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Analysis of runoff sources and water uptake by trees using isotopic data in a small forested catchment

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Motivation

- Plant transpiration is an important component of the hydrological cycle: eco-hydrological implications deriving from climatic and land-use changes in vegetated areas

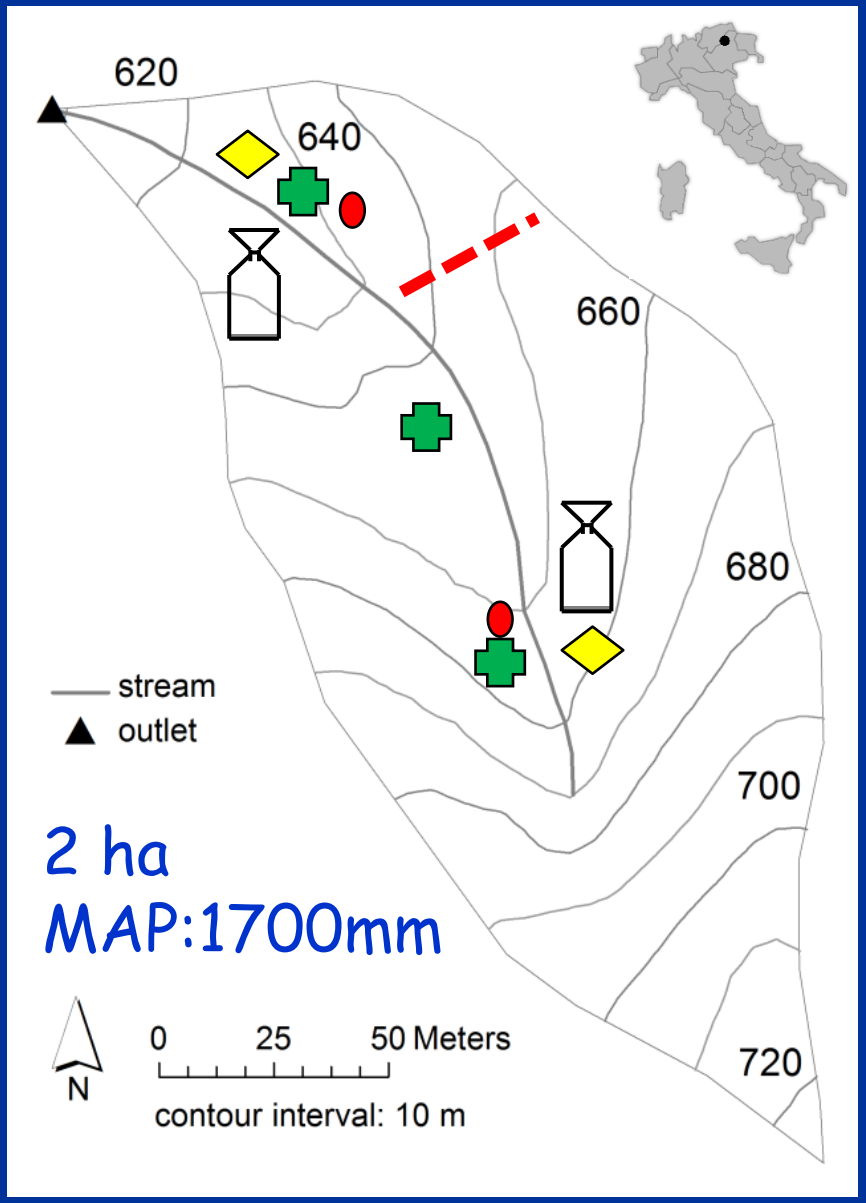
- Need to :
  - identify the main water sources for tree transpiration
  - evaluate exchanges of soil-vegetation-atmosphere fluxes and their influence on runoff response

- Establishment of a new experimental catchment in the densely forested Italian Pre-Alps.

Research Questions

- Which are the main sources of water uptake by trees under different conditions?
- Where does the water contributing to streamflow come from?
- What is the seasonal variability of the different water sources?

Ressi catchment



bulk precipitation

beeches (6- *Fagus sylvatica*)

piezometer

soil water

soil moisture TDR (0-30 cm)

Multiple tracer approach

- Electrical conductivity (EC)
- Water stable isotopes (^{2}H and ^{18}O)

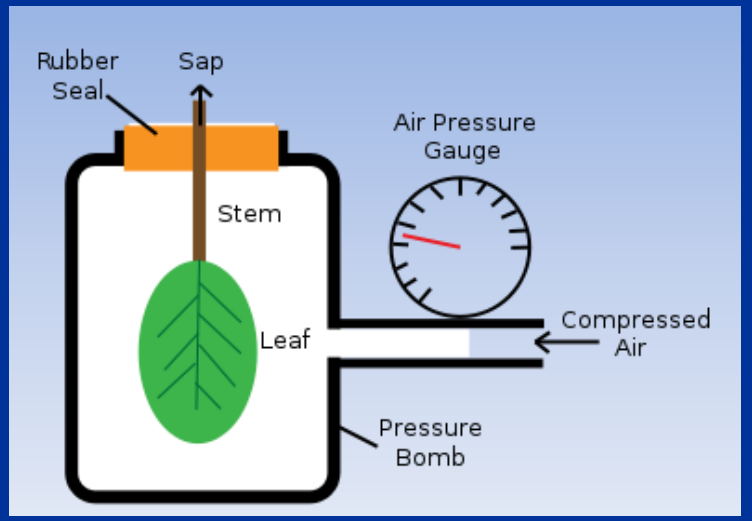
- no isotopic fractionation occurs during water uptake by plant roots
  (Allison et al., 1984; White et al., 1985; Dawson and Ehleringer, 1991)

- use of stable isotopes to identify the water used by plants
  (Dawson and Ehleringer, 1991; Ehleringer and Dawson, 1992)

Water sampling and instrumentation

Samples of:

