REMOTE SENSING OF LAKE ICE OVER COLD REGIONS OF NORTHERN HEMISPHERE

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ABSTRACT

Lake ice serves as a key Environmental Climate Variable (ECV) in the Global Climate Observing System (GCOS), where ice extent, phenology, thickness, and type are crucial indicators for assessing climate change and ecological research. However, global warming is causing a decline in ice coverage, with delayed freeze-up dates and earlier ice breakup dates.

Based on MODIS NDSI data, we applied cloud removal methods to reduce the cloud in the data, and extracted the daily lake ice coverage data for over 23,000 lakes across Eurasia from 2002 to 2022. To classify lakes with different lake ice cover trends, we have developed a method for time series classification of lake ice cover.

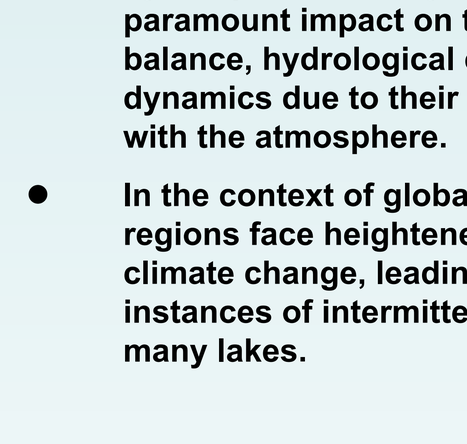
Based on passive microwave data, we employed the nearest neighbor algorithm to reduce the impact of mixed pixels and extracted brightness temperature data for 753 lakes in the Northern Hemisphere from 1978 to 2022. We then derived corresponding lake ice phenological parameters and verified the results to have a high degree of accuracy.

INTRODUCTION

- **Lakes, serving as crucial links between the hydrosphere and cryosphere, have a paramount impact on the global energy balance, hydrological cycle, and climate dynamics due to their intricate interactions with the atmosphere.**
- **In the context of global warming, cold regions face heightened challenges from climate change, leading to increased instances of intermittent winter ice cover in many lakes.**

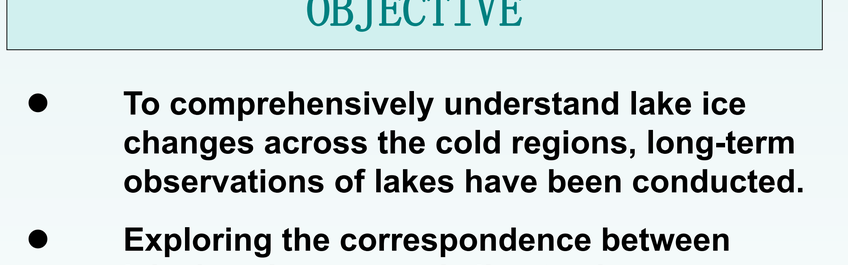
OBJECTIVE

- **To comprehensively understand lake ice changes across the cold regions, long-term observations of lakes have been conducted.**
- **Exploring the correspondence between lake ice changes and climate changes.**



753 lakes in the Northern Hemisphere monitored by PWM data

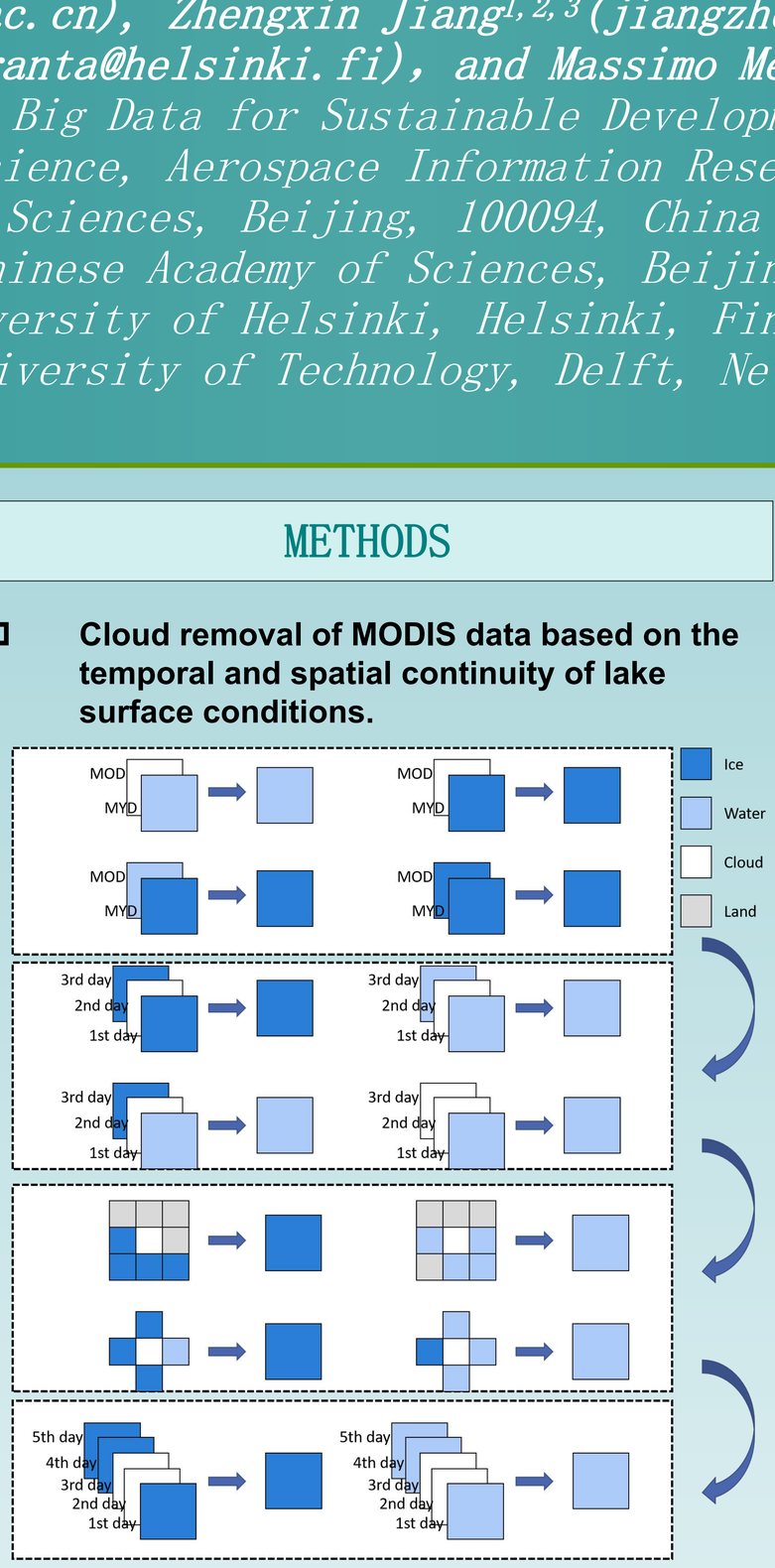
1. **1978-2022,409 lakes**
2. **2002-2022,344 lakes**



