Modeling terrestrial δ^{18}O gradients in lowland and mountain environments

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Terrestrial gradients in the oxygen isotopic composition of meteoric water (δ^{18}O), as reconstructed through proxies, reflect characteristics of ancient hydrologic conditions. These gradients are primarily influenced by the water balance, the transport of vapor, and topographic distillation. Here, we incorporate these effects into a one-dimensional model that predicts the spatial evolution of δ^{18}O based on topography and the moisture-energy budget. Specifically, we build on existing reactive transport models [1, 2] by incorporating parameterizations of orographic precipitation [3] and energetic constraints on evapotranspiration following the Budyko hydrologic balance framework [4-6]. We test our model on three modern transects that represent topographically distinct environments. These are the Amazon (lowlands), the Cascade Range (mountains), and the Himalaya inland from Bangladesh (lowlands + mountains). Comparison of these gradients demonstrates the sensitivity of isotope records in different topographic regimes to hydrologic conditions. Finally, we discuss the implications of our work for disentangling topographic and climatic signals through Earth history.

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