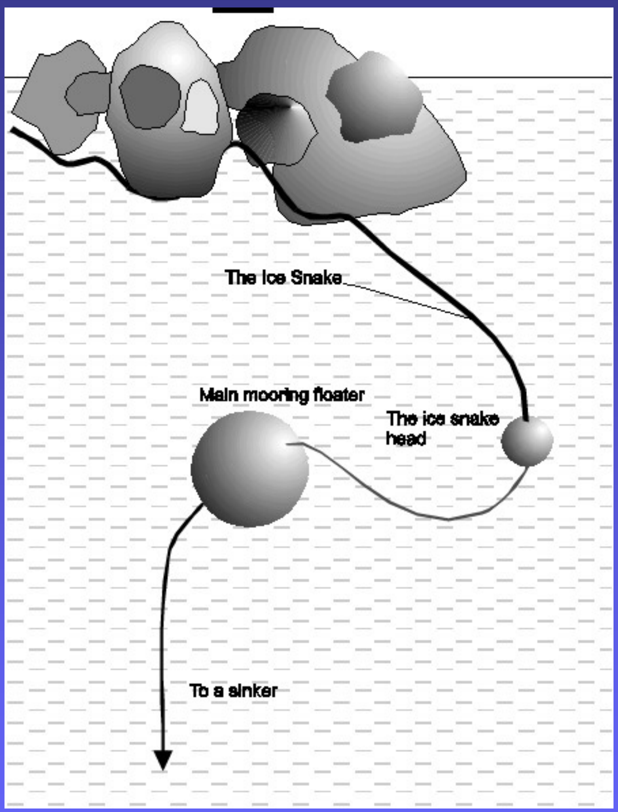
The Ice Snake

method for Eulerian real time measurements of polar ice drift and thickness



The actual poster describes the idea of the Ice Snake and reports from prototype work.
It shows opportunities with an instrument "swimming in the ice field" - and how simple/cheap such an instrument may be made.

by
Reinert Korsnes,
Norwegian Defense Research establishment, Division of electronics, Box 25, NO-2027 Kjeller, Norway;
&
Denis Zyryanov,
Water Problems Institute, RAS, Gubkina st. 3, GSP-1 119991, Moscow, Russia;

How the Ice Snake works:

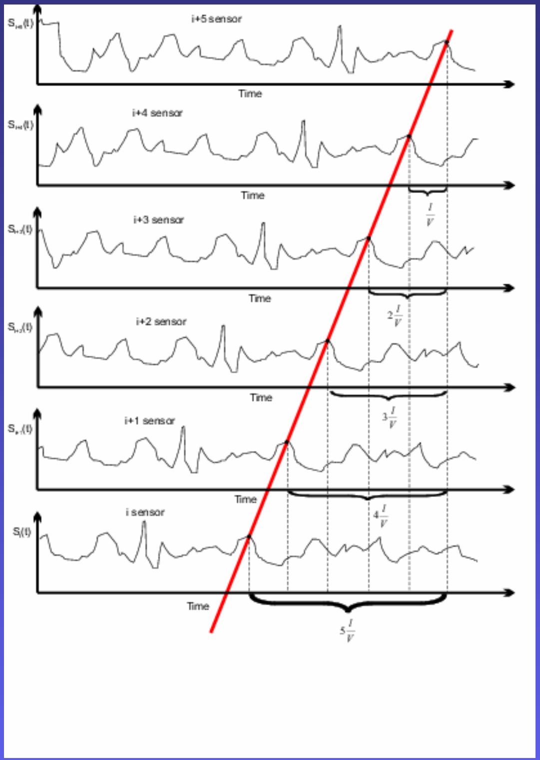


Figure 2.1 (schematic draw): pressure data from six different pressure sensors along the ice snake. A data series are higly correlated since they pass below the same irregularities of the ice bottum.
The time lag depends of ice drift velocity and the distence between the sensors (the inclined red line).

