August 3, 2022

Dear Paul,

Thank you for your interest shown to our research. We tried to consider all mentioned issues and hereafter answer on your comments (comments are italicized).

Summary

This paper is a good general summary of the progress made of a novel sonde instrument, its current capabilities and recent successes in field testing. It is great to see progress being made in this direction with due consideration of the unique aspects of subglacial lake access.

Thanks for your kind words about our progress. We believe that the sonde will be a good alternative instrument to study polar subglacial lakes in the future.

Page 2

The methods section is a little confusing as it is largely written in the past tense following an idealised deployment.

Originally the methods section was written in the present tense. However, the English editor converted all description into the past tense. We will consider language polishing before submission of the revised version.

Maybe a more detailed and more heavily annotated diagram of the deployment and recovery process could replace much of the more prosaic descriptions of the deployment? Personally I would like to see a diagram of the instrument itself, similar to that found in the associated paper on electrical

We will add additional notes on Fig. 2.

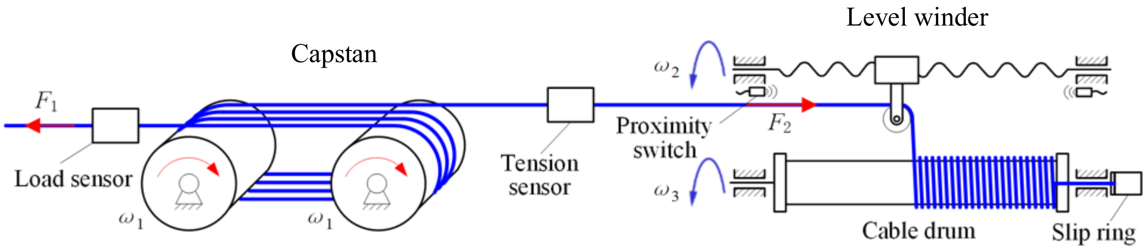
Page 3

Line 69: Paragraph above this point should be in the introduction

We will move this paragraph to introduction in the revised version of the paper.

Line 72: What mechanism is actually used, is it anything like a spider climbing?

At the very beginning we compared four different driving mechanisms. Finally, we chose the structure of the inner winch, in which three different motors are used to drive capstan, drum with the cable and level winder as shown in the figure below. The mechanism is really quite similar to the spider climbing.



Line 76: How closely to deployment was sterilisation carried out? Was there any sampling of sonde surfaces before and after deployment to verify cleanliness? Any background measurements of the camp/snow to help identify potential sources of contamination?

The sterilization procedure was basically the same to the microbial control method designed by the Lake Ellsworth Consortium for UK subglacial sampling probe (Siegert et al., 2012). Before equipment was transported to Antarctica, the RECAS sonde was disassembled into individual easy-to-clean parts or modules and sterilized using a combination of chemical wash, autoclaving, HPV, and UV in China. Then RECAS parts were assembled into independent modules in the clean room and packed into vacuum bags for shipment. The deployment procedure did not include assessment to provide data for control or verification of the cleanliness in the field. However, snow samples were collected at the site for microbiological and chemical analysis.

Line 82: Was the system left entirely unsupervised? What was the reasoning behind this? Was there remote real time monitoring available? Is there redundancy in the system to manage problems if they occur i.e. power downs?

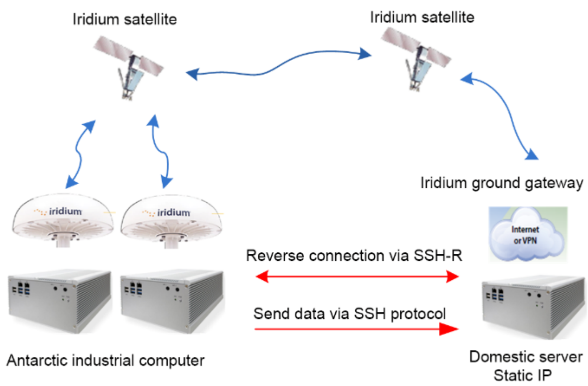
Sampling of a relatively shallow subglacial lakes (500-1000 m) can be conducted during the summer season (1-2 months) and the system can be supervised by personnel. However, exploration of a deeply buried subglacial lake requires 4–6 months. In this case, it was proposed that the research personnel leave the site after deployment and the sonde operates as a fully autonomous system. The uninterrupted power supply system was designed to provide power supply for at least 6 months in unmanned mode. The status parameters of RECAS sonde and auxiliary systems are regularly sent to monitoring center in China through the iridium system. The remote personnel can not only monitor the drilling process in the field but also send commands to intervene in the process at any time.