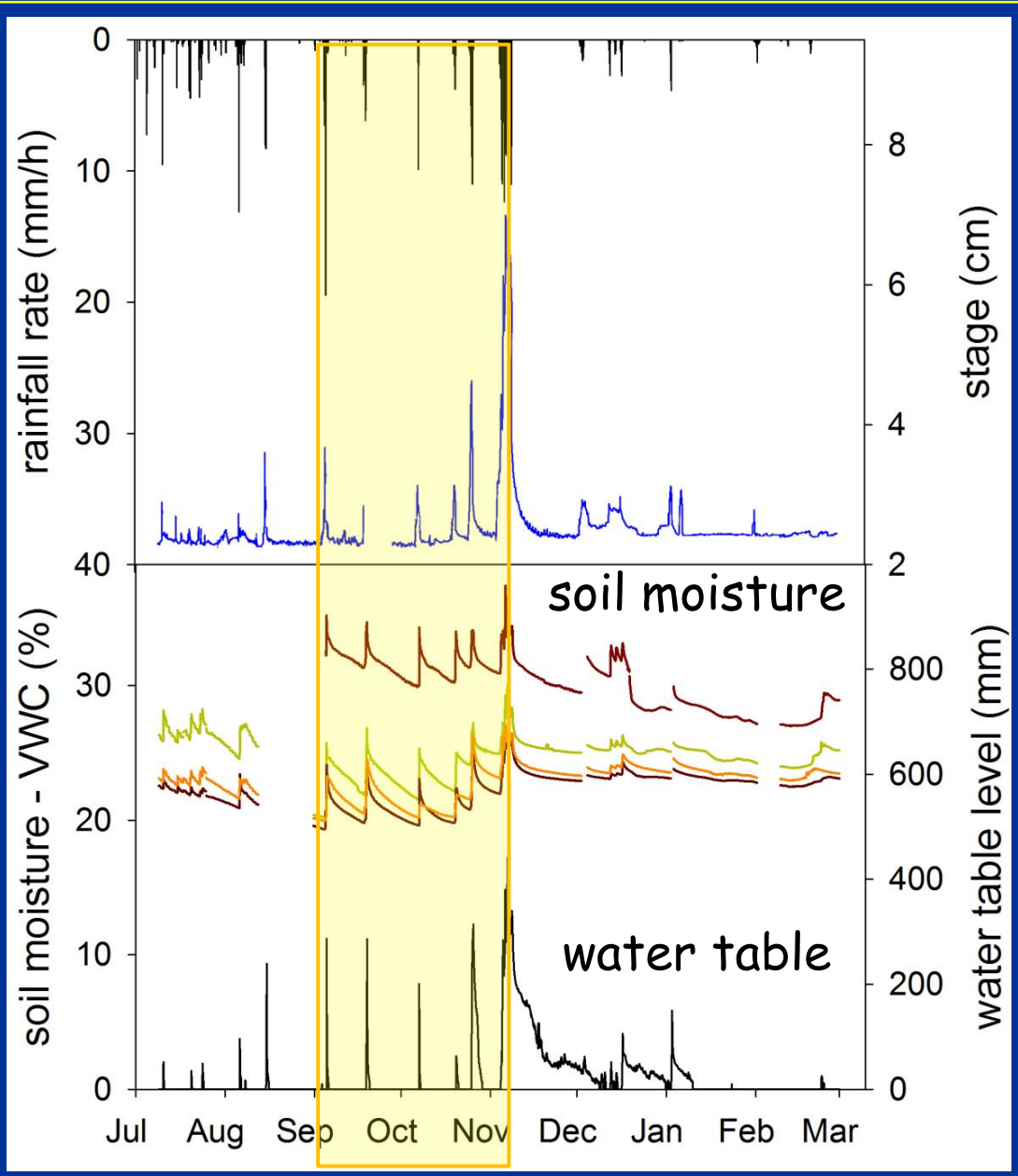
- Precipitation → rainfall collector
- Stream → grab
- Groundwater → grab
- Soil water → suction cups
- Sap → pressure bomb



- Portable EC meter
- Laser spectroscopy

(Penna et al., 2010, HESS; Penna et al, 2012, HESSD)

