INFLUENCE OF MOSS, LITTER AND SOIL LAYERS ON FOREST EVAPORATION BY MEANS OF STABLE ISOTOPES

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INTRODUCTION

Within the hydrological cycle evaporation is a key component for water and energy fluxes and plays an important role in hydrological and meteorological processes. The major challenges with evaporation lie in the difficulty of observation, the identification of the relative contributions of evaporation fluxes and the uncertainty in regard to climate change. Current methods run into limitations when it comes to partitioning evaporation fluxes into relative shares of evaporation and transpiration. Within a forest ecosystem soil and litter layers are the biggest source of water vapour in terrestrial ecosystems and evaporation rates are influenced by (i) temperature, (ii) soil moisture, (iii) hydraulic properties and (iv) humidity. The Speulderbos in the Netherlands is a temperate Dutch forest with dense canopy and different ground cover types such as mosses and litter layers. The main objective of this research was to determine the influence of these layers on the evaporation rate through the use of the stable water isotopes ^{18}O and ^{2}H.

METHODS AND MATERIALS

Four different cover types were selected from a Douglas fir (*Pseudotsuga menziesii*) forest. The first type is a simple litter layer made up of fir needles, small twigs and other organic material. This layer represents the litter layer dominated by needles and branches, common for coniferous forest stands (Figure 1a). The second type is Thamariskmoss (Thuidium *tamariscinum*) (Figure 1b), the third is Rough-Stalked Feathermoss (*Brachythecium rutabulum*) (Figure 1c) and the fourth type is Haircapmoss (*Polytrichum commune*) (Figure 1d). Local soil and litter was collected from the forest and placed in containers (60x40x28cm). A wooden frame at the bottom functioned as a support structure to hold the weight of the soil. Soil moisture and temperature sensors were placed at 10cm depth (Figure 2). A small meteo station recorded the atmospheric conditions (Figure 3).

Figure 1. Four different cover types a) Litter layer, b) Thamariskmoss, c) Rough-Stalked Feathermoss and d) Haircapmoss (Warter, 2016)

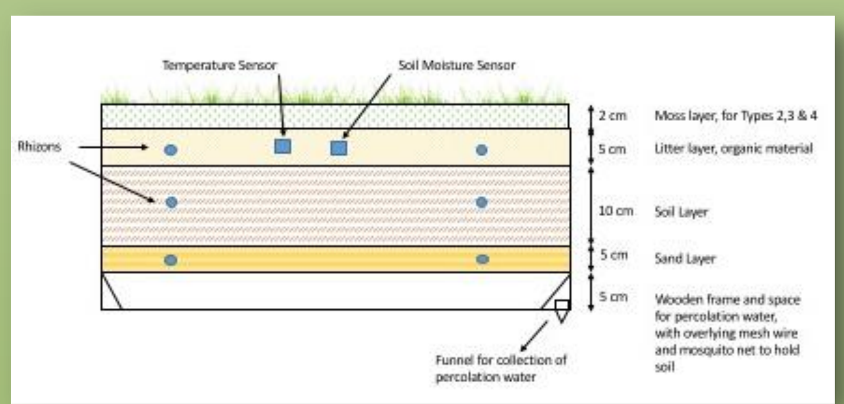

Figure 2. Schematic Set Up (Warter, 2016)

Figure 3. Experiment Set Up (Warter, 2016)

SAMPLING AND ANALYSIS

The experiment was set up inside the Water Lab at TU Delft. Rainfall was administered artificially according to a schedule over four weeks (24. -18.11.2016) (Figure 4a). Atmospheric conditions were monitored via a small meteo station (Figure 4b). Soilwater content and temperature was recorded constantly through sensors in the soil. Daily water samples were taken via Rhizons from the soil and litter layers between 0 - 25 cm. If the soil/litter was too dry centrifugation was used to extract the soil water. Over 200 samples were collected for Liquid Water Isotope Analysis (*LGR-LWIA*). The isotope analysis also includes a sample of the rainfall and the percolation water from each cover type (Figure 5). To get an estimation of the evaporation and water holding capacity of each container, gravimetric analysis of a small extract of the mosses was done on a daily basis. Based on a soil water balance we gave a rough estimation of the evaporation rates for each cover types.

