Biogeosciences Discuss., 7, C2290–C2296, 2010
www.biogeosciences-discuss.net/7/C2290/2010/

Biogeosciences Discussions

Interactive comment on "Contributions of secondary forest and nitrogen dynamics to terrestrial carbon uptake" *by* X. Yang et al.

X. Yang et al.

jain1@uiuc.edu

Received and published: 12 August 2010

Note: For clarity purpose, we have listed the reviewer's comments in bold, and our response in the normal font.

The manuscript was well prepared, and I found no serious logical fault. One caveat is that the authors did not clarify the range of estimation uncertainty even for the main result (e.g., 1.22 Gt C/yr emission by LUC, without a range of uncertainty). By addressing uncertainties in the assumptions, forcing data, and model parameters, the authors should evaluate the range of uncertainty in the estimation of carbon budget of the secondary forests. At least, I recommend the authors discussing this point in the section of conclusion.

We agree with reviewer's comments about the uncertainty issue with modeling studies. As requested by the reviewer, the uncertainty analysis is now added in the conclusion section.

Our results presented here are subject to uncertainties related to uncertainty in the data used, incomplete representation and/or simplifying assumptions of processes in the model. First, we believe there is a large uncertainty in the land use change data used in this study. Since global spatial historical land use change data is not available directly, land use change data used in this study was reconstructed based on earlier land use history reconstruction for agricultural land (Ramankutty and Foley, 1999; Klein Gokdewijk, 2001), and wood harvest in spatial detail based on several assumptions (Hurtt et al., 2006). In our previous study (Jain and Yang, 2005) we estimated the uncertainties in the land use emissions and net land-atmosphere CO2 fluxes using two different land cover data sets for croplands (Ramankutty and Foley, 1999; Houghton and Hackler, 2001), each was combined with one single set of pastureland data (Klein Goldewijk, 2001). We concluded that differences between the two sets of land use fluxes are primarily due to the differences in the rates of changes in land area amount for croplands and argued that further investigation in data for croplands with ground and satellite-based measurements is needed. The introduction of wood harvest (Hurtt et al., 2006) in this study might have further amplified the uncertainty range associated with land use change data. In the case of secondary forests, this study assumes that secondary forests are naturally developed through reforestation and forest regrowth on abandoned land. However, in some parts of the world, for example in Japan and South East Asia, secondary forests are not naturally developed, but are planted (Kenji, 2000; Merker et al., 2004). So, this study may be underestimating the secondary forest area.

Another potential area of uncertainty is that the representation of certain processes, such as fire suppression and woody encroachment, which are suggested to contribute greatly to regional carbon sink (Pacala et al., 2002), are not included in this study, because the effects of these processes have not been well defined yet due to lack *of comprehensive data (Denman et al., 2007). Moreover, shifting cultivation activity is not included in this study because neither the area in shifting cultivation nor the carbon dynamics related to this process is well understood. This could lead to the underestimation of both the land use emissions and secondary carbon sink. Lastly, we assume that plants only take up mineral nitrogen in soils. We are not considering the pathway for nitrogen uptake through the stomata of leaves, which has been suggested as an important pathway for forest to assimilate deposited nitrogen (Jenkinson 1999; Sievering 1999; Sievering et al., 2000). This may cause the underestimation of carbon sink due to secondary forest, especially in regions where nitrogen deposition level is high.*

REFERENCES:

Kenji, Kanda, 2000: Recycling of Forests: Overseas Forest Plantation Projects of Oji Paper Co., Ltd., Japan TAPPI Journal, 54 (1); 45-48.

Merker, S. Yustian, I. and Muhlenberg, M., 2004: Losing Ground but Still Doing Well-Tarsius dianae in Human-Altered Rainforests of Central Sulawesi, Indonesia. In: Gerold, G., Fremerey, M. and Guhardja, E., eds., Land Use, Nature Conservation and the Stability of Rainforest margins in Southeast Asia, Springer, 299-311.

Jenkinson, D. S., K. Goulding, and D. S. Powlson (1999), Nitrogen deposition and carbon sequestration, Nature, 400, 629–630.

Sievering,H. (1999), Nitrogen deposition and carbon sequestration, Nature, 400, 629-630.

Sievering, H., I. Fernandez, J. Lee, J. Hom, and L. Rustad (2000), Forest canopy uptake of atmospheric nitrogen deposition at eastern U.S. conifer sites: Carbon storage implications?, Global Biogeochem. Cycles, 14(4), 1153–1159, doi:10.1029/2000GB001250.

All other reference cited here are given in the references section of the original

manuscript.

Page 2743 Line 1: Excessive nitrogen deposition brings about nitrogen saturation, passively leading to ecosystem degradation. Did your model study consider the possibility of the adverse effect of nitrogen deposition?

We have not accounted for this adverse effect of N deposition in this study. It will be stated in the revised manuscript (MS) with the following text:

In some areas that receive excessive amounts of N deposition from the atmosphere, N saturation may happen. An overabundance of available N may lead to undesired ecosystem effects including greater losses of nitrate to receiving waters, increased soil acidity, increased aluminum mobility and ultimately the decline of forest productivity (Aber et al., 1998). However we have not accounted for this adverse effect of N deposition in this study.

Page 2744 Line 12 Does the ISAM consider symbiotic nitrogen fixation?

