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The Cryosphere Discussions

Interactive comment on "Multi-modal sensing drifters as a tool for repeatable glacial hydrology flow path measurements" *by* Andreas Alexander et al.

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Alexander et al. present a statistical assessment of the performance of a new sensing system – a Lagrangian drifter – for glacier hydrological experiments. They report results from repeated tests in a supraglacial channel and suggest (though never that directly) that there may be future potential for deploying the drifter within the subglacial environment. The sensor system is novel and this manuscript makes an important contribution to the very limited literature on Lagrangian drifters in glaciology. Although it is verbose, the paper is generally well-written. The figures and tables are clear, though the number of tables and figures within the manuscript could be reduced. Citations are

appropriate, however, it is unclear why the introduction focuses (e.g. Table 1) on wireless in situ sensor systems, which are not really relevant, while previously published drifter studies from fluvial and oceanographic studies are not discussed in detail. I have three major comments and several minor comments listed below.

Major comments

1. With the exception of the "Moulin Explorer" and the eTracer, the introduction lacks a section describing what drifters are currently available (or have been used before). I believe that there are citations to drifters used in fluvial and oceanographic studies but no detail or discussion is present of their capabilities or performance. This is odd given the space afforded to wireless in situ sensors within glaciology, much of which isn't really relevant to this study. I would recommend that the introduction of Lagrangian drifters is expanded and that the removal of any strictly unnecessary sections is considered.

2. Given that this paper introduces a new instrument, the methods section lacks a decent description of the drifter electronics or the sensor's physical construction. The drifter's sensors are described but there is no description of the microprocessor used or the method of data storage. No schematic is provided and the method of fabrication is not mentioned. Hence, many questions present themselves such as how is the microprocessor programmed and in what language? What is the sensor housing made from and how robust is it? Could it survive deployment in a subglacial channel? What water depth can the housing withstand? It would not be easy to replicate the experiment without further information and it is currently difficult to assess the limitations of the existing system

3. The description of the results is very verbose with many unnecessary explanations of standard statistical techniques and detailed descriptions of what is plotted in the figures. As such, the manuscript could be condensed with no loss of important detail. Please see specific comments below. Condensing the text may also highlight opportunities for minor restructuring (e.g. combining sections).

Minor comments

P2L8 – “has also been” rather than “was also”

P2L9 - delete “the” before “channel”

P2L21 – given the intention to discuss new methods, SF6 tracing should be mentioned (e.g. Chandler et al. 2013).

P2L25 - Andrews et al. (2014) also instrumented moulins and their results I would argue are more than encouraging. There are also a few other studies that are not cited so I suggest you use e.g. before the citations.

P2L29 - while this is arguably true, it could also be argued that the majority of data still comes from wired sensors. There have also been recent developments in wired sensors. I’m not sure this needs mentioning and I would recommend focusing the introduction on drifters rather than borehole sensors.

P2L34 – The sentence beginning “Drifters . . .” needs fragmenting, e.g. with commas. (Other sentences may benefit from this as well).

P3L16 - please state what you mean by “multimodal”.

P3L29 – avoid the colloquial phrase ‘already coming up’

F1 caption – change “pressure holes” to “holes for pressure transducers”

P7L3 - define POM

P7L7 - by total pressure do you mean what is normally referred to as gauge pressure, which is the pressure indicated by the gauge and not corrected for e.g. atmospheric pressure variability? What digital communications protocol do these sensors use? What resolution? Accuracy? More detail is required here.

P7L9 – ‘linear calibration’ rather than ‘linearly rated’

P7L12 - please explain what is meant by a second order corrective algorithm. Is this

a second order polynomial? I realise this is described below but it could be clearer. If I follow right the zeroing is one-off so it’s not right to say sub-diurnal variability is calibrated out as any post-zeroing variability in atmospheric pressure would not be corrected for.

P8L10 - more discussion of the BNO055 calibration would be worthwhile. My understanding is that this sensor self-calibrates continuously, which I expect has advantages and disadvantages with implications for the data collected. Is changing this sensor one of the future technical improvements you allude to below?

P5L2 - write out month in full

P12L8 – typos: extra “an” and on L13 an extra “in”.

P12L21 - filtered how?

P13L14 – This section could be condensed by assuming the reader understands basic statistics and with the use of symbols and terminology. See below.

P13L24 – ‘assess’ should be ‘assesses’, though ‘identifies’ or similar may be a better word here. That said skewness and kurtosis should not need defining, as they are standard statistical techniques.

P13L25 – the terms ‘magnetometer in the y-direction’ and ‘gyroscope in the y-direction’ are somewhat awkward which makes it difficult to read. Perhaps use symbols instead? E.g. My, Gy. Euler angles are often referred to as yaw, pitch and roll and have standard symbols.

P13L26 – “are slightly skewed towards values above the mean” can be written in less words as “are positively skewed”.

P13L30 – high kurtosis is referred to as ‘leptokurtic’. A kurtosis which is nearly Gaussian can be referred to as no kurtosis (or almost no kurtosis). This section can be condensed significantly if these terms are used.

P15L3 – delete 'data set' as its not necessary. The manuscript would be easier to read if unnecessary words were removed.

P16L4 – you don't need to explain Pearson's correlation coefficient. Scientific papers would become impractically long if every standard technique was introduced. If a non-standard technique is used by all means describe it in the methods (not the results). It's also not necessary to list the classifications of Cohen et al. (1992) in full. Just say that you use their classifications in a single sentence and give the citation. If the reader is interested they can look it up. I would also recommend avoiding the style of describing what the figures show, as you do on L9-10. Instead I would recommend the style of making a statement or argument followed by the figure reference. This paragraph could be condensed to a few sentences without any loss of important detail. As it stands there are seven sentences before a result is described.

P18L5 and P23L3 and other occurrences – Phrases such as "the next plot in Figure 8" and "as shown in Figure 9" can be shortened by just giving the figure reference in brackets.

P23L2 and other occurrences – the first sentence here is methods and should not need repeating here.

P25L5 – Referring to sample sizes on P14L9 you state that "These high numbers are however not necessarily an indicator of sensor accuracy, but rather an indicator of spatial and temporal flow variability", which obviously casts doubt on whether the calculations of a required sample size are useful at all. However, here you refer to the required sample size calculations again to conclude that such experiments will require "a significant number of deployments". Which of these is your preferred interpretation of your analysis on sample sizes?

P25L8 – Do you mean ($p > 0.05$) rather than less than?

P25L8/9 – how will technical improvements to the drifter reduce the number of de-

ployments required? Please be specific. What are the specific issues with the drifter presented here? What needs to be improved?

References

Andrews, L. C., Catania, G. A., Hoffman, M. J., Gulley, J. D., Luthi, M. P., Ryser, C., Hawley, R. L. & Neumann, T. A. 2014. Direct observations of evolving subglacial drainage beneath the Greenland Ice Sheet, Nature, 514, 80-83

Chandler, D.,Wadham, J., Lis, G., Cowton, T., Sole, A., Bartholomew, I., Telling, J., Nienow, P., Bagshaw, E., Mair, D., Vinen, S. & Hubbard, A. 2013. Evolution of the subglacial drainage system beneath the Greenland Ice Sheet revealed by tracers, Nature Geoscience, 6, 195-198

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