Natural convection in a reservoir induced by periodic thermal forcing at the water surface

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Natural convection in nearshore waters induced by differential heating has significant biological and environmental impact. The present investigation is concerned with natural convection in a reservoir model induced by periodic thermal forcing at the water surface. A semi-analytical approach coupled with scaling analysis and numerical simulation is adopted to resolve the problem. The scales for temperature and flow velocity, as well as the phase delay of flow response to the thermal forcing have been derived. These derived scales have been verified by results from numerical simulations. Flow response at different stages of the periodic forcing has been illustrated through snapshots of isotherms and streamlines. An effect of phase delay is observed and the details of flow response are analyzed. The phase delay of the flow response to the thermal forcing decreases as the length of period increases. For sufficiently long periods, much higher values of horizontal exchange rate are identified during the cooling phase than during the heating phase.

Keywords: Natural convection, Buoyant boundary layers, Scaling analysis, Semi-analytical solution, Numerical simulation, Periodic thermal forcing