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Characterize the catchment regime by applying optimal monitoring strategies

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Commonly, chemical catchment regimes are described by a simple regression slope of log-concentrations versus log-discharges measured in the catchment outlet river. The slope value of these plots defines the chemical regime of a catchment. A slope=-1 corresponds to a constant contaminant release subject to dilution by rainfall (an unrealistic extreme but needed as a base flow); whereas a slope=0 means that there are chemostatic effects in the catchment or a washout of contaminants at a constant concentration. However, reality shows that actual time-series measurements of discharge and concentrations conflict with this naive representation since the measurements show temporal hysteresis that defies regression assumptions (i.e. that regression residuals must be uncorrelated). To represent this time interaction beyond regression, we design a simple stochastic time-series model that accounts for fluctuating concentration release and transport with memory. In this work, we also establish how to get the observation data required for a robust estimation of the slope with the least effort. To show the capability of our proposed model and method, we apply a retrospective optimal design of experiments to a high-frequency data series of nitrate concentration (collected by online probes) and discharge of a real catchment in Germany. We thin out the data by applying frequency and event-based monitoring strategies to find out the key components of the strategies that best predict the catchment behavior. Results indicate that our catchment under study (the Ammer catchment in southwestern Germany) is relatively close to a chemostatic type catchment and that our stochastic model, in fact, provides more accurate results for small data sets. Also, optimal data collection schemes for this purpose should be event-based, considering both high and low extremes of discharge that are spread out over time.