Line 85: Where is 'mainland'? Jilin or still in Antarctica?

“Mainland” will be changed to “China”.

Line 86: What sort of control does this allow? Real time access or a subset of data transmitted periodically?

The communication architecture of the remote control system is shown in the figure below, which is composed of the Antarctic industrial computer, the Iridium satellite, the Iridium ground gateway and the domestic server. The Antarctic industrial computer and domestic server are configured with keys and SSH access environment to establish a secure data transmission channel. The Antarctic industrial computer directly accesses the IP (static) and port of the domestic server, and uses the Secure Copy (SCP) command in the SSH protocol to copy the field data to the server. At the same time, a reverse connection channel was established using SSH -R command to map the communication port of the Antarctic industrial computer to the server, so that the server can issue control commands to the Antarctic industrial computer by accessing the local mapped port, so as to solve the problem that the IP address provided by the iridium service in Antarctic is not fixed. Based on a communication link established according to this structure, the data transmission between the Antarctic industrial computer and the domestic server is safe, simple and reliable. Except for the transmission rate limited by the Iridium bandwidth, there is no difference between the data interaction with the two computers in the local area network. The main parameters of RECAS and the uninterrupted power supply system will be packed and sent to monitoring center in China at regular intervals (>1 min).



Line 87: Be more explicit that a subglacial lake wasn't actually entered during this test. Or am I wrong and you did actually enter a lake at 200m?!

Please, pay attention to the lines 100-101: "Even the site demonstrates cold-based condition (Talalay et al., 2021), it was thought to be enough for the principal testing of RECAS functionality." There is no subglacial water at the site, we collected meltwater from the basal ice at the boundary of the ice sheet with bedrock.

Line 88: Was this data internally logged and/or returned to the surface? What proportion of data collected was returned to the surface?

We have two storage modes for CTD data, one is directly stored internally (update data every 2 seconds), and the other is transmitted to the surface in real time (update data every 5 seconds). The two modes can be switched under surface or remote control. For the working mode of RECAS sonde, we do not think that it is necessary to set too high data collection frequency.

Line 91: Some detail of how the spooling works might be nice here, if not covered earlier in the paper.

We will add into revised version of the paper: "The sonde is raising and lowering using dual wheel capstan driving mechanism. Three different motors are used to drive capstan, drum with cable and level winder. The rotation of capstan motor and corresponding moving speed of the sonde is automatically controlled depending on the signal from the load sensor. The rotation of the drum's motor is also automatically controlled according to the signal from the tension sensor installed between capstan and drum in order to keep the cable tension in the predetermined range."

The separate paper "Recoverable autonomous sonde for subglacial lakes exploration: driven unit design" is currently in the works. TC brief communication type papers have limits of 2–4 journal pages, 3 figures and/or tables, and a maximum of 20 references. Our submitted paper already exceeds the limits, so we have no way to give detailed description of the spooling mechanism here.

Page 4

Line 106: Some examples of the preparations that are specific to this instrument would be interesting here

Preparations included the routine activities like camp construction, sonde assembly and debugging, etc.

Line 110: How was the base of the ice stream recognised by the sonde?

The base of the ice was recognized at the point when RECAS penetration ultimately stopped. The final depth was about two meters deeper than the depth of the IBED borehole drilled to the bedrock by electromechanical drill ~60 m to the north-east in 2019 (Talalay et al., 2021).

