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

Natalie Ceperley (contact: natalie.ceperley@giub.unibe.ch), Giulia Zuecco, Harsh Beria, Luca Carturan, Anthony Michelson, Daniele Penna, Joshua Larsen, and Bettina Schaeffli

Paper in Review
in *Hydrological Processes*

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?

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, $\phi_P = \phi_{Air} \text{ Temperature}$

2. Simple Snow Model => P_{eq} (equivalent precipitation)

- Degree-day
- $P_{eq} = \text{Melt} + \text{Rain}$
- 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:

- $\alpha = 0.54$
- $\tau = 6409$

$F_{yw} = 6 \%$

Findings

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

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.