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Can the latest generation of regional climate models reproduce European snow conditions and how do biases translate into uncertainties of snow cover projections?

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Snow cover is a crucial part of the climate system due to its distinctive alteration of surface reflectance (snow-albedo-feedback) and its influence on further physical surface properties (e.g. heat conduction and water storage). These effects are particularly relevant in alpine areas and high latitude regions, where snow coverage prevails for a significant part of the season. In addition, various human activities rely on snow cover duration and/or snow amounts, such as winter tourism, agriculture and hydropower production.

The EURO-CORDEX project provides an RCM ensemble with a horizontal resolution of ~50 and ~12 km for both present-day and future climates assuming different emission scenarios. These simulations present a potentially valuable information source for the future snow cover evolution. Prerequisite, however, is the ability of RCMs to reproduce historical snow cover conditions. These issues are addressed in the present work on a European scale. A horizontal resolution of ~12 km allows for an improved representation of topography and is thus particularly interesting for snow cover studies, as snow in alpine regions strongly correlates with elevation. We therefore only consider the high-resolution EURO-CORDEX RCMs and, for the climate projection part, simulations for RCP2.6, RCP4.5 and RCP8.5.

To assess the RCMs' ability of reproducing current snow cover conditions in Europe, we evaluate simulated snow water equivalent and snow cover duration/extent by comparison against different reanalysis data (e.g. ERA5, UERRA MESCAN-SURFEX) and snow products derived from remote sensing. Regarding the spatial domain, we consider entire Europe with a focus on four mountainous regions (Alps, Norway, Pyrenees and Carpathians). The evaluation reveals that, on a European scale, mean yearly snow cover duration is well captured by the ensemble mean of the models. However, the majority of the RCMs underestimates snow cover extent throughout the season. This bias is more pronounced in the reanalysis (ERA-Interim) driven set of simulations than in the GCM-driven runs. In regions with complex topography, winter snow water equivalent is distinctively overestimated in some simulations - whereas certain grid cells reveal glaciation (i.e. year-round snow coverage). A comparison with E-OBS data indicates that biases in snow cover duration and amount are, besides arising from inaccurate snow schemes, linked to mismatches in

simulated air temperature and precipitation patterns. Scenarios for the 21st century show a distinctive reduction in snow cover duration for low-elevation regions, whereas the magnitude of this decrease depends, amongst other factors, on the climate scenario. Projected decreases in the snow cover are less pronounced for medium to high-elevation regions.