Hydrological data: July 2011 - March 2012

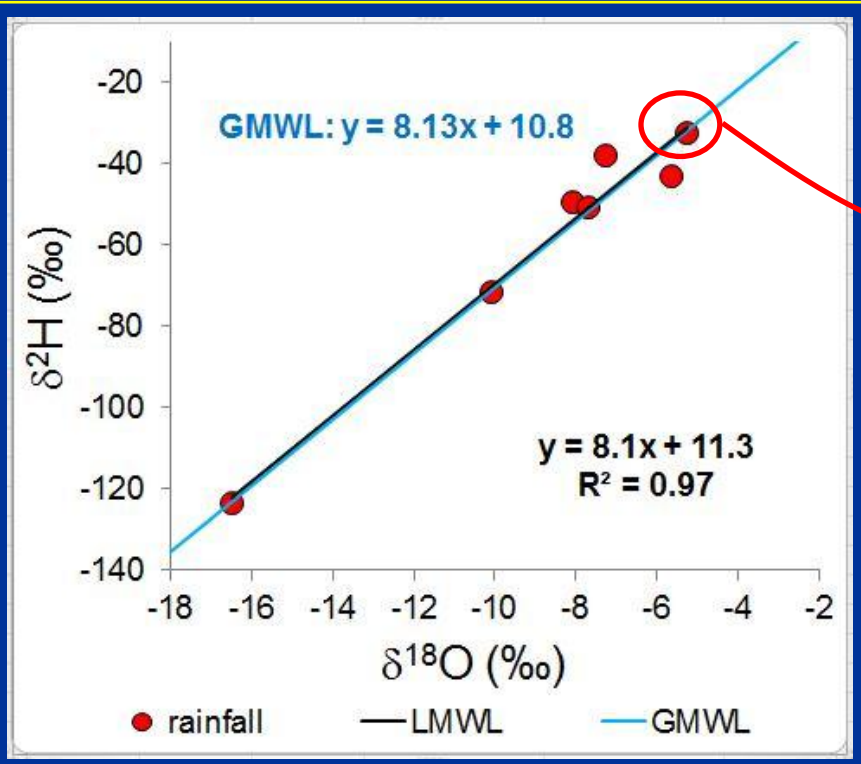


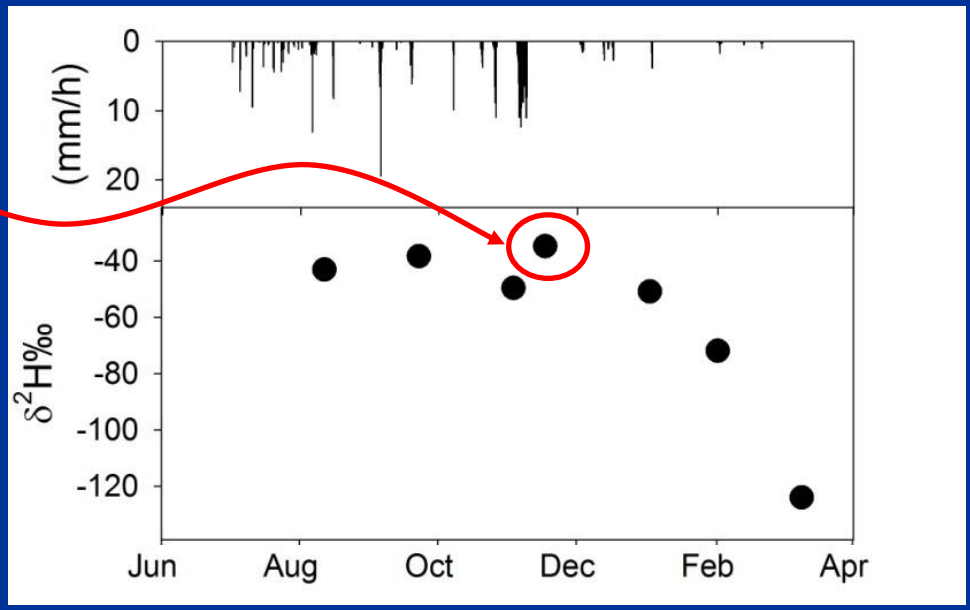
- Impulsive hydrological response → shallow soil → fast subsurface response due to impermeable bedrock?

New insight from future geophysical analysis

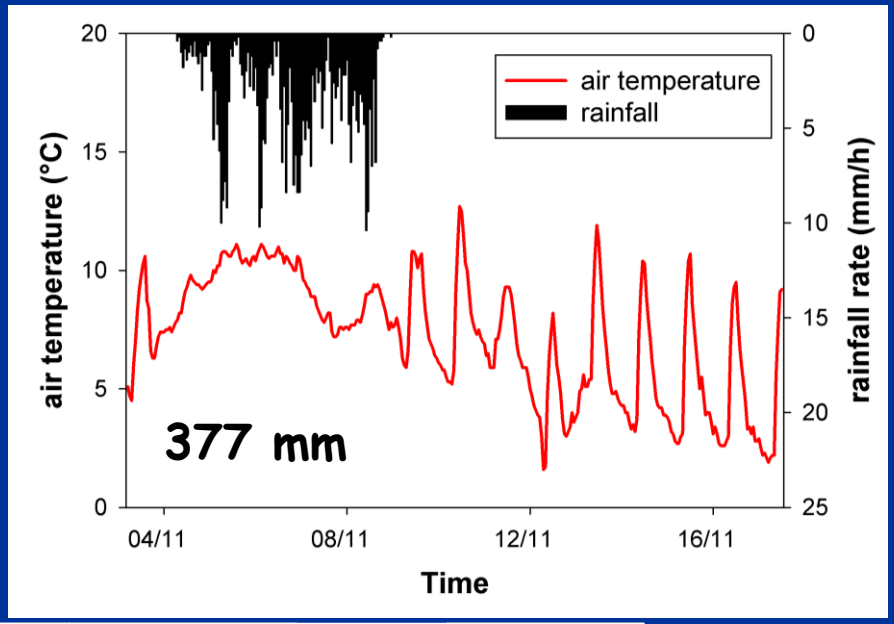
- Sept. ↔ early-Nov: concurrent sampling of sap, soil, stream, ground water

