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How would the eastward propagation of surface uplift in the Alps affect regional climate and isotopic composition of precipitation?

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Reconstructions of topography and surface uplift histories of mountain ranges over geological time help constrain the geodynamic evolution of collisional domains and improve our understanding of the interactions between climate, tectonics, and surface processes. Stable isotope palaeoaltimetry is a powerful tool to estimate past surface elevations. However, recent studies suggest that knowledge of climate conditions is needed to accurately interpret the isotopic composition of water recorded in geologic archives. Furthermore, the geodynamic history of the European Alps is hypothesized to have resulted from the eastward propagation of surface uplift that could be reflected in palaeoaltimetry data. In this study we apply high-resolution isotope-tracking ECHAM5-wiso General Circulation Model (GCM) to forward-model the climate and water isotopes in meteoric water for different surface uplift histories of the Alps. Our emphasis is on understanding the climate and topographic signals preserved in the isotopic composition of precipitation ($\delta^{18}O_p$) which is eventually recorded in paleosol carbonates. More specifically, we test the hypothesis that different topographic configurations for Eastern and Western Alps result in significantly different regional climates and spatial distributions of $\delta^{18}O_p$. We present sensitivity experiments with two free parameters: the height of the Western/Central Alps and the height of the Eastern Alps. Results indicate a different response of $\delta^{18}O_p$, precipitation, surface temperature, low level wind patterns and isotopic lapse rate for the different topographic scenarios. In addition, we find $\delta^{18}O_p$ locally increases up to 2‰ when the Eastern Alps are reduced to 0% of their current height, and decreases up to -8% when uplifted to 200%. The precipitation amount increases by ~60 mm/month in response to surface uplift due to orographic effects. The surface temperature locally decreases by -4°C in response Eastern Alps uplift due to both adiabatic and non-adiabatic cooling and increases by -8°C for reduced elevation scenario. The results of our study suggest that the hypothesized west-to-east surface uplift should be reflected in the isotopic composition of meteoric water. Furthermore, our simulated isotopic response to different uplift scenarios provides a basis for the interpretation of isotopic composition derived from geological archives in a stable isotope palaeoaltimetry approach.