Biogeosciences Discuss., 8, C2012–C2024, 2011
www.biogeosciences-discuss.net/8/C2012/2011/
© Author(s) 2011. This work is distributed under
the Creative Commons Attribute 3.0 License.

Biogeosciences Discussions

Interactive comment on "Carbon budget of tropical forests in Southeast Asia and the effects of deforestation: an approach using a process-based model and field measurements" *by* M. Adachi et al.

M. Adachi et al.

adachi.minaco@nies.go.jp

Received and published: 15 July 2011

Dear Sir,

Thank you very much for your reply, received in 3rd June, 2011, with regard to our manuscript (bg-2010-345) together with the valuable comments and suggestion from the reviewers. We resubmit this manuscript to Biogeosciences after carefully considering the suggestions made by reviewers. Our responses for comment from reviewers as follows, and corrected sentences are shown in this sheet. And, the revised manuscript

and Table and Figures were attached as a supplement. We believe the manuscript has been improved satisfactorily and hope it will be accepted for publication in Biogeosciences.

Comment from Referee #1 Abstract: I couldn't understand the last two sentences "The C stock _ and observations. "How would "the rate of remaining residual debris" or "46% of the rainforest's C" be related with "adequate forest management"? —We corrected these sentences to as follows: "According to the model simulation, the total C stock (total biomass and soil C) of the oil palm plantation was about 35% of the rainforest's C stock at 30 yr following initiation of the plantation. However, there were few field data of C budget and stock, especially in oil palm plantation."

Abstract: Is there any specific reason why you came up with a rather general conclusion of "C budget must be evaluated over a long term"? Please make the paragraph more logical and scientific. —We rewrote this sentence: "The C budget of each ecosystem must be evaluated over the long term using both the model simulations and observations to understand the effects of climate and land-use conversion on C budgets in tropical forest ecosystems."

P3055L15: Please specifically describe the improvement of VISIT compared to SimCycle. —We added new figure of model overview (Fig.2), and explanation to "2.2 Model overview".

P3045L23: "40% and 27% of total biomass C was returned to the atmosphere within the 1st and 10th year, respectively": This reads no return from the 2nd year until the 9th year. Didn't you mean 40% was returned during the first year and 27% was returned during the period from the second year and the tenth year? —We rewrote this sentence to "We assumed that 60% of harvested wood C is consumed and returned to the atmosphere within 1 yr and that the remaining 40% is decomposed over the course of the next 9 yr (i.e., all is decomposed after 10 yr)" in Material and methods. And Table 5 was changed to new results.

P3056L28: I couldn't understand the sentence of "C flux from soil in 1 yr and total C flux in 10 yr in Table 5 were in addition to . . .". Please rephrase the part. —We rewrote this sentence to "Cumulative C flux induced by land-use change represents the sum of C flux from soil during a 2-yr period (1977–1978) and 10-yr period (1977–1986) plus harvested C within the 1st and 10th yr, respectively." in the results.

P3057L26: Quantitatively evaluate the NCEP/NCAR forcing data (Figure 2) with in-situ measured data (Figure 1). —We compared the NCEP/NCAR data and in-situ data in Fig.3. And we corrected the NCEP/NCAR data using the in-situ data, and simulated all over again. The explanation of correction method for the NCEP/NCAR data was written in "2.4 Input data for the VISIT model". And these results were presented in the beginning of the result: "3.1 C budget in the primary forests".

P3058L1: "The diurnal patterns of GPP from 2003 to 2005 were compared with GPP data gathered by two satellites" – Where is the result and evaluation? —We added the results of GPP by satellites data to end of "3.3 Validation of the temporal variation on SR, soil water content and GPP", and we discussed about the results in "4.1 Comparison of the two primary forest".

P3058L6: What is "the quality assurance"? Describe. –We rewrote this sentence to "Data that passed the quality assurance testing by the U.S. Oak Ridge National Laboratory were used for the comparison" in the end of "2.6 Validation data for the VISIT model".

P3058L17: "Based on the field data"; a reference is needed. –We rewrote this sentence and added references, as follows: "Based on soil C content and bulk density measured in the field (Adachi et al., 2006; Yamashita et al., 2010; Table 2), soil organic C at 5-cm depth was estimated as 13.0 t C ha–1 in DEF, which was higher than the estimate of 10.8 t C ha–1 in RF." We moved this sentence to Discussion (at the first paragraph in section of "4.1 Comparison of the two primary forest").

