EGU2020-2764
https://doi.org/10.5194/egusphere-egu2020-2764
EGU General Assembly 2020

On the role of CO2 in enhancing the temporal clustering of heavy precipitation across Europe

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Heavy precipitation has increased across many areas of the world, not only in terms of amounts but also of intensity and frequency, causing billions of dollars in economic losses and numerous fatalities. Our ability to prepare for and adapt to these events is tied to our understanding of the physical processes responsible for these events, and how they may respond to changes in anthropogenic forcings. Here we focus on the temporal clustering of heavy precipitation across Europe, highlight what the major climate drivers responsible for it are, and how it may change in response to changes in the concentration of greenhouse gasses. More specifically, we use a peak over threshold approach to identify heavy precipitation events, and Cox regression to relate the occurrence of these events to four climate modes that have been connected with the occurrence of heavy precipitation across Europe: the Arctic Oscillation (AO), the North Atlantic Oscillation (NAO), the East Atlantic (EA) pattern, and the Scandinavia pattern (SCAND). We use outputs from the Coupled Model Intercomparison Project Phase 5 (CMIP5), and experiments that allow us to focus on the response to CO_2 (pre-industrial, 1pctCO_2, abrupt4×CO_2). To further detect the effects of downscaling on model-simulated precipitation, we also considered the accuracy of the EURO-CORDEX regional climate model (RCM) on capturing the temporal clustering in heavy precipitation across Europe. We find that: 1) the CMIP5 models can capture the temporal clustering in heavy precipitation across Europe as a function of these four climate modes; 2) the increases in CO_2 are expected to lead to a strengthening of the relationship between the climate modes and the occurrence of heavy precipitation events; 3) the response to an abrupt increase in CO_2 is generally stronger compared to a more gradual one.