Coupling Remote Sensing and Modelling to Monitor Spatial Trends and Distribution of Surface Temperature and Ice Phenology on Sub-Arctic Lakes

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Lake Surface Temperature (LST) and Lake Ice thickness (LIT), and Lake Ice phenology (LIP) are crucial climate variables that provide critical evidence for understanding and predicting climate change. They offer direct indications of regional weather and climate conditions, and their interactions with the atmosphere have an impact on climate processes and infrastructure in Northern regions. However, continuous in-situ monitoring of these variables is challenging in addition to the gaps in remote sensing data, which makes monitoring of these changes difficult. To overcome these limitations, a multimethod monitoring approach was adopted, using remote sensing data coupled with a spatially distributed thermodynamic lake ice model to study the trends and spatial distribution of LST, LIT, and LIP.
The study utilized Landsat satellite series data to generate an LST dataset (North Slave LST) for predominantly small/medium lakes in the North Slave Region (NSR), NWT, from 1984 to 2021. The dataset showed increasing temperature trends during the open water period of up to 2 °C over the past four decades. North Slave LST data and European Centre for Medium-Range Weather Forecasts Reanalysis v5 ECMWF (ERA5) data were used as inputs to develop a spatially distributed thermodynamic model to simulate LIT and LIP. The model effectively estimated lake ice thickness and highlighted the spatial variation of ice thickness and its extent over the lake. Preliminary results showed decreasing trends in ice cover duration (-0.28 day/year to -0.35 day/year) and ice thickness (-0.12 cm/year to -0.14 cm/year) on lakes surrounding Yellowknife from 1984 to the present. Additionally, later freeze-up up (0.08 day/year to 0.22 day/year) and earlier break-up (-0.16 day/year to -0.21 day/year) were observed. This research provides an open-source LST dataset and information on LIT and LIP that will be continuously updated for community use and further lake research. The methods and dataset description have been documented to facilitate replicability.