P3058L25: VISIT's GPP at DEF is always smaller than at RF, where it is opposite in the

observation. This seems a significant fault of the model. How would this be interpreted in the other results? —We added a new figure of the relationship between GPP and annual precipitation as Fig.6. And, we added the following sentences to results section; "The relationship between the annual precipitation and GPP rate in RF was expressed as a quadratic equation (Fig.6). The low simulated GPP rate in RF would have been affected by the lower precipitation from 2002 to 2004 (Figs. 4b, 6), because single-leaf photosynthetic capacity was assumed to be limited by low soil water content induced by low precipitation in the VISIT model."

P3059L4: "The VISIT model was able to capture appropriately the impacts of disturbances" How could it be? Need more explicit description. What is the controlling physical process(es) to capture the impacts? —We deleted this sentence, and add the more detail explanation about the impacts of disturbances to "3.2 Effect of plantation formation on C stock". However, the VISIT model does not consider changing of the physical process after deforestation. We discussed about this problem at the second paragraph in section of "4.2 Effect of land-use change to an oil palm plantation on the ecosystem C budget".

P3059L11: "Estimation of total C flux was lower than in the undisturbed forest. . ."- When all three parameters are 100%, the total C flux (9.5) is less than no-disturbance (18.1). —This sentence was rewritten to "The analysis suggested that SR during the 10 yr was lower than the no disturbance (forest) ecosystems at the some case of ratios of remaining residual debris."

P3060L24: "The differences between Terra and Aqua data for OPP were not consistent" What is the reason of the inconsistency? —We cannot explain the obvious reason of this inconsistency. However, we discussed about it at the fourth paragraph in section of "4.1 Comparison of the two primary forest".

P3060L25: Please be more specific to explain why "these data were not suitable for validation of the model simulation" —We rewrote this sentence to "The Terra and Aqua

GPP data at OPP varied widely, but the estimated GPP by the VISIT model was consistently lower than the MODIS observation (Fig. 9c)." at the end of results.

P3061L3: It seems that the model simulation results were consistent only in long term averages. —We deleted this sentence, and cleared the difference between model simulation and field observation at the first paragraph of "4.1 Comparison of the two primary forests". The development for accuracy estimation of daily variation in C budget and stock is next task in our study.

Figure 5 clearly displays inconsistency in the temporal variability. —We changed Figure 5 to Figure 8, and we matched the period of two figures.

P3061L9: How did the model estimates differ from the actual plant properties? —We added the detail of difference between model estimated and actual plant properties at second paragraph of "4.1 Comparison of the two primary forests".

Figure2: Why did you show the data for only 1997-2007, not the whole period? Figure2: Why are the differences between MAX and MIN temperatures decreasing? What is the consequence of this trend on the carbon cycle simulations? —We corrected Figure 2 to new Figure 4, and we showed the only annual mean air temperatures in Fig. 4a. Maximum and minimum temperatures were deleted because these were unrelated to the result.

Figure2: You need to compare the NCEP atmospheric forcing with in-situ data in Figure 1. You may want to add NCEP's monthly climatology to Figure1. —We compared the NCEP/NCAR data and in-situ data, and the results were presented in Fig.3.

Figure3: Carbon stocks are increasing at both places! Does it imply that the spin-up period is not enough? —We added the explanation to the end of first paragraph of "2.4 Input data for the VISIT model " as follows: "The VISIT model incorporates the increase of background atmospheric CO2 concentration from 310 ppmv in 1948 to 392 ppmv in 2008, leading to a CO2 fertilization effect on the photosynthetic rate."

Comment from Referee #2 P3054, L26, A clear-cut in 2001 and replanting in 2002: The simulated carbon stock and flux don't seem to include the processes in Fig. 4. But the comments are not found. P3060, L1, Fig.4: The design of the numerical simulation should be described in Materials and Methods. This numerical simulation doesn't consider the process of a clear cut in 2001 and planting in 2002. —We added the comment about second disturbance to results and discussion. We added the following sentences to results section: "The second disturbance of replanting oil palms might have caused the decrease in observed SR from 2001 to 2002 in OPP (Fig. 8a); however, the VISIT model did not consider the process of the second disturbance." And, we added the following sentences to discussion: "Oil palm trees are clear-cut and seedlings are replanted at 25- to 30-yr rotations in Southeast Asia (Corley and Tinker, 2003). These events occurred again for the second rotation in OPP in 2001, however, the VISIT model can simulate the event of disturbance and planting of oil palm seedlings only once. The VISIT model needs to improve for evaluation of the C budget in maintained agricultural management, because the second disturbance was different from first disturbance (e.g. amount of residual debris and its decomposition rate)."We added new figure of model overview in oil palm plantation (Fig.2b), and explanation to "2.2 Model overview".

