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A new approach to evaluating landslide hazard in the mountain glacial environment – mass and hypsometry

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The magnitude and frequency of glacial hazards is central to the discussion of the effect of climate change in the mountain glacial environment and has persisted as a research question since the 1990s. We propose a new approach to evaluating mass flow (including landslides) hazard in the glacier environment conditioned by temporal and elevation changes in glacier-ice loss. Using digital topographic data sets and InSAR techniques we investigate the hypsometry of ice loss in a well-defined glacial environment in the southwest Coast Mountains of SW British Columbia (the Mount Meager Volcanic Complex - MMVC). The volume and elevation of major mass movements that have taken place in the MMVC since the 1930s is established and compared to the volume and hypsometry of glacial ice loss in the same time period. In the analysis, the volumes of ice loss and landslides are converted to units of mass. The elevation of a sequence of large-scale mass movements do not suggest a close correlation with the elevation or temporal sequence of greatest ice loss. Instead, the temporal relationship between the mass of ice loss and mass lost from slopes in landslides (including ice, rock, and debris) is suggestive of a steady state. The same approach is then applied to the Cordillera Blanca (Peruvian Andes) where we show that the greatest mass moved from the glacier system by glacier-related mass flows since the 1930s, corresponded generally to the period of greatest ice loss suggesting a decay-based response to recent glacier ice loss. As in the MMVC, the elevation of mass flow events is not correlated with the estimated hypsometry of glacial ice loss; in both regions the largest landslide in the period investigated occurred from a high mountain peak defining a topographic divide and where ice loss was minimal. It thus appears that mountain glacial environments exhibit different landslide responses to glacier ice loss that may be conditioned by the rate of ice loss and strongly influenced by seismic events. The role of thermal, geomorphic and geotechnical factors in this complex response requires further investigation. Finally, we discuss the implications of these results for the response of glacial environments to climate-change-driven ice loss particularly with respect to the spatial and temporal occurrence of glacier-related mass flows.