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Session 6 – Climate & Environmental Change

Quantifying methane fluxes and their source using a Bayesian inverse model and observations of co-emitted tracers

Alice Ramsden
University of Bristol, PhD Student

Methane is the second most influential greenhouse gas in the atmosphere and has a range of natural and anthropogenic sources. These sources include wetlands, agriculture and livestock management, biomass burning and the production and use of fossil fuels. Concentrations of atmospheric methane are rising rapidly, but the source of these recent increases has not been found conclusively. This is likely due to the high uncertainties involved in the methods currently used to assign methane emissions to their source. This work aims to solve this problem by developing an improved method of source attribution. This new method uses observations of a secondary gas as a tracer for certain methane sources. For example, ethane can be used as a tracer for fossil fuel methane as it is not present in fluxes from other methane sources. By using concurrent observations of both gases and their ratio, the location of fossil fuel sources of methane can be inferred more accurately.
This new attribution method will be built into a Bayesian atmospheric inversion model, a commonly used method for quantifying regional methane fluxes. The inverse model compares observations of methane mole fractions to estimates of fluxes from bottom-up models, to find the most probable emission values. The ratio of methane to the tracer gas will be incorporated into this inverse model and used to assign derived fluxes to their source. However, there are also uncertainties and spatial and temporal variability involved in tracer emission ratios. I aim to study the effect of these uncertainties on sectoral methane quantification by building this added uncertainty into the inverse model. This new method will be tested on UK datasets before being used to study fossil fuel sources of methane in the US, where natural gas and oil industries are a large and changeable source of methane.

What is the cause of a spontaneous rapid climate change in transient simulations of the last ice age to the present?

Brooke Snoll
University of Leeds, MRes Student

Rapid climate fluctuations occur in Greenland's geological record throughout the last glacial and deglaciation periods; however, the underlying cause for these events is yet to be agreed upon. An abrupt climate change is observed in Greenland about 16 thousand years ago, in a transient model simulation of the last deglaciation using a general circulation model called the HadCM3. Analysis of the output data from the simulation will be manipulated and investigated with the use of plots and figures to determine a possible mechanism for this abrupt change. Using the previous research on abrupt climate changes, such as on the Dansgaard-Oeschger events, one will begin by inspecting the usual suspects of Atlantic Meridional Overturning Circulation (AMOC) changes and freshwater discharge and move into less common hypotheses such as changes in atmospheric circulation. Unlike other abrupt changes, however, this particular one does not show the expected immediate evidence of being linked with AMOC. Therefore, a new mechanism for abrupt climate changes could be identified, such as an atmospheric process. The results of this research will provide beneficial knowledge on the performance of the HadCM3 as well as the behaviour of climate processes and how to better replicate them in models.

Disentangling the drivers and spatial patterns of secondary forest regrowth in the Brazilian Amazon biome

Viola Heinrich
University of Bristol, PhD student

The key outcome from the Paris Agreement was an international agreement to hold "the increase of global average temperatures to well below 2C above pre-industrial levels and … to limit this increase to 1.5C". Many studies have shown that to achieve this goal requires not only reductions in CO_2 emissions but also an increase in removals by carbon sinks such as forests. 'Secondary' forests – forests regrowing on deforested land – have a large potential to absorb carbon compared to mature forests, which are largely in equilibrium with the carbon cycle. However, there remains uncertainty of the true mitigation potential of these forests because of the ongoing impact of climate change and interannual climate variability on fire and drought occurrence, which reduce the carbon stock. In this remote sensing study, we focus on tropical secondary forest regrowth within the Brazilian legal Amazon with the overall aim of assessing their climate mitigation potential. We use a new land cover product, MapBiomas, to identify secondary forests and their ages. Following this we aim to use further remote sensing products measuring Aboveground Carbon to construct regrowth curves of secondary forest with age. The impact of fires and drought on the regrowth of the forest will be explored. We also assess whether the products used in this study can be applied in other tropical countries with the intention of being used by countries' Greenhouse Gas emissions inventory compilers. Initial results show that the method identifying areas secondary forests used in this study is in good agreement with another, widely used land cover product in Brazil. There is a strong linear relationship between the two products (Pearson's R value of 0.7). This is a promising result, suggesting that given the automated nature of MapBiomas, it has the potential for tropical wide applications, which could benefit countries' inventories.

The elevational gradients of mountain forest loss in the 21st century

Xinyue He
University of Leeds, PhD student

Forests cover approximately one third of Earth's surfaces. Many montane ecosystems are currently experiencing forest loss or gain. These changes may exert drastic changes on hydrological cycles (e.g., evapotranspiration, river flow) via modifying land surface properties (e.g., surface roughness, albedo) tied to land use and land cover. Previous studies revealed most of the deforestation or afforestation in lowlands, while how forest cover changes at different altitudes in the mountains and how it effects hydrological components in the surrounding basins have not been fully understood. Here we present a study aiming to explore the effects of mountain forest change on the downstream hydrology. We use the high-resolution global map of forest change during 2000-2018 and the elevation data to

complete a global analysis of the deforestation-elevation and the treeline-elevation relationships. We also assess which climate variables (temperature, rainfall, wind speed) might explain these variations. Then we quantify the evapotranspiration and river flow in the lowlands affected by forest cover change in the highlands. These results suggest that mountain forests provide unique hydrological services for downstream inhabitants and that these changes would trigger different physical, chemical, and biological processes altering the water cycle, even energy budget and atmospheric composition.

Climate change and the extreme heat related impacts on the London Underground infrastructure

Sarah Greenham, University of Birmingham, PhD student

Rail infrastructure is particularly vulnerable to extreme weather events, and damage to rail networks results in negative socioeconomic consequences such as reduced work productivity due to loss of access to commuting. The world's oldest subway system, the London Underground (LU), operated by Transport for London (TfL) identified that extreme heat impacts the network now, and is likely to increase in future. However, previous studies are limited to passenger comfort on the deep tube and do not focus on infrastructure or a significant proportion of the network, which is in fact above ground. This research therefore aims to investigate whether causality can be determined between extreme heat events and infrastructure failure on the LU network, in order to understand the risks posed by future climate change and extreme heat events in the United Kingdom. Building on previous research using 2011-2016 data (accepted, awaiting publication), this research synthesises 2006-2018 data in greater depth, from UK Met Office archives, LU environmental observations and LU fault data with UKCP18 climate projections. Statistical tests identify the conditions, sites and assets on the LU most vulnerable to extreme heat and consequently likely to cause maximum disruption to customers in future. Preliminary findings identified a difference in surface level and deep tunnel environmental conditions and thus expect a difference in the characteristics of faults and delays accumulated. Increase in surface temperatures in the future as indicated by UKCP18 are expected to exacerbate these; scenario dependent. Results will provide TfL with quantitative information to support the business case for appropriately designed and placed climate change adaptation activity. This will ultimately help keep London moving, while simultaneously protecting a vital cultural asset to the United Kingdom.