past community dynamics and extinction.

IV

The Holocene spread of spruce and beech in Europe. Climatic control, human influence or migration biology? (Richard Bradshaw)

- The establishment of large populations of spruce and beech in northern Europe occurred during the late Holocene, long after the establishment of pine, oak, elm alder and other tree species. Why was this the case? In this project you will review the evidence for climatic control, migration biology and disturbance processes on the dynamics and distribution of spruce and beech in Europe during the Holocene.

V

Global change effects on biodiversity (Dörte Lehsten)

- There are multiple pressures on the biodiversity within ecosystems, independent of climate change. Among these pressures are land use change, direct effects of CO_2, N deposition and exotic plant invasions. Rapid climate change may increase or decrease these pressures. The idea would be to examine (probably in selected ecosystems) in the context of climate change how these other drivers of change either alone, or in combination, might influence both biodiversity and ecosystem processes.

VI

What does biodiversity do for us? (Dörte Lehsten)

- What are ecosystem services? What is the link between biodiversity and ecosystem services? What would be the effects to create substitutes for ecosystem services?

X

Changes in fire regimes over the Holocene and their potential driving forces. How can a knowledge of the past help to predict the future? (Chiara Molinari)

- Fire is a global phenomenon affecting ecosystems, land-surface properties, the carbon cycle, atmospheric chemistry, aerosols and human activities at all spatio-temporal scales (ranging from days to centuries and from microsites to biomes). Despite that, comparatively little is known about the patterns and driving forces of fire activity through time. Historical records, remotely sensed data, tree rings data and sedimentary charcoal records provide information about the linkage of fire, climate variability, vegetation dynamics and human activities. A better understanding of the role of fire in terrestrial biosphere is essential in order to protect and manage present and future ecosystems for the provision of ecological services and the conservation of biological diversity.
- This project should describe fire dynamics during the Holocene at a global or continental scale and discuss the potential drivers of these changes. Particular attention should be paid to the importance of palaeo-environmental researches in the prediction of future fire increase in response to future global warming.

XIV

Reducing emissions from deforestation and degradation (REDD): opportunities and obstacles (Dan Metcalfe)

- REDD is a strategy gaining increasing ground in climate policy circles to encourage sustainable resource and carbon storage, mainly in developing tropical countries. While the strategy offers a potentially powerful tool to achieve multiple positive environmental objectives simultaneously there exist multiple practical, scientific, cultural and ethical obstacles.
- What are the major obstacles to successful implementation of REDD and what can be done to overcome these obstacles?

XVI

Effects of animals on ecosystem structure and dynamics (Dan Metcalfe)

- Trophic interactions between predators and herbivores are affected by, and in turn affect, a wide range of ecosystem processes. However, most predictive models of ecosystem functioning under present and potential future climate largely ignore animals. To what extent is this a problem and what can realistically be done about it?
- Are there any consistent shifts in trophic interactions across ecosystem types and with climate. What might this tell us about future ecosystem processes under projected climate change?

XVII