Stable isotope-based approach to validate effects of stand structure and understory on soil water in a Japanese forest plantation

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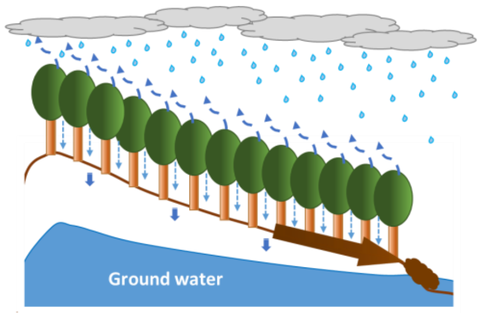
EGU General Assembly 2020

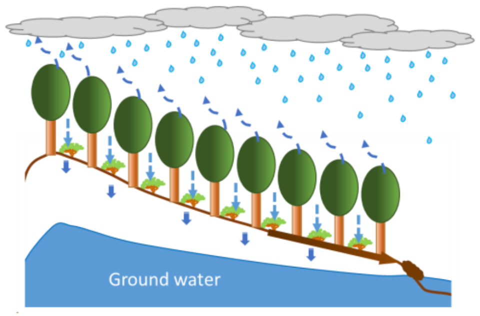
CREST

Introduction



Plantation forest not properly managed

Increasing of canopy blockage
Decreasing of understory vegetation
Decreasing of drought flow
Increasing of sediment discharge



Expected effects of thinning

Improving the forest environment
(Decreasing of canopy intercept,
Increasing of understory vegetation,
Increasing of drought flow, ect)

Despite the complexity of the effects of thinning on groundwater recharge, such as the soil surface becoming covered with vegetation over time after thinning, the effects of thinning on groundwater recharge have not been studied yet.

Brooks et al. (2009) classified soil water into three types: tightly bound water, mobile water, and preferential flow, showing that tightly bound water is absorbed by plants, while mobile water and preferential flow recharge groundwater and rivers.

Isotope analysis of mobile water and preferential flow should be taken to determine the type of soil water that actually recharges the groundwater.

Object

Suction lysimeter

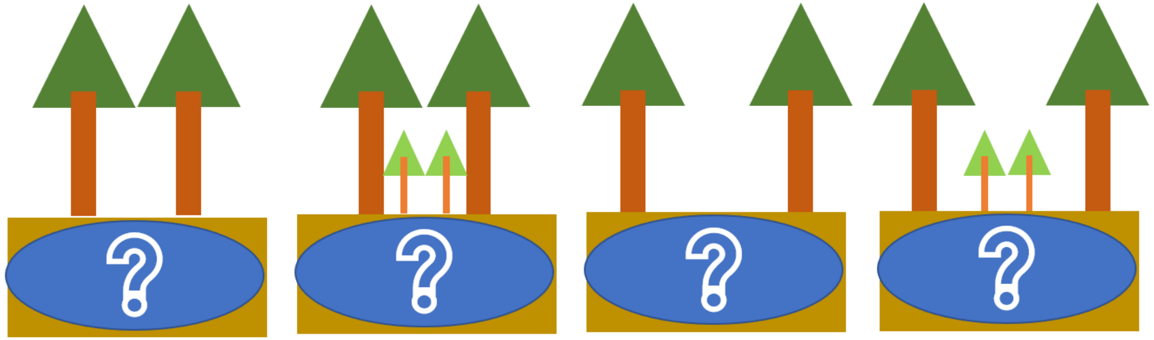
Zero tension lysimeter

Mobile water ?

Preferential flow ?

Separate collection of mobile water and preferential flow to determine what water recharges groundwater

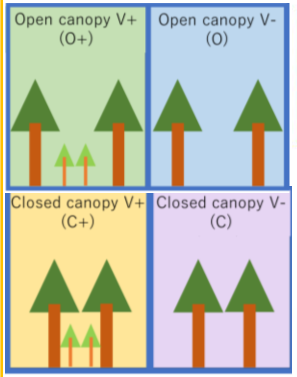
To investigate the effects of thinning on soil moisture in four plots with different overstory and understory vegetation distributions.