- It is a snake-like floater assumed to be moored below sea ice.
  Buoyancy presses it up to moving drift ice.
  Its head is pulled down to a deep not reached
  by the deepest ice keels.
  It includes pressure sensors along its body.

- Time series of pressure data from these sensors provide
  estimates of ice thickness and velocity.
  Other possible data are: salinity and high resolution
  radiation measurements from below the ice.

- These data also provide estimates of atmospheric pressure.

- An antenna on the snake can facilitate real time access
  to data via satellite.

Can the ice snake get fixed to drifting ice ?

- Salt within ice tend to migrate out of it and to the surface.
  Hence, if ice freeze on the surface of snake, salt tend to concentrate at the surface of the snake. Since the snake will have a temperature close to the ambient water, the ice therefore tend to slip off the surface of the snake.

- The ice drift, the shape and stiffness of the snake makes it unlikely to freeze into drifting ice.

- If the sea ice field above the snake gets fixed to land contours (shore fast ice),
  there is currents below the ice, which can make it moving to avoid getting fixed.

Prototype work

Mov. 4.1: Preliminary experiments with a silicone rope in a water tank. The sensors marks (tags) were visually analyzed.

We preliminary visually analyzed a floating flexible rope where a length is L = 1458±1 mm and the outer diameter is 9±1 mm (inner diameter is 5±1 mm). The model consists of tube of industrial silicone tissue (mov. 4.1).

The developed Ice Snake prototype consists of 5 Motorola MPX2200AP pressure sensors located in hermetic vials (fig. 4.2) together with amplifier microchip LM358. The simulations took place in iron fresh water tank equipped with two round glass windows of 0.6 m diameter each. The tank is 2.5 m long and 1.5 m wide and the depth is 2.0 m.

Figure 4.2: Pressure sensors with amplifier microchip in hermetic vials (front, opened).

The lab experiments results with pressure sensors:

The experiments showed that average meaning of the pressure sensors data adequately describes ice thickness whereas the least-square method provides the ice drift.

# of pressure sensor	Water depth	Mean value	Dispersion
1	8.0±2.0 cm	10.8 cm	2.8 cm
2	8.0 ±2.0 cm	10.8 cm	2.8 cm
3	10.0 ±2.0 cm	10.8 cm	0.8 cm
4	12.0 ±2.0 cm	10.8 cm	1.2 cm
5	16.0 ±2.0 cm	10.8 cm	3.2 cm

Table 4.1: The results of ice floes thickness estimation based on pressure sensors data.

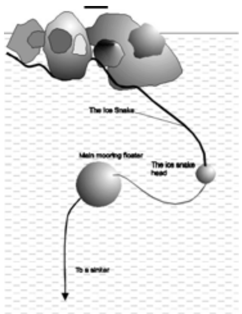
s / #	1.0	2.0	3.0	4.0	5.0	6.0	7.0
1	4.0	5.0	7.0	4.0	0.0	0.0	0.0
2	6.0	7.0	10.0	8.0	6.0	4.0	0.0
3	0.0	0.0	8.0	6.0	8.0	10.0	6.0
4	0.0	0.0	0.0	0.0	4.0	6.0	6.0
5	0.0	0.0	0.0	0.0	0.0	0.0	2.0

Table 4.2: Ice floes drift dynamic experiment based on pressure sensors data in time series.

More details are on our poster. Welcome!

Method for Eulerian real time measurements of polar ice drift and thickness

Reinert Korsnes,
Norwegian Defense Research establishment, Division of electronics, Box 25, NO-2027 Kjeller, Norway;
Denis Zyryanov,
Water Problems Institute, RAS, Gubkina st. 3, GSP-1 119991, Moscow, Russia;



Introduction

The Ice Snake can measure ice drift and thickness at a fixed location within drift ice in the Arctic and Antarctic. It can also measure atmospheric pressure and transfer data near real time to users. The Ice Snake provides a unique concept for measurements as compared to known alternatives. The main market for it is related to meteorological service, environment monitoring and scientific process studies. The Ice Snake can be used to measure surface air pressure. A large scale monitoring of ice drift and air pressure in the Arctic may (as a rough estimate) include one ice snake each 5 deg longitude at for example 85 deg North. This gives 72 snakes/positions. A similar number of snakes could cover Antarctica.

