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HS2.2.4 Isotope and tracer methods: flow paths characterization, catchment response and transformation processes

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OESCHGER CENTRE CLIMATE CHANGE RESEARCH

Reduced fraction of young water in Alpine catchments with increased seasonal snow cover

Paper in Review in Hydrological Processes

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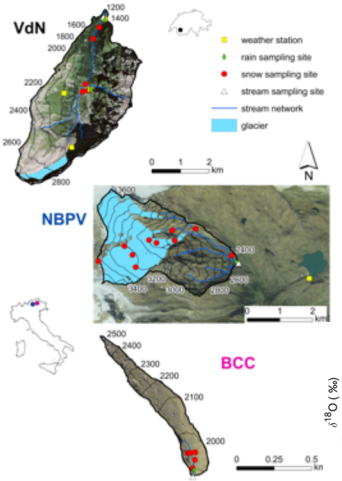
Background

- Water age is important for water management
  - Improve drought management
  - Relevant in cold climates with snow melt
  - Especially as snowpacks more intermittent (global climate change)
- Alps are an importance water source for downstream areas

➢ How (and how fast) does snow move through catchment?

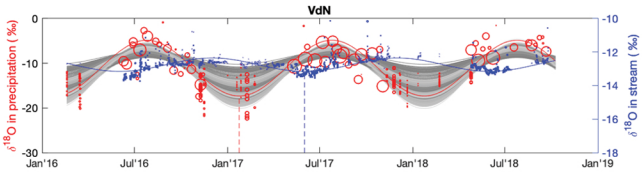
Study Sites

- Vallon de Nant, Vaud, CH: 13.5 km², 1189-3051 m. asl., stream 5 km, LC mix grassland, forest, rocks (3% glacier)
- Noce Bianco at Pian Venezia, Italy: 8.5 km², 2298-3769 m. asl., stream3 km, LC dominated by bare rock, and glacier (42%)
- Bridge Creek Catchment, Italy: 0.14 km², 1932-2121 m. asl., stream <300 m, LC dominated by alpine grassland (no glacier)



Approach

Stable Isotopes of water, becoming easier and more cost-effective to analyze, allow for an estimation of the fraction of young water (with an age < 3 months).



Amplitude of $\delta^{18}O$ in:
- Q- discharge
- Precipitation

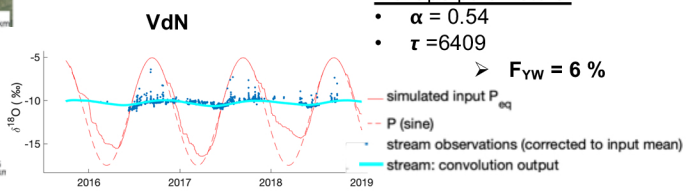
$$F_{yw} \approx \frac{A_Q}{A_p} = \frac{0.40}{6.22} = 6.5\ \%$$

Ratio Method (Kirchner, 2016)

➢ Shortcomings:
- Does not account for snowpack storage
- Does not account for irregularities in sampling (widespread in seasonally inaccessible locations)
- Assume Gamma distributed transit times

We propose a new framework to assess young water fraction

1. **Sine fit incoming precipitation**
   - Effect date assignment, weight, handling multiple samples for rain and snow
   - Isotope phase shift, φ_p, = $\varphi_{Air\ Temperature}$
2. **Simple Snow Model => P_{eq} (equivalent precipitation)**
   - Degree-day
   - P_{eq} = Melt + Rain
   - Full mixing
   - 100 m elevation band
   - Temperature Lapse Rate
3. **Convolution**
   - Allows estimation of F_{yw} without fitting sine curve
   - Uses all information from input and output
   - Fourier transform of gamma distribution
   - Identifies distributional parameters matching observations

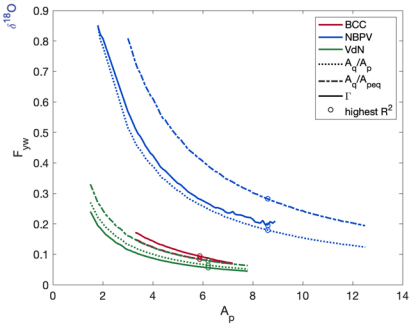


Γ shape parameters:
- α = 0.54
- τ =6409

➢ F_{YW} = 6 %

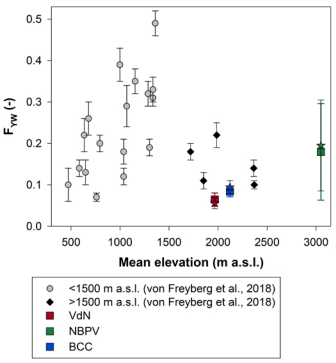
Findings

- New framework finds a greater fraction of young water.
- Sampling design and construction of time series can have important changes on final Fyw.



Conclusions

➢ High elevation Alpine catchments might have relatively "old" water or low fractions of young water.



➢ Critically important to understand the affect of the transition from seasonal to intermittent snow cover on water resources in alpine environments.

References

- Kirchner, 2016. HESS, *20*(1), 279-297.
- von Freyberg, J. et al., 2018. HESS, *22*(7), 3841-3861.

Photos show changing snowpack in Vallon de Nant, by authors.