Wintertime weather-climate variability and its links to early ice-out in Maine lakes

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In the past three decades, there has been an increased frequency of unusually early spring ice breakup events in Maine lakes. The seasonal to inter-annual predictability of these events can provide insight to future lake conditions as recent studies have linked the decline in the water quality of temperate lakes to increase in the annual ice-free period. Hence, this paper for the first time examines winter (January-February) weather-climate links in Maine and their role on early lake ice breakup from 1950-2010. Analysis of the relationship between winter temperatures (AFDD & AMDD) and lake ice-breakup dates in Maine using correlations and kernel density estimators reveals that variability in seasonal winter temperatures and derived variables significantly ($p<0.05$) affects lake ice breakup dates in all regions of Maine. Furthermore, they show that there are threshold temperatures within seasonal winter temperatures that disproportionately favor anomalous lake ice breakup dates in spring. When the time series of the first principal component (PC1) of seasonal AFDD and AMDD in Maine was regressed against the geo-potential height at 500mb, signatures of Tropical/Northern Hemisphere (TNH) and North Atlantic Oscillation (NAO) were observed. Comparison of the empirical probability density curves of seasonal winter temperatures at various stations during different TNH and NAO phases indicate that pronounced negative indices of TNH and to a lesser extent positive indices of NAO disproportionately amplify the occurrence of 'warm' winters in Maine. On the other hand, there was a significant ($p<0.05$) shift in the median ice- breakup date of Maine lakes in different regions during lower quartile TNH phases signaling that patterns of TNH and to a lesser extent NAO influence the ice-breakup regime of Maine lakes. Studies have shown that pronounced negative phases of TNH accompany strong ENSO episodes and the inter-seasonal to inter-annual predictability of El Nino episodes in the tropical Pacific suggests the predictability potential of anomalous ice breakup events in Maine lakes.