

Interactive comment on “PEATBOG: a biogeochemical model for analyzing coupled carbon and nitrogen dynamics in northern peatlands” by Y. Wu and C. Blodau

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“Decoupling the O₂ and WT boundary is an interesting enhancement beyond many other models. This did not get much attention in the discussion; is that planned for a separate manuscript? I think it would be very useful to discuss this further, as modeling methane emissions remains a challenge after 20+ of work. However, I also think that this paper should not get any longer, so if this is planned for another manuscript, please make that clear.”

The decoupling of WT and O₂ boundary was set in the model for separate control of water related processes and O₂ related processes. A separate manuscript on the

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belowground controls on CH₄ production and emissions is planned in which the advantages and disadvantages of our representation of oxygen and soil moisture dynamics will be further discussed (p. 5, line 40 and p. 6, line 1, 2).

P1628, line 20: “The simulation of longer-term N saturation impacts was an interesting additional study, where the model showed interesting dynamics in terms of lag (or threshold) in response. Would you expect the impact to be related to cumulative N input (i.e., something like 100 years of low excess N is roughly equivalent to 10 years of high excess, or would the N-loss mechanisms be able to ‘handle’ low excess inputs indefinitely? If the latter, can the model generate a hypothesis about these values (N-dep rate and time to impact)? (This may be beyond the scope of this model-introduction paper, but seems like it would be an interesting model application.) Is there a reason why vegetation lost 2.5% of its N per year (p. 1628; line 20)? Was this due to changes in PFT N contents, or changes in relative proportions of PFTs? Was there an equivalent loss in biomass?”

The simulation of long-term N saturation impact is explicitly discussed in a couple of upcoming manuscript that will be submitted this year. These manuscripts also analyze the form of N application in the N fertilization experiments in the Mer Bleue Bog, in which the difference of cumulative impact and long-term low impact is compared. Indeed, this model application suggests that the peatland is able to better adapt to less intensive N deposition than to short-term intensive N fertilization when total N load is equal. The N loss of vegetation was due to mainly the annual variation in the biomass of shrub roots, which ranged from 554 gC m⁻² to 523 gC m⁻² during the simulation period (Table S1). Changes in N content throughout the N pools were thus of subordinate importance compared to the slow loss of shrub root biomass containing N.

P 1629, line 22: “I think ‘implying’ should be changed to ‘resulting in’. It is good that the model performance is consistent with parameterization, but the overall behavior (preferential loss) was somewhat built-in. Of course, other factors could have dominated, but there is a ‘hard-wired’ sensitivity relationship in place.”

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We agree and rephrased the sentence (p. 1629, line 22, now p. 19 line 8).

MINOR POINTS P 1600, line 22: ‘...about 547 Pg C ...’; this is reported to three figures (i.e., 0.1%); that is not an ‘about’ value for something as uncertain as global peat C.

We agree and rephrased the sentence (p. 1600, line 22, now p. 1, line 30).

p. 1604, line 13: do you mean vertical spatial resolution or horizontal?

We rephrased the sentence as “vertical spatial resolution” (p. 1604, line 13, now p. 4, line 3).

p. 1606, line 17: HMP rather than HPM

We changed “HMP” to “HPM” in p. 1605, line 4; p. 1606, line 7; p. 1607, line 4; p. 1613, line 23 (now p. 4, line 17; p. 5, line 1; p. 5, line 27; p. 9, line 23).

p. 1609, line 24: “is consumption of O₂ in methane oxidation insignificant to the O₂ budget?”

The annual consumption of O₂ in methane oxidation was between 5% and 7% of the annual input of O₂ from the atmosphere that diffused into the soil during the simulation period. Therefore methane oxidation was not an insignificant sink of oxygen, yet it was not highly important either. We added the information to the manuscript (now p. 17, line 18 to 21).

p. 1613, line 28: “...about one order of magnitude ...”

We rephrased the sentence as “...one order of magnitude...” (now p. 9, line 27).

p. 1614, line 10: “... C and N are present ...”

We rephrased the sentence as “...C and N are present...” (now p. 9, line 38).

p. 1616, line 8: use of both DOM and DOC may be confusing. Do they differ only by a carbon fraction factor? Is that factor constant in the model? If so, could you just use

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one?

