Continuous observation of tree interception effects on water stable isotopes

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Motivation

The isotopic composition of throughfall is affected by complex exchange and mixing processes in the canopy. The differences are driven by evaporation from the canopy during or between storms, isotopic exchange with ambient vapor and canopy storage effects, where water is differentially retained by the canopy during rainfall events. These interception processes occur simultaneously in time and space generating a complex pattern of throughfall in amount and isotopic composition. Therefore, the aim of this study is to

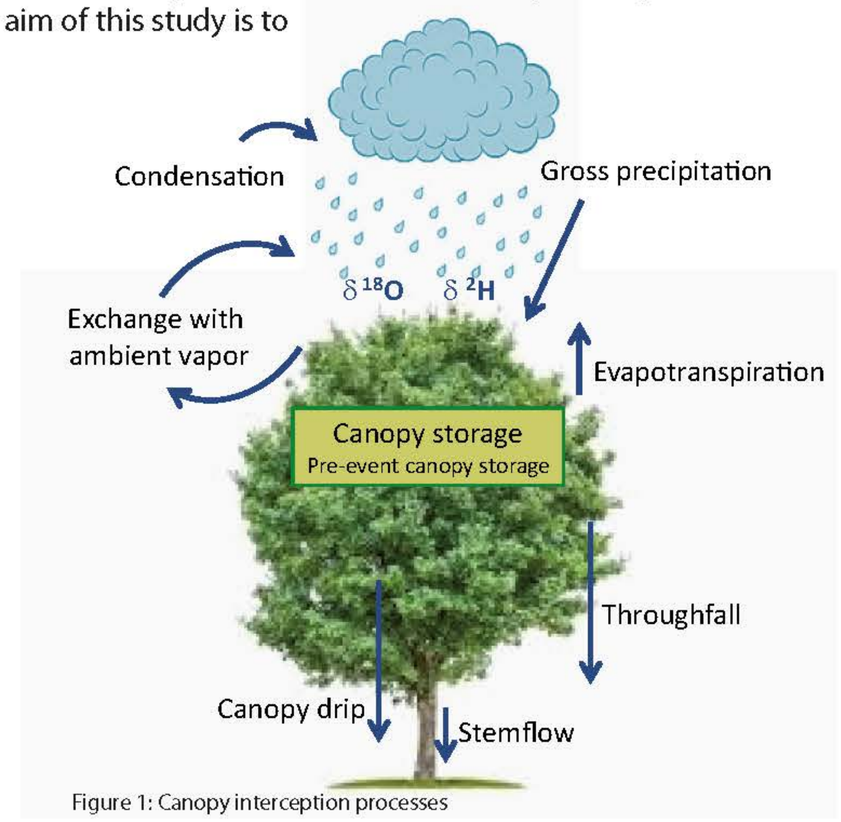

Figure 1: Canopy interception processes

- investigate the dynamics in gross precipitation (P_g) and throughfall (TF) in high temporal resolution to test the different hypotheses of canopy interception processes
- adequatly predict the isotopic signal of throughfall under a variety of precipitation and environmental conditions

Methodology

In combination with a CRDS instrument we established an in-situ method to transfer liquid water to water vapor within seconds (Herbstritt et al., WRR, 2012). Core of the method is an off-the-shelf microporous hydrophobic membrane contactor, originally designed for degassing liquids. It is used in reverse mode with nitrogen as carrier gas in order to continuously transform a small fraction of liquid water to water vapor which is then transferred directly to the analyser.

Based on this method and with two CRDS instruments in parallel, the isotopic composition of **throughfall (TF)** below a decidious tree canopy and **gross precipitation (P_g)** 15 m away were measured continuously (0.5 Hz) by the analysers.
Additionally, rainfall amounts were recorded every minute at both sites by tipping buckets.
Liquid grab samples, representing rainfall sums of 30'' were taken from time to time, as well as bulk samples for each event.
Meteorological parameters RH (%) and T_a (°C) were recorded every minute.

