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Hillslope spatial variability in sub-surface characteristics on the southern edge of patchy permafrost over Tibetan Plateau by using ground-penetrating radar

Yingzhao Ma (1,2) and Sebastian Zubrzycki (3)

(1) Key Laboratory of Tibetan Plateau Environment Changes and Land Surface Processes, Institute of TibetanPlateau Research, Chinese Academy of Sciences. Beijing, 100101, China, (2) University of Chinese Academy of Sciences. Beijing, 100049, China, (3) University of Hamburg, Institute of Soil Science, Hamburg, Germany (sebastian.zubrzycki@uni-hamburg.de)

High-frequency ground-penetrating radar (GPR) is employed along the southern margin of sporadic permafrost regions over Tibetan Plateau in order to evaluate the spatial variability of sub-surface characteristics (i.e. maximum freeze depth and soil moisture) at hill-slope scales. The field observation site comprise on diverse topography (e.g. slope, aspect and elevation), and surface environment (e.g. vegetation and stream). To account all of these factors, we describe the soil moisture (SM) and maximum freeze depth (MFD) patterns in various conditions. The results depict that (i) MFD is much higher along the shaded slopes as compared to sunny side, and its thickness varies considerably within the elevations on each slope. (ii) MFD is much thinner where the plentiful canopy exists. (iii) Shallow SM was more variable as compared to other depths at each GPR site, which responded to the climate more sensitively. (iv) SM along the southern slope is higher than the other side during the early thawing period. However, on both slopes, the SM profile keeps similar within the variable depths, which decreases with depths but with different amplitudes. This study also demonstrates the complicated interactions between surface and subsurface soil processes in this environment, whereas GPR seems an optimal choice for improving sub-surface quantification in the plateau region. Our overall results conclude that the continuous permafrost in this region is currently disappearing, which is a typical example of permafrost degradation due to climate warming over the Plateau.

Keywords: Hillslope spatial variation; GPR; Soil moisture; Maximum freeze depth; Tibetan Plateau