Changing Lake Ice Conditions in Central Ontario

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Introduction

Lakes are a dominant component of the Central Ontario landscape, with almost all experiencing some degree of ice cover each year. Sensitivity of lake ice is tied to climate variability, with ice cover being strongly affected by air temperature. Studies have shown that ice cover has been reducing under current climate conditions, and this reduction is projected to continue. In Central Ontario, a mix of trend directions for ice break up have been identified. Typically air temperature is the dominant influence on ice phenology. However, climate variables such as wind speed and cloud cover, and local factors such as topographic controls on solar radiation (shading), lake inflows, and elevation can all be utilized to provide a detailed analysis of the local variability of ice break up for each lake in the region.

This study is dedicated to a more complex investigation of climate-ice relationship displayed by lakes in the Central Ontario region. Specifically looking at what are the driving climate factors behind the mixed directions of ice break up trends, for specific lakes seen in the region.

Methodology

- **Lake Ice Off Records**
  - Canadian Ice Database
  - IceWatch Database
  - Global Lake and River Ice Phenology Database
  - Private Local Records for Head Lake in Haliburton, ON. Provided by the Haliburton Highland Museum
- **Climate Data**
  - ECMWF ERA-5 reanalysis data for Central Ontario (1979-2019)
  - Environment and Climate Change Canada Haliburton Station (1889-2019)
- **Analysis**
  - Zhang Trend Analysis on Lake Ice Break Up dates

Study Area

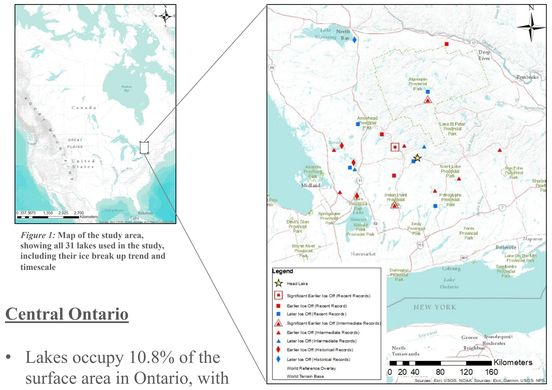


Figure 1: Map of the study area, showing all 31 lakes used in the study, including their ice break up trend and timescale

Central Ontario

- Lakes occupy 10.8% of the surface area in Ontario, with Central Ontario containing many of these lakes.
- Ice break up data are obtained for a total of 31 Lakes in the region.

Haliburton, ON.

- Head Lake **(45.05°N 78.52°W)**
- Haliburton is being used to represent the long term trends for Central Ontario as there is a long record of both temperature and ice off records from observations.

Results and Discussions

1. Mixed Directions of Ice Break Up

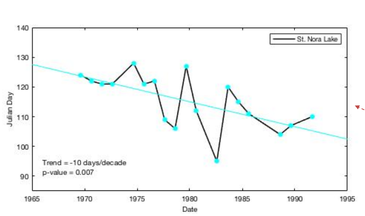


Figure 2: Ice break up dates for St. Nora Lake (45.15°N 78.83°W). This dates span from 1968 – 1990 and shows a significant trend of 10 days/decade earlier break up.

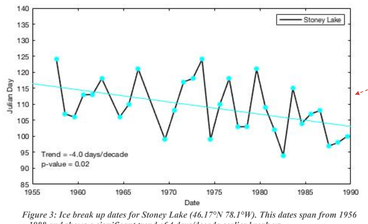
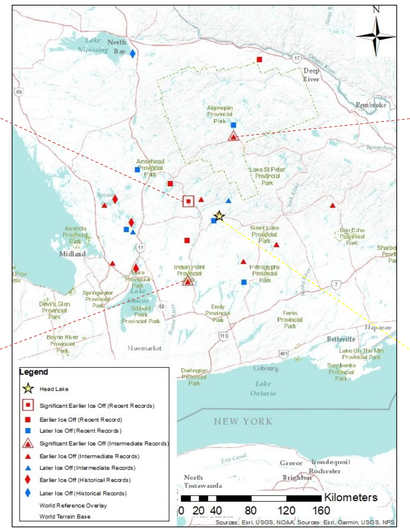


Figure 3: Ice break up dates for Stoney Lake (46.17°N 78.13°W). This dates span from 1956 – 1988 and shows a significant trend of 4 days/decade earlier break up.



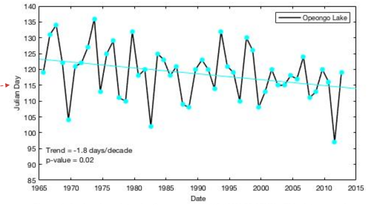


Figure 4: Ice break up dates for Opeongo Lake (45.63°N 78.37°W). This dates span from 1964 – 2011 and shows a significant trend of 1.8 days/decade earlier break up.

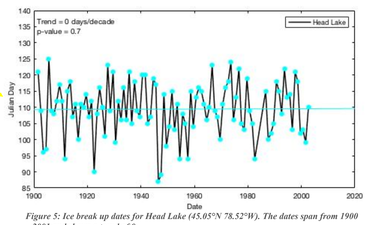


Figure 5: Ice break up dates for Head Lake (45.05°N 78.52°W). The dates span from 1900 – 2001 and shows a trend of 0.