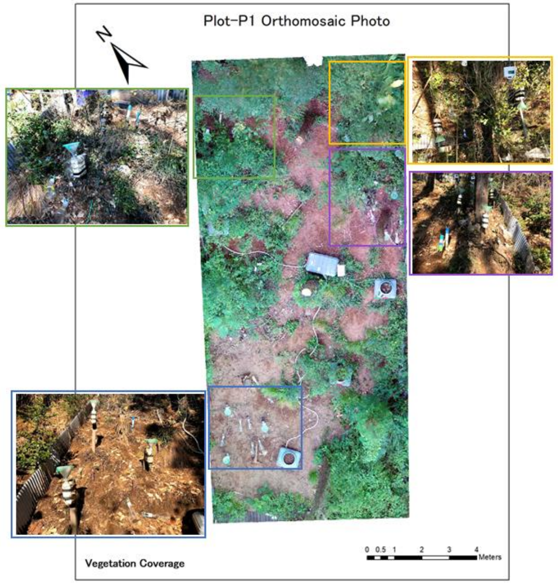
Determine the impact of thinning on groundwater recharge

Method

Field



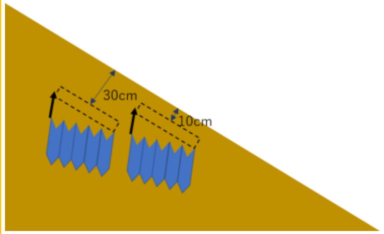
(https://www.google.com/maps/place)



P1：Cypress, Line thinning　P3： Cedar, Point thinning

Japan, Tochigi-prefecture, Mt. Karasawa
(Field museum of Tokyo University of Agriculture and Technology)

Installing zero-tension lysimeter



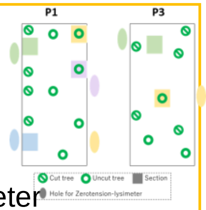
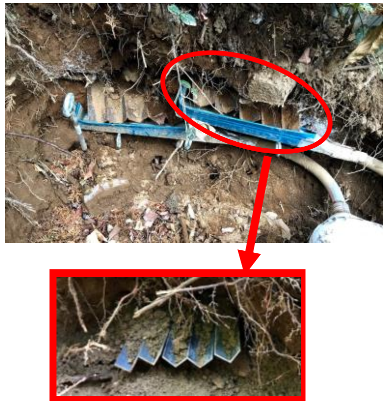


表1：Catchment area of zero tension lysimeter

	P1O	P1O+	P1C	P1C+	P3O+	P3C+
10cm cm^2	666	600	640	668	672	676
30cm cm^2	700	628	552	700	626	600

Modular zero tension lysimeter

- It can be inserted without breaking soil and have a wide catchment surface
- This shape also prevents the release of soil water and improves collection efficiency.



