**Response to Anonymous Referee #2 on Manuscript bg-2019-319: "*Increasing soil carbon stocks in eight typical forests in China*"**

*Using soil inventory data from four forest sites, authors of this paper explores soil carbon stock change between 1990s and 2010s. They found a significant carbon sink in the forest soils, though magnitude varies greatly. Overall, the manuscript is well written. The core message is clear and contributing to growing knowledge of forest carbon cycling. I believe the manuscript can be accepted for publications after some revision.*

**Response**: Thanks for your positive comments.

*The change of soil carbon stock is almost the most uncertain component of ecosystem carbon balance. Although previous studies (e.g. Pan et al., 2011) suggest globally the dominant component of ecosystem carbon sink is in the forest biomass, it is of great interest to compare the sink strength in the soil and in the biomass at different forest ecosystems. Therefore, the authors should compare the strength of the biomass carbon sink and soil carbon sink over these sites, instead of at regional scale with other inventory data.*

**Response**: We agree that a comparison of biomass and soil carbon sinks across eight forest plots is useful to better classify the carbon budget of the forest ecosystems. Forest biomass of China has functioned as a significant C sink over recent decades (Pan et al., 2011; Fang et al., 2014, 2018). Increased vegetation C accumulation might produce more C inputs into soils, including inputs of litter, woody debris and root exudates, and then result in SOC accumulation (Schlesinger, 2013; Zhu et al., 2017). However, no statistic relationship between the SOC change rate and biomass change rate was detected across our plots (Fig. R1). We found that SOC stock in the subtropical old-growth forest increased at the highest sink rate of 908±60 kg C $ha^{-1}$ $yr^{-1}$, but the vegetation functioned as a significant C source (-1000±78 kg C $ha^{-1}$ $yr^{-1}$) during the past two decades. This is probably because the relatively higher mortality created large amount of litterfall and dead wood in the old-growth forest, which subsequently resulted in soil C accumulation (Fig. 4). This result is consistent with a long-term observation in southern China by Zhou et al. (2006) and a global flux synthesis by Luyssaert et al. (2008). We added this discussion into the Section "4.2 Links between biotic and climatic factors and SOC accumulations".

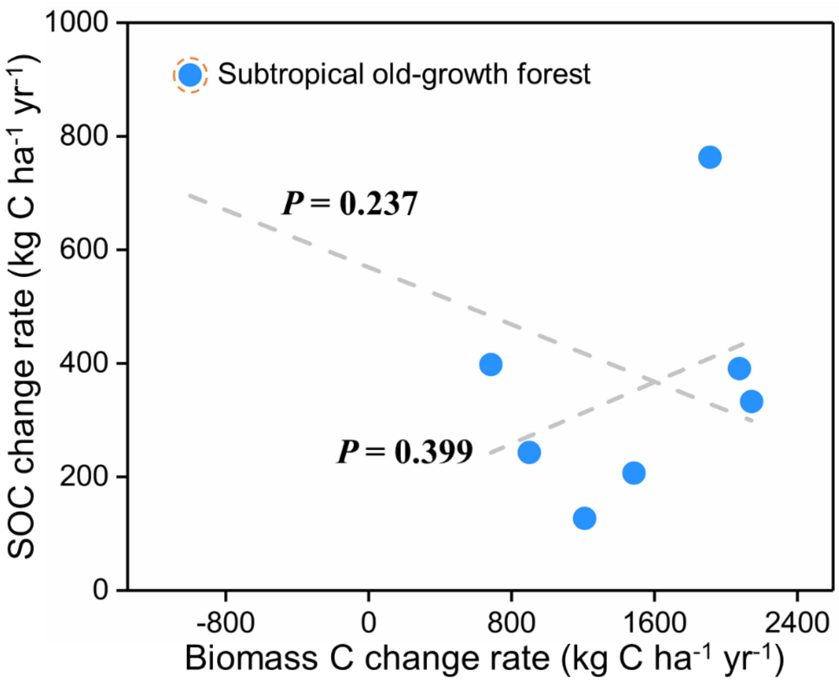


Fig. R1. Relationship between biomass carbon change rate and soil organic carbon change rate.