- **Historical records (100+ years): 4 out of 5 lakes show a slight trend of earlier Ice break up (p > 0.05), with very little variability between each lake.**
- **Intermediate Records (~40-60 years): 12 out of 15 lakes show a moderate trend of earlier break up (3 lakes, p < 0.05), with some variability between each lake.**
- **Recent Records (~15-30 years): Only 5 out of 11 lakes show trends of earlier break up (1 lake, p < 0.05). These trends are stronger and there is greater variability between each of the lakes.**

2. Air Temperature Trends

- **Annual and Spring Mean Air Temperature trends from 1900 – 2000 show a minor increase, 0.0003°C/decade (p > 0.05) and 0.0005°C/decade (p > 0.05) respectively. This coincides with the time period of the historical length ice break up records.**

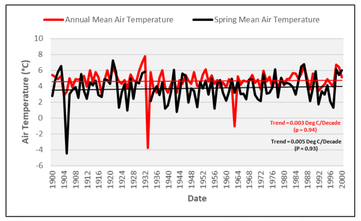


Figure 6: Annual and spring mean air temperature from Haliburton Weather Station, from 1900 – 2000.

- **Annual and Spring Mean Temperature trends from 1950-2010 show a slight increase, 0.18°C/decade (p < 0.05) and 0.17°C/decade (p > 0.05) respectively. This coincides with the time period of the intermediate length ice break up records.**

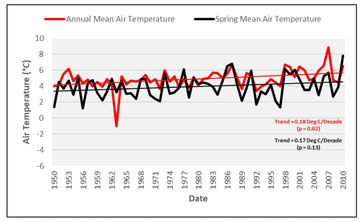


Figure 7: Annual and spring mean air temperature from Haliburton Weather Station, from 1950 – 2010.

- **Annual and Spring Mean Temperature trends from 1989 – 2019 show a slight increase but have been quite variable, 0.26°C/decade (p > 0.05) and 0.17°C/decade (p > 0.05). This coincides with the recent break up records.**

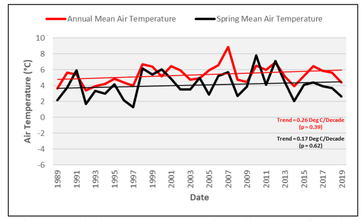
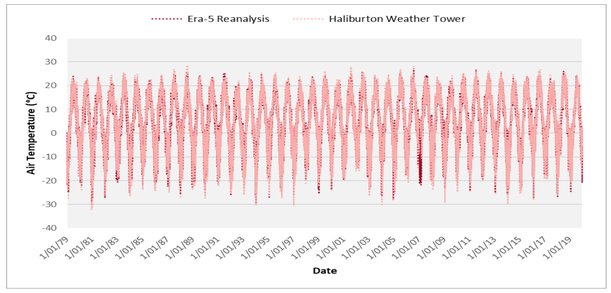


Figure 8: Annual and spring mean air temperature from Haliburton Weather Station, from 1989 – 2019.

3. Reanalysis Data

Figure 9*: Daily 2-meter Air Temperature from Haliburton Weather Tower (45.03°N 78.53°W) and Era-5 Re-analysis data over the Haliburton area (45°N 78.5°W).*



- **Air Temperature is highly correlated for both climate data sources at *0.9903***
- **The good fit suggests ERA 5 gridded reanalysis data can be used to represent the nearby region without ECCC weather stations**
- **Reanalysis Data can be used for obtaining other climate variables to do analysis on lake Ice break up trends**

Ongoing Work

Historical Records:

1. Lake Nipissing
2. Head Lake
3. Lake Muskoka
4. Lake Rosseau
5. Lake Couchiching

Intermediate Records:

1. Muskoka Bay
2. Percy Lake
3. Haystack Bay – Lake of Bay's
4. Crow River
5. Robert's Bay – Lake Joseph
6. Little Hawk Lake
7. Menominee Lake
8. Ashby Lake
9. Dorset Lake
10. Bass Lake – Medonte
11. Gold Lake
12. Lake Memphremagog
13. ***Stoney Lake***
14. ***Skiff Lake***
15. ***Lake Opeongo***

Recent Records:

1. Deer Bay Creek
2. Goshen Lake
3. South Muldrew Lake
4. Little Boshkung Lake
5. Kashagawigamag Lake
6. Fox Lake
7. Long Pond
8. DRC Lakes
9. Robertson Lake
10. Devil's Lake
11. ***St. Nora Lake***

- Red – Earlier Ice Break Up
- Blue – Later Ice Break Up
- ***Bold and Italics – Significant Trend***

Ongoing Work

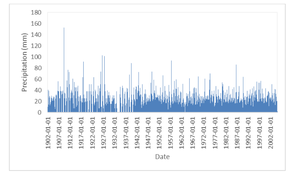


Figure 10: Daily precipitation (mm) at the Haliburton Weather Station (45.03°N 78.53°W) from 1901 – 2004.

- Annual precipitation from 1889 – 2019 is compared to trends in ice break up for Lake Nipissing.
- This analysis can be applied to specific lakes in Central Ontario to see what climate variables are influencing the ice break up trends of those lakes.
- Other variables to investigate: Snow Density, Snow Depth, Surface Pressure, Wind-speed (u and v), dew-point temperature (2m), and Total Cloud Cover.

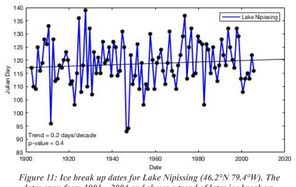


Figure 11: Ice break up dates for Lake Nipissing (46.2°N 79.4°W). The dates span from 1901 – 2004 and shows a trend of later ice break up.

References

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