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Atmospheric Chemistry and Physics Discussions

Interactive comment on "What are the greenhouse gas observing system requirements for reducing fundamental biogeochemical process uncertainty? Amazon wetland CH_4 emissions as a case study" *by* A. Anthony Bloom et al.

Anonymous Referee #1

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The paper by Bloom et al. investigates the required performance parameters of satellite missions aimed at gaining quantitative insight into the biogeochemical processes driving methane wetland emission in the Amazon region. To this end, the authors first examine the variability (in space, time, magnitude) of the carbon cycle and hydrological processes that control CH_4 emissions. Then, they use observing system experiments to derive mission requirements (spatial and temporal resolution; precision) that would allow for disentangling the processes under natural variability. The study covers satellite concepts in low-earth-orbit (LEO) as well as in geostationary orbit (GEO).

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Discussion paper

The applied methodology is most interesting since it outlines an approach how to quantitatively derive mission requirements based on the actual variability of the targeted process parameters. I would tend to criticize the study as being too simplistic in one or the other way outlined below. But certainly, the paper is well written, methods are robust and rigorous, and thus, it is suitable for publication in ACP after considering my questions/comments below.

Questions/comments:

(1) A shortcoming of the study is the assumption of purely random error sources implying that measurement uncertainty improves with the square root of the number of binned soundings. This assumption results in maps such as Figure 4 where the measurement precision of GEO soundings binned on 300×300 km^2 is in the range of 0.1 ppb (given 1800 ppb background) which is a clearly unrealistic assumption for the overall measurement error. Experience with the current generation of passive greenhouse gas sounders such as GOSAT and OCO-2 tells that, at aggregated scales, random errors are dwarfed by systematic errors which typically exceed 0.1 ppb by far. Systematic errors are hard to address and, indeed, the manuscript concedes the neglect of systematic errors but a major caveat should be issued when discussing the achievable flux precisions.

(2) The manuscript restricts the advantage of a GEO sounder to massively enhanced data density. Wouldn't it make sense to actually exploit the quasi-contiguous temporal sampling of a GEO sounder? A GEO sounder would allow for resolving variability due to source and transport patterns on the time scale of hours. Running an inverse model with monthly flux resolution (and probably imposed sub-monthly variability) might simply discard some of the available process information.

Technical comments:

P5,L16: Focusing the study on March reduces data amount and related logistics but it neglects seasonal variability. Is there any indication that March is a benign or malign

case? For example: is the CH_4 flux precision requirement of 3 mg CH_4/m^2/day valid for all seasons?

P5,L16: MODIS cannot provide information on diurnal variability in cloud cover. Would you expect a significant effect e.g. for choosing an optimal LEO overpass or for optimizing GEO revisits?

P7,L8: Looking at the correlation matrix (Figure A1), there is substantial correlation among (C1, C2, C4) and (H1,H2) on spatial scales down to 100 km which means that they would be hard to distinguish by an observing system. So, actually, the requirement L$\leq$300 km only allows for discriminating carbon and hydrological controls but not for discriminating the type of carbon (except for C3 vs (C1,C2,C4)) or the type hydrological process (except for H3 vs (H1,H2)). Is that correct? Probably, this should be discussed in more detail.

P9,L1: It would be appropriate to cite an original TROPOMI paper at least once (instead of Wecht et al., 2014, repeatedly): P. Veefkind, I. Aben, K. McMullan, H. Förster, J. de Vries, G. Otter, J. Claas, H.J. Eskes, J.F. de Haan, Q. Kleipool, M. van Weele, O. Hasekamp, R. Hoogeveen, J. Landgraf, R. Snel, P. Tol, P. Ingmann, R. Voors, B. Kruizinga, R. Vink, H. Visser, P.F. Levelt, TROPOMI on the ESA Sentinel-5 Precursor: A GMES mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications, Remote Sensing of Environment, Volume 120, 15 May 2012, Pages 70-83, ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2011.09.027.

P10,L9: “March and September 2007”. The rest of the paper is restricted to March. So, I guess, September needs to be removed.

Equation (2): The multiplication of the vectors $\mathbf{N}$ and $\mathbf{O}$ is not a scalar product but an element-wise multiplication, right? Probably, this needs to be stated somewhere.

P11,L7: Is the unperturbed CH_4 flux assumed constant (12 mg/m^2/day) throughout the domain?

P11,L17: Figure A2 -> Figure C1

P11,L11: A further advantage of GEO is several revisits per day.

Appendices: It would be useful to have a meaningful title for the appendices (instead of only Appenix A, B, C).

Equation C1: What is the inverse of a vector, $\mathbf{f}'^{-1}$?

P16,L22: Figure A1 -> Figure A2.

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