Mixing and baroclinic structure in a stratified shallow lake, Lake Kasumigaura, Japan

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This study presents mixing and baroclinic structure associated with hypoxia in a shallow lake, Lake Kasumigaura, using field observations and numerical simulations. Hypoxia in stratified lakes is one of the pressing issues for maintaining water environment and ecosystems. Mooring observations show that hypoxia events occur when the stratification is enhanced by the surface heat flux. The stratification (N^2) is controlled by the ratio between the surface wind stress and surface heat (buoyanvy) flux. The strength of the stratification/mixing can be simply explained by the Monin-Obukov length scale, L_{MO}. N^2 is linearly related with L_{MO} in a log scale with a correlation coefficient of approximately 0.7. According to the heat budget analysis, the bottom sediment heat flux toward the bottom significantly contribute to the heat content as well as the surface heat flux. The heat flux toward the bottom is roughly an order of 100 W m^{-2} during the summer season, which suppresses mixing near the bottom. The internal wave-like baroclinic structure was observed by high resolution survey using the YODA Profiler. Baroclinic motions are enhanced by the surface wind stress, and they transport the hypoxic water, suspended sediments and phytoplanktons. In addition to field surveys, three-dimensional simulations were conducted with SUNTANS to further investigate physical processes in the lake. Numerical results well agree to observational results and show that baroclinic motions influence in the whole of the lake basin. The wind-induced baroclinic energy is generated in the middle of the lake basin and propagate to the onshore. This study suggests that mixing and baroclinic motions due to buoyancy and wind effects play an important role in the oxygen distribution in Lake Kasumigaura.

Keywords: Mixing, Hypoxia, Internal waves

