Investigating Quaternary climate sensitivity to orbital variations using an energy and moisture balance climate model.

Daniel Gunning$^{1,2}$

$^1$University of Bergen, Faculty of Mathematics and Natural Sciences, Department of Earth Sciences, Norway (daniel.gunning@uib.no)

$^2$Bjerknes Centre for Climate Research, Bergen, Norway (daniel.gunning@uib.no)

A comprehensive understanding of what caused the repeated growth and decay of northern hemisphere ice sheets (otherwise known as glacial-interglacial cycles) during the Quaternary Period has remained allusive. The importance of changes in the Earth’s orbital parameters for ‘pacing’ these cycles is widely acknowledged. However, the transition from 41 kyr to quasi-100 kyr glacial-interglacial cycles at the Mid-Pleistocene Transition (MPT) occurs without any significant variations in the Earth’s changing orbit. Even the dominance of 41 kyr cycles in the Early Pleistocene is unusual, given the notable absence of strong 19 and 23 kyr precession cycles. Put simply, climatic precession is the orbital parameter that alters the time of the year when the Earth is closest to the Sun, which considerably influences the intensity of summer insolation. As summer insolation is considered critical for the growth and decay of northern hemisphere ice sheets according to Milankovitch Theory, it would be expected that precession cycles would strongly feature throughout the Quaternary. Explanations that account for this absence of strong precession cycles during the Early Pleistocene include an anti-correlation between summer insolation intensity and summer duration or the cancellation of out-of-phase precession cycles between the northern hemisphere ice sheets and Antarctica. Here, we introduce a zonally averaged energy and moisture balance climate model to investigate the response of the Quaternary climate system to changes in the Earth’s orbital parameters. The purpose of the model is to investigate these problems related to glacial-interglacial cycles of the Early Pleistocene. We present equilibrium simulations of the model for the pre-industrial period and the Last Glacial Maximum, to demonstrate the suitability of the model to study climate change on these large spatial and temporal scales of interest. In addition, we show the equilibrium and transient sensitivity of the model to changes in the Earth’s orbital parameters. Factors that influence the relative contributions of obliquity and precession on global temperatures and/or ice volume will be investigated in the context of the 41 kyr cycles of the Early Pleistocene.