Review of

Physical controls on CH4 emissions from a newly flooded subtropical freshwater hydroelectric reservoir: Nam Theun 2

By C. Deshmukh et al.

This manuscript describes the results from a very detailed study of methane emissions from a newly flooded hydroelectric reservoir using various methods and ultimately determines the main methane emission pathway and the controls on its emission. I applaud the authors for completing such detailed measurements in what I presume would be not the easiest of environments. This paper is not entirely unique in its methods, except for the type of model (artificial neural network model, ANN) that is for the first time used to predict and gap fill a time series of emissions from the reservoir. This is interesting and significant for the community. While the title of the paper suggests that physical controls will be the main issue, the way the paper is structured now tends to make it look more like a methods paper. There are a lot of good points in the paper in regards to ebullition in hydroelectric reservoirs, which there is relatively little information about currently, but it is hard to get a clear message based on the current state of the paper. I think this paper is full of valuable information and it should be published once some minor changes are made to its structure.

General comments:

1. The language needs some help still in order to make this paper a bit easier to read.
2. Abstract – The artificial neural network should be briefly explained in the abstract and then say that it explained 46% of the variability. Really pull out the main points of your paper and make the abstract full of those points. I think you can stress less on the methods used in the first part of the abstract. Just mention them briefly and get right to the main points about emission results and physical drivers.
3. The introduction gives me the impression that this is a methods paper, but the title of the paper says it will talk about physical controls on emissions. Therefore, I would scale back the methodology talk in the introduction and bring out the physical part more. Right now you jam a lot of physical information into basically one sentence. The fact that you used all those different technologies is a unique part of this study but if the physical results are a bigger deal, as the title suggest, then you should focus on that more in the introduction. You also conducted a study on a dam, not a natural system, yet you do not discuss dams much at all in your introduction. You should at least bring up the age factor in regards to measuring dams. In general, the introduction needs a rewrite to focus it more on the main findings of the study.
4. To better illustrate the complicated sampling scheme of this study I suggest adding a table and a map figure. The table would actually be an expansion of Table S3, which has the details of the EC deployments but not of all the other ebullition deployments. IT would be good to know the deployments and depths for trap measurements. I understand you have a lot of measurements but perhaps they can be summarized somehow. Secondly, a map figure should definitely be added (can be placed in supplemental) that will first give the reader the idea of where the reservoir is, what its shape and size are, but also some details regarding sampling should be shown. IT would be good to actually see 4 maps with the EC footprint for each deployment and then approximately where FC and Trap sampling took place in the footprint. This would also be nice to see for the trap measurements that you additionally did for a year and over different flooded ecosystems. I highly suggest some maps to help the reader follow what is going on where. Perhaps also tables in the supplementary stating how many funnel and FCs were done, etc.

5. In the sampling strategy section there is a quite confusing description of the water depths and water level changing rates for each deployment. Perhaps a figure in the supplemental could help illustrate this better. Can you acquire water level data for the entire 3 or 4 year period and then point out on there where your deployments were? If you could also divide the figure into seasons (WD, WW, CD) then this would really help facilitate the reader in understanding the hydrological conditions of the reservoir.
6. Clearly by my questions below about the ANN, it needs to be more clearly explained in both the manuscript and the supplemental. The text should begin with a very general description of what it is and why you are using it. Terms should be described, such as 'training' and 'generalization cost' and 'weights'. The supplemental would benefit from text too so that the reader can follow the equations better.
7. Results and discussion section – There is a lot of good data and analyses in this paper, but it is hard to keep it all straight while you are reading it. I would highly suggest splitting this section into two separate sections – results then discussion. Actually, I believe the first section (Assessment of emissions) is primarily results, while the rest of the sections are more discussion already. I have made some suggestions in the specific comments as to where to do some splitting, but they are definitely not comprehensive. If you choose to leave the results and discussion together, however, I implore you to split the first section (Assessment of emissions) into separate sections: (1) diffusion, (2) ebullition, (3) total emissions including comparison between methods, and (4) discussion ebullition specifically (from page 14, line 14 to the end of that section). The rest of the sections are sufficient as is. But I highly suggest splitting results from the discussion.
8. Very important: the abbreviations are different between the text and the figures and tables. Please be consistent. This will put a strain on the reader to understand your already complicated study. You use $FC_{GA}$ and $FC_{GC}$ in the text but $D_{GC}$ and $D_{GA}$ in the tables and figures. And I understand that you use DE in the tables and figures for the diffusion plus ebullition measurements, but I would suggest using T for 'total' instead. So my suggestion for variables to remain consistent throughout the paper text, tables, and figures are the following:
    a. $D_{FC}$, $D_{GA}$, $D_{TBL}$, $E_{FUN}$, $T_{EC}$, $T_{FC+FUN}$
9. You use the word 'evidences' a lot but it does not sound right. You should use other words instead like 'indicates'.