Collecting data and sampling

Various micrometeorological

Soil moisture content

Radiation

Evaporation

Weighing lysimeter

Soil water potential

Tensiometer

Various water samples

Throughfall
Open rainfall

Mobile water

Suction lysimeter

Preferential Flow

Zero tension lysimeter

Result : The time series of δO^{18} and precipitation

Open rainfall and throughfall

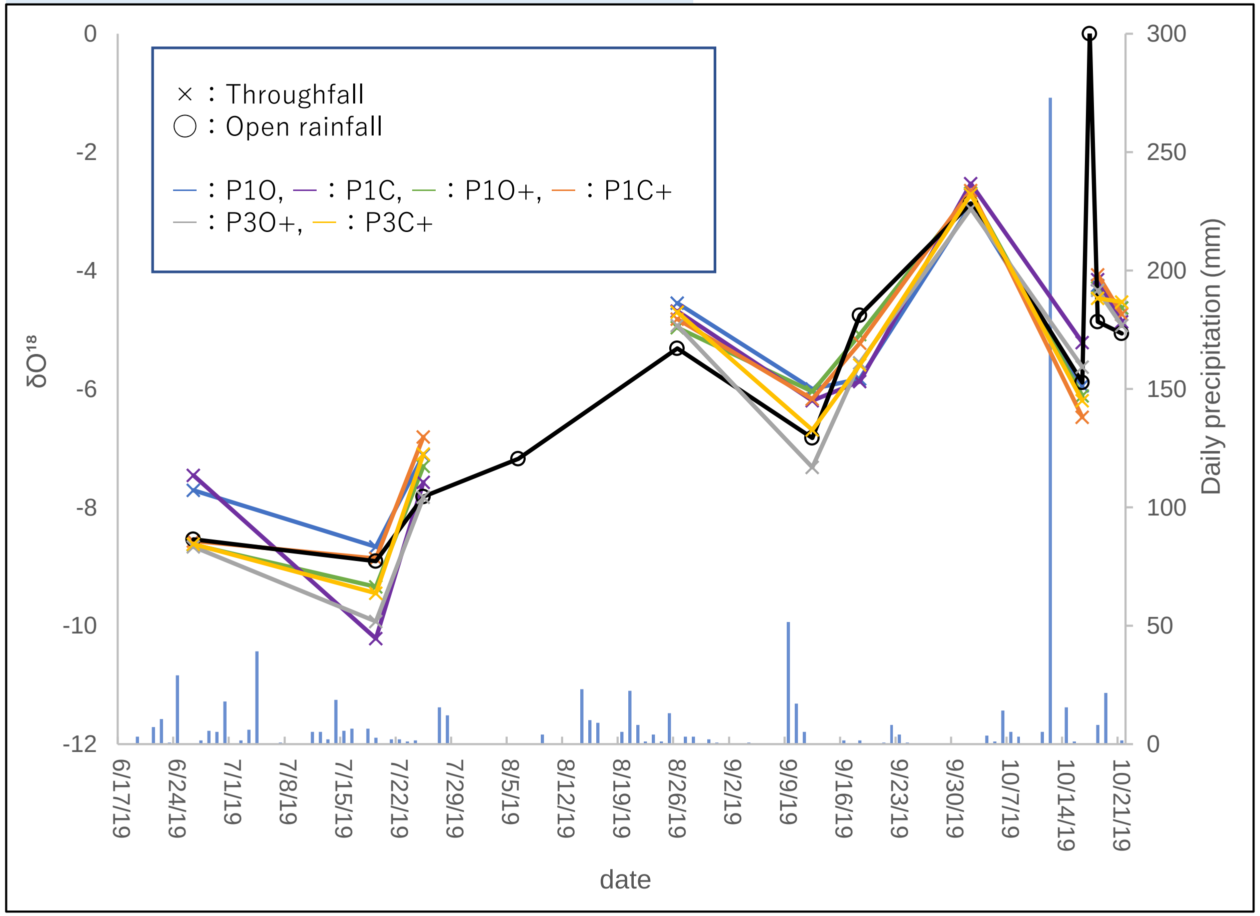


Fig.1：Time series change of δO^{18} for open rainfall and throughfall, and the daily precipitation.

Soil water (suction lysimeter and zero-tension lysimeter)