Isotopes in rainfall and GMWL

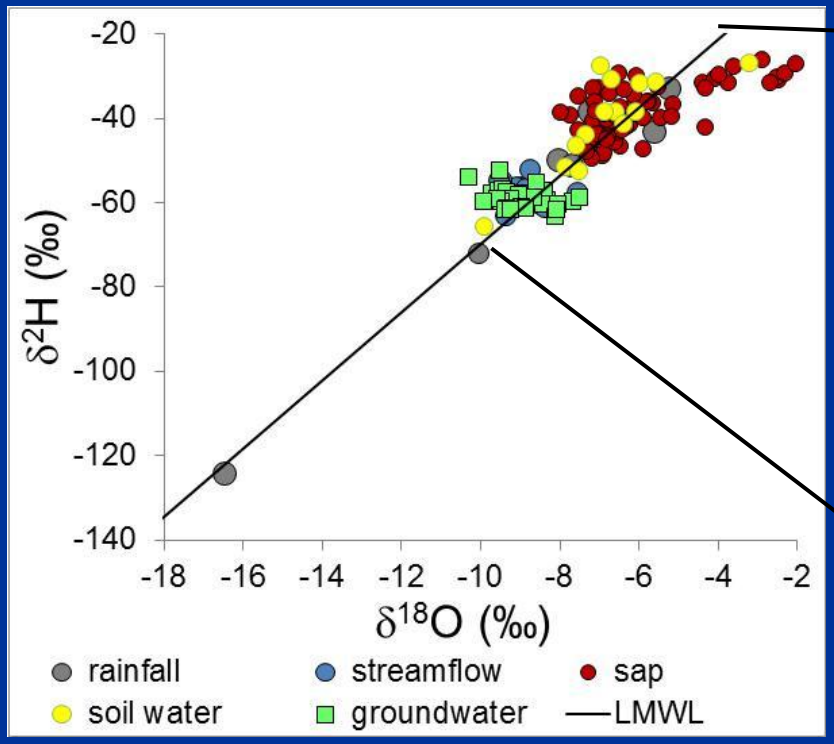


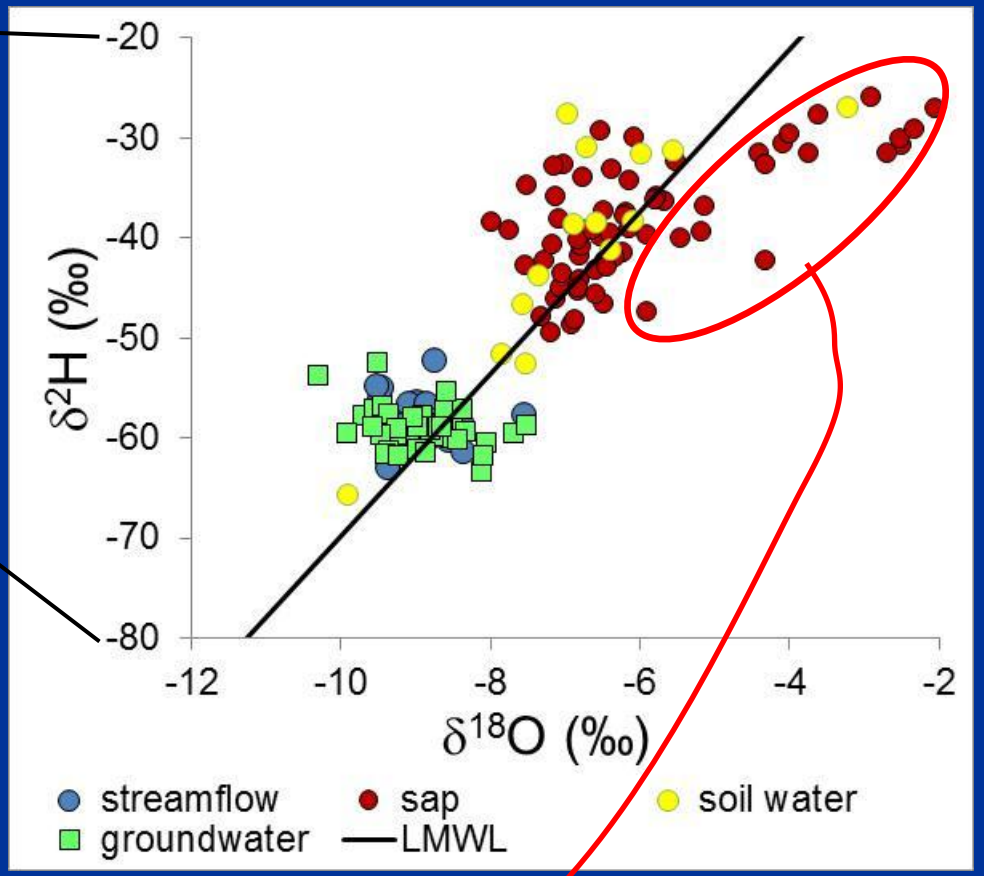


Temperature	Mean	Min	Max
October	9.6	0.6	23.0
November	6.0	0.5	12.8
4-8 Nov.	9.4	7.2	11.1



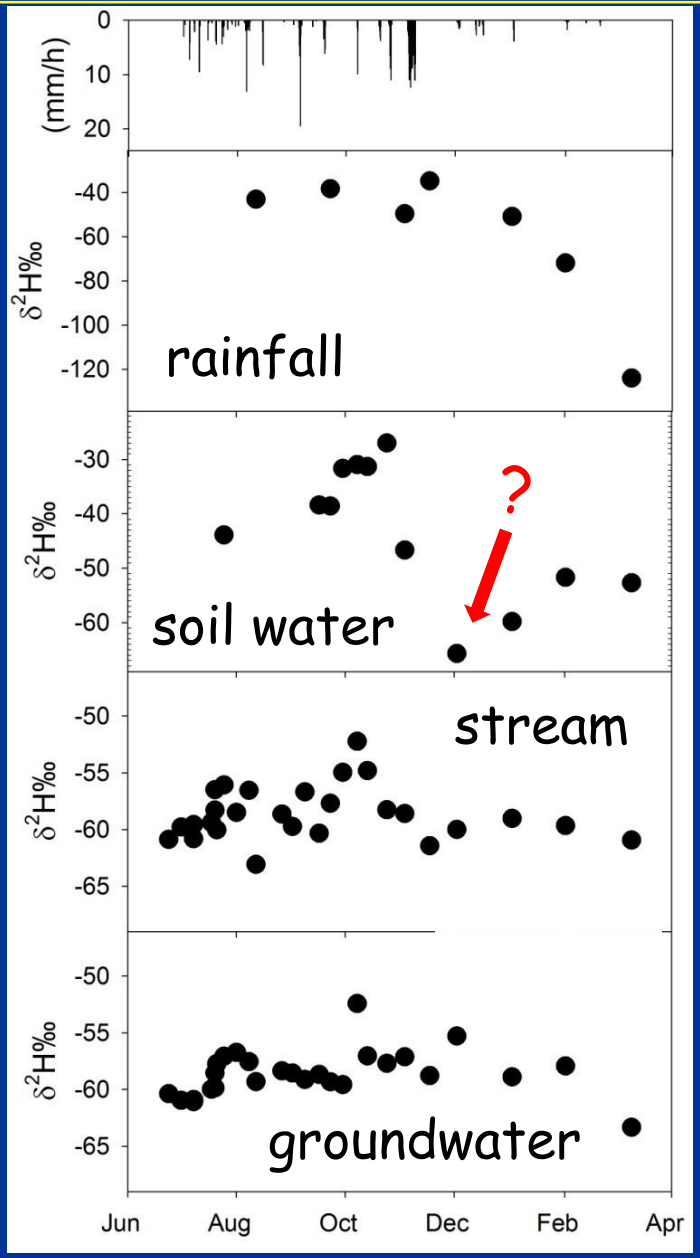
Water cicle components: relation to GMWL

