Abstract n°1985

Infiltration and potential recharge of esker aquifer in Central Finland - observation and simulation of daily soil moisture and temperature profile

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Introduction

Soil moisture controls water fluxes at the land surface and affects the partitioning of rain and snowmelt water to overland flow, infiltration and potential recharge rates of aquifers. In cold snow dominated regions, as in Finland, understanding the soil moisture and soil temperature dynamics also affects the development of soil frost that controls snowmelt runoff, infiltration and recharge in winter periods (Stadler *et al*. 1997; Sutinen *et al*., 2007; Okkonen and Kløve 2010).

In sustainable groundwater usage, prediction of recharge rates with numerical models are of high importance because it can be used in optimizing groundwater pumping rates of an aquifer. This study was initiated in order to investigate diurnal soil moisture and soil temperature profiles during the period 2011-2016 and the performance of integrated hydrology model, CLM-Parflow (Maxwell et al. 2016), in simulating soil moisture and temperature profiles in esker aquifer in Central Finland (Fig. 1).

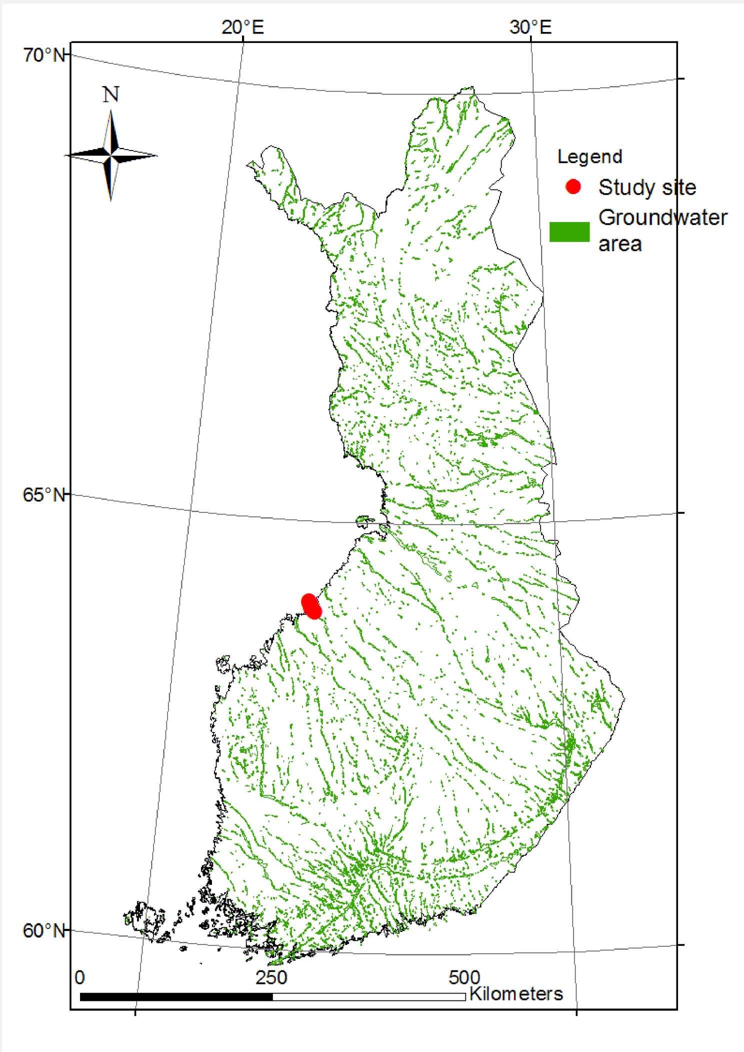

Figure 1. Study site in central Finland

References

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Stadler, D., Flühler, H. & Jansson P-E. 1997. Modelling vertical and lateral water flow in frozen and sloped forest soil plots, Cold Regions Science and Technology 26, 181-194.

