An isotopic comparison of waters obtained by destructive and non-destructive methods to evaluate mixing and runoff processes at the mini-hillslope scale

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**Introduction**
- Technical developments have fostered the application of stable water isotopes (δH and δ18O) to measure, understand and predict water flow paths and different pools of subsurface water.
- To gain the isotopic information preserved in the soil, many pore water extraction methods exist, but their effects on natural soil water isotopic composition are poorly understood.

**Null hypothesis:**
Destructive and non-destructive extraction methods sample isotopically the same soil water pool.

We intercompared destructive and non-destructive water extraction methods on an outdoor mini-hillslope:
- Non-destructive: Suction cups (Slope 1) and in-situ vapour ports (Slope 2).
- Destructive: Centrifugation and vapour equilibration method (Slope 3).

**Materials and Methods**
- Hillslopes contain volcanic basalt rock of loamy sand texture (Bioseph 2, U of A, USA).
- Slopes initially filled with tap water.
- Afterwards, natural precipitation used as input function to study water flow paths isotopically over and through the soil profile of the hillslopes.
- Measurement equipment: Climate station, soil moisture & temperature sensors, load cells under each hillslope, bottom outflow and surface runoff gauges.
- 6 non-destructive sampling; 3 replicates per depth and zone.
- δH and δ18O analyses on a laser spectroscope (AR-450EP Analyzer, LGR Inc., US; precision: ±0.5% for δH and ±0.1% for δ18O for liquid water; ±0.2% for δH and ±0.05% for δ18O for water vapor).
- Local Meteoric Water Line (LMWL) from regression analysis of local precipitation data.
- δc-excess as indicator for non-equilibrium fractionation:
  \[ \delta c = \delta H - \delta ^{18}O \times a + b \]
  with a=slope and b=intercept.

**Results and Discussion**
- Zone 1:
- Zone 2:
- Zone 3:

**Dual isotope data**
- All methods’ isotope results fall within the range of precipitation and runoff, except for the in-situ vapour ports.
- Isotope results from the in-situ vapour ports showed the greatest offset from the LMWL and the input signal, especially for the lowest depth (30-40cm).
- Issues with in-situ vapour ports were mostly due to high water contents causing condensation in the tubing.

**Surface runoffs**
- Suction cups failed when soils were dry and pores most likely became clogged with soil material.
- Centrifugation and vapour equilibration method plotted in the same isotopic range for all hillslopes and even showed a 1:1 relationship.
- Destructive and non-destructive extraction methods did not sample the isotopically same soil water pool.

**Temporal variation**
- Precipitation was isotopically more enriched in summer than in autumn as air temperatures dropped below zero.
- Surface runoff followed the isotopic trend of the precipitation input and fell on the LMWL.
- Bottom outflow was not always present and was isotopically more depleted.
- Soil temperatures of both slopes were almost identical and followed air temperature trends.

**Conclusions**
- Centrifugation and vapour equilibration were most reliable.
- Applied extraction methods most likely sampled the more mobile soil water pool as results fell within the range of precipitation.
- Aim of individual study dictates which method is suitable for particular results, sample types and properties, timeline, cost, and precision.

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**Footnotes:**
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