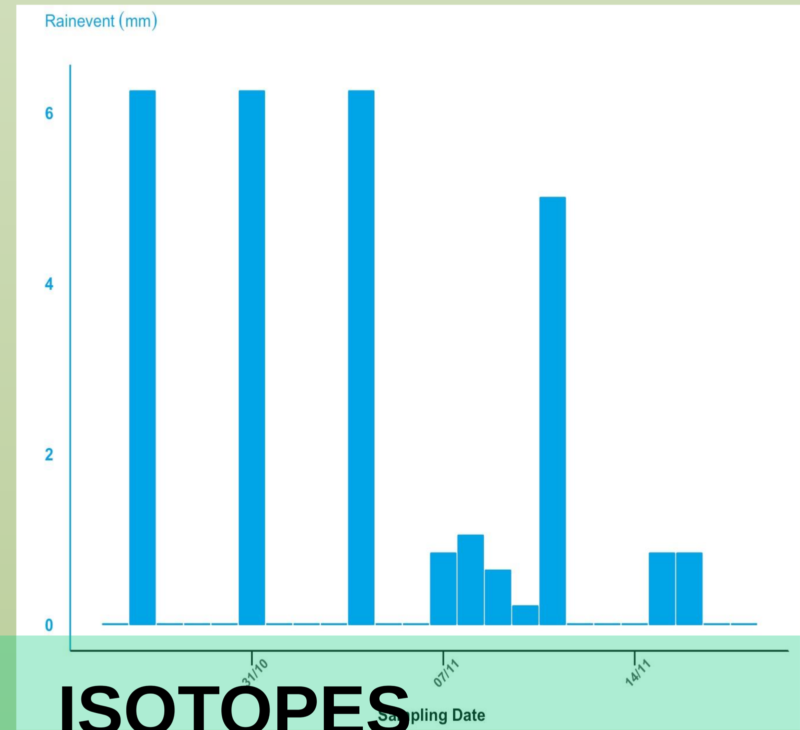

Figure 4a. Rainfall simulations

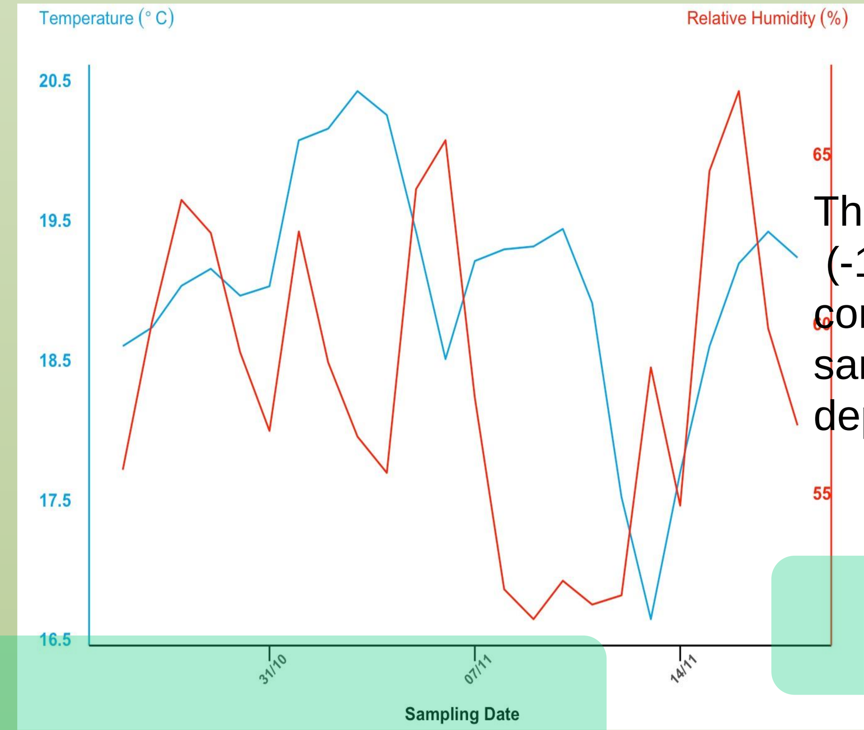

Figure 4b. Temperature and Relative Humidity over the sampling period

ISOTOPES

The analysis of the soil water showed that the reference precipitation water is stable for all four cover types with an average of δ^2H of -42.59 ± 1.15‰ and for $\delta^{18}O$ of -6.01 ± 0.21‰. The evaporation front is visible between 5 – 10 cm as the level of fractionation is at the highest in the litter layer (δ^2H=-29.79‰ and $\delta^{18}O$ -2.21‰). The Haircapmoss shows the lowest levels of fractionation between 5 and 10cm. The percolation water is slightly more enriched then the precipitation but not as strongly fractionated as the water in the top layers. This illustrates no or very minimal fractionation is occurring at depth.