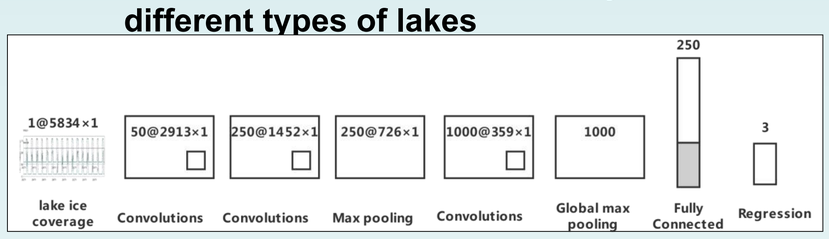
23812 lakes in the Eurasian monitored by MODIS data.

METHODS

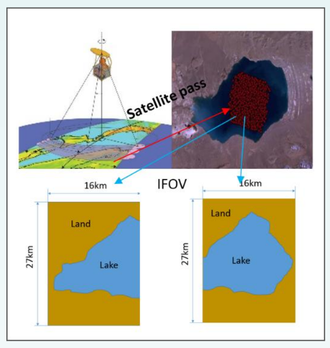
- **Cloud removal of MODIS data based on the temporal and spatial continuity of lake surface conditions.**



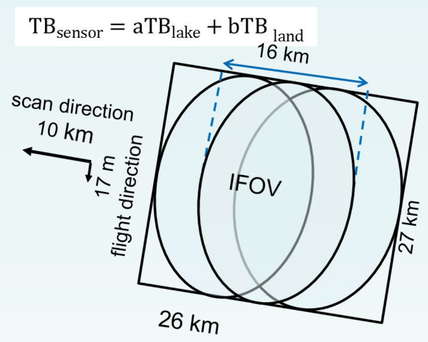
- **The CNN architecture to classify the different types of lakes**



- **The nearest neighbor algorithm and the mixed pixel decomposition method for PMW data.**

