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Interactive comment on "Improvement of Soil Respiration Parameterization in a Dynamic Global Vegetation Model and Its Impact on the Simulation of Terrestrial Carbon Fluxes" *by* Dongmin Kim et al.

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Anonymous Referee #3 Received and published: 20 March 2017 The authors developed PFT-dependent Q10 values for soil organic matter (SOM) decomposition processes using a multiple regression method. They demonstrated that the spatially-distributed Q10 had the potential to improve the simulation of both soil respiration and GPP compared with the CLM4 simulation with a uniform Q10. It's necessary and important to use spatially-distributed Q10 rather than a constant Q10 in global simulations. I would like the authors to further clarify the "multiple regression" method used in this

study as I don't quite understand it while reading the manuscript:

We appreciate the reviewer's critical comments. We reply to the reviewer's comments in detail as in the below. For clarification, we also attach the Excel file showing data and the regression results between Rs and soil temperature and moisture for each 17 PFTs.

(1) what are the response variables (Rs?) and explanatory variables (T & M?) in the regression analysis?

The response variable is soil respiration (Rs) data from Hashimoto et al. (2015) and explanatory variables are soil temperature (T) and moisture (M) from off-line land surface reanalysis conducted in this study by driving land surface model with observation forcing from Sheffield et al. (2006).

(2) what datasets at what time-scale are used for regression?

This study used the monthly data for regression for the period of 30 years (1981-2010, total 360 samples each grid points).

(3) what is the relation between the equations 4-8 and the regression analysis?

The Q10 value in this study is defined as in Eq. (5) to (6). To solve it, this study defined "q" as in Eq. (4), which represents the fractional change of Rs. This is determined by subsurface soil temperature and other abiotic factors such as moisture, which is represented by Eq. (7)-(8).

From Eq. (8), if we know the change rate of Rs by soil moisture ($(\partial R\_s (T,M))/\partial M$) and temperature ($(\partial R\_s (T,M))/\partial T$), we can obtain q(T,M) and Q10 subsequently. Multiple regression analysis was conducted for each plant functional type (PFT) for solving q in Eq. (9).

(4) how do you calculate Q10 at every time interval as you stated in Line 381? Q10 is temperature-dependent as indicated in Eqs. 2 & 5, do you mean that you will also

change Q10 based on the temperature at current time-step? Another concern of mine is related to the calculation of Q10 using soil respiration data. We know that generally soil respiration includes both heterotrophic respiration from SOM decomposition and root respiration (growth + maintenance). It seems the PFT-dependent Q10 is developed for SOM decomposition processes, thus how do you use total soil reparation to determine the Q10 for SOM decomposition?

In the original CLM4 model used in this study, the decomposition rate is calculated in every time step using Eq. (1)-(3). During this calculation, the Q10 value is also needed to be determined for Eq. (2). Soil temperature (T) and moisture (M) for the current time step for the top 5 soil layers are used in the calculation.

As the reviewer's comment, soil respiration (Rs) consists of root respiration (root autotrophic respiration; Ra) and heterotrophic respiration (Rh). Rh of soil organic matter (SOM) is closely dependent on Q10 variation. Rs data from Hashimoto et al. (2015) does not separate explicitly Ra and Rh. Instead, they used the empirical relationship between Rs and Rh derived from the meta-analysis (Bond-Lamberty et al., 2014; See Seection 2.5 in Hashimoto et al., 2015). Ra is the residual from Rs minus Rh. The relationship which they adopted is as following:

lnâĄą(R_h)=1.22+0.73 lnâĄąãĂŰ(R_s)ãĂŮ

Therefore, we used total Rs data to determine Rh of SOM in this study.

Minor comments:

(1) Fig.5 & Fig. 9: please indicate the units of Rs and Ra. In addition, please explain what are Ra and Rs, i.e., plant autotrophic respiration and soil respiration.

We added the units and the definition of Ra and Rs clearly in the revised manuscript.

(2) Figs.4, 7, 8 & 9: please indicate the units of GPP.

We added the units.

