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Interactive comment on "Rates and potentials of soil organic carbon sequestration in agricultural lands in Japan: an assessment using a process-based model and spatially-explicit land-use change inventories" *by* Y. Yagasaki and Y. Shirato

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- Thank you for your time and effort with this paper. We have carefully considered all comments and suggestions of the referees (in gray plain text) and respond to each of comments and suggestions in a point-by-point manner.

* : Referee comments in gray plain text

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- : Author reply in red italics
"": Newly inserted or revised text to be used for manuscript for revision in blue italics.

Response to Referee #1

* The authors evaluate the effect of current and future land use and management on soil organic carbon stocks in Japan using modeling, soil carbon monitoring, and various scenarios regarding land use and climate. To start with: The study has a very high information density and is partially difficult to follow because so many different factors and variables were studied. Despite extensive explanations the applied methods are sometimes difficult to comprehend. On the other hand, the authors see many shortcomings in their work, particularly concerning inherent uncertainties in measurements, modeling, and scenarios. I suggest to split the current manuscript into two separate papers, one dealing with the comparison of SOC modeling and monitoring including the method of assigning virtual land use units to the perimeter, and the other one addressing scenarios and their effect on future SOC. In case the authors should decide to revise their paper, more detailed comments below may help to sharpen their work. I suggest copy-editing of the manuscript; many sentences are very difficult to follow and I found some orthographic errors, some examples are given below.

- We appreciate comments and advice from referee, and would like to employ the suggestion from the referee to split the manuscript into two papers, also to respond to comment from the referee #2 to improve the manuscript in terms of readability and conciseness. We have constructed structure of the splitted two papers, as indicated below;

Paper 1:
Main title: Rates and potentials of soil organic carbon sequestration in agricultural lands in Japan: an assessment using a process-based model and spatially-explicit

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land-use change inventories
Sub title: Historical trend and validation with soil monitoring dataset

1 Introduction

2 Materials and methods

2.1 Basic framework of simulation system

2.2 Land-use change

2.3 Soil organic carbon dynamics

2.4 Climate

2.5 Soil

2.6 Agricultural activity

2.7 Simulation

2.8 Validation of model simulation using soil monitoring data

3. Results

3.1 Land-use change

3.2 Agricultural activity

3.4 Soil organic carbon stock-change

3.5 Validation of model simulation using soil monitoring data

4 Discussions

4.1 Historical trends of changes in SOC stock in agricultural lands in Japan

4.2 Uncertainties

4.3 Performance and potential of simulation system to predict SCSC

5 Conclusions

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Paper 2:
Main title: (Same as Paper 1)
Sub title: Future scenario

1 Introduction

2 Materials and methods
2.1 Basic framework of simulation system
2.2 Future agricultural activity
2.3 Future land-use change
2.4 Future climate
2.5 Experimental design of simulation
2.6 Accounting CO2 removals and emissions

3. Results
3.1 Soil organic carbon stock change
3.2 Net-net accounting on SCSC
3.3 Baseline accounting on SCSC

4 Discussions
4.1 Scenario analysis on SOC sequestration potential
4.2 Factoring out direct human-induced influence
4.3 Course of SOC sequestration
4.4 Feasibility of future scenario
4.5 Uncertainties

5 Conclusions

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- Also, we are going to have copy-editing of the manuscript as suggested by the referee.

* P 18360 l 21: Sentence starting with 'scenario analysis' is not clear.

- The sentence will be revised as follows;

"The reduction of CO_2 emission by soil carbon sequestration estimated for a scenario to increase organic carbon input to agricultural fields with intensified crop rotation in combination with suppressing conversion of agricultural lands to other land-use types were comparable to that of business-as-usual scenario which assumed a relatively lower rate of organic matter input to agricultural fields but with an increased rate of abandoning of the agricultural fields."

* P 18361 l 7. Which 'system' is referred to here?

- This referred to the entire simulation system we developed. To be precise, however, this should refer to Module 1 (spatial and temporal inventories) and Module 2 (SOC turnover simulation module) of the system. Module 3 (accounting, either net-net or base-line based accounting) has nothing to do with SOC stock change simulation, but only processes its output. As description on the three modules were shown later in the manuscript, we used the term 'the system' here concisely.

* L 10. What is an 'acceptable level of validity'?

