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Modern and Paleoclimate Variations over the Tibetan Plateau from Climate Modeling

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The development of mountain topography over geologic time scales can influence regional climate and orographic precipitation (Kutzbach et al., 1993). Climate change associated with mountain building can impact erosion and sedimentation rates, as well as climate sensitive data used for paleoelevation reconstructions (e.g. δ18O in soil carbonates). For example, the changes in low-level winds and onset of convective precipitation during ~ 10 and 6 Ma over the Andes may overestimate the rapid rise of the Andes by up to several kilometres (Ehlers and Poulsen, 2009). These effects are most pronounced for large orogenic plateaus such as the Tibetan Plateau (TP).

In this study, the environmental controls on modern δ18Op (δ18O in precipitation) and the response of δ18Op to variable plateau elevations are investigated using an atmospheric general circulation model (Echam5-wiso; Werner et al., 2011). The model predicts the δ18O isotopic fractionation of precipitation for all compartments of the hydrological cycle. Simulations are conducted at a resolution of T63L31 (spatial resolution of $1.9^\circ \times 1.9^\circ$, and 31 vertical levels). The simulations were forced with modern boundary conditions as a function of variable paleo TP elevations (specified at 75%, 50%, 25% of TP modern elevations, and 500m). This approach identifies the sensitivity of regional climate and water isotopes to changes in plateau elevation.

Results are as follows. The modern simulation successfully predicts three δ18Op distribution zones on the TP: a 'temperature effect' is dominant in the northwest region, an 'amount effect' is prominent in the southwest region of the TP, and a transitional zone exists in between. These general zones are also suggested by various observations (Tian et al, 2007 and Yao et al, 2013). Spatial and temporal variations in δ18Op - elevation lapse rates are also investigated. A δ18Op - elevation lapse rate of ~-3.1 ‰km is found in both winter and summer seasons at the Himalaya front, whereas the western side of the TP has a lapse rate of ~-3.4 ‰km in the winter and -1.7‰km in the summer.

Results from initial simulations with variable paleo plateau heights indicate significant changes from modern conditions. TP paleo-elevations have a significant influence on regional climate. Lowering the TP results in generally higher temperatures, lower precipitation and more enriched δ18Op across the TP and eastern China. Wetter and colder conditions occur in the Gobi and Taklimakan desert areas for lower plateau elevations. The precipitation weighted annual mean δ18Op and elevation lapse rate also change significantly with lower plateau elevations. For example in the region around Lasha, the δ18Op and elevation lapse rate change from ~-4.4 ‰km in the modern to ~-3.4‰km, ~-2.5‰km, ~-0.2‰km and ~1.7‰km for TP elevation of 75%, 50%, 25%, and ~1% of modern elevations, respectively.