In the model there are separate pools for DOC and DON. DOM is not explicitly modelled but in the discussion it needs to be referred to when we discuss C and N in organic dissolved form. In the manuscript we use “DOM” to refer to dissolved organic matter that contains both C and N. DOC refers to dissolved organic C that does not necessarily contain N. It is necessary to use DOM when mentioning humic substances as well. We changed “DOM” to “DOC” and “DON” in one instance (p. 1616, line 8, now p. 11, line 1), but in our opinion it would be difficult to generally change all “DOM” to “DOC”.

p. 1616, line 23: second equation was deduced...

We changed “deducted” to “deduced” (now p. 11, line 16).

p. 1619, line 9; how long are ‘short gaps’? what about longer gaps?

We rephrased the sentences to clarify the procedure of data filling for short gaps and long gaps (now p. 14, line 25 to 27).

p. 1620, line 22: nitrification occurs in anoxic layers?

We rephrased the sentences to “...nitrification and denitrification in the oxic and anoxic layers, respectively” (now p. 13, line 30).

p. 1630, line 14: change ‘lead’ to ‘led’

We changed “lead” to “led” (now p. 19, line 25).

p. 1635, lines 19 & 20: change ‘leave’ to ‘leaf’; line 25: change ‘build’ to ‘built’

We changed “leave” to “leaf” (now p. 22, line 25, 26), “build” to “built” (now p. 22, line 29).

p. 1638, line 2: delete ‘ranged’; line 14: grass-rich; line 26: change ‘transportation’ to ‘transport’.

We deleted “ranged” (now p. 23, line 40); changed “gras-rich” to “grass-rich” (now p.

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24, line 7); changed “transportation” to “transport” (now p. 24, line 17).

p. 1639, line 17: suggest changing ‘: : :’, and in reality reported : : :’ to something like ‘: : :’, as observed : : :’

We changed “. . .in reality reported. . .” to “. . .as observed. . .” (now p. 24, line 37).

p. 1641, lines 13-15: suggest moving ‘in the future’ to ‘other below ground processes in the future’; competition among electron acceptors won’t change in the future, just the model

We agreed and rephrased the sentence. (now p. 25, line 41).

Table 4: I don’t think that all of the sources cited in footnotes are included in the reference list.

We are thankful for this comment, as indeed we omitted the references of this table in the reference list. We changed Table 4, reference 7 to “Thornley 1998b”, reference 13 to “Bartsch and Moore, 1985”, reference 14 to “Moore et al., 2005”, deleted reference 35 “King 1990”, reference 47 to 53 and changed the following numbering.

We added below references:

Aber, J. D., and Federer, C. A.: A generalized, lumped-parameter model of photosynthesis, evapotranspiration and net primary production in temperate and boreal forest ecosystems, *Oecologia*, 92(4), 463-474, 1992.

Bartsch, I., and Moore, T. R.: A preliminary investigation of primary production and decomposition in four peatlands near Schefferville, Quebec, *Canadian Journal of Botany*, 63(7), 1241-1248, 1985.

Bond-Lamberty, B., and Gower, S. T.: Estimation of stand-level leaf area for boreal bryophytes, *Oecologia*, 151(4), 584-592, 2007.

Bragazza, L., Limpens J., Gerdol, R., Grosvernier, P., Hajek, M., Hájek, T., Hajkova, P.

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et al.: Nitrogen concentration and $\delta^{15}\text{N}$ signature of ombrotrophic Sphagnum mosses at different N deposition levels in Europe, *Global Change Biology*, 11(1), 106-114, 2005.

Cannell, M. G. R., and J. H. M. Thornley: N-poor ecosystems may respond more to elevated [CO₂] than N-rich ones in the long term. A model analysis of grassland, *Global Change Biology* 4 (4), 431-442, 1998.

Clein, J. S., and Schimel, J. P.: Microbial activity of tundra and taiga soils at sub-zero temperatures, *Soil Biology and Biochemistry*, 27, 1995.

Frolking, S., Goulden, M. L., Wofsy, S. C., FAN, S. M., Sutton, D. J., Munger, A. M., Bazzaz et al.: Modelling temporal variability in the carbon balance of a spruce/moss boreal forest, *Global Change Biology*, 2 (4), 343-366, 1996.

