

Why full overturning in Lake Biwa was incomplete in spring 2019? : Simulation study

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This study addresses the reason why the seasonal full-overturning or monomictic-mixing in Lake Biwa was partially incomplete in spring 2019 based on the heat budget analysis using the numerical simulation. The overturning induced by convection or turbulent mixing in lakes vertically provides dissolved oxygen and materials to lake water, and dominantly influences water environment associated with biota such as fishes and aquatic plants. In particular, the monomictic-mixing that reaches to the lake bottom in the water column increases dissolved oxygen in the benthic zone and determines the survival of benthos. However, previous studies reported that many monomictic lakes possibly mix less or become permanently stratified lakes in response to climate change. Recently, Lake Biwa Environmental Research Institute reported that the monomictic-mixing in Lake Biwa was partially incomplete in spring 2019. On the other hand, the monomictic-mixing in spring 2018 occurred in late January. We analyzed the heat budgets of the whole lake focusing on the wintertime cooling in both years based on the numerical simulation. The simulation reproduced the seasonal overturning and spatiotemporal distribution of water temperature of Lake Biwa in the cooling period from summer to next spring in 2017-2018 and 2018-2019. Our analysis indicated that the surface cooling in 2018-2019 was weaker than that in 2017-2018 because the latent and sensible heat fluxes in 2018-2019 is smaller than 2017-2018. The smaller latent and sensible heat fluxes were attributed to the higher air temperature and weaker wind speed, respectively, in 2018-2019 than in 2017-2018. As a result, the simulated whole heat quantity of Lake Biwa in 2018-2019 never fell below approximately 1000 PJ, meanwhile, the heat quantity in 2017-2019 underran below 1000 PJ from January to March in 2018. We proposes a heat quantity index (~ 1000 PJ) that the seasonal overturning can complete the monomictic-mixing in Lake Biwa. The index suggests Lake Biwa that is currently monomictic can change into the meromictic lake in the future climate or the oligomictic lake that turnovers every few years.

Keywords: Lake Biwa, full-overturning, surface cooling, heat quantity, lake surface wind, latent heat flux