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Climatological study of natural avalanche activity of the past 50 years in the French Alps

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Snow avalanches are mainly ruled by temperature fluctuations, heavy precipitations and wind regimes, so that climate change is likely to modify the frequency and magnitude of both ordinary and high-magnitude events. However, risk is always managed under the assumption of a stationary process for avalanche frequency, magnitude, spatial distribution or type of preferred releases. On a more phenomenological point of view, contrary to other phenomena such as tropical storms, snow avalanches are very rarely used as proxy indicators that point out signals of climate change. This all comes from the fact that the response of snow avalanche activity to climate fluctuations remains poorly documented. One of the reasons is that long and reliable avalanches series are seldom. Another reason is that extracting a climate signal in a series of data avalanche is a complex statistical problem.

Following previous work focusing on the direct extraction of trends in avalanche and winter climate data, we employ in this study a "time implicit" method to model avalanche activity from the most representative snow and weather time dependant parameters. The aim of the work is to quantify the evolution of avalanche counts per winter in the French Alps during the last decades, and its links with climate. It is based on modelled snow and weather data (Météo-France) for different elevation and exposition, avalanche activity data (Enquête Permanente sur les Avalanches, Cemagref) and instability indexes used operationally for avalanche forecasting (MEPRA, Météo-France).

Standardized avalanche counts and instability indexes present similar fluctuations at the scale of the entire French Alps over the 1958-2008 study period. A stepwise procedure is used to obtain regression models that represent them well in terms of trends and high/low peaks, showing their climatic relevance. The regression model, seen as a time series, shows a predominant pattern that has already been observed for climate parameters and avalanche runout elevations: an inflection at the end of the 80's. Furthermore, the regression model allows quantifying the respective weight of the different covariates for the trend and for exceptional winters, e. g. temperature anomalies and south-facing snow depths to explain the fluctuations of standardized avalanche counts, and fresh snow depth anomalies for most of the exceptional winters. Regional differences between Northern and Southern Alps are discussed.