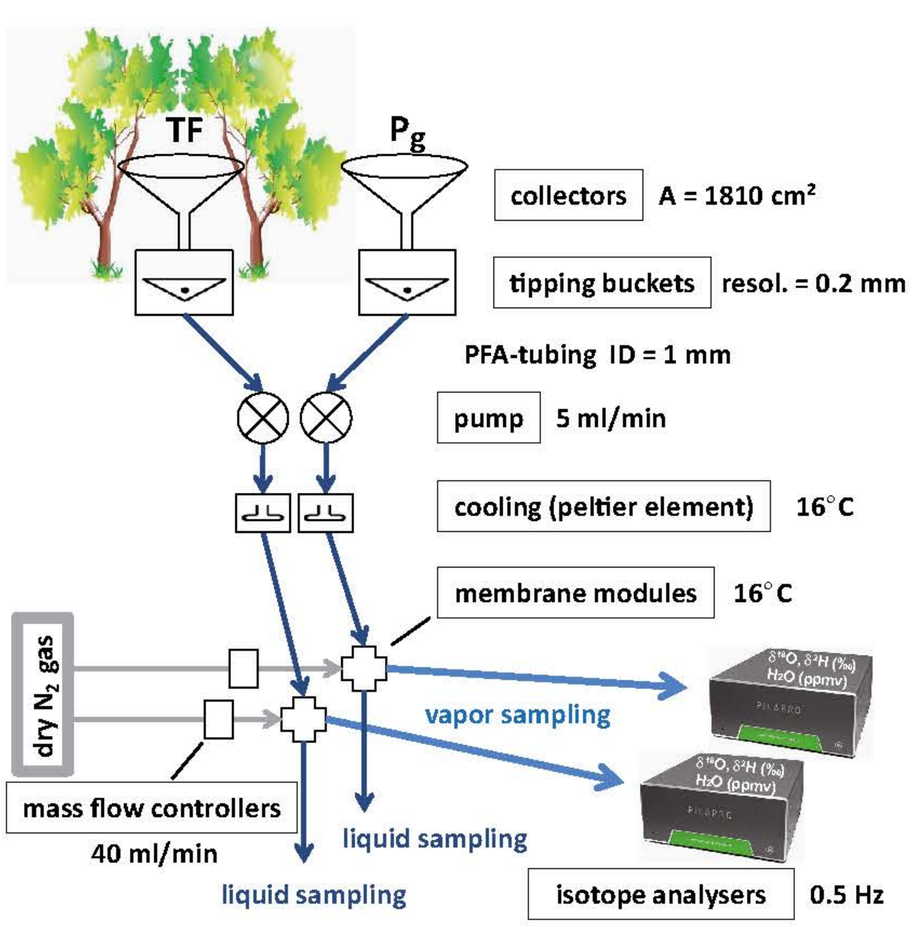

Figure 2: Experimental setup

Results

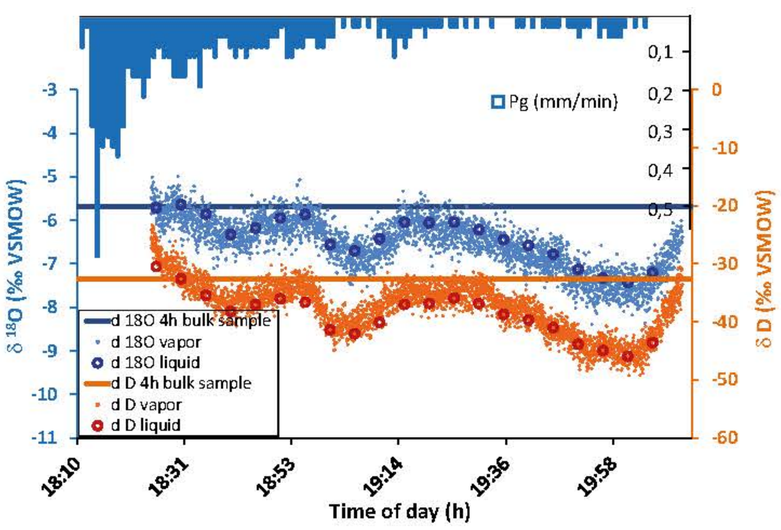

Figure 3: Continuous sampling of gross precipitation (P_g) (small dots) during a convective rainfall event, 5' grab samples (circles) and bulk sample of whole event (horizontal lines)

