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Snowmelt runoff from northern alpine tundra hillslopes: major processes and methods of simulation

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Abstract. In northern alpine tundra, large slope gradients, late-lying snow drifts and shallow soils overlying impermeable substrates all contribute to large hillslope runoff volumes during the spring freshet. Understanding the processes and pathways of hillslope runoff in this environment is, therefore, critical to understanding the water cycle within northern alpine tundra ecosystems. This study: (a) presents the results of a field study on runoff from a sub-alpine tundra hillslope with a large snow drift during the spring melt period; (b) identifies the major runoff processes that must be represented in simulations of snowmelt runoff from sub-alpine tundra hillslopes; (c) describes how these processes can be represented in a numerical simulation model; and d) compares field measurements with modelled output to validate or refute the conceptual understanding of runoff generation embodied in the process simulations. The study was conducted at Granger Creek catchment, 15 km south of Whitehorse, Yukon Territory, Canada, on a north-facing slope below a late-lying snow drift. For the freshet period, the major processes to be represented in a runoff model include the rate of meltwater release from the late-lying snowdrift, the elevation and thickness of the saturated layer, the magnitude of the soil permeability and its variation with depth. The daily cycle of net all-wave radiation was observed to drive the diurnal pulses of melt water from the drift; this, in turn, was found to control the daily pulses of flow through the hillslope subsurface and in the stream channel. The computed rate of frost table lowering fell within the observed values; however, there was wide variation among the measured frost table depths. Spatial variability in frost table depth would result in spatial variabilities in saturated layer depth and thickness, which would, in turn, produce variations in subsurface flow rates over the slope, including preferential flowpaths.

Keywords: subsurface runoff, alpine tundra, permafrost, organic soils, model simulation

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