Specific comments:

1. I have labeled my specific comments based on the pdf that I downloaded for the review that is not in the online biogeosciences format; therefore the page numbers I cite below are simply 1-24 of the phd and all the line numbers start over on each page.
2. PAGE 1, Line 24 – add 'respectively' after 'chambers'
3. Line 24 – add the 'EC' abbreviation if you use it later after the 'eddy-covariance' term – and be sure to be consistent with 'eddy-covariance' or 'eddy covariance'
4. Line 25 – delete 'in' in the parentheses
5. line 26 – 'LDR' needs to be spelled out
6. PAGE 2, Line 25 – Saying inland waters are the main source of CH4 on earth is a little misleading as its predominantly only wetlands … CHECK THE IPCC 2013
7. Line 31 – 'little' should be 'low'
8. PAGE 3 - Line 7 – use 'etc.' instead of '…'
9. Line 14 – start a new paragraph with the 'The release of bubbles is triggered by…' and expand upon this. How were these parameters measured before? Was the resolution high enough? As high as what you will show? Are some physical drivers more relevant in certain places than others and why?

10. PAGE 4, line 10 – delete ‘latter’
11. Line 11 – delete the ‘a’ at the end of the sentence
12. Line 19 – ‘was shown to be….’
13. Page 5, line 19 – ‘maxima during the WW season and minima by the end of the WD season.’
14. Page 6, line 9 – why do you start with ‘Table S3’ as your first table? It should be renamed S1 in the supplemental.
15. Line 16 – delete ‘all along’
16. Page 7, line 14 – add ‘data’ to ‘The 10 Hz raw data’
17. Page 8, line 22 – replace ‘more important’ with ‘higher’
18. Line 29 – does ‘mn’ mean ‘minute’? I would change all ‘mn’ to the more standard ‘min’
19. Line 29 – This sentence trying to explain the sampling scheme for the FCs confuses me. So you took 4 samples within 45 minutes every 15 minutes. Does this mean you took them at times 0, 15, 30, and 45. If that is the case then I would say ‘Duplicate samples were taken from the FCs at time 0 and then every 15 minutes for 45 minutes for a total of four samples per chamber deployment.’ And do not use the term ‘air samples’ when you mean ‘chamber samples’. That’s confusing.
20. Page 9, line 2 – You have not described ‘GC’ yet. You need to spell it out and put all GC details here.
21. Line 2-8 – I would make this a separate paragraph first off. Then I think you need to make this classification a bit more clear – actually it can be explained more simply. I would say something like ‘Diffusion chambers will collect diffusive emissions as well as ebullition emissions if they are present. Therefore, if the slope of the linear regression of gas concentration in the chamber versus time was linear with an $R2 > 0.8$ then the chamber was assumed to be collecting only diffusive emissions. If $R2 < 0.8$ then the chamber was assumed to collect total (diffusive + ebullitive) emissions.’
22. Line 25 – shouldn’t $C_a$ be the solubility concentration of atmospheric methane?
23. Line 27 – how did you get k600? That is not described
24. Page 10, line 4 – change all ‘ebullition of CH4’ to ‘CH4 ebullition’
25. Line 4-11 – I do not understand what you are trying to describe here. Oh, I think I see. You are saying that since you had ebullition in your chambers that a k600 could not be determined from the chambers measurements via k = F/Cw-Ca. Therefore, you completed the Dtbl formula with a k600 determined from wind speed from both those references and then averaged them. You need to state all of this more clearly. Clearly, this whole paragraph is about k600 and I did not get it at first since I asked question #22. You should perhaps show the formulas you used from those references as well. How different are they?
26. Line 13-20 – You have no description of the funnels nor a reference that would describe them. You need to add something here. What material? How tall? What was the collecting container on top? How did you sample it? You also don’t describe the sampling resolution. How many times did you sample in that 24-48 hour period? IF you left it there that long, should you be worried about re-dissolution into the water in the collecting container? Did you refresh the funnel?
27. Line 20-23 – I don’t understand what you did with Ega and FC measurements. Please explain more clearly. It appears you did something with the FCGA measurements to get at ebullition but you must state that clearly here.
28. Line 25 – there is the GC information that needs to be put earlier.
29. Page 11, line 2 – The ANN and MLP both need references
30. Line 5 – same day and same depth? But is it the same location? Why do you do this? Why by depth?
31. Line 9 – what is a training process?

