Hydrology and Earth System Sciences

Discussions

HESSD

Interactive
comment

Interactive comment on "Greenhouse gas flux studies: An automated online system for gas emission measurements in aquatic environments" *by* Nguyen Thanh Duc et al.

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1 Introductory remark

According to the Steps of the HESS process of peer review, I expected the following from stage 2, Access review:

The editor is asked to evaluate whether the manuscript is within the scope of the journal and whether it meets a basic scientific quality and if it contributes something new to the field of hydrology. They can suggest technical corrections (typing errors, clarification of figures, etc.) before posting in HESSD.

Unfortunately this step was skipped and thus I am a bit annoyed by the sloppy presentations with plenty of technical issues that should have been solved before exposing the manuscript for discussion. Since I do not feel this to be my task I will simply dump technical remarks at the end and ask the Editor to make sure that step 2 is following after step 4 (open discussion) to address the "technical corrections (typing errors, clarification of figures, etc.)". In this case it should have been done.

2 Scientific contents

The authors present their newest developments of an automated online system for gas emission measurements over water surfaces, which uses low-cost sensors for CO_2, CH_4 and the necessary meteorological variables. From the pressure sensor they deduce ebullition flux, and with a smart solution using an inflatable tube to open the chamber for venting they provide a solution for automatic long-term deployments.

Thus, this is quite innovative work and my review tries to honor this, although some details were not well described (or are confusing) for a reader like me who would like to understand the details. In any case, after having gone through step 2 (all technical issues rectified), and moderate revisions, I think this paper should be acceptable for HESS.

I explicitly appreciate the technical details with 3-D printing code etc. which is something the technicians I work with definitely find useful information that they could potentially profit from.

2.1 Major Issues

1. The authors use three low-cost sensors, all from Figaro Inc.: the TGS2611-E00, the NGM2611-E13 (which uses the same TGS2611-E00), and the Panterra from

Neodym (I assume), which in the version I used had a percursor version of the TGS2611 or so built in. I think the authors should more clearly specify (a) what sensor the Panterra uses (and provide the company names of all sensors), (b) clarify that these are (most likely) all the same sensors in different configurations (as it reads now the reader could be getting the impression that three different sensor types were tested, which is not the case)

2. I am concerned about the low voltages that the TGS2611-E00 gives, ca. 18–35 mV according to Fig. 3. The TGS2600 that I use delivers 400-600 mV for ambient conditions, and when I look at the specifications it appears that the manufacturer considers the TGS2611-E00 to be useful in the range of 300–10,000 ppm CH_4 which is way above ambient range (the TGS2600 is shown with a sensitivity to CH_4 in the range 1–100 ppm CH_4 that's the reason we selected this one for near-ambient measurements in Eugster & Kling, 2012). Now there are some other publications that show that the TGS2611-E00 is actually sensitive also to near-ambient conditions, but I am not yet convinced that this is the best choice for your application given the low CH_4 concentrations well below the range indicated on the technical specification sheet of the manufacturer. Some more critical discussion on the sensor selection would be required in my view.

3. The authors only sample data every minute, which I find utterly coarse. They may have a reason for this, but in my own tests with the TGS2600 a one-minute measurement interval **in combination** with a 5-minute data rejection after chamber deployment (page 6, line 26; this information should actually have been given in the Methods section already, because this is an essential flaw in the system in my view) I would have lost all the information relevant to chamber fluxes (see graph below and description of unpublished internal example graph from my experiments at Toolik Lake, Alaska, USA). Thus, the authors should more precisely describe their method and critically discuss such shortcomings to help others to do better.

4. The ebullition (bubble) counter is quite interesting, but with a bubble volume of 3–4 mL required to actually leave a defensible signal, this does not yet seem to be an optimum choice. Here, a reference to and comparison with the (commercial) system of Andreas Mäck (doi:10.5194/bg-11-2925-2014) would be helpful. Since the Varadharajan et al. (2010) reference (pages 2,3,8, lines 30,22,21) is not listed in the References, I could not convince myself that this bubble counter system is really thoroughly tested and reliable. In the discussion you only say "For a long term solution, the recent study using optical sensors in an open path funnel (Delwiche and Hemond, 2017) 30 suggests an alternative and interesting design for ebullition studies, which could be combined with the present sensor approach to also quantify CH4 content in the bubbles." – thus does this mean that you are satisfied with the performance for short-term investigations? I am not really convinced and would appreciate a somewhat clearer statement what your recommendation is for studies that are shorter than a "long-term solution".

5. Your regressions (I assume you use ordinary least-squares regressions) are not correct from a statistical viewpoint (Figs 4 and 5): you must reverse the dependent and the independent variable: you want to find out how to use the signal to compute the true concentration using your regressions, not the other way round (i.e. to predict the signal based on knowledge of the concentration – that's what your regressions show).

