Geophysical Research Abstracts
Vol. 19, EGU2017-15533, 2017
EGU General Assembly 2017

Modeling the response of precipitation oxygen stable isotopes to the Eocene climate changes over Asia

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The Himalayas and the Tibetan Plateau have become a focus of the Earth sciences because they provide a classical example of tectonics-climate interactions. Present-day high elevations of the Himalayas and the Tibetan Plateau is the ultimate result of the collision between Indian and Asia plates during the Cenozoic, however, the precise uplift history of the Himalayas and the Tibetan Plateau is still uncertain, especially for the early Cenozoic. For the purpose of paleoelevations reconstructions, multiple methods are available, but stable oxygen paleoaltimetry is considered to be one of the most efficient techniques and has been widely applied in Asia. However, paleoelevations studies using stable oxygen presume that climatic processes control δ^{18}O in a uniform way through time. We use climate modeling tools in order to investigate Eocene climate and δ^{18}O over Asia and its controlling factors. The state-of-the-art general circulation model embedded with isotopes LMDz-iso has been applied together with Eocene boundary conditions and varied Eocene topography of the Himalayas and Tibet. The results of our simulations suggest that topography change has a minor direct impact on δ^{18}O over the Himalayas and the Tibetan Plateau. On the contrary, Eocene δ^{18}O in precipitation is primarily controlled by the atmosphere circulation and global temperature changes. Based on our numerical experiments, we show that despite persistence of large-scale atmospheric flows such as the monsoons and westerlies, Eocene δ^{18}O over the region is different from those of the present-day due to global higher temperatures, southward shift to a zone of strong convection and increased role of westerlies moisture source. We show that the Rayleigh distillation is not applicable for the Eocene Himalayas and conclude that the assumption about the stationarity of δ^{18}O-elevation relationship through geological time is inaccurate and misleading for paleoelevation estimates. We also show that Eocene precipitation δ^{18}O is rather insensitive to topographic height in Asia. However, carbonate δ^{18}O still records paleoelevation because the fractionation between calcite and water is sensitive to temperature, which depends on altitude. Comparison of simulated Eocene δ^{18}O patterns with data from the carbonate archives suggest that the Himalayas and the Tibetan Plateau did not reach high present-day like elevations during the Eocene. Our simulations highlight the limit of standard atmospheric distillation models when they are applied to deep time.