CGU HS Committee on River Ice Processes and the Environment
15th Workshop on River Ice
St. John's, Newfoundland and Labrador, June 15 - 17, 2009

Suitability of Aerial GPR Deployments for River Ice Thickness Mapping

N. Kovachis, J. Maxwell and F. Hicks
Dept. of Civil and Environmental Engineering
University of Alberta, Edmonton, AB, T6G 2W2

kovachis@ualberta.ca, joshua.maxwell@ualberta.ca, faye.hicks@ualberta.ca

EXTENDED ABSTRACT

Ground penetrating radar (GPR) systems are used to profile subsurface conditions by transmitting radio waves into the ground and detecting the reflected echoes from varying substrates. Traditionally, the GPR has been used on solid ground for non-destructive testing, locating buried structures and utility lines, studying soils and bedrock and even for archeological surveys. It has also become a practical commercial tool when working with ice and has been studied extensively for use in ice road profiling as well as glaciology studies (Arcone, 1990).

The conventional approach for data collection using GPR is to drag the antenna across the surface of the ice. The primary objective of this study was to investigate the viability of deploying a GPR from a helicopter instead. There are several benefits of aerial data collection. From a safety perspective, aerial collection does not require personnel to work on a potentially unsafe ice cover. From an efficiency perspective, aerial collection greatly reduces the time required to map out large areas of the ice cover. More specific objectives were to explore whether the ground or airborne GPR deployment is effective for finding the edge of water under the ice (useful in mapping fish habitat perimeters) as well as for locating the depth to river bed. Finally, we would like to see if the GPR could identify the thickness of the above water portion an ice jam accumulation. If so, it could facilitate an estimate of ice jam thickness.

The study reach is located on the Athabasca River, 25 river km north of Fort McMurray, AB. Two transects were laid out and ice thicknesses were manually measured at ten locations along each transect. In addition, the GPR was dragged twice along each transects, and then the helicopter flew the GPR low along the river reach. Positioning was determined using a Real Time Kinetic Global Positioning System (RTK GPS) for the ground tracks, while a handheld Garmin 76Csx GPS was used to track the helicopter path for the airborne measurements. A 400 MHz antenna was selected for data collection, as it allows for deeper penetration of the radar waves. This deeper range was used with hopes of locating the bed of the river and the edge of water under the ice, in addition to measuring ice thicknesses.

Figure 1: Conventional ground based and aerial GPR data collection via helicopter.

Data processing procedures included manual interpretation of the radar images to identify the air to ice, ice to water or water to bed interfaces. Once the data was calibrated using dielectric constants determined from the manual measurements, both passes of the ground based data strongly agreed with the measured depths (Figure 2). As the figure shows, ice thicknesses averaged about 60 cm, and ranged from about 50 to 90 cm.

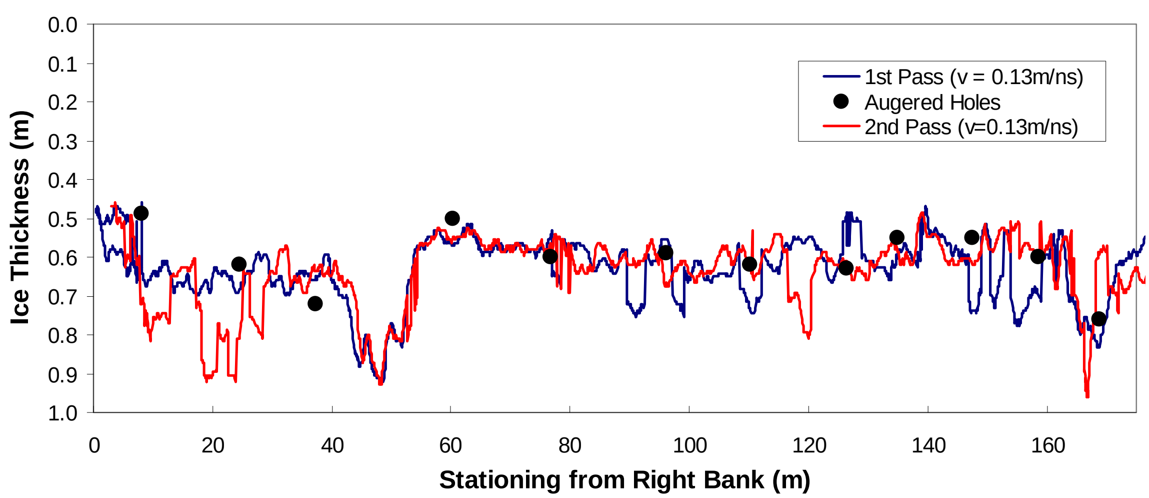

Figure 2: Ground based data collection using 400 MHz antenna on cross section 2.

