
Interactive comment on “Exchange of CO₂ in Arctic tundra: impacts of meteorological variations and biological disturbance” by Efrén López-Blanco et al. Anonymous

Referee #2

Received and published: 29 June 2017

The article “Exchange of CO₂ in Arctic tundra: impacts of meteorological variations and biological disturbance” by Lopez-Blanco and co-authors presents eight years of eddy covariance measurements from a tundra site in Greenland. The data set is rich and the authors apply current and appropriate methods in data analysis to derive gap-filled net carbon fluxes, as well as to partition these fluxes into the photosynthetic and respiration components. The authors attempt to analyze gap-filling procedures and use autochamber data towards these efforts. The undertaken analyses reveal valuable insight into the behavior of tundra carbon cycling in response to environmental variability from hourly to inter annual scales. Novel methods are applied to analyze the role of environmental drivers of C cycling as well as biological factors such as a pest outbreak. In general, the manuscript is a solid and valuable contribution. Greater attention to grammar, structure, and clarity will greatly improve the article. In some cases, additional justification for statements or references to literature are needed. The comments that follow provide suggestions for addressing these concerns before publication.

We are thankful for the reviewer’s insightful comments that have improved the manuscript. We have carefully considered the reviewer’s remarks and clarified our manuscript accordingly.

General comments:

There is too much repetition in portions of the manuscript (specific comments identify some of these sections), and efforts to reduce repetition will increase the readability of the paper.

Taking your advice into account, and also based on your guideline in one the very last specific comments (P10), the conclusions have been reduced to put the key findings in a more general context.

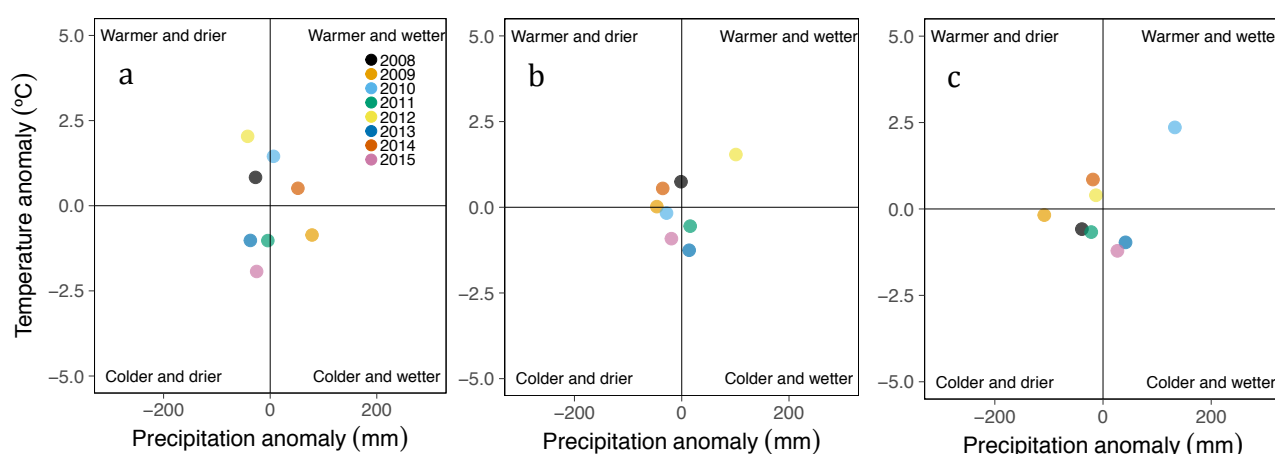
More attention is needed to grammar throughout the manuscript. Importantly please play close attention to the correct use of singular or plural nouns. Here are some examples where they should be switched (but please address on a case by case basis): Singular case instead: temperatures -> temperature, exchanges -> exchange, budgets -> budget, precipitations -> precipitation, references -> reference, evidences -> evidence Data: plural -> data are rare Capitalize Earth and Arctic when proper nouns

Thanks for finding these errors; now corrected.

With respect to figure 6, what causes the different direction (clockwise vs counter-clockwise) in the hysteresis observed in 2010 vs 2012 vs 2013? It would be interesting to know whether the causes for early versus late season decoupling of GPP and Reco are the same or different.