P 3055, L21-23: Although it explains how to decide the initial conditions of C stock, I think it is not sufficient. I want to know whether the balance of C input and output in an ecosystem at each site is almost maintained under the initial conditions and climate conditions. Figures 3a and 3b shows the C stocks are gradually increasing. This indicates that C input remains beyond C output instead of mature forests. The readers may feel that the initial conditions were decided so that the simulated results can agree with observations (Table 4). —The C stocks in both of DEF and RF was increased because increase of background atmospheric CO2 concentration from 310 ppmv in 1948 to 392 ppmv in 2008. Therefore, increasing CO2 concentration was effected to the photosynthesis rate. And, we added the following sentences to the first paragraph of "3.1 C budget in the primary forests": "The gradual increase of C stock at both sites

from 1948 to 2008 (Figs. 5a, b) would be induced by the increase of atmospheric CO2 concentration, that is, by the CO2 fertilization effect."

P3055, L24&25: The authors stated the ecosystem structure of the C stock is four sectors (i.e., tall canopy, understory plants, dead biomass and mineral) in the model. But simulated results in Figures 3 and 4 show the different sectors (i.e., aboveground biomass, belowground biomass, tree biomass under the canopy, etc.). The relationships among these sectors should be described in the methods before Results. Also, the authors should explain the model overview and the sectors of C stock, showing a figure of the model concept. —We corrected the manuscript, and Fig.5 and Fig.7 to be same sectors. We added new figure of model overview (Fig.2), and explanation to "2.2 Model overview".

P3056, L14, "production of woody and root debris": This should be "residual (or leaving) woody and root debris"? —We corrected this word to "residual (or leaving) woody and root debris (residual debris)" in the manuscript.

P3056, L19-23: I could not understand the sentence, "40% and 27% of total biomass C. . . within the 1st and 10th year, respectively", when I first read it. After I read McGuire et al. (2001), I understood it. Please describe it clearly and concretely as McGuire et al. (2001), with showing the above-mentioned figure. Also, these values of 33 40, and 27 % don't seem from McGuire et al. (2001) but originally from Houghton et al. (1983). —We corrected these sentence to the following sentences: "Houghton et al. (1983) reported various conversion ratios for the amount of C stored in products obtained from tropical ecosystems, that is released into the atmosphere: 33% of total biomass C remained in the soil as residual woody debris, and the other 67% was removed as wood harvest. We assumed that 60% of harvested wood C is consumed and returned to the atmosphere within 1 yr and that the remaining 40% is decomposed over the course of the next 9 yr (i.e., all is decomposed after 10 yr)."

P3057, L4-7: Are they, in "they are harvested from 10 yr of age", leaves or/and fruits?

A reference on this management of oil palm plantations should be needed. Or is it assumption in the model? Please explain it clearly. —We corrected this sentence to the following sentence at the end of "2.2 Model overview": "oil palm fruits are harvested from stem at 10 yr of age in the VISIT model, accounting for a C loss of 3.3 t C ha–1 yr–1 based on a report of palm oil yields (2.8 t ha-1; Stone, 2007)."

P3057, L11-13: The authors changed the parameters from evergreen forest into oil palm plantation after clear-cut. It is clearly stated in P3063, L16&17 in Discussion, but it should be already stated here. I wonder why the ratios of both sand and clay contents change after a clear-cut or planting oil palm. If any, please make comments about the changes. —We added the comments about change of sand and clay content at the end of second paragraph in "4.2 Effect of land-use change to an oil palm plantation on the ecosystem C budget" as follows; "Clay content in OPP was lower than that in RF, whereas sand content showed the opposite pattern. Islam and Weil (2000) also reported that land-use change from tropical forest to cropland caused a decrease in silt and clay content. These results suggest that soil properties would be affected by land-use change. The relationship between clay content and soil organic content was not clear, but clay minerals help to stabilize soil organic matter (McLauchlan, 2006)."