6. I always use a fan in chambers, you don't. I understand that this corresponds to some static chambers that people use with syringe sampling, but in your case I am concerned that without a fan to mix the volume of the chamber the CO_2 (which is heavier than air) starts to accumulate above the water surface, and then a steep gradient creeps upwards where I expect your sensors; hence this linear increase in Fig. 5. Contrastingly, CH_4 which is lighter than air, quickly would accumulate under the top of the chamber, and hence probably the curvature although I would have expected that the CO_2 saturation should occur earlier than

the CH_4 saturation in such a chamber. Please comment on this and justify why not to mix the air inside the chamber to ascertain representative concentration measurements inside the flux chamber.

7. According to the manufacturers information the sensor resistance **decreases** as the CH_4 concentration **increases**, thus in principle the voltage you measure should **decrease** not increase with increasing CH_4 – but your measurements in Fig. 4 show the exact opposite of what one would expect from the manufacturer information. Do you have an explanation for this? I must admit that on short timescales I see the same (see Figure inserted below), but on longer timescales I see what I would expect from the manufacturer's data sheet. Our procedure suggested by Eugster & Kling (2012) solve this issue with the calibration – after linearisation the use of a high and low calibration point simply reverses the sign if the response is of the kind that you show in Fig. 4. If you have an explanation why the TGS2611-E00 has increasing voltage with increasing CH_4 concentration then this would be a helpful insight for the reader. If you don't have an explanation, maybe you have an opinion?

2.2 Minor Issues

1. p2/33: "The eddy covariance (EC) technique is increasingly used for long-term monitoring, but it is expensive in terms of equipment and is still being evaluated for aquatic environments." – what do you mean with this statement? I don't consider this to be correct, the method is in use beyond evaluation. Please provide some references and reword the second part. For example, we have authored a couple papers and also written a chapter in the book Eddy Covariance: A Practical Guide to Measurement and Data Analysis (chapter on lakes: doi:10.1007/978-94-007-2351-1_15). Thus the method is established (at least better than your chambers, to be more direct) – but I agree that it is costly and I agree that such low-cost sensors are important

2. p2/45: " The CH4 sensor tested here is a Taguchi Gas Sensor (TGS) (Figaro Engineering Inc., Osaka, Japan). It is a high sensitivity CH4 gas sensor...":
I completely disagree, it is a **low-sensitivity sensor** which (in the version you use) only has a manufacturer specified lower measurement range of 300 ppm CH_4! I already realize that our more cautious wordings about the TGS2600 (which has a higher sensitivity than the TGS2611-E00) is ignored by some others, which can lead to frustration. Be clear that this is experimental work trying to squeeze the tiny bit of information out of a sensor that is **not** made for ambient concentrations – but I agree that it has some value for such measurements.

3. You never specified which pressure sensor you used, thus it is unclear to me why you did not use an I2C sensor, there plenty of those on the market. What is the special advantage of your pressure sensor that requires an AD620 amplifier to be useful? This remains obscure to the reader.

4. Eq. 1 should use SI units or at least the same units of the same physical quantity and not include obscure conversion factors. Thus, you must decide whether your time variables should be in hours or in seconds (the primary SI unit) or minutes, please no mixtures.

5. p5/25: check your instrument information, most likely this was an LGR FGGA (not a DLT-100, which as I remember is a CH_4-only instrument) that measures CH_4 and CO_2.

6. p6/8: you did not specify what your "baseline noise" actually is. Is it the square-root of the variance or the noise baseline derived from an Allan variance plot, or anything else? Some more details in the Methods section would be really helpful.

7. p6/13: "The pressure in the trap was affected by air temperature, especially the diel temperature cycle." – this sounds like an error, pressure is a physical entity that is independent of temperature, thus this must be wrong. What I can imagine

is that you mean that your pressure sensor signal (but not the pressure itself) depended on air temperature. Please correct.

8. p8/39: "However, since the sensor is not calibrated for very high concentrations, we could not determine the flux rate observed during these events." – I completely disagree, at least for CH_4 (you do not really reveal any necessary details on the CO_2 measurements . . .): the TGS2611-E00 has a specified measurement range from 300 to 10,000 ppm according to the manufacturer. Although the sensors come uncalibrated (at any concentration, not only at high ones), this wording is not correct. Maybe you wanted to say that **you did not calibrate** the sensor at higher concentrations, but the sensor per se is always uncalibrated from this manufacturer.

9. p9/14: "The Panterra CH4 sensor signal has been compensated for the temperature effect, but is probably not applicable for temperatures lower than 15°C." – please give the details of the sensor used in the Panterra (it is a TGS if you use the same model that I used years ago and threw away because it was unreliable); as it is, this statement is pure speculation and should either be removed or substantiated with some arguments.