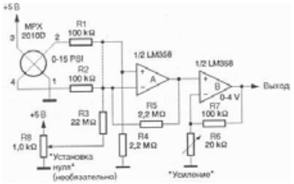


Figure **2. a**: Electronic chart of Motorola MPX2200AP pressure sensor equipped by two cascade amplification microchip LM358. **b**: The Ice Snake on a table. **c.** Free drift of the pressure sensors in water tank of institute of mechanics MSU.

The prototype development

There are five pressure sensors located in hermetic cans. The size of each can is 30.5 mm (diameter) x 97.2 mm (long), weight = 0.040 kg. The pressure sensors themselves are Motorola MPX2200AP providing pressure range of 0 - 200 kPa. Each of them is equipped with two-cascade electronic amplifier microchip LM358. All electronic components are inside the cans - only silicone tiny pressure tube as well as three wires go outside (fig. 1a,b). The sensors need input of DC +9V for functioning and provide output analogue signal in the standard range of 0 - 5V. The all five pressure sensors (cans) are located along electronic bus with a step of ~ 1.5 m (modifiable). We applied the Ice Snake prototype to water tank experiments without external silicone cover (snake 'scales') since there is no need to protect sensitive electronic components from outside in a lab.

Figure 1a,b: Motorola MPX2200AP pressure sensors in hermetic vials equipped by two-cascade amplification microchip LM358 .

The results of lab experiments with the Ice Snake prototype in a water tank

Table 1 summarises the results of floating ice floes thickness estimation based on the pressure sensors data. The ice floes are simulated by floating plastic cans partly filled with water. The total amount of the cans is chosen thus to pull down the all pressure sensors simultaneously. The applied pressure sensors measure the water depth with accuracy of ±20 mm (1mV of output voltage). They are calibrated to avoid dispersion in origin values caused by difference in technical parameters and fluctuations of atmospheric pressure. Averaged ‘ice floes’ draught constitutes 10.0 cm.

# of pressure sensor	Water depth	Mean value	Dispersion
1	8.0±2.0 cm	10.8 cm	2.8 cm
2	8.0 ±2.0 cm	10.8 cm	2.8 cm
3	10.0 ±2.0 cm	10.8 cm	0.8 cm
4	12.0 ±2.0 cm	10.8 cm	1.2 cm
5	16.0 ±2.0 cm	10.8 cm	3.2 cm

Table 1: The results of ice floes thickness estimation based on pressure sensors data.

Table 2 shows the results of ice drift velocity estimation based on the pressure sensors time series data. To model the ice drift, a few plastic cans partly filled with water are dragged with constant speed of 50.0±10.0 cm/s (draught is 10.0 cm) along the Ice Snake body. Its sensors come through the ‘ice floes’ irregularities in series and the drift speed is calculated by the least-square method. The more inhomogeneous the ice bottom is, the more precise the drift speed is defined. The estimated ice floes speed constitutes a value of ~ 40 cm/s by data shown in the table 2.

s / #	1.0	2.0	3.0	4.0	5.0	6.0	7.0
1	4.0	5.0	7.0	4.0	0.0	0.0	0.0
2	6.0	7.0	10.0	8.0	6.0	4.0	0.0
3	0.0	0.0	8.0	6.0	8.0	10.0	6.0
4	0.0	0.0	0.0	0.0	4.0	6.0	6.0
5	0.0	0.0	0.0	0.0	0.0	0.0	2.0

Table 2: Ice floes drift dynamic experiment based on pressure sensors data in time series.

Acknowledgements

We wish to thank Vladimir Eroshin & Vitaliy Samsonov (Ins. of mechanics (NIIMECH) of the Moscow State University) for their giant help in arranging lab experiments in a water tank. We are especially grateful to NIIMECH director prof. V. Okynev for his wide support and permission of evaluation this research in labs.