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Polar lake circulation during ice break-up

Georgiy Kirillin (1), Alexander Forrest (2), Kelly Graves (3), and Bernard Laval (3)

(1) Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Ecohydrology, Berlin, Germany (kirillin@igb-berlin.de), (2) Australian Maritime College at the University of Tasmania, (3) University of British Columbia, Canada

An extensive dataset on lake physical properties has been collected during the final stage of the ice-covered period in May-June 2013 in polar Lake Kilpisjärvi, Finland. The data reveal several important features of lake dynamics, which shed new light on the mechanism of ice cover break-up and ice melting in lakes and marginal seas. CTD transects with high spatial resolution showed up a 300m-wide upwelling zone in the center of the lake, driven by downslope converging flow of warm waters from open-water 'moat' along the lake shoreline. The resulting radial density gradient, balanced by the Coriolis force, created a lake-wide anti-cyclonically rotating gyre with a measured peak azimuthal velocity of 0.05 m/s. Appreciable marginal heating is driven in polar enclosed basins by high amount of solar radiation and by surface inflow of meltwater. Hence, quasi-geostrophic anticyclonic circulation is suggested to be a general feature of polar lakes, redistributing heat within a water body and potentially accelerating ice melting. In addition, high-resolution records of pressure, current velocities and water temperature revealed under-ice seiches with periods of 10 to 25 min. The ice breakup was associated with 10 times increase of seiche amplitudes under ice. The seiches decayed within 10-15 hours; during this short period, the previously ice-covered lake became ice-free. We suggest that seiche-driven vertical motions of the soft ice sheet contribute significantly to breaking and melting of seasonal ice in enclosed reservoirs.