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Interactive comment on "Ecosystem fluxes of carbonyl sulfide in an old-growth forest: temporal dynamics and responses to diffuse radiation and heat waves" *by* Bharat Rastogi et al.

Anonymous Referee #2

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General Comments

Rastogi et al. present observed patterns of OCS uptake in an old-growth forest during 2015. Their observations are consistent with previous studies in similar ecosystems, and are valuable in corroborating those studies and in confirming that the community's general understanding of OCS uptake holds in old-growth forests. The methods seem valid, subject to some concerns noted below. The manuscript is easy to read and clearly organized. This is not a manuscript that presents new insights or methods.

Unfortunately, the inferences drawn from the observations in the manuscript are not quantitatively supported. In particular, the inferences about stomatal responses to soil

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moisture and heat waves seem to be not only unsupported but also incorrect (see below).

The core weakness of the manuscript, which contributes to the inference problem just mentioned, is that it is overly descriptive in terms of both the analysis and the writing. In terms of the analysis, 5 of the 6 figures (and all but subsection 3.4 of the text) present time series of data, and the associated analysis is restricted entirely to 'eyeballing' correlations between those time series. The authors do not calculate correlation coefficients, or use multiple regression or a simple model to support their causal inferences. In terms of the writing, many patterns in the data are described in the text even though they aren't clearly connected to any conclusions. The manuscript would be more effective if it were to focus on what was learned from the data, referring to the data as necessary to support those findings. Other patterns could be gleaned from figures or tables by any reader with a particular interest.

Specific Comments

- lines 193-195: This justification doesn't make sense to me. The resistance to turbulent eddy transport through open air from 70m to 60m should be much less than the resistance to eddy transport through the dense canopy from 60m to the leaf surfaces. If the aim is to establish the gradient across only the stomata, then using 60m instead of 70m hardly helps. The full transport resistance from the tower top to the substomatal cavity of some particular leaf is r_ac + r_wc + r_lbl + r_s, where r_ac and r_wc are the above-canopy and within-canopy turbulent eddy resistances, r_lbl is the leaf boundary layer resistance, and r_s is the stomatal resistance. Of these, r_ac is probably negligible, r_s is probably most limiting, and r_lbl is probably second most limiting. The authors appear to have neglected r_lbl and r_wc, so that their Gc is not exactly the canopy-scale stomatal conductance but rather a canopy-scale combination of the stomatal, leaf boundary layer, and within-canopy turbulent eddy conductances, i.e. Gc = 1/(r_wc + r_lbl + r_s). It is possible to measure r_ac and some portion of r_wc by comparing concentration measurements within the canopy to those above the

canopy and using flux = conductance x gradient; this approach ought to be superior to using the theoretical u*^2/u. In any case, the authors should clarify what they mean by "the" boundary layer, as the boundary layer that is usually discussed in the context of stomatal uptake is the leaf boundary layer, i.e. the thin layer of stagnant air against the surface of individual leaves, through which gas transport is substantially diffusive rather than advective or convective. Transport through the canopy airspace, or the 10m above the canopy, on the other hand, will not be diffusive at all.

- line 223: You are talking about computing the change in canopy storage, which is a good idea, but why not do that at all times? In general, the flux through the stomata should be equal to the flux past the eddy flux sensor plus the flux into the canopy storage airspace, i.e. Eq. 1 should have a storage term appended to the right hand side (perhaps you used to have one there, as suggested by your reference to the "first term in right hand side of equation (1)" on line 221?). Here you are saying that when the eddy flux term was near zero, you considered the storage flux term. But the storage flux term might be substantial even when the eddy flux term is not near zero.

- line 236 (Eq. 6): Given the considerations about energy imbalance and the PM equation raised by Wohlfahrt et al., 2009 (Agricultural and Forest Meteorology 149, 1556–1559) and by Wehr et al., 2017 (Biogeosciences 14, 389–401), it should be stated why this particular form of the PM equation was used (or why the PM equation was used at all instead of just using sensible heat flux measured from the tower). Those papers indicate that retrieved values of stomatal conductance can be substantially affected by the choice of equation.

- line 329: Regarding "declined precipitously with soil moisture", it is a bit hard to tell from the color scale in Fig. 3a, but it looks like the decline in OCS (which matches the decline in Gc), is better correlated with the rise in VPD than with the drop in soil moisture. People often assume that soil moisture drives seasonal patterns in stomatal conductance (and it surely does at some sites), but it is also possible that the seasonal pattern in Gc and F_OCS is explained entirely by VPD (that was the finding for the

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mesic Harvard Forest site used in the Wehr et al., 2017 paper you cite). It would be interesting to try to disentangle those two water-related drivers here, at least with a simple regression approach.

- line 380-1: Did the estimation of ER from the tower include measurements of canopy CO2 storage? If turbulence is low at night, most of the respired CO2 is probably accumulating in airspaces below the eddy flux sensor.

- line 427-9: I don't see how this inference is connected to the preceding observations, and I don't see any evidence in the manuscript that soil moisture (as opposed to VPD) is limiting gas exchange.

- line 452-5 and 483-4: These inferences are flawed. It is not true that "canopy scale stomatal conductance during these events is dramatically reduced". Figure 6 shows that Gc was not reduced at all during the first heat wave, and was not reduced until the end of the second heat wave, at which point the water flux also dropped. During the third heat wave, Gc was reduced, but the water flux did not increase. Even more importantly, Gc was estimated based on the assumption that the water flux was exclusively transpiration, so it makes no sense to say that the behavior of Gc implies the increased water flux was not transpiration. If the approach used to calculate Gc is valid, then the increased water flux was indeed due to increased transpiration, on account of an increased VPDL.

Technical Corrections

- line 23: "established theoretical relationships" is vague and perhaps overly confident; better to say "we employ the flux-gradient method to infer" - line 109: should be "severely light- and temperature-limited" - line 45: add a "the" before "branch scale" or remove the "the" before "ecosystem scale" for grammatical parallelism - line 111: should be "are shown in Figure 1 and" - line 122: fix capitalizations (should be "Daily mean air temperature (a), precipitation (b) mid-day VPDa (c) and soil moisture" - line 127: citation format is flawed (don't put comma and parentheses) - line 236 (Eq. 6):

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variables need cleaning up (e.g. Cp should have p as subscript and same for delta_e), and the description of variables below the equation needs to match the equation (e.g. Y is not gamma). - line 221: should be “the water flux in equation (1) was” (the right side of Eq. 1 has only one term, containing three variables) - line 269: should be “intact” - line 276: delete “and” at end of line - line 342-3: nighttime ecosystem was measured by EC, not modeled, if I understand correctly - line 352 “Site” should be plural at end of line - line 392: “diffused” should be “diffuse” - line 397: remove comma between “periods” and “during” - line 398: “was” should be “were” - line 392: again, variables have to stay consistent in capitalization, italicization, subscript, etc. (fdiff). - line 418: “Correspondingly” doesn’t fit. Should be “Additionally”. - line 444: should be Fig. 6, not Fig. 5 (and throughout this paragraph) - line 447: “3Kpa” should be “3 kPa” - line 450: “the third events lead” should be “the third event led”

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