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Spatial and Temporal Changes in Paleoclimate across the Himalaya-Tibet Orogen

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Paleoclimate and environmental proxy records from the Himalaya-Tibet region provide a basis for reconstructing Tibetan Plateau climate change and paleoelevation reconstructions. Proxy records are often used to document changes in precipitation and temperature, as well as stable isotopes (e.g. water isotopologues). Tibetan proxy records have previously been used to reconstruct paleoclimate ranging from the Early Cenozoic (∼50 Ma) to Late Quaternary (∼21 ka BP). In this study, we synthesize a series of recent results from atmospheric General Circulation Model (GCM, ECHAM5-wiso and LMDZ-iso) experiments that highlight two main components of Himalaya-Tibet paleoclimate. First, we explore the impact of Cenozoic changes in Tibetan Plateau elevation through a series of sensitivity tests. These simulations provide a template for understanding some of the largest magnitude paleoclimate changes the region has experienced over the last ∼50 Ma. Second, we explore global paleoclimate change over more recent (shorter) timescales for discrete time slices that include: Pre-industrial (PI, Pre-1850 AD), Mid Holocene (MH, 6.5 ka BP), Last Glacial Maximum (LGM, 21 ka BP), and Pliocene (PLIO, 3 Ma) time periods. Model predictions are compared with existing proxy records when possible.

Model results for long (Cenozoic) timescale changes in plateau elevation suggest a significant decreas in precipitation rates across the Himalaya (3-4 m/yr) and Tibet (∼0.2 m/yr) when the plateau elevation was 50% of the modern topography. Continued lowering of the plateau towards sea-level results in widespread drier conditions across the Himalaya-Tibet region. Over more recent (Quaternary) timescales, muted climate changes are found across the plateau during the MH and larger changes occur during the LGM. During the LGM surface temperatures are ∼2.0–4.0 degrees C lower across the Himalaya and Tibet, and >5.0 degrees C lower at the northwest and northeast edge of the Tibetan Plateau. LGM mean annual precipitation is 200–600 mm/yr lower over on the Tibetan Plateau. Comparison between model predictions and proxy data shows a good agreement for the LGM, but large differences for the MH. However, significant differences are also present between MH proxy studies located near each other, highlighting a lack of internal consistency between previous studies. Finally, climate change over glacial-interglacial cycles is found to have significant impact on the Indian monsoon intensity. More specifically, rainfall associated with the Indian monsoon (between 70E–110E Longitude and 10N–30N Latitude) is about 44% less in the LGM than during PI times. The LGM monsoon period is about one month shorter than in PI times. Taken together, these results document significant spatial and temporal changes in temperature and precipitation over the last ∼3 ka, and even more dramatic changes over the Cenozoic during surface uplift of the Himalaya and Tibet.