Soil Water Content Sensors as a Method of Measuring Ice Depth

Emily Whitaker[1], David Reed[2], Ankur R. Desai[2]
Dickinson College, Department of Physics and Astronomy[1]
University of Wisconsin-Madison, Department of Atmospheric and Oceanic Science[2]

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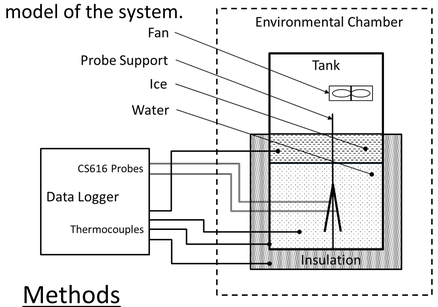
Introduction

Lakes are a critical part of an ecosystem and our world, yet their ice depth can be very difficult to measure continuously and remotely. By using CS616 sensors to convert volumetric water content into both temperature and ice depth we have developed a cheap and fast way of measuring ice depth that has many practical uses.

Figure 1: Conceptual model of the system.



Methods

A model lake was made with a tank and store bought insulation. A Tenney (Versa Tenn V) environmental chamber realistic insured that winter lake temperatures could be met.

Air temperatures ranged from -30°C to 30°C. Thermal couples were placed in the insulation and in the water to measure heat flux throughout the system and to have another way of sensing ice growth. After each trial all ice was melted off.

Figure 2: picture of system inside the chamber.

A second set of experiments was done in a smaller tank, looking to see if any bending or breaking of the rods or ionizing of the water would impact the response of the sensors.

Results

Equation 1: Relates volumetric water content to ice depth. Found by determining the resting volumetric water content of the sensor (a) then by solving the first equation for m, the slope. The piece- wise equation determines how the volumetric water content relates to ice depth based on temperature and the sensor's output.

$$0 = am + 30$$

$$y = \begin{cases} 0, & if\ x \geq a \\ mx(t) + 30, & if\ x < a \end{cases}$$

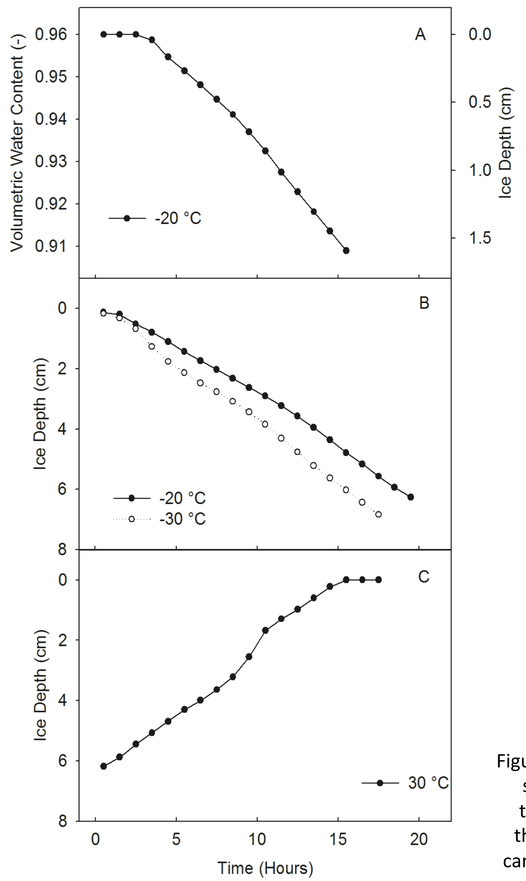


Figure 4: Panel one shows ice growth to volumetric water content , using equation one, over time. Panel two compares the slope when the chamber was set at two different air temperatures. Panel three shows a period of ice melt when the chamber was set at to 30°C.

Figure 3: Shows the relationship between volumetric water temperature, temperature, and ice depth.

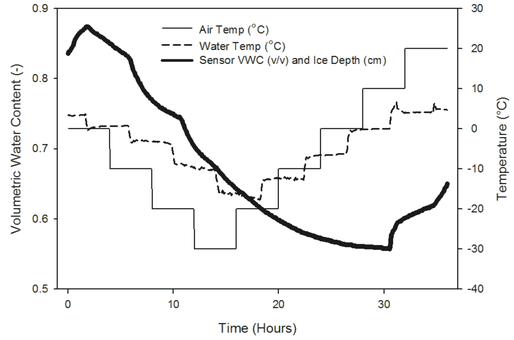


Figure 5: Shows a comparison of two models of soil water content sensors

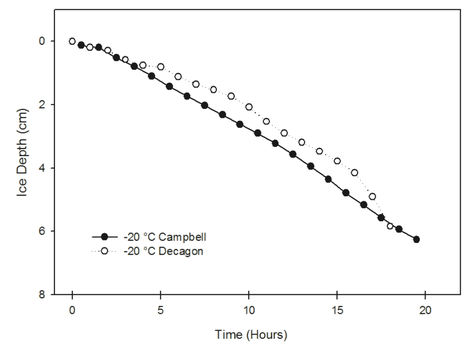
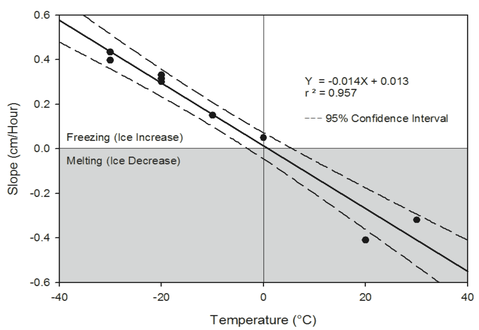


Figure 6: Showing how the slope directly relates to temperature. By finding the slope in cm/hour we can determine if the ice is growing or melting.



Discussion

- Will be continued winter 2015-2016 on Lake Mendota in Madison, Wisconsin.
- Ice core should be done once an ice growing season while sensors are on a lake.
- Ionized Water changed a value slightly
- Having an inorganic material between probes greatly effects a values
- Local DNR groups can use this method of recording ice depth to improve safety conditions of recreational ice activities.

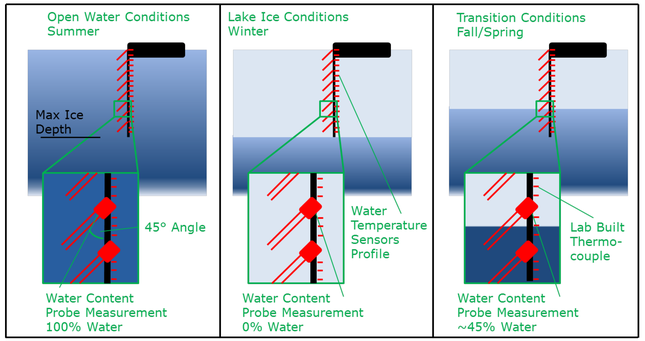


Figure 7: Conceptual model of on-lake ice-depth measuring system.

Figure 8: Lake Mendota frozen over, winter 2013, source Center for Limnology University of Wisconsin-Madison

Conclusions

- Cheap, sturdy, and can be placed almost anywhere,
- Can detect fairly small changes in ice growth, but have trouble recognizing thin ice sheets,
- Can gather ice depth information quickly and reliably,
- Records heat flux.

Acknowledgements

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