*Heterotrophic respiration was found to significantly increase at global scale (Bondlamberty et al., 2018), the existence of soil carbon sink would indicate that the increment of NPP outweighs the increment of HR. This could be further discussed in order to better clarify the processes that contribute to the formation of the carbon sink. The ratio of soil carbon sink to NPP seems very large for some sites, it would be great to extend discussions on why this large ratio of soil sink to NPP is plausible.*

**Response**: We agree that heterotrophic respiration of global forest soil has increased considerably over the recent decades (Bond-Lamberty et al., 2010, 2018). We discussed this and clarified the relationship between SOC sink and NPP, and its potential driving mechanisms in the revised manuscript.

"First, the increasing heterotrophic respiration of forest soil are mainly due to the ongoing climate changes, especially increasing temperature. Whilst the increasing forest biomass are due to the increasing temperature, together with increasing $CO_2$ and nitrogen fertilization (Norby et al., 2010; Feng et al., 2019). Thus, the sensitivity of forest NPP to ongoing climate change should outweigh that of respiration. Second, we found that SOC stock increased from 68.4 Mg C $ha^{-1}$ to 86.6 Mg C $ha^{-1}$, albeit the biomass carbon stock decreased significantly, from 1988 to 2008 in the subtropical old-growth plot. Meanwhile, the highest amount of litter and dead wood production and standing crop occurred in the old-growth plots, which resulted in relatively higher soil carbon sequestration in the old-growth compared to other plots (Figure 4, Table S4)."

*Since the soil carbon were measured over four sites (8 plots), it is a bit misleading to call it as "8 typical forests" in the title. The scarcity of available data has made even four sites of data much valuable. There is no need to exaggerate what has been nicely achieved in this study.*

**Response**: Thanks for this comment, and we changed the title as "Increasing soil carbon stocks in eight permanent forest plots in China" in the updated manuscript.

*In the analyses, it could be interesting to know whether forest types or climatic variations plays a more important role in the size of soil carbon sink. Since some sites only have one plot, it is probably important to further acknowledge this limitations when interpreting the results, which is particularly the case when looking at figure 2.*

**Response**: We agree that the limited observations may induce uncertainties. We added an "Uncertainty analysis" section in the revised manuscript. "The SOC change rates of our study and inventory-based forest area and forest types were used to roughly estimate the carbon budget of forest soil of China's forests. However, only eight permanent forest plots were observed in this study will inevitably lead to uncertainty for national estimate."

*It is also important to report uncertainties of the magnitude and change of soil carbon stock in figure 3.*

