New water fractions and transit time distributions at Plynlimon, Wales

Julia L. A. Knapp[1], and James W. Kirchner[1,2]

[1] Department of Environmental Systems Science, ETH Zurich, Zurich, Switzerland
[2] Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf, Switzerland

follow the link!

These results are published here:
Knapp et al. (2019), *Hydrology and Earth System Sciences*.

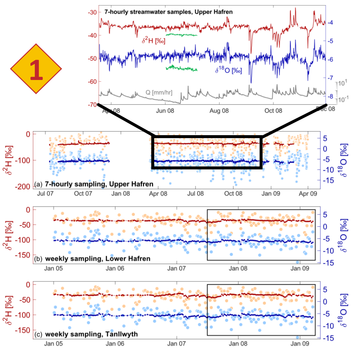
ETH zürich

Data

Stable water isotopes in precipitation and streamwater at 3 subcatchments:
- Upper Hafren: 17 months of 7-hourly sampling
- Lower Hafren, Tanllwyth: 4.25 years of weekly sampling

The precipitation isotope signal is highly variable; mixing and transport processes result in damping of the signal from precipitation to streamwater.

1



Analysis: *Ensemble Hydrograph Separation*

The new water fraction F_{new} quantifies the average contribution of recent precipitation to streamflow across an ensemble of time steps, using the slope of the simple linear regression (Kirchner, 2019):

$$c_{Q_j} - c_{Q_{j-1}} = F_{\text{new}}\left(c_{P_j} - c_{Q_{j-1}}\right) + \alpha + \varepsilon_j$$

c_{P_j} and c_{Q_j} represent the tracer concentrations in precipitation and streamwater, respectively, for a series of sampling times j; α is the regression intercept, and ε_j is the error term.

Results

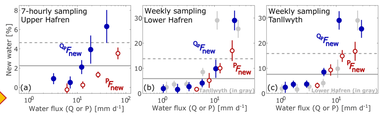
On average, only around 3 % of streamwater was made up of precipitation that fell within the previous 7 hours, and 13-15 % of streamwater consisted of precipitation that fell during the previous week.

	7-hourly sampling at Upper Hafren	Weekly sampling at Lower Hafren	Weekly sampling at Tanllwyth
New water fractions for all time steps, ${}^{Q}F_{\text{new}}$ (%):	0.88 ± 0.11	4.93 ± 0.72	5.58 ± 0.71
Volume-weighted new water fractions for all time steps, ${}^{Q}F^{*}_{\text{new}}$ (%):	2.95 ± 0.41	13.19 ± 1.88	14.61 ± 1.81
Event new water fractions, ${}^{Q_P}F_{\text{new}}$ (%):	2.42 ± 0.31	7.36 ± 1.08	8.33 ± 1.07
Volume-weighted event new water fractions, ${}^{Q_P}F^{*}_{\text{new}}$ (%):	5.02 ± 0.70	14.57 ± 2.087	15.90 ± 1.97

New water fractions as function of water flux:

The contribution of recent precipitation to streamflow was highest during large events, likely due to greater saturation of soils resulting in faster transport. Additionally, channel network expand with increasing precipitation, causing raindrops to fall closer to the channel and reach the catchment outlet faster.

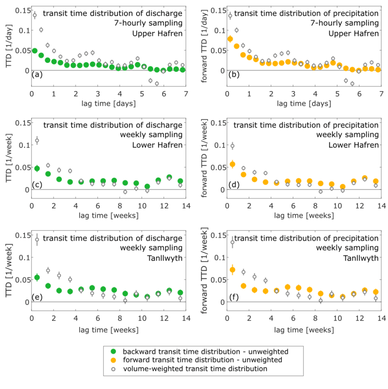
2



${}^{Q_P}F_{\text{new}}$: event water fraction
${}^{P}F_{\text{new}}$: new water fraction of precipitation

Transit time distributions:

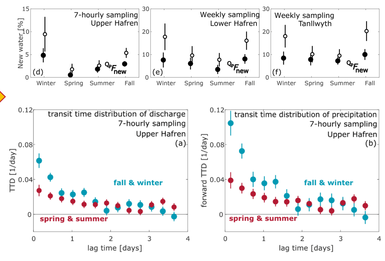
Transit time distributions (also estimated from Ensemble Hydrograph Separation) were low and broad. Volume-weighted transit time distributions showed somewhat stronger peaks at short lag times, consistent with transport being faster during larger events.



Dependence on seasons:

The dependence of new water fractions on water fluxes was also reflected in their seasonal variations, with lower new water fractions and more damped catchment transit time distributions in (drier) spring and summer compared to (wetter) fall and winter.

2



1 Damping of isotope signals allows quantifying **recent contributions of precipitation to streamflow ("new water fractions" F_{new})**.

2 New water fractions and transit time distributions **vary as function of discharge and season**, indicating changes in catchment connectivity and faster transport under wetter conditions.

References

For more details on this study please see:
Knapp, J. L. A., Neal, C., Schlumpf, A., Neal, M., & Kirchner, J. W. (2019). New water fractions and transit time distributions at Plynlimon, Wales, estimated from stable water isotopes in precipitation and streamflow. *Hydrology and Earth System Sciences*, *23*(10), 4367-4388.

click to view the paper!

For more information on the Ensemble Hydrograph Separation approach, please see:
Kirchner, J. W. (2019). Quantifying new water fractions and transit time distributions using ensemble hydrograph separation: theory and benchmark tests. *Hydrology and Earth System Sciences*, *23*(1), 303-349.