EGU22-1468
https://doi.org/10.5194/egusphere-egu22-1468
EGU General Assembly 2022

The African monsoon during the early Eocene from the DeepMIP simulations

Charles J. R. Williams[1] and the The African monsoon DeepMIP team[*]
[1]University of Bristol, School of Geographical Sciences, Bristol, United Kingdom of Great Britain – England, Scotland, Wales (c.j.r.williams@bristol.ac.uk)
[*]A full list of authors appears at the end of the abstract

Here we present a study of African climate (with a focus on precipitation) during the early Eocene (~55-50 million years ago, Ma), as simulated by an ensemble of state-of-the-art climate models under the auspices of the Deep-time Model Intercomparison Project (DeepMIP). The early Eocene is of particular interest, because with CO_2 levels ranging between 1200-2500 ppmv (and a resulting temperature increase of ~5°C in the tropics and up to ~20°C at high latitudes) it provides a partial analogue for a possible future climate state by the end of the 21st century (and beyond) under extreme emissions scenarios. This study is novel because it investigates the relatively little-studied subject of African hydroclimate during the early Eocene, a period from which there are very few proxy constraints, requiring more reliance on model simulations.

A comparison between the DeepMIP pre-industrial simulations and modern observations suggest that model biases aremodel- and geographically dependent. However, the model ensemble mean reduces these biases and is showing the best agreement with observations. A comparison between the DeepMIP Eocene simulations and the pre-industrial suggests that, when all individual models are considered separately, there is no obvious wetting or drying trend as the CO_2 increases. However, concerning the ensemble mean, the results suggest that changes to the land sea mask (relative to the modern) in the models may be responsible for the simulated increases in precipitation to the north of Eocene Africa, whereas it is likely that changes in vegetation (again relative to the modern geographical locations) in the models are responsible for the simulated region of drying over equatorial Eocene Africa. When CO_2 is increased in the simulations, at the lower levels of increased CO_2, precipitation over the equatorial Atlantic and West Africa appears to be increasing in response. At the higher levels of CO_2, precipitation over West Africa is even more enhanced relative to the lower levels. These precipitation increases are associated with enhanced surface air temperature, a strongly positive P-E balance and cloud cover increases. At the lower levels of increased CO_2, anticyclonic low-level circulation increases with CO_2, drawing in more moisture from the equatorial Atlantic and causing a relative drying further north. At higher levels of CO_2, the increased anticyclonic low-level circulation is replaced by increased south-westerly flow.

Lastly, a model-data (using newly-compiled Nearest Living Relative reconstructions) comparison suggests that whether the Eocene simulations (regardless of CO_2 experiment) over- or underestimate African precipitation is highly geographically dependent, with some of the CO_2 experiments at some of the locations lying within the uncertainty range of the reconstructions. Concerning the ensemble mean, the results suggest a marginally better fit with the reconstructions at lower levels of CO_2.

The African monsoon DeepMIP team: Charles J. R. Williams1,2, Daniel J. Lunt1, Ulrich Salzmann3, Tammo Reichgelt4, Gordon N. Inglis5, David R. Greenwood6, Wing-Le Chan7, Ayako Abe-Ouchi7, Yannick Donnadieu8, David K. Hutchinson9, Agatha M. de Boer9, Jean-Baptiste Ladant10, Polina A. Morozova11, Igor Niezgodzki12, Gregor Knorr13, Sebastian Steinig1, Zhongshi Zhang14, Jiang Zhu10, Matthew Huber15, Bette L. Otto-Bliesner16 1School of Geographical Sciences, University of Bristol, UK 2NCAS / Department of Meteorology, University of Reading, UK 3Geography and Environmental Sciences, Northumbria University, UK 4Department of Geosciences, University of Connecticut, US 5National Oceanography Centre, University of Southampton, UK 6Department of Biology, Brandon University, Canada 7Atmosphere and Ocean Research Institute, The University of Tokyo, Japan 8Laboratoire des Sciences du Climat et de l'Environnement, France 9Department of Geological Sciences, Stockholm University, Sweden 10Earth and Environmental Sciences, University of Michigan, US 11Institute of Geography, Russian Academy of Sciences, Russia 12Polish Academy of Sciences, Poland 13Alfred Wegener Institute for Polar and Marine Research, Germany 14Bjerknes Centre for Climate Research, University of Bergen, Norway 15Department of Earth, Atmospheric and Planetary Sciences, Perdue University, US 16National Center For Atmospheric Research, US