Yes, Model accounts for both symbiotic biological nitrogen fixation (BNF) and non-symbiotic BNF. Following text will be added in the revised MS to clear this point:

Model accounts for both symbiotic biological nitrogen fixation (BNF) and non-symbiotic BNF. We incorporated the empirical function developed by Schimel et al. [1996] to estimate BNF based on evaportranspiration (ET). We modified the parameters in the function in such a way so that the estimated BNF for each biome type is consistent with that given by Cleveland et al. [1999], which based on the field measurements and included both symbiotic BNF and non-symbiotic BNF [Yang et al., 2009].

Page 2744 Line 20-23 Dominant plant functional types change through time, along the secondary successional series. However, I guess that the ISAM model assumed stationary land cover types of secondary forests. Is it correct?

Yes, it is correct. The following text will be added in the revised MS:

We are aware that dominant plant functional types change through time during secondary succession [Guariguata and Ostertag, 2001]. However in this study, we assume stationary land cover types of secondary forests for simplification.

Page 2746 Line 6 'and' should be between 'cropland' and 'pastureland'.

Thanks for pointing this out. 'and' will be added.

Page 2746 Line 15 Does the model consider the difference between dry deposition and wet deposition? They may, more or less, differ in biogeochemical properties. And, you should more clearly explain how the deposited nitrogen is handled in the nitrogen cycle scheme. For example, which compartment the deposited nitrogen goes?

We are not considering the difference between dry deposition and wet deposition in this study. Following text will be added in the revised manuscript for clarification:

In ISAM-NC, the deposited NOy-N and NHx-N enter ammonium-N pool and nitrate-N pool respectively [Yang et al., 2009]. The deposited N could enter into the system either in the form of dry deposition or wet deposition, but this study do not make a distinction between these two types of deposition.

Page 2747 Line 20 and Table 1 It is unclear how the experiment "without nitrogen deposition" was conducted. Did you assume zero deposition? Or, constant (i.e., fixed to the level in 1765) deposition rate?

In the experiment without nitrogen deposition, we assume constant deposition level (i.e., fixed to the level in 1765) between 1765 and 2000. Following text will be added in the revised MS to clear this point.

In the experiments where N deposition is not considered, we assume constant deposition level (i.e. fixed to the level in 1765) between 1765 and 2000.

Page 2748 Line 12 A citation, Van Minne et al. (2009), is not found in the reference

list.

Thanks for pointing it out. The citation will be added in the reference list.

Van Minnen, J. G., K. Klein Goldewijk, E. Stehfest, B. Eickhout, G. van Drecht and R. Leemans (2009), The importance of three centuries of land-use change for the global and regional terrestrial carbon cycle, Climatic Change, 97(1-2), 123-144.

Page 2748 Line 22-26 and Figure 3 This part simply describes the spatial and temporal patterns of secondary forests provided by the data of Hurtt et al. (2006), which is not a result of this study. This part should be moved to Section 2.2.1.

We agree. The text will be moved.

Page 2751 Line 8 'on' should be after 'based'.

'on' will be added.

Page 2751 Line 20 'increase C uptake' would be revised as 'increased C uptake'.

It will be revised.

Page 2751 Line 25 to Page 2752 Line 2 The mechanisms 1) and 2) can happen to every secondary forests, and may not explain the specific phenomena in southern Europe and India. Instead, you should give further explanation for the mechanism 3), i.e., climatic characteristics in these regions.

We agree with the reviewer's comment. We will add further explanation for the regionally specific mechanisms. Following is the suggested revised text with additional points 2-5, which explains the regionally specific mechanisms:

However, southern Europe and Indian secondary forests are sequestering more C when N dynamics are considered. Possible reasons are: 1) when natural vegetation was cleared for cropland, pastureland, or wood harvest, both above- and below-ground litter increases because of the unburned slash and the buried roots. The increased lit-

ter associated with LUC would lead to more litter decomposition and N mineralization, therefore increasing N availability in soils; 2) ash additions resulted from burned slash immediately increases inorganic N supply; 3) the warm and moist climate in India leads to the rapid decomposition of soil organic matter, which releases mineral N due to nitrogen mineralization. These released mineral N is taken by the plants for the regrowth of secondary forests, thus enhancing secondary forest carbon sink; 4) the temperature and precipitation conditions in India region favors biological nitrogen fixation, which provides substantial amount of nitrogen for India secondary forests and enhance their productivity; 5) nitrogen deposition effect in southern Europe is enhancing the productivity of secondary forests in this region.

Page 2752 Line 26 Disagree. Houghton (2003) estimated LUC-induced emission mainly using inventory data, which implicitly include nitrogen limitation in the real world; he did not assume a nitrogen-rich condition.

We don't agree that Houghton (2003) estimated LUC-induced emission mainly using inventory data. After carefully going through Houghton (2003) paper and papers cited in that, we find that Houghton used a book-keeping model to keep track of carbon in vegetation, litter and soils for the land area cultivated, harvested or reforested. Houghton (2003) used land use change area per year as an input in the book-keeping model. Changes in carbon stocks in each reservoir following land use change are defined by a series of idealized response curves. These idealized curves do not account for the effects of various environmental factors, such as increasing atmospheric CO2, climate change and nitrogen limitation induced by increased N demand due to increasing CO2 concentrations.

Page 2755 Line 20 Correct family name is 'Klein Goldwijk' (this may be Dutch name). Please look the original paper.

It will be revised.
