Seasonal Ice Mass Balance Buoys

Adapting Tools to the Changing Arctic

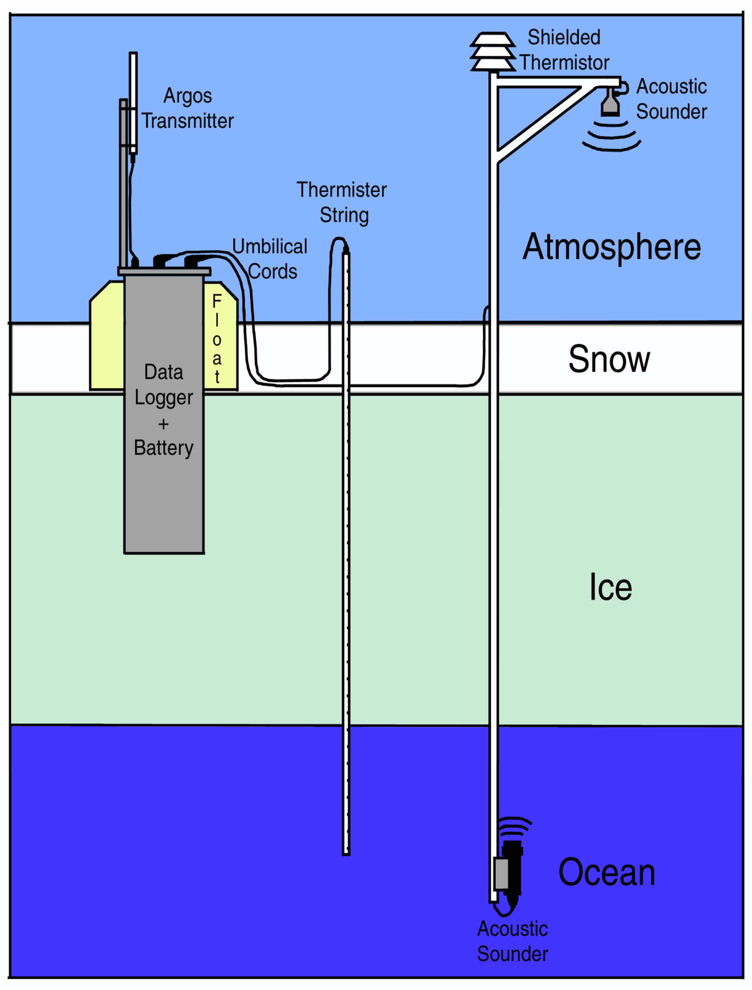
Chris Polashenski,[1] Don Perovich,[2] Jackie Richter-Menge,[2] Bruce Elder[2]
[1]Thayer School of Engineering, Dartmouth College, Hanover NH [2]CUS Army Engineering Research and Development Center, Cold Regions Research and Engineering Laboratory

