

Interactive comment on “The impact of climate variation and disturbances on the carbon balance of forests in Hokkaido, Japan” by R. Hirata et al.

R. Hirata et al.

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Thank you for your comments. We hope that our responses and the resulting revisions will be satisfactory, but we will be happy to work with you further to resolve any additional issues..

General comment

General comment 1:

it should be clearly stated that only NEP is a 'measurement'. GPP and RE are results of a flux partitioning model. Reply: In accordance with the reviewer's comment, to clarify how we estimated GPP and RE, we have revised the sentence "The results of the simulation were compared with observed NEP, GPP, and RE" as follows: "The

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results of the simulation were compared with NEP observed by the eddy covariance technique and with GPP and RE, which were estimated from the observed NEP by using semi-empirical models"

General comment 2:

parts of the discussion are quite loose

Reply:

In accordance with the reviewer's specific comments, we have added discussion as follows.

"Whereas Janisch and Harmon (2002) and Thornton et al. (2002) simply examined the effect of disturbance without taking climate variations into account, we simulated carbon balances while accounting for both disturbance and climate variations. Despite the difference in simulation design and the type of model, the results of all three studies suggest the importance of residues to the carbon balance of forest ecosystems."

"This could be one of the reasons why our results differed, and it suggests that treatment of residues affects carbon flux after thinning."

"Both GPP and RE increase with increase in temperature. When increase in GPP exceeds increased in RE, NEP increases, and vice versa. Increased temperature affects many ecosystem processes (e.g., photosynthesis, plant respiration, soil respiration, biomass, phenology), and the sensitivities of all of these differ among plant species, soil types, and climate zones (Luo, 2007). Therefore, it is quite difficult to find a consistent pattern in the response to increased temperature (Luo, 2007), and further case studies should be conducted."

"Although it is well known that drought affects soil respiration (Borken et al., 2006; Koppitke et al., 2013; Wang et al., 2014), reduced RH was not detected by our simulation under severe drought conditions. At the Tomakomai site, the relationship between soil respiration and soil water on the basis of chamber measurements was not clear (Liang

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et al., 2010). A much longer observation period is needed for detecting signals when severe drought occurs. Data based on a longer observation period are also useful for validating the VISIT model.”

“Yi et al. (2013) focused on the regional scale (boreal and arctic area), whereas we focused on the point scale in a cool temperate forest. The effect of disturbance depends on the area and strength of disturbance, because various types of disturbance occurred heterogeneously at the regional scale. The effect of climate might also differ among regions. In future research, we need to evaluate the spatial effect of disturbance and climate by gathering information on disturbance in Hokkaido or Japan.”

In addition, we have rewritten section 4.2. We have moved the passage beginning “By applying” in P2862L15–L24 (original manuscript) to the end of this section. To clarify the effects of temperature and precipitation, we have added new text regarding the effects of temperature and precipitation, in separate paragraphs.

General comment 3:

the conclusions need to be rewritten (see specific comments)

Reply:

In accordance with the reviewer’s specific comment, we have removed P2865L2 in the original manuscript and have added our conclusions about the roles of disturbance and climate as follows.

“We evaluated the long-term effects of disturbances and climate on the carbon balance of forest ecosystems in a cool temperate region by using the process-based model VISIT. Clear-cutting strongly affected the carbon balance, not only just after clear-cutting but also 52 years after the disturbance. The effect of clear-cutting was larger than that of climate, even 52 years later. Disturbance controlled the long-term trend in carbon balance, whereas climate factors controlled the yearly variation. Among the climate factors, increased temperature and severe drought played vital roles in in-

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terannual variation of the carbon balance. The three ecosystem compensation points are useful indices for evaluating the recovery of a forest ecosystem from disturbance with respect to the carbon balance.”

General comment 4:

the results of the scenarios should be discussed against the background of the model quality (validation, Fig. 3), very relevant for the TSE model runs

Reply:

We have added a discussion of the uncertainty of the scenario tests in connection with the validation test.

General comment 5:

please provide more details on how the parameters listed in Table A1 were derived. Which of the parameters were calibrated or even inverted?

Reply: In previous studies (Ito, 2008; Ichii et al., 2010, 2013), most of the parameters were determined manually by the trial-and-error method. We have added an explanation.

Specific comments

Specific comment 1:

‘three experimental simulations’ better write ‘The model was validated, scenarios were computed and a sensitivity analysis was performed.’

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 2:

‘attribution simulations’ better use the term ‘scenario’, this should be used consistently

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throughout the entire manuscript

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 3:

please add 'tree biomass' before 'residues', or simply use the term 'litter'?

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 4:

replace 'attributable to' with 'driven by'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 5:

replace 'pay back' with 'balance' and replace 'debt' with 'budget'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 6:

Do not understand

Reply:

We have revised the sentence as follows.

"Changes in carbon flux and storage in forest ecosystems are influenced by climate at various temporal and spatial scales. However, they are also affected heterogeneously

C3519

by artificial and natural disturbances at the local scale."

