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Dynamic Topography and The Mantle Forcing on Climate: A Missing Link in Earth System Science

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Global topography plays a fundamental role in shaping climate, influencing atmospheric circulation and precipitation patterns through orographic effects. While much of Earth's topography arises from isostatic support due to variations in crustal and lithospheric thickness and density, a significant portion of up to 1-2km results from dynamic forces driven by slow yet vigorous mantle convection. Despite decades of research on the spatial and temporal evolution of such 'dynamic topography', its impact on global climate remains largely unexplored. In this study, we address this gap by quantifying the influence of mantle-induced dynamic topography on present-day atmospheric circulation and precipitation patterns. Using an Earth Model of Intermediate Complexity forced with different models of global dynamic topography, we isolate the mantle's contribution to climate patterns. Our findings reveal prominent climatic effects linked to mantle dynamics, particularly along the American Cordillera, the East African Rift System, and other regions across latitudes which are critical to biodiversity and the evolution of life. These results uncover a hitherto unknown connection between Earth's deep interior and surface environments, with the mantle dynamics as active driver of climate processes, enhancing our understanding of the Earth System. By linking mantle dynamics to global climate, our study offers new opportunities for paleoclimate investigations and insights into how geodiversity and biodiversity have co-evolved throughout Earth's history.