EGU2020-11141
https://doi.org/10.5194/egusphere-egu2020-11141
EGU General Assembly 2020

Long-term stability of large-scale hydroclimate processes in the North American Great Plains revealed by a Neogene stable isotope study

Livia Manser[1], Tyler Kukla[2], and Jeremy K. Caves Rugenstein[3]
[1]Departement of Earth Sciences, ETH Zürich, Zürich, Switzerland (lmanser@student.ethz.ch)
[2]Department of Geological Sciences, Stanford University, Stanford, CA, USA
[3]Max Planck Institute for Meteorology, Hamburg, Germany

The North American Great Plains are characterized by a sharp aridity gradient at around the 100th meridian with a more humid climate to the east and a more arid climate to the west. This aridity gradient shapes the region's agriculture and economy, and recent work suggests that arid conditions on the Great Plains may expand eastward with global warming. The abundant Neogene sediments of the Ogallala Formation in the Great Plains present an opportunity to reconstruct regional hydroclimate conditions at a time when $p\mathrm{CO}_2$ and global temperatures were much higher than today, providing insight into the aridity and ecosystem response to warming. We present new paleosol carbonate δ^{13}C and δ^{18}O data (n=366) across 37 sites spanning the Great Plains and compile previously published measurements (n=381) to evaluate the long-term hydroclimatic and ecosystem changes in the region during the late Neogene. This study combines a spatial and temporal analysis of carbon and oxygen isotope data with reactive-transport modeling of oxygen isotopes constrained by climate model output, providing critical constraints on the paleoenvironmental and paleoclimatological evolution of the Neogene Great Plains. Carbonate δ^{18}O demonstrate remarkable similarity between the spatial pattern of paleo-precipitation δ^{18}O and modern precipitation δ^{18}O. Today, modern precipitation δ^{18}O over the Great Plains is set by the mixing between moist, high-δ^{18}O moisture delivered by the Great Plains Low-Level Jet and drier, low-δ^{18}O westerly air masses. Thus, in the absence of countervailing processes, we interpret this similarity between paleo and modern δ^{18}O to indicate that the proportional mixing between these two air masses has been minimally influenced by changes in global climate and that any changes in the position of the 100th meridian aridity gradient has not been forced by dynamical changes in these two synoptic systems. In contrast, prior to the widespread appearance of C_4 plants in the landscape of the Great Plains, paleosol carbonate δ^{13}C show a robust east-to-west gradient, with higher values to the west. We interpret this gradient as reflective of lower primary productivity and hence soil respiration to the west. Close comparison with modern primary productivity data indicates that primary productivity has declined and shifted eastward since the late Neogene, likely reflecting declining precipitation and/or a reduction in CO_2 fertilization during the late Neogene. Finally, δ^{13}C increases across the Miocene-Pliocene boundary, which, consistent with previous studies, we interpret as a shift from a C_3 to a C_4 dominated landscape. We conclude

that, to first order, the modern aridity gradient and the hydrologic processes that drive it are not strongly sensitive to changes in global climate and any shifts in this aridity gradient in response to rising CO_2 will be towards the west, rather than towards the east.