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Possible effects of ongoing and predicted climate change on snow avalanche activity in western Norway

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As snow avalanche formation is mainly governed by meteorological conditions as, e.g., air temperature fluctuations, heavy precipitation and wind conditions, it is likely that the frequency and magnitude of both ordinary and extreme snow avalanche events is modified through the documented effects of current and future climate change. In the Northern Hemisphere, 1983-2013 was likely the warmest 30-year period of the last 1400 years (IPCC, 2013). Meteorological records of western Norway show the general trend that the last 100 years, especially the last three decades, have been warmer and wetter than the time periods before. However, it is not evident that snow avalanche activity will increase in the near future. Today, the number of studies assessing the impact of climate change on the occurrence and magnitude of snow avalanches is limited.

This work focuses on recent and possible future effects of climate change on snow avalanche activity along the western side of the Jostedalsbreen ice cap representing one of the areas with the highest snow avalanche activity in entire Norway. We have analyzed long-term homogenized meteorological data from five meteorological stations in different elevations above sea level, three of them with a long-term record of 120 years (1895-2015). In addition to the statistical analyses of long-term datasets, gained results and insights from a four-year (2009-2012) high-resolution snow avalanche monitoring study conducted in the same study area are incorporated. The statistical analyses of mean monthly air temperature, monthly precipitation sums and mean monthly snow depths showed that there is a trend of increasing air temperatures and precipitation sums whereas no clear trend was found for mean snow depths. Magnitude-frequency analyses conducted for three defined time intervals (120, 90, 60 years) of monthly precipitation sums exhibit an increase of precipitation especially during the last 30 years with the tendency that more precipitation is occurring in February and March. Results from the four-year monitoring study detected that the main snow avalanche peak season occurs between March and April. In addition a high statistical correlation ($R2 = 0.8$) between the total amount of snow accumulated over the winter months and the total number of snow avalanches occurring in spring was found.

As heavy snow fall is identified as the main triggering mechanism along the SW coast of Norway an increase in the number of days with high amounts of precipitation may lead to a generally higher snow avalanche frequency. There might be more precipitation measured as rain fall at the meteorological stations (generally located in low elevations above sea level) during the future winter periods. However, this will not necessarily reduce the current and near future snow avalanche activity as snow avalanches are triggered in higher elevations above sea level where precipitation will still occur as snow fall.