Cryologger: a low-cost, open-source datalogger and telemeter for cryospheric research

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Introduction

- Polar environments are undergoing rapid environmental change, yet there is a lack of high spatial and temporal monitoring data available in these remote regions.
- Reliance on expensive and proprietary commercial data acquisition and telemetry systems can inhibit both researchers and citizen scientists and present a significant barrier to the establishment of widespread monitoring networks [1].
- The development of low-cost, open-source instrumentation can greatly reduce the cost of cryospheric research, improve the spatial density and coverage of collected data, and produce new ways to observe and monitor the cryosphere [2].

Objectives

- The goal of this project is to determine if the Cryologger, an open-source datalogger and telemeter comprised of low-cost, off the shelf components, is capable of supporting the physical measurement needs of a variety of cryospheric scientific applications.

Materials & Methods

- The Cryologger design is based on the open-source Arduino platform (www.arduino.cc) and built using easy-to-use, do-it-yourself electronics.
- The initial Cryologger was configured as an ice tracking beacon that records and transmits temperature, pressure, pitch, roll, magnetic heading, GPS location, and battery voltage (Figure 1).
- Code was written using the open-source Arduino integrated development environment (IDE) and compiled from community generated libraries. Programming logic is highly focused on power optimization (Figure 2).
- A second Cryologger configuration, based on a low-cost L1/L2 GNSS receiver, is intended for use as a glacier velocity measurement system.
- Cryologger deployments rely on industrial rated components, IP67 rated enclosures and lithium thionyl chloride ($LiSOCl_2$) batteries to withstand harsh the Arctic environment and ensure operation in temperatures as low as -40°C.

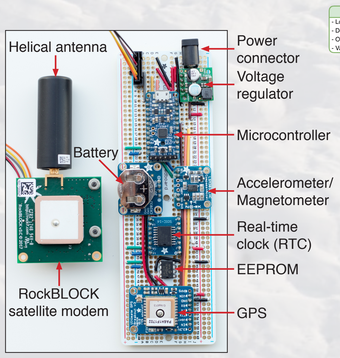

Figure 1. Design of Cryologger tracking beacon configuration.

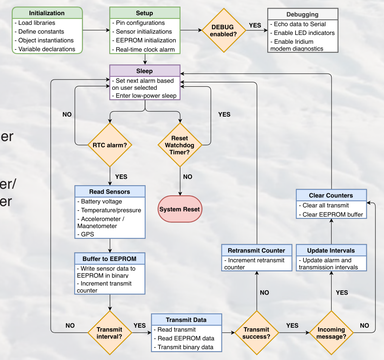

Figure 2. Programming logic followed by the tracking beacon configuration.

Results

- Six Cryologger tracking beacons were successfully deployed by helicopter (Figure 3) on icebergs and ice islands along the coasts of Ellesmere Island and Baffin Island (Figure 4) during Leg 3 of the 2018 CCGS *Amundsen* Expedition.

Figure 3. Assembled Cryologger beacon housed in Nanuk 905 enclosure prior to deployment (left), suitable target for beacon deployment (centre), helicopter deployment and measurement of beacon compass heading (right).

- Following deployment, communications with each beacon were successfully established in order to remotely modify their operational parameters for optimal battery efficiency.
- As of December 10, 2018, all six tracking beacons have achieved over 100 days of continuous operation, and transmitted a total of more than 2700 messages via the Iridium satellite network.

