ABSTRACTS AND BIOGRAPHIES

The Pliocene: The Last Time Earth had >400 ppm of Atmospheric CO2

The Pliocene: An accessible example of a world in equilibrium with 400 ppmv CO2?

Prof A Haywood, University of Leeds

ABSTRACT | The Pliocene is an epoch of geological time spanning from ~2.6 to 5.3 million years ago. At this time the configuration of the continents and ocean basins were similar to present-day, but with some important exceptions that will be discussed. Techniques for the reconstruction of past environments, combined with climate and ice sheet model simulations, indicate an overall picture of a warmer world with an enhanced hydrological cycle. Global annual mean surface temperatures were ~3°C warmer then the pre-industrial era. Warming was most pronounced in the higher latitudes, thus creating a reduced pole-to-equator surface temperature gradient. Zonal surface temperature gradients may have also been reduced in the tropics. These changes had profound effects on large-scale atmospheric circulation, such as the Hadley and Walker circulation. Tundra was replaced by boreal forests at the Arctic coastline, and the Greenland and West Antarctic ice sheets may have largely collapsed raising global sea levels. The nature of the East Antarctic Ice Sheet during this time is more uncertain. The geographical coverage of arid deserts declined and they were replaced by savannah type vegetation. Globally, forests became more dominant in the landscape. These changes are fascinating given that geological proxies indicate an elevated concertation of atmospheric CO2 (absolute value of ~400 ppmv), compared to the pre-industrial era. As such the Pliocene has been proposed as an accessible example of a climate state in long-term equilibrium with 400 ppmv CO2, and has been used as a prime target to evaluate the predictive ability of climate models. Unfortunately the complexity of the real world rarely conforms to simple narratives, regardless of the attractiveness of the narrative itself. The Pliocene was certainly not one long homogenous epoch in terms of climate. Climate varied from interglacial events, of varying intensity, to relatively cool episodes and potentially even glacial periods. The geographical and seasonal intensity of the warming (or cooling) varied as a result of the specific character of Earths' changing orbit around the sun, and the resulting insolation pattern at the top of the atmosphere. So what part of the Pliocene we refer to matters deeply. Furthermore, geological proxies for temperature and CO2 reconstruction have associated uncertainties, in the same way that climate model simulations have known uncertainties and limitations. This means our current appreciation of Pliocene climate and regional climate variability through time is incomplete. This suggests a degree of caution is needed when considering the utility of the Pliocene in addressing big climate questions raised by the anthropogenic emission of greenhouse gases. In this talk I summarise the current state-of-the-art in terms of Pliocene climate science, and highlight the challenges and scientific questions that that lay ahead in order to be able to confidently say that the 'Pliocene' is indeed an accessible example of a world in equilibrium with 400 ppmv CO2.

BIOGRAPHY | Alan Haywood is Professor of Palaeoclimate Modelling at the School of Earth and Environment, University of Leeds. He specialises in the integration of past climate and environmental data from the geological record with climate model simulation. He has been actively working on the reconstruction and modelling of Pliocene climate for the last 21 years, gaining a PhD in the subject from the University of Reading in 2001. Following his PhD he became the principal investigator of a British Antarctic Survey core research programme, before moving to Leeds in 2007 as a Reader and then Professor in 2011. Since 2009 he has been a member of the steering committee of the Palaeoclimate Modelling Intercomparison Project, and from 2008 has co-led the Pliocene Model Intercomparison Project.

The Pliocene and IPCC - How does The Pliocene inform the future?

Prof Dan Lunt, University of Bristol

ABSTRACT | The Pliocene, 3 million years ago, provides a fascinating and important window into what our planet may look like in the future under climate change. However, is it possible to quantify this in some way? How does our understanding of the past actually affect our predictions of the future? In particular, to what extent does the Intergovernmental Panel on Climate Change (IPCC), which informs climate policy, take into account paleoclimate data and modelling. Here, exploring one particular aspect of future projection - the

climate sensitivity of our planet - I review how the Pliocene has informed past reports, and how it could be used in the next report, due out in 2021.

BIOGRAPHY | Dan Lunt is Professor of Climate Science at the University of Bristol. Dan has over fifteen years' experience in developing and running climate models in order to address questions and hypotheses related to past and future climate change. A particular focus has been on climate and climate sensitivity in the past. He is leader of the international DeepMIP project (www.deepmip.org), and its predecessor, EoMIP. Dan has worked extensively in the Pliocene, including characterising Earth system sensitivity, and is he currently working with the UK Met Office to configure the Pliocene CMIP6 paleoclimate simulations with UKESM. He was a contributing author to the IPCC AR5, is a Lead Author in AR6, and in 2010 was awarded the Philip Leverhulme Prize for his work on climate modelling. Dan was founding Chief Executive Editor of Geoscientific Model Development, an EGU journal designed primarily for the description and evaluation of models of the Earth System. He has provided oral evidence to a UK Government Select Committee on Geoengineering.