- In line 7-11, we aimed to describe validity of the system we developed with referring to the fact that the SOC stocks estimated by simulation were, in some cases, comparable to those observed in soil monitoring as shown in Fig. 9 in original manuscript. However, now we consider the term the referee pointed out is not suitable to describe it, as we did not laid out discussions or criteria on what is acceptable and what is not. We consider revising the line 7-11, with including additional information to be more

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precise, as following;

"The SOC stocks estimated by the simulation for several soil groups and land-use types were comparable to those observed in nation-wide stationary monitoring conducted during year 1979-1998. While for other conditions the simulation output deviated from the monitoring output which were affected also by setup of initial SOC level."

* L 3 and p 18364 l 18ff. Terms net net, land based and activity based accounting must be explained.

- The line 3 in page 18361 in Abstract will be revised as follows;

"A net-net based accounting on SCSC, defined as differences between the emissions and removals during the commitment period and the emissions and removals during a previous period (base year or base period of Kyoto Protocol), was largely influenced by variations in future climate. This highlighted an importance to apply process-based model for estimation of this quantity. Whereas a baseline-based accounting, defined as differences between the net emissions in the accounting period and the ex ante estimation of net business-as-usual emissions for the same period, was shown to have robustness over variations in future climate and effectiveness to factor out direct human-induced influence on SCSC."

- In addition, the line 18 in page 18364 will be revised as the followings;

*"Two different methodologies have been used to calculate figures on SOC stock-change to be used under current framework of international agreement; i.e. reporting for United Nations Framework Convention on Climate Change (UNFCCC) and accounting for KP (*Prag et al., 2013*), as follows:*

1. *UNFCCC: Reporting based on land area ('land-based').*
2. *KP: Accounting based on specific land-use activities ('activity-based').*

In this study, we employ only land-based accounting. Activity-based accounting employed in KP, defined in 'Supplementary Methods and Good Practice Guidance Arising

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from the Kyoto Protocol' in Chapter 4 of GPG-LULUCF, was not employed in this study to avoid any misleading interpretation on SCSC as this method allows to deal with unequal size of land area between base year and commitment period."

* P 183623 l 15 ff. Various sentences here are awkward and difficult to understand.

- A draft for revision is shown below. Also we are planning to make copy-editing for manuscript for revision.

"For SOC stock-change in agricultural lands, in particular, it is important to give realistic estimates for the stock and flow of livestock waste and manure so that the estimates should be in consistent with estimates for their production, treatment, and consumption (?)Mondini2012). Study done by Koga et al. (2011) *demonstrated that estimation of a regional-scale SOC stock-change could result in figures with large uncertainty due to large variations in parameters used to estimate manure input to soils.*

In this study, we developed a system to perform estimation on SOC stock-change in agricultural lands in Japan, with objectives 1) to give useful output for decision support for policy making concerning a country-scale potential of soil carbon sequestration, as well as 2) to produce figures to be used for national green house gas inventory reporting to United Nations Framework Convention on Climate Change (UNFCCC) and accounting for KP commitment. In order to complete these objectives, the following conditions should be fulfilled, as we implemented in designing and construction of the system;

1. *Use of spatially-explicit land-use change data, rather than statistics on land-use change only weakly associated with other geographical inventories on soil and climate.*

2. *Application of process-based model on SOC dynamics with future climate projections, rather than book-keeping model, e.g. stock-change factor.*

3. *Realistic estimation of the rate of organic matter input to soils with ensuring mass-balance between production and consumption of biomass (manure and plant*

residue).

4. *Estimation of SCSC rate in both base year and reporting/commitment period in line with KP to allow net-net accounting with an intension to assist policy making.*

* P 18363 l 25. As I understand this sentence Monte Carlo simulations were applied but I could not find the corresponding results in the text.

- We did not apply Monte Carlo simulation. As we found the original text somewhat misleading, as the referee pointed out, we revised the text to make this point more clear as follows;

"As to uncertainty analysis, we performed only a limited number of simulation using a set of rather different and contrasting scenarios of future climate and land-use changes, in combination with scenarios of agricultural activity that were calculated with employing only mean, rather than probability distribution function, of each parameters. A lack of a full implementation of uncertainty analysis using Monte Carlo simulations with a set of probability distribution functions on input parameters, that are still under development, may rate the assessment of our current study as preliminary, especially when potential of relatively high uncertainty in a large-scale SOC stock-change estimation due to uncertainty in agricultural activity estimation reported by Koga et al. *(2011) is taken into account.".*

* P 18365 l 10 ff. More detailed information on the decision tree and the assignment of the 9 land use types is needed. For example, it is not clear whether all of these land use types occur in every single grid cell.