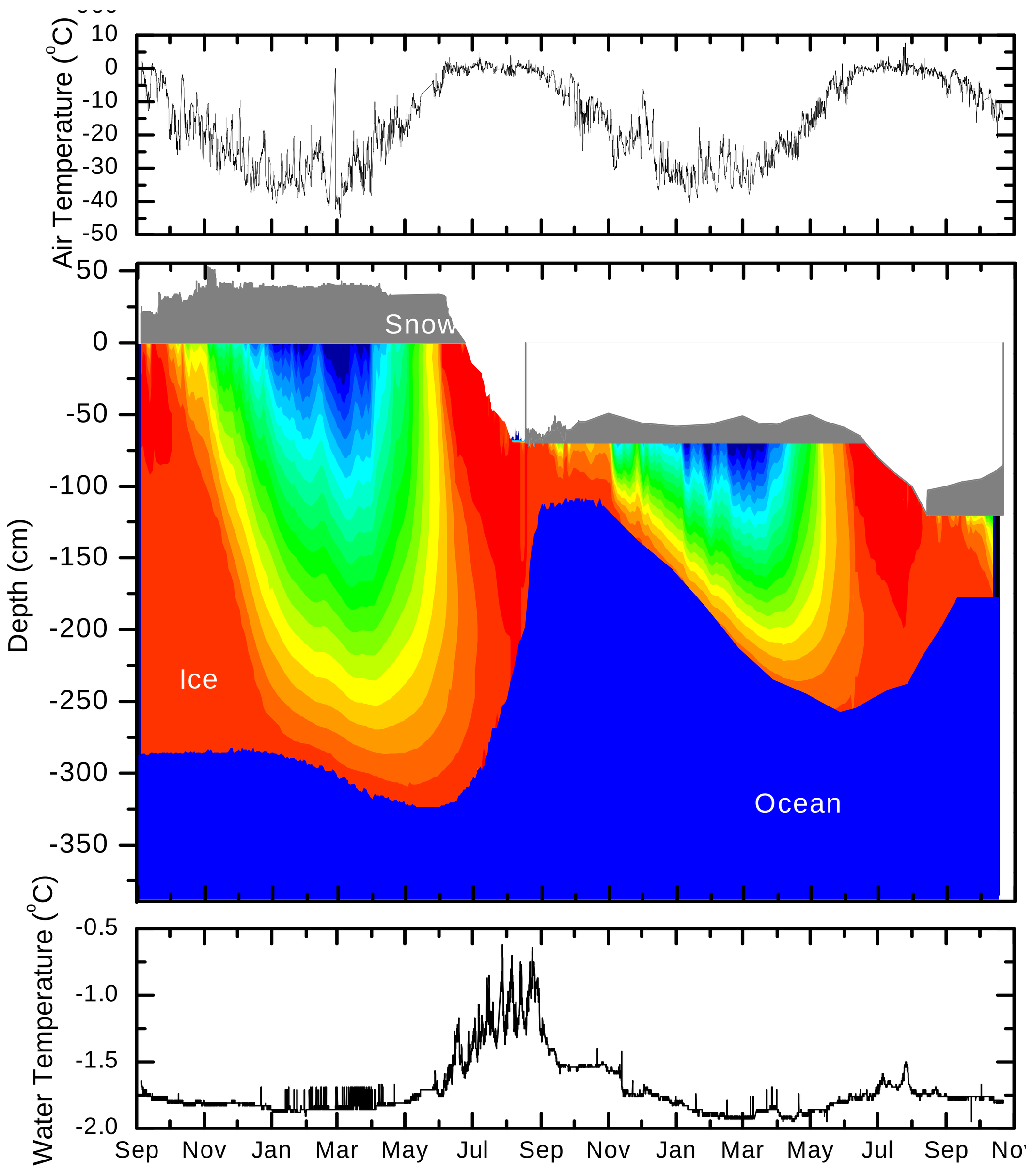
ABSTRACT

Arctic sea ice is in decline. Evaluating the role of various factors influencing this decline is critical to understanding, modeling and predicting the future ice cover. The local mass balance of Arctic sea ice is an important, observable variable which provides opportunities to differentiate the roles of various factors and to attribute the observed changes in a floe's mass balance to specific forcing phenomena. Since 1997, local sea ice mass balance has been measured by a Lagrangian array of autonomous buoys. A shift from multiyear to seasonal ice in large portions of the Arctic presents a challenge for existing autonomous ice mass balance measurement buoys, which were designed with a perennial ice cover in mind. Here we present a new autonomous buoy designed to monitor ice mass balance in the seasonal ice zone along with results from a prototype deployment.

The Importance of Local Mass Balance Measurements

The local mass balance is measured by tracking the amount of ice growth in the winter and the amount of surface and bottom melt in the summer occurring on a particular ice floe. Changes in local mass balance reflect the integration of all the terms in the surface heat budget and ocean heat flux on a single piece of ice, tracking an ice floe's journey through both space and time. Measurements of local mass balance can help to quantify the impact of specific thermodynamic factors on ice loss. When this information is coupled with meteorological and oceanographic measurements it provides evidence which can be used to connect measured anomalies in forcing factors to their impacts on the ice mass balance.