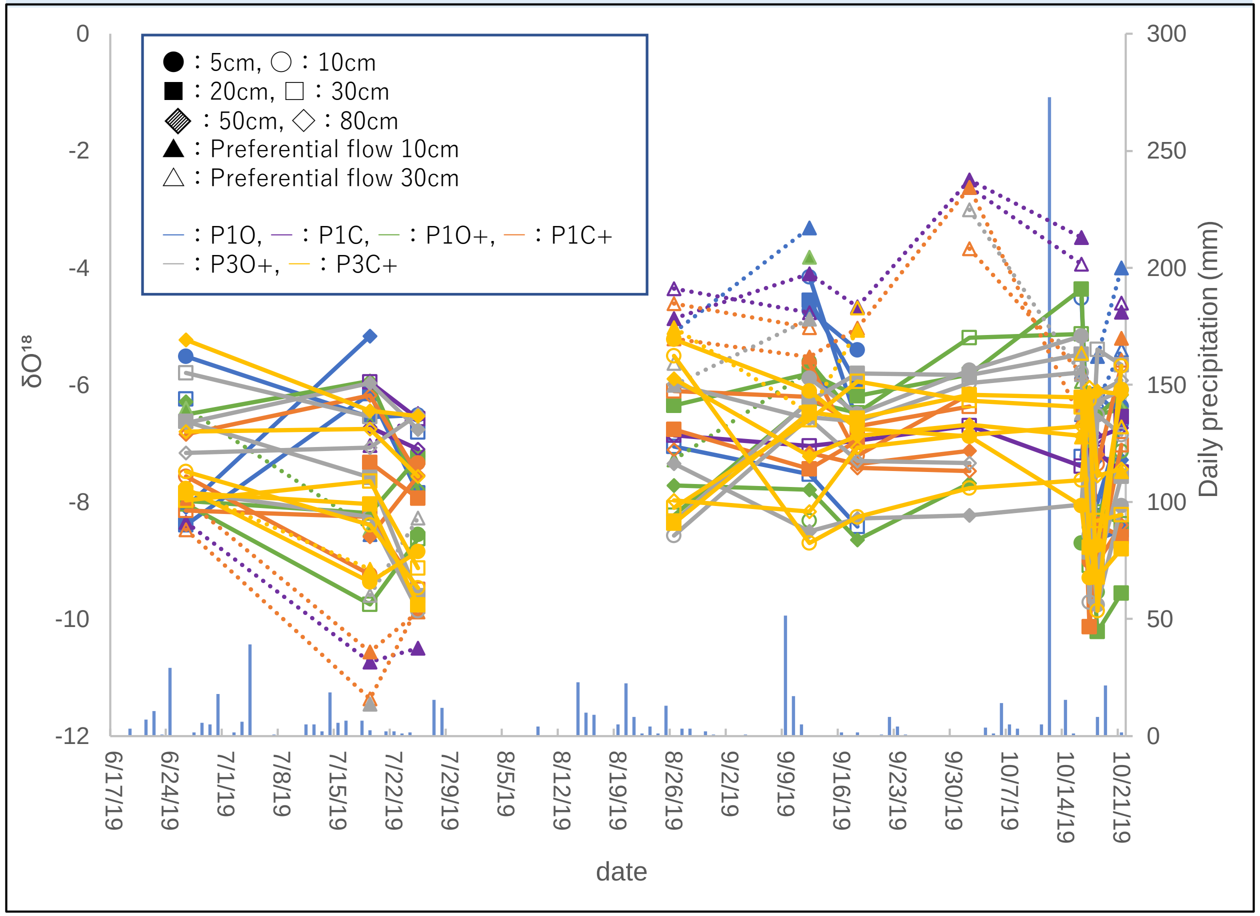
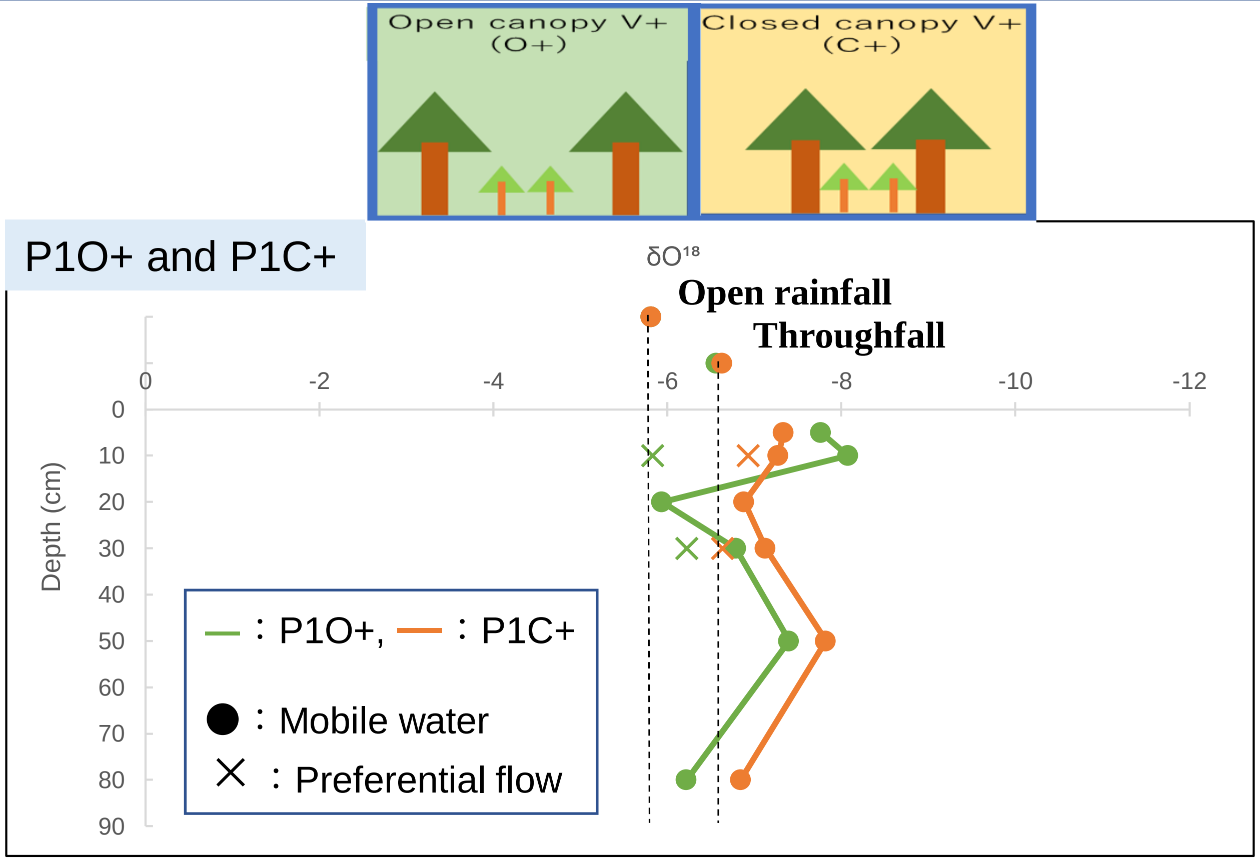