This is actually a very good comment. The data suggest that the clockwise 2012 hysteresis was due to greater gross C cycling (GPP and R_{eco}) in June and July; while in 2010 and 2013 (counter-clockwise hysteresis), the higher gross C fluxes have been measured in August.

In the following figures it has been plotted (from left to right) June, July and August temperature and precipitation anomalies. We can observe warmer and drier (in June) and warmer and wetter (in July) conditions in 2012 (yellow), whereas 2010 has had warmer and wetter conditions in August (light blue). These differences could explain the different direction in the hysteresis observed.



Temperature (°C) and precipitation (mm) anomalies in June (a), July (b) and August (c) of the analyzed years (2008-2015).

Specific comments:

- *Abstract: I find the use of meteorology and climate to be a bit conflicting here. Please ensure whether you mean meteorology or climate with reference your conclusions in this study.*

The referee is right; we should keep consistency in the terminology. Since this is an 8-years dataset, we decided to use the term meteorology rather than climate.

- *P2L69: The terminology “C balance state” does not carry an immediate clear meaning. Does this refer to the annual balance of net carbon exchange? Clarify what C state refers to and how relates to fluxes versus carbon stocks and over which time frames. What is your definition of C uptake and C storage, and over what time frame?*

The text has been changed to sign and magnitude of the C balance instead

- *P2L52: Eddy covariance data can include other types of gases, so good to specify: Eddy covariance measurements of CO₂*

Corrected accordingly

- *P3L82: Resiliency in which sense? Should clarify right away.*

We meant the resiliency of the sink. However, this part has been removed, so the objectives are more direct and clear. The resiliency of the sink will be just briefly mentioned in the discussion.

- *P3: Sections of the end of the introduction are too detailed to be placed in the introduction and should be moved to the materials and methods section. Please separate material between L82-91 into intro vs methods as appropriate*

Following your suggestion, we have moved the second part of the paragraph into section 2.2 (Measurements) (L109-113).

- *P3L116: clarify what 5+5 min means*

The computer running these automatic measurements activates the chambers in succession for 10 minutes. During the first 3 minutes the chamber is open for ventilation, then closed for 5 minutes, and opened again for the last 2 minutes. Each chamber is therefore activated once per cycle while the inactive chambers remain open.

In the text we have updated “*in succession for 10 min every hour*” (L120)

- *P3L120: spell out km if used in this sentence*

Corrected accordingly

- *P5L184: Please clarify what is meant by “sums the variable’s importance up to 1”. This sentence could be clearer*

We changed the sentence to: “This version of Random Forest sums the relative importance of each variable from 0% up to 100 %, which correspond to the fraction of decision in which a variable is involved to cluster the data.” (L188-190)

- *P5L198: Check grammar: “also exposed a larger variability”*

Corrected: “also exhibited larger variability”.

- *P6L205: what is a non-lap year?*

Typo, we meant non-leap year. Now corrected.

- *P6L216: measurement period*

Agreed, changed accordingly.

- *P6L223 & Fig S4: The largest GPP and Reco were found in wetter and warmer years, but what is the statistical measure to support a “tendency towards larger GPP and Reco during wetter and warmer years”? For example, for Reco, half of warmer/wetter are larger and half are smaller than colder/drier.*

The referee is right, the Figure S4 (now Figure S3) is not correct as such. It shows the annual and precipitation anomaly of the analyzed years (2008-2015) compared to the 1866-2007 time series. This graph should only include the anomalies within the measurement period (i.e. 2008-2015). Based on Ref#1, we have updated the Figure 2b including annual, cold and warm periods during the measurement period. This new input shows that both annual and cold period in 2010, 2012 and 2013 had larger GPP and R_{eco} during wetter and warmer conditions. Figure S3 has been also updated.

