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Investigating the role of orbital forcing on East Asian monsoons using a statistical emulator

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Variations in the strength and timing of past East Asian monsoons can be inferred from high-resolution speleothem records, particularly from south-east China, along with insights in to the factors that may influence them. However, there is still uncertainty associated with the role of orbital forcing in East Asian monsoon dynamics. In part, this is due to the difficulty associated with performing transient simulations spanning multiple glacial cycles using a sufficiently complex model that includes a representation of the regional monsoon systems. State-of-the-art General Circulation Models (GCMs), for example, require large amounts of computing power and time, thus simulations of one or more glacial cycle are simply not feasible. Here, we present long-term "continuous" projections of the evolution of climate over the Middle to Late Pleistocene (500,000-0 years before present) via the use of a statistical emulator. The emulator is calibrated using ensembles of GCM simulations, giving it the resolution of a GCM, which have varying orbital configurations, atmospheric CO_2 concentrations and global ice sheet volumes (spanning glacial and interglacial conditions). Changes in global surface air temperature and precipitation over the period are modelled in response to orbital, atmospheric CO_2 and global ice sheet variations derived from paleo-proxy data, and the evolution of the East Asian monsoon is examined. In order to gain insight into the relative roles of orbit versus atmospheric CO_2 versus ice volume, further simulations of climate are also performed which are forced by orbital and atmospheric CO_2 variations, and orbital variations only. This volume of sensitivity studies could only be carried out using an emulator, given the long timescales being considered. The emulated reconstructions of the East Asian monsoon are compared to δ18O data (a proxy for the East Asian monsoon) from speleothem records from China, as both a model-data comparison and a validation of the emulator results.