Fig.2：Time series change of δO^{18} for mobile water and preferential flow, and the daily precipitation.

・Analysis for soil water and throughfall sample of 8/6/19 isn’t finished yet.
・We couldn’t collect much water sample in P1O and P1C. Therefore, We discuss using the data in P1O+, P1C+, P3O+ and P3C+
・Soil water sampled by the zero tension lysimeter is assumed to be preferential flow, and soil water sampled by the suction lysimeter is assumed to be mobile water.

Discussion : The change of the δO¹⁸ value



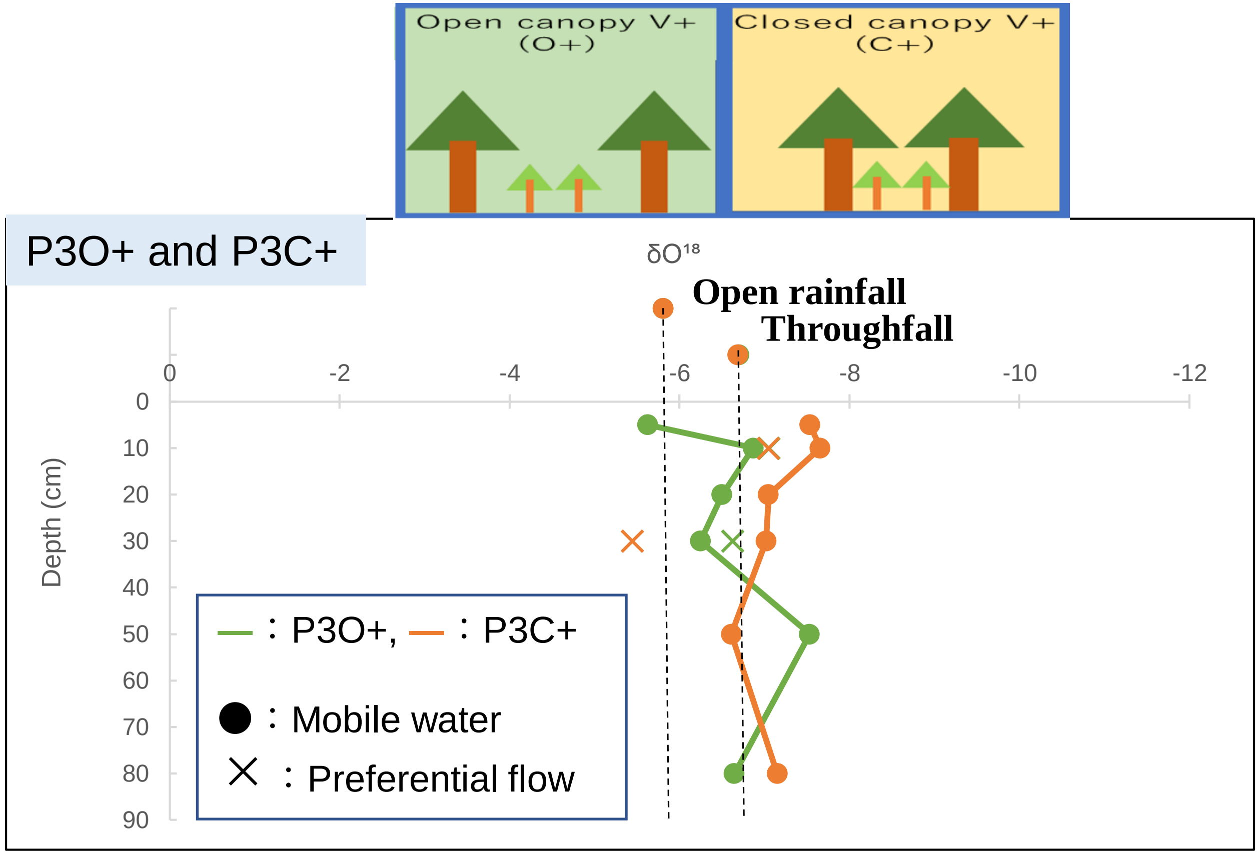


Fig. 3: The weighted average of δO¹⁸ value for each water samples in P1O+, P1C+, P3O+ and P3C+.

- Mobile water (Suction lysimeter)

The average of δO¹⁸ value in P1O+ and P3O+ is closer to open rainfall than it in P1C+ and P3C+. The change of δO¹⁸ value for mobile water become smaller as deeper points.

- Preferential flow (Zero-tension lysimeter)

