Hydrology and Earth System Sciences
An Interactive Open Access Journal of the European Geosciences Union

Hydrol. Earth Syst. Sci., 13, 327-341, 2009
www.hydrol-earth-syst-sci.net/13/327/2009/

Impacts of changes in vegetation cover on soil water heat coupling in an alpine meadow of the Qinghai-Tibet Plateau, China

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Abstract. Alpine meadow is one of the most widespread grassland types in the permafrost regions of the Qinghai-Tibet Plateau, and the transmission of coupled soil water heat is one of the most crucial processes influencing cyclic variations in the hydrology of frozen soil regions, especially under different vegetation covers. The present study assesses the impact of changes in vegetation cover on the coupling of soil water and heat in a permafrost region. Soil moisture (θ_v), soil temperature (T_s), soil heat content, and differences in θ_v–T_s coupling were monitored on a seasonal and daily basis under three different vegetation covers (30, 65, and 93%) on both thawed and frozen soils. Regression analysis of θ_v vs. T_s plots under different levels of vegetation cover indicates that soil freeze-thaw processes were significantly affected by the changes in vegetation cover. The decrease in vegetation cover of an alpine meadow reduced the difference between air temperature and ground temperature (ΔT_{a-s}), and it also resulted in a decrease in T_s at which soil froze, and an increase in the temperature at which it thawed. This was reflected in a greater response of soil temperature to changes in air temperature (T_a). For ΔT_{a-s} outside the range of −0.1 to 1.0 °C, root zone soil-water temperatures showed a significant increase with increasing ΔT_{a-s}; however, the magnitude of this relationship was dampened with increasing vegetation cover. At the time of maximum water content in the thawing season, the soil temperature decreased with increasing vegetation. Changes in vegetation cover also led to variations in θ_v–T_s coupling. With the increase in vegetation cover, the surface heat flux decreased. Soil heat storage at 20 cm in depth increased with increasing vegetation cover, and the heat flux that was downwardly transmitted decreased. The soil property varied greatly under different vegetation covers, causing the variation of heat conductivity and water-heat hold capacity in topsoil layer in different vegetation cover. The variation of heat budget and transmitting in soil is the main factor that causes changes in soil thawing and freezing processes, and θ_v–T_s coupling relationship under different vegetation fractions. In addition to providing insulation against soil warming, vegetation in alpine meadows within the permafrost region also would slow down the response of permafrost to climatic warming via the greater water-holding capacity of its root zone. Such vegetation may therefore play an important role in conserving water in alpine meadows and maintaining the stability of engineering works constructed within frozen soil of the Qinghai-Tibet Plateau.

Final Revised Paper (PDF, 1120 KB) Discussion Paper (HESSD)

Citation: Genxu, W., Hongchang, H., Guangsheng, L., and Na, L.: Impacts of changes in vegetation cover on soil water heat coupling in an alpine meadow of the Qinghai-Tibet Plateau, China, Hydrol. Earth Syst. Sci., 13, 327-341, 2009. Bibtex EndNote Reference Manager