Specific comment 7:

better write '...Ueyama et al., 2013). Damage by insects had a similar...'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 8:

replace 'absorption' with 'sequestration' and replace 'clarifying' with 'quantifying'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 9:

'northernmost' please rewrite

Reply:

We have revised the sentence to "northern main island".

Specific comment 10:

replace 'to correct the problem noted by' with 'according to the shortcoming reported by'

Reply:

We have revised the sentence as follows.

"to amend the shortcomings noted by"

Specific comment 11:

The time series climate data for Tomakomai (2001-2003) is very short. Climatic data

C3520

should cover a period of 20-30 years at least. If those 3 years are not representative of the local climate the spin-up equilibrium result will be biased.

Reply:

In response to the reviewer's suggestion, we used long-term data (1948–2010) for the spin-up and recalculated the simulated carbon fluxes in the mixed forest and young and middle-aged larch forests. Although Figures 2 and 3 and the relevant statistics have been changed slightly, there are no dramatic changes related to the results. We have also changed the relevant sentence, as follows: "The model was initialized by a spin-up run for 2000 years to create the dynamic equilibrium of soil organic matter and vegetation components using the reanalysis climate data corrected by in situ observational data from 1948 to 2010 for the Teshio and Tomakomai sites. CO₂ concentrations were constant at 312 ppm until 1948. After the spin-up run, a simulation was conducted for the observation period (11-year for Teshio and 3-year for Tomakomai sites) and for the long-term period for Tomakomai."

Specific comment 12: 26 'from the first year of observation' ? do not understand

Reply:

We have revised the sentence as follows.

"The annual atmospheric CO₂ concentration was linearly increased from 312 ppm in 1948 to 404 ppm in 2012 for Teshio, from 312 ppm in 1948 to 380 ppm in 2003 for Tomakomai, and from 312 ppm in 1948 to 398 ppm in 2010 for 52-year simulation for Tomakomai."

Specific comment 13:

add 'the' before 'blizzard'

Reply:

We have revised the sentence as suggested by the reviewer.

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Specific comment 14:

replace 'exported' with 'removed'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 15: please write '..., 55% of the stems were ...'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 16:

replace 'in' with 'on the'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 17:

replace 'manner' with 'details'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 17:

'mixed' instead of 'mix'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 18:

replace 'general manner' with 'common practice'

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Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 19:

I suggest 'Management and climate scenarios' as title of section 2.4

Reply:

We have revised the title as suggested by the reviewer.

Specific comment 20:

replace 'exported' with 'removed'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 21:

this list of variables with subscripts is not very intuitive. Please explain in more detail

Reply:

In accordance with the reviewer's comment, we have added an explanation, as follows:

"full scenario (Sfull) calculated by using all historical climate data and historical disturbances such as clear-cutting, conversion and thinning, climate constant (Sconst-climate), in which temperature, precipitation, solar radiation, and vapor-pressure deficit (VPD) are constant; temperature constant (Sconst-Ta); precipitation constant (Sconst-precipitation); solar radiation constant (Sconst-Sd); VPD constant (Sconst-VPD); and CO2 constant (Sconst-CO2). These scenarios were run with clear-cutting and conversion of mixed forest to larch forest and without thinning. We also conducted a non-conversion scenario (Snon-conv), in which a mixed forest without clear-cutting continued to exist (neither clear-cutting nor plantation occurred); a non-clear-cutting

C3523

scenario (Snon-cut), in which a larch forest without clear-cutting continued to exist; and a non-thinning scenario (Snon-thin)"

Specific comment 22:

better write '... the ecosystems turns into a carbon sink in the recovery...'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 22:

replace 'exported' with 'removed'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 23:

well, the EC-based determination of NEP could be referred to as a measurement. However, GPP and RE are basically estimates derived by a very simple model from the NEP (see 2852, line 13). Thus, for GPP and RE you compare VISIT model results to other model results and not to observations.

Reply:

We have revised the sentence by adding a more precise explanation, as follows: "The results of the simulation were compared with NEP observed by the eddy covariance technique and with GPP and RE, which were estimated from the observed NEP by using semi-empirical models"

Specific comment 24:

I guess it is important to mention at this point that the R2 for NEP (Fig. 3) differs substantially between the three sites/periods. The R2 for both periods of TSE is quite

C3524

low (about 0.5), whereas for TMK you have a nice R2 of 0.9. Please discuss...

Reply:

In response to the reviewer's suggestion, we now discuss the reason why NEP of TSE was low, as follows:

"The relationship of young larch forest monthly NEP between model estimation and observation was not strong (Fig. 3, Table 3), and the simulated annual NEP of young larch forest was slightly biased compared with the observed NEP (Table 3). One possible reason for these trends is that there might be differences in some ecological parameters between young and middle-aged larch forests, whereas we used the same parameters for stands of both ages. The weak relationship and bias might have caused larger uncertainty in the case of the young larch forest than with the mature larch forest. Therefore, in the scenario test (Fig. 4, Table 5), the effects on carbon fluxes in the initial stage of recovery (i.e. in the first decade after disturbance) might have had some uncertainty."