**Response**: Thanks for your suggestion. We added this information in Figure 3 in the revised manuscript (Figure 3).

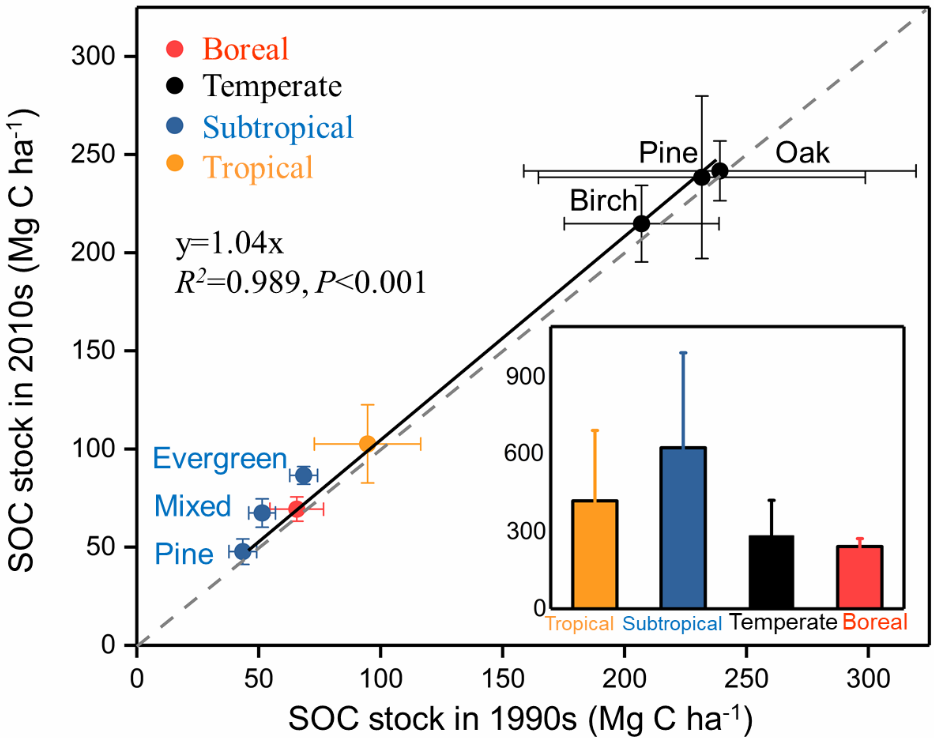


**Figure 3.** Comparison of soil organic carbon stocks in eight forests of China between the 1990s and the 2010s. The soil organic carbon (SOC) stocks in all forests in the two periods are above the 1:1 line, suggesting that all SOC stocks of these forests have increased during the study period. The inset graph shows the SOC sink rates by forest biomes (i.e., boreal, temperate, subtropical and tropical forests) which are categorized from the eight forests. SOC stocks in this study are presented as means ± 1 SD

*The authors spent quite some efforts discussing why their results is in contrast to one study over the Alps. Can the loss of soil carbon in the Alps result from soil erosion? The wood harvests not only reduce the carbon input into the soil, but also expose the soil to erosions, which could be of particular importance in mountainous area. This would be* *a very interesting discussion since carbon stock change was often treated without considering horizontal soil carbon loss.*

**Response**: Thanks for your suggestion. Although Prietzel et al. (2016) did not discuss the possibility of soil erosion, we agree that the dead wood harvests might expose the mountain forest soil to erosions. We added the discussion and re-organized this paragraph in the revised manuscript:

"In other subtropical and tropical forest ecosystems, the direct evidence regarding SOC dynamics is relatively scarce. However, based on the estimates from regional comparisons, Pan et al. (2011) showed that tropical forest of the world was a C source of 1.38 Pg C $ha^{-1}$ $yr^{-1}$ from 1990 to 2007. At the global scale, land-use changes have caused a sharp drop in forest area in tropics, which also led to a large C releases in tropical forest soils. Without land-use change and deforestation, soils of the subtropical and tropical forests have functioned as considerable C sink during the past two decades in this study (626±370 and 398±84 kg C $ha^{-1}$ $yr^{-1}$, respectively, Table 3). Not only catastrophic land-use changes, but even slight forest management (e.g. litter and dead wood harvest) can also result in the loss of forest soil carbon. Prietzel et al. (2016) reported a large loss of SOC in forests in the German Alps, where half of the woody biomass and dead wood has been harvested in recent decades. On the one hand, the harvest of forest floor could decrease litter and dead wood inputs into soils and subsequently leads to the loss of soil carbon pool (Davidson and Janssens, 2006). On the other hand, weakened protection of forest floor could lead to increased soil erosion, especially in the mountain forests (Evans et al., 2013). Additionally, the high-elevation ecosystems are expected to warm more sensitive than other regions with associated changes in soil freezing and thawing events and snow cover, which are probably another reason for the SOC losses of forests in the German Alps."

