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Late Cenozoic Climate Change and its Implications on the Denudation of Orogen Syntaxes

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The denudation history of active orogens is often interpreted in the context of modern climate gradients. Despite the influence of climatic conditions on erosion rates, information about paleoclimate evolution is often not available and thus not considered when denudation histories are interpreted. In this study, we analyze output from paleoclimate simulations conducted with ECHAM5-wiso at T159 (ca. 80x80km) resolution. Specifically, we analyze simulations of pre-industrial (PI, pre-1850), Mid-Holocene (MH, ca. 6ka), Last Glacial Maximum (LGM, ca. 21ka) and Pliocene (PLIO, ca. 3ka) climates and focus on a selection of orogen syntaxes as study regions (e.g. Himalaya, SE Alaska, Cascadia, and Central Andes). For the selected region, we carry out a cluster analysis using a hybrid of hierarchical and k-means clustering procedures using mean annual temperature (MAT), temperature amplitude, mean annual precipitation (MAP), precipitation amplitude and u-wind and v-wind in different months to provide a general overview of paleoclimates in the study regions. Additionally, we quantify differences between paleoclimates by applying two-group linear discrimination analyses to the simulation output for a similar selection of variables. Results indicate the largest differences to the PI climate are observed for the LGM and PLIO climates in the form of widespread cooling and reduced precipitation in the LGM and warming and enhanced precipitation during the PLIO. These global trends can be observed for most locations in the investigated areas, but the strength varies regionally and the trends in precipitation are less uniform than trends in temperatures. The LGM climate shows the largest deviation in annual precipitation from the PI climate, and shows enhanced precipitation in the temperate Andes, and coastal regions for both SE Alaska and the US Pacific Northwest Pacific. Furthermore, LGM precipitation is reduced in the western Himalayas and enhanced in the eastern Himalayas, resulting in a shift of the wettest regional climates eastward along the orogen towards the eastern syntax. The cluster-analysis results also suggest more climatic variability across latitudes east of the Andes in the PLIO climate than in other time-slice experiments conducted here. Results from the discriminant analysis show that the quantified differences in climate and the relative contribution to these differences by each of the analyzed parameters are highly variable in space for each of the paleoclimates. Taken together, these results highlight significant changes in Late Cenozoic regional climatology over active orogens on time scales ranging from glacial cycles to geologic. As a result, future interpretation of recent and paleo denudation rates in these areas from sediment flux inventories, cosmogenic radionuclides, or low-temperature thermochronology techniques warrant careful consideration of these changes.