Interdisciplinary Environmental Models: Water Quality, Hydrology, Hydraulics

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The flow of nutrients in watersheds profoundly shapes ecosystem resource utilization and health. However, disturbances like climate change disrupt nutrient cycling, leading to imbalances that can trigger cascading impacts, including invasive species outcompeting native ones. Currently, we lack the ability to understand and predict the spatial distribution and temporal evolution of biomes in response to changing conditions, hindering our predictive capabilities and ecosystem management strategies. This requires the ability to holistically simulate nutrient flow across watersheds, to understand and predict the spatial distribution and temporal evolution of biomes in response to changing conditions.

We address the knowledge gaps by improving our understanding of nutrient dynamics' influence on species distribution and interactions and improving our predictive capacity for targeted ecosystem restoration strategies, fostering ecosystem resilience. To achieve this, we are integrating flow, water quality, and ecosystem models. Our Corps Library for Environmental Analysis and Restoration of Watersheds (ClearWater) was linked with external hydrologic (GSSHA) and hydraulic (HEC-RAS) models using the Basic Modeling Interface (BMI). ClearWater simulates temperature and nutrient interactions, algae dynamics, dissolved oxygen, and organic matter, given inputs from the hydraulic and hydrologic models and observed meteorology and water quality data. To develop holistic environmental watershed models, ClearWater will be linked with ecological models, particularly aquatic and terrestrial vegetation models.

Our approach has broad implications for next-generation ecological modeling. Model linking via BMI facilitates seamless data exchange, fostering interdisciplinary collaboration among scientists. These integrated models offer a comprehensive view of ecosystem dynamics. This enables accurate predictions of nutrient flows and ecosystem responses to environmental changes, improving decision-making and ecosystem management. Applications include setting nutrient loading limits, designing buffer zones, and implementing best practices to safeguard water resources and ecosystem health. Our work represents a significant step towards a more integrated and sustainable approach to environmental modeling.

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