



Supplement of

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

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Supplement

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):

$$C_P(t) = A_P \sin(2\pi ft - \phi_P) + k_P, \quad (S1)$$

$$C_S(t) = A_S^{(*)} \sin(2\pi ft - \phi_S^{(*)}) + k_S^{(*)}, \quad (S2)$$

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 unweighted 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):

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

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

$$C_S(Q, t) = A_P [1 - (1 - F_0^{*}) \exp(-Q S_d^{*})] \sin(2\pi ft - \phi_S^{*}) + k_S^{*}, \quad (S4)$$

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

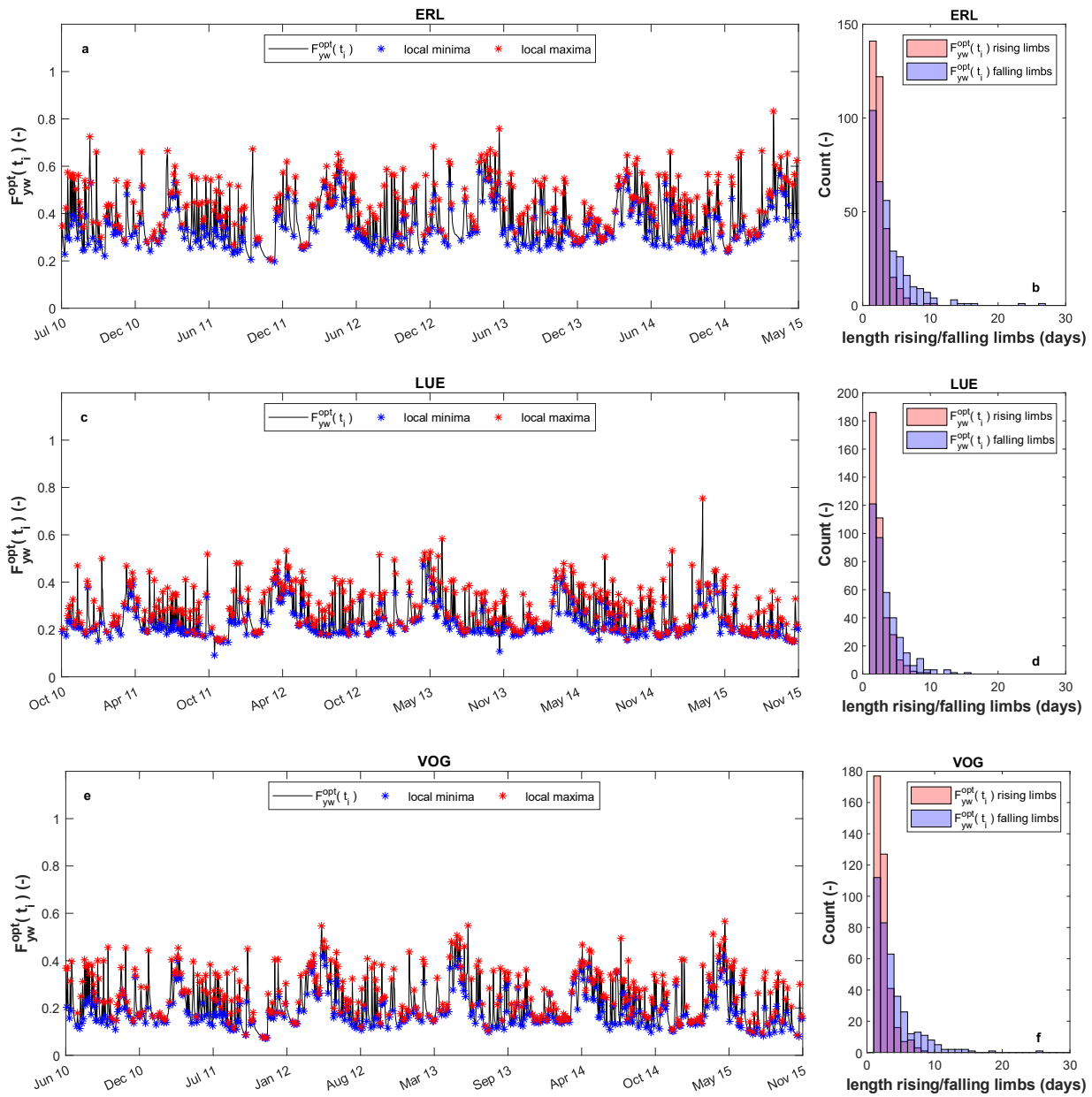


Figure S1. Daily F_{yw}^{opt} timeseries of the three-study catchment with indication of local maxima/minima (panels a,c,e) and distribution of F_{yw}^{opt} rising/falling limbs length (panels b,d,f). These distributions indicate that F_{yw}^{opt} rapidly increases after an event, while it recedes slower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