Horizontal diffusion and resident time scale evaluated by a tracer dispersion model for Lake Kasumigaura

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This study presents horizontal diffusion and transport processes in Lake Kasumigaura using a high resolution numerical simulator, SUNTANS. Lake Kasumigaura consists of two primally lakes, West Lake and North Lake. Although meteorological conditions are mostly the same for the two lakes, shape and surface area is much different. West Lake is larger and wider than North Lake. The surface area is 172 km2 and 36km2 for West Lake and North Lake, respectively. The model is forced by observed wind stress and river discharges at 36 river mouth. The initial tracer concentration is unity and the tracer concentration of river discharge water is zero, which allows us to evaluate mixing between initially located lake water and outflowing river water. The domain averaged horizontal diffusion coefficient can be obtained from the advection-diffusion formula when the tracer concentration is zero at the upstream boundary. The estimated domain averaged diffusion coefficient is much higher for the large West Lake (229 m^2 s^{-1}) than the small-narrow North Lake (72 m^2 s^{-1}). This difference is simply explained by the scale of the lake, viz., eddy-induced mixing increases as increase in Reynolds number (Reynolds number is in proportional to length scale). The Péclet number, the ratio of advective transport rate and diffusive transport rate, is 0.43 and 1.13 for West Lake and North Lake, respectively. These results imply that diffusive processes dominate in water transport in West Lake and that diffusive and advective processes are equally important in North Lake. Dispersion processes significantly influence the resident time scale in the lakes. The highly diffusive condition in West Lake results in a long resident time scale in the lake basin.

Keywords: Horizontal diffusion, Lake, Resident time scale, Numerical simulations

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