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Recent environmental dynamics associated with global climatic warming: debris flow occurrence in close proximity of glaciers

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In recent years, areas in proximity to the snout of Italian glaciers have been the starting zones for debris flows on occasion of heavy rainfalls or sudden emptying of englacial or proglacial lakes. In similar cases, the well-known mobility of debris flows has been emphasised by the high energy of the mountain, the large amount of water and of readily available material, continuously increasing as glacial retreat proceeds. Inhabited areas, even very far from the start zone, have been reached by debris flows, sometimes with severe damages. For instance, in the north-western Alps, during a rainstorm in September 1993, a violent debris flow, resulting from strong downcutting of a small stream on the face of the LIA moraine of Mulinet Glacier, mobilized about 800.000 m^3, travelled as far as 4.5 km and hit the village of Forno Alpi Graie. More recently, in July 2003, during a dry period, debris flows deeply incised the large polygenic fan at the foot of the Glacier de Frébouge (Mont Blanc Massif) and deposited about 30.000 m^3 of coarse material in the distal part of the fan. In this case, debris flows were probably triggered both by a glacial water pocket outburst flood and by proglacial torrent damming due to ice falls from the glacier front. So, these phenomena are a potential glacier-related hazard worthy of consideration, especially in areas of alpine valley development or recreational use (i.e. the southern side of Mount Blanc, Aosta Valley, overlooked by several hanging glaciers), and in the context of recent environmental changes associated with modifications in the global climatic system. Propositions and guidance for evaluation of debris flow hazard are based on case studies, referring to: involved debris volumes, run out distances, kinematics features, geomorphic effects and damage produced.