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# Thermal stratification and mixing conditions in ice-covered lakes of Tibetan Plateau

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The Tibetan Plateau is covered by thousands of lakes, which play a crucial role in the hydrological regime and climate interactions within the Asian monsoon system. However, the thermal regime of the Tibetan lakes remains largely unknown to date making difficult estimation of their contribution into the regional-scale energy and mass exchange between land and the atmosphere.
The lakes are covered by ice during 4-5 months of the year. We present first information on the heat storage by the Tibetan lakes during the ice season. The temperature data were collected in Lake Ngoring—the largest freshwater lake of Tibet— and cover the entire ice-covered season 2015-2016.
The observations revealed a temperature and mixing regime cardinally different from that in temperate and polar seasonally ice-covered lakes. The high amount of the solar radiation at the surface and the low snow amount ensured strong radiative heating of the water column under ice immediately after ice cover formation. As a result, free convection had mixed the entire 25 m deep water column already in mid-February, 2 months after ice-on. Only 2 weeks later, in early March, the water temperature achieved the maximum density value that cancelled free convection and produced stable vertical stratification in the bulk of the water column with an inversion layer adjoining the ice-water interface. The stable conditions lasted until the ice breakup in mid-April, with temperatures right beneath the ice cover grown up to 6°C.
The new findings demonstrate that all freshwater (and apparently the majority of brackish) lakes on Tibet encounter full mixing under ice, so that the convenient concept of winter stagnation, as known from traditional lake science, is inapplicable for these lakes. The direct consequences of the deep convective mixing are aeration of the deep lake waters and upward supply of nutrients to the upper photic layer, both suggesting versatile biogeochemical and ecological interactions specific for high-altitude lakes. The 1-2 month long period of stable stratification at water temperatures above the maximum density value is an exceptional feature of high-altitude freshwaters. The resulting strong temperature gradient at the ice-water interface and a thin unstable layer right beneath intensify the heat flow from water to ice and make by this a crucial contribution to ice cover melting.