Limnology in the 21st century: Incorporating data-intensive research, open science, and team science to address broad-scale problems

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Human-induced global stressors, such as global climate change, land use intensification, and the spread of invasive species, are emerging as the greatest environmental challenges of the 21st century. These stressors are having and will have significant consequences for aquatic resources, ecosystem and human health, and the economy. Knowledge gained from studying single systems intensively will not provide all of the solutions needed to understand these broad-scale and complex problems. Therefore, new perspectives and approaches are needed to help meet such challenges. This plenary will provide examples of the ways that three emerging strategies are likely critical for helping aquatic science meet broad-scale environmental challenges—data-intensive research, open science, and team science. I will highlight data-intensive research about lakes and their major nutrients, which are affected by many human and natural drivers that operate and interact across scales of time and space. My collaborators and I compiled and harmonized data from ~8,000 lakes in 17 U.S. states spanning 1,600,000 km^2 and 30 years into a multi-scaled geospatial lake and landscape database. We use data-intensive tools from statistics and computer science (e.g., Bayesian multi-level modeling, data mining, machine learning) in an science framework in which we publish and make available our datasets, code, and tools. As limnology's quantitative methods change, so too must our cultures and practices. In fact, data-intensive approaches are best served by large, interdisciplinary teams. Therefore, I will also present examples of how we have used team science to create, train, and assess our interdisciplinary research teams to function to their fullest potential. Ultimately, such data-intensive and team-based research will inform freshwater management and policy by providing ways to incorporate lake-specific knowledge and understanding into continental and global-scale freshwater solutions.