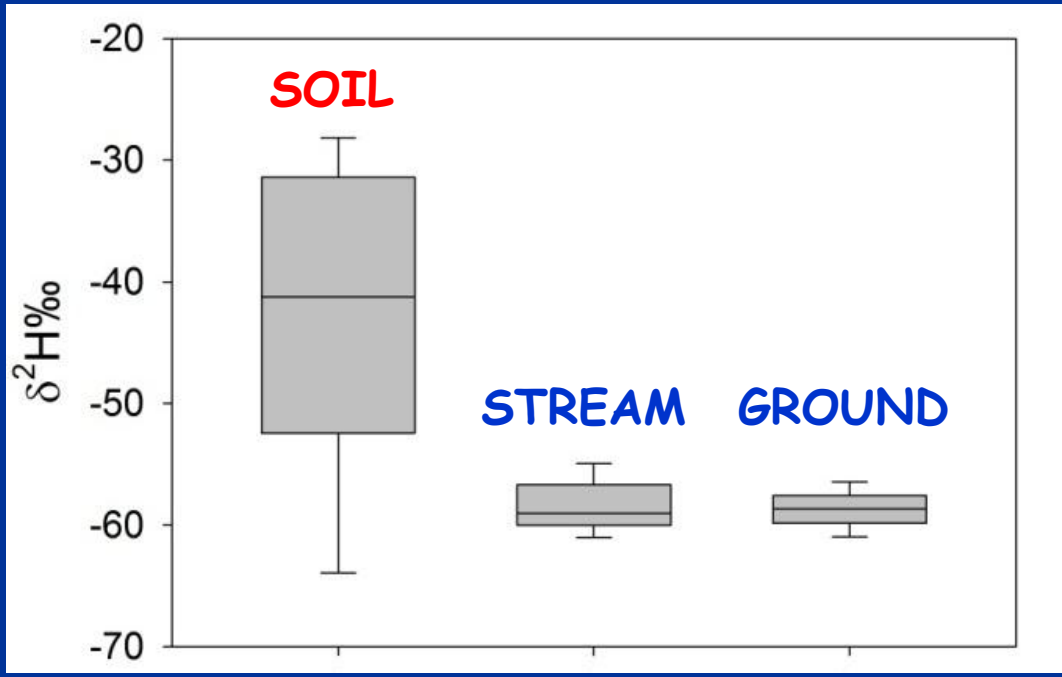




Temperature	Mean	(Min \ Max)
Jul	16.9	7.3 \ 27.4
Aug	19.3	10.0 \ 30.9
Sept	16.7	7.3 \ 26.1
22 Aug	23.2	18.0 \ 30.9
26 Aug	22.4	18.2 \ 28.7

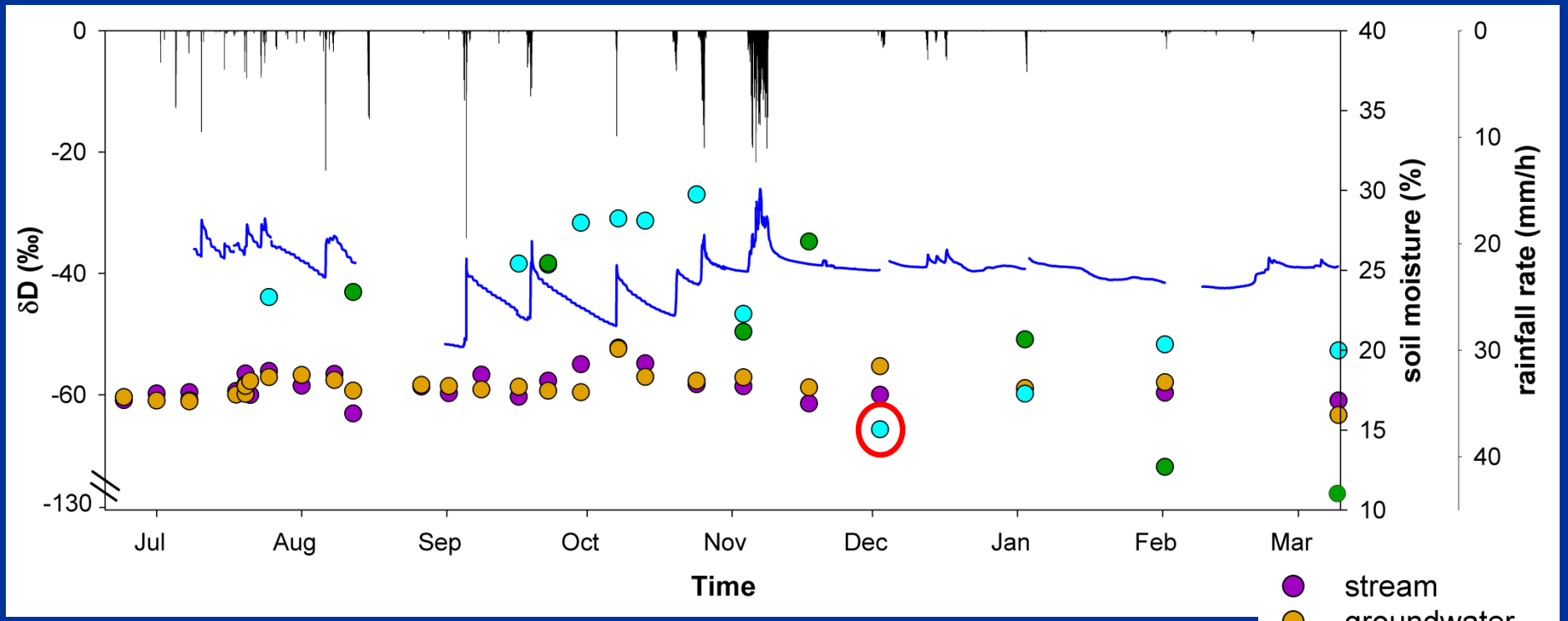
Analysis of different water sources: isotopes





