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Density currents induced by night-time cooling: offshore transport of littoral waters

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Differences in bathymetry between the pelagic and littoral areas in lakes cause lateral transport as a result of differential cooling (the shallower littoral areas cool fastest). This process occurs at night when the surface heat flux is directed towards the atmosphere. Differential cooling leads to cross-shore temperature gradients that can trigger buoyancy-driven currents (known as thermal siphons), which cascade downslope. This offshore transport of water from the lake littoral perimeter may have important biogeochemical consequences; yet, key mechanisms triggering the discharge of littoral waters in lakes and the associated overall transport remain poorly understood. Lake Rotsee, a small (0.48 km2) monomictic perialpine lake in Switzerland, is here investigated as an example of wind sheltered lake where thermal siphons occur recurrently during the stratification period. Simulations of tracer experiments conducted with a non-hydrostatic RANS model show the three-dimensionality of the process, with gravity currents forming at multiple locations around the lake perimeter. Numerical results show that once thermal siphons develop, littoral water is rapidly flushed, with 90% of littoral water transported offshore in the order of several hours.