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Investigation of hydrological connectivity at catchment scale through a dual-storage concept

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The effects of connectivity dynamics at catchment scale on hydrological response and geochemical signatures have been largely documented for a variety of catchments. However, the way how this time-variance in hydrological connectivity is modulated remains poorly understood. This is essentially due to the still rather simplistic mechanistic conceptualisations that do not account for the spatio-temporal dynamics of storage at the catchment scale that may eventually control connectivity. The objective of this contribution was to investigate catchment connectivity by improving our understanding of storage compartments and dynamics. We evaluated the potential for a combined lumped approach (i.e. combining storage estimated from the water balance and a recession analysis) to partition catchment storage into hydrologically connected and disconnected storages. We furthermore assessed the benefits of the proposed approach in comparison to the information on connectivity provided by classical storage-discharge relationships. The water balance calculation yields the total amount of water stored in the catchment (above a defined zero level), while we obtain hydrologically connected storage through the recession analysis. Disconnected storage was derived by subtracting the connected storage from total storage. The study was carried out in the forested Weierbach catchment in Luxembourg (0.45 km2). The catchment is characterized by a complex hydrological behaviour (i.e. double-peak hydrographs, non-perennial discharge). The recession analysis suggested that the catchment behaves like a simple dynamical system. However, the sensitivity of water balance calculations to accumulation and propagation of errors induced some uncertainty to the disconnected storage time-series. This restricted the use of the combined approach to event dynamics. Compared to classical storage-discharge relationships, the dual-storage relationship provides a better mechanistic understanding on how new water contributed to the storage function (i.e. connected or disconnected to the streamflow dynamic). Furthermore, this approach highlighted changes in the connectivity of storage to streamflow in the catchment by indicated ranges when all storage was disconnected, partially disconnected or completely connected. This is also evident from the dynamical transfer of water in the water-table fluctuation zone between the disconnected and connected components. This dual-storage concept may prove useful for catchment classification and illuminating key processes that control stream water chemistry.