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The Role of Topography in Local Climate Change

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A map of observed annual mean precipitation is strikingly asymmetric in the zonal direction. Understanding the cause of this asymmetry and its response to changes in global greenhouse gas concentrations requires an understanding of how zonal asymmetries such as mountain ranges and continental boundaries affect the transport of heat and moisture. We use an idealized GCM with a slab ocean to study the effect of a gaussian mountain ridge and a large midlatitude continent on the regional climatology around the globe across a wide range of climates. We find that in addition to the well known orographic precipitation effect near the mountain range, precipitation patterns are affected globally due to moisture transported by topographically driven stationary Rossby waves. Because Rossby waves propagate equatorward, there is a particularly large influence on precipitation patterns in the subtropical region south and southeast of the mountain range. With an increase in greenhouse gas concentrations, represented in our model by optical thickness in a grey atmosphere, the amplitude of the stationary Rossby wave decreases while the overall specific humidity of the atmosphere and the associated moisture fluxes increase due in part to the Clausius-Clapeyron relation. This leads to a peak in the amplitude of the stationary wave induced precipitation pattern near the present value of optical thickness. Understanding the change of regional patterns of precipitation in a changing climate is essential for understanding changes in surface hydrology and corresponding changes in erosion rates and ecology.