Specific comment 25:

replace 'derived from' with 'estimated by'

Reply:

In response to the suggestion made by reviewer 2, we have removed this sentence.

Specific comment 26:

significant bias (deviation from the 1:1 line) is visible for some models in Fig. 3, please discuss

Reply:

In response to the suggestion made by reviewer 2, we have removed this sentence.

Specific comment 27:

C3525

title...

Reply:

We have revised the sentence as suggested in specific comment 19.

Specific comment 28:

skip 'we found that'

Reply:

We have removed "we found that" as suggested by the reviewer.

Specific comment 29:

skip 'at'

Reply:

We have removed "at" as suggested by the reviewer.

Specific comment 30:

replace 'these' with 'the corresponding'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 31:

skip 'it' and write 'observations'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 32:

three times 'via' in this section, please reformulate

C3526

Reply:

We have revised the sentence by changing the first “via” to “because of” and the second “via” to “by”.

Specific comment 33:

14, 15 and 24 'whereas we found the opposite', '...', also in contrast to our result' and ...'which was the opposite of our results'; discussion is a bit loose here. You often mention what is not in agreement without expressing an idea of the reasons for the disagreement.

Reply:

We have added discussion as follows.

“Whereas Janisch and Harmon (2002) and Thornton et al. (2002) simply examined the effect of disturbance without taking climate variations into account, we simulated carbon balances while accounting for both disturbance and climate variations. Despite the difference in simulation design and the type of model, the results of all three studies suggest the importance of residues to the carbon balance of forest ecosystems.”

“Both GPP and RE increase with increase in temperature. When increase in GPP exceeds increased in RE, NEP increases, and vice versa. Increased temperature affects many ecosystem processes (e.g., photosynthesis, plant respiration, soil respiration, biomass, phenology), and the sensitivities of all of these differ among plant species, soil types, and climate zones (Luo, 2007). Therefore, it is quite difficult to find a consistent pattern in the response to increased temperature (Luo, 2007), and further case studies should be conducted.”

“In Ito (2012) study, the minimum annual precipitation was 1065 mm in 1994 (study period 1999–2009), whereas that in our study was 694 mm in 1984 (study period 1948–2010). Therefore, Ito (2012) did not detect severe drought.”

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“Yi et al. (2013) focused on the regional scale (boreal and arctic area), whereas we focused on the point scale in a cool temperate forest. The effect of disturbance depends on the area and strength of disturbance, because various types of disturbance occurred heterogeneously at the regional scale. The effect of climate might also differ among regions. In future research, we need to evaluate the spatial effect of disturbance and climate by gathering information on disturbance in Hokkaido or Japan.”

Specific comment 34: drought will not only affect GPP, but also RE. Heterotrophic respiration is sensitive to soil moisture. Reply: We have added a discussion about the effect of drought on soil respiration, as follows: “Although it is well known that drought affects soil respiration (Borken et al., 2006; Kopitke et al., 2013; Wang et al., 2014), reduced RH was not detected by our simulation under severe drought conditions. At the Tomakomai site, the relationship between soil respiration and soil water on the basis of chamber measurements was not clear (Liang et al., 2010). A much longer observation period is needed for detecting signals when severe drought occurs. Data based on a longer observation period are also useful for validating the VISIT model.”

Specific comment 34:

replace 'faster' with 'shorter'

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 35:

skip this section, this is not related to the results of this study 2865

Reply:

We have revised the sentence as suggested by the reviewer.

Specific comment 36:

C3528

I suggest to skip. This section is weak, mostly common knowledge and hardly related to the results of this study. Conclusions need to be rewritten.

Reply:

In response to the reviewer's suggestion, we have removed this section. In place of it, we now discuss the effects of disturbance and climate in the Conclusion as follows.

"We evaluated the long-term effects of disturbances and climate on the carbon balance of forest ecosystems in a cool temperate region by using the process-based model VISIT. Clear-cutting strongly affected the carbon balance, not only just after clear-cutting but also 52 years after the disturbance. The effect of clear-cutting was larger than that of climate, even 52 years later. Disturbance controlled the long-term trend in carbon balance, whereas climate factors controlled the yearly variation. Among the climate factors, increased temperature and severe drought played vital roles in interannual variation of the carbon balance. The three ecosystem compensation points are useful indices for evaluating the recovery of a forest ecosystem from disturbance with respect to the carbon balance."

Specific comment 37:

Table 2 better use 'yes' or 'no' instead of 'occur' and 'not occur'

Reply:

We have revised Table 2 as suggested by the reviewer.

Specific comment 38: Fig 5 upper x-axis label: better write 'years after clear-cutting...'

Reply:

We have revised the x-axis label in Fig. 5 as suggested by the reviewer.

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