Evidence of Antarctic mass loss from offshore sediments
Prof T van der Flierdt, Imperial College London

ABSTRACT | Polar ice is an important component of the climate system, affecting global sea level, ocean circulation, ocean biogeochemistry, and heat transport. Today most of the Antarctic continent is covered by up to four kilometres of ice. Melting just a small fraction of this ice would constitute a major challenge to coastal cities and people around the globe. Understanding the response of the large Antarctic ice sheet to warmer than present climates, such as the Pliocene, is hence a major focus of ongoing research. Computer models represent a powerful way to address the question of ice vulnerability to changing environmental conditions. However, it is vital to ground truth such models with observational data from the geological past. Using sophisticated drilling technology, we can recover sediments from below the seafloor right next to the Antarctic continent. These sediments work a bit like time machines: the deeper one drills into the seafloor the further one steps back in time. The chemical fingerprint of the sediment is like our own fingerprint or DNA – it holds unique information about where the material was coming from. We can hence use chemical fingerprinting of ancient marine sediments to learn where the eroding ice margin was located back in time, providing information on ice extent during warmer than present periods such as the Pliocene. At the meeting I will share impressions and findings from some of the spectacular Antarctic drilling expeditions that took place over the past decade. What uncovers is a fascinating story of waxing and waning ice, under environmental conditions that are not too different from the ones we may encountered in the near future.

BIOGRAPHY | Tina van de Flierdt is a Professor of Isotope Geochemistry at Imperial College London. She is a geologist by training, whose academic background includes a PhD in Natural Science from the ETH Zurich, and a postdoctoral Fellowship and Associate Research Scientist position at Lamont-Doherty Earth Observatory of Columbia University. She now co-leads the MAGIC isotope facility at Imperial College London. Her research spans a variety of fields from understanding chemical cycles of trace elements and pollutants in the ocean, over reconstructions of past ocean circulation patterns, to the history of continental ice sheets and their vulnerability to future climate change.

Environment on Antarctica from the fossil record
Prof Dame J Francis, British Antarctic Survey

ABSTRACT | Geological evidence from the rock record indicates that during the Pliocene the continental landmass of Antarctica was covered with glaciers and ice sheets. However, at times the ice sheets retreated to allow the colonization of small shrubby vegetation deep in the interior of Antarctica. Climate analysis of features of the fossil plants indicate that during these periods of glacial retreat summer temperatures may have been as warm as 5°C, over 20°C warmer than present in central Antarctica, ultimately resulting in less ice and much high global sea levels.

BIOGRAPHY | Jane Francis is Director of the British Antarctic Survey, Cambridge. A geologist by training from the University of Southampton, she was a NERC Postdoctoral Fellow in London, palaeobotanist at the British Antarctic Survey, Australian Research Fellow at the University of Adelaide, a Royal Society Leverhulme Trust Senior Research Fellow and Professor of Palaeoclimatology at the University of Leeds, where she was also Dean of the Faculty of Environment. Her research interests include ancient climates and fossil plants from the Arctic and Antarctica, used to decipher ancient polar climates of the past. She was awarded the Polar Medal for her contribution to British polar research and was appointed as Dame Commander of the Order of St Michael and St George for services to UK polar science and diplomacy.

<u>What the Pliocene can tell us about the world we are heading toward</u>

Prof R DeConto, University of Massachusetts-Amherst

ABSTRACT | The extraordinary sea-levels reconstructed from geologic records of the Pliocene and other past warm periods have pushed the glaciological and modeling communities to reassess the physical processes that can deliver glacial ice to the ocean. As a result, the potential for multi-meter sea level rise on century timescales is now recognized as an emerging possibility. However, deep uncertainty remains regarding what's possible at the high end of future sea level projections, making long-term coastal planning difficult. Here, we will review some examples of elevated sea levels during late Pleistocene interglacials, when the Earth's surface temperature was similar to today's, and the Pliocene, when global mean temperature was a few degrees warmer- but sea level was possibly several tens of meters higher. We will explore glaciological mechanisms that could be responsible for such extreme sensitivity of the polar ice sheets to relatively modest warming in the past, the possible implications for future sea-level rise, and newly proposed mechanisms that could trigger the onset of catastrophic rates of sea level rise by the turn of the century.

BIOGRAPHY | Rob DeConto is a Professor of Geosciences at the University of Massachusetts-Amherst. Rob's background spans geology, oceanography, atmospheric science, and glaciology. Before joining the faculty at the University of Massachusetts he held research positions at both the US National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA). Rob's research is focused on understanding the evolution of the Earth's cryosphere, particularly the great polar ice sheets on Greenland and Antarctica, and the future fate of those ice sheets in a warming world. This has included field work on Antarctica, the development of climate and ice sheet models, and the application of those models to a wide range of past and future climate scenarios. Rob serves on a number of national and international science boards and advisory panels. He is the 2016 recipient of the Tinker-Muse Prize for Science and Policy in Antarctica, and he is currently serving as a lead author for the Intergovernmental Panel on Climate Change (IPCC).