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How certain physical and meteorological catchment parameters influence water ages and transit times

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We employed a physically-based spatially explicit 3D model to investigate how certain catchment parameters influence water ages and water transport dynamics in low-order catchments. The parameters we explored were catchment shape, porosity, bedrock conductivity, soil conductivity decay with depth, water retention curve, precipitation frequency, precipitation sequence and precipitation event amount. Each one of the parameters has its own specific influence on water ages and transport. Some of the results were expected (higher porosity = longer transit times), some were surprising to us. For example, we found that bedrock conductivity does not have a simple straightforward relationship with catchment transit time (i.e. an increase in conductivity causing a decrease in transit time). Instead, an increase in bedrock conductivity can also result in the overall increase in catchment transit time – e.g., when this increase allows a larger proportion of water to infiltrate into the comparatively less conductive bedrock instead of flowing towards the outlet in the more conductive soil. Also, the sequence of precipitation events that constitute the atmospheric forcing does play a less important role than we expected, i.e. it does not matter how the differently-sized precipitation events driving the water flow through the catchment are arranged – as long as the precipitation event frequency is high (≤3 days) and the event amounts are Poisson-distributed. We conclude that the multitude of influences from the different parameters makes it very challenging to find rules and underlying principles in the integrated catchment response, therefore it is necessary to look at the individual parameters and their potential interactions and interdependencies in a bottom-up approach.