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Lake ice phenology changes in the northern hemisphere

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Lake-ice phenology is an essential indicator of climate change impact for different regions (Livingstone, 1997; Duguay, 2010), which helps understand the regional characters of synchrony and asynchrony. The observation of lake ice phenology includes ground observation and remote sensing inversion. Although some lakes have been observed for hundreds of years, due to the limitations of the observation station and the experience of the observers, ground observations cannot obtain the lake ice phenology of the entire lake. Remote sensing has been used for the past 40 years, in particular, has provided data covering the high mountain and high latitude regions, where the environment is harsh and ground observations are lacking. Remote sensing also provides a unified data source and monitoring standard, and the possibility of monitoring changes in lake ice in different regions and making comparisons between them. The existing remote sensing retrieval products mainly cover North America and Europe, and data for Eurasia is lacking (Crétaux et al., 2020).

Based on the passive microwave, the lake ice phenology of 522 lakes in the northern hemisphere during 1978-2020 was obtained, including Freeze-Up Start (FUS), Freeze-Up End (FUE), Break-Up Start (BUS), Break-Up End (BUE), and Ice Cover Duration (ICD). The ICD is the duration from the FUS to the BUE, which can directly reflect the ice cover condition. At latitudes north of 60°N, the average of ICD is approximately 8-9 months in North America and 5-6 months in Eurasia. Limited by the spatial resolution of the passive microwave, lake ice monitoring is mainly in Northern Europe. Therefore, the average of ICD over Eurasia is shorter, while the ICD is more than 6 months for most lakes in Russia. After 2000, the ICD has shown a shrinking trend, except northeastern North America (southeast of the Hudson Bay) and the northern Tibetan Plateau. The reasons for the extension of ice cover duration need to be analyzed with parameters, such as temperature, the lake area, and lake depth, in the two regions.