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On the Synergistic Climatic Effects of Covarying Major Mountain Range Topographies

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The interpretation of Earth surface archives often requires consideration of distant off-site events. One such event is the surface uplift of Earth's major mountain ranges, which affects climate and the Earth's surface globally. In this study, the individual and synergistic climatic effects of topographic changes in major mountain ranges are explored with a series of General Circulation Model (GCM) experiments and analyses of atmospheric teleconnections. The GCM experiments are forced with different topographic scenarios for Himalaya-Tibet (TBT) and the Andes (ADS), while environmental boundary conditions are kept constant. The topographic scenarios are constructed by successively lowering modern topography to 0% of its modern height in increments of 25%. This results in a total of 5 topographic scenarios for TBT (tbt100, tbt075, tbt050, tbt025, tbt000) and ADS (ads100, ads075, ads050, ads025, ads000). TBT scenarios are then nested in ADS scenarios, resulting in a total of 25 experiments with unique topographic settings. The climate for each of those 25 scenarios is simulated with the GCM ECHAM5-wiso. We then explore possible synergies and distant impacts of topographic changes by testing the hypothesis that varying ADS has no effect on simulated climate conditions in the TBT region (c_{tbt}) and vice versa. This can be expressed as the null hypothesis $c_{tbt}(ads100) = c_{tbt}(ads075) = c_{tbt}(ads050) = c_{tbt}(ads025) = c_{tbt}(ads000)$ for each of the 5 TBT scenarios, and vice versa. We conduct Kruskal-Wallis tests for a total of 10 treatment sets to address these hypotheses. The results suggest that ADS climate is mostly independent of TBT topography changes, whereas TBT climate is sensitive to ADS topography changes when TBT topography is high, but insensitive when TBT topography is strongly reduced. Analyses of atmospheric pressure fields suggest that TBT height acts as a control on cross-equatorial atmospheric transport and modifies the impact of ADS topography on northern hemisphere climate. These results dictate a more careful consideration of global (off-site) conditions in the interpretation of Earth surface records.

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