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Topographic control of the depth of ground thaw in a peat covered continuous permafrost site in the Canadian arctic tundra

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Recent research has suggested an energy-based framework for delineating runoff contributing areas for permafrost dominated, tundra environments, where end of winter snow cover, and turbulent and radiant fluxes of energy and water are affected by topography, and control both snowmelt and the depth of ground thaw. The resulting spatially variable thaw depth, when combined with spatially variable water supply, spatially variable organic soil thickness, and depth variable hydraulic conductivity in organic soils, has a significant impact on the flow of water from uplands to the stream channel.

In order to consider the effects of a spatially variable depth of thaw on runoff in a tundra basin, the hydrologic model GEOtop was applied to the Siksik Creek drainage basin located approximately 50 km north of Inuvik, NWT, Canada, characterized by a relatively gentle topography, with elevation ranging from 0 and 80 m a.s.l.. The small surface area of the basin (approximately 1 km2) allows the model to be run at a relatively high resolution. GEOtop is a grid based model with a complete surface energy balance scheme that accounts for variations in both the turbulent fluxes of sensible and latent heat, as well as for variations in radiant fluxes. The model also has a complete subsurface heat and water flux scheme that is able to route water and energy both vertically between a large number of soil layers, and horizontally between grids.

Field data for model validation include meteorological data, depth of thaw, and runoff data for a 3 year period between 1992 and 1994, and high resolution DEM and vegetation height data obtained from airborne LiDAR in 2004.

The purpose of this work is studying how topography controls the depth of thaw, and, therefore, the effects of a spatially variable snow cover are intentionally neglected. GEOtop was then run in a simple configuration, assuming an initial condition of uniform frost table at the ground surface at the end of snow melt, with snow being removed at the same time across the entire basin. It is shown that in Siksik drainage basin, topography affects the depth of thaw through its control exerted on subsurface flow, and not on the surface energy balance. In fact, subsurface flow directly affects soil moisture, and, as a consequence, the thermal conductivity of the peat soil, but also affects the depth of soil thaw through advection of energy. It is also shown that the effect is prevalent.

Ongoing research will also consider the effect of a spatially variable end of winter snow cover, and spatially variable snowpack energy balance, on controlling when the snowcover is removed, when soil thaw begins, and hence the depth of