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RESEARCH ARTICLE

Short-term variation in thermal stratification complicates estimation of lake metabolism

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Abstract Previous studies have used sondes to measure diel changes in dissolved oxygen and thereby estimate gross primary production (GPP), ecosystem respiration (R), and net ecosystem production (NEP). Most of these studies estimate rates for the surface layer and require knowing the depth of the mixed layer (Z_{mix}), which is usually determined from discrete daily or weekly temperature profiles. However, Z_{mix} is dynamic, as the thermal structure of lakes may change at scales of minutes rather than days or weeks. We studied two thermally stratified lakes that exhibited intermittent microstratification in the mixed layer. We combined sonde-based estimates of metabolism with high-frequency measurements of stratification using thermistor chains to determine how the short-term dynamics of stratification affect metabolic rates. We calculated estimates of metabolism using time series of Z_{mix} measured at seasonal, weekly, daily, and 5-min intervals. Areal rates of GPP and R were up to 24 and 29% less, respectively, using the 5-min measurements of Z_{mix} rather than weekly Z_{mix}, while NEP was not significantly different. These reduced areal rates are mostly the consequence of the reduction in the depth of the mixed layer. Microstratification occurred frequently in both lakes and affected volumetric rates in one lake where R was significantly lower, NEP was significantly higher, and GPP was marginally lower compared to days without microstratification. Hence, microstratification not only affects the depth of the mixed layer, but also alters the processes that influence photosynthesis and respiration. Future studies should consider microstratification and possibly employ multiple sondes with thermistor chains that enable integrating metabolic rates to a specific depth, rather than assuming a stable upper mixed layer as the basis for calculations.

Keywords Lake metabolism · Gross primary production · Respiration · Net ecosystem production · Stratification