

Helicopter Fixed-mount Electromagnetic-Induction Ice Thickness Sensor

A helicopter-towed Electromagnetic-induction (EM) sensor has been used since 1996 in the Gulf of St. Lawrence to complement ice information inferred from satellite imagery by the Canadian Ice Service (CIS) in support of Canadian Coast Guard (CCG) icebreaking operations. A second, fixed-mount system was developed in 2000 to simplify the use of helicopter landing decks on Canadian icebreakers as refuelling sites, thereby increasing the operating range of ice reconnaissance flights.

Figure 1. "EISFlow™" EM sensor, also known as "Ice Pic", mounted on a Canadian Coast Guard BO-105 helicopter on board the CCG icebreaker Edward Cornwallis. The fixed-mount sensor package (20 Kg) consists of a laser, an EM transmitter and EM receiver mounted inside a cylindrical tube, fitted to the nose of the helicopter. Four EM frequencies (1.67, 5.02, 11.7, and 35.1 KHz) are used to measure the distance to the ice-seawater interface while the laser measures the distance to the ice surface. The difference gives the snow-plus-ice thickness.



The system can be used to spot sample by soft-landing and averaging the incoming 10 Hz data, or to profile floes by low flying slowly over the floe. The EISFlow™ console runs on 28-volt helicopter power, and, in addition to the EM/laser data, it logs GPS position and radar altimeter data derived from the helicopter's avionics.



Figure 2



Figure 3

On-board system console strapped into the back seat of the helicopter (Fig. 2), and the hand-held operator's control unit on the front seat (Fig. 3), with the power and GPS input connectors to the helicopter visible in the background.



Figure 6. Helicopter and EISFlow™ collecting ice thickness profile data while flying slowly over undeformed first-year ice.

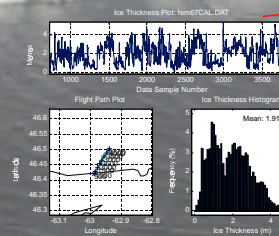


Figure 7. Ice thickness profile (9.5 km length) and histogram from middle line shows undeformed thin ice (35-40 cm thick) between undeformed medium first-year ice (75-100 cm thick) and ice rubble (1.5-4.5 m thick).

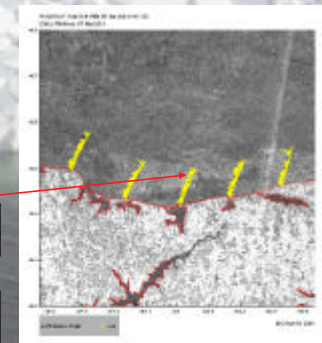
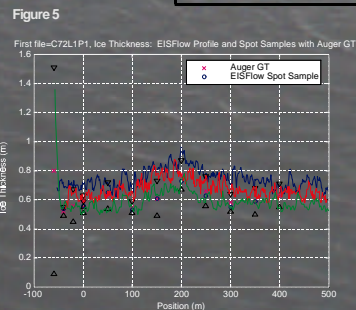
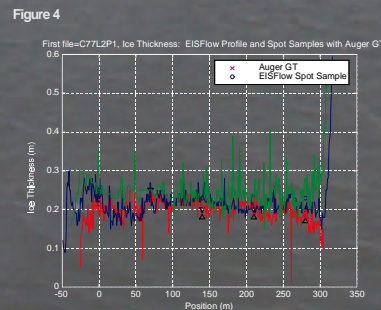


Figure 8. RADARSAT Scan SAR Wide (70 km x 70 km) sub-image of March 8, 2001 overlain by five ice thickness profiles collected on March 7 over the rough, ridged inshore ice compacted against the Prince Edward Island coast by northwesterly winds.



Comparison of auger data with EISFlow™ spot samples and low flying profiles. The auger data is shown as a 3-hole average (x) and deviation (triangles) for 5 locations from the thin ice calibration line (Fig. 4) and for 11 locations from the thick ice calibration line (Fig. 5). Profiles were collected at three different flying heights, with the sensor at 1.6 m (red), 3.3 m (blue) and 6.0 m (green) above the ice surface. Auger and EM spot samples compare well, and the flight profiles show good repeatability of the data regardless of sensor flying height.



Figure 9. Ice conditions along the profile line shown in Fig. 7: a) looking at 17:21 EST north along the flight line at 150 m altitude; b) at 17:26 EST along the line (2.5 m altitude); and c) at 17:27 EST looking down from 50 m at end of the line.

Acknowledgements

The EISFlow™ sensor was developed and built by Geosensors Inc. of Toronto for the sea ice program of the Bedford Institute of Oceanography. The project was funded through the Panel on Energy Research and Development and through the Canadian Coast Guard R&D program. We thank the Canadian Coast Guard for their helicopter logistic support and Canadian Space Agency for providing the SAR imagery through the ADRO-2 program.

For More Information: <http://www.mar.dfo-mpo.gc.ca/science/ocean/seaice/icepic.htm>