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Response of precipitation extremes to warming: what have we learned from theory and idealized cloud-resolving simulations, and what remains to be learned?

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In this work, we review recent important advances in our understanding of the response of precipitation extremes to warming from theory and from idealized cloud-resolving simulations. A theoretical scaling for precipitation extremes has been proposed and refined in the past decades, allowing to address separately the contributions from the thermodynamics, the dynamics and the microphysics. Theoretical constraints, as well as remaining uncertainties, associated with each of these three contributions to precipitation extremes, will be discussed. Notably, although to leading order precipitation extremes seem to follow the thermodynamic theoretical expectation in idealized simulations, considerable uncertainty remains regarding the response of the dynamics and of the microphysics to warming, and considerable departure from this theoretical expectation is found in observations and in more realistic simulations. We also emphasize key outstanding questions, in particular the response of mesoscale convective organization to warming. Observations suggest that extreme rainfall often comes from organized system in very moist environments. Improved understanding of the physical processes behind convective organization is needed in order to achieve accurate extreme rainfall prediction in our current, and in a warming climate.