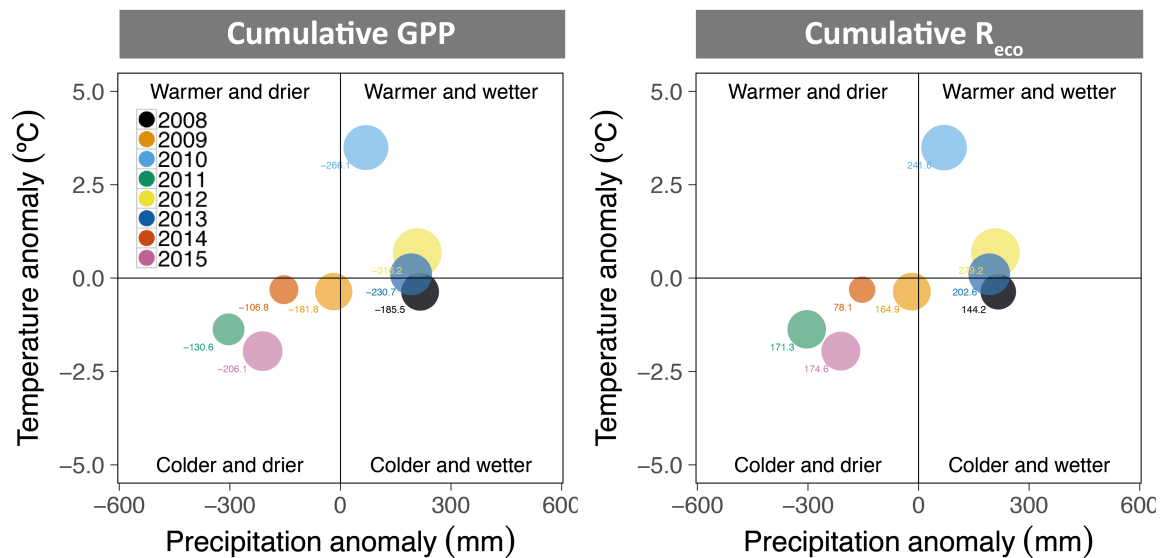


Figure S3: Annual cumulative GPP and R_{eco} defined by annual temperature and precipitation anomalies (2008-2015). The flux size is categorized depending on the flux magnitude (g C m^{-2}), i.e. larger diameters with greater fluxes.

- *P6L228: perhaps be more specific about what the response to the outbreak was in terms of fluxes (not really a response of measurements, but of actual fluxes). Just GPP?*

We have implemented the text to: “coinciding with high NEE and very low GPP (Figure 4)” (L258).

- *P7L281: I wouldn’t use “momentarily” to describe hourly data*

We wrote “temporarily” instead.

- *P7L285: What is meant by “although T_{air} appeared to be the less limiting factor”. It seems that T_{air} is the most important variable for Reco, but I’m not sure how it would be limiting or not*

The referee is correct, the sentence as such sounds odd. We reformulated the text:
In terms of CO₂ release (R_{eco}) the pattern is less clear and noisier, although T_{air} appeared to be the most important variable.

- P8L1286: Check grammar in the last sentence. I wouldn't use "catch". Please elaborate on what the connection here is. Why would a decrease in PAR's importance are sense here?

We changed "catches" with "revealed". PAR is interesting because it includes information about cloudiness. Negative PAR anomalies in 2011 show less bright growing season compared to the other years, which could have contributed to the C dynamics in the cited year.

- P8L293: What tendency is that? Also, don't use 'mirror effect'. Use clearer language.

The first part of this point has been answer earlier (P6L223 & Fig S4). With respect the mirror effect wording, we updated the text:

"The results suggest that the relative insensitivity of NEE to meteorological conditions during the snow-free period could be the result of the correlated response of ranked cumulative GPP and R_{eco} (Figure 5). In this study, larger rates of C uptake (GPP) implied also larger rates of C release (R_{eco}), with exception of the anomalous year 2011." (L333-336)

- P8L298: I'm not sure this sentence is a natural conclusion from your results: "Thus, the effects on C balance of warming from climate change are not straightforward to infer." Would these processes not be predicted by models? If so, then it could be misleading to state that it is difficult to infer. Provide some context from current literature here if in fact current understanding would have missed this.