(3) Line 304: "The Rs Simulation difference between CTL and EXP is given in Figure 5, in terms of global distribution as well as zonally-averaged distribution". I understand we may identify the zonal difference between CTL and EXP. However, Fig.5a shows the difference between EXP and Hashimoto data, not between EXP and CTL.

We modified the sentence as:.

(L304-305) The changes in Rs simulation by EXP are given in Fig. 5, in terms of global distribution as well as zonally-averaged distribution.

(4) Line 314: "the difference between EXP and CTL increases with temperature". It may be true for boreal and B_Shrub PFTs. I would suggest doing statistical tests to show whether the relation is significant or not.

Following the reviewer's comment, we conducted the significant test for the changes.

Figure 6 shows the scatter plots for Rs change (EXP minus CTL in y-axis), as a function of soil temperature (x-axis). Presumably due to the sub-biome variability in biotic and abiotic conditions, the scatter plots exhibit some nonlinearity in the curvature, but most of the values lie in the positive range for the moderate to warm temperatures (i.e., increased Rs at the given temperature by the variable Q10 formulation). Note that this relationship is not uniform in space, as the change of Q10 is not uniform in EXP (as shown in Fig. 2).

After adjusting 90% significant level in the scatter plots, the grid of grass, crop and shurbland are too many reduced. However, boreal, temperate forest regions and boreal shrub regions shows enhanced strong relationship between changed Rs and soil temperature in EXP comparing with CTL.

References Bond-Lamberty, B., and Thomson, A.: Temperature-associated increases in the global soil respiration record., Nature, 464, 579-582, doi:10.1038/nature08930, 2010. Hashimoto, S., Carvalhais, N., Ito, A., Migliavacca, M., Nishina, K. and Reichstein, M.: Global spatiotemporal distribution of soil respiration modeled using a global

database, Biogeosciences, 12(13), 4121–4132, doi:10.5194/bg-12-4121-2015, 2015.
Qi, Y., Xu, M., and Wu, J.: Temperature sensitivity of soil respiration and its effects on ecosystem carbon budget: nonlinearity begets surprises, Ecolog. Model., 153, 131–142, 2002.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/bg-2016-549/bg-2016-549-AC4-supplement.zip

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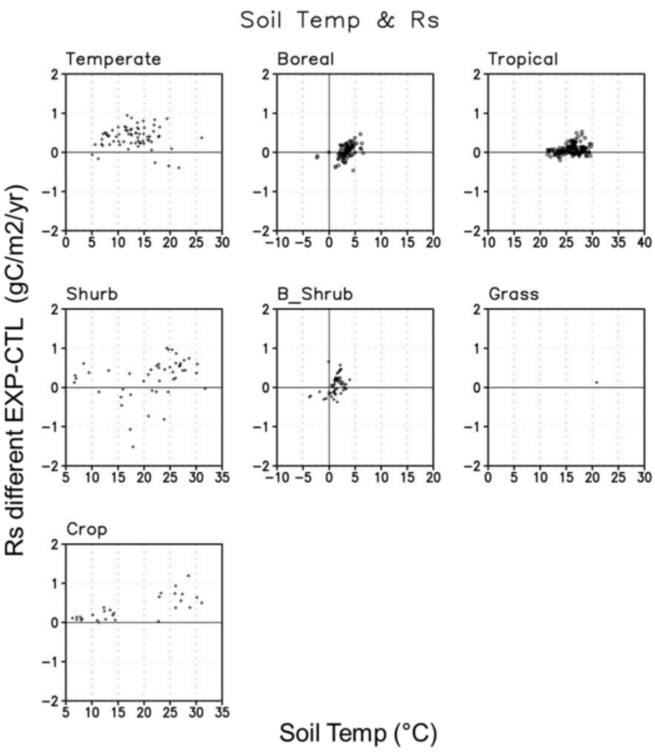

Fig. 1. Figure S1. Scatter plots of change of Rs (y-axis) between EXP and CTL simulation as a function of soil temperature (x-axis). Scatters are calculated only over 90% significant level. Each panel shows