

# ***Interactive comment on “Causes of uncertainty in observed and projected heterotrophic respiration from Earth System Models” by Cary Lynch et al.***

## **Anonymous Referee #3**

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### Overview

The manuscript provides an assessment heterotrophic decomposition simulated by CMIP5 models to temperature and soil moisture (using precipitation as proxy) and how these sensitivities vary in space. Simulation of heterotrophic respiration remains a highly uncertain process in many models and thus any analysis which aims to diagnose the strengths, weaknesses and identifies strategies for improvement are valuable. However, in this case I find the manuscript misses many key areas of existing research in both the introduction and discussion. The writing clarity needs to be improved throughout the manuscript to make the reading as easy as possible. Unfortunately these issues leave me unclear as to what novel information is brought to the fore by this analysis. I hope the authors are able to clarify their message and highlight their

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novel finding.

General comments

Writing style:

The authors frequently use overly complex and long sentences with many comma. This makes the manuscript more difficult to read as it frequently obscures the key point of the sentence / paragraph. Below are some examples:

P1 L15: “There is little understanding, however, of the causes of this variability and its consequences for future model development and scenarios evaluation, and examining the relationships between RH and key climate variables may help to understand where and why models are divergent” Would be clearer if broken down e.g. “There is little understanding of the causes of this variability and its consequences for future model development and scenario evaluation. <However,>Examining the relationships between RH and climate variables may help to understand where and why models are divergent.”

P1 L27: “The RH-TAS relationship explored here, and more pattern scaling methods mode generally, can be used to efficiently explore uncertainty and projected changes in RH under a wide range of future emission scenarios, and understand how models’ structural and parametric choices produce divergent results.” Would also be clearer if broken down e.g. “The RH-TAS relationship explored here can be used to efficiently explore uncertainty and projected changes in RH under a wide range of future emission scenarios. Such information is essential to understand how models’ structural and parametric choices produce divergent results.”

P1 L30 & P8 L25: You should not begin a sentence and definitely not a paragraph with “Because”.

Title:

I think that the title should be changes as it is misleading. The manuscript does not

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assess the causes of uncertainty in observations as far as I can see. It might be more useful to mention both the CMIP5 models and temperature / precipitation.

Abstract:

The abstract needs greater clarity. It is not clear what if any recommendation are made as to which processes may be missing in the CMIP5 models. What is the pathway to improvement? The authors state that their approach can be used to diagnose causes for divergent results but it is not clear why they do not present any causes for the divergent results found here in the abstract.

P1 L13: It would be good it include a quantification of RH to put into context.

P2 L22: "...RH dataset." This is a little misleading. As the authors point out this is a observation-driven analysis. P1 L25-27: "The relationship between observed RH and precipitation (PR) relationship is strong and positive ( $r > 0.5$ ,  $P < 0.005$ ), but few models consistently show this sensitivity of RH and PR." Are the models which do not show a correlation those which do not include a soil moisture response to RH? How many model fail to show the observed behaviour?

Introduction:

The writing style needs addressing. There appears to be some large areas of the existing literature missing from the introduction which is needed to support their analysis. The authors also miss existing literature attempting to diagnose the decomposition processes in CMIP5 models. This information is needed to more clearly define the novelty of the authors work.

The second paragraph of the introduction states most models simulate increasing RH and that existing RH process representation is simple (first order kinetics) compared to many others ecosystem processes (I assume e.g. photosynthesis?). Then moving on to compare observation driven estimate of RH with NPP estimates. I think this is too many concepts in one paragraph without adequately describing any of them. Para-

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graph two should deal with a description of exiting RH model structures. Highlighting known issues with first order kinetic, e.g. lack of a microbial pool and difficulties in responding to changes in litter quality versus quantity (e.g. Wieder et al., 2013, Xenakis & Williams 2014). The importance of soil moisture (Exbrayat et al., 2013ab, Exbrayat et al., 2014) or nutrient cycles (Manzoni & Porporato 2009; Exbrayat et al., 2013a).

