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学　位　論　文　題　名

Study on the ground thermal regimes under a forest-steppe mosaic in the area of discontinuous permafrost, Mongolia

（モンゴル不連続永久凍土帯の草原森林混在域における地温動態に関する研究）

In continental scales, the areas with the active-layer underlined by permafrost are mostly overlapped with the biomes of tundra and boreal forest, while seasonally frozen ground is distributed in steppe biome. In the northeastern Eurasia, natural transitional shift from the Siberian boreal forest to the steppe is clearly seen in central and northern Mongolia, where the landscapes are generally characterized by a mosaic-like distribution of forest and steppe, and such mosaic region roughly lies on the southern edge of the Siberian discontinuous permafrost zone. These situations would reflect complicated distribution of permafrost and seasonally frozen ground, and their symbiotic features with local geographic settings such as topographic relief, vegetation cover and micro-climate. In a warming climate, such mosaic regions are likely sensitive and susceptible to environmental and climate changes. It is therefore important to understand the factors determining the occurrence or absent of current permafrost in this region. To better understand this, it is necessary to describe the physical interaction between the ground thermal regime, vegetation cover, and local climate parameters using the intensive field observations in various locations. Since the aim of this study is to examine physically the interactive manners between the ground temperatures and site-specific factors, using five-year records of comparable hydro-meteorological parameters obtained from permafrost underlying forested slopes and its adjacent permafrost-free ground underlying steppe slopes.

The local topography together with the forest cover was found to be the most important factors that control the different amount of solar radiation on the ground surface at each site. During the winter, the topographic effect on the solar radiation seems to be very important for the forested north-facing slopes, as it strongly reduces potential solar radiation (PSR) compared with adjacent south-facing slopes. Inversely, the topography effect on solar radiation at each slope is less, and the differences in PSRs among the sites are identical during the summer. However, large differences in solar radiation at the ground surface between the sites were observed. This indicates that the considerable differences in observed solar radiation at the ground surface between the sites were caused mostly by forest cover, rather than the topography effect during the summer. Significant reduction in the amount of solar radiation on the forest floor probably caused lower ground surface temperature than air temperature. In contrast, the mountain steppe on a dry south-facing slope receives a large amount of solar radiation, and therefore the ground surface temperature exceeds air temperature during the summer, leading to a warm soil profile.

During the summer, solar radiation is the dominant factor to control the magnitude of the energy budget. The magnitudes of net radiation below the forest on north-facing slope was considerably smaller than that on the south-facing slope. This difference in net radiation primarily contributes to differences in heat fluxes at each site, and the ground heat, sensible and latent heat fluxes. It was found that these heat flux components on the north-facing slope were 5.0, 3.6 and 2.3 times lower than those on the south-facing slope. These results indicate that the small amount of solar radiation reduced by forest cover and slope on the north-facing slopes has also potential to reduce heat exchanges between atmosphere and permafrost.

The thick organic layer within the forested slope impedes the effects of air temperature to the deep ground during summer, and this is confirmed by the lower thawing ratios computed within active-layer at the forested north-facing slope. Consequently, the active-layer thaws slowly, although the active-layer thickness (ALT) was determined during the summer warmth. In winter, the surface temperature is warmer on the forested slopes than on the steppe slopes, owing to the greater amount of accumulated snow cover and its low heat conductivity. However, the thick organic layer beneath the snow cover and the ice-rich substrate at the forested slopes greatly enhance the freezing rate, which leads to rapid refreezing of the active layer. The duration and thickness of snow cover at the mountain steppe have a considerable influence on the seasonal development of seasonally frozen ground, and is inversely related to seasonally frozen ground thickness (SFGT). Furthermore, despite of similar geographical conditions and soil textures at the sites, there was a later onset of soil thawing in the forested area than in the adjacent mountain steppe, even though soil freezing began simultaneously in both areas.

These results exhibit that forested slope and the underlying thick organic layer at the edge of the Siberian forest are important factors contributing to the ground cool and the existence of permafrost only beneath the forested north-facing slopes in this region. Under the abovementioned circumstance, permafrost degradation would be resulted from not only climate warming but also disturbances of vegetation cover. Especially the later could have considerable impact on the current permafrost occurrence. Therefore, it is important to preserve forest cover and organic layer in order to negate further degradation of ecosystem over permafrost.

All the committee members agreed that this dissertation provides a new data set that is useful for the in interdisciplinary community of permafrost sciences and relevant environmental sciences and that Mr. Dashtseren is honest and enthusiastic as a researcher. In addition to the excellent achievements in the research, his academic improvement throughout the Ph. D course are excellent. Based on these evidences, the committee reached to a conclusion that Avirmed Dashtseren deserves to become a Doctor of Environmental Science.