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# Heat flux at the base of lake ice cover estimated from fine structure of the ice-water boundary layer

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Seasonal lake ice is a highly changeable part of the cryosphere undergoing remarkable impact by global warming. Vertical heat transport across the boundary layer under ice affects strongly the growth and melting of lake ice cover. The existing models of ice cover dynamics focus basically on the dependence of the ice thickness on the air temperature with implicit account of the snow cover effects. The heat flux at the water-ice boundary, in turn, is usually neglected or parameterized in a very simplistic form. However, neglecting of the basal ice melting due to heat flux at the ice-water interface produces appreciable errors in the modeled ice cover duration. We utilize fine-structure observations taken during 2009-2015 in ice-water boundary layers of Lake Baikal and arctic Lake Kilpisjärvi to reveal the major physical drivers of the heat exchange at the ice bottom and to explain the high geographical, spatial, and temporal variability in the heat flux magnitudes. The methods provide first detailed estimations of the heat exchange beneath the ice cover, available previously only from bulk estimations. The fluxes in Lake Baikal have magnitudes of $10^1$ W m$^{-2}$ and vary strongly between different parts of the lake being influenced by large-scale horizontal circulation with current velocities amounting at up to 7 cm s$^{-1}$. The shallow lake fluxes, while an order of magnitude weaker, are highly non-stationary, being affected by the turbulence due to oscillating currents under ice. Our results demonstrate the role played by the boundary layer mixing in the ice growth and melting, as well as characterize the physical processes responsible for the vertical heat exchange and provide a basis for an improved parameterization of ice cover in coupled lake-atmosphere models.