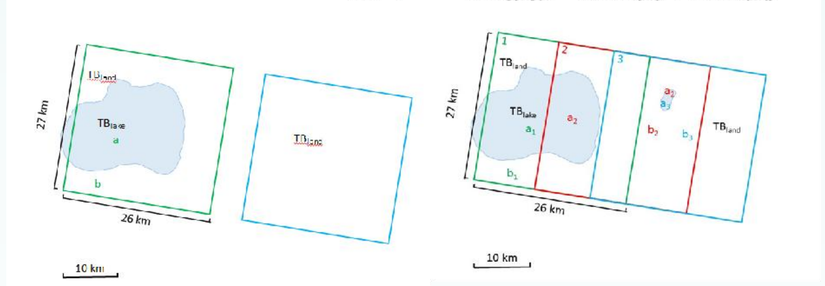


$$TB_{sensor} = aTB_{lake} + bTB_{land}$$



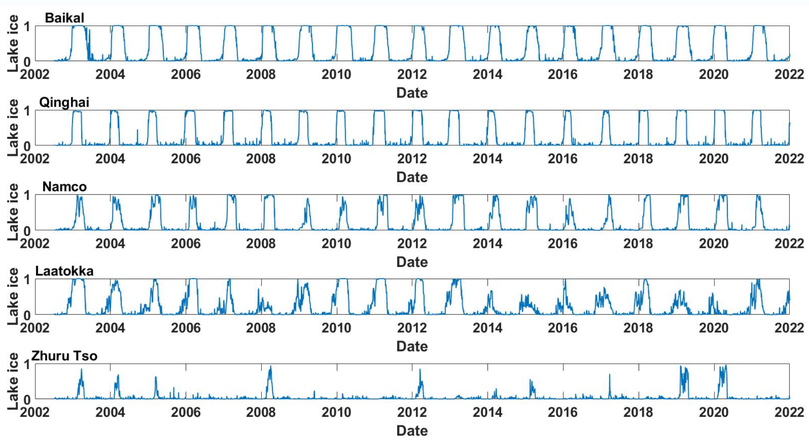
$$TB_{sensor} = aTB_{lake} + bTB_{land}$$

$$TB1_{sensor} = a1TB_{lake} + b1TB_{land}$$
$$TB3_{sensor} = a3TB_{lake} + b3TB_{land}$$

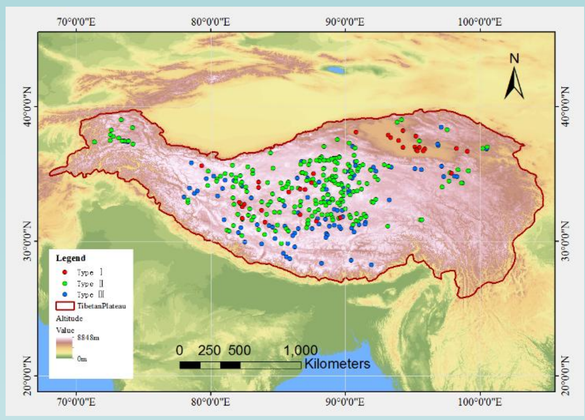


RESULTS

- **The daily lake ice coverage of lakes in the Eurasian based on MODIS data**



- **Lake classification through CNN based on daily lake ice coverage data**

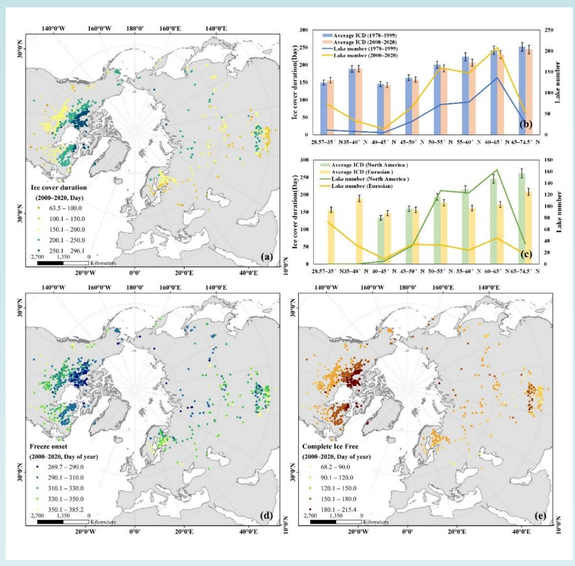


Type Ⅰ:Without periodic changes.

Type Ⅱ: With obvious periodic changes.

Type Ⅲ:Without periodic signal ascribe.

- **Analysis of changes in lake ice phenology based on PMW data**



a. Average ICD

b. Average ICD in two durations

c. Average ICD in two continents

d. Average FO

e. Average CIF

Conclusion

- **Using MODIS data, daily lake ice coverage are calculated for 23812 lakes in the Eurasian.**
- **The CNN proves effective in classifying lakes, achieving accuracy rates of 100%, 92%, and 90% for type Ⅰ, Ⅱ, and Ⅲ, respectively.**
- **Using PMW data, lake ice phenology data for 753 lakes in the Northern Hemisphere are obtained during 1978 to 2022.**
- **Lakes in the Northern Hemisphere are significantly influenced by climate change, exhibiting an overall trend of delayed thawing and early freezing.**

REFERENCE

1. **Xingxing Wang, Yubao Qiu*, Yuxiao Zhang, Wenshan Liang, Juha Lemmetyinen, Bin Cheng, Matti Leppäranta, A lake ice phenology dataset for the Northern Hemisphere based on passive microwave remote sensing, Big Earth Data, 2021 https://doi.org/10.1080/20964471.2021.1992916**
2. **Yubao Qiu*, Pengfei Xie, Matti Leppäranta, Xingxing Wang, Juha Lemmetyinen, Hui Lin & Lijuan Shi (2019) MODIS-based Daily Lake Ice Extent and Coverage dataset for Tibetan Plateau, Big Earth Data, 3:2, 170-185, DOI: 10.1080/20964471.2019.1631729**
3. **QIU Yubao,WANG Xingxing,RUAN Yongjian,XIE Pengfei,ZHONG Yu,YANG Suping.Passive microwave remote sensing of lake freeze-thawing over Qinghai-Tibet Plateau. J. Lake Sci.2018,30(5):1438-1449. DOI:10.18307/2018.0525**