Geophysical Research Abstracts, Vol. 8, 01631, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01631

Permafrost thermal properties and thaw and its relationship to soil and plant cover characteristics at Lake Hövsgöl, Mongolia

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Northern Mongolia represents the southern-most extension of continuous permafrost and the border of the Siberian taiga forest in Asia. The mountainous watershed valleys of Lake Hövsgöl (51°13’ N; 100°55’ E) are in a forest/steppe transition zone characterized by continuous permafrost in the upper valleys and ridge tops and discontinuous permafrost in lower valley areas. Valley bottoms and south-facing slopes have steppe vegetation dominated by grasses and sedges with increasing amounts of forbs in heavily grazed areas. The north-facing slopes and ridge tops are covered by taiga forest, dominated by the larch (Larix sibirica). The mean annual air temperature in the region is c. -4.5 °C. Total annual precipitation averages about 300 mm with most falling in mid summer. Wintertime precipitation is mostly snow that on south-facing slopes tends to sublimate. Wet and dry years alternate with one heavy rain year followed by 2-3 dry years. The region has been inhabited by nomadic groups for thousands of years but it is unclear what their impacts have been prior to the present. The objectives of the Hövsgöl GEF/World Bank research project include the identification of the spatial distribution and characteristics of permafrost and possible permafrost thaw associated with modifications in the watersheds due to nomadic pastoralism and to climate change. Permafrost thaw has been documented elsewhere along the south-western margin of the Lake (Sharkhuu and Sharkhuu) and there are indications that a severe thaw has occurred in the study area as a result of heavy pastoralism. We are

monitoring changes and experimentally testing factors that maintain low soil temperatures and high soil moisture, both critical for permafrost protection, in six valleys that have similar meteorological conditions but affected by pastoralism ranging from heavy grazing in two northern valleys nearest the Russian border to light or no grazing in two southern valleys farther from the border, and moderate grazing in the middle two valleys. Soil temperature (oC) and soil moisture are measured in plots in each valley, composing a range of soil bulk densities and texture, plant cover, plant taxa, green plant biomass, and dead plant biomass (necromass) estimates, largely dependent upon livestock grazing levels. Our experiments are measuring decomposition rates for different plant taxa, and effect of different amounts of necromass cover on soil temperature and soil moisture. In this paper we contrast conditions in the six valleys for south-facing non-permafrost steppe with north-facing lower steppe areas with permafrost. The area has warmed by c. 1.6o $^{\circ}$C between 1963 and 2004 ($P < 0.0001$) but there has been no corresponding significant change in annual precipitation. There also has been a shift towards a longer growing season as a result of the warming trend. The objective of this presentation is to assess the highly complex relationships between climate warming, grazing, vegetation cover and the thermal state of permafrost. Permafrost and the active layer thickness is a governing factor for available soil moisture for plant growth, and thus affects the soil water balance. The increase of the active layer thickness rapidly leads to drying out the soils resulting in a change of soil thermal regime and vegetation composition. First model estimations show an increased evapotranspiration in the last 10 years. Ground temperatures are monitored in 16 boreholes in the region since 2002, and during this period some differences in the abovementioned factors are evident, e.g., active layer thicknesses in morphometrically similar topographic positions are higher in grassed than in un-grassed settings. Comparable results of vegetation-permafrost interactions are revealed by an intensive measurement campaign of DC resistivity tomography. Altogether 22, 200 m and longer profiles indicate significant differences in subsurface properties, permafrost thicknesses and ice content in relation to vegetation cover and topographic setting. The combination of solid property data and thermal data from bore holes makes it now possible to model the response of ground thermal regime on boundary condition changes (surface temperature, vegetation cover) using physical heat conduction modeling. This work is in progress.