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

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Introduction

Sub-arctic region climate has warmed at a faster rate than global average over the last few decade. Changes in snow to precipitation ratio and snowmelt and soil freeze/thaw timing can greatly alter infiltration patterns into the soil, which will further affect subsurface solute dynamics and the distribution of plant available water. Additionally, recent studies indicate that there is limited mixing between soil matrix and macropore water, but such research has been less frequent in Northern, seasonally snow covered catchments.

Our objective is to investigate mixing and transport processes in glacial till soil, specifically focusing on mechanisms of soil matrix water replenishment. Research questions are:

- What is the extent of soil water mixing at different depths?
- What is the effect of rising groundwater table on soil water mixing?
- Can all soil matrix water be displaced during high volume infiltration events?
- When does newly introduced soil water become available to the plants?

The research is implemented in a watershed in Finnish Lapland – Pallas, which represents typical sub-arctic landscape and possesses one of the most important infrastructures for soil-vegetation-atmosphere research in Finland.

Figure 1. Catchment location, approximately 170 km north of the Arctic circle

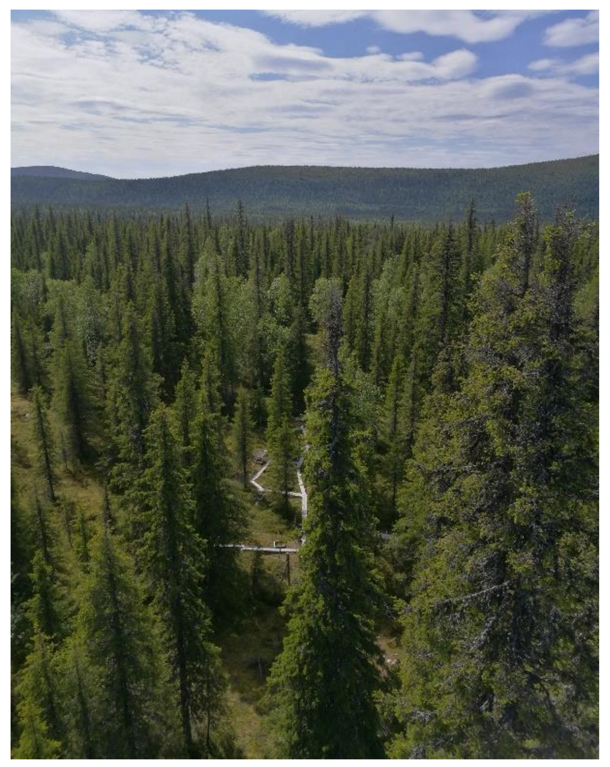

Figure 2. Aerial view of experimental plots. Treeline at Pallas has extended by 55 m in elevation over the last 60 years

Experiment setup (tracer experiment + geophysical survey):

- 5x20m plot was irrigated with deuterated water (170 mm over 29 hours, d^{2}H 80‰) until continuous surface ponding was observed
- Soil moisture was monitored by a network of sensors at three depths (5 cm, 30 cm, 60 cm)
- Soil water was sampled hourly with suction cups in two profiles and at three depths (5 cm, 30 cm, 60 cm) and zero tension lysimeters at 35 cm depth
- Groundwater was sampled each hour
- GPR survey was completed 4 times during the experiment
- Xylem samples and soil cores were taken multiple times before, during and after the experiment

Initial results

- A lot of variation both in depth and between locations
- Although the soil was fully saturated, isotopic composition of soil water was still far from irrigation water
- Prompt response at 60 cm depth indicates possible bypass flow
- Strongest signal was observed in groundwater, but it started converging back towards its previous value immediately after irrigation stopped

