

## Characteristics of precipitation extremes in Europe from CMIP5: Changes from the last millennium to the end of the 21st century

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Due to warming climate, more frequent and damaging extreme hydrological events are predicted in Europe. Variations between different basins and regions are observed, ranging from an increase in north-western Europe to no trend or a decrease in other parts of the Europe. However, large uncertainties are surrounding the magnitude and frequency of river flood occurrences in Europe by previous studies. One of the critical challenges remains in understanding precipitation extremes in Europe. More importantly, it is difficult to evaluate the future projections of precipitation extremes and flood, given the high degree of natural hydroclimatic variability and the limited instrumental measurements covering only the last hundred years. Our study aims to better understand the current precipitation extremes and future projection in Europe in the context of long-term climatic variability from the last millennium to the future 2100. In this case, the precipitation observation and simulations from Global Climate Models (GCM), including the Last Millennium (850-1849), the historical (1850-2005) and anthropogenically-forced simulation of the 21st century (RCP8.5), are chosen to investigate the natural variability and extremity of precipitation in Europe. Firstly, the phase 5 of the Coupled Model Intercomparison Project (CMIP5) historical simulations are evaluated against the observational data for precipitation amounts at monthly, seasonal, and annual time scales and statistics of extreme precipitation (i.e., 100-yr return events). Secondly, the characteristics of extreme precipitation are explored using CMIP5 experiments of the Last Millennium, historical control, and the 21st century, focusing on the seasonality, inter-annual and multi-decadal variability of precipitation, the spatial and temporal distribution of extreme precipitation including 50-year, 100-year, and 500-year return events. Finally, two major questions will be addressed in the study: (1) whether the last hundred years of instrumental measurements (1900–present) could represent precipitation variability and extremes statistics from CMIP5 models; (2) what are the realistic changes of precipitation extremes in Europe due to anthropogenic climate change.