- More detailed description on the decision tree and assignment of 9 land-use types are added as a new figure (Fig. 1 in this document) as well as text to be indicated in Paper 1 Section 2.2 Land-use change as follows;

"A decision tree for land-use type identification was created and applied to individual or grouped map legend item(s) in these four different geographical data layers. As a

result, for each grid cell, the decision tree assigned any one of the following 9 land-use types, that are in consistent with six top-level land categories and their subdivisions in GPG-LULUCF (Table A2 in Supplement); i.e. (1) paddy fields (PD), (2) upland crop fields (UP), ..."

* L 25 ff. After reading these sentences it is still not clear how the spatially explicit future land use map was generated.

- A new section was added in Supplement to explain the method to create spatially-explicit future land-use map we developed more clearly. As the referee pointed out, we think that original text described only outlines and not details of the methodology. Now we think it needs to be explained in detail as this methodology is a little complicated, probably a unique approach, and in addition, an important basis for characterization of our study employing spatially-explicit land-use data. We are pleased to follow the referee's suggestion to split the manuscript into two that enables us to insert more detail explanation, as followings;

1) A new text to be inserted in '2.3 Future land-use change' in '2 Materials and Methods', as follows;

"The details on the method to create spatially-explicit future land-use map with specified land-use area target or prediction we developed is shown in Supplement."

2) A new figure (Fig. 2 in this document)

3) A step-by-step guide on the method in the Supplement (Supplement in this response)

* P 18366 l 12. Where do this three groups stem from? Above it is referred to 9 land use types.

- The three geographical zonings were based on administrative zoning for regulation of land-use change in Japan. Land-use change matrix for future land-use map creation was prepared for each of the three different zones. The Land-use change matrix de-

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fines area of land-use conversions to occur for each of 9 land-use types in a period of interest. Graphical explanation on the entire scheme of future land-use map creation is now shown in a new figure to be added in revised manuscript (Fig. 2 in this document).

* P 18367 l 16. I wonder how the phosphate adsorption coefficient was used to tune the decomposition rate of HUM in Andosols? Details are required here.

- The text will be revised to explain details of the methodology as the following;

*"RothC-26.3_v: for all land-use types excluding PD (i.e. UP, OC, MG, UG, FL, ST, and OT) with Andosols. A simple tuning on decomposition rate constant of HUM, expressed as a function of the size of pool of active aluminium bound to humus, had been introduced (*Shirato et al., 2004*). Shirato et al. (2004) introduced a stability factor 'H' (though this was expressed as '$H(f)$' in original text, we alter the expression for the sake of convenience and clarity) for this tuning using the following equation;*

SOC_{obs} - SOC_{sim} = HUM_{obs} - SOC_{sim}
= (H-1) $\times$ HUM_{sim} (1)

H = SOC_{obs} - (SOC_{sim} - HUM_{sim}) HUM_{sim} (2)

Decomposition rate constant of the HUM pool in original RothC model was then divided by the H so that model simulation output agree with the observed SOC content. Shirato et al. (2004) *obtained linear regression model to obtain best fit of the values of H using sodium-pyrophosphate extractable aluminium (Al_p) based on long-term monitoring data at 32 sites with Japanese Andosols;*

H = 1.20 + 2.50Al_p (r^2 = 0.518) (3)

Another recent modification that employs phosphate adsorption coefficient (PAC), more commonly available data attribute in the soil database, as a single parameter for *this tuning (Takata et al., 2011), was employed in this study to assure to run model simulation across entire country. The PAC is used as an indicator for the content of amorphous aluminium and iron soil mineral compounds, as well as criterion for the Andosol group in the Japanese soil classification system. Using similar approach and almost identical dataset, Takata et al. (2011) obtained another empirical model using PAC to obtain the values of H;*

$$H = 1.126\exp(0.00077Al_p)\ (r^2 = 0.57)\ (4)$$

Although, both two models differ in its formulation with respect to soil attributes to take account and thus were leaving space for interpretation or mechanistic explanations, however, should be regarded as simple empirical model made for practical use. Due to limited data availability of Al_p, some previous studies applied equation 3 employed estimation of the Al_p from soil organic carbon content. However, such approach may cause a risk of circular logic as discussed by Takata et al. (2011) and thus should be avoided."

