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Comment on acp-2021-721

M.E. Whelan (Referee)

Referee comment on "Long-term fluxes of carbonyl sulfide and their seasonality and interannual variability in a boreal forest" by Timo Vesala et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-721-RC2>, 2021

The eddy flux covariance data from this research effort is a valuable contribution to our community. Vesala and his team have worked hard to advance our understanding of ecosystem carbonyl sulfide (OCS) exchange. It would be appropriate to do more with this data and to set it into a greater context.

The motivation for studying OCS over terrestrial ecosystems is to be able to observe leaf-level behavior, specifically stomatal conductance, at scales larger than a leaf. For over a decade, the great promise of OCS has been to improve the representation of stomatal conductance in land surface models. However, there are other equally important questions to be answered, e.g. the contribution of nighttime stomatal conductance to the atmospheric water budget. Given the potential applications of OCS data, the interpretation and application of this dataset appears incomplete.

Vesala et al. present an impressive observational dataset. They proceed to optimize a set of equations that comprise a semi-empirical model of OCS (Eq 2-5, the results of the first optimization plotted in Figure 1). In order to compare to the land surface model SiB4, the optimization is performed with the same equations again, but this time using variables from SiB4 for the 0.5 x 0.5 degree grid cell containing the field site. The observations are not on a 0.5 x 0.5 degree scale. SiB4 has OCS leaf and soil exchange coded into it. SiB4 can also be run on the site level. An explanation is needed as to why the optimization was performed twice in this manner. Why not compare the OCS exchange predicted directly by SiB4 to the output of semi-empirical model run with related inputs?

The largest departure between the optimized model and observations occurs in July 2014. It is noted that VPD and temperature were both high in the afternoons during this period. Was this a drought or typical variation? This could be an interesting time period to investigate improving the modeling effort. Error attribution would be helpful and/or comparing to another model like SiB4.

Some explanation as to the provenance of the process-informed equations would help a wider readership understand where they came from. For example, the VPD equation looks related to the one mentioned in Medlyn et al., 2011 which itself was based on earlier work. It would be useful to justify why this approach is used instead of Ball-Berry, for example. Also, I have not encountered the variable S before to be able to recognize it as a measure of phenology. All this is not helped by some possible errors in rendering the equations themselves.

This analysis does not partition ecosystem fluxes between soil and leaf uptake. Sun et al., 2018 measured and analyzed a substantial soil flux record at this site. While it is difficult to satisfactorily model the soil fluxes here, it is straightforward to average them over seasons and include them as an uncertainty for analyzing the ecosystem OCS fluxes. This may prove to be important since the semi-empirical model is based on leaf interactions alone. Related, examining the daytime/nighttime OCS fluxes could be an important foray into nighttime stomatal conductance if soils and other minor fluxes are taken into account.

There are many directions to improve the impact of this study as you suggest in section 3.5. Is there a way that we could use this data and this modeling effort to improve the performance or diagnose problems in SiB4 or another land surface model? Can we use this information to compare the many large-scale regional modeling efforts that have recently come out? Of note, the study by Hu et al., 2021 focusses on the Arctic and Remaud et al., 2021 finds a different pattern than the Ma et al., 2021 study.

Finally, some additional data does exist in the broader study area. Multiple efforts by Rastogi et al. in 2018 examined fluxes at a site that appears to be in the southwestern corner of Figure 5. It would seem prudent to compare your model performance with an additional observational dataset.

Minor comments

194-200 and Table 1: This effort might be better put into the supplement for a curious reader. The main modeling work here is not a multivariate linear regression and including this in the main text seems a bit confusing.

201-209: This analysis could be better incorporated into the overall narrative of this study. The wavelet analysis revealed the lack of time lag between OCS uptake through stomata and PAR, which is reassuring but not surprising. Kooijmans et al., 2019 did an excellent job investigating the role of VPD and OCS uptake at this site. It is not obvious what the wavelet analysis achieves here.

242: Were there bounds on the possible values for the empirical fits? Since many of the fittings parameters have multiple significant digits, it stands out that $b=1000$.

257: Can some of the increase in OCS uptake interannually be attributed to the canopy growing 2 m over this time period?

This is interesting and important work and I look forward to seeing its evolution.

Mary Whelan

Citations

Hu, Le, Stephen A. Montzka, Aleya Kaushik, Arlyn E. Andrews, Colm Sweeney, John Miller, Ian T. Baker, Scott Denning, Elliott Campbell, Yoichi P. Shiga, Pieter Tans, M. Carolina Siso, Molly Crotwell, Kathryn McKain, Kirk Thoning, Bradley Hall, Isaac Vimont, James W. Elkins, Mary E. Whelan, Parvatha Suntharalingam: COS-derived GPP relationships with temperature and light help explain high-latitude atmospheric CO₂ seasonal cycle amplification, *Proceedings of the National Academy of Sciences* Aug 2021, 118 (33) e2103423118; DOI: 10.1073/pnas.2103423118

Rastogi, B., Berkelhammer, M., Wharton, S., Whelan, M. E., Meinzer, F. C., Noone, D., and Still, C. J.: Ecosystem fluxes of carbonyl sulfide in an old-growth forest: temporal dynamics and responses to diffuse radiation and heat waves, *Biogeosciences*, 15, 7127–7139, 2018. <https://doi.org/10.5194/bg-15-7127-2018>

Rastogi, B., Berkelhammer, M., Wharton, S., Whelan, M. E., Itter, M. S., Leen, J. B., Gupta, M. X., Noone, D., and Still, C. J.: Large Uptake of Atmospheric OCS Observed at a Moist Old Growth Forest: Controls and Implications for Carbon Cycle Applications, *J. Geophys. Res. Biogeosci.*, 123, 3424–3438, 2018. <https://doi.org/10.1029/2018JG004430>

Remaud, M., Chevallier, F., Maignan, F., Belviso, S., Berchet, A., Parouffe, A., Abadie, C., Bacour, C., Lennartz, S., and Peylin, P.: Plant gross primary production, plant respiration and carbonyl sulfide emissions over the globe inferred by atmospheric inverse modelling, *Atmos. Chem. Phys. Discuss.* [preprint], <https://doi.org/10.5194/acp-2021-326>, in review, 2021.