

Responses to anonymous referee #1

General comments

Century model was calibrated and validated to simulate the response of soil organic carbon stock to grazing intensity in alpine meadow on the Tibetan Plateau. The manuscript focused on the recovery speed of SOC stock in degraded grasslands, which is of great importance in both the understanding of ecosystem succession and formulation of grassland management strategies, especially in the fragile alpine ecosystems on the Tibetan Plateau. However, I am not satisfied with the description of model calibration and the completeness of model calibration and validation. (1) These two processes are the core of the whole study. Therefore, it is necessary to list the parameters that were modified during model calibration in detail, for example, in the form a table. (2) Since the object of the study is SOC stock, it should be selected as an output parameter for model calibration, besides aboveground biomass. (3) In model calibration, after running for 5000 years to get to the equilibrium state in 1980, the modeled SOC stock should be used to compare with SOC measured in a degraded grassland. SOC stock in year 1980 is not necessary, instead, the value measured recently is also acceptable if the grassland have been continually grazed at similar intensity. (4) As there are plenty of soil samples in Zeku county, it seems better to randomly select a part of the samples for model calibration, and the others for model validation. The method of calibration by comparing the aboveground biomass in a fenced grassland in Haibei has two shortcomings. First, SOC stock is more

appropriate than aboveground biomass. Second, Haibei is not near to Zeku, as shown in the text, which may introduce extra uncertainty for model validation.

<Reply> Thanks for the general positive evaluation of our manuscript.

(1) More detailed information about model calibration were added in the revised paper. “First, we changed the effect of temperature on plant growth which depends on monthly mean temperature. The mean annual aboveground net primary productivity (NPP) and belowground NPP are of $0.12 \pm 0.33 \text{ kg C m}^{-2}$ and $0.23 \pm 0.04 \text{ kg C m}^{-2}$, respectively (Zhao et al., 2009). To attain these values, we then adjusted the aboveground potential monthly production parameter- PRDX (1) and C allocation parameters. We also compared the shoot-to-root ratios against observed data for the alpine meadow field. In addition, we adjusted the effect of annual precipitation on atmospheric N fixation by changing the parameters, EPNFS (1) and EPNFS (2), as suggested by Fang et al. (unpublished data). The parameters are list in Table S1.” (line 164-173).

(2) It is ideal that aboveground biomass and SOC data can be compared with observed data simultaneously. However, unfortunately, long-term monitoring SOC data are not available at present because the alpine meadow field at Haibei Station was not originally designed for assessing SOC stock changes. Instead, we compared our model simulated and observed grassland soil carbon densities in the year 1999 (line 231-232).

(3) Sorry for your misunderstanding. We first ran the model for 5000 years to reached

steady state equilibrium in 1980 with the initial grazing intensity of 50%, using the mean climatic values from 1960 to 2005. Starting from this equilibrium state, we simulated a fenced scenario (exclosure from grazing) in the Century management schedules. The model was integrated for 1998-2007, forced by observed weather data (line 156-162). Therefore, the grazing management changed over the time. Comparing SOC modeled in the year 1980 and the values observed at present is not appropriate.

(4) This is a good point. SOC dynamic models prefer to select long-term observation data for model parameterization, calibration and validation. Haibei Station represents the key ecosystem type- alpine meadow on the Tibetan Plateau, and details of its climate, elevation, soils, N deposition, and seasonal plant primary productivity are available. Therefore, Century model parameterization and calibration was taken at Haibei site. Unfortunately, SOC was not measured since the establishment of the station. Alternately, we calibrated Century model by comparing outputs with the temporal aboveground biomass data and SOC stock in the year 1999. Although Zeku county is about 200 km distant from the Haibei Station, highly similarity between these sites were for climate, vegetation type, soil type and grazing history, etc. This sufficiently similarities ensure that the Century model adjusted at Haibei station can be applied in Zeku county, which was illustrated by our model validation. This model extrapolation from site-calibration to regional validation or projection was also widely used in other published papers and was proved to be successful (Feng et al., 2011; Tan et al., 2010; Zhang et al., 2007; Zhuang et al., 2010). Therefore, we kept our

modeling framework related to parameterization, calibration and validation in the paper, and speculated the concomitant model extrapolation uncertainty would be small as high similarities between these sites.

Feng, X. and Zhao, Y.: Grazing intensity monitoring in Northern China steppe: Integrating CENTURY model and MODIS data, *Ecological Indicators*, 11, 175-182, 2011.

Tan, K., Ciais, P., Piao, S., Wu, X., Tang, Y., Vuichard, N., Liang, S., and Fang, J.: Application of the ORCHIDEE global vegetation model to evaluate biomass and soil carbon stocks of Qinghai-Tibetan grasslands, *Global biogeochemical cycles*, 24, GB1013, 2010.

Zhang, Y. Q., Tang, Y. H., Jiang, J., and Yang, Y. H.: Characterizing the dynamics of soil organic carbon in grasslands on the Qinghai-Tibetan Plateau, *Science in China Series D-Earth Sciences*, 50, 113-120, 2007.

Zhuang, Q., He, J., Lu, Y., Ji, L., Xiao, J., and Luo, T.: Carbon dynamics of terrestrial ecosystems on the Tibetan Plateau during the 20th century: an analysis with a process-based biogeochemical model, *Global Ecology and Biogeography*, 19, 649-662, 2010.

Specific comments

In model calibration, 13 biomass data from year 1998 to 2010 were used. However, in Fig. 1, the number of data were $n=19$. Why? In addition, the aboveground biomass varied so largely in the fenced meadow. Please check the values.

<Reply> In fact, we used 19 biomass data for model calibration as illustrated in Fig.1, which includes 6 biomass data measured from March to August 2003. If these seasonal data were excluded, a significant positively linear relationship was also found ($p=0.002$, $r^2=0.60$). We modified the text for this clarification in line 226-228 and Figure 1.

In model simulation, a series of scenarios were set as list in Table 2. However, this seems different from those shown in Fig. 3 and Fig. 4.

<Reply> We double checked the scenarios in Table 2, Fig.3 and Fig.4. The scenarios were consistent in the text. Due to the selection of these scenarios for grassland with different degraded status and grazing seasons, it seems somewhat complex when first encountered.

The terms, such as “shoot : root ratio”, “winter grassland”, and “summer grassland”, were confusing. “shoot : root carbon allocation ratio”, “winter grazing grassland”, and “summer grazing grassland” may be used instead.

<Reply> Thanks for this suggestion. We changed “winter grassland”, “summer grassland” and “shoot : root ratio” with “winter grazing grassland”, “summer grazing grassland” and “shoot : root carbon allocation ratio” in the revised manuscript.

Whether SOC stock will become saturated after implementation of a certain management strategy is interesting and important. I suggest to add this part in the manuscript.

<Reply> We have discussed it in the revised paper. “SOC accumulation tends to decrease with time, as C stocks reached a steady state in restored alpine meadow after about 15 years. SOC pools at this steady state are not necessarily saturated, because the simulated alpine meadow soil C stocks by 2030 still somewhat lower than the

estimated equilibrium before degradation. It is likely that C pools in a ‘transient steady-state’ are on a path to a saturation behavior which required hundreds of years (O'Brien and Jastrow, 2013).”(line 304-309).