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Hysteretic analysis of nitrate dynamics in the nested Selke catchment (Germany)

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Nitrate transport into streams is closely controlled by hydrological processes and catchment characteristics. Storm events usually lead to high variability of nitrate-N concentration. Hysteresis patterns during storm events can be used to disentangle factors controlling stream nitrate-N concentrations and they reveal insight into the nitrate-N concentration in the flow pathways activated during storm events. In this study, six year (2012-2017) of high frequency (15 min) discharge and nitrate-N concentration at three gauging stations in the 456 km^2 Selke catchment (Germany) were used to investigate hysteresis during storm events. The three gauging stations: Silberhütte, Meisdorf and Hausneindorf are located in the upper (mixed land use), middle (forest) and lower parts (arable) of the Selke catchment, respectively, representing different combinations of the dominant land use and soil type classes. Both spatial and temporal variations of nitrate-N concentration in the catchment were analyzed. First, the event detection resulted in 88, 76 and 75 events for the three stations Silberhütte, Meisdorf and Hausneindorf, respectively. Second, the hysteresis loops were classified into clockwise and anticlockwise patterns, indicating different nitrate transport mechanisms (e.g., accretion or dilution from different flow paths). Results showed different numbers of clockwise and anticlockwise hysteresis patterns among the three stations. For instance, the Hausneindorf gauging station was characterized by larger number of anticlockwise hysteresis loops compared to the other stations. This can be explained by the large share of arable land and urban area land use classes in the downstream part of the Selke, compared to the upstream part where forest is dominating. This confirmed the land use effect on hysteresis loops. Also, among the three stations, boxplot results showed significant differences in the distribution of nitrate concentration but not of discharge. This reflected the nested nature of the catchment, where the high precipitation occurred in the upper part of the Selke resulting in high correlation between the discharges of the three gauging stations. Considering all stations together, the anticlockwise hysteresis patterns appeared more pronounced during summer and autumn, when discharge was relatively small, than during spring and winter. The study findings support the necessity of a long-term high-frequency monitoring program at controlling positions, which helps to gain further insights in nutrient transport processes and further guiding efficient agricultural management options.