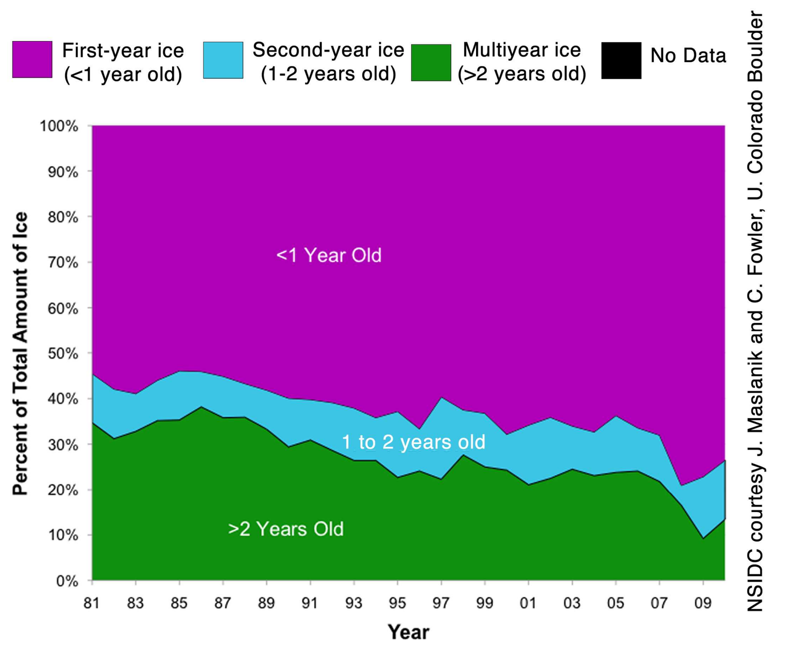




Measurements of the local mass balance taken with a series of Ice Mass Balance buoys (IMBs) deployed by CRREL over the past decade have been used to investigate thermodynamic processes affecting the ice cover. The buoys (see illustration above) are designed to be deployed on multiyear sea ice. The IMB has 3 separate elements and depends upon the integrity of the ice for supporting instruments and keeping it afloat.