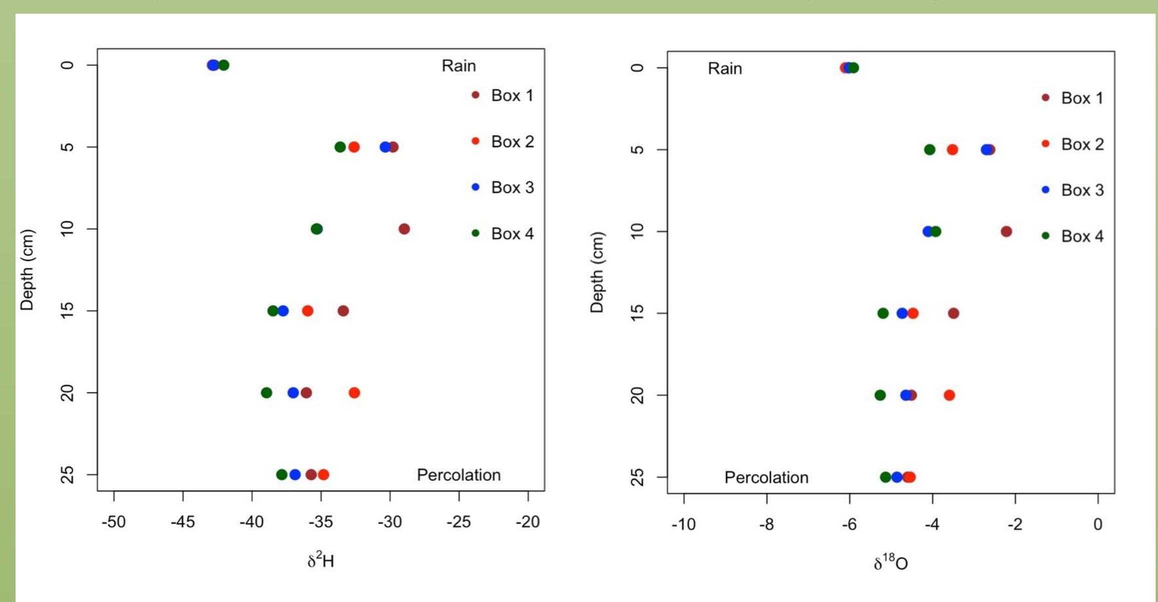

Figure 5. Average δ^2H and $\delta^{18}O$ concentrations of soil water in ‰

The isotope of hydrogen in water is much less prone to kinetic fractionation then oxygen, in relativity to deuterium. The relationship between H and O in terrestrial waters can be described through the deuterium excess. The isotopic concentrations are adapted along the Global Meteoric Water Line. In general the more negative the deuterium excess values, the higher the rate of evaporation.

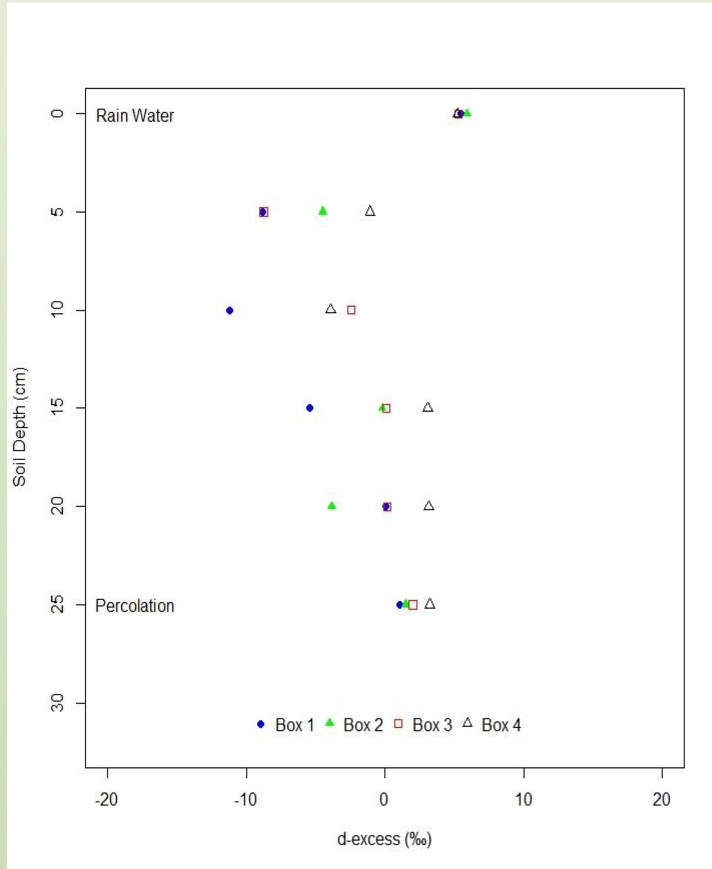

Figure 6. Deuterium excess of soil water

The litter layer (Type 1) shows the highest levels between 5 – 15 cm (-11,24‰). The Haircapmoss (Type 4) shows by far the lowest levels in contrast to the litter layer. Rainwater and percolation water are almost at the same level, with small variations. The level of fractionation is declining with depth, confirming the main evaporation front is situated at the surface.

RESULTS AND DISCUSSION

The differences in fractionation between 5 – 10 cm suggests that mainly soil evaporation is taking place. The biggest difference was found between the layer of needles (Type 1) and the Haircapmoss (Type 2). This confirms that a bare soil layer, or a thin layer made of needles allows more evaporation then a moss cover. Depth is not as important as the type of cover, which was shown through an Analysis of Variance. The variability of atmospheric conditions and influence of a natural forest environment is not considered in this experiment. For further confirmation and expansion of the results gained in this study it is highly recommended to repeat this experiment in a natural forest environment. Spatial variations of cover types and their reaction to periods of heavy rain/drought can give insights into the behaviour and dynamics of the forest floor. In regard to climate change and groundwater decline this could be used to gain insights in to how forest ecosystems deal with the decline of water supply and how the lower levels are dealing with water stress.

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