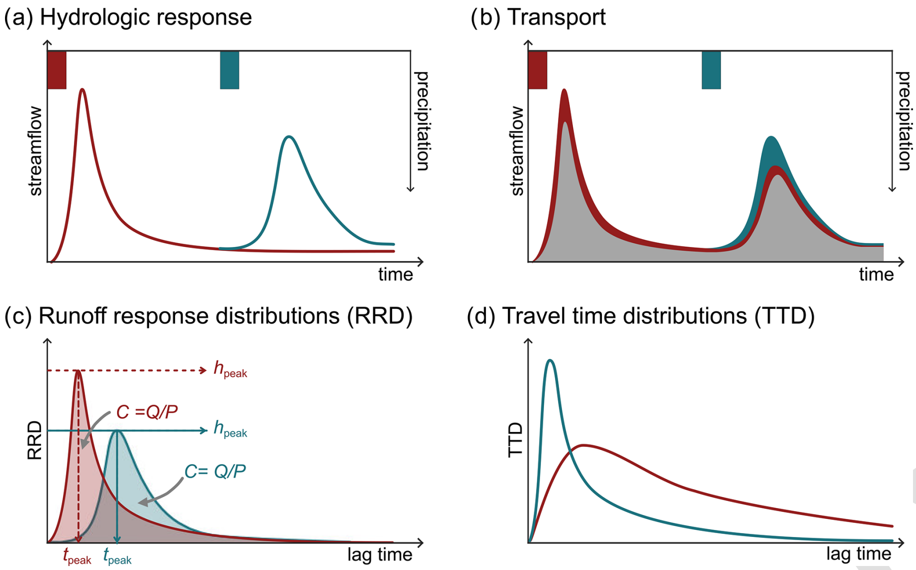

Figure 2. Hydrologic response and transport exemplified across two events (red and green). Streamflow is generated in response to precipitation inputs **(a)**, but only some fraction of the generated streamflow consists of precipitation from the most recent precipitation event **(b)**. Runoff response distributions (RRD, **c**) and travel time distributions (TTD, **d**) shape the observed response and transport and can take many different shapes, with ensemble distributions (not shown) characterising the "typical" response under specific conditions. The RRD **(c)** quantifies the time that the precipitation input takes to generate streamflow, and the illustrated metrics describe runoff characteristics in response to each unit of precipitation (i.e., the peak height h_{peak}, the peak time t_{peak}, and the runoff coefficient C). The TTD **(b)** quantifies the time for precipitation inputs to become streamflow. New water fractions (F_{new}) can be derived from the TTDs and assess the amount of precipitation contributing to streamflow that is "new" since the last sampling of streamflow.

3.1 Effect of antecedent wetness

Antecedent wetness affected the hydrological response and transport at both the Erlenbach and Upper Hafren catchments (illustrated in blue in Fig. 4). The peak height of the RRD h_{peak} and the runoff coefficient C increased with antecedent wetness, more than doubling between dry and wet conditions. This suggests a much greater response in streamflow to the same precipitation input under wetter conditions (Fig. 4a, c, i, k, m, and o), which is similar to the behaviour one would expect from a nonlinear storage–discharge relationship. Notably, the timing of the arrival of the runoff peak t_{peak} did not change substantially with antecedent wetness (Fig. 4e and g), suggesting that the streamflow responses occurred equally quickly during dry and wet conditions.

When tracking the transport of water through the catchment, we focused on transport metrics (i.e., the new water fractions ${}^{Q_P}F_{\mathrm{new}}$ and ${}^{P}F_{\mathrm{new}}$) rather than the full TTDs due to the limited number of isotope data points available. Both forward and backward new water fractions were small (around 5 %) and did not increase with greater antecedent wetness (Fig. 4q and s). We also quantified new water fractions over aggregated intervals of 21 h (Fig. S1 in the Supplement). New water fractions were larger for these longer intervals than for the original sampling intervals (1 and 7 h at Erlenbach and Upper Hafren, respectively), partly as a natural consequence of the fact that the fraction of new water will inherently grow with the interval of water age that is considered "new" (see Sect. 5.3 of Knapp et al., 2019, for a more detailed explanation). Across all time intervals, however, new water fractions exhibited similar patterns of small increases with antecedent wetness (Fig. S1).

Our findings indicate a strong dominance of older water in streamflow and show that antecedent wetness affects the transport of water through the catchment much less than it affects the streamflow response. Intriguingly, the two catchments had similar RRD and TTD metrics and similar sensitivities to antecedent wetness (Fig. 4), despite their substantial differences in topography, land cover, and geology.

3.2 Effect of precipitation intensity

The precipitation intensity affected the hydrologic response and transport in both catchments (red symbols in Fig. 4). Higher precipitation intensities shortened the RRD peak arrival time t_{peak} by factors of approximately ~~10~~ at Erlenbach and 4 at Upper Hafren (between the lowest and highest precipitation intensities; Fig. 4f and h). Higher precipitation intensities also increased RRD peak heights h_{peak} (Fig. 4j and l) and runoff coefficients C (Fig. 4n and p), approximately doubling both metrics between the lowest and highest precipitation intensities. These results suggest a stronger and quicker streamflow response to higher-intensity precipitation inputs.