Interactive comment on "Carbon Exchange in an Amazon Forest: from Hours to Years" *by* Matthew N. Hayek et al.

Matthew N. Hayek et al.

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(RC1) This paper investigates the influences of climate, phenology, and disturbance to NEE across various timescales in an evergreen Eastern Amazon forest using a statistical model to represent eddy covariance-derived NEE. What I concerned is the research questions are not clear and lack of storyline through the manuscript. I am curious to know what environmental drivers are responsible for the hourly, seasonal and interannual variability of NEE, respectively, and how many are the relative contributions to the variability of NEE between exogenous changes and endogenous biophysical changes.

(AC1) We thank the reviewer for the suggestions and we restructured the manuscript to make the narrative clearer and more coherent.

We have reframed our motivating research questions in the last paragraph of the introduction, to respectively reflect the exogenous and endogenous influences upon NEE which we discuss throughout the paper (1) meteorology at hourly to interannual timescales (2) phenology at seasonal timescales, and (3) disturbance at interannual timescales, specifically those caused by droughts.

We reordered the subsections in our results and discussion to in turn reflect the reframing of our introduction. Specifically, the we re-numbered the subsections of Results Section 3.4, which concerns our empirical modeling of NEE on various timescales, dedicating subsections to quantify the influences upon modeled NEE on hourly timescales (3.4.1) and seasonal timescales (3.4.2), and also discusses the extent to which modeled meteorology and phenology explain NEE on interannual timescales (3.4.3). For each of these sections, we explicitly quantify the relative contribution of each influence upon NEE.

Our Discussion section now more closely mirrors the timescale-based structure of the Results section as well, with sections devoted to discussing the influences upon the hourly and seasonal variability (4.1) and the interannual variability (4.2). Importantly, the sections of the Discussion that the reviewer found disconnected, those concerning droughts and disturbances, were moved into subsections of the interannual variability (4.2.1 and 4.2.2, respectively). This gives the discussion of these phenomena a more fitting home: as potential explanations for the patterns seen in annual NEE.

(RC1) Throughout the abstract, it should be more quantitative in nature. For example, how many are the relative influences of climate, phenology, and disturbance to NEE across various timescales?

(AC1) We agree that the abstract would benefit from additional quantitative information concerning the relative influences upon NEE. We included information regarding the extent to which phenology influences NEE (1% and 26% on hourly and monthly timescales respectively) in our revised abstract, explaining that the rest of the modeled

variability on these timescales is due to meteorology alone. Our abstract discusses and quantifies the extent to which meteorology and disturbance affect annual NEE at this site.

(RC1) Line 46-49 please cite the references for each driver respectively.

(AC1) We considered separating references by drivers, but most of the studies we cited examine and quantify the effects of multiple drivers simultaneously.

(RC1) Line 81-82 did Urbanski et al. (2007) answer this question? Please double check and use the same term: R/RE.

(AC1) Urbanski et al. answered this question as it applied to the Harvard Forest, a seasonal temperate mid-latitude mixed deciduous forest. Additionally, we corrected this term to RE, consistent with the abbreviation throughout the rest of the manuscript.

(RC1) Line 80-89 what are relationships among these three questions? Each question looks individual.

(AC1) We revised them to clarify the connections amongst them. Our three research questions now reflect meteorology, phenology, and drought respectively, and our concluding sentence in this paragraph summarizes them in tandem (see first comment above for details).

(RC1) Line 94 There was 1918 mm of annual rainfall. Why did it have a 5 month long dry season?

(AC1) We clarified the dates of the dry season and the definition which we and Hutyra et al. (2007) use: mean monthly precipitation of less than 100 mm.

(RC1) Line 91-98 Please describe more about the climate condition (temperature), species composition, vegetation/soil type, forest age, water table depth etc.

(AC1) We have added more site-specific information as requested.

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(RC1) Line143-145 did you create the correlation and verified each other for these three data sets?

(AC1) We now clarify that the correlation between the monthly rainfall datasets for the years 2001-2012 was R2=0.88. We clarify that additional information about the robustness of the meteorological data sets can be found in Longo (2014).

(RC1) Line 165-170 did you make any validation for predicted CWD from the box model?

(AC1) We now clarify that a validation of the model was made against our second and final measurement of CWD in 2012.

(RC1) Line 172 what is the low-parameter empirical model?

(AC1) We specify that this refers to the model of Eq. 2.

(RC1) Line 222-225, these sentences should be placed in Methods, rather than Results.

(AC1) We removed these sentences from the results and placed them the Methods Section 2.3.

(RC1) Line 227-230 since Hutyra et al. (2007) has reported these results, what is the sense of your results here? Same problem with line 238-239.

(AC1) We specify that our slightly different gap-filling methods (Section 2.3) did not create a discrepancy within 95% confidence intervals of random measurement error, between our annually integrated NEE and that of Hutyra et al. (2007), which gives us more confidence that the post-2008 carbon balance results are consistent with previous analyses.

(RC1) Line 271 Were there any disturbance for 1998-2000?

(AC1) We did not measure CWD in 1998-2000. However, we added the caveat that

we assumed that the disturbance occurred in 1998, because 1999 and 2000 were not characterized by below-average rainfall, to Results Section 3.3, to clarify that we could only infer but did not measure that a disturbance occurred in this year. We provide additional recent evidence that drought events are accompanied by increased mortality and canopy turnover rates, signifying disturbance (Leitold et al., 2018).

(RC1) Line 762 how about the dry seasonal? Why only 9 days, rather than 90 days?

(AC1) We chose a small sampling of day from the wet season as an example to highlight the variability between days of different cloudiness. Dry season days tend to be consistently sunny and high-uptake, and therefore an example time series from the dry season would not exemplify variability between days. We specify in the Results Section 3.4.1 "Modeled hourly variability frequently captured the difference in magnitude in NEE between high and low uptake events". We chose 9 days for our example time series because many more would make the time series figure too crowded and make it hard for the reader to notice the variability between hours and days.

(RC1) The results section is pretty confusing. Please organize the idea logically. As your title: 'Carbon Exchange in an Amazon Forest: from Hours to Years', what environmental drivers are responsible for the hourly, seasonal and interannual variability of NEE, respectively? How many are the relative contributions to the variability of NEE between exogenous changes and endogenous biophysical changes?

(AC1) See our response above to the first comment for substantial revisions made to the organization of the Results section.

(RC1) How did you define the hourly, seasonal and interannual variability of NEE?

(AC1) Our usage of the term "variability" in NEE reflects the standard within a long history of applied statistical research: deviations of our dependent variable around its mean value. Throughout the paper and for the various timescales examined in our analysis, our use of the term "variability" is consistent with this definition; we therefore

did not see the need to define it explicitly within the manuscript.

(RC1) Line 325 what is the R2 between modeled and observed annual NEE?

(AC1) We added to this paragraph in Section 3.4.3 that the correlation between modeled and measured yearly NEE was low ($R^2 = 0.17$; $p = 0.37$) owing to the 2002 outlier; if 2002 is excluded, the correlation is high and significant ($R^2 = 0.81$; $p = 0.014$). Much of our discussion section is then devoted to discussing why 2002 was an outlier with respect to other years.

(RC1) It is also difficult to follow the Discussion section. What are the relationships between these four subtitles? They look pretty individual. Did you discuss the hourly and seasonal variability of NEE? Why don't you focus on explaining your results instead of talking about implications so much? The reader is really curious about your findings.

(AC1) See our response above to the first comment for substantial revisions made to the organization of the Discussion section.