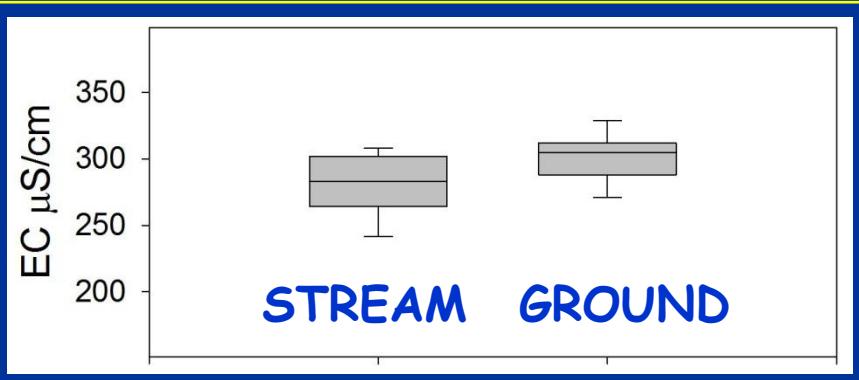
- Soil water is more variable → reflects the variability of precipitation
- Soil water ≠ from stream and groundwater (Kruskal-Wallis, $p < 0.001$)

Analysis of different water sources: isotopes



- Low variabilty of stream water and groundwater isotopic composition
- Higher variability of soil moisture and soil water isotopic composition as response to precipitaton

Analysis of different water sources: EC



$p < 0.05$

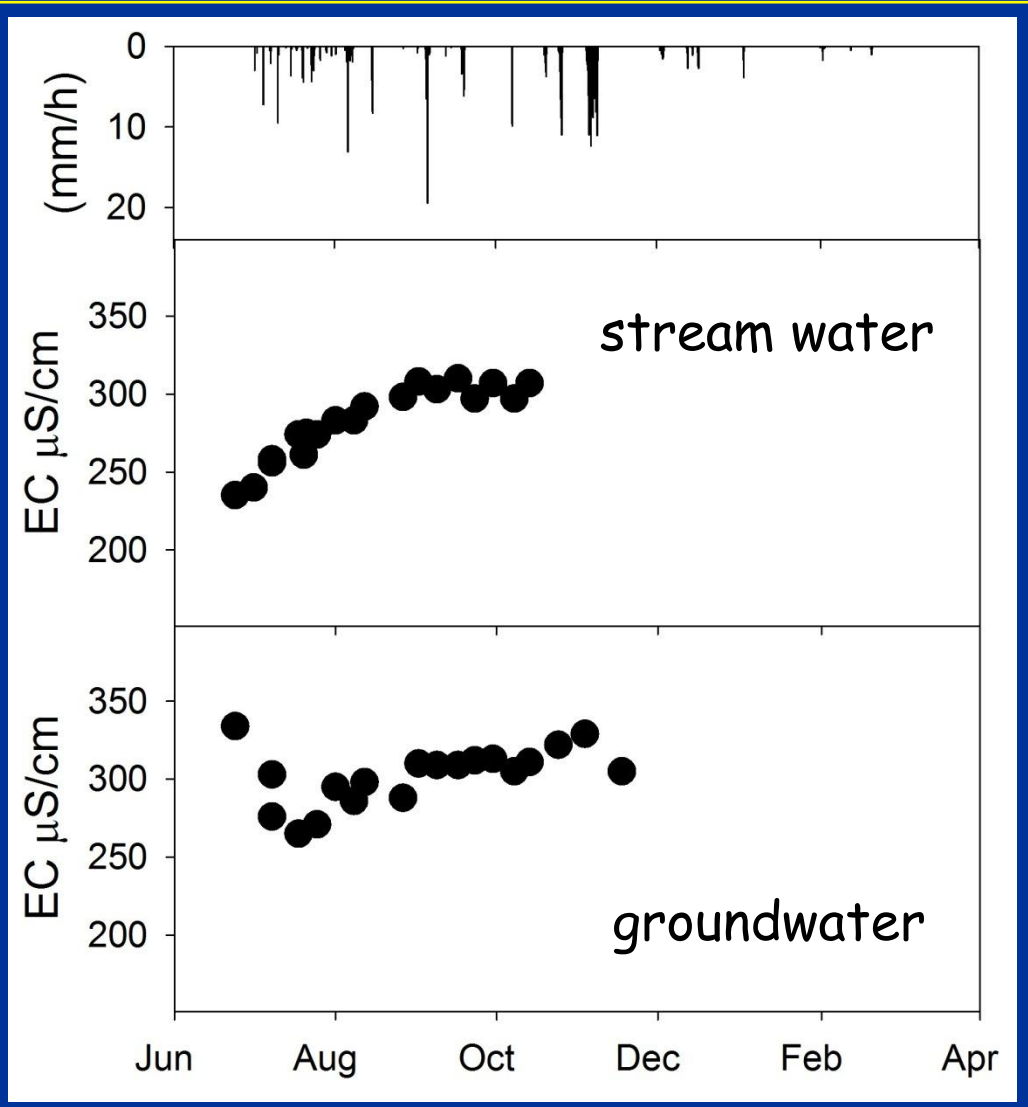
Hp of groundwater origin: snowmelt infiltrating from upper catchments

Increasing trend in streamflow EC…

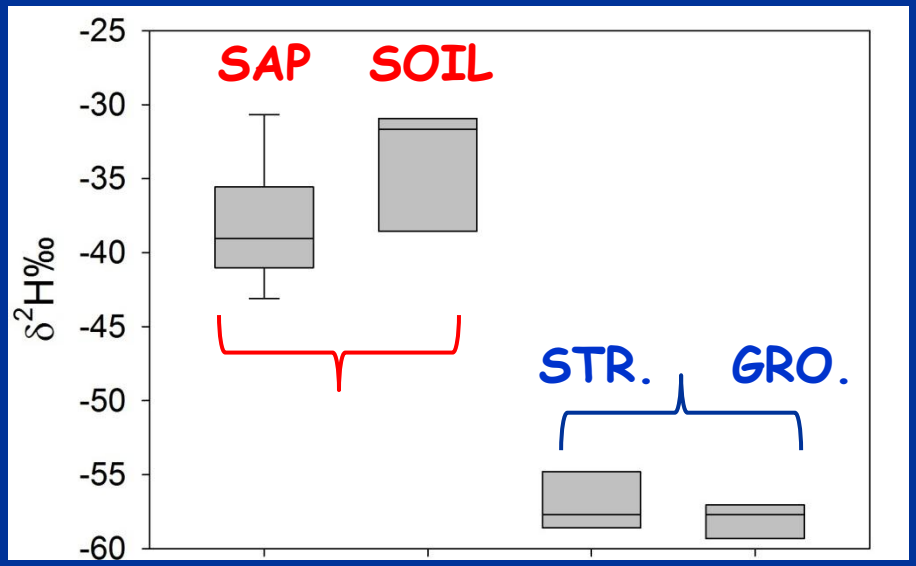
…decreasing contribution of snowmelt? Unlikely!

