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Interactive comment on "Diurnal, seasonal and long-term behaviour of high arctic tundra-heath ecosystem dynamics inferred from model ensembles constrained by time-integrated CO_2 fluxes" *by* Wenxin Zhang et al.

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We thank the reviewer to take time for reading this manuscript and giving general comments. However, we feel very sorry that the language issues bring the difficulties to the reviewer for digesting our study results and understanding the whole scientific story. So, to improve the language will be one of the major focus of our revision. However, to help the reviewer understand the motivation and implication of this study, we make the following clarification.

The aims of the study are (1) to show how three calibration methods minimize uncertainties in ensembles of model candidates to describe within the day, seasonal or long-term variabilities of CO2 fluxes and (2) to elucidate what important parameters or processes tightly control these temporal variabilities based on the posterior parameterization distribution. For most land models or dynamic vegetation models in simulating CO2 fluxes for the sites, they are commonly calibrated against measurements using a fixed time resolution. Temporal patterns of model errors may be hidden since the model-measurement residuals are often assumed to be random following a normal distribution for the entire period. Few models have ever tried to discuss how the patterns of model errors are allocated within a day, a year or a long-term and if these patterns depend on the calibration approach or not. This study is to search patterns of model errors by using a filter applying time integration of data to different lengths of time windows (daily, yearly and long-term). Our results have demonstrated the success of each model ensemble to best describe the targeted temporal behavior. The crucial links between parameters/processes and model performance can be identified and used to indicate the controlling factors that are critical to explaining CO2 flux variabilities across time scales. The relative importance of abiotic and biotic processes across time scales have been discussed by some studies (e.g. Richardson et al., 2007; Wu et al., 2017). However, for the High-Arctic ecosystems, characterized by permafrost thawing, snow dynamics and how young and old carbon decomposition responses to rapid warming, our study may be the first study to explore drivers of these processes across different time scales. Particularly, the soil decomposition processes in the CoupModel account for the vertical distribution of organic carbon (old and young carbon) and nitrogen, dynamics of which are tightly coupled with heat and water exchange during soil freezing and thawing. The complexity of the processes makes the model as one of the state-of-the-art ecosystem models. Figure 9 shows key indications from the calibrated model ensembles, that is, the normalized drivers of photosynthesis and respiration across time scales. These indications are important to improve our understanding of the drivers of the Arctic ecosystem processes and future modeling.

Our calibration approach is based on the transformed CO2 fluxes. For the original carbon flux in a high Arctic tundra heath ecosystem, the diurnal, seasonal and long-term C flux exhibit distinct behaviors, as shown in Figure 1S. Before calibration, we transformed the time series of CO2 measurements by accumulating the hourly values into a daily cumulative time series, which always starts from the first measurement in that day. The second time step of the transformed time series was the sum of the first and second measurements. The same procedure applies for the rest time steps in the day. We made a similar transformation of CO2 fluxes based on the yearly and long-term time window. The transformed cumulative fluxes look like Figure 2S. So, our three behavior model ensembles were generated based on the calibration of these three transformed data sets. We don't fill the gaps in the measurements. So, the transformed data sets also have the gaps. But we decide to delete the section of wavelet analysis in the revision. The purpose of using the wavelet analysis was to justify how three models reproduced well the variance of CO2 along with a time series. As the Figures 3, 4 and 5 have already demonstrated details of model errors, there is no need to come up with another evaluation approach.

Richardson, A. D., Hollinger, D. Y., Aber, J. D., Ollinger, S. V., and Braswell, B. H.: Environmental variation is directly responsible for short- but not long-term variation in forest-atmosphere carbon exchange, Glob. Chang. Biol., 13, 788-803, 2007.

Wu et al., 2017.: Partitioning controls on Amazon forest photosynthesis between environmental and biotic factors at hourly to interannual timescales, Glob. Chang. Biol., 23, 1240–1257, doi: 10.1111/gcb.13509, 2017.

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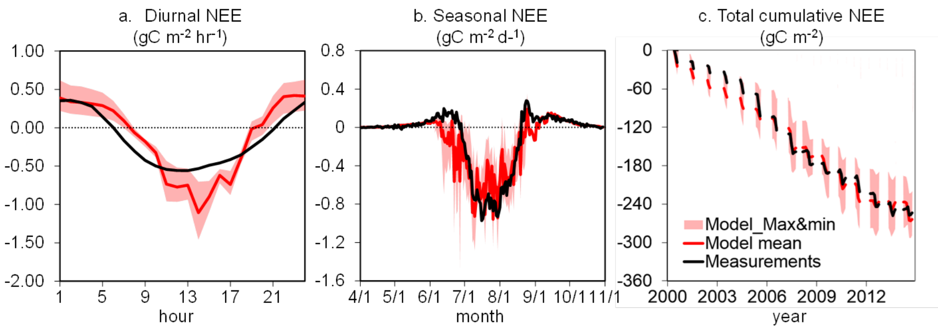

Fig. 1. The diurnal, seasonal and long-term behavior of CO2 fluxes (models: red; measurements: black)

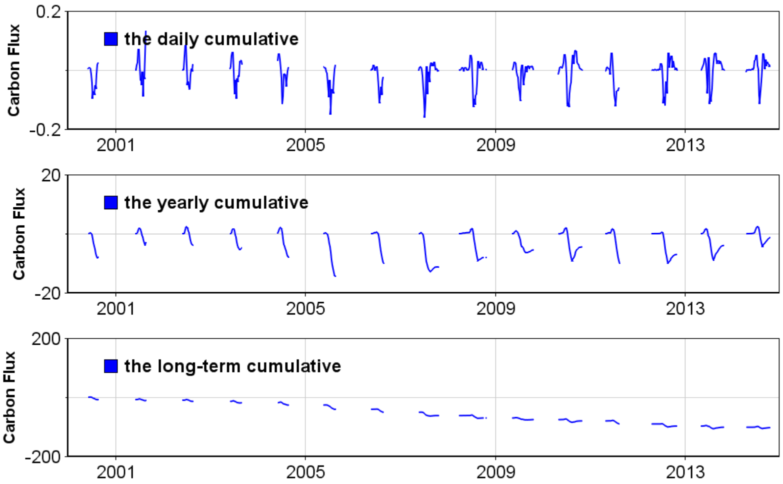

Fig. 2. The daily, yearly and long-term cumulative CO2 fluxes (g C m-2)