Observations of vertical mixing and sediment heat flux in a shallow lake

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This study presents observational results of vertical mixing and heat budget in a shallow lake, Lake Kasumigaura, Japan, during summer season. Coastal seas and lakes are known as important areas for material, heat and buoyancy exchanges between lands and oceans. A recent study of Masunaga and Komuro (2019, Limnology) reported that the sediment heat flux is not negligible and it influences vertical mixing in a shallow lake. However, mixing observations in shallow areas are limited due to difficulty in microstructure surveys. We carried out observations to estimate the vertical eddy diffusivity with a newly developed method using the Ellison scale from high frequency temperature mooring arrays (Ivey et al., 2018, JGR: Oceans). The estimated eddy diffusivity well matches to the gradient Richardson number (*Ri*), thus, the vertical mixing can be simply inferred from *Ri* in the study area. In addition, the daily averaged *Ri* is highly correlated with the Monin-Obukhov length scale and the internal Froude number. The sediment temperature at 0.2 m below the sediment-water interface was approximately 1.5 degrees lower than the water temperature at the lake bottom (0.2 m above the interface), which implies the heat flux toward sediments. The sensible sediment heat flux *(H_{sed})* was estimated using the bulk method with consideration of *Ri* (viz, the Stanton number decreases with increasing in *Ri* (Louis, 1979)). H_{sed} is consistent with the surface residual heat flux (H_R) (H_R is the residual heat flux component computed by a difference between water temperature from observations and from the surface heat flux parameterization). The correlation between the daily averaged H_{sed} and H_R is 0.84. Therefore, stability/mixing and the sediment heat flux have to be considered to estimate the heat budget in the lake water. We suggest that the sediment heat flux controlled by mixing largely affects physical processes in shallow coastal lakes and ocean.

Keywords: mixing, Heat flux, Coastal areas

