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The influence of groundwater regime by seasonally frozen soils

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Seasonally freezing and thawing processes occur in approximately 50% of the land area in the Northern Hemisphere and play a significant role in some hydrological processes. In the last several decades, there are numerous numerical studies of hydrological processes in seasonally frozen soils, however, numerically modeling of considering water movement in both unsaturated and saturated zones still remains a challenge. Based on this scientific problem, we chose the climate condition in New Brunswick, Canada as a typical seasonally frozen ground and used the SHAW model to simulate the vertical freezing-induced water movement and resulting water table decline during a complete freezing period in different water table depths and soil textures. According to the numerical results, as water table depth increases, the upward flux towards the freezing front and the water table decline both decreases significantly, which are determined by the lower unsaturated hydraulic conductivity and smaller hydraulic gradient. Moreover, compared with coarse-texture soils (i.e. sand and loam), fine-texture soils (i.e. silt and clay) lead to larger freezing-induced upward flow and water table decline because of the soil water characteristics, which are different from Harlan's (1973) theoretical results based on simulation with limited time duration. Therefore, this research enhances understanding on the coupling of atmospheric conditions, soil water and groundwater in seasonally frozen regions.