

Responses to interactive comment of Anonymous Referee #3 on "Interannual variability of the atmospheric CO₂ growth rate: relative contribution from precipitation and temperature"

Dear Referee,

Thanks very much for your efforts to deal with our manuscripts and provide constructive comments. We have tried our best to re-summarize the results, and modify this manuscript accordingly. The following is our point-by-point reply to your comments.

1. title: as per the claim, I do not feel the paper really attempted to quantify the "relative contribution" of temperature and precipitation on CO₂ sources sinks. To be precise I was looking for number how much fraction of the CO₂ IAVs is due to precipitation, and how of much of the CO₂ IAVs is due to temperature. I only found the total sensitivities of CO₂ IAVs to T & P.

Reply: Thanks very much for your suggestions. Indeed, we do not think we can give out the detailed contributions from temperature and precipitation by linear statistical analyses. And we regard that sensitive experiments by models can show us more reasonable results, but we do not have these runs. So we do not present the statistical contributions from temperature and precipitation, though it is easy to do that. On the contrary, we regard the precipitation as the dominant factor by process analyses. We think we can remove the "relative contribution" from the title and change it as "Interannual variability of the atmospheric CO₂ growth rate: roles of precipitation and temperature".

2. p.19074, l.15 : The models look to be more sensitive to T and P compared to measurements. Why is that. One of the reasons I can imagine is that the models do not include fires, but they are producing the IAV by increasing sensitivity to climate variables.

Such tuning is probably also leading to the large sink increased simulated by the models in the recent years.

Reply: Thanks very much for your suggestions. From the Table 1, we can know that five out of these DGVMs include the fire modules, but few of them contain nitrogen

limitations. Figure 8 shows the individual model's sensitivities to temperature and precipitation. We can find out that CLM4C and TRIFFID are more sensitive to these two climatic elements than the other models. They will influence the ensemble result to some extent. The other models are more close to the observations.

3. p.19076, l.1 : I think this is true mainly in the temperate and boreal regions.
p.19078, l.1 : as you may know some part of this record has to come to Keeling's data, until about 1970. including a reference to SCRIPS/Keeling is appropriate here.

Reply: Thanks very much. We also calculated the interannual variabilities of NPP and Rh in the temperate and boreal regions, and we can find out that NPP and Rh cancel each other strongly. Maybe temperature plays an important role in these regions. It still needs further studies.

Thanks for your suggestion. We have added two references of Keeling et al., 1976 and Masarie and Tans, 1995 for these datasets.

4. p.19079, l.19 : Is this the real reason? how about low cloudiness and greater amount of incoming solar radiation?

Reply: Thanks for your suggestions. Tropical land temperature and precipitation are closely correlated. The high correlation is partly due to that less land precipitation (for instance during El Niño) can inhibit the evapotranspiration over Tropics, promoting the higher temperature (Zeng et al., 2005), and also is due to the ENSO-related circulation adjustments (less low cloudiness and greater amount of incoming solar radiation) (Gu and Adler, 2010). We have modified it accordingly.

5. p.19080, l.16 : is there a mismatch in '-v1' and '/V2/'?

Reply: It is right here. The datasets come from TRENDY-v1. But we do download the data from <http://www-lscedods.cea.fr/invsat/RECCAP/V2/>. We consulted Sitch for this information and he told us this /V2/ is because they re-run these experiments.

6. p.19081, l.7 : if you are interested only in the region of 23S-23N, the previous step of making data at 1x1 deg wasn't needed.

Reply: Thanks. In the last figure, we attempt to give out the sensitivities to T & P grid by grid. So it is necessary to make data at 1x1 degree first.

7. p.19083, l.10 : 'temperature over land lags ENSO by 4 months'. I cannot understand the significance of this general statement. The timing of heat wave due to ENSO cycle vary from continent to continents (America, Africa and Asia) and the location, say the northern and the southern Southeast Asia. This study would have been more useful for process-level understanding if the authors broke down the tropical regions by continents and by hemispheres.

