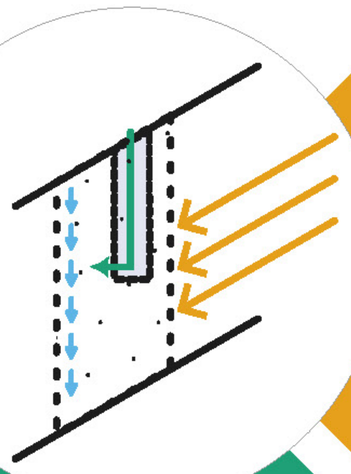
Detecting the occurrence of preferential flow in soils with stable water isotopes

by Jonas Pyschik & Markus Weiler

Background

- 80% of the world's streams are within headwaters
- most headwaters are hillslopes.
- understanding hillslope runoff processes = better understanding most hydrological systems
- isotopes can be used to detect otherwise hard-to-measure processes in hillslope soils

3 processes of hillslope soil water movement



Vertical flow

Lateral flow

Preferential flow

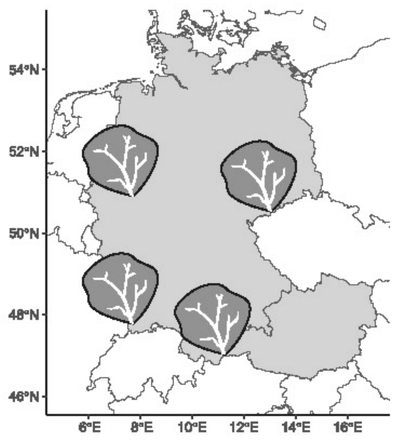
Study Sites

Ore Mountains

Black Forest

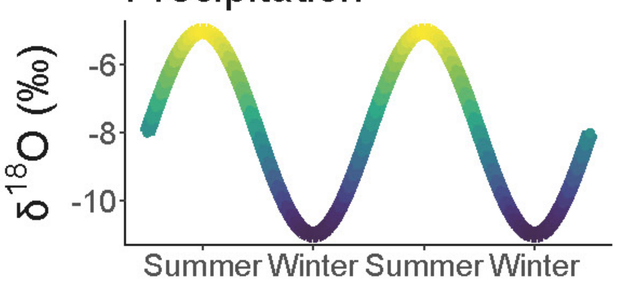
Sauerland

Alps



Isotope Seasonality

Precipitation



Summer precipitation is isotopically heavier than that in winter

Graph produced by the authors with data by [1]

Sampling Methods

1. Drilling to bedrock depth (1-4 m) with an auger

2. Sampling in consecutive intervals in Aluminium bags

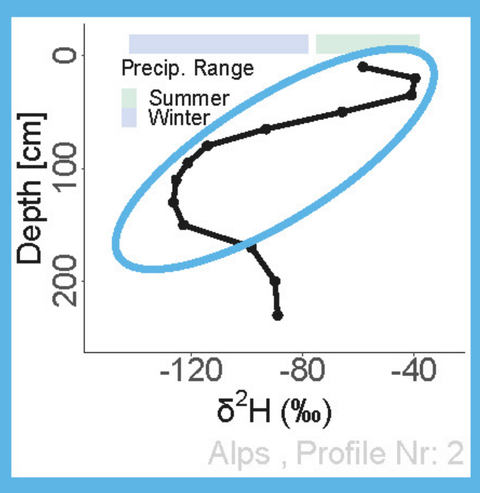
3. Equilibration: inflate with dry air & wait 48 h

4. Analysis of ^{2}H & ^{18}O: cavity ring down spectrometer

Are the 3 processes visible in soil water isotope profiles? Does their occurrence differ between catchments?

