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Understanding the regional pattern of changes in extreme precipitation in a warming climate

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Changes in extreme precipitation belong to the most impact-relevant consequences of climate warming. Regional projections of such changes are uncertain because of natural variability and model deficiencies in relevant physical processes. Extreme precipitation is affected by changes in both atmospheric thermodynamics and dynamics, but these contributions are typically diagnosed with spatially aggregated data or using a statistical approach that is not valid in all locations. Here we decompose the forced response of regional-scale extreme daily precipitation in climate-model simulations into thermodynamic and dynamic contributions using a robust physical diagnostic. We show that thermodynamics alone would lead to a spatially homogeneous fractional increase, which is consistent across models and dominates the sign of the change in most regions. However, the dynamic contribution regionally amplifies the increase in extreme precipitation, for instance, in the Asian monsoon region, and weakens it in regions such as the Mediterranean, South Africa and Australia. Over subtropical oceans, the dynamic contribution is strong enough to cause robust regional decreases in extreme precipitation, likely partly as a result of a poleward circulation shift. The dynamic contribution to extreme precipitation is key to understand present-day model biases and to narrow down the large uncertainties in future projections of extreme precipitation on regional scales.