Reply: Thanks for your good suggestions. Firstly, Cross correlation shows the temporal relationships among variables. It demonstrates the tropical land temperature lags ENSO by 4 months. Secondly, it is a good idea to study the relative process from continent to continent. But observations reflecting the regional interannual flux are unavailable. Therefore, the tropical or global total fluxes are most adopted. This is maybe a good idea for a future study.

8. p.19083, l.17 : PCP or TMP and ENSO shows similar correlation coefficient. then why conclude the 'soil moisture plays a key role ...'?

Reply: Thanks very much. The correlation coefficients are just statistical values. Physically, we can easily understand that ENSO results in precipitation and temperature fluctuations (T lags P by 4-5 month), affecting the terrestrial carbon fluxes. But precipitation does not directly affect them, but via soil moisture. Further, precipitation and temperature are physically correlated. The high correlation coefficient between temperature and carbon fluxes may come from precipitation effects. The model sensitivity experiments also show the precipitation (soil moisture) is more important than temperature (Qian et al., 2008). Here we modified this sentence as "soil moisture plays an important role ..."

9. p.19083, l.25 : why blame inverse models, if you are not analysing those results. The inversion models still have some advantages to be used..

Reply: Thanks very much. We do not blame inverse models, and we just want to announce their different techniques. We have changed this sentence as "Different from inversion models, ..."

10. p.19086, l.2 : this is an overstatement - the bottom line is that the NPP models are oversensitive to climate, and the tuning of all 7 DGVMs are perhaps biased. for example, we may need greater disturbance flux compared to what is simulated by the models, if one compare the DGVM results with say fire emissions from say GFED.

Reply: Thanks very much for your suggestions. Figure 8 illustrates that the sensitivities to temperature and precipitation of most models are close to observations. Only a few models are oversensitive to climate. Though DGVMs are perhaps biased, multi-model results are somewhat convincing. In addition, most models include the fire processes (Table 1). And we agree that carbon emissions caused by fires, triggered by droughts, in some years are very important (Van der Werf et al., 2004).

11. p.19086, l.13 : I think the negative correlation are a bit strange for VEGAS model. Any explanation?

Reply: Thanks very much. The version of VEGAS participating in TRENDY behaves like this. Soil respiration is simultaneously influenced by temperature and soil moisture. For example, higher temperature can enhance R_h , but less precipitation can inhibit R_h during El Nino. In this version, R_h is too sensitive to soil moisture factor. And in later version, we have modified this process.

12. p.19086, l.28 : does this mean CFta and NPP are not casually related?

Reply: I do not agree. The little phase discrepancy between CFta and NPP can be caused by R_h and D variabilities, though their small amplitudes. And some individual model shows the in-phase variability.

13. p.19089, l.15: need some reference on grided analysis, which seems to exist as per the sentence

Reply: Thanks very much for your suggestions. We have added some references of Zeng et al., 2005a, Qian et al., 2008, W. Wang et al., 2013 here.

14. p.19089, l.19: this is not the real world! some areas are more influenced by fires, which you do not capture by these DGVMs

Reply: Thanks very much for your suggestions. I agree with you that this is not the real world. But models are good tools for understanding these processes. And five out of these DGVMs have taken the fire effect into considerations, though few models include the nitrogen limitations (Table 1).

15. p.19089, l.26: interesting observations, but too speculative...

Reply: Thanks very much. Owing to absence of observations, the results in this paragraph are difficult to validate. We give out this paragraph mainly due to their good performance in aggregated flux variability. Also we explain these phenomena based on the model structure.

16. p.19090, l.4 : you should mention whether your results agree with some others - from this sentence there seems to be some

Reply: Thanks very much. We have added the reference of Qian et al., 2008 here.

17. p.19092, l.2 : maybe because there is a time lag between emissions to occur and concentration growth rate. Also note that not the whole tropical land experience the severity of an El Nino at the same time. Do have an alternative explanation ?

Reply: Thanks very much. It is actually true that there is a time lag between emissions and Mauna Loa CO₂ growth rate. But we do not yet clearly understand their lag time scales, and which regions Mauna Loa CO₂ growth rate is sensitive to. Therefore, It needs more work by transport models to understand these processes.

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