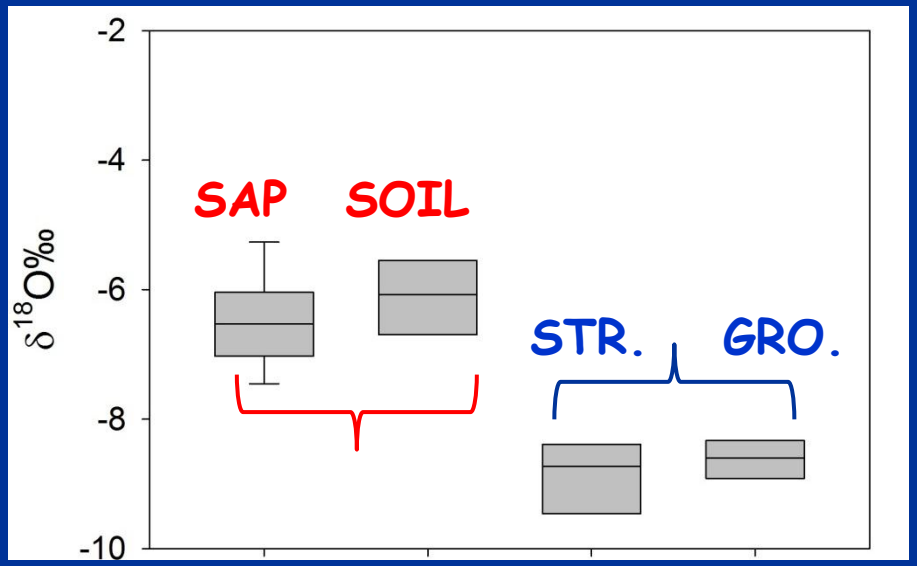
…anthropic influence?

…?



What is the origin of sap water?

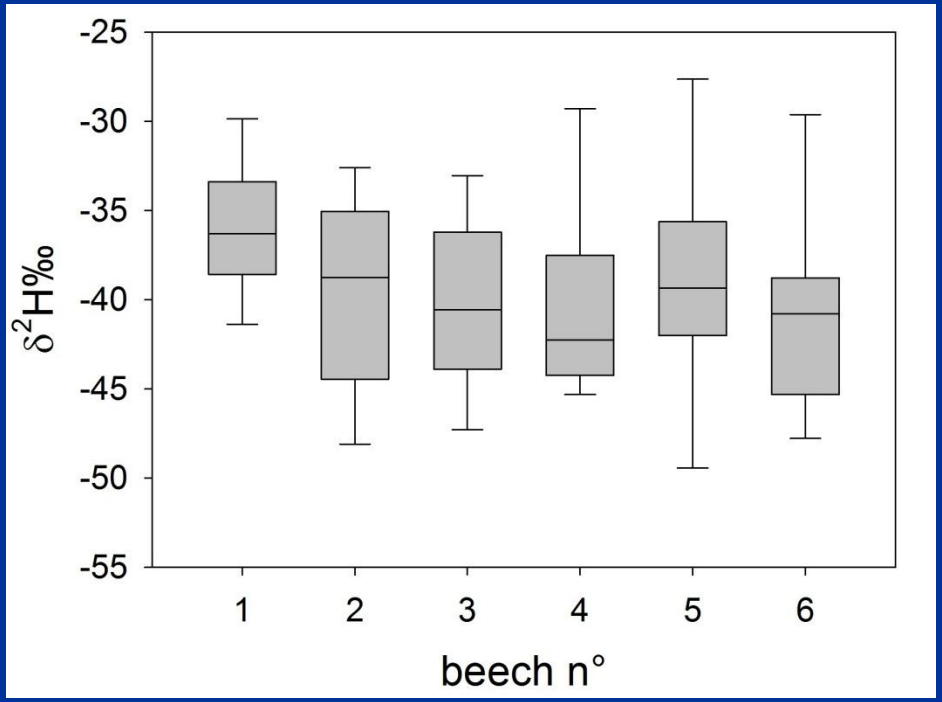




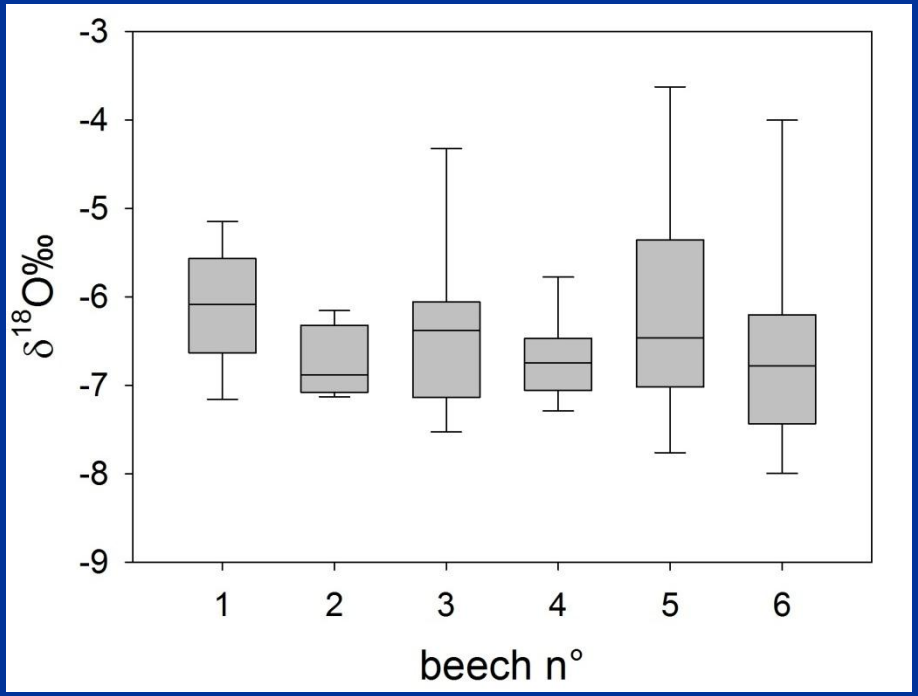
- Sap water = soil water
- Stream water = groundwater
- Sap water & soil water ≠ stream water & groundwater (multiple comparisons test, $p < 0.05$)