Unfortunately, the data bridge used to connect the GPS to the GPR console was faulty; and so the GPS data could not be directly integrated with the GPR data. Furthermore, the clock in the GPR console was found to be relatively inaccurate, which made manual integration of the airborne GPR and GPS data impossible. Therefore, the helicopter data could not be geo-referenced to a particular spatial location, and so was analyzed to determine ice thickness only.

As Figure 3 illustrates, the ice thicknesses measured from the helicopter appear to be quite consistent with the ground track values. It was also observed that the bed and the edge of water could be detected from the aerial GPR measurements; however, it was somewhat inconsistent in terms of producing a strong enough return to be an effective approach for bathymetry mapping.

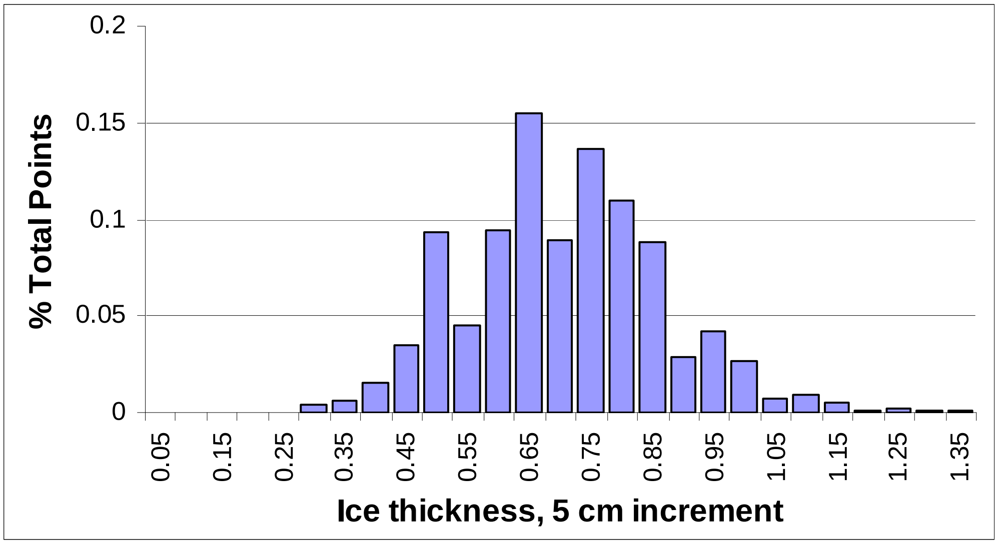

Figure 3: Distribution of ice thickness values obtained from aerial GRP deployment.

Several practical considerations were revealed during this investigation. For example, in terms of data management, it was found that it is actually useful to minimizing the quantities of data collected, since post-processing is the most time consuming aspect of the measurement. However, this may prove to be less onerous, when a data bridge between the GPR and the GPS can be used. Helicopter safety is also an issue. Flying low over the ice cover can stir up snow creating dangerous whiteout conditions. Discrete point ('touch and go') measurements are particularly impractical from this perspective.

In summary, the 400 MHz GPR antenna produced reasonable measurements of ice thickness using both ground and aerial deployments. The GPR did not consistently provide a bed location and was thus deemed unsuitable for this task; however, it may be suitable for detecting the edge of water. Further work to be included in the poster includes using the GPR and helicopter to measure an ice jam profile this spring. This will be done by deducing a total thickness from the unsubmerged thickness that the GPR will return. If successful, this would be a great potential application of aerial GPR data collection.

References

Arcone, S.A. and Calkins, D.J., 1990. RADAR surveying of the bottom surface of ice covers. *Canadian Journal of Remote Sensing*, 16, 30-39.