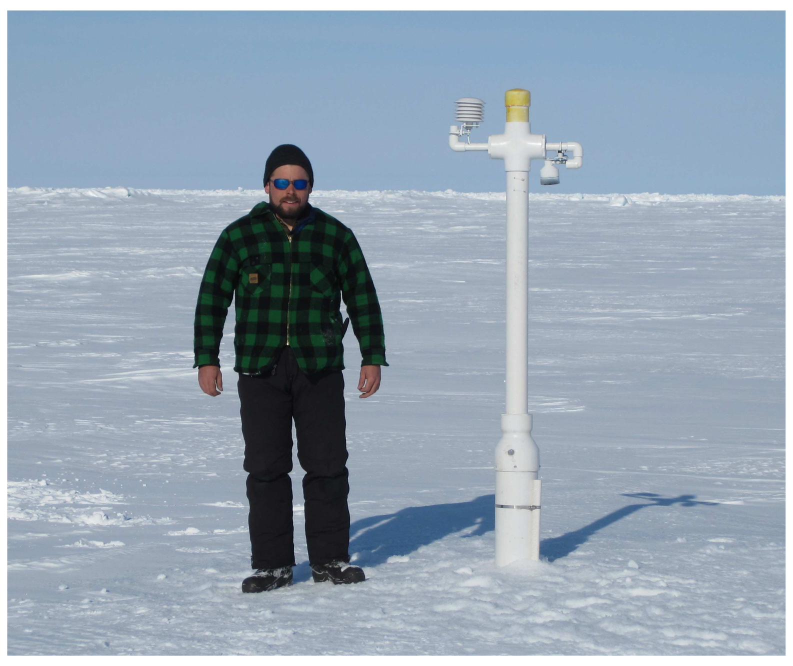
A Changing Sea Ice Cover

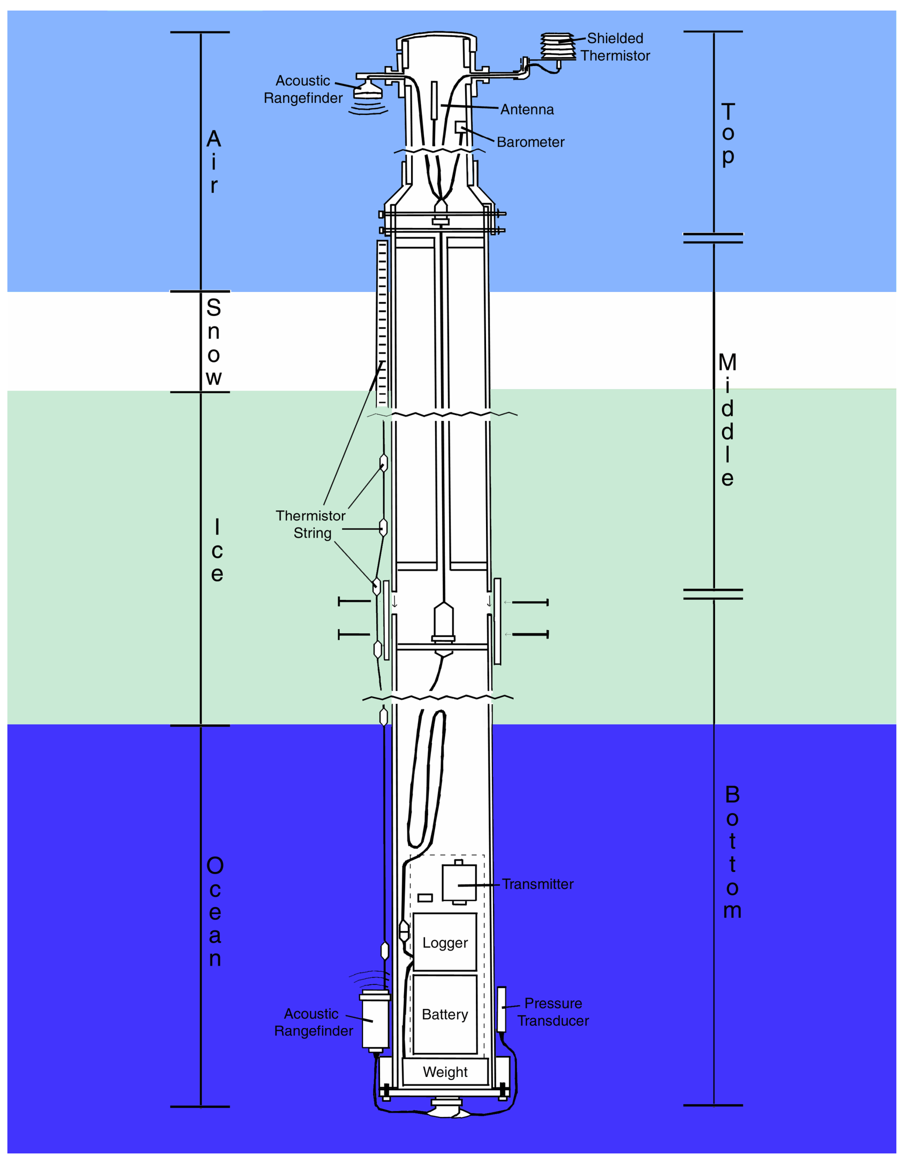
The perennial ice cover has been retreating faster than the seasonal ice cover significantly *increasing* the area of the Seasonal Ice Zone (SIZ). In recent years, ice less than one year old has represented as much as 70% of the maximum winter ice extent in the Arctic. With trends and predictions pointing to further reductions in perennial ice and the potential for a seasonally ice-free Arctic, understanding the processes contributing to mass balance changes in understudied seasonal ice is of growing importance.



The Seasonal Ice Mass Balance Buoy

The result of our design process is the patent pending Seasonal Ice Mass Balance Buoy (SIMB). The SIMB, shown at right and below, has been built around a single six inch diameter spar-buoy type hull which contains, protects, and positions the sensors. The buoy incorporates a number of design features intended to enhance ease of deployment, reduce costs, improve data quality control, and, most importantly, enhance survivability in the Seasonal Ice Zone.

