Biogeochemical Model Complexity, or There and Back Again

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Biogeochemical models range from simple empirical relationships to highly complex mechanistic models. Selecting the structural complexity of a model depends on a variety of factors including, for instance, the level of conceptual understanding of the biogeochemical system, the availability and quality of data, the identifiability of the model parameters, and the sophistication of the model developer(s). A key criterion for model complexity, however, is the scope and use of the model. We illustrate this through two end-member examples of model applications to biogeochemical processes and cycles in artificial reservoirs. With over 50,000 large reservoirs worldwide, the damming of rivers represents one of the major anthropogenic perturbations of the continental water cycle. The associated environmental impacts range from global-scale modifications of elemental cycles, to regional and local effects, such as stream bank erosion and in-reservoir eutrophication. In the first example, we estimate the global retention of reactive silicon (Si) by river dams. Previous estimates are all based on a very small number of reservoirs for which reactive Si budgets can be reconstructed. We show that a simple biogeochemical mass balance model for Si cycling in reservoirs, combined with Monte Carlo simulations, can help overcome the limited availability and representativity of the existing data set. In the second example, we analyse the hydrodynamic drivers of nutrient cycling and algal productivity in reservoir systems. Preliminary numerical simulations for a tributary of the Three Gorges Reservoir indicate that the timing of algal blooms is closely linked to variations in the reservoir water level. A quantitative understanding of how the latter modulate circulation patterns in the tributaries may ultimately help refine the operation of China's mega dam, in order to reduce the frequency and severity of algal blooms.