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Gone for good? Future snowfall in the Alps.

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The snowfall climate of the Alps is central to the state of the Alpine cryosphere, determining accumulation conditions and impacting society through associated natural hazards. Accordingly, the assessment of future changes of Alpine snowfall is highly relevant for various sectors. The situation is complex, however, as snowfall reductions driven by the projected temperature increase could potentially be offset by an increase of winter precipitation. Furthermore, changes in heavy snowfall do not necessarily mirror changes in mean snowfall conditions.

Here we take a closer look at these issues by assessing 21st century snowfall changes over the European Alps in high-resolution regional climate model (RCM) data that recently became available through the EURO-CORDEX initiative. Fourteen different combinations of global and regional climate models with a target resolution of 12 km, and two different greenhouse gas emission scenarios are considered (RCP4.5, RCP8.5). A newly developed method to separate snowfall from total precipitation based on near-surface temperature conditions and accounting for subgrid topographic variability is employed. The evaluation of simulated snowfall amounts against an observation-based reference indicates the ability of RCMs to capture the main characteristics of the snowfall seasonal cycle and its elevation dependency, but also reveals considerable positive biases especially at high elevations. These biases can partly be removed by the application of a dedicated RCM bias correction that separately considers temperature and precipitation biases.

Twenty-first Century snowfall projections reveal a robust signal of decreasing mean September-May snowfall amounts over most parts of the Alps for both emission scenarios. Domain and multimodel-mean decreases by the end of the century amount to -25% and -45% for RCP4.5 and RCP8.5, respectively. Snowfall in low-lying areas in the Alpine forelands could be reduced by more than -80%. This decrease is driven by the projected warming and is strongly connected to an important decrease of snowfall frequency and snowfall fraction. It is also apparent for heavy snowfall events. In contrast, high elevated regions could experience no change or even a slight snowfall increase in mid-winter for both emission scenarios despite the general decrease of the snowfall fraction. This increase in mean and heavy snowfall can be explained by higher winter precipitation and by the fact that, with rising temperatures, snowfall occurs more often at temperature conditions favoring higher snowfall intensities.