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The current evolution of complex high mountain debris-covered glacier systems and its relation with ground ice nature and distribution: the case of Rognes and Pierre Ronde area (Mont-Blanc range, France).

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The current climate forcing, through negative glacier mass balance and rockfall intensification, is leading to the rapid burring of many small glacier systems. When the debris mantle exceeds some centimeters of thickness, the climate control on ice melt is mitigated and delayed. As well, debris-covered glaciers respond to climate forcing in a complex way. This situation is emphasised in high mountain environments, where topo-climatic conditions, such as cold temperatures, amount of solid precipitation, duration of snow cover, nebulosity or shadow effect of rockwalls, limit the influence of rising air temperatures in the ground. Beside, due to Holocene climate history, glacier-permafrost interactions are not rare within the periglacial belt. Glacier recurrence may have removed and assimilated former ice-cemented sediments, the negative mass balance may have led to the formation of ice-cored rock glaciers and neopermafrost may have formed recently under cold climate conditions. Hence, in addition to sedimentary ice, high mountain debris–covered glacier systems can contain interstitial magmatic ice.

Especially because of their position at the top of alpine cascade systems and of the amount of water and (unconsolidated) sediment involved, it is important to understand and anticipate the evolution of these complex landforms. Due to the continuous and thick debris mantle and to the common existence of dead ice in deglaciated areas, the current extent of debris-covered glacier can be difficult to point out. Thus, the whole system, according to Little Ice Age (LIA) extent, has sometimes to be investigated to understand the current response of glacier systems to the climate warming.

In this context, two neighbouring sites, Rognes and Pierre Ronde systems (45°51’38”N, 6°48’40”E; 2600-3100m a.s.l), have been studied since 2011. These sites are almost completely debris-covered and only few ice outcrops in the upper slopes still witness the existence of former glaciers. Electrical resistivity tomographies, kinematic data and ground surface temperature show that heterogeneous responses to climate forcing are occurring despites their small areas (> 0.3 km2). This complex situation is related to Holocene climate history and especially to glacier systems evolution since LIA. The current dynamics depend of ground ice nature and distribution. Five main behaviours can be highlighted:
- Debris covered glacier areas are the most active. Their responses to climate forcing are relatively fast, especially through massive ice melt-out each summer.
- Ice-cored rock glacier areas are quite active. The existence of massive glacier ice under few meters of debris explain the important surface lowering during the snow free period .
- Ice-cemented rock glacier areas are characterised by winter and summer subhorizontal downslope creeping.
- Moraine areas containing dead ice have heterogeneous activities (directions and values of detected movements) related to the ice vanishing.
- Deglaciated moraine areas are almost inactive, except modest superficial paraglacial rebalancing.