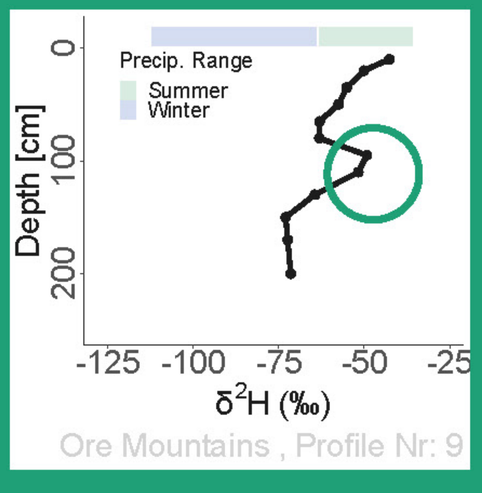
Results

Vertical flow



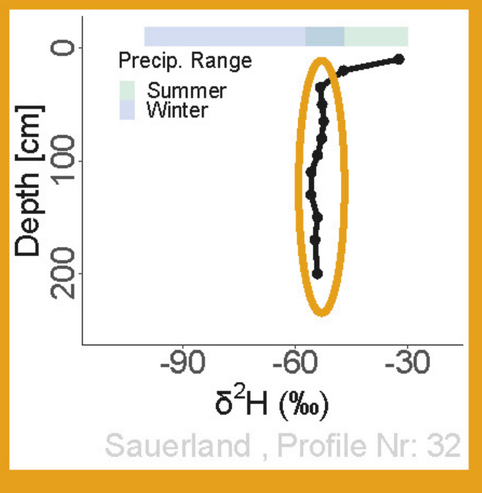
Alps , Profile Nr: 2

Preferential flow

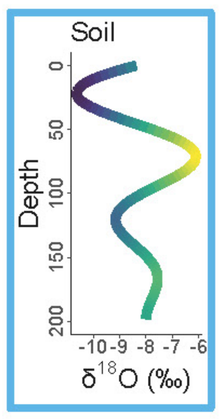


Ore Mountains , Profile Nr: 9

Lateral flow

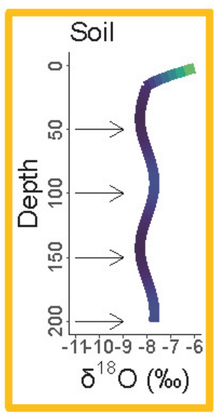


Sauerland , Profile Nr: 32



Seasonality is transferred into the soil with young event water near surface and older water further down.

Preferential flow-paths transport young event water down where it alters the isotopic signature.



Lateral flowing water of different transit times, thus different ages dampen the isotope profile.

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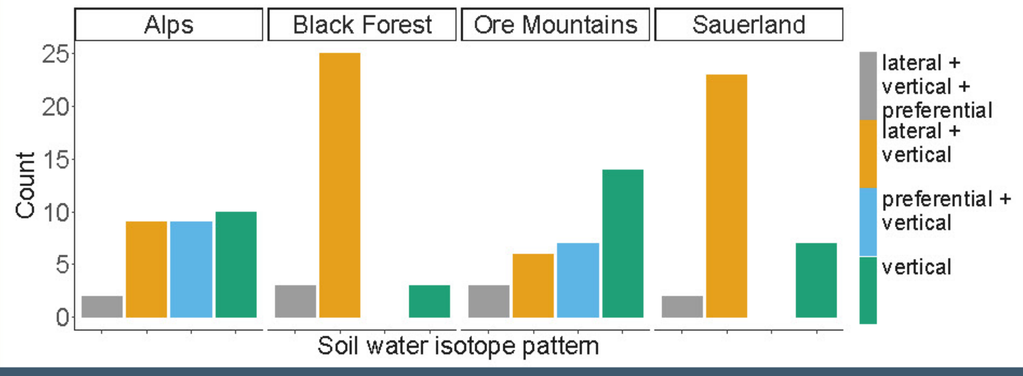
Animation

Graphs produced by the authors with data by [1]

Pattern Occurrence Comparison



Conclusion

- All 3 processes are visible in soil-water isotope profiles
- Not all processes are visible in each catchment
- Analysis will be enhanced by comparison with WSOC and eDNA

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Sources:

[1] Nelson, Basler, Kahmen; PNAS 2021 Vol. 118 No. 26

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