

Trends in hydrometeorological avalanche indicators in Norway and Svalbard in 1957-2023

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ABSTRACT

In Norway, avalanches are common in the mountainous areas during the winter and spring seasons, obstructing roads and railway lines, and sometimes causing fatalities when a house, vehicle or a skier is hit and possibly buried by an avalanche. Moreover, north of Norway, on the Arctic islands of Svalbard, the settlements have in recent years had to increasingly cope with avalanches and the danger they pose to the local society and tourists. Most of the fatal avalanche accidents in Norway happen in connection with winter-sport activities (skiing, snowboarding, winter-climbing, snow-mobiling etc.) where the persons themselves trigger the avalanche. However, a vast majority of the total number of avalanches are triggered by natural causes without any direct human interaction, i.e. due to hydrometeorological, snow- and weather-related factors. It is these naturally triggered avalanches that cause damage to infrastructure (roads, railways, houses, powerlines).

It is obvious that hydrometeorological factors, such as snow depth, length of the snow season, wind speed and direction, air temperature, as well as rain and snow precipitation are closely connected to avalanche activity. Moreover, the ongoing climate change may have affected these factors in several ways. For example, the air temperature and precipitation have been generally increasing in Norway during the last decades. Also, the snow conditions in Norway have been changing and show a general reduction in the maximum yearly snow depth and a shortening of the snow season (i.e. starting later and ending earlier). On Svalbard, the climate has been changing even more rapidly during the recent decades. Consequently, a natural question to ask is: “How has avalanche activity in Norway and Svalbard changed during the last 50-100 years along with a changing climate?” While there are many long time series of air temperature, precipitation, snow depth, etc. observations in Norway, there are very few, if any, similarly long time series of observed avalanche activity. Therefore, it remains still uncertain how avalanche activity may have changed during the last 50-100 years.

In order to provide answers to our research question on changes in historical avalanche activity, we derive four different avalanche activity “proxy” indicators, calculated on the basis of different hydrometeorological variables, such as air temperature, liquid and solid precipitation, wind speed, snow depth, snow melt, and runoff from snowpack (daily values at 1×1 km resolution). We analyse and present changes and historical trends in our avalanche indicators over the 65-year period from 1957 to 2023 for mainland Norway. Moreover, we evaluate the performance of our indicators against time series of daily avalanche problems and danger levels issued by the Norwegian avalanche warning service (NAWS) since 2013, as well as against satellite-based detection of avalanche activity. For avalanche indicator analysis on Svalbard (the Nordenskiöld Land region), we use hydrometeorological data from the “C3S Arctic Regional Reanalysis” (CARRA) data set available since 1991 at daily 2.5×2.5 km resolution.

Keywords: avalanches; climate change