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Observing Lake Ice and Winter Water at Multiple Scales in the National Petroleum Reserve – Alaska

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Introduction

Most lakes on the Arctic Coastal Plain are shallow and near the threshold of maximum ice thickness such that many lakes freeze solid by the end of winter with bedfast ice. Slightly deeper lakes maintain perennial liquid water atop floating ice and can provide over wintering fish habitat and supply water for ice roads. Evidence from synthetic aperture radar (SAR) suggests a shift in many previously bedfast ice lakes to floating ice conditions due to thinning ice (Arp et al. 2012). This trend could allow more economical development in some regions where winter water supplies were previously limited, yet greater field verification of SAR imagery is needed to confirm and refine these results. A similar concern is the need to understand how this lake regime shift is impacting lake physical and ecological processes so that any new water extraction from these lakes can be accomplished in a low-impact and sustainable manner.

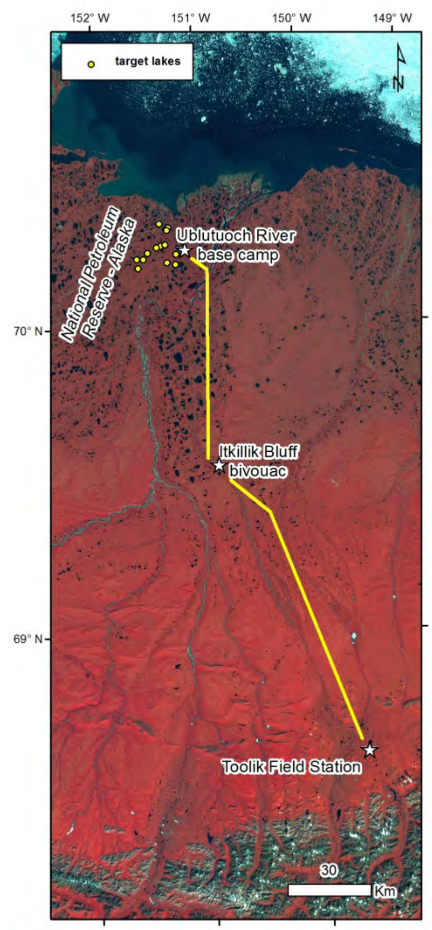


Figure 1 Travel route from Toolik Lake Field Camp to the Fish Creek study area in early March 2013.

Approach and Methods

The intent of this field campaign was to focus on two regions in the NPR-A where a large number of lakes are transitioning from bedfast ice to floating ice conditions from 1980 to present (Arp et al. 2012). Acquisition of TerraSAR-X (TSX) in early March and again in early April was used to detect floating ice and grounded ice in lakes and streams. We collected ground data during two concurrent field visits to these locations using ground penetrating radar (GPR) and point measurements of ice thickness and lake depth with ice augering equipment.

Figure 2 Collecting ground penetrating radar data at a Fish Creek study lake.

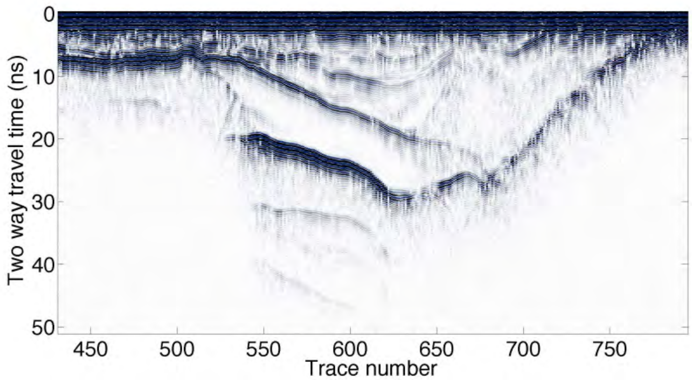
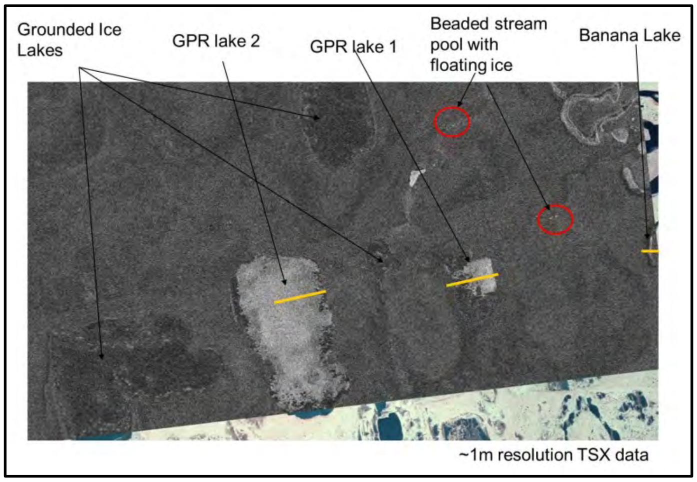


Figure 3 An example of ground penetrating radar transect data collected across a lake ice gradient.

Figure 4 High resolution (1-m) TerraSar-X imagery showing floating ice and ground ice conditions in early March 2013 with corresponding GPR survey transects indicated.



Though we have conducted winter work at these sites in the past, abnormally windy conditions limited our ability to conduct the full extent of planned work. A video documentary of showing the travel and weather conditions can be accessed at http://www.youtube.com/watch?v=_JOmDGZuqhM. Still the level of field verification data collected far exceeded what is typical from this type of remote sensing of Arctic lakes.

Figure 5 Ublutuoch River base camp in early March.