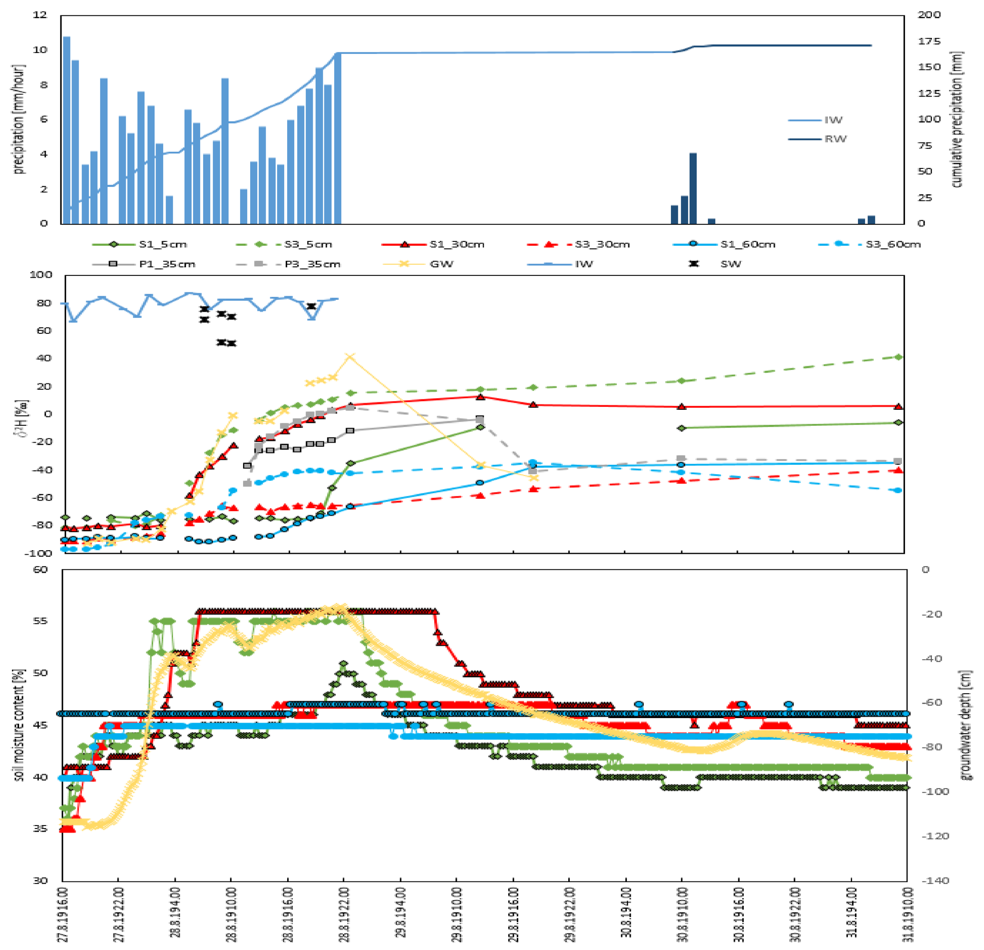

Figure 3. Initial results – hydrometric and isotopic response to heavy irrigation (S=suction cup lysimeter, P=zero tension lysimeter, IW=irrigation water, RW=rain water, GW= ground water, SW=surface water)