Water uptake by trees from the first 30-50 cm of soil

Spatial variability of sap water among trees



p = 0.20



p = 0.26

Low variability of isotopic composition of sap flow, not statistically different (Kruskal-Wallis test)

Tree use the «same» water

Summary of preliminary results

- Fast hydrological response → role of small scale, soil properties and unfracturated (?) basement
- Soil water isotopic composition reflects the precipitation signal
- Same composition (→ similar origin) of stream and groundwater but different EC temporal dynamics
- Sap water = soil water → mainly extraxted by unsaturated zone
- No spatial variability of water uptake

Future perspectives: still lots to do…

- To install:
  - Rain gauge below/outside canopy
  - Automatic water sampler + continuous EC meter
  - Sap flow sensors
  - Eddy tower (?)

- To perform:
  - Complete yearly monitoring
  - 2- and 3-component hydrograph separation
  - Water sampling before, during and after ra
  - …

Last month (bad?) surprise: forest cut!

No more selected trees but opportunity to monitor streamflow changes, hillslope instability, space recolonization

ORIGIN OF SURFACE AND SUBSURFACE WATERS IN A PERIGLACIAL CATCHMENT ANALYSED BY MEANS OF ENVIRONMENTAL TRACERS

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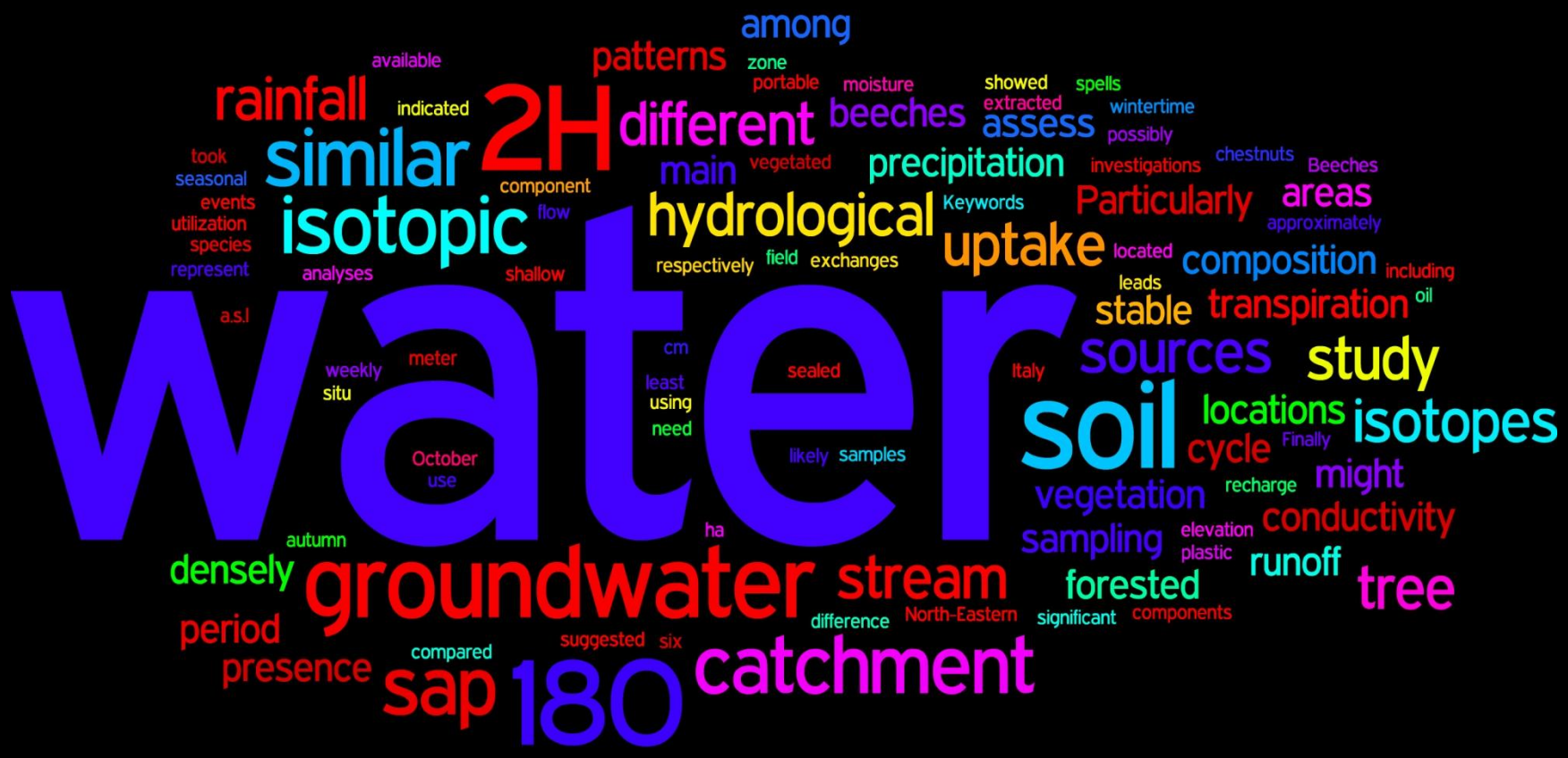
Poster Programme HS2.8 - A112

(EGU2012-5738)



Thank you for your attention