Submitted Abstract

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Abstract

Thawing mountain permafrost is expected to introduce changes in land surface cover, flow regimes, and ecosystem structure in high mountain regions. Existing infrastructure and communities near steep mountain slopes are living under the direct threat of slope failures. Permafrost degradation increases sediment loading, therefore, it is also anticipated to contribute to the frequency and distribution of compound and cascading hazards, which can cause devastation far downstream. To understand the implications of thawing permafrost under a warming climate in the Himalaya, more comprehensive knowledge of permafrost distribution and dynamics in the region is necessary.

Existing information about permafrost occurrence and distribution in the Himalaya is essentially limited to permafrost zonation index maps and global estimates of permafrost area. A few field-based studies have focused on the estimation of the lower limit of mountain permafrost using geophysical techniques. Some remote sensing based studies have combined meteorological records, global climate projections and computational modeling to understand the spatial extent and distribution of permafrost for specific areas. Permafrost monitoring using long term ground temperature measurements in this region is almost non-existent. While satellite temperature products, such as Moderate Resolution Imaging Spectroradiometer (MODIS) land surface temperature (LST) data, have been applied to investigate permafrost distribution in some parts of the Himalaya, these products are not validated against ground temperature measurements.

We develop permafrost probability distribution maps for the Langtang Valley, in the Central Himalaya using downscaled reanalysis based climate data, global climate projections, MODIS LST products and neural networks. Climate data from different sources are downscaled to 30 m grid size to produce probability distribution maps with same spatial resolution. These maps are compared to define the past and present extent of permafrost and understand the changes in permafrost distribution in recent decades. Additionally, these maps are cross-validated using recent ground-based temperature data, available between 2014 and 2021 from an elevation range of 4520 to 5542 m a.s.l. MODIS LST products are compared with ground temperature measurements to evaluate the use of satellite temperature records in future monitoring of permafrost in the region. Changes in permafrost extent are correlated with the spatial distribution of slope-failures, debris flows and other documented hazards in the valley to understand the potential influence of permafrost change on the occurrence of these hazards.