Interactive comment on “Underestimation of boreal soil carbon stocks by mathematical soil carbon models linked to soil nutrient status” by B. Ňupek et al.

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Author’s reply to Prof. G. I. Ågren (Referee):

!Referee: referee’s comments #Authors: author’s reply

GENERAL COMMENTS

!Referee: Three structurally quite different soil carbon models give very similar predictions of forest soil carbon stocks when they are driven by the same litter inputs and differ also similarly from observations. The critical question is why they fail in their predictions for 22% of the test sites. The authors attribute the failure to weaknesses in how the models handle soil nutrient status. This might well be the case, but such a failure can come from two quite different sources. On one hand, is the litter input correctly calculated?

#Authors: Yes the litter input is calculated correctly, as we are aware that the correct calculation of the litter input is essential for the simulation of the soil carbon sequestration and the estimation method has large influence on the sequestered soil carbon. E.g. see SOC and litter relations in supplement figure FS6 and results lines 306 - 310.

!Referee: The procedure used to generate litter input is not transparent.

#Authors: We are aware that our description of the novel approach of litter input estimation may not be transparent in general concept in Sect. 2.1.1 “Biomass and litterfall estimates”, therefore we added detailed descriptions for reproducing the methods to appendices (Appendices A, B, and C, Tables A1, B1, and C1, and Figures A1, B1, and S9). At first, the novel method could seem complicated compared to the estimation by using only the allometric biomass models. However, the measurements of actual state forest could not be applied directly to biomass models in order to derive the long-term litter inputs due to differences in stand age classes and our method to remove the effect of the actual stand development was crucial for estimating long-term mean litter input correctly.

!Referee: The calculation is based on fAPAR (the fraction of absorbed photosynthetically active radiation) but the maximum/potential value of absorbed radiation seems to be ignored. However, both the potential production and fAPAR vary with the nutrient status of the stand. In the end, it seems to me that the procedure generates tree biomasses and thus litter production only depending on latitude;
Authors: We are sorry that you partly misunderstood whether the maximum/potential value of absorbed radiation was taken into account. What we meant to describe was that fAPAR was based on the field data, the maximum observed fAPAR was certainly taken into account, and it was specific for latitude and nutrient status, and served as a prerequisite for the estimated 70th percentile of fAPAR (fAPAR70). The nutrient status was in our data represented by a productivity class (H100, height of the dominant trees at the age of 100 years in meters). Both latitude and the H100 data were used in estimation of the fAPAR70 values (Appendix A1 lines 508 - 513, Table A1 and Fig. A1). We think that adding panels showing the relation between modeled fAPAR70 and H100 data into Fig. A1 will clear the confusion about relation between fAPAR and site productivity/nutrient status (see attached updated Fig. A1).

Referee: this will ignore the large regional differences in nitrogen deposition that play an important role in tree productivity, likely leading to an underestimate of litter production in high deposition areas.

Authors: Figure 2 in this reply shows that productivity class (H100) of deciduous, pine, and spruce forests used in this study for the long-term litter input modelling was well correlated with Nitrogen deposition data (panels a, b, and c). However if using the actual state forests measurements directly, with only the allometric biomass models approach, the forest stage development masked the relationship between the nutrient status and the litterfall estimates (actual state forest litter in panels d, e, and f). In our approach with the stage development set to a 70th percentile of the maximum production potential, the litterfall estimates (long-term mean litter) reflected well the differences in Nitrogen deposition (panels g, h, and i).

Referee: On the other hand, it is clear that soil nitrogen modifies the carbon use efficiency of decomposers; increasing nitrogen availability increases CUE, which increases soil carbon stocks (Ågren et al. 2001, Franklin et al. 2003). In all three models, inclusion of either of these two factors would improve the model performance at the high nutrient sites.
Authors: In lines 386-388 based on finding of Orwin et al. (2011) we suggest that not accounting for the available nutrients from the organic (not inorganic) uptake by models contributes to their underestimation of SOC stocks on sites with higher nutrient status. We reformulated the sentence.

“Expanding on the CENTURY model structure, the MySCaN model incorporating the organic nutrient uptake by mycorrhizal fungi estimated positive effect on SOC accumulation, relatively larger in poor than in fertile sites (Orwin et al., 2011). Therefore, not accounting for the organic nutrient uptake by mycorrhizal fungi by the Yasso07, Q, and CENTURY models probably led to the underestimation of SOC stocks in sites with higher nutrient status.”


Authors: Thank you for providing these references.

Authors: Figure captions

Figure 1. or Figure A1 in our BGD paper. Actual state fraction of absorbed radiation (fAPAR, estimated as in Härkönen et al., 2010) (actual fAPAR) and steady state fAPAR (modeled fAPAR70) which was set to 70th percentile of maximum fAPAR for given species, latitudinal degree, and site productivity class. Panels a), b), and c) show relation between fAPAR and latitude (°) for forest stands dominant by Scots pine, Norway spruce and deciduous species, whereas panels d), e), and f) show relation between fAPAR and site productivity class (H100, height of dominant trees at 100 years in meters).

Figure 2. Scatterplots between the Nitrogen deposition (kg N ha-1 y-1) and a), b), c) site productivity class (H100, which is the height of the dominant trees at the age of 100 years in meters) , d), e), f) actual state forest litterfall (t C ha-1 y-1), and g), h), i) long-term mean “steady state” forest litterfall (t C ha-1 y-1) for deciduous species, Scots pine, and Norway spruce dominated stands.

Please also note the supplement to this comment: http://www.biogeosciences-discuss.net/bg-2015-657/bg-2015-657-AC1-supplement.pdf

Fig. 1.

C7

Fig. 2.