32. Line 11-18 – this should be the first paragraph of the section but should begin with a very general description of what an ANN for a general audience and why you are using it
33. Line 19-22 – the weights were found during the training? This should go with the first paragraph (lines 2-10)
34. Line 24 – what is a generalization cost??
35. Line 29 – should be Tables S2 and S3
36. Page 12, line 2 – 'in the CH4 emissions' – in all emissions or just ebullition?
37. Line 7 – what is with the backslash instead of a dot or parentheses around the 1, 2 and 3?
38. Line 11 – by seasonal basis I guess you mean those 3 seasons (WD, WW, CD)? You should be specific here.
39. Page 12, line 28 – after 'four methods' list the methods in parentheses to remind the reader.
40. Line 30, 31 – you list 'FC' and '$FC_{GC}$' – but shouldn't they both be '$FC_{GC}$' – however they should match Table 1 and figures too.
41. Page 13, line 1 – change the sentence starting with 'Whatever the methods' to 'No matter the method used nor the pathway measured, the reservoir emitted…'
42. Page 13, line 2 – change 'studied' to 'study'
43. Page 13, line 3 – you cite Figure 1 here but then barely discuss it at all here and only very little later on – is the figure necessary in the main manuscript? Could it be in the supplemental?
44. Line 4 – remind the reader what the acceptance criterion are again by putting them in parentheses – they are the $R2 > 0.8$, right?
45. Line 6 – 'water level was at its…'
46. Line 8 – replace 'evidences' with 'indicates'
47. Line 10-12 – Because you have these numbers already in tables, you do not need to display them again in the text. You can things like this for example 'Overeall, the average Dgc (~1.1) was comparable to the average Dtbl (~1.4) for all four field campaigns, however the range for Dtbl was slightly larger.'
48. Line 14 – should be 'significantly'
49. Line 18 – the EGA abbreviation should not be right after saying 'ebullition of CH4' but after saying that you used the FC with a GA to measure it. This is all confusing. The way you measured ebullition with the FCGA was not described in the methods either.
50. Line 22-24 – again here you can get rid of numbers since they are in tables and only mention an approximate average
51. Line 18-27 – I would start this paragraph stating that 'the FCGA was used to measure diffusion but about 50% of the measurements also showed ebullition emissions' and then state the results/averages of the this method and the funnels and then state that these methods differed by deployment times.
52. Line 28 – here starts the next results section of total emissions
53. Line 32 – should be 'bubbles'
54. Line 33 – should 'significantly higher'?
55. Page 14, line 1-2 – I don't understand this last sentence. The chamber measurements were higher than the EC measurements? And you think since only 50% of the chamber measurements caught bubbles while the EC should have been measuring them all the time that the chambers will over estimate emissions if they get sporadic bubble measurements, opposed to the EC system that integrates over both emissions? Did you not get peaks in the EC from when you think bubbles occurred? While the average measurements from EC was lower than FCs in Eugster et al. 2011, the peaks in EC data coincided with chamber measurement values. You need to back up this statement but I think you should do this in a

discussion section (if you separate results from discussion). Plus everything in this section up until now was results – these can clearly be made into a results section.

