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Interactions between groundwater and surface water – A numerical modelling study of a boreal forest catchment

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This study focuses on the complexity of surface and groundwater water interactions caused by heterogeneity in a catchment's physical characteristics and freeze-thaw processes. Sub-catchment representatives with distinctive characteristics (including e.g. freeze-thaw processes and soil and vegetation characteristics), were chosen for a nested sub-catchments analysis approach, within a numerical modeling framework. These representative sub-catchments were selected in order to identify which processes are necessary to represent in a model to accurately reproduce interacting surface water and groundwater dynamics within a boreal catchment. The numerical modelling tool Mike-SHE takes into account the major parts of the hydrologic cycle, including precipitation, evaporation, unsaturated and saturated groundwater flow and overland flow. Our simulations reproduce observed stream discharge with an average accumulated error of 1 % and average groundwater level mean error of 0.1 m, in addition to capturing observed seasonal patterns in stream discharge and groundwater levels well. Representations of soil freeze and thaw processes improve groundwater and surface water partitioning during snow melt, while peatland characteristics are important for reproducing observed dampening of rain event signals in stream discharge. The results clearly show the need to represent these processes in numerical models of boreal catchments for accurate representation of surface and subsurface water dynamics at full catchment and sub-catchment scales.