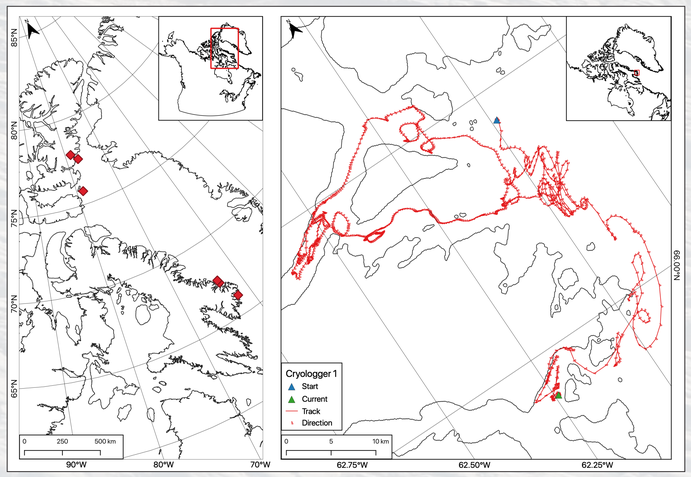

Figure 4. Successful deployments of Cryologger ice tracking beacon deployments (left) and transmitted location data from Cryologger 1 between September 6 and December 1, 2018 (right). Total track distance is approximately 371 km.

- Beacons have maintained stable operation since deployment and have already experienced temperatures as low as -40°C.
- Combined, all six tracking beacons have travelled a total distance of more than 1000 km since August 26, 2018.
- Two Cryologger glacier velocity measurement systems were succsesfully deployed on the Milne Glacier, Ellesmere Island, Nunavut in the summer of 2018 (Figure 5).

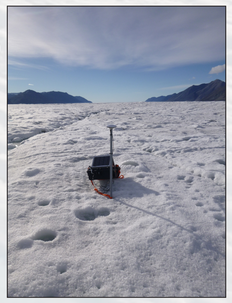

Figure 5. Glacier velocity measurement system installation on Ellesmere Island, Nunavut.

Results

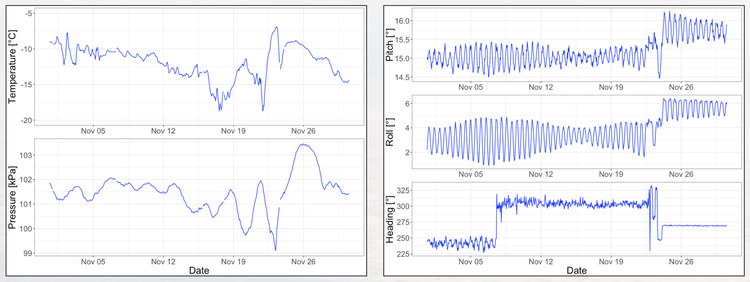

Figure 6. Sample subset of temperature and pressure (left) and orientation data (right) transmitted by Cryologger 1 beacon during the month of November, 2018. Gaps present in the data are due to intermittent anomalous sensor readings.

- Data recorded from a grounded ice island (Cryologger 1) revealed the accelerometer is capable of detecting both diurnal and lunar-phase components of the tidal cycle (Figure 6).
- All data collected by the beacons is stored and made freely available on http://cryologger.org/data.php, allowing for the monitoring of movement and identification of drift patterns of icebergs in Canadian Arctic.
- Scan the QR code in the bottom left to view tracking beacon data in real-time!

Conclusions & Future Work

- Preliminary results from the Cryologger tracking beacon have demonstrated it is possible to design and build a low-cost data logging and telemetry system capable of withstanding the harsh conditions of remote polar regions.
- Development of the next version of the Cryologger is currently underway and will incorporate the Adafruit Feather ecosystem of development boards to improve overall processing capabilities and modularity.
- Future versions of the ice tracking beacon will explore ice surface drilling and drone deployment methods, and incorporating the use of environmentally friendly 3D printed materials in the construction of enclosures and external sensor housings.
- Recovery, servicing and redeployment of the glacier velocity measurement systems deployed on Ellesmere Island is planned for the summer of 2019.
- Deployment of a Cryologger configured as an automatic weather station is also planned in Nain, NL in January, 2019.

Figure 7. Field testing of Cryologger automatic weather station to be deployed in Nain, NL.

References

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[2] Lockridge, G., Dzwonkowski, B., Nelson, R., & Powers, S. (2016). Development of a Low-Cost Arduino-Based Sonde for Coastal Applications. Sensors (Basel, Switzerland), 16(4). https://doi.org/10.3390/s16040528

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