56. Line 3-13 – I think this paragraph can be with the previous section too in regards to total emissions.
57. Line 5 – delete 'among four since' and put the rest of the sentence in parentheses or make it another sentence.
58. Line 12 – here is the only time you state how many funnel measurements were ever used and we have nothing else to compare this too. You should have a table in the supplementary or something describing the funnels and chamber measurements performed.
59. line 14-to end of section – this should be a separate section as it specifically talks about ebullition and it is mostly a discussion point
60. Line 15 – add '(surface area of funnel/chamber)' after 'less than a m2'
61. Line 16 – change to 'emissions determined within an EC footprint of thousands of m2' – and you don't report the actual EC footprints anywhere. You should have them in figures or at the very least a table somewhere.
62. Line 16 – 'However, on a handful of occasions, '
63. Line 24-26 – you are saying here that the funnel measurements were similar to the EC estimates for ebullition but earlier (page 14, line 33) you said that they were different (at least for the totals, which I presume the totals were mostly controlled by ebullition). So then back to the statement on line 1-2, why would chambers overestimate emissions but not funnels relative to EC values? I see your point at the end of this page about longer versus shorter deployment times. I think this is the main issue. Of course the longer you measure or the more area you measure the larger the integration of all values (low, which are more common, and high) and thus the lower the resulting fluxes. These are great points but need to be made much clearer in their own section in the discussion!
64. Page 15, line 8 – how was this measured exactly?? Which methods were used?
65. Line 12 – should be 'especially'
66. Line 15 – why is 'versus' italicized?
67. Line 16 – don't use 'evidences'
68. Line 16 – you are talking about an analysis of the time series but what analysis? Is it what you describe on line 21? I would start with describing this analysis (line 21) and then discuss it later. You can report this analysis and figure in the results and then save the discussion points for later in the discussion when you can talk about the various physical controls you are investigating (the major point of the paper).
69. Line 21 – 'Daily DEec was plotted'
70. Line 26 – 'and the marine environment'
71. Page 16, line 8 – delete the comma after the parentheses
72. Page 16, line 9 – why the dots in the unit?
73. Line 17- this section is mostly discussion
74. Line 20 – 'these emission peaks'
75. Line 30-31 – 'change in atmospheric pressure, indicating a strong control…'
76. Page 17, line 1 – no 'evidencing'
77. Line 8 – 'Both observations'
78. Line 8-11 – why do both observations prove this? Is it because peaks occurred no matter the buoyancy flux? Be more specific here.
79. Line 12 – atmospheric pressure?
80. Line 23 – perhaps use the term 'Spatiotemporal variability of CH4 ebullition' and a lot of this section can be results only.
81. Line 26-29 – should be in methods

