

Interactive comment on “Field-warmed soil carbon changes imply high 21st century modeled uncertainty” by Katherine Todd-Brown et al.

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We thank the reviewer for their excitement about this study and the detail with which they have treated this review. We hope that the below address the concerns raised here.

Regarding the quasi-steady state assumption: Since the reviewer acknowledged the necessity of this assumption in the field data we'll confine our reply to the Earth system model analysis here. We would direct the reviewer to a figure in the SI that regrettably was poorly referenced in the main manuscript. Figure S3 shows the ratio between the annual change in soil carbon stock divided by either the maximum input or output to the soil at the beginning and end of the 21st century. While there are some grid cells in

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most models with a relatively high imbalance, the vast majority of models have a ratio below 10%. That is the change in soil carbon stock is at least an order of magnitude less than the input/output fluxes, allowing us to assume that the inputs approximate the outputs and apply equation 3 as stated. We will expand on the numerical justification illustrated in Figure S3 in the methods and would draw the reviewer's attention to the second paragraph in the result section that expands on this point.

The reviewer also expressed concerned about not using a direct Q10 estimate from the heterotrophic respiration. This Q10 estimation from simulated heterotrophic respiration was an approach previously taken in Todd-Brown et al 2014. While we considered this approach for the current study and indeed worked up the analysis and included it in the SI (see Figure S4), we ultimately decided to try to follow the field analysis as closely as possible. The results from this alternate calculation of Q10 did not significantly deviate from the current analysis. We will expand on the implications of Rh vs soil inputs in the methods section.

Regarding the field input assumption: As was correctly pointed out in the manuscript we do address what the implications of changes in inputs would be for this analysis. However given the limitations of the data we are working with this is not possible with the current dataset. We feel we have been upfront about this limitation of the approach and hope that the reviewer can agree that this is a valuable analysis none the less. We plan to address this directly in future studies.

Regarding alternative calculations of the field Q10: The reviewer is entirely correct that we could have chosen to calculate a site by site Q10 instead of the fitted linear regression. We chose the regression approach because of the clear cutoff in Q10 fit at the 2 standard deviation point described in the methods and familiarity of the field with this statistical approach. We've added a comment to the methods section to this effect.

Line by line:

P1L25: We will 'stimulate' for simulate.

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P1L27: We respectfully disagree and have kept this in for clarity.

P3L20: Thank you for catching this. We have written the equation to reflect the version in the SI where we use the form $(Q_{10} \cdot K^A) \cdot C(t)$. This does not change the results of the analysis.

P3L20: We will substitute 'scalar' for scaler.

P4L2: We will substitute 'vice-versa' for vis-versa.

P6L16: We will substitute 'data-driven' for data-drive

P6L18: We will substitute cell for cells.

P8L10-11: We will replace this topic sentence and rework this paragraph as several reviewers found this confusing. A draft topic sentence now reads: "Typically extrapolating decadal trends from annual results is problematic and understandably controversial. However, given the mathematical structure of traditional soil models and the numerical results seen in the Earth system models, it is appropriate in this specific case of inferring long term temperature sensitivities."

P8L16: The citation for Figure S4 is correct. We have revised and split this paragraph to better explain figure 4 which shows both the implications of using heterotrophic respiration instead of soil inputs to calculate Q10, and how those Q10 distributions shift over time.

P8L25: We fixed this typo.

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