* P 18368 paragraph 2.5 'Soil'. It must be clearly indicated whether all three soil datasets included the minimum information namely soil organic carbon concentration and soil bulk density. Was % carbon always measured with the same method? It is mentioned that gravel content was not considered due to poor data availability. I see this as a crucial factor; the authors acknowledge that this may become a source of error but without a proper error estimate I would argue that ignoring gravel is a major flaw.

- With regard to effect of gravel in estimation of soil organic carbon stock, we totally agree with opinion of the referee that we need to elaborate to give any estimate either on the gravel content itself or the size of error occurred by ignoring it. For this, we developed a new set of methods to estimate SOC stock with taking account gravel content, with including data from the latest soil survey project. For revision, the line

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19-21 in page 18369 of the original manuscript will be replaced with the following text; "For gravel content, 'gravel content in air-dried soil' was used for BSSFC dataset, as a substitute for gravel content in soil core sample to be used for SOC stock calculation. Whereas for stationary monitoring dataset, no data on gravel content was available. We employed gravel content data observed in another latest soil survey project, as shown below, and applied it to the SOC stock estimation for the stationary monitoring dataset;

4. Soil Carbon Survey Project, having been conducted since 2008, with annual interval of monitoring changes in SOC stock, in about 3 000 survey points including managed grasslands for which survey points were missing or included only with limited numbers in the BSSFC or the stationary monitoring, respectively.

- With taking the gravel content into account, the revised estimate for initial SOC stock for year 1970 for agricultural lands (5.49 M ha) was found to be around 438 M tC, about 9 % lower than that of original estimate (482 M tC) (Table 1 in this document). The difference is due to the effect of gravel content. We run simulation with the revised initial SOC and have updated all results on SOC stock and stock-change rate (figures, tables, and body text) to be presented in manuscript for revision. For comparison of original and revised estimate on the SOC stock and stock-change, please see Fig. 3, Fig. 4, Fig. 5 and Fig. 6 in this document.

- With regard to methodology of the measurement of % SOC content in the existing datasets, we acknowledge the comment from referee on the need to clearly indicate it. A new text was prepared to explain this clearly in paragraph 2.5 'Soil' as follows;
"Based on some document-based evidences, observations and knowledge of experts we can indicate the followings;
A) In the BSSFC in year 1959-1977, it is considered that wet oxidation methods (e.g. known as Tyurin method or Walkley Black method) were used as major analytical

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procedures, while including some possibility for a use of dry combustion method in later stage. A document-based, immediate reference on methodology is not available (i.e. at least not attached with the dataset). Conducting a survey through old domestic reports might find some relevant information on the methodology, however, will not be enough to fully elucidate it as many different laboratories conducted the analysis.
B) In the BSEMP stationary monitoring in year 1979-1998, operation manual for soil chemical analysis did specify to use either dry or wet combustion methods and not to use wet-oxidation methods. However, no record on selection of the method exists in the dataset."

- *We regret that we did not elaborate enough to solve this problem before submission of the original manuscript and would like to challenge to include additional measures to give either an estimate on potential errors in estimation of SOC stock or to develop method to correct measured SOC concentration in the dataset (e.g. correction factor), in our study. It may be necessary to employ Monte Carlo simulation to deal with correction factor with assumed distribution as the SOC content measurements were conducted by different methods in different laboratories. We consider such work should be done as a work implementing a full uncertainty analysis including agricultural activity as well as this problem on soil initial state setup. It will be necessary to develop a measure to be able to run a number of spin-up simulations required for initial setup of model SOC compartments in RothC that takes long computation time. This will require a major upgrade of our system, which has been undertaken but will take us some time to complete. With regard to this option, please see also our considerations on the idea to conduct a full uncertainty analysis for agricultural activity scenario including response of NPP to future climate change shown later in this document. As another alternative option, we consider to add the following statement to enable readers to make their judgment and interpretation on strong- and weak-points of our approach, respectively;*

"As to methodologies used to determine SOC concentration in these datasets, it is considered wet-oxidation methods (e.g. known as Tyurin method or Walkley and

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Black method) were used as a major methodology in the BSSFC. No records or document-based evidence on which methodology has been used are attached to this dataset. Whereas in the BSEMP stationary monitoring, either dry or wet combustion methods were used. Although, no record on selection of the method exists in this dataset."

- Please also note