Winter-Weather/climate variability and its impact on early ice breakup dates in Maine lakes

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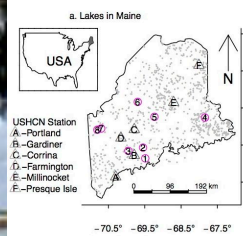[2] Climate change Institute, University of Maine, Orono, Maine
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1. Introduction

• Increase in the ice-free period of temperate lakes has been linked to lowering of lake water quality stemming from severe algal blooms and shortening of the clear-water phase (Paerl & Huisman 2008).
• The state of Maine, located in the northern New England region of United States, has over 5000 lakes and the frequency of unusually early lake ice-breakup events in these lakes has increased in the recent three decades.
• There is a growing concern about the future state of Maine lakes raising the question 'Can we predict future ice-breakup events?'
• El Nino-Southern Oscillation (ENSO) can be predicted from seasonal to decadal time scales (Timmermann et al. 1999, Ramesh & Murtugudde 2012, Hoskins 2013).
• Given that the predictability stemming from ENSO is embedded in the winter season of extra-tropics, we believe that understanding the role of winter-weather climate link on ice breakup dates of Maine lakes can give insight into future lake ice breakup events in Maine lakes.

a. Lakes in Maine

c. Chronology of Ten Earliest Ice−Out Events (n = 8)
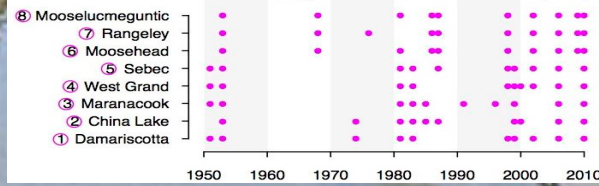
2. Data and Method

• The ice breakup dates of eight Maine lakes from 1950-2010 was collected from a publication by USGS (Hodgkins 2010) and by the department of conservation for the state of Maine (MDOC 2013).
• The daily mean temperature data for January and February used in our analysis was obtained from five USHCN stations in Maine. These data was later used to calculate the accumulated freezing and melting degree days (AFDD and AMDD) during winter.
• The indices for relevant teleconnection patterns were collected from NWS climate prediction centre (NOAA NCEP 2013) and were later averaged to compute the mean winter indices of the circulation patterns.
• Parametric (correlation) and non-parametric metric (kernel density estimators, bootstrap) were used to examine the association between lake ice out dates, seasonal winter temperature (and its derived variables) and teleconnection patterns.

3. Results

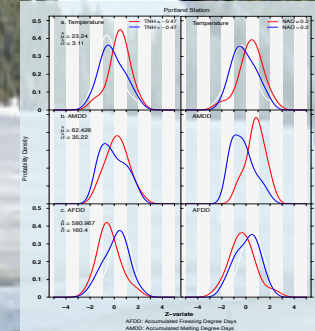### 3.1 Link between seasonal winter temperatures and anomalous lake ice breakup dates
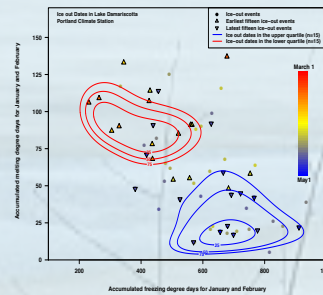
• There is a clear delineation in the quantity of AMDD and to a lesser extent AFDD between the majority of anomalously early and late ice breakup dates.
• This implies the presence of seasonal winter temperatures (thresholds) that disproportionately favor unusually early or late ice breakup events at lake Damariscotta.
• Similar results are observed in other lakes as well.

3.2 Link between seasonal winter temperatures and Large-scale climate patterns (teleconnections)
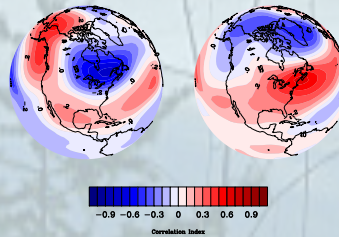

• Regression analysis shows that the first EOF mode of winter AFDD responds to the Tropical/Northern Hemisphere (TNH) while the first EOF mode of winter AMDD responds to North Atlantic Oscillation (NAO).

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• Ramesh N. & R. Murtugudde. 2012. All flavors of El Nino have similar early subsurface origin. Nature climate change, 3: 42-46
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• Timmermann A., J. Oberhuber, A. Bacher, M. Esch, M. Latif & E. Roecker. Nature 398, 694-696
• Hodgkins, G.A., 2010, Historical ice-out dates for 29 lakes in New England, 1807–2008: U.S. Geological Survey Open-File Report 2010–1214, 32 p., at http://pubs.usgs.gov/of/2010/1214/

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• Comparison of the empirical probability density curves of seasonal winter temperatures during different TNH and NAO phases shows that the strong negative phases of TNH and to a lesser extent positive phases of NAO disproportionately amplify the occurrence of warm winter temperatures in Maine.

3.3 Response of Lake Ice-breakup dates to Teleconnection Patterns
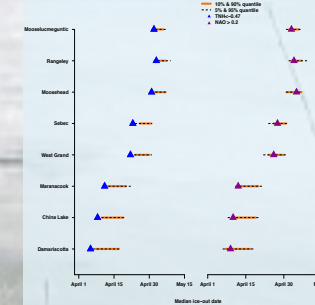
• During upper quartile NAO phases, all eight lakes showed shifts in their median ice out date to earlier dates but this shift was significant (p<0.05) only in coastal lakes.
• On the other hand, during lower quartile TNH phases, all lakes including those found in the deep interior displayed significant shift in their median ice breakup dates to earlier dates.

4. Conclusion

• This study for the first time shades light into the links between winter weather-climate patterns in the New England region and their role on anomalous lake ice breakup events.
• Results show clearly that patterns of TNH and to a lesser extent NAO influence the ice-out date regimes and seasonal winter temperatures in Maine lakes.
• Studies have found that pronounced negative phases of TNH accompany strong El-Nino episodes in the tropical Pacific. This relationship suggests that lake ice breakup events in Maine may be predictable from inter-seasonal to inter-decadal time scale.

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