

## ***Interactive comment on* “Open-source Arduino-derived data loggers designed for field research” *by Andrew D. Wickert et al.***

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We thank the anonymous referee for their kind words and detailed constructive criticism in a project that has been a longstanding labor of love. The referee’s comments are in Roman text, whereas our responses are *italicized*.

General comments:

This article describes the development and technical details of the ALog data logger series, an open-source and low cost data logger that is based on Arduino technology. The article and the described data loggers are a significant contribution to the science community and readers of HESS, as the data loggers may provide a useful technology

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to many environmental scientists. The article summarizes the substantial development that has gone into the data logger development over many years, and provides detailed background information. The article also includes supplemental material and codes provided online. This helps to make the data logger accessible to the science (and general public) community. The article is well written and well organized throughout, with clear descriptions of the technology. I only have a few minor questions, mostly regarding field deployment, and minor comments that should be addressed. Apart from these, I recommend this article for publication.

*Thank you.*

## Specific Comments:

1) Please also discuss some of the challenges that you have faced with the ALog data logger in the field, and that a potential user of this data logger may encounter and should be aware of. You mention several field experiments with ALog data loggers in adverse conditions. How long were the data loggers actually in the field, how robust were they found to be? What field issues did you encounter that were specific to the ALog? Were you able to remediate these in the next iterations? I realize the ALogs have been developed over a long period, but a few more examples would be helpful to a potential user of the technology.

*We will add a sentence stating, "Field deployments ranged from a few days to three years.". Furthermore, we will add a full paragraph on field deployments to demonstrate how we have developed in response to challenges/failures.*

2) For instance, did you encounter clock drift? It is referred to a really low clock drift value in the article, but was this value based on 'theoretical lab experiments', or tested in the field?

*We encountered minimal clock drift in the field, and insofar as we were able to tell, the*

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clock remained in spec. Because this was not tested by us rigorously (i.e., these are just our casual observations) and the reported drift is simply the data-sheet-provided value for the full temperature range, we do not wish to comment very extensively on its accuracy. However, this is a very common component from a reputable manufacturer.

3) The low power use is impressive. Was this value also experienced in the field? I.e., one data logger actually ran for  $\sim 2$  years on three AA batteries? Or is this a theoretical value based on consumption? Also, what kind of sleep-awake cycling is typically used? A 1 second per minute interval is mentioned, was that typically used? It probably depends on sensor and application, but some examples would be good.

*We have run loggers in the field for >1 year on alkaline batteries (typically D), but we try not to let the batteries die completely! We will add text to clarify that these are calculations extrapolated from lab measurements with partial field validation. Towards the question about the sleep cycle, we will add a sentence in the paper stating, "In our field deployments, we typically recorded data once every ten minutes, further increasing battery life."*

4) In line with the above questions, please also include some more information on how the data loggers were installed in the field. What kind of encasing have you found to work well with these data loggers? Do you typically use batteries or solar panels?

*We will add a section on enclosures based both on this comment and one by the other referee (Hut). We will add text indicating that we practically always used batteries due to the low power consumption.*

## Technical corrections

*If a specific technical correction is not listed here, it is because we plan to correct it precisely as suggested by the referee and therefore had no comment to make.*

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P. 1, Line 17 – likely also capacity challenges, especially in developing countries.

*We will add, “technology that can function and be repaired in least-developed countries (Reda et al., 2017), ...”*

P. 2, Line 1 – delete “extreme”, and “lightweight”; lightweight is repeated again just below.

*Text will be updated to: “What the field-monitoring community requires from the open-source movement is a low-power, modular, single-board data logger that is easy to use and whose code and hardware designs are well documented and freely available.”*

P. 2, Line 2 – Line 2 - “whose” - typically used to refer to humans - better to say: “and has well documented and freely available code and hardware designs.”

*Understood, but “whose” is actually correct in this case, see <https://www.merriam-webster.com/words-at-play/whose-used-for-inanimate-objects>*

P. 2, Line 6 – remove dash in data-logger to be consistent. Also check through document for consistent writing of data logger.

*This is a hyphen rather than a dash, and is required when two nouns are used together to modify another noun. When “data logger” is not used in this way, there should be no hyphen. I will check to make sure that this is the case.*

P. 3, Line 1 – What are these performance upgrades? Please elaborate more.

*Will update text to, “version 3.0 has a more powerful microcontroller core and a dedi-*

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*cated 16-bit analog-to-digital converter (ADC)”*

P. 3, Line 6 – First the ALog Shield 2.2 is described in detail, but then no further details are provided right away for the following models. I assume much of what comes below refers mostly to the later versions, this should be made clear however through a transition sentence.

