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Bridging global and basin scale water quality modeling towards enhancing global water quality modeling and management

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The world's water resources are under increasing threat from a wide range of pollutants, which potentially limit the usability of water for both society and ecosystem functioning. Water quality (WQ) modeling plays an important role in better understanding the magnitude and impact of water pollution and in providing evidence for implementing policies and management practices. Global WQ modeling is increasingly used to gain unique insight into the state (e.g., pollution hotspots) and trend of global WQ issues under global climate and socio-economic changes. Global WQ models, such as Global-NEWS, account for the wide range of possible pollutant sources (e.g., agricultural, domestic and industrial). They are therefore excellent instruments to pinpoint the dominant drivers and sources for given pollutants. Information from such models can be used to guide policy-making for pollution abatement and mitigation. However, policy implementation and management plans are often at the basin or administrative (e.g., national or provincial) level rather than the global scale, wherein regional and basin scale models are more appropriate. Hence, there is a need to combine the identification of global pollution with pollution mitigation at a more context-specific and smaller scale. This need indicates that WQ models of different spatial scales should be actively linked and support each other to ensure responsive policy-making and effective WQ management. Currently, the different WQ modeling communities have limited communications, mainly because of the different modeling approaches underpinning global and basin scale models.

Global WQ modeling nowadays are mostly empirical (e.g., using the export coefficient approach) due to practical constrains such as data availability and computational costs. Empirical source-load relationships do not account for the underlying mechanisms. Consequently, the relationships are not necessarily transferrable to future conditions, if the modeled systems (e.g., river basins) undergo significant biophysciochemical changes (e.g., geomorphological alterations). In contrast, basin-scale WQ models generally quantify pollutant load by employing mechanistic approaches based on the underlying biophysciochemical processes. Mechanistic models are more transferrable than empirical models especially when the modeled systems undergo fundamental changes. Numerous basin scale WQ models have successfully been applied at the regional or continental scale, such as SWAT (Soil and Water Assessment Tool) and HYPE (HYdrological Predictions for the Environment). They are excellent demonstrations in employing basin mechanistic understanding in larger-scale WQ modeling. Although we do not argue for developing highly complex mechanistic global WQ models, future global WQ model development should take full advantage of mechanistic understanding from basin-scale WQ models.

In this work, we explore the missing linkages among WQ models of different spatial scales and discuss the possibilities and feasibility to bridge them. Two directions are proposed for better linking WQ modeling across different spatial scales: first, multiscale WQ modeling towards enhanced WQ and water resource management, and second, refinement and enhancement of global WQ models using basin-scale mechanistic understanding. We demonstrate our proposals using nutrients (nitrogen and phosphorus) and pesticides as the main water quality parameters.