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Useless arithmetic or useful scientific tools? Evaluation of the current state and future perspectives of aquatic biogeochemical modeling

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What is the capacity of the current models to simulate the dynamics of environmental systems? How carefully do modelers develop their models? Which model features primarily determine our decision to utilize a specific model? How rigorously do we assess what a model can or cannot predict? The first part of my presentation is to answer some of these questions by reviewing the state of aquatic biogeochemical modeling; a research tool that has been extensively used for understanding and quantitatively describing aquatic ecosystems. Mechanistic aquatic biogeochemical models have form the scientific basis for environmental management decisions by providing a predictive link between management actions and ecosystem response; they have provided an important tool for elucidating the interactions between climate variability and plankton communities, and thus for addressing questions regarding the pace and impacts of climate change. The sizable number of aquatic ecosystem modeling studies which successfully passed the scrutiny of the peer-review process along with the experience gained from addressing a breadth of management problems can objectively reveal the systematic biases, methodological inconsistencies, and common misconceptions characterizing the modeling practice in environmental science. My arguments are that (i) models are not always developed in a consistent manner, clearly stated purpose, and predetermined acceptable model performance level, (ii) the potential "customers" select models without properly assessing their technical value, and (iii) oceanic modeling is a dynamic area of the current modeling practice whereas, model application for addressing environmental management issues on a local scale faces challenges as a scientific tool. The second part of my presentation argues that (i) the development of novel methods for rigorously assessing the uncertainty underlying model predictions should be a top priority of the modeling community, and (ii) the model complexity should be commensurate to the available knowledge from the system; we need to adopt techniques that allow selecting parsimonious models over unjustifiably complex or oversimplistic modeling constructs. In this context, we will illustrate how the Bayesian inference techniques can be used to optimize the complexity of our mathematical models.