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Inter-annual variations and large-scale atmospheric forcing on ice thickness and composition during the last decade in an Arctic lake

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A thermistor-string-based Snow and Ice Mass Balance Apparatus (SIMBA) was deployed in an Arctic lake Orajärvi in northern Finland (67.36°N, 26.83°E) during winter seasons 2011/2012 - 2019/2020. The snow depth and ice thickness (total and separately for congelation ice and granular ice) were retrieved from SIMBA temperature measurements. The average maximum ice thickness was 72 cm with a standard deviation of 10 cm. The interannual variability of lake ice composition was large. In the past 3 ice seasons, the granular ice dominated the total ice thickness. For example, granular ice accounted 80% of the total ice thickness in May 2020. A high-resolution thermodynamic snow/ice model was applied to simulate ice mass balance, with special attention to the lake ice composition. Local weather station data and ECMWF reanalysis products were used as model forcing.

The increase of granular ice formation is a result of more snow precipitation during the ice season, increased variability of seasonal air temperature, and a warming trend. The observed snow thickness on land showed a high correlation with snow-ice thickness on top of lake ice. The relationships between the ratio of snow-ice to total ice thickness and the large-scale atmospheric circulation indexes were investigated. Precipitation and, consequently, snow ice thickness on Lake Orajärvi correlated with the phase of the Pacific Decadal Oscillation, which is in line with previous results for precipitation and ice conditions in northern Finland, but an eventual causal teleconnection still requires further studies.