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Dear Editor,

Thank you very much for this important comment. We agree that the representation of nitrogen processes and their interaction with the carbon cycle in Agro-C should be described more clearly. Please find our point-to-point responses below and the revisions/corrections in the changes-tracked version of the re-submitted manuscript. The comments are shown in normal text and our responses are in blue.

Question

While reading the reviewers' comments, I have a further question regarding the Agro-C model. You mentioned that nitrogen fertilizer application is included as one of the key management input to the model. But "the effects of nitrogen on photosynthate allocation are not explicitly represented." Can you describe more clearly on how nitrogen fertilizer and related nitrogen processes are represented in the model and how nitrogen cycle interact with carbon cycle in Agro-C? Usually, a coupled C-N model allocates C to different vegetative compartments according to their N content and C:N ratio. Thus, lower C:N ration /higher N content in different organs can directly affect the photosynthate allocation coefficients, which seems contradictive to your revised discussion. I think the reviewer raised an important question. And since your model includes N fertilization process, its effect on photosynthate allocation through mediating C:N ratios should be more clearly explored.

Response:

In the original Agro-C model developed by Huang et al. (2009), nitrogen cycling is explicitly represented within the Crop-C framework. Crop N uptake is determined by both N demand and N availability. N availability is calculated from soil N mineralization and synthetic fertilizer N application, with these processes further

regulated by soil moisture, temperature, and soil properties. Crop N demand is linked to crop growth and the N:C ratio of newly formed plant tissue. Therefore, nitrogen fertilization can influence crop carbon dynamics through changes in plant N availability and uptake. In particular, canopy photosynthetic capacity is determined by green leaf nitrogen content, while maintenance respiration is also related to canopy nitrogen concentration. Thus, nitrogen availability affects photosynthetic carbon assimilation and subsequent biomass production in the original Agro-C framework.

However, we would like to clarify an important distinction regarding photosynthate allocation. In the original Agro-C model, the fractions of photosynthate allocated to roots (PR) and leaves (PL) are prescribed primarily as crop- and DVI-dependent parameters, rather than being dynamically determined by the N content or C:N ratio of individual organs. Therefore, although nitrogen processes are coupled with the carbon cycle and affect carbon assimilation and biomass production, their effects on organ-level photosynthate allocation coefficients are not explicitly represented through dynamic organ-specific C:N constraints.

In the present study, we retained the original representation of nitrogen processes in Agro-C, including site-specific fertilizer application rates, while focusing specifically on improving the dynamic response of photosynthate allocation to water availability. The observed fertilizer application rates for each experimental site were used as model inputs. Our major modification was therefore to introduce water- and phenology-dependent regulation of PR, PL, and YGR, rather than to re-parameterize the nitrogen-allocation relationships.

We acknowledge that this aspect is not yet fully represented in the current model. Although nitrogen availability affects crop carbon assimilation and biomass production through the existing C–N processes in Agro-C, the allocation coefficients are not dynamically regulated by organ-specific N status or C:N stoichiometry. We agree that explicitly representing such regulation would further improve the mechanistic description of photosynthate allocation. Future work will therefore investigate how nitrogen availability and organ-specific C:N relationships regulate

photosynthate allocation and will further develop the model to represent dynamic water–nitrogen interactions.

We have further discussed this issue in Section 4.3.2 of the revised manuscript.
(581-594)

Huang, Y., Yu, Y., Zhang, W., Sun, W., Liu, S., Jiang, J., Wu, J., Yu, W., Wang, Y., and Yang, Z.: Agro-C: A biogeophysical model for simulating the carbon budget of agroecosystems, *Agricultural and Forest Meteorology*, 149, 106–129, <https://doi.org/10.1016/j.agrformet.2008.07.013>, 2009.