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Influence of spatial and temporal flow variability on solute transport in catchments

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The present study quantifies the separate and combined effects of spatial and temporal variability of waterborne solute transport through catchments. The questions addressed are whether, when and why different types of variability may dominate catchment-scale transport. We utilize a versatile numerical solute transport code with a particle-based Monte Carlo time domain random walk method to simulate waterborne transport through a generic catchment. The methodology is exemplified by performing simulations using data on spatiotemporal flow and transport variability from direct stream discharge observations and independently calculated advective solute travel time distributions for catchments within the water management district Northern Baltic Proper (NBP) in Mid-Eastern Sweden. A main conclusion of the study is that projections of catchment mass loading based on spatial variability alone are robust estimates of long-term average solute transport development. This is especially true when annually aggregated mass load rather than finer temporal resolution of mass flux is considered. Temporal variability yields short-term fluctuations around the long-term average solute breakthrough development, and earlier or later arrival than the latter, depending on the timing and duration of solute input relative to the temporal flow variability. The exact temporal characteristics of future solute breakthroughs are thus fundamentally uncertain but their statistical expectation may be well quantified by only spatial variability account.