P3057, L26&27: Here, reanalysis data in precipitation and temperature in reanalysis are shown in Fig. 2. There are different from the annual precipitation and temperature by site-observations shown in Site description. In particular, the annual values of precipitation are much larger than site observations. The authors should point out the differences here. They have to consider the impact of these input data on model output in Discussion. P3061, L6 – 16: The precipitation and temperature data (maybe, solar radiation) is different between reanalysis and site-observation as I mentioned. The modeled results may be close to observed ones (Table 4), because the difference might influence model output. —We compared the NCEP/NCAR data and in-situ data of precipitation in Fig.3. And we corrected the NCEP/NCAR data using the in-situ data, and simulated all over again. And these results were presented in the beginning of the

result: “3.3 Validation of the temporal variation on SR, soil water content and GPP”. And we discussed about effect of climate data on model output in Discussion as follows: “On the other hand, the annual precipitation influenced annual GPP in RF (Fig. 6), this result suggested that meteorological data was also important to accuracy evaluation.” Air temperature by NCEP/NCAR data was not greatly different with the in-situ data.

P3058, L19&20: Simulated seasonal change in RF seemed to depend on the input data of soil temperature rather than precipitation in DEF, as the timing of peak (around April) is similar to that of air temperature (Fig. 1a). Please check this point and the procedure in model. —We checked the relationship between air and soil temperature, and daily NEP and SR in both site. However, we cannot see the obvious relationship, we added a new figure of the relationship between GPP and annual precipitation as Fig.6. And, we added the following sentences to results section; “The relationship between the annual precipitation and GPP rate in RF was expressed as a quadratic equation (Fig.6). The low simulated GPP rate in RF would have been affected by the lower precipitation from 2002 to 2004 (Figs. 4b, 6), because single-leaf photosynthetic capacity was assumed to be limited by low soil water content induced by low precipitation in the VISIT model.”

P3059, L4&5: I wonder why the authors can state it. The comment seems not suitable in Results. Here, they should interpret the simulated results in Fig. 4 etc. in detail and objectively. —We deleted this sentence. However, we presented the results of simulation at the section of “3.2 Effect of plantation formation on C stock”

P3059, L5-7: The topic on the model sensitivity is abrupt. The design of numerical experiments should be described in Materials and Methods. P3059, L9&10: The key factor is the amount of residual debris rather than the proportion of residual stem debris in the model, since the decomposition rate of the debris after a clear-cut is same instead of leaves, stem and root debris (see P3056, 24&25). —We rewrote these sentences to the Material and methods as a new section: “2.5 Sensitivity analysis of C flux induced by land-use change”

P3060, L9, Fig.5a: Fig. 5a shows both simulated and observed soil respiration (SR) in the oil palm plantation in 2000 - 2004. Does the simulated SR consider a clear-cut in 2001 and planting seedlings in 2002? But the authors don’t state this point clearly. The measured RS following the clear-cut was the lowest, and I feel the clear-cut reflected RS. —The VISIT model did not consider the process of the second disturbance, therefore we did not present the results of SR at the case of clear-cut in 2001 and planting seedlings in 2002 to this figure. Because second disturbance was different from first disturbance at some points (e.g. amount of residual debris, and its decomposition rate), we thought that this problem is next task. Please see the corrected sentence in the response of “P3056, L19-23”.

P3060, L16&17: I feel that this attributes to the difference in saturated volumetric water content among measurement points (i.e., soil-sample points and soil-water-content measurement points). For soil properties are not vertically and horizontally homogeneous, even although the distance is very near. Rather I am concerned about the larger seasonal changes in simulated RE soil water content in 2003 – 2005. The input data of precipitation may have larger seasonal changes than that of precipitation by site observations, as Fig. 1b. Please check it. —We compared the NCEP/NCAR data and in-situ data, and the results were presented in Fig.3. And we corrected the NCEP/NCAR data using the in-situ data, and simulated all over again. Therefore, our results were slightly changed, and we rewrote this sentence to as follows:” The SR and soil water content in RF estimated by the VISIT model was lower than that measured in the field from 2003 to 2005 (Fig. 8), mainly because precipitation based on NCEP/NCAR data tended to be low during this period (Fig. 4).”