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Materials and Methods

During the period 2011-2016, soil water content and soil temperature was measured hourly at depths 5, 10, 20, 30, 50, 80, 110, 140, 170 and 200 cm using time-domain reflectometry (TDR) probes; and temperature using thermocouples. At these depths, soil samples were also collected. Snow depth, air temperature and precipitation were observed at a meteorological station located 5 km from the soil monitoring station. The groundwater depth and temperature was also measure daily from the borehole located 2 meters from the soil monitoring station. Groundwater level was measured using Solints level loggers and air pressure using Solints barologger to compensate the effect of air pressure. The soil water content and temperature were simulated using CLM-Parflow software. The modeling domain (1D) was from the ground surface to the bedrock. The thickness of the modeling domain was 25 meters and the groundwater level was on the average 5 meters below the ground surface. From the soil samples, the grain size distribution curves were made and the hydraulic conductivity values were determined using the empirical methods (Odong 2008). The soil material varies between sand, coarse sand and gravel.

Results and Discussion

The water content varied between 0.05-0.2. At the soil surface, diurnal changes in water content was clearly shown. During winters, water content remains static near the soil surface and decreased at the bottom of the profile (Fig. 2). At the bottom of the profile, the water content increased due to infiltrated water but changes were smooth. The time delay between the maximum water content and tempreratures at the uppest soil layer and the lowest soil layer were on the average 4 days.

The soil surface temperature followed air temperature. At the depths higher than 110 cm, the soil temperature decreased below the 0 °C, indicating the lower frost boundary. At the depth 110 cm, the minimum temperature, -1.2 °C, was observed in January 2016 (Fig. 2).

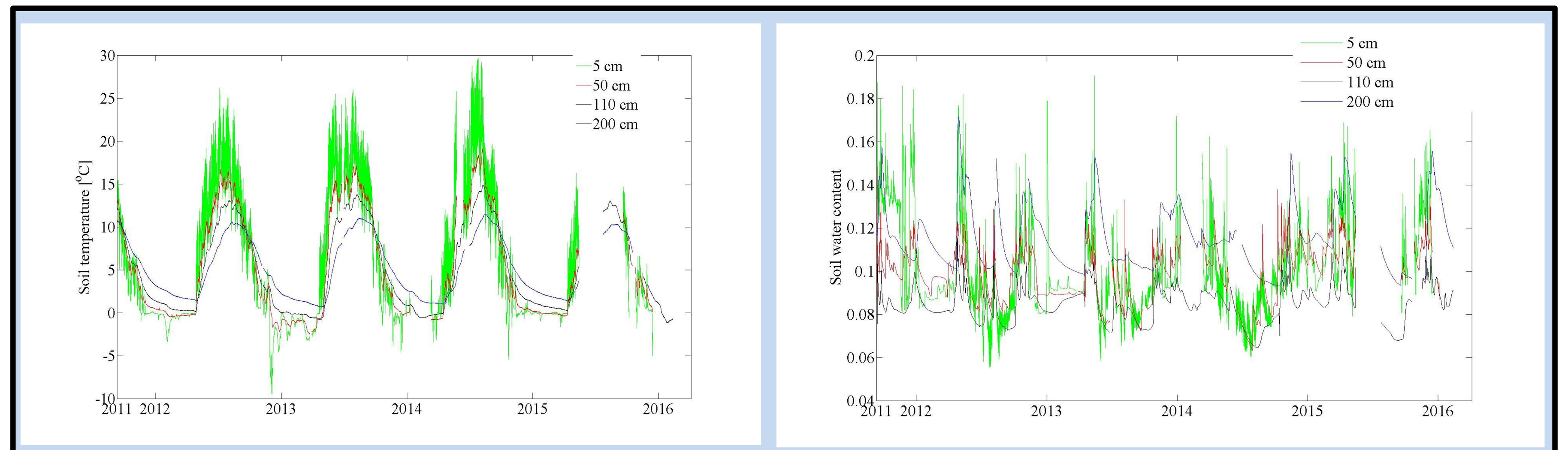

Figure 2. Observed hourly soil temperature and soil water content during the period 2011-2016.

Hourly time step was used in the CLM-Parflow simulations. The 1D model was run during the period 1.8.-18.8.2012 (calibration). The model simulated the level and changes in water content fairly well (Fig. 3) but the recession after infiltration was not obtained. The model was then run and tested during the period 4.10.-31.10.2014. The initial results indicated that the model did not capture the soil freezing, or in other words, temperatures below 0 °C (Fig. 4). This could be due to fact that the model may not be spun-up enough affecting the heat of fusion.