Line 111: Was the sampling system triggered automatically or manually?

The sampling system is triggered manually.

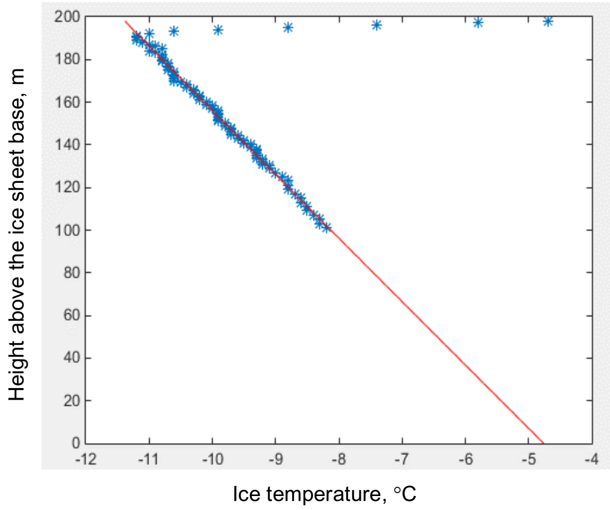
Line 113: How does the lay up of the cable on the spool work? How is it monitored? Is the top of the sonde identical to the bottom? Does the cable penetration through the heated tip have any effect on melting on recovery to the surface?

Coiling/recoiling mechanism is shortly described above. We cannot monitor cable laying – everything is going on automatically. Top and bottom thermal tips are totally identical except for the central hole for cable in the top thermal tip. During lab tests under equal conditions, the bottom thermal tip drilled faster in 1.2 times than the top thermal tip (see Fig. 9a in Li et al., 2020). This is because the top thermal tip has an unheated central hole that slows down the rate of penetration. However, during field tests in Antarctica the average downward penetration rate was 1.6 times lower than the upward penetration rate. This is because drilling in the freshly frozen 'warm' ice is easier than in the cold glacier ice.

Line 116: Any knowledge of the temperature profile through the ice column? Can a temperature profile be recovered from the probes' measurements?

Ice temperature was measured in the IBED borehole (see figure below: blue markers – measured data, red line – approximated temperature profile). Temperature at the surface is -11.4 °C, and temperature at the ice sheet base is -4.8 °C (data are not published yet).

The sonde is equipped by four temperature sensors: two at the melting tips, one in the sampling/monitoring section and another one in the motors/electronics section. All of them are not intended to measure in situ ice temperature during drilling.



Page 5

Line 134: I know this is for future work, but I would be interested to know if there are plans to protect the hose and instrument cable from tangling together whilst hot water reaming 2400m+ borehole.

We agree that tangling of the RECAS cable and the reamer hose would be a concern. As the first step, we plan to test anti-wrap fixture suggested by Blake and Price (2002, Fig. 3).

References

Blake, E.W., Price, B. (2002). A proposed sterile sampling system for Antarctic subglacial lakes. Mem. Natl. Inst. Polar Res., 56, 253-263.

Li, Y., Talalay, P.G., Sysoev, M.A., Zagorodnov, V.S., Li, X., and Fan, X. (2020). Thermal heads for melt drilling to subglacial lakes: Design and testing. Astrobiology, 20(1), 1-15.

Siegert, M.J. et al. (2012). Clean access, measurement, and sampling of Ellsworth Subglacial Lake: A method for exploring deep Antarctic subglacial lake environments, Rev. Geophys., 50, RG1003.

Talalay, P., Li, X., Zhang, N., Fan, X., Sun, Y., Cao, P., Wang, R., Yang, Y., Liu, Y., Liu, Y., Wu, W., Yang, C., Hong, J., Gong, D., Zhang, H., Li, X., Chen, Y., Liu, A., and Li, Y. (2021). Antarctic subglacial drill rig. Part II: Ice and Bedrock Electromechanical Drill (IBED). Ann. Glaciol., 62(84-85), 12-22.

On behalf of the authors,

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