Future Changes in Extreme Precipitation: Why Mountains Are Different

Climate-model simulations predict an intensification of extreme precipitation in almost all areas of the world under global warming. Local variations in the magnitude of this intensification are evident in these simulations, but most previous efforts to understand the factors responsible for the changes in extreme precipitation focused on zonal averages and neglected zonal variations, leading to uncertainties in the understanding and estimation of regional responses.

Here the spatial heterogeneity of the warming-induced response of midlatitude 6-hour extreme precipitation is studied in climate- and mesoscale-model simulations with idealized orography on the western margins of otherwise flat continents. The sensitivity of extreme precipitation to warming (i.e., its fractional rate of increase in intensity with global-mean surface temperature) is 3% per K lower over the mountains than the oceans and plains. This difference in sensitivity is primarily produced by differences in the dynamics governing vertical ascent over the three regions. In these extreme events, mountain-wave dynamics control the moist ascent over the mountains, and the sensitivity of this ascent to global warming is mainly controlled by changes in upper-level dry static stability and the cross-mountain winds. In contrast, midlatitude cyclone dynamics govern moist ascent over the oceans and plains. Ascending motions in intense midlatitude cyclones are sensitive to the ratio of the moist static stability in their saturated cores to the dry stability in surrounding regions. This ratio decreases in the warmer world, intensifying the maximum vertical velocities while reducing the horizontal extent of the regions of the rising air within the cyclone.

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Refreshments and Meet the Speaker at 3:00pm