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## Strong increase of probability of Northwestern European multi-year droughts in a warmer climate

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Three consecutive dry summers in western Europe (2018-2019-2020) had widespread negative impacts on society and ecosystems, and started societal debate on (changing) drought vulnerability and needs to revise adaptation measures. To facilitate that discussion, we investigate multi-year droughts in the Rhine basin, with a focus on event probability in the present climate and in future warmer climates. Additionally, we studied the temporally compounding physical processes leading to multi-year drought events. A combination of multiple reanalysis datasets and multi-model large ensemble climate model simulations was used to robustly analyse the statistics and physical processes of these rare events. In these data, we identify two types of multi-year drought events (consecutive meteorological summer droughts and long-duration hydrological droughts), and show that these occur on average about twice in a 30 year period in the present climate, though natural variability is large (zero to five events in a single 30 year period). Projected decreases in summer precipitation and increases in atmospheric evaporative demand, lead to a doubling of event probability in a world 1 °C warmer than present and an increase in the average length of events. Consecutive meteorological summer droughts are forced by two, seemingly independent, summers of lower than normal precipitation and higher than normal evaporative demand. The soil moisture response to this temporally compound meteorological forcing has a clear multi-year imprint, resulting in a relatively larger reduction of soil moisture content in the second summer and potentially more severe drought impacts. Long-duration hydrological droughts start with a severe summer drought followed by lingering meteorologically dry conditions. This limits and slows down the recovery of soil moisture content to normal levels, leading to long-lasting drought conditions. This initial exploration provides avenues for further investigation of multi-year drought hazard and vulnerability in the region, which is advised given the projected trends and vulnerability of society and ecosystems.