One-dimensional Solute Transport Models: Parameter Uncertainty Implications for Quantifying Biogeochemical Cycling in Stream Networks

Erika Smull, Adam Wlostowski and Michael Gooseff
Department of Civil and Environmental Engineering, Colorado State University

Abstract. Stream restoration efforts rely on scientific knowledge of the system, which may include transient storage and biogeochemical processing in regards to nutrient cycling and water quality. Solute transport modeling is a common tool used to quantify storage characteristics in natural channels. The information to inform such models can be obtained from a conservative stream tracer experiment, where a known amount of injected solute is tracked at the downstream end of the reach. One-dimensional transport models such as OTIS attempt to simulate the concentration-time profile from the tracer experiment, through a generated set of parameters (notably channel area, storage zone area, storage zone exchange rate, and dispersion). These parameters can then be used to calculate transient storage residence times and exchange rates to better understand storage-related biogeochemical processes. The extent to which we can rely on the parameters remains a topic of debate, and the use of such parameters, if uncertain, to calculate storage metrics, may result in order of magnitude differences in results. There has been a large body of work in recent years to better understand the underlying assumptions in parameter identifiability of the OTIS model, and the implications for solute transport studies. This study seeks to further this understanding by applying the OTIS model to tracer data from field studies performed on streams of varying morphologies and discharges (0.02-2.00 m^3/s) on Alaska's North Slope. Using a modified OTIS framework, which provides for parameter optimization and further Monte-Carlo based global sensitivity analyses, "best fit" parameters, as well as uncertainty bounds for model parameters, can be determined. The main goal of this work is to understand how parameter uncertainty translates into our interpretation of storage metrics, including storage residence times. Do our outcomes highlight differences in transport due to contrasting morphologies? The range of storage metrics as calculated from the range of viable parameters can indicate the applicability of transport models in remediation studies. The results of this study will help to inform scientists and engineers alike of the potential error ranges in storage metrics in relation to the transport model outputs.