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Ice Detection and Measurements using Sonar in a Frozen River

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Opinion

The acquisition of time series data and other, less temporally comprehensive, information on frazil, anchor, mobile floe, and stable ice in freezing rivers has long been a serious difficulty for both researchers and those responsible for river and flood control. Many of the challenges stem from the fact that winter river settings are notoriously hostile to underwater instruments, necessitating operations in the presence of both big blocks of moving ice and small frazil particles. The latter particles not only change the physical characteristics of the water column, but they may also coat all surfaces with thick coatings of "anchor ice" if the conditions are correct. Such ice increases buoyancy and, as a result, can destabilise apparatus and infrastructure that isn't properly secured.

The purpose of this study is to outline technical elements of recent advancements in using bottom-mounted Shallow Water Ice Profiling Sonar to monitor ice on and beneath the surface of a winter river. The majority of this improvement was made during BC Hydro's four yearly winter measuring programmes in the Peace River near the town of Peace River, Alberta, Canada. The information offered here is meant to serve as background material for interpreting data obtained with similar technology in the past or present. The substantial data gained in the Peace River projects directly connected to the characteristics and sources of particle or frazil ice will be reported and interpreted in a second publication. Additional results on other elements of river ice seasons are currently being investigated, such as the intricacies of the lead-up to ice cover stability and break-up, with results to be published in future publications. Our present focus will be on descriptions of the Peace River initiatives' approach and tools.

These explanations will stress growing understandings of basic aspects while also clarifying the links between measurable metrics and physical quantities crucial to understanding and modelling a winter river. The approaches employed to mitigate the above-mentioned physical effects of the winter river environment on measurement and data collecting technology will, of necessity, receive a lot of attention. SWIPS technology grew out of a vast body of earlier work that used upward-looking sonar draught measurements to estimate the thickness of floating marine ice covers and, to a lesser degree, to estimate the amount of suspended particle ice beneath such ice covers. The draught measuring application used equipment like ASL's IPS4 Profiler to work at depths of 25 m to 50 m below the ice cover, generally from bottom-anchored moorings.

Individual brief acoustic pulses or "pings" related to scattering/reflection by the ice cover under the surface are monitored for signal return time delays. Freshwater applications were first centred on using time delays to estimate the draughts of drifting or stable ice, similar to marine applications. Returns from the water column's body, on the other hand, were consistent with increased detection of suspended frazil ice. This discovery, made with the first SWIPS instrument, prompted instrument modifications that finally allowed SWIPS studies of both suspended and floating ice to be conducted simultaneously. Section-2 goes through the fundamentals of the IPS and SWIPS technologies as they evolve. Instrument design, setup, and settings have changed throughout time, and these changes have been linked to motivating variables such instrument deployment stability, data continuity, and seasonal and depth-dependent variances in the targets of interest. The latter sections of this Section are devoted to recent advances in instrument capabilities as well as current understandings of what is required for effective instrument deployments.

Our experiences in the Peace River with alternate deployment options are discussed and reviewed, as well as a reasonably full explanation of the design and deployment concepts used during an almost entirely successful data collection programme in 2007–2008. Section-3 explains how SWIPS equipment collects data and how it relates to the river ice characteristics being studied. This method employs the Sonar Equation, as well as a backscattering term, to capture all ice-related data available from SWIPS readings. Applications on several bulk and numerous individual particle ice targets are differentiated. Backscattering data is linked to parameters used to define floating and suspended ice wherever possible. Section 4 presents some instances of the collected acoustic signal data, as well as their sensitivity to frequency and other parameters, to demonstrate the types of information made available by the new technique.

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