Sensitivity of global nonhydrostatic atmospheric model to changes in orbital forcing for the early Holocene

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Various types of geological records have extensively shown consistent patterns of warmer and moister areas over Asia and Africa during the early to mid-Holocene. Previous sensitivity simulations of many global climate models to the changes in the earth’s orbital parameters during this period have equally shown the enhancement of the Asian and African monsoons, providing a successful interpretation on the qualitative patterns of these records. This study aims to shed a new light on the climate of this period by running sensitivity simulations by a global nonhydrostatic atmospheric model which began to be available for climate studies in recent years. The model used in this study is Nonhydrostatic ICosahedoral Atmospheric Model (NICAM) developed by a Japanese meteorological community: a framework of a cloud resolving model which resolves cumulus convection when used with a proper resolution and does not adopt any cumulus parameterizations. Because of the limit of computational resources, we use NICAM with a horizontal resolution of 56km. Despite not resolving cumulus convection, previous studies confirmed that it behaved similarly to the one with much higher resolution and provided practically reasonable mean-states and variability. The simulations were run with a slab ocean model and orbital parameters of 9000 years B.P. (9kBP). The Integrations were continued for 5 years. The seasonal mean precipitation in the control run is largely overestimated, however, it shows very good spatial distributions in terms of the locations of the ITCZs and peak precipitation. In particular, because of the high resolution enough to represent the steep terrain of the Tibetan Plateau, the model successfully reproduces a narrow rain band along its southern edge. The boreal summer precipitation of the 9kBP simulation shows a well-known northward shift of the African ITCZ, consistent with previous studies. Over Asia, the narrow precipitation band at the south of the Tibetan Plateau is significantly enhanced. The precipitation also increases over the Indian ocean. In between, there is a band-like structure of the suppressed precipitation over the India and Indochinese Peninsula. Although the resolution is not sufficient to resolve cumulus convection, the global nonhydrostatic atmospheric model appears to have a potential to represent small structures of the earth’s topography and evaluate its effect on precipitation which had not been discussed in previous studies. It is expected to be useful in discussing regional scale patterns of the geological records.

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