2.3 Feedback on Supplementary Information

- in `PowerControlBoard.zip` remove the deleted file
`~$Copy of Bomexample(1).xlsx`
- in `BOM_PWCv8c_digikey.xlsx` remove unused "Sheet1"

2.4 Technical issues

- homogenise your variable names in text and figures (d0CH$_4$sens, d0_CH$_4$sens, d0_CH$_4$sensor; d0CH$_4$conc, d0_CH$_4$conc, d0_CH$_4$concentration,

d0 CH$_4$concentration)
- decide whether you want to use upper case or lower case letters in figure panels
- use a space between axis title and parentheses around units
- use a degree sign where a degree sign is required (not ^{0})
- define all your variables that appear in text and figures
- spell out abbreviations upon first occurrence (e.g. AFC on p2/39)
- use some more adequate natural intervals in time axes (e.g. Fig. 5: start at midnight 00:00 and then use 3-hour intervals not some 2:24 hour intervals)
- make figure captions standalone so that the figure is understandable without reading the entire text; also define all symbols and line types (maybe a legend could help)
- do not use the term "plot" for lines or symbols in a panel of Fig. 1
- remove the erroneous and confusing superfluous ticks at the right border of panels (b) and (c) in Fig. 1
- Fig. 2: conventionally panels are labeled from left to right, then top to bottom (which would group a,b and c,d in your caption); explain what each line type indicates and what the symbols with vertical stems indicate.
- Fig. 3: add the 0 label at the beginning of the time axis; I would call this "Elapsed time" and put minute into plural
- add subscript in CH$_4$ in Fig. 3 caption and everywhere else where this was forgotten.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2019-83, 2019.
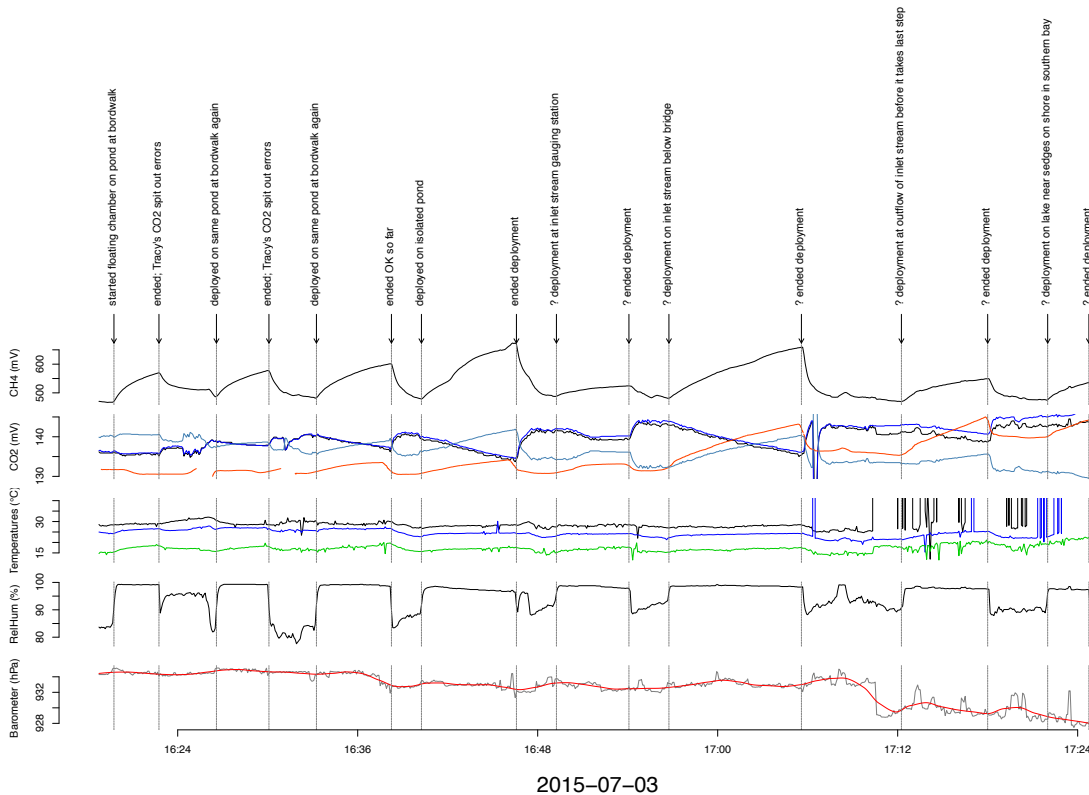
Fig. 1. Unpublished example of a time series with my test chamber deployed at a few ponds near Toolik Lake, Alaska, on 3 July 2015. The top panel shows the raw voltages from a TGS2600 sensor.