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The *EXPECT* method: a multi-tracer approach for reliable high temporal resolution young water fraction estimates

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The portion of recently introduced water molecules in a stream, known as the young water fraction, is crucial in catchment intercomparison studies. The unweighted or flow-weighted average young water fraction in a catchment, over the period of isotope sampling, can be assessed through the ratio of flow-weighted or unweighted seasonal isotope cycles amplitudes in streamwater ($A^{(*)}_S$) and precipitation (A_P), respectively. The symbol '*' here indicates a flow-weighted variable. However, the young water fraction resulted to be a no-stationary quantity within individual catchments.

Indeed, past studies revealed that young water fractions increase with stream discharge (Q). Accordingly, the rate of increase in young water fraction with increasing Q has been defined as the discharge sensitivity of young water fraction (S^*_d). S^*_d has been quantified as the parameter of a non-linear equation that expresses how $A_S(Q)$ varies with Q. Such parameter is directly obtained by fitting a sine curve, with amplitude $A_S(Q)$, on streamwater isotope data. Accordingly, in catchments with sparse isotope data S^*_d could be highly uncertain.

In this study, we introduce a novel approach designed to enhance the temporal resolution of young water fraction estimates, consequently refining the determination of S^*_d. Our proposed method, referred to as *EXPECT*, is grounded in three fundamental assumptions.

- We propose a mixing relationship that follows an exponential decay of *EC* with an increasing young water fraction.
- We posit that the two-component hydrograph separation technique, utilizing measured Electrical Conductivity *(EC*) as a proxy of water age and the aforementioned exponential mixing relationship, can effectively delineate the proportion of young and old water in a stream by using appropriate end-members.
- We assume that the *EC* value of the young water endmember (EC_{yw}) is lower than that of the old water endmember *(*EC_{ow}).

The two endmembers, EC_{yw} and EC_{ow}, have been adjusted through a calibration process by

aligning the unweighted and flow-weighted average young water fractions obtained through hydrograph separation with the corresponding values derived from seasonal isotope cycles (A_S/A_P and A^*_S/A_P, respectively).

The method has been tested in three small catchments in the Alptal valley, Switzerland, returning promising results. Nevertheless, we emphasize the importance of considering the limitations of *EC* as a tracer and the peculiar characteristics of the catchments under investigation for the appropriate application of the *EXPECT* method.

Keywords: Stable water isotopes, Electrical Conductivity, Young water fraction, Discharge Sensitivity

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References

Gentile, A., von Freyberg, J., Gisolo, D., Canone, D., and Ferraris, S.: Technical Note: two-component Electrical Conductivity-based hydrograph separaTion employing an EXPonential mixing model (EXPECT) provides reliable high temporal resolution young water fraction estimates in three small Swiss catchments, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-1797, 2023.