Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-215-RC1, 2020

Interactive comment on "Drought years in peatland rewetting: Rapid vegetation succession can maintain the net CO_2 sink function" *by* Florian Beyer et al.

Anonymous Referee #1

Received and published: 10 August 2020

Peer Review: Florian Beyer et al. Submitted, EGU Biogeoscience August 2020

Thanks for the opportunity to review your interesting manuscript. This work delivers a snapshot of the biogeochemical impact of drought processes on restored peatlands, using a variety of remote sensing and micrometeorological methods. Given the potential importance of restored peatlands as a 'natural climate solution', it is critical to understand the potential carbon cycle changes associated with disturbances, such as prolonged drought.

The manuscript's strengths lie in laying out the multi-year data – which essentially constitutes a comparison between previous 'normal' years, and the 2018 disturbance

year. However, it is light on context, discussion, and implications. Below are some questions that may be considered, that would add more richness to the manuscript.

General comments:

1. Consider adding more context, in the intro, concerning why re-wetted peatlands could be an important climate change mitigation strategy. One important consideration is that many 'natural climate solution' potential portfolios often lack any consideration for how future climate change and disturbance regimes will impact the potential enhanced (or avoided) sequestration. There is an opportunity to better make the case of how crucial it is to use natural experiments like this to understand the implications of disturbance on C sink potential of restored landscapes. Some references on NCS and peatlands:

Leifeld, J., & Menichetti, L. (2018). The underappreciated potential of peatlands in global climate change mitigation strategies. Nature Communications, 9(1), 1071. https://doi.org/10.1038/s41467-018-03406-6

Griscom, B. W., Adams, J., Ellise, P. W., Houghton, R. A., & Lomax, G. (2017). Natural Climate Solutions. Proceedings of the National Academy of Sciences, (6), 11–12. https://doi.org/10.1073/pnas.1710465114

Bossio, D. A., Ellis, P. W., Fargione, J., Sanderman, J., Smith, P., Wood, S., et al. (2020). The role of soil carbon in natural climate solutions. Nature Sustainability, 0–1. https://doi.org/10.1038/s41893-020-0491-z

2. Get more explicit about methane and N2O, two other important GHG's that are quite dynamic in wetland/peatland systems, especially during drawdowns.

While I understand the focus on CO2, given the long-term climate forcing of re-wetted peatlands (supported by Gunther et al, 2020), the paper seems to drop the fact that drought, and thus water table dropping, will have effects on denitrification and N2O evolution, as well as redox conditions and CH4 evolution. This needs to be addressed.

For example (different ecosystem), but some rice growers have attempted alternate wetting and drying to reduce CH4 in rice production.

Runkle, B. R. K., Suvočarev, K., Reba, M. L., Reavis, C. W., Smith, S. F., Chiu, Y. L., & Fong, B. (2019). Methane Emission Reductions from the Alternate Wetting and Drying of Rice Fields Detected Using the Eddy Covariance Method. Environmental Science and Technology, 53(2), 671–681. https://doi.org/10.1021/acs.est.8b05535

3. More discussion of future legacy effects. As you say in the final lines, "Although our observations are confined to the year of drought, it is conceivable, that such extreme events initiate distinct carry-over effects that extend beyond the actual drought period and can set the course for the future development of restored fens and their C cycle". As much as the immediate impacts are relevant, it seems like the legacy effects of post-disturbance are as interesting, biogeochemically. Is it possible to include 2019, to say something about these impacts? What is the difference between a long and short disturbance? Between intense and gradual disturbances? Are there any other disturbance types in the record at your site? It could be helpful to at least explicitly describe 2-3 hypotheses of how the legacy effects of disturbance will impact future multi-year biogeochemistry. If the initial disturbance resulted in a reduced, but persistent, CO2 sink, but the following year when water rises again the system 'crashes', this would change the story substantially. How can we manage restored peatlands for future disturbances?

4. Better diagnosis of the mechanistic biophysical drivers of the biogeochemical changes. It is unclear what the specific biophysical cause of the reduced GEP and enhanced Reco is during the drought, and it would be interesting, especially if we are to integrate this disturbance response information into broader models, to diagnose or at least discuss. Right now, 'drought' constitutes less precip, dropping water table, and higher temps. Can you use variation in other years of observations, in which one of these parameters changed and the others were relatively constant, to tease apart what is actually driving this?

One approach is an information theory approach that can help distinguish between drivers, and lags, associated with temp vs. precip vs. water table vs. vpd impacts on the CO2 sink function. See, for CH4, for example:

Sturtevant, C., Ruddell, B. L., Knox, S. H., Verfaillie, J. G., Matthes, J. H., Oikawa, P. Y., & Baldocchi, D. D. (2016). Identifying scale-emergent, nonlinear, asynchronous processes of wetland methane exchange. Journal of Geophysical Research: Biogeosciences, 121(1), 188–204. https://doi.org/10.1002/2015JG003054

Specific comments:

Line 27: "Therefore, climate mitigation measures in peatlands need to focus primarily on the reduction of the CO2 source". Though isn't reducing CH4 of the resulting rewetted peatland also a goal, and could lessen the short-term warming?

Line 37: "drought implies a lowering of the ground water level" What about impacts on CH4 evolution if redox conditions change? Lowering of the ground water level should oxidize and cause less CH4 emission. See this study on the impacts of drought-induced salinization on restored wetlands in California, using mutual information approach :

Chamberlain, S. D., Hemes, K. S., Eichelmann, E., Szutu, D. J., Verfaillie, J. G., & Baldocchi, D. D. (2019). Effect of Drought-Induced Salinization on Wetland Methane Emissions, Gross Ecosystem Productivity, and Their Interactions. Ecosystems, 1–14. https://doi.org/10.1007/s10021-019-00430-5

Technical corrections:

abstract, line 21: 'even by' needs to be reworded to be clearer line 35: remove 'also'

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