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Contribution of climatic changes in means and variability to temperature and precipitation extremes

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Weather or climate extreme events disproportionately affect societies and ecosystems. Physical understanding of the impact of global climate change on the occurrence of such extreme events is therefore crucial. Here we separate changes in the occurrence of high-temperature and heavy-precipitation events in a part caused by climatic changes of the mean state and a part caused by climatic changes in variability. We extend the frequently used Probability Ratio (PR) framework, used to quantify changes in the occurrence of extreme events, such that it produces a 'PRmean' value for changes due to a change in mean climate and a 'PRvar' value for changes due to changes in climate variability. Large ensemble climate model simulations are used to quantify changes in extreme events in a 2C warmer world. It is found that the increased occurrence of high-temperature extremes is predominantly caused by the increase of mean temperatures, with a much smaller role for changes in variability (PRmean >> PRvar). The spatial differences are considerable, however, with the polar regions standing out as regions where changes in temperature variability do have a considerable limiting effect on extreme event occurrence. Changes in heavy-precipitation extremes are generally due to changes in both mean climate and variability (PRvar ≈ PRmean). Despite complex feedbacks in the global climate system, the ratio of PRmean to PRvar is largely independent of the event threshold and the climate scenario. These results help to quantify robustness of projected changes in climate extremes, given that projections of changes in the mean state are in many cases much better constrained than projections of changes in variability.