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On detection of mountain permafrost boundary using ground-temperature lapse rate

Tetsuo Sueyoshi[1*], Atsushi Ikeda[2], Go Iwahana[3]

[1]JAMSTEC, [2]University of Tsukuba, [3]Grad. School of Env. Sci. Hokkaido Univ.

Ground-temperature lapse rates at 50cm depth in late summer had been used for detecting the lower boundary of permafrost distribution in a mountainous terrain (Fukui et al., 2006; Fujii and Higuchi, 1972). The aim of this study is to generalize this method to use ground temperature of certain depth, to validate and to check its limit.

The basic ideas behind this method are that (1) the shallow depth ground temperature is generally controlled by the balance of mean daily air temperature and ground heat flux, and that (2) this balance is then also affected by latent heat from permafrost within permafrost zone. This effect from permafrost is considered to cause a ”bend” in lapse-rate plot along the slope, which has been interpreted as the lower boundary of permafrost zone. The method is suitable for the field work in the areas with difficulties in logistics, especially for steep mountains or remote regions.

Although the method was used in some cases for its usefulness, it had not been theoretically validated. The method should have certain limits of application, because 50-cm ground temperature depends on the variation of ground heat flux, the amount of latent heat, etc. In this study, we verify this method quantitatively, as general ”ground-temperature lapse rate method”. The distributed 1-D ground temperature calculation was made in a idealized semi-infinite slope, assuming uniform atmosphere-land energy exchange. To evaluate the effectiveness of the method, temperature profile of equilibrium state for the ideal slope was calculated. As in the previous studies, ground temperature was plotted against the altitude for different time slice (i.e. corresponds to seasonality).

From the result, the correlation between the altitude of boundary and the altitude of ”bend” was partly confirmed, while it was suggested that some offset in the diagram should be considered for its altitude. Effect of variation in soil water content and soil thermal properties are examined to investigate its sensitivity. Further parameter studies are necessary toward the realistic application for specific site.

Keywords: permafrost, ground temperature, observational method, numerical experiment, mountain area