82. Line 29-32 – are results
83. Page 18, line1-6 – all results and you could place these values in a table and then you don't have to repeat them
84. Line 6 – I feel like a discussion of what differences in volumes means is missing. If this is simply in the results and not important then it really doesn't need to be discussed in the discussion section
85. Line 12 – DelSontro et al. 2011, not 2010
86. Line 20 – 'lower'
87. Line 22 – 'bubbles were released'
88. Line 23 – 'concentrations in CD bubbles might result from (1) and increase of solubility of CH4…. ….other seasons, and/or (2) potential'
89. Line 27 – should be WW??
90. Line 30 – 'higher in the shallow zones (median = 21.52%) compared to the deeper zones (12.78%), which can be explained by the dissolution of CH4 from bubbles being more efficient in deeper waters (McGinnis et al. 2006)'… however your waters were only 10 m deep at the deepest, right? That's not a huge difference in terms of CH4 dissolution but size can double in that 1 atmosphere. Use Ostrovsky et al. 2008 (L&O Methods) to get an estimate.
91. Line 34 – no 'evidencing'
92. Page 19, lines 3-11 – this is mostly results
93. Line 11-13 – could be a discussion point
94. Line 13-17 – about the flooded ecosystem should be in results and is also very much thrown in here – you don't really mention much about this aspect of the study – is it important? Or relevant???
95. Line 17-21 – is a discussion point and a good point but belongs in a discussion section of the spatiotemporal variability of emissions
96. Line 22 – a lot of this section is good discussion material
97. Line 26 – 'The strong scatter in …'
98. Line 27 – '…factors is likely due to the fact that ebullition is controlled by a combination of all those factors (Fig.7).'
99. Line 28-32 – if this is about Fig. 7f, g then it should be discussed later after Fig. 7a-e
100. Page 20, line 7 – 'First, a deeper water column means higher hydrostatic pressure, which could prevent the formation of bubbles by increasing CH4 solubility in the sediment pore waters.'
101. Lines 8-13 – this can all be condensed as it is already known
102. Line 14-33 – parts of this are results and parts are discussion – try to separate
103. Line 29 – 'whatever' should be 'whether'
104. Page 21, line 14 – is r2=0.03 even worth discussing? Was temperature really negatively correlated? The absence of correlation is more believable.
105. Line 23 – change sentence starting 'As a matter of fact, it is worth trying…' to 'Ultimately, relevant parameters, such as those identified here, should be considered in non-linear models for ebullition even if they are not highly correlated with ebullition.' … but why? I don't see the reasoning for this here. Temperature didn't correlate and it did not meet your *a priori* expectations. This would say to me that it is simply not relevant in this situation but of course trying it at first to determine this is the proper procedure.
106. Page 22, line 3 – delete '(MLR)'
107. Line 4 – where is this 21% results presented? You mention MLR very briefly and it seems to not have worked, which is fine. If this is the only presentation of the results then put '(data not shown)' in the sentence.

108. Line 8 – ‘Taking into account that controlling factors are integrators of several parameters, as shown in the previous section via analyses with TSP, change in TSP, and bottom water temperature, the ANN model resulted in much better agreement between calculate and measured ebullition fluxes (…).’
109. Line 13 – ‘Two input parameters….’
110. Line 1-17 – this all results
111. Line 18-31 – this is mostly discussion
112. How was the ANN validated? Was the 4 year time series results only evaluated with the short four campaigns or with the full year dataset? Modeled series looks higher than measured. Why?
113. Line 24 – this 50% - is it 50% of the ANN results?? – same question for the 60-80% on line 26
114. Line 27 – replace ‘underlines’ with ‘further supports the idea’ – and should put the word ‘hot moments’ somewhere in this last sentence too
115. Page 23, line 1 – I would not say this your method is ‘costless’ or ‘effortless’ – you couldn’t have done the ANN without real data, correct? Therefore, you do have to put forth effort and cost. Please rephrase
116. Line 6 – why must it be used during a period of stable ebullition? I don’t see the point.
117. Line 16 – ‘The EC system captured a diurnal…’
118. Line 16-23 – I would say those are discussion points
119. Line 24-27 – this is a concluding sentence
120. Line 27-31 – this is more discussion and is an important discussion point!
121. Page 24, line 1-8 – these are good for a conclusion I think
122. Line 8-12 – these sentences are exactly the same as in the previous section
123. Line 12-16 – I think it is obvious now that ebullition is an overlooked pathway in reservoirs and I think you have more important points from your data to conclude on. Find the most outstanding points and make those your ending and really put forth why they are important for others.
124. Table 1 – you have FC in the notes for floating chamber but you don’t use FC in the table. And I made suggestions above as to how to change the variables and you need to make them consistent throughout the text, tables and figures.
125. Figure 1 – I am not sure I see the point of Figure 1. Either put it in supplemental or bring the point out more in the text. Also put a box around the legend in all panels. In the caption describe what the variables are.
126. Figure 2 – Why is Ega not here? I would try to exaggerate the boxes in the lower scale more (from 0 to 30) so it is easier to tell what the small boxes have in them. Also make clear in the caption why March 210 has no ebullition data and what the difference is between the first two boxes in May 2009 and March 2011. Put variable descriptions in figure caption.
127. Figure 4 – what are the solid and dashed lines in panels e-h?
128. Figure 7 – why is the line and r’2 not shown in panel h?
129. Figure 8 – does the box description also apply to panel a? Then say so or if not, then what? And why is Fig S3 not part of this figure? S3 seems to be important and it can easily fit in this figure.