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Effect of transparency and climate warming on lake mixing characteristics

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The mixing regime is fundamentally important to lake ecology. Whereas shallow lakes mix to the bottom regularly (polymictic regime), deep lakes tend to stratify seasonally (dimictic or monomictic regimes). Global climate warming shifts polymictic lakes towards the dimictic regime and dimictic lakes towards the monomictic regime. Moreover, within certain depth ranges, water transparency strongly affects stratification duration and the mixing regime. We therefore investigated the interactive effect of climate warming and decreased transparency, a predicted effect of warming, on the mixing characteristics of temperate lakes. We simulated water temperature and mixing in four German lakes of different depth and water transparency using the hydrodynamic model Flake with ensembles of climate projections (RCP4.5). Warming increased annual mean surface and bottom temperatures as well as the summer mixed layer depth in all studied lakes, and increased stratification duration in the two deep lakes. Lower transparency decreased bottom temperatures and the summer mixed layer depth, but had no effect on surface temperatures or winter mixing characteristics. Polymictic - dimictic regime shifts were restricted to narrow depth ranges and were more sensitive to transparency than warming, whereas dimictic – monomictic regime shifts were more sensitive to warming than transparency. A decrease in transparency exacerbates the effects of climate warming in temperate lakes between about 3 and 10 m deep.