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Quantifying the drivers of European precipitation changes: Large-scale thermodynamics, lapse-rate and circulation changes

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Recent coordinated climate modeling studies such as CMIP5 or CORDEX provide a unique set of simulations for assessing projected changes in the hydrological cycle. Yet the reasons for the project changes often remains obscure. Here we examine, by extending a previous study (Kröner et al., 2016, DOI:10.1007/s00382-016-3276-3), the large-scale drivers for changes in European precipitation statistics (mean, intensity, frequency, heavy precipitation and dry days). Regional climate model ensembles suggest a bipolar climate change pattern over Europe, with decreasing (increasing) mean precipitation and wet-day frequency in the south (north). Increases in precipitation intensity and occurrence of heavy events show a similar pattern but the increases extend further south. An extended surrogate approach is applied to disentangle the influence of large-scale thermodynamic, circulation and lapse-rate changes on the projections. Additionally a subset of a multi-model ensemble (EURO-CORDEX) is utilized to evaluate the findings. The thermodynamic effect is found to increase precipitation intensity, but to have no influence on the precipitation frequency. Its influence on heavy precipitation events is stronger than on mean precipitation. The large-scale circulation in contrast is decreasing the precipitation frequency and has only a small influence on precipitation intensity. In general its influence becomes weaker for heavy precipitation events. The lapse-rate effect is important in summer over southern Europe. For this region and season, its effect is as strong as the large-scale circulation effect, and it is also decreasing precipitation frequency. The strong influence of the lapse-rate effect on Mediterranean precipitation change is quantified for the first time in this study.