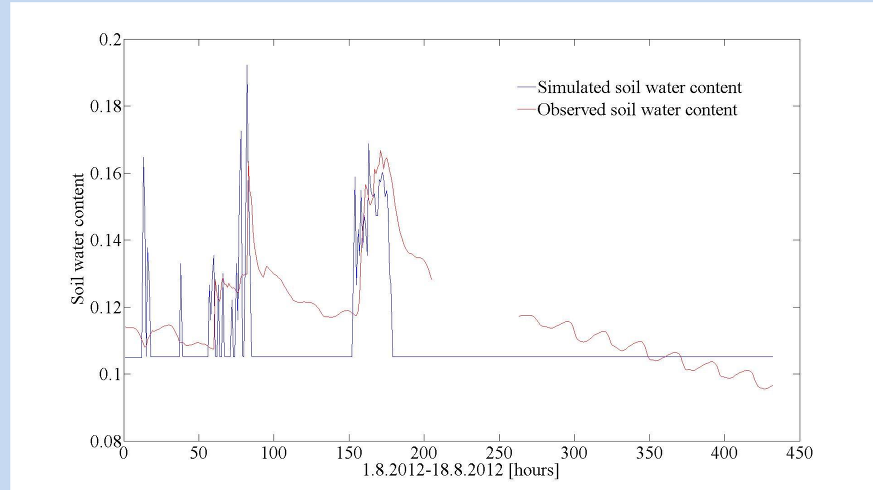

Figure 3. Observed and simulated soil water content (at 10 cm) during the period 1.8.-18.8.2012.

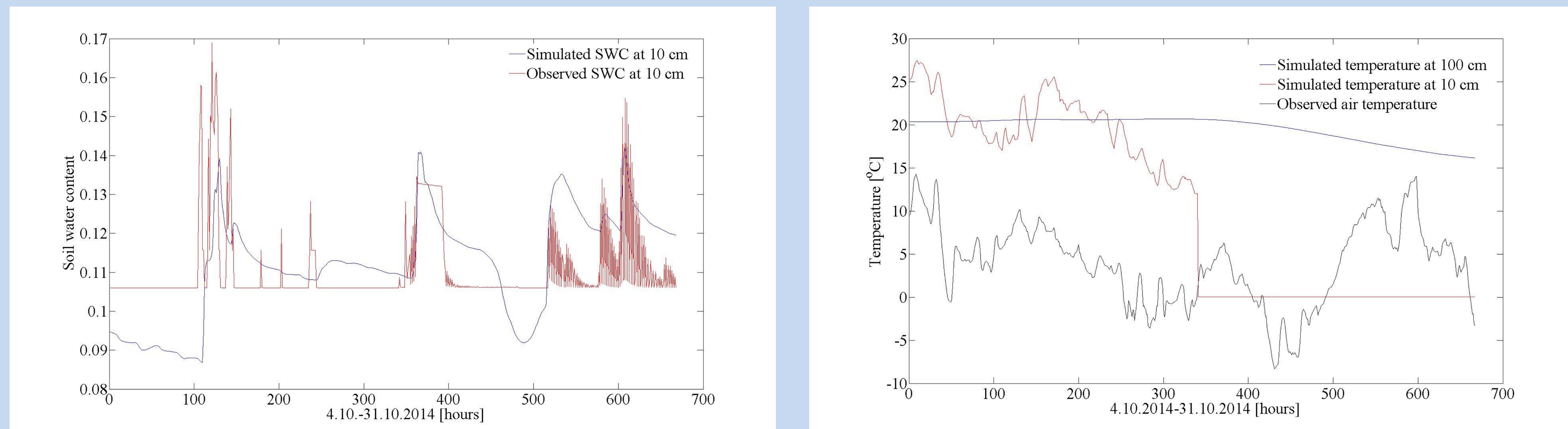

Figure 4. Simulated and observed water content and simulated temperatures and observed air temparature during the period 4.10.-31.10.2014.

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