Molards, a "new" landform to track permafrost degradation around the globe

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Abstract

Few landforms exist that can be directly related to permafrost degradation, particularly in areas of discontinuous permafrost. Landform indicators of permafrost degradation such as retrogressive-thaw slumps, thermokarst lakes, and baydjarakhs are scarce, and generally occur only in zones of continuous permafrost (e.g., Ashastina et al., 2017; Séjourné et al., 2015). Other periglacial landforms such as active rock glaciers, ice-cored moraines, or palsas need long-term monitoring of air/ground temperature or repeat geophysical surveys to detect the state of permafrost (e.g., Hilbich et al., 2009; Sæmundsson et al., 2012). This study explores the possibility to use the landform dubbed "molards" as a marker of permafrost degradation around the globe. Molards in permafrost terrains are cones of loose debris that result from thawing of blocks of ice-rich sediments mobilised by a landslide. Molards cannot form without ground ice, which cements the source material, allowing it to behave like solid during transport. Once the ground ice has thawed, its cementing action is lost, inducing collapse of the material into molards (Morino et al., 2019). In this study, we show that molards can be the only landform directly revealing permafrost degradation under different permafrost conditions, from continuous to discontinuous. We report on molards in landslides that we have identified and analysed from remote sensing around the globe, including Kamchatka, Iceland, Canada, Pakistan, and Greenland. We illustrate the different topographic and geomorphological settings where these molards are located, and we detail their morphometric and distribution characteristics, which give important insights into the permafrost conditions and landslide dynamics that brought to their emplacement. This study highlights the need for a better understanding of molard formation, evolution, morphology, longevity, and their environmental settings, and we emphasise that they can be used as a geomorphological tool to understand climate change and natural hazard.

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