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Cryoegg - field trials of a wireless subglacial sensor platform for deep, fast-moving ice

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Overview

Wireless subglacial sensors (e.g. Hart 2006, Smeets 2012) are a valuable tool for exploring subglacial environments. This is especially true on fast-moving ice where cables are damaged by ice motion within weeks of installation. We present a fully-redesigned version of our 'Cryoegg' sensor platform and demonstrate its utility in boreholes, moulins and proglacial streams. We show that it can transmit data through 1.3km of cold ice in Greenland, using a new radio standard designed for utility metering.

Scientific questions

- What do subglacial hydrological networks look like?
- How do they respond to climatic drivers on the surface?
- How do they affect the ice dynamics?

These questions are hard to answer with current instrumentation. Cryoegg (fig 1) – a self-contained instrument that can travel through the subglacial channels and wirelessly report temperature, pressure and electrical conductivity of meltwater – is our approach to finding answers. After a long period of engineering development (Bagshaw 2014), the instrument will soon be used to start answering these important questions.

Fig 1 – Cryoegg ready for deployment at Store Glacier

Fig 2 – Cryoegg receiving antenna at EGRIP

Technology

Cryoegg has previously been tested in temperate and cold ice in Greenland using 151 MHz, but it required improvement for reliable communication from the ice sheet bed. Cryoegg has had a complete redesign with new electronics (fig 3) and uses a new radio protocol, Wireless M-Bus.

Benefits from the redesign:

- Lower standby power consumption between measurements – now around 1.5uW
- Versatile 32-bit ARM processor (STM32L433RC) giving more flexibility for firmware development
- Better radio link performance

Wireless M-Bus is an international standard radio protocol that was developed for utility metering, to remotely read meters in France and Italy. We use the 169MHz variant which offers very long-range performance – up to 10km in air. It is easy to work with and inexpensive (~£26, Radiocrafts). Wireless M-Bus is designed for returning small amounts of data a few times a day from battery powered devices, so it is ideal for use in the environmental sciences.

Cryoegg measures T, P and EC at user-defined time intervals and transmits the data to the surface via the radio link. A large crossed Yagi-Uda antenna is used to received the signal (fig 2).

Performance in the field

We tested Cryoegg at three sites during July and August 2019:

- **EGRIP** borehole (2km deep) on the Greenland ice sheet
- **RESPONDER** borehole (1km deep) on the fast-moving Store Glacier in West Greenland
- **Rhône Glacier** (200m thick) in the Swiss Alps.

Headline results:

- **Data received from 1350m down the EGRIP borehole**
- Tested in moulins at RESPONDER and Rhone sites – live readout from Cryoegg proved very helpful in detecting plunge pools (fig 5)
- Very effective for salt tracing streams and moulins (fig 4)

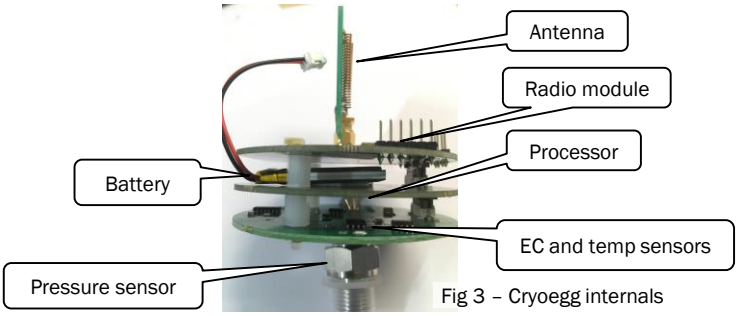

Fig 3 – Cryoegg internals

Fig 4 – two Cryoeggs used for salt tracing in a stream

Fig 5 – Cryoegg deployment in an artificial moulin on Rhône Glacier

Future work

- Improving mechanical design to reach 2.5km at EGRIP
- Producing a variant in a sausage-shaped form factor for borehole studies, and testing it in Canada
- Enhancing the user interface to draw graphs in real time
- Radiopositioning studies – we would like to be able to track Cryoegg as it travels through the subglacial channels

References

- **Hart** et al. (2006). A wireless multi-sensor subglacial probe: Design and preliminary results. doi:10.3189/172756506781828575
- **Smeets** et al. (2012). A wireless subglacial probe for deep ice applications. doi:10.3189/2012JoG11J130
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EASTGRIP ice core

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