Progress and opportunities in advancing near-term forecasting of freshwater quality

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Abstract

Near-term freshwater forecasts, defined as sub-daily to decadal future predictions of a freshwater variable with quantified uncertainty, are urgently needed to improve water quality management as freshwater ecosystems exhibit greater variability due to global change. Shifting baselines in freshwater ecosystems due to land use and climate change prevent managers from relying on historical averages for predicting future conditions, necessitating near-term forecasts to mitigate freshwater risks to human health and safety (e.g., flash floods, harmful algal blooms). To assess the current state of freshwater forecasting and identify opportunities for future progress, we synthesized freshwater forecasting papers published in the past five years. We found that freshwater forecasting is currently dominated by near-term forecasts of water quantity and that near-term water quality forecasts are fewer in number and in early stages of development (i.e., non-operational), despite their potential as important preemptive decision support tools. We contend that more freshwater quality forecasts are critically needed, and that near-term water quality forecasting is poised to make substantial advances based on examples of recent progress in forecasting methodology, workflows, and end user engagement. For example, current water quality forecasting systems can predict water temperature, dissolved oxygen, and algal bloom/toxin events five days ahead with reasonable accuracy. Continued progress in freshwater quality forecasting will be greatly accelerated by adapting tools and approaches from freshwater quantity forecasting (e.g., machine learning modeling methods). In addition, future development of effective operational freshwater quality forecasts necessitates substantive engagement of end users throughout the forecast process, funding, and training opportunities. Looking ahead, near-term forecasting provides a hopeful future for freshwater management in the face of increased variability and risk due to global change, and we encourage the freshwater scientific community to incorporate forecasting approaches in water quality research and management.

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