



Non-linear reduction of Indian summer monsoon rainfall in response to global warming

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In climate model simulations of the coming two centuries, we observe a marked reduction of the Indian summer monsoon (ISM) circulation along with rising global temperature due to anthropogenic greenhouse gas emissions. At the same time, the decadal-average seasonal mean rainfall associated with the ISM first increases by about 10% during the 21st century, but then experiences a rapid reduction by about 20%, compared to pre-industrial values, during the 22nd century. The frequency distribution of seasonal mean rainfall changes its shape during this process, with the skewness of the distribution changing sign, so that weak monsoon years become much more likely. We explain this non-linear response on the basis of two distinct monsoon modes. While an increase in specific humidity and in the land-ocean temperature contrast shifts the baseline towards stronger rainfall, initially leading to increased mean rainfall, the share of the weak monsoon mode increases at the cost of the strong mode, causing the subsequent reduction in mean rainfall.