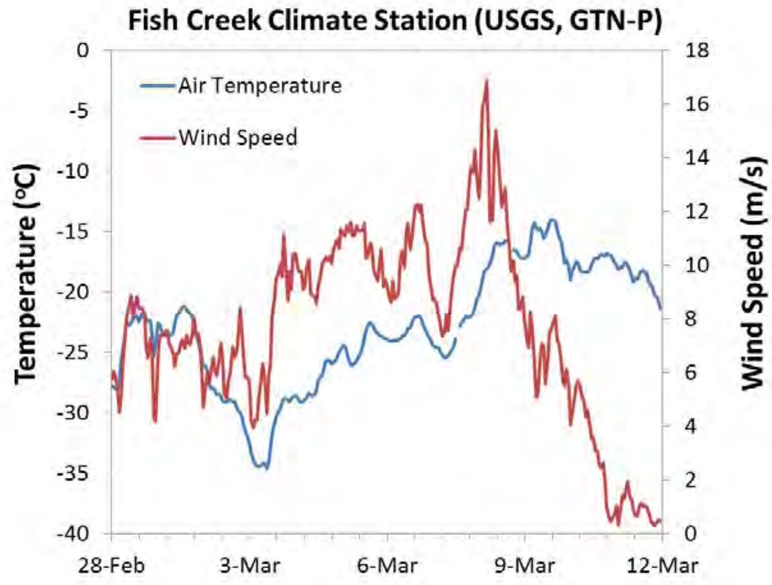


Figure 6 Weather data from the nearby Fish Creek station showing abnormally high windy conditions that contributed to an exciting field campaign.

Preliminary Results

Field surveys, GPR, and SAR imagery have all been used before to determine whether freshwater ice exhibited floating or grounded ice conditions. However, few studies have combined the use of these techniques on the same day and no studies have been conducted at the spatial resolution in which we imaged our study area. Combining the field surveys with image acquisition on the same day allows for the direct detection of the SAR backscatter intensity value with respect to ice condition. Our findings indicate that the TSX data may slightly over-estimate potential over-wintering freshwater habitat due to double-bounce backscattering that occurs at the transition from grounded to floating ice. However, in general the TSX performed quite well at providing a high-resolution potential over-winter freshwater aquatic habitat map (Figure 7).

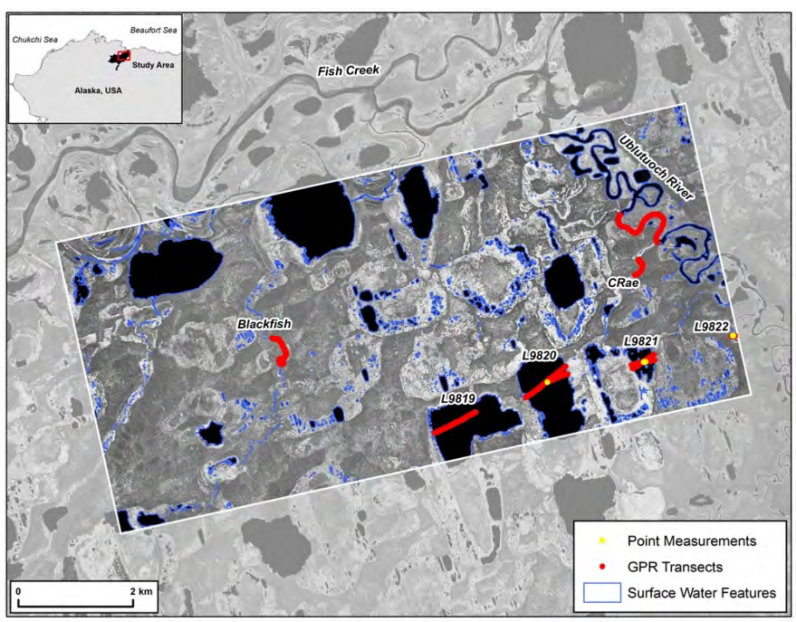


Figure 7 High-resolution (1.25 m) orthorectified radar image (ORRI) acquired in 2002 showing the Fish Creek study region (footprint of HR Spotlight TSX imagery) outlined with the white rectangle. Surface water features, outlined in blue, were extracted from the ORRI dataset and used as a mask for the 1.25 m resolution TSX data. The red lines depict the location of GPR transects and the yellow dots indicate locations of point measurements taken in the field. The inset map in the upper left shows the Fish Creek watershed and the study area within the watershed (from Jones et al in prep).

Analyzing the landscape at a ground resolution of 1 m^2 allows for the detection of ice conditions with great detail on larger bodies of water but also for the detection of ice conditions on small ponds and beaded stream pools that ranged in size from 0.001 to 0.5 ha. Thus, for the first time we have been able to image whether beaded stream pools contain unfrozen water below ice and thus which ones may potentially serve as over-wintering freshwater habitat (Jones et al. in prep).

Analysis of floating ice conditions across all surface water components of the landscape is essential for better understanding the refugia that may exist for freshwater biota during the winter, particularly in an area with active oil and gas development activities. Overwintering habitat is a major factor constraining fish populations in the Arctic and the extent of ice cover can influence primary productivity and the composition of algae and invertebrate communities. However, the magnitude and distribution of winter liquid water habitat on the Arctic Coastal Plain is poorly understood, especially at the scale provided by this study; even small, isolated pockets of water may be critical to maintaining the viability of aquatic species. Analysis of floating ice conditions across all surface water components of the landscape is essential for better understanding the winter refugia that may exist for freshwater biota and improving land management decisions in areas with oil and gas exploration and development.

Acknowledgements

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References

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