Frolking, S., Roulet, N. T., Moore, T. R., Richard, P. J., Lavoie, M., and Muller, S. D.: Modeling northern peatland decomposition and peat accumulation, *Ecosystems*, 4(5), 479-498, 2001.

Granhall, U., and Selander, H.: Nitrogen fixation in a subarctic mire, *Oikos*, 8-15, 1973.

Güsewell, S.: Responses of wetland graminoids to the relative supply of nitrogen and phosphorus, *Plant Ecology*, 176(1), 35-55, 2005.

Kimball, J. S., Thornton, P. E., White, M. A., and Running, S. W.: Simulating forest productivity and surface-atmosphere carbon exchange in the BOREAS study region, *Tree Physiology*, 17(8-9), 589-599, 1997.

Kronzucker, H. J., Siddiqi, M. Y., Glass, A. D., and Kirk, G. J.: Nitrate-ammonium synergism in rice. A subcellular flux analysis, *Plant Physiology*, 119(3), 1041-1046, 1999.

Murray, R. E., and Knowles. R.: Production of NO and N₂O in the presence and absence of C₂H₂ by soil slurries and batch cultures of denitrifying bacteria, *Soil Biology*

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and *Biochemistry*, 35(8), 1115-1122, 2003.

Nedwell, D. B., and Watson, A.: CH₄ production, oxidation and emission in a UK ombrotrophic peat bog: Influence of SO₄²⁻ from acid rain, *Soil Biology and Biochemistry*, 27(7), 893-903, 1995.

Reddy, K. R., Patrick, W. H., and Broadbent, F. E.: Nitrogen transformations and loss in flooded soils and sediments, *Critical Reviews in Environmental Science and Technology*, 13(4), 273-309, 1984.

Reynolds, J. F., and Thornley, J. H. M.: A shoot: root partitioning model, *Annals of Botany*, 49(5), 585-597, 1982.

Ryan, M. G.: Effects of climate change on plant respiration, *Ecological Applications* 1(2), 157-167, 1991.

Ryan, M. G.: Foliar maintenance respiration of subalpine and boreal trees and shrubs in relation to nitrogen content, *Plant, Cell and Environment*, 18(7), 765-772, 1995.

Smart, D. R., and Bloom, A. J.: Influence of root and content on the temperature response of net and uptake in chilling sensitive and chilling resistant *Lycopersicon* taxa, *Journal of Experimental Botany*, 42(3), 331-338, 1991.

Well, R., Augustin, J., Meyer, K., and Myrold, D. D.: Comparison of field and laboratory measurement of denitrification and N₂O production in the saturated zone of hydromorphic soils, *Soil Biology and Biochemistry*, 35(6), 783-799, 2003.

Xu-Ri and Prentice, I. C.: Terrestrial nitrogen cycle simulation with a dynamic global vegetation model, *Global Change Biology*, 14, 1745–1764, 2008.

Fig. 9 either caption or figure labels mis-ordered. Caption has CH₄ on left, CO₂ in middle, while figure has CO₂ on left and CH₄ in middle.

We changed in caption "...dissolved CH₄ (a), dissolved CO₂ (b)..." into "dissolved CO₂ (a) and dissolved CH₄ (b)..."

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Fig. 10 – font for text is quite small.

We enlarged Fig. 10.

Citations in Supplement Table 6 – these are not all in the main manuscript reference list.

We added following references in the manuscript reference list: Krom, M. D., and Berner, R. A.: The diffusion coefficients of sulfate, ammonium, and phosphate ions in anoxic marine sediments, *Limnology and Oceanography*, 25, 327-337, 1980.

Sander, R.: Compilation of Henry's law constants for inorganic and organic species of potential importance in environmental chemistry (version 3), <http://www.mpch-mainz.mpg.de/~sander/res/henry.html>, 1999.

Please also note the supplement to this comment:

<http://www.geosci-model-dev-discuss.net/6/C636/2013/gmdd-6-C636-2013-supplement.pdf>

Interactive comment on *Geosci. Model Dev. Discuss.*, 6, 1599, 2013.

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