P1 L44-45 “While both temperature and precipitation have a positive effect on the global terrestrial carbon flux” Are you still talking about respiration? Net ecosystem exchange, Net biome exchange?

Methods:

Linking back to the decomposition review from the introduction details of which temperature and soil moisture response functions used in the CMIP5 models seems appropriate to me.

P3 L1-6: Does the observation-driven estimates come with an uncertainty analysis?

P3 L21: “...we only used the first realisation...” Would it not be more appropriate to use the mean across ensembles?

Results:

P5 L14-20: It is not immediately clear whether you are talking about correlations in space or time. Also please be clear throughout the manuscript that precipitation is a proxy for soil moisture availability. Therefore you should not be talking about both soil moisture and rainfall being limiting. Soil moisture / plant available water is limited.

P5 L28-30: “This is likely due to less land (and this higher variability is model averages)...” Is it not equally or more likely that greater divergence between models occurs because the models are trained and developed using observations which are bias to the temperate northern hemisphere?

P6 L13-21: Is there no observation equivalent for this analysis?

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P7 L1-14: I think both of these paragraphs need to be clearer. It is not always obvious to me whether you are talking about simulated vs observed RH. Would be improved if you make better use of the available figures in this section.

Discussion:

P8 L19-20: This is the first time pools have been mentioned. This should be first mentioned in the introduction.

Moreover, I feel a more thorough discussion of the associated literature is needed.

P8 L25-46: I think both these paragraphs need rephrasing to improve clarity. There is no use of any figures or tables from you manuscript here.

P9 L15-17: Your text appears to be referring to the global average but what about spatial patterns? You present a large number of figures with spatial variation, can you make greater use of these?

P9 L22-30: I think this would be a good area to discuss some of the possible parameterisation / model processes missing within the existing models within the context of the material I suggested should be added to the introduction.

P9 L39: "...temperature response (Q10)..." please provide range for context.

Specific comments

P1 L22 "Compared to observations, ESMs consistency..." -> "Compared to observations ESMs consistently..."

P1 L36 "carbon cycle" -> "carbon (C) cycle"

P2 L31 "...an observation-based data product." -> "...observation-driven analysis."

P2 L46 "(Hashimoto et al., 2015):(Hashimoto et al., 2015)"

P4 L40: "...majority (65 %)..." please state number of models.

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P5 L1: "...smallest projected trend..." trend in what? not clear from text.

P6 L24: "...weaker correlated models..."

P7 L21: "...ESMs examined here (Figure X)" ?

P7 L23: delete "On one hand, "

P7 L25: delete "On the other,"

P7 L30: "...soil moisture response functions."

P7 L35: "robustly" I'm not convinced you can say this. "Consistently" would be a more appropriate word

P8 L1: delete "Interestingly,"

P8 L9: "...across empirical datasets." Such as?

P8 L25: "Because..." you should not begin a sentence with "because", let alone a paragraph or subsection. Please rephrase.

References not included in original manuscript Exbrayat J-F, Pitman AJ, Zhang Q, Abramowitz G, Wang Y-P (2013a) Examining soil carbon uncertainty in a global model: response of microbial decomposition to temperature, moisture and nutrient limitation. *Biogeosciences* 10:7095-7108. doi: 10.5194/bg-10-7095-2013

Exbrayat J-F, Pitman AJ, Abramowitz G, Wang Y-P (2013b), Sensitivity of net ecosystem exchange and heterotrophic respiration to parameterization uncertainty. *Journal of Geophysical Research: Atmospheres* 118:1640-1651. doi: 10.1029/2012JD018122

Exbrayat J-F, Pitman AJ, Abramowitz G (2014) Response of microbial decomposition to spin-up explains CMIP5 soil carbon range until 2100. *Geoscientific Model Development* 7:2683-2692. doi: 10.5194/gmd-7-2683-2014

Xenakis, G., and Williams, M. (2014) Comparing microbial and chemical approaches for modelling soil organic carbon decomposition using the DecoChem v1.0 and Deco-

Bio v1.0 models, Geoscientific Model Development , 7, 1519-1533, doi:10.5194/gmd-7-1519-2014

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