The average of δO¹⁸ value for preferential flow at 30cm and The average of δO¹⁸ value for mobile water at 80cm is very close in P1O+, P3C+.

Summary

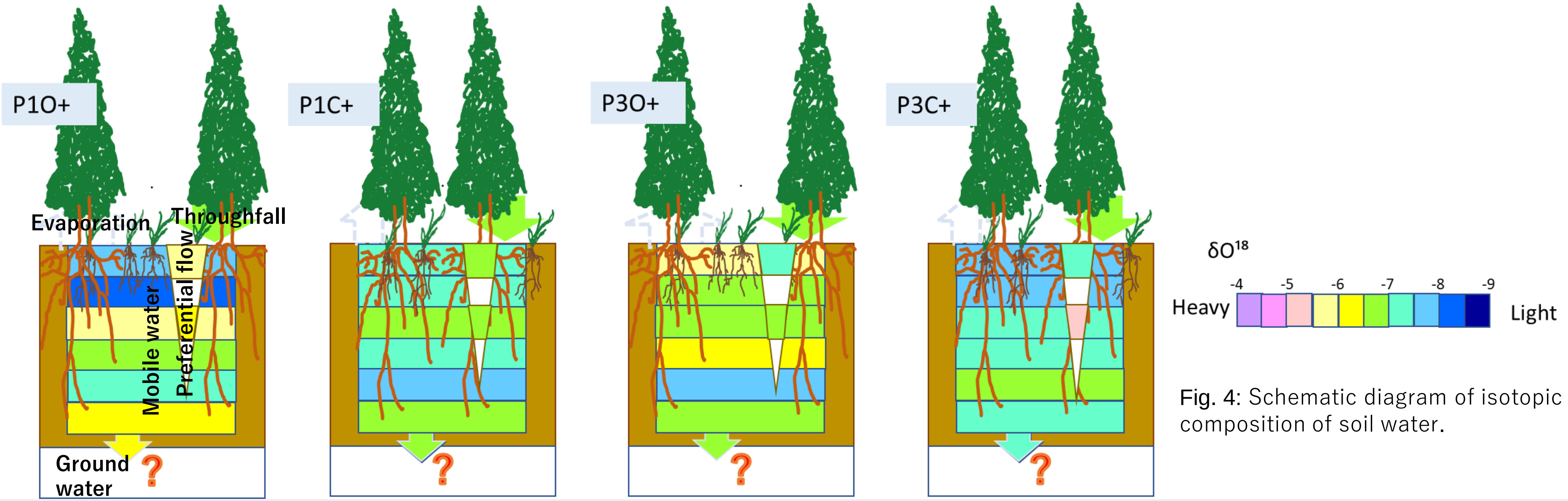


Fig. 4: Schematic diagram of isotopic composition of soil water.

Since the soil water $\delta^{18}O$ collected by the zero tension lysimeter are close to the $\delta^{18}O$ values of open rainfall, the soil water collected by the zero tension lysimeter can be judged as the preferential flow.

The value of $\delta^{18}O$ for groundwater-recharging soil water is changed before and after thinning in response to the changing of input rainfall $\delta^{18}O$ values.

The 80cm soil water $\delta^{18}O$ value can be judged as the mixture of the preferential flow and mobile water at 30 cm depth.

The impact of thinning on groundwater recharge could be clarified by determining the percentage of preferential flow in soil water at each depth.