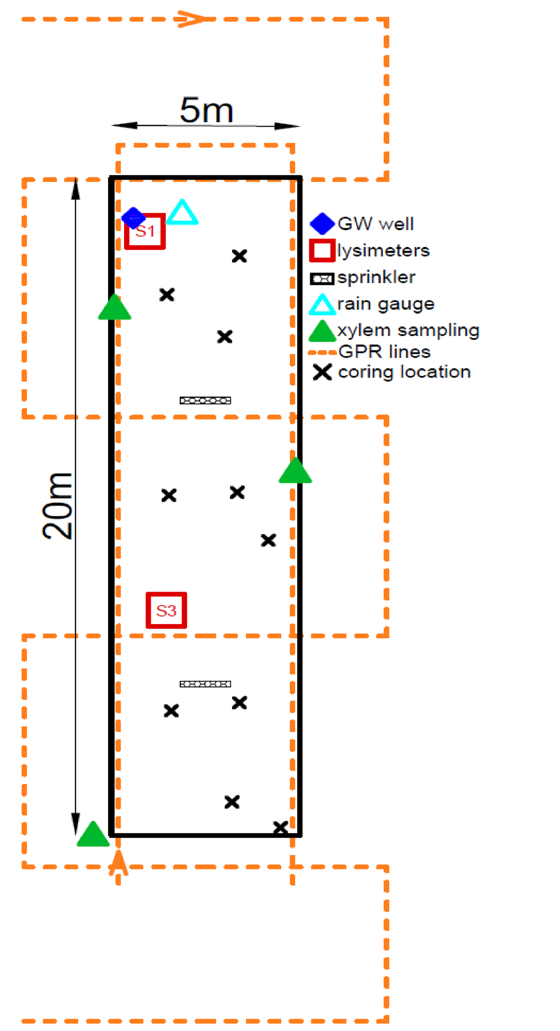

Figure 4. Experimental plot sketch

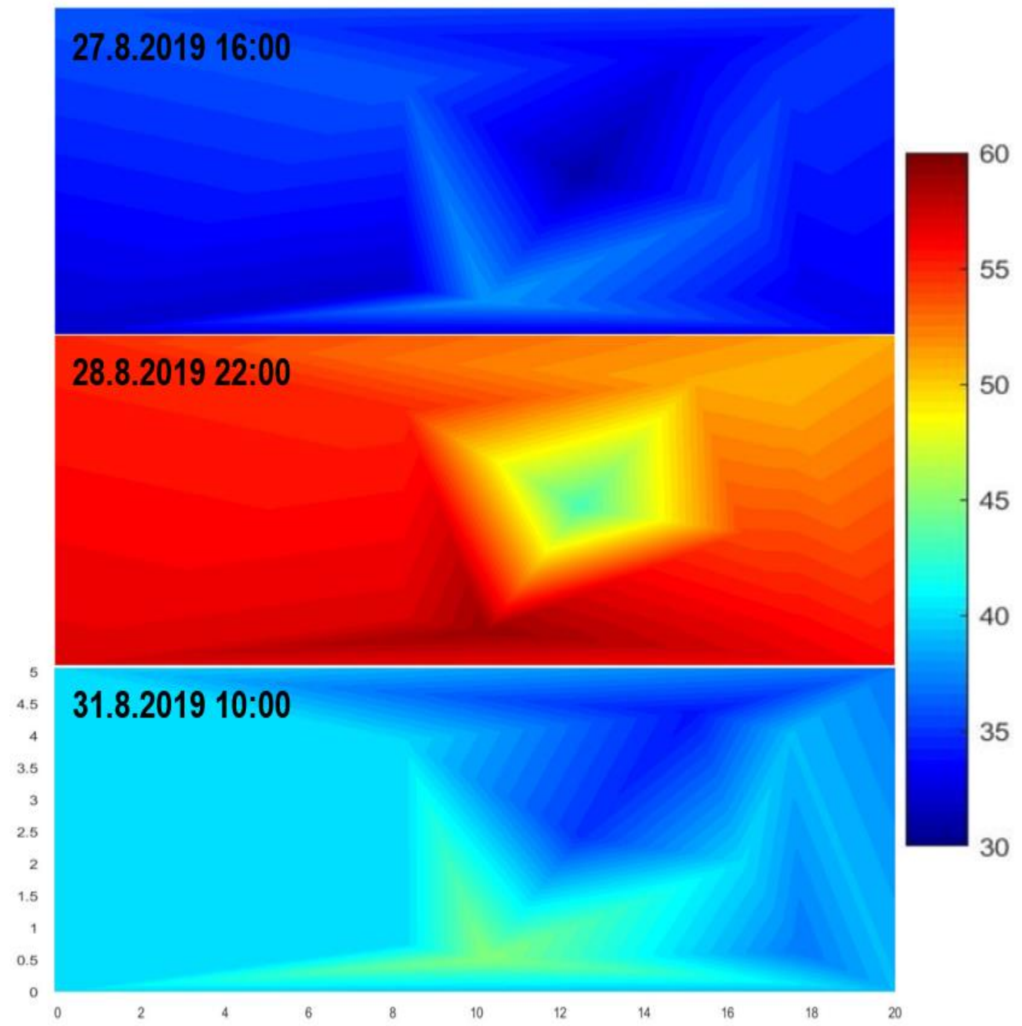

Figure 5. Spatial variability of soil moisture at 5 cm depth at different stages of the experiment

Future plans

What will happen with irrigation water under snowpack and during the snowmelt?

- Regular soil water sampling with suction lysimeters during the snowmelt
- Collecting soil cores under deep snowpack and after the snowmelt
- Xylem sampling throughout summer

Figure 6. Extracting soil core in winter conditions

Figure 7. Window sampler with podsol soil from the experimental plot

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Science with Arctic Attitude

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