Biogeosciences Discussions

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Comment on bg-2022-153

Anonymous Referee #1

Referee comment on "The paradox of assessing greenhouse gases from soils for nature-based solutions" by Rodrigo Vargas and Van Huong Le, Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-153-RC1, 2022

General Comments:

The authors present an interesting and novel evaluation of the bias inherent in sampling strategies at relevant timescales to capture estimates of GHG fluxes. As the authors point out, the ability to measure all three GHGs (CO2, CH4 and N2O) simultaneously is now more common and has advanced understanding of the complex drivers of these important gases. Discrete, manual flux chamber sampling in which all three GHG fluxes from soils as tends to be the most common method, with good spatial but limited temporal representation. For convenience and cost effectiveness, discrete sampling strategies simultaneously measure all three GHGs, however, this strategy relies on the underlying assumption that each GHG responds similarly to biological and physical drivers at these same fixed temporal steps. Systems that automated the GHG flux sampling process are becoming more common but are still limited in application due to the costs associated with them, limiting spatial representation but providing high temporal sampling frequency. Automated, continuous measurement of all three GHG fluxes as high temporal frequency is better able to capture their temporal response to drivers that may not be co-occurring and offer a better understanding of the underlying drivers of each GHG flux as well as estimates of annual GHG budgets.

In this work, the authors aim to address how discrete manual flux sampling strategies in which all three GHGs are measured simultaneously at fixed temporal stratification (FTS) may violate the underlying assumption of co-occurring responses at temporal timesteps and bias the interpretation and understanding of each GHG. The authors utilize a dataset in which all three GHGs were sampled at hourly timesteps via an automated sampling system, for one year (Sept 2014-Sept 2015) in a temperate forest. By extracting subsets from this dataset at discrete timesteps, the authors create a series of examples of FTS at common sampling strategies (12, 24, 48 sample dates per year). The authors then utilize a novel technique, temporal univariate Latin hypercube sampling (tuLHs) to subsample the same annual dataset at the same temporal frequency (12,24 and 48 annually). tuLHS optimizes the temporal selection of these subsets to reflect the same statistical properties and temporal patterns specific to each individual GHG reflective of the yearly GHG dataset. The authors argue that optimizing the sampling strategy for each GHG (tuLHS)

is needed to avoid bias that may be inherent in FTS, particularly when the annual sample size is small (for example monthly, 12)

The authors carefully show that measuring GHGs at common FTS biases estimates at annual timesteps, for this specific dataset, and that the tuLHS method produces a more representative reflection of yearly patterns of GHG fluxes providing a proof of concept for this novel method.

This work is useful and informative and will provide a method (tuLHS) to aid researchers when developing a discrete manual sampling strategy for each GHGs. My concern is how easily this method is implemented broadly, either across years at the same site or how representative a tuLHS derived sampling strategy may be across similar ecosystems. The authors acknowledge that the tuLHS method needs to be site specific, but a minimum of 1 year of automated continuous GHG fluxes (one without large data gaps) is needed to determine the optimal sampling strategy for each GHG using tuLHs. This also assumes that one year is representative of annual and interannual variation in each GHG flux patterns. Although this may be sufficient for CO2, CH4 and N2O are more variable at sub-daily to annual timesteps. A strategy developed in one year, may not be appropriate for the following year, especially if there are shifts in climate. It would seem that multiple years of site specific automated GHG measurements would be needed to determine if there are any wide variations in the optimal sampling strategy under different climate conditions. Further, the tuLHS method may produce an optimal sampling strategy for each GHG, which logistically may be unreasonable to pursue given time, labor and cost constraints. To me this work highlights the need to either have an automated sampling system or co-locate automated and manual sampling strategies to truly capture temporal and spatial GHG fluxes from sites.

As a "proof of concept" in this site-specific case, the authors clearly show that FTS does produce bias in magnitudes and temporal patterns compared to tuLHS, which optimizes the sampling strategy, when compared to a one-year automated GHG flux dataset. More analysis, at multiple sites and conditions, is needed to ascertain the broad applicability of tuLHS. I recommend minor revisions.

Specific comments and questions:

- Was Sept 2014-Sept 2015 a typical climate (temperature and precipitation) year at the site? Can the authors provide insight on how deriving a sampling strategy from one year, particularly if it is not a normal climatic year, and utilizing that strategy in subsequent years may impact results?
- Do the authors think there was any influences in results due to missing automated GHG flux data, which appears predominately in the winter- early spring? It seems curious for N2O to have tuLHS select predominately in the fall/winter period as representative of annual N2O flux temporal and statistical characteristics.
- Lines309-311: the results show that tuLHs provided closer estimates of cumulative sums and uncertainty ranges than FTS. Were these estimates significantly better?

- Overall, since the means for FTS and tuLHs were not statistically different, if a researcher's goal is only to estimate an annual GHG flux, is FTS, particularly at bi-weekly time steps, a sufficient strategy?

Technical corrections/comments:

- In the graphs the authors use Time (days) from 1-365. I assume that is DOY and 1 is Jan 1. The data collected by the automated chambers is Sept 2014-Sept 2015 and I just want to clarify that day 1 is not Sept 2014 and the year follows that timeline.
- Figure 2: The blue line is very difficult to see. Perhaps make the open black circles smaller, thicken the horizontal lines for better clarity.
- Figure A1, A2, A7 and A8: These figures are too small to read when printed.
- What program did the authors use to apply the tuLHs to their automated dataset and can they provide that code alongside their already referenced dataset?