Climate change effects on hydrometeorological compound events over southern Norway

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Compound events are characterized as a combination of multiple drivers and/or hazards which contributes to societal, economical or environmental risk. In southern Norway, hydrometeorological compound events can trigger severe floods, for instance the joint occurrence of rainfall and snowmelt in south-eastern Norway in 1995 and 2013.

Due to this high impact, the investigation of compound events is important, but is hampered by some limiting factors. The multivariate character and the associated very rare occurrence of these events require a large database in order to conduct statistically robust investigations, whereas the available meteorological observations are too scarce in space and time.

With this current study, we present a quantile-based framework to define and examine compound events within a single model initial condition large ensemble (SMILE). To overcome the limitation of data scarcity, we use 50 high-resolution climate simulations from the SMILE CRCM5-LE to investigate two hydrometeorological compound event types in southern Norway:

1. Heavy rainfall on saturated soil during the summer months (June, July, August, September),
2. Concurrent heavy rainfall and snowmelt (also often referred to as rain-on-snow).

Furthermore, the application of climate model data enables us to quantify the impact of climate change on the frequency and spatial distribution of both types of compound events. Thereby, we compare current climate conditions (1980-2009) with future conditions (2070-2099) under the high-emission scenario RCP 8.5. We find that the frequency of heavy rainfall on saturated soil increases by 38% until 2070-2099 on average. In contrast, the occurrence probability of rain-on-snow is projected to decrease by 48% over the whole study area, largely driven by decreases in snowfall. The spatial patterns of both events are found to shift. Additionally, we assess the range of the natural variability of the drivers and of the compound event probability within the 50 members of the CRCM5-LE. The univariate spread of the meteorological drivers is found to be relatively small, whereas the occurrence probability of both compound events shows a high inter-member variability. Hence, we conclude that the frequency of the joint occurrence of the contributing
drivers is highly variable, which is why a SMILE is needed to assess this probability.

Our current work shows the limitations of regional climate models, stressing the need for even higher-resolution setups to resolve the complex topography of Norway. However, it also highlights the benefits of SMILE simulations for the analysis of compound events.