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The effect of transparency on stratification and mixing regime in lakes

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The mixing regime is fundamentally important to lake ecology. Whereas shallow lakes mix to the bottom regularly, deep lakes tend to stratify seasonally. Water transparency strongly affects stratification duration and the mixing regime of lakes of intermediate depth. We review our recent research on how water transparency affects stratification duration and mixing regime in lakes. Firstly we derive physical scaling for the critical depth at which lakes switch from polymixis to seasonal stratification based on the radiation balance, the wind speed, water transparency and lake length. This scaling relation showed that the critical depth varies almost linearly with Secchi depth (transparency) and successfully classified the mixing regime of over 80% of the 379 lakes in our dataset. Secondly we investigated how seasonal variation in transparency due to phytoplankton affects stratification and mixing by analysing long term lake data and performing simulations with a hydrodynamic model. Here we found that the spring clear water phase, which is caused when zooplankton graze the spring phytoplankton bloom, can strongly influence stratification duration and sometimes also the mixing regime. Finally using model simulations of climate scenarios, we show how global warming and a change in transparency can potentially affect lake mixing regimes. Polymictic - dimictic regime shifts were more sensitive to transparency than warming, whereas dimictic – monomictic regime shifts were more sensitive to warming than transparency. Transparency has the strongest effect on stratification in clear lakes between 4 and 10 m deep. Changes in transparency due to biotic interactions or anthropogenic impact may lead to mixing regime shifts in these lakes.