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Conceptualizing Peatlands in a Physically-Based Spatially Distributed Hydrologic Model

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In as part of a research effort focused on climate change effects on permafrost near Fairbanks, Alaska, it became apparent that peat soils, overlain by thick sphagnum moss, had a considerable effect on the overall hydrology. Peatlands represent a confounding mixture of vegetation, soils, and water that present challenges for conceptualizing and parametrizing hydrologic models. We employed the Gridded Surface Subsurface Hydrologic Analysis Model (GSSHA) in our analysis of the Caribou Poker Creek Experimental Watershed (CPCRW). GSSHA is a physically-based, spatially distributed, watershed model developed by the U.S. Army to simulate important streamflow-generating processes (Downer and Ogden, 2004). The model enables simulation of surface water and groundwater interactions, as well as soil temperature and frozen ground effects on subsurface water movement. The test site is a 104 km2 basin located in the Yukon-Tanana Uplands of the Northern Plateaus Physiographic Province centered on 65˚10' N latitude and 147˚30' W longitude. The area lies above the Chattanika River floodplain and is characterized by rounded hilltops with gentle slopes and alluvium-floored valleys having minimal relief (Wahrhaftig, 1965) underlain by a mica shist of the Birch Creek formation (Rieger et al., 1972). The region has a cold continental climate characterized by short warm summers and long cold winters. Observed stream flows indicated significant groundwater contribution with sustained base flows even during dry periods. A site visit exposed the presence of surface water flows indicating a mixed basin that would require both surface and subsurface simulation capability to properly capture the response. Soils in the watershed are predominately silt loam underlain by shallow fractured bedrock. Throughout much of the basin, a thick layer of live sphagnum moss and fine peat covers the ground surface. A restrictive layer of permafrost is found on north facing slopes. The combination of thick moss and peat soils presented a conundrum in terms of conceptualizing the hydrology and identifying reasonable parameter ranges for physical properties. Various combinations of overland roughness, surface retention, and subsurface flow were used to represent the peatlands. The process resulted in some interesting results that may shed light on the dominant hydrologic processes associated with peatland, as well as what hydrologic conceptualizations, simulation tools, and approaches are applicable in modeling peatland hydrology.

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