EGU2020-17597
https://doi.org/10.5194/egusphere-egu2020-17597
EGU General Assembly 2020

Impacts of land-cover changes on dendrogeomorphic reconstructions of snow avalanches: Insights from the Queyras massif (French Alps)

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In the course of the 20th century, high-mountain regions, such as the Alps, have experienced a significant warming with temperature increase twice as much as the global average. Such warming strongly alters the cryosphere components. It induces, for example, a shift from solid to liquid precipitation, more frequent and more intense snowmelt phases or a strong decrease in the amount and duration of snow cover, especially at the location of the snow-rain transition. Such changes in snow cover characteristics are expected to induce changes in spontaneous avalanche activity.

On forested stands, dendrogeomorphic analyses provide long and continuous chronologies of snow avalanche events and can thus contribute to the detection of trends potentially related to climate change. However, the non-stationarities found in tree-ring based chronologies of snow avalanches may also be related to socio-environmental changes. In this context, based on the latest the latest developments in dendrogeomorphology, we reconstructed the snow avalanche activity for 6 contiguous paths located in the Grand Bois de Souliers slope (Queyras massif, French Alps) with the aim to :

- Detect and illustrate such confounding effects;
- Disentangle the trends inherent to tree-ring approaches from real fluctuations in avalanche activity.

The resulting reconstruction covers the period 1750-2016 and evidences two clearly different

trends: on the three southern avalanche paths, a sharp increase in the frequency of reconstructed events is observed since the 1970s. The distribution of tree ages, in combination with old topographic maps, allows an attribution of this non-stationarity to the destruction of a large part of the forest stand in the 1910-20s, presumably related to a devastating avalanche event. This extreme event induced a sudden change in the capability of newly colonizing trees to yield dendrogeomorphic records as information on previous or subsequent events has been removed. By contrast, on the three northern paths, snow avalanche activity is truly characterized by a strong reduction since the 1930s related to the progressive afforestation of the paths since the mid-18th century and to the colonization of the release areas since World War 2. Even if we cannot rule out the possibility that global warming may have played a certain, yet likely minor, role in the evolution of these avalanche-forest ecosystem, we conclude that the contrasted evolutions observed between the avalanche paths can, above all, be explained by socio-environmental factors (e.g., forest and grazing management) during the 18th century that have gained in importance by the rural exodus and the abatement of pastoral practices during the 20th century. In that sense, our results evidence quite clearly the crucial need for future studies aimed at detecting changes in mass-movement activity from tree-ring analyses to systematically interpret trends in activity considering interrelations between forest evolution, global warming, social practices and process activity itself.