P3060, L19 – 21, (a): I think the GPP simulated with VISIT don’t capture the seasonal changes by Tera, in particular in 2004 - 2005. The reason is needed in Discussion. —Because the seasonal variation in VISIT model would have some problems, we did not refer about it. However, the range of GPP by the VIST model was not greatly different with satellite data.

P3060, L19 – 21, (b): The largest difference of RF-GPP between Aqua and Tera seems probably due to the short distance between OPP and RF, although the reason is stated in Discussion. —We added this reason at Discussion, as follows: “The direct distance from OPP and the edge of RF was about 4-km, and this could cause the inconsistency of GPP data between Terra and Aqua at OPP (Fig.9c).”

P3060, L19 – 21, (c): Simulated GPP in OPP shown in Fig. 6 appears to consider the processes of a clear-cut in 2001 and planting oil palm trees in 2002. Please describe it clearly in Materials and Methods. —We added the following sentence to “2.2 Model overview”: “The year of disturbance and planting of oil palm seedlings can be set for anytime, but this event occurred only once in this model. Because oil palm seedlings were replanted in 2002 for second rotation in OPP, the disturbance event from forest to oil palm plantation in the VISIT model was set for 2001 in Fig 9c.”

P3062, L12-14: The sentence is not consistent to that in P3058, L19&20. —We deleted this sentence.

P3062, L25-28: I wonder how the value of maximum photosynthesis rate of oil palm is decided in Table 1. It needs a reference. This agreement of above ground biomass (Table 4) between model simulation and observation is maybe due to the parameter tuning, I think. Dufrene and Saugier (1993) reported that the value was 20 micro-mol/m2/sec, which is higher than that in the model (Table 1). Dufrene and Saugier (1993) also stated that the photosynthesis reduced with frond age in the Abstract. (Because I have to purchase the paper to read the all content, I read Abstract only.) They might state that the reduction was not significant in the result/ discussion as the authors stated. Also please check it. —We simulated again using the maximum photosynthesis rate:20 micro-mol/m2/sec. And we rewrote this sentence to as follows: “The maximum photosynthetic rate was 20 μmol m–2 s–1, it decreased with leaf ages in oil palms (Dufrene and Saugier, 1993). The estimated seasonal mean light-saturated photosynthesis rates by the VISIT model were 11.8 μmol m–2 s–1 in OPP, but the reduction of photosynthesis rates induced by leaf senescence was not considered in

this model.”

P3063, L19 & 20: Please show the carbon loss per area and the area of deforestation used to estimate the value of 1.47MtC. The calculation should need the processes of both the clear-cut in 2001 and planting seedlings in 2002 although it is not stated clearly. Therefore, the authors can fill up the values at all “nd” in OPP site in Table 4. The values will be variable information. — We calculated using corrected NCEP/NCAR data, and corrected the sentences to as follows: “Using the VISIT model and the deforestation rate reported by FAO (2010), the total C emissions induced by land-use change in Malaysia between 1995 and 2004 were estimated as 16.8 Mt C. This value was calculated by multiplying the deforestation area and the estimated NEP by VISIT model at every year.”

P3071, Table 3: I wonder how the both maximum and minimum air temperatures and cloud cover are used in the model. Does the cloud cover influence downward long wave radiation, and both direct and indirect downward shortwave radiations? The both maximum and minimum air temperatures influence physiological condition? —We deleted the maximum and minimum air temperatures from Table 3, because we didn’t these parameters in the VISIT model. The cloud cover was used to estimate the net long wave radiation and the beam/ diffuse PAR. Basically, these calculation methods were same as Sim-CYCLE (Ito & Oikawa. 2002). Therefore, we corrected the sentences in Materials and methods as follows: “The model simulations were conducted at a daily time step, using daily average meteorological forcing data (Table 3). Ito and Oikawa (2002), and Ito et al. (2006) indicated the detail of calculation methods for radiation and water budget of the Sim-CYCLE model, and these methods were used in the VISIT model.”

P3076, Fig. 3: Please the difference among different colored areas in Fig. 3a and b as captions in Fig.4. —We corrected these figures and presented in Fig.5 and Fig.7.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/8/C2012/2011/bgd-8-C2012-2011-

supplement.zip

Interactive comment on Biogeosciences Discuss., 8, 3051, 2011.