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Using in-situ hyperspectral reflectance data for cyanobacterial bloom monitoring and forecasting

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Abstract: We investigated bio-optical properties, stratification and cyanobacteria bloom formation in a multi-purpose reservoir, Lake Hume, Australia, by combining in-situ sampling, remote sensing technology with hydrodynamic and algal growth models. Using an in-situ remote sensing hyperspectral instrument (HydraSpectra), which exploits the spectral reflectance signals from the water surface with high frequency (15 min temporal resolution), we derived cyanobacteria indices over time. We tested several band ratio formulations with the best outcome achieved using a three-band algorithm (Dall'Olmo and Gitelsen 2005) adapted to cyanobacteria data collected across Queensland and New South Wales (unpublished). Time series of indices were compared to simulated surface appearance of cyanobacteria and in-situ samples of cell counts.

Cyanobacteria distribution of a buoyant species (*Chrysosporum ovalisporum*) was simulated with an algal growth model (Joehnk et al. 2008, Mehnert et al. 2010), driven by meteorological data and modelled temperature stratification and mixing dynamic from a one-dimensional, vertical k-epsilon turbulence model (LAKEoneD, e.g., Joehnk et al. 2008). Comparison between simulations and monitoring data for thermal stratification showed good performance during the bloom phase. However, temperature profiles during autumnal cooling were not well represented by the 1-D model due to cooler river water inflows, pointing to the need for a 3-D model to resolve such events. Simulations of cyanobacteria concentration (cell counts) reflected the dynamic mixing behaviour in the lake with daily phases of near-surface accumulation and subsequent daily mixing due to wind or night-time cooling. Using cyanobacteria concentrations derived from the hyperspectral reflectance data the growth model was re-initialized on a daily basis ("forecast" mode) to visualize the effect of mixing dynamics on short-term development of blooms.

Results of the cyanobacteria model showed good promise for bloom risk prediction. To determine surface concentration of cyanobacteria on sub-daily time scales, the combined use of high-resolution water temperature profiles, HydraSpectra reflectance data and hydrodynamic model to quantify the mixing dynamics are essential. Having these tools in place allows to quantify risks of cyanobacteria blooms and can inform options for reservoir management to avoid, e.g., downstream seeding of cyanobacteria through hydropower and irrigation outlets of the dam when water levels fall below specific thresholds – a negative outcome of previous lake blooms leading to mega-blooms (>1000 km river length) in the downstream Murray River in previous years.

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