Supplemetary material - Technical Note: two-component *E*lectrical *C*onductivity-based hydrograph separa*T*ion employing an *EXP*onential mixing model (*EXPECT*) provides reliable high temporal resolution young water fraction estimates in three small Swiss catchments

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Summary:

This document contains a focus about the discharge sensitivity estimation following the approach used by Gallart et al. (2020b). Figure S1 shows the daily F_{yw}^{opt} timeseries of the three-study catchment with indication of local maxima/minima (left panels) and the distribution of F_{yw}^{opt} rising/falling limbs length (right panels).

The discharge sensitivity of young water fraction

The seasonal isotope cycles in precipitation c_P(t) (‰) and in streamflow c_S(t) (‰) can be modelled using a sinusoid function, as reported in Eq. (S1) and Eq. (S2):

$$c_P(t) = A_P \sin(2\pi f t - \varphi_P) + k_P \ , \quad \text{(S1)}$$

$$c_S(t) = A_S^{(*)} \sin\left(2\pi f t - \varphi_S^{(*)}\right) + k_S^{(*)} \ , \quad \text{(S2)}$$

where A_P and A_S are the amplitudes (‰) of seasonal isotope cycles, *f* is the frequency of the cycle (1 y^{-1}), *t* is time (decimal years), ϕ_P and ϕ_S are the phases (rad) of seasonal cycles and k_P and k_S are the vertical shift (‰) of the seasonal cycles. The symbol "*" refers to a streamflow-weighted variable. The coefficients A_P, ϕ_P, k_P can be obtained by fitting volume-weighted Eq. (S1) on precipitation isotopic composition c_P(t) using iteratively re-weighted least squares (IRLS), a robust estimation method that minimizes the influence of outliers. By using the same technique, the coefficients $A^{(*)}_S$, $\phi^{(*)}_S$, $k^{(*)}_S$ can be obtained by fitting (unweighted or flow-weighted) Eq. (S2) on streamwater isotopic composition c_S(t). The amplitude ratio $A^{(*)}_S/A_P$ can be used to estimate the time-weighted or flow-weighted average fraction (F_{yw} or F^*_{yw}) of water younger than a threshold age (τ_{yw}). For a wide range of transit time distributions, τ_{yw} is approximately 2.3 ± 0.8 months (Kirchner, 2016a).

In order to understand the statistical sensitivity of F^*_{yw} to *Q*, Gallart et al. (2020b) assume an exponential-type $F^*_{yw}(Q)$ relationship that converges toward 1 (i.e. streamflow is composed entirely of young water) at the highest flows, as reported in Eq. (S3):

$$A_S^*(Q) = A_P F_{yw}^*(Q) = A_P[1 - (1 - F_0^*)\exp(-Q\, S_d^*)] \ , \quad \text{(S3)}$$

By inserting Eq. (S3) into Eq. (S2) yields:

$$c_S(Q,t) = A_P[1 - (1 - F_0^*)\exp(-Q\ S_d^*)]\sin(2\pi f t - \varphi_S^*) + k_S^*\ , \qquad \text{(S4)}$$

Where S_d^* (Q^{-1}) is called the discharge sensitivity of the young water fraction and F_0^* (-) is the virtual young water fraction for Q = 0. Such parameters can be estimated by fitting flow-weighted Eq. (S4) on streamwater isotopic composition c_S(t) using IRLS method.

F_{yw}^{opt} timeseries with analysis of the F_{yw}^{opt} rising/falling limbs duration

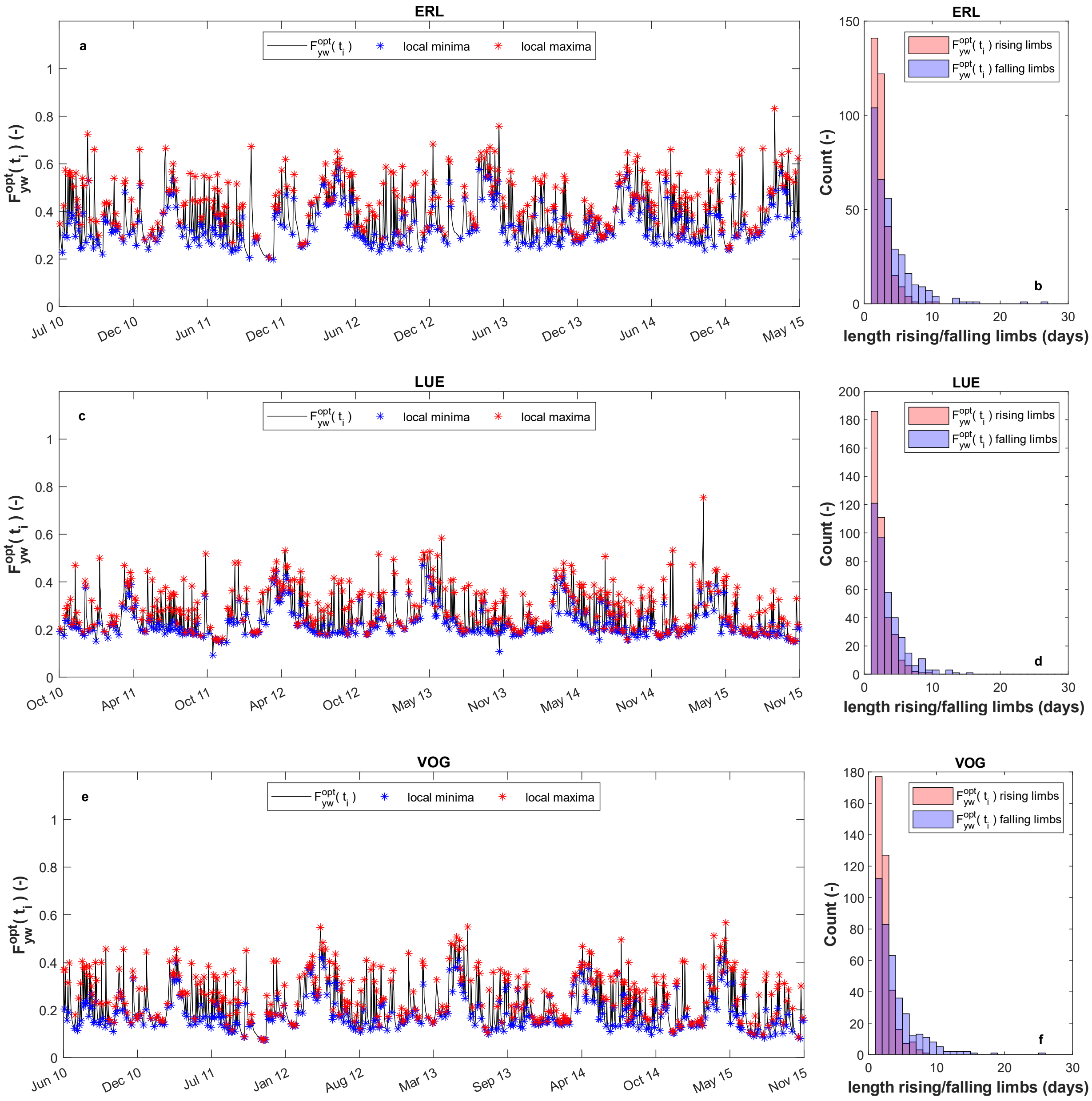

Figure S1. Daily F_{yw}^{opt} timeseries of the three-study catchment with indication of local maxima/minima (panels a,c,e) and distribution of F_{yw}^{opt} rising/falling limbs length (panels b,d,f). These distributions indicate that F_{yw}^{opt} rapidly increases after an event, while it recedes slower during no-input days.