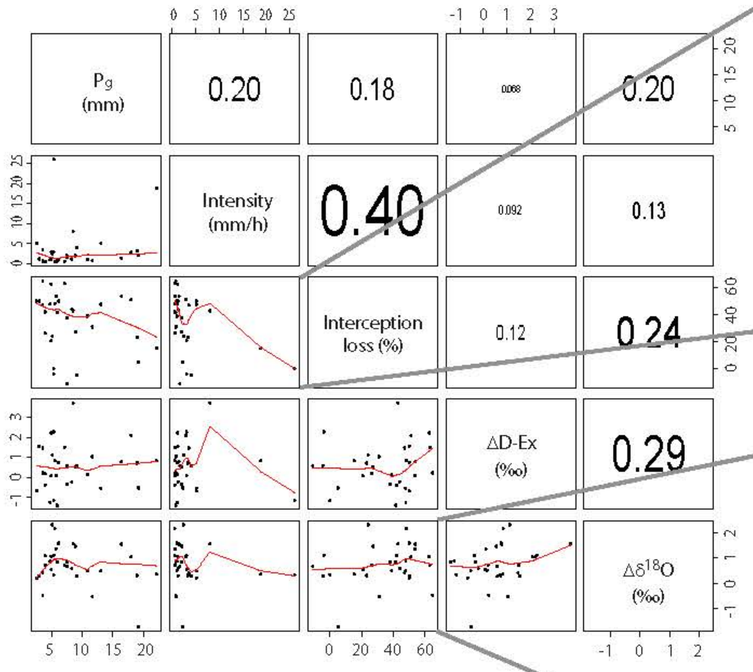

Figure 4: Interception scatter plot matrix of bulk samples

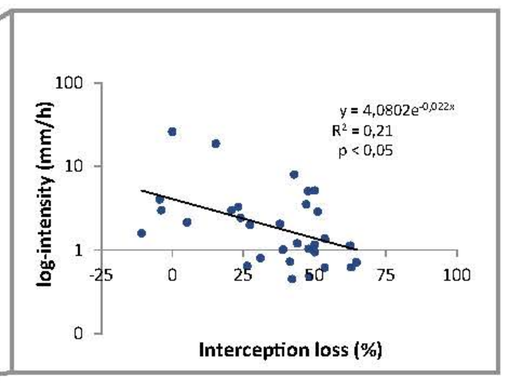

Figure 5: Correlation between Rainfall intensity and Interception loss of bulk samples

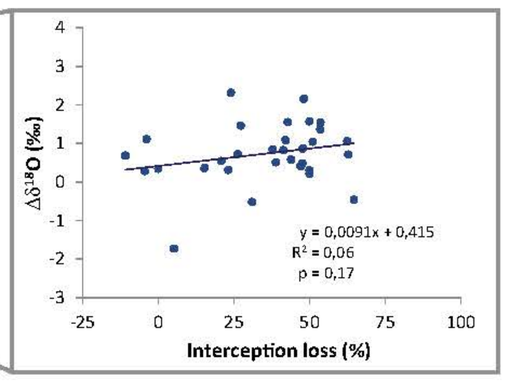

Figure 6: Correlation between Interception loss and $\Delta\delta^{18}O$ of bulk samples

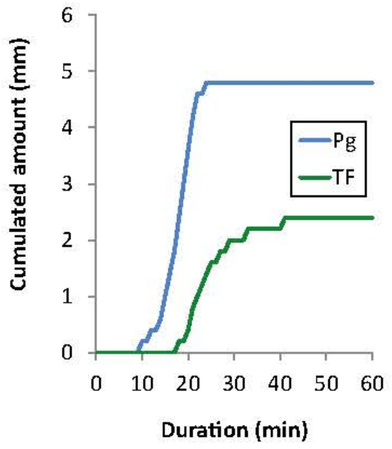

Figure 7: Typical pattern of cumulated rainfall affected by interception
→ TF later and less than P_g

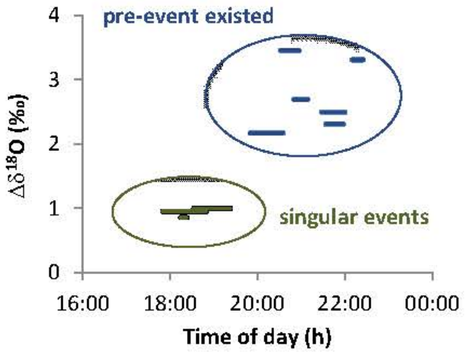

Figure 8: Deviation of isotopic signature ($\Delta\delta^{18}O$) between TF and P_g of continuously analysed events

Conclusions

Gross precipitation exceeds throughfall amounts.
Throughfall typically starts and ends later than gross precipitation
A negative exponential correlation exists between interception loss and rainfall intensity.
Throughfall is enriched in heavy isotopes.
A weak positive correlation exists between Dd18O and interception loss.
Antecedent conditions seem to have an impact on isotope enrichment of throughfall.

Reference

Herbstritt, B., B. Gralher, and M. Weiler (2012): Continuous in situ measurements of stable isotopes in liquid water; Water Resour. Res., 48, W03601; doi:10.1029/2011WR011369

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