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Mechanisms of soil matrix water replenishment in a sub-arctic till soil based on an isotope tracer experiment

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Due to changes in the snowmelt timing and the potential shift towards less snowfall and more rainfall, infiltration patterns into the soil will increasingly be altered in a warming climate. Mixing and transport processes of water in the unsaturated topsoil layer regulate the subsurface transport and retention of solutes and contaminants, as well as the distribution of plant available water. Recent advances in soil isotope ecohydrology indicate that in some ecosystems, water in macropores largely bypasses soil matrix and rapidly percolates into the groundwater. Here we combine tracer experiments and geophysical surveys to explore soil water mixing in non-stratified till soil in the Pallas catchment located in sub-arctic conditions in Finnish Lapland. A 5x20 m plot at the Kenttärova hilltop was sprinkled with deuterated water (d^2H 88‰) for two days (totally 200 mm at average intensity of 6.7 mm/h), until surface water ponding was observed on substantial share of the plot. Soil moisture dynamic were monitored by a network of soil moisture sensors and manual soil probe measurements. Soil water was sampled hourly with suction cup lysimeters at three (5 cm, 30 cm, 60 cm) depths and pan lysimeter at 35 cm depth in two soil profiles on the irrigation plot. Groundwater was sampled hourly, while xylem samples from spruce and birch trees in the plot were collected on each day of the experiment and on a weekly basis during the following month. Ground penetrating radar (GPR) survey and soil coring with window sampler down to 1 m depth were completed four times over the course of the experiment, and additional set of soil cores were taken two weeks after the experiment to inspect how natural precipitation events have infiltrated into the deuterium enriched zone. We investigate the mechanisms of soil matrix water replenishment by answering the following questions: i) Can all soil matrix water be displaced during high volume events and when does newly introduced soil matrix water become available to the plants?; ii) What is the extent of soil water mixing at different depths?; and iii) What is the effect of increased moisture content and groundwater table rise on soil water mixing? Due to paucity of field data sets and inability of most hydrological models to accurately simulate soil freezing and thawing effects, ecohydrologic partitioning has been barely studied in Northern regions with seasonal snow cover. We present a novel field data set that focuses on soil matrix water replenishment in glaciated till soil at sub-arctic conditions. Results support our understanding of ecohydrological processes in northern environments where hydrological cycle is dominated by intense infiltration events as it occurs during snowmelt.