Background

Antarctic ice plays a significant role in regulating the Earth's weather systems. The harsh environment and high cost of existing ocean current sensors presents a barrier to large scale data collection. A low cost sensor capable of being deployed in large arrays for long periods would drastically increase the amount of data collected from the region. Ocean current temperature and velocity data is collected to estimate energy deposition in ice shelves. This data can then be used to predict trends in Antarctic and global weather.

Requirements

In order to provide a significant advantage over commercially available sensors the LOCATS project must meet certain minimum requirements. Areas of particular interest are measurement precision, mission capabilities, and cost of production.

- Temperature measurements to ±0.05 °C from -2 to 10 °C
- Current speed measurements ±0.25 cm/s from 0 to 25 cm/s
- Current direction accurate within 5°
- Timestamp accurate to 5 min over a year

Mission Capabilities

- 1000 meter operating depth
- 1 year mission life
- 0 degree celsius operating temperature
- Production
- Maximum cost of $1,000 per sensor

A comprehensive list of requirements is recorded in the symposium paper.

The current iteration sensor has been verified to meet temperature measurement and cost requirements. Further tests are required to validate or invalidate the completion of the remainder of deliverables.

Concept of operations

The LOCATS sensor is being designed and tested with large scale deployment in mind. When the sensor is commissioned for a research mission production and quality assurance will take place in Colorado. Integrated sensors will be shipped to the research vessel on which they will journey to the deployment site. This phase may take several weeks. Once on site, research vessel staff will follow a power-up procedure and perform final mating of the pressure seal. The sensors will then be affixed to the mooring line and deployed.

On the mooring line the sensors periodically log data until they are recovered or run out of power. Finally, the sensors are recovered when weather allows and the data returned to the customer for analysis.

Electronics

The electronics system is built upon and commanded by an ATmega328 in an Arduino Pro Mini. The processor controls all sensors through the Arduino programming language, and sensor communication is performed through the I2C and SPI buses as well as the digital and analog inputs/outputs. For design ease and data protective, data is written to a microSD card. To save power, the processor will enter sleep mode, and data is taken only during the active portion of the duty cycle.

The power system must be capable of driving the sensor for the full mission duration of a year. The batteries will experience temperatures near zero degrees Celsius continuously, and the sensor must have a specific buoyancy, so the mass is restricted. In light of these challenges and the power demands of the electronics system, Energizer Ultimate Lithium AA size batteries were selected as the power supply.

The temperature sensing system is comprised of four thermistors. The thermistor test March 3 2016: 1 sec intervals performed in which the sensor logged data in a well mixed ice water bucket for 18 hours. Each recorded measurement is the average of thirty samples to help mitigate sensor noise. Over the course of eleven entries the maximum standard deviation was 0.005 °C from thermistor 1.

Next steps

Since March the team has been incorporating design improvements in a second iteration of hardware. This platform will serve to facilitate more comprehensive testing and characterization. A short term ocean deployment test is planned for summer.

Project structure

Project LOCATS is led by students in the Colorado Space Grant Consortium (COSGC) at the University of Colorado, Boulder. Funding and consultation is provided by the Cooperative Institute for Research in Environmental Sciences (CIRES) and the National Snow and Ice Data Center (NSIDC).

Temperature test results

Temperature testing shows that the precision of the thermistor ADC system far exceeds requirements.

A day in the life (DITL) test was performed in which the sensor logged data in a well mixed ice water bucket for 18 hours. Each recorded measurement is the average of thirty samples to help mitigate sensor noise. Over the course of eleven entries spanning ten minutes the maximum standard deviation was 0.005 °C from thermistor 1.