*I will add a sentence stating that, “Both are described in more detail in this section.”*

P. 3, Line 9 – Has this been tested in the field? See comments above too, and add reference to field experience here, or later on in field section.

*I will add the phrase here: “based both on extrapolation from laboratory power-consumption measurements (Table 1) and field deployments (Armstrong et al., 2016)”*

P. 3, Line 11 – SD cards are also easy to download data from for field assistants / citizen scientists who are not technical experts.

*Thank you for this point. We will add, “The use of text files on SD cards also simplifies the act of downloading and viewing the data, making it easier for field staff and citizen scientists to work with the ALog.” We will add this to the paragraph after the one in which this suggestion was made, as this is entirely about the SD cards.*

P. 4, Line 1 – Rephrase “While a simple design decision”, maybe: “While it is a simple design, using an SD card. . .”

*“While it is a simple design decision, using an SD card...”*

P. 4, Line 7 - “aggressive sleep cycle” - It should be explained what is meant by 'sleep

cycle'. Otherwise readers who are not familiar with Arduinos might not understand. It is explained further below, consider moving the section upward, or referring to it here. Does the 'aggressive sleep cycle' refer to the 1sec per minute awake cycle?

*We will make this more descriptive: 'we implemented a "sleep" cycle to shut down all non-essential subsystems while not logging'*

P. 6, Line 3 and line 8 – are these values theoretical, tested in the lab, or actually experienced in the field?

*We will clarify that these are laboratory tests; we never allowed the batteries to fully run down in the field: we needed our data!*

P. 6, Line 16) – Remove dash. (*and later instance*)

*This hyphen is grammatically required. For a quick review, see <https://www.grammarly.com/blog/hyphen-with-compound-modifiers/>*

P. 9, Line 7 – mention in introductory overview or abstract that field deployment is also discussed, and examples are provided.

*Will add to abstract: "The ALog has been deployed at field sites in Colorado, Alaska, Louisiana, and Minnesota, USA; Ontario, Canada; Argentina; and Ecuador." For the introductory section, we retain, "We iterated development and field testing from 2010 to present"*

P. 9, Line 8 to 12 – could mention some examples of deployment in abstract, this really strengthens the ALog argument.

*Thank you for this suggestion; our response to your above comment is based on these lines.*

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P. 9, Line 26/27 – Delete this last sentence, this is not relevant to the ALog development and out of context here. Instead, you can highlight the consistent data recording over the period of a year in extreme conditions.

*We will replace this sentence with: “Figure 4e contains the first five days of data from this deployment, which lasted one year.”*

P. 10, Figure caption (e) – Better to remove ‘covary’ here, and highlight consistency of recording instead. Add start and end date of recording. Refer to paper where these data are discussed.

*I think that the figure itself demonstrates the consistency of the data, and it also indicates the dates of the recordings. I now note in the main text that the station recorded for one year. I feel it might be valuable to include a bit of interpretation, as an example of a use case. These data are published only in the present work.*

P. 11, Line 10 – Could make this point earlier on in introduction already, i.e. that Arduinos were originally developed/are often used for hobby electronics etc by the general public.

*We will add a brief mention of this in the short introduction (to give it appropriate weight) as follows: “Hardware advances alone cannot produce an effective standalone measurement platform, so we paired our new designs with custom-built firmware libraries – built atop the popular and easy-to-use Arduino platform – and software to streamline data-logger programming.” (Text between the endashes is newly proposed.)*

P. 11, Line 23 – “In doing so”

*“In so doing” is the intended phrasing.*

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P. 13, Line 11 – user guides

*We will remove this phrasing and instead refer to these via their doi and reference, following the recommendation of R. Hut and, indeed, EGU policy on citation of data/code/etc. items.*

P. 13, Line 12 – Supplemental

*“Supplementary” is used by EGU journals, e.g., [https://www.hydrology-and-earth-system-sciences.net/for\\_authors/submit\\_your\\_manuscript.html](https://www.hydrology-and-earth-system-sciences.net/for_authors/submit_your_manuscript.html)*

P. 14, Line 12 – Add University, location and page numbers, also for other theses that are cited.

*University is included. Strangely enough, EGU journals do not seem to include page numbers (at least not per their BibTeX style file).*

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2018-591>, 2018.

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