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Analyses of Hyporheic Flow and Nitrate Removal for In-stream Bedforms using Perturbation Method

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Analytical models are important tools for our basic understanding of physical water movement within hydrological systems at various scales. Analytical models often are based on the Toth technique that truncates the physical flow domain into a rectangle, the so called Toth domain, for which the governing equations are solved analytically. The truncation from the physical into the Toth domain introduces errors and in-accuracies in the flow solution, if the obtained results are re-scaled into the original flow domain. Truncation artifacts can be corrected by applying perturbation methods, where a 1st-order approximation can be used that is valid for the entire, un-truncated flow domain. The latter is used for hyporheic flow modeling, providing the advective flow characteristics which are used for simulation of typical biogeochemical processes (aerobic respiration, ammonification, nitrification and denitrification). Application of the 1st-order approximation instead of the standard Toth approach for hyporheic systems, ranging from rippled bed-forms at the centimeter scale up to riffle structures of 10m and above, indicate that the accuracy of the water budget can be increased by up to 60% with dramatic implications for denitrification analyses. Results further indicate important implications of the presented method for hyporheic flow and transport analyses.