*The conclusion section also needs some improvements since it highlights the potential role of disturbances, which had not been well discussed or supported before. It is of course reasonable to assume disturbance may affect the soil carbon stock, but the impacts are very complex and uncertain. The SOC change of protected forests are not very informative to the relationship between disturbances and SOC change, unless further evidences on disturbed forest sites are presented.*

**Response**: We agree the comments. We did not analyze the impacts of disturbances on the SOC dynamics in our forest plots. We rephrased the sentence as: "Forest soils store large amounts of C and steadily and often slowly accumulate C, but will rapidly release C to the atmosphere once they are disturbed." in the revised manuscript.

**References**

Bond-Lamberty, B., and Thomson, A.: Temperature-associated increases in the global soil respiration record. Nature, 464, 579–582, https://doi.org/10.1038/nature08930, 2010.

Bond-Lamberty, B., Bailey, V. L., Chen, M., et al.: Globally rising soil heterotrophic respiration over recent decades. Nature, 560, 80–83, https://doi.org/10.1038/s41586-018-0358-x, 2018.

Davidson, E. A., Janssens, I. A.: Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. Nature, 440, 165–173, https://doi.org/10.1038/nature04514, 2006.

Evans, A. M., Perschel, R. T., and Kittler, B. A.: Overview of forest biomass harvesting guidelines. J. Sustain. Forest., 32, 89–107, https://doi.org/10.1080/10549811.2011.651786, 2013,.

Fang, J., Guo, Z., Hu, H., Kato, T., Muraoka, H., and Son, Y.: Forest biomass carbon sinks in East Asia, with special reference to the relative contributions of forest expansion and forest growth. Glob. Change Biol., 20, 2019–2030, https://doi.org/10.1111/gcb.12512, 2014.

Fang, J., Yu, G., Liu, L., Hu, S., and Chapin III, F. S.: Climate change, human impacts, and carbon sequestration in China. P. Natl. Acad. Sci. USA, 115, 4015–4020, https://doi.org/10.1073/pnas.1700304115, 2018.

Luyssaert, S., Sculze, E. D., Börner, A., Knohl, A., Hessenmöller, D., Law, B. E., Ciais, P., Grace, J.: Old-growth forests as global carbon sinks. Nature, 455, 213–215, https://doi:10.1038/nature07276, 2008.

Norby, R. J., Warren, J. M., Iversen, C. M., Medlyn, B. E., and McMurtrie, R. E.: $CO_2$ enhancement of forest productivity constrained by limited nitrogen availability. P. Natl. Acad. Sci. USA, 107, 19368-19373, 2010.

Pan, Y., Birdsey, R. A., Fang, J. Houghton, R., Kauppi, P. E., Kurz, W. A., Phillips, O. L., Shvidenko, A., Lewis, S. L., Canadell, J. G., Ciais, P., Jackson, R. B., Pacala, S. W., McGuire, A. D., Piao, S., Rautiainen, A., Sitch, S., and Hayes, D.: A large and persistent carbon sink in the world's forests. Science, 333, 988–993, https://doi:10.1126/science.1201609, 2011.

Prietzel, J., Zimmermann, L., Schubert, A., and Christophel, D.: Organic matter losses in German Alps forest soils since the 1970s most likely caused by warming. Nat. Geosci., 9, 543–548, https://doi.org/10.1038/ngeo2732, 2016.

Schlesinger W H, Bernhardt E S. Biogeochemistry: an analysis of global change. Academic press, 2013.

Zhou, G., Liu, S., Li, Z., Zhang, D., Tang, X., Zhou, C., Yan, J., Mo, J.: Old-growth forests can accumulate carbon in soils. Science, 314, 1417, https://doi:10.1126/science.1130168, 2006.

Zhu, J., Hu, H., Tao, S., Chi, X., Li, P., Jiang, L., Ji, C., Zhu, J., Tang, Z., Pan, Y., Birdsey, R. A., He, X., and Fang, J.: Carbon stocks and changes of dead organic matter in China's forests. Nat. Comm., 8, 151, https://doi.org/10.1038/s41467-017-00207-1, 2017.