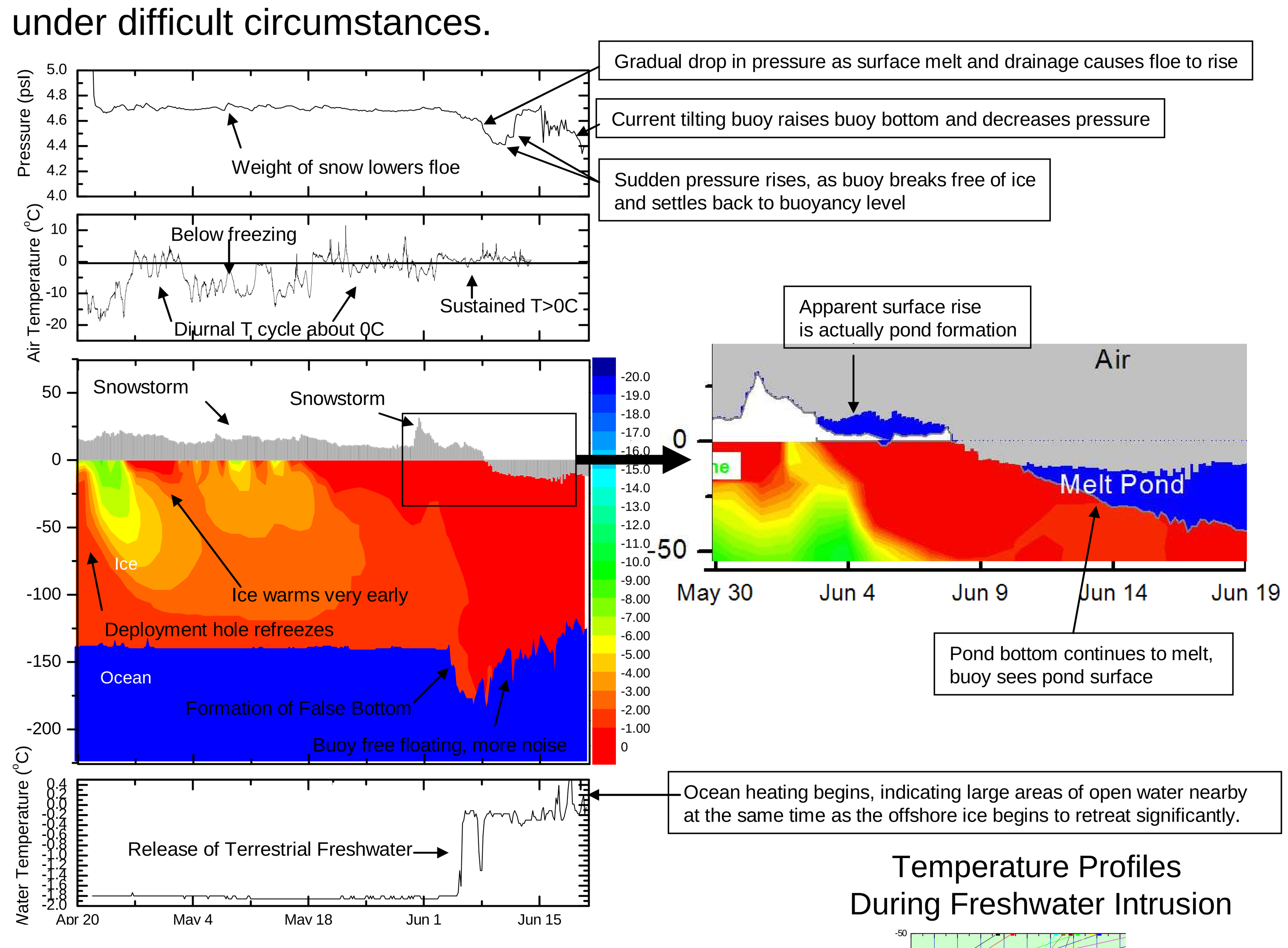




- ► Very simple, rapid deployment
- ► Only one hole to drill
- ► No external wires
- ► Floats with righting moment
- ► Doesn't need ice for support
- ► Ships in 3 pieces <2.45m long
- ► Total weight 65kg
- ► Deployable in thin ice
- ► Iridium SBD Transmissions
- ► Data quality control sensors
- ► White, foam filled PVC hull minimizes affects on ice
- ► Testing lower cost sensor and control components for cost reductions in production version.

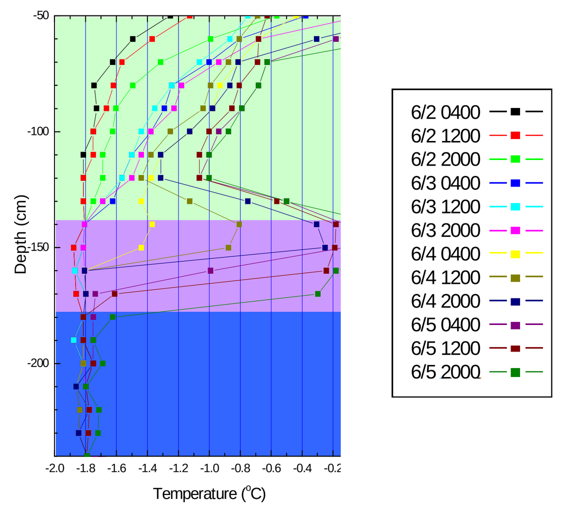
Results from Test Deployment

The SIMB prototype was test deployed in a 1.35m thick undeformed, seasonal, landfast ice approximately 1 km offshore, just north of Barrow, AK from April 21, 2009 to June 23, 2009. The prototype buoy was intentionally deployed in an area of locally thinner snow cover, where past observations show a melt pond would form. A second, un-instrumented buoy hull was deployed at a location of deeper snow adjacent to the prototype for comparison. Results from this deployment, plotted below, illustrate the buoy's ability to detect a number of complicating factors, and produce valid data under difficult circumstances.



From the raw data we can infer ice thickness, ice draft, snowfall, melt rates, and causal relationships The data above and to the right shows the intrusion of a freshwater layer and formation of a false bottom, melt pond formation, and freeboard changes associated with pond drainage in addition to these core data.

Temperature Profiles During Freshwater Intrusion



The SIMB is now deployed off the Alaskan coast in the floating pack ice. Data will be available online soon at http://imb.crrel.usace.army.mil/

ACKNOWLEDGMENTS

This work has been funded by the National Science Foundation Arctic Observing Network Program and Arctic Research Program of the NOAA Climate Program Office.