EGU24-6612, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-6612
EGU General Assembly 2024

Eco-evolutionary Modelling of Global Vegetation Dynamics and the Impact of CO_2 during the late Quaternary: Insights from Contrasting Periods

Jierong Zhao[1], Sandy P.Harrison[1], and Iain Colin Prentice[2]
[1]Department of Geography and Environmental Science, University of Reading, Whiteknights, Reading, RG6 6AB, UK
[2]Georgina Mace Centre for the Living Planet, Department of Life Sciences, Imperial College London, Silwood Park Campus, Buckhurst Road, Ascot, SL5 7PY, UK

Changes in climate have had a significant impact on global vegetation patterns during the Quaternary. However, variations in CO_2 levels also play a key role in shaping vegetation dynamics by influencing plant water-use efficiency, and consequently, the competitive success of employing the C3 and C4 photosynthetic pathways. In this study, we use an eco-evolutionary optimality (EEO) based modelling approach to examine the respective impacts of climate fluctuations and CO_2-induced alterations on vegetation shifts. We consider two distinct periods, the Last Glacial Maximum (LGM, 21,000 years before present) and the mid-Holocene (MH, 6,000 years before present) and compare these to contemporary conditions. The LGM, characterised by generally colder and drier climate, had a CO_2 level close to the minimum threshold for effective C3 plant operation. In contrast, the MH had warmer summers, increased monsoonal rainfall in the northern hemisphere, with CO_2 levels lower than the present day. We simulate vegetation changes at the LGM and the MH using a light-use efficiency model that simulates gross primary production (GPP) coupled to an EEO model that simulates leaf area index (LAI) and C3/C4 competition. We show that low CO_2 at the LGM is as important as climate in reducing tree cover, increasing the abundance of C4 plants and lowering GPP. Global GPP is also lower than today in the MH (although increased compared to the LGM), reflecting CO_2 constraints on plant growth despite the positive impacts of warmer and/or wetter climates experienced in the northern hemisphere and tropical regions on plant growth. These results emphasise the importance of taking account of impacts of changing CO_2 levels on plant growth in order to simulate ecosystem changes correctly.