We implemented the text with the following explanation:

Further, this study agrees with Parmentier et al., (2011), who suggested that a longer growing season does not necessarily increase the net carbon uptake. Here a more negative NEE indicated a stronger C sink (i.e.) in 2012 compared to 2010. Parmentier et al., (2011) hypothesized that this behavior is due to site-specific differences, such as meteorology and soil structure, and that changes in the carbon cycle with longer growing seasons will not be uniform around the Arctic. Thus, the effects of climate change on the tundra C balance of are not straightforward to infer. (L344-348)

- P8L303: a bit redundant with 'growing season' twice

Agreed, we took out the first "growing season".

- P8L314: outbreak of what?

We updated the text with "outbreak of autumn and winter moths". (L363)

- P8L317, L330: *check grammar*

Corrected, previous referee also pointed towards this sentence. Thanks.

- P8L322: *shortest-lasting, longest-lasting*

Corrected

- P9L337: *This first two sentences are very unclear as written*

Agreed, we updated the text in a clearer way.

“The NEE gap-filling and subsequent partitioning are needed to understand the responses to the environmental forcing. However, these procedures expose partial inconsistencies between approaches (Figure 4) and unavoidable uncertainties in the seasonal C budget calculation (Table 2).” (L302-304)

- P9 section 4.2: *I don't find this analysis of gap filling to be very informative because estimates regarding which method is best are not testable. Why not test the performance of the gap-filling on years where you have good data coverage by creating artificial gaps and testing model performance against real data? I would find that exercise to be much more compelling and would help you determine which method to apply in years where data is really missing.*

Quantifying the uncertainty introduced by measurement gaps is difficult. One possibility would be a sensitivity analysis of time series with artificially introduced gaps as the referee suggest. But the choice of gap length and position is difficult, and would render the uncertainty assessment itself quite uncertain. We think the paper already contains a lot of information. So the best way to give the reader an idea about why we decided to use the auto-chamber (AC) data is that the MDS gap-filling alone introduced NEE values out of range. Instead of blindly trust a gap-filling script, which create odd numbers, we decreased the gap length introducing AC data. We understand AC data incorporated uncertainties to the calculations, although they have been included in the total uncertainty estimation.

- P9L365: *How was the filtering done? This is not clear.*

We separated the dataset in 3 subgroups: all day data (0-24hr), daytime data (11-14hr) [when GPP is the strongest and will represent the largest part of NEE], and nighttime data (00-03hr) [when NEE=R_{eco}]. By doing this, we make sure that the Random Forest approach will not include bias from the partitioning analysis.

- P10: *I would avoid using ‘interesting’ so much as a way to describe your observations. It would be more informative to put in context with extant literature. You should not just repeat results here that are listed elsewhere, but put into context. For example, this is done in the latter half of the L380-387 paragraph, but not the first part. The first half of the conclusion is a bit repetitive as well - should not be a repetition of abstract, should be more general.*

Two ‘interesting’ words have been removed from the text.

The conclusion part was reduced to put the key findings in a more general context, omitting detailed values and districting information which has been addressed previously in the results and discussion sections (L417-424):

We have analyzed eight snow-free periods in eight consecutive years in a West Greenland tundra (64° N) focusing on the net ecosystem exchange (NEE) of CO₂ and its photosynthetic inputs (GPP) and respiration outputs (R_{eco}). We find that Kobbefjord acted as a consistent sink of CO₂, during the years 2008-2015, except 2011 that was associated with a major pest outbreak. The results do not show a marked meteorological effect on the net C uptake. The relative insensitivity of NEE during the snow-free period was the result of the correlated response of GPP and R_{eco}. The ranges in annual GPP and R_{eco} were >5 fold larger and more variable than for NEE. Here we show a tendency towards larger GPP and R_{eco} during wetter and warmer years. The anomalous year, 2011, constituted a relatively strong source for CO₂ and has decreased its C sink strength due to the biological disturbance, which reduced GPP more strongly than R_{eco}. The changes of environmental forcing across diurnal, seasonal and annual time scales unmasked patterns of functional responses to C fluxes.

- *Table S1: Avoid using N°*

Corrected.

- *Where is Figure S1?*

The indexing in the supplementary material has been changed to Equations S1, Figures S1, S2, S3 and S4, Tables S1 and S2.

Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-506, 2016.