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Changes in continental Europe water cycle in a changing climate

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Changes in atmospheric water vapor content provide strong evidence that the water cycle is already responding to a warming climate. According to IPCC's last report on Climate Change (AR5), the water cycle is expected to intensify in a warmer climate as the atmosphere can hold more water vapor. This changes the frequency of precipitation extremes, increases evaporation and dry periods, and effects the water redistribution in land. This process is represented by most global climate models (GCMs) by increased summer dryness and winter wetness over large areas of continental mid to high latitudes in the Northern Hemisphere, associated with a reduction in water availability at continental scale. Observing changes in precipitation and evaporation directly and at continental scale is difficult, because most of the exchange of fresh water between the atmosphere and the surface happens the oceans. Long term precipitation records are available only from over the land and there are no measurement of evaporation or redistribution of precipitation over the land area. On the other hand, understanding the extent of climate change effects on various components of the water cycle is of strategic importance for public, private sectors, and policy makers when it comes to fresh water management. In order to better understand the extent of climate change impacts on water resources of continental Europe, we developed a distributed hydrological model of Europe at high spatial and temporal resolution using the Soil and Water Assessment Tool (SWAT). The hydrological model was calibrated for 1970 to 2006 using daily observation of streamflow and nitrate loads from 360 gauging stations across Europe. A vegetation growth routine was added to the model to better simulate evapotranspiration. The model results were calibrated with available agricultural crop yield data from other sources.

As of future climate scenarios, we used the ISI-MIP project results which provides bias-corrected climate data from the GCMs participating in the CMIP5 at 0.5° x 0.5° resolution. Data cover the time period from 1901 to 2099, i.e. the historical period, and future projections for all Representative Concentration Pathways (RCP2.6, RCP 4.5, RCP 6.0, and RCP 8.5). We used four different models output (GFDL, HADGEMES, MIROC, and IPSL) for all RCPs for near (2006-2035) and far (3065-2099) future. Multi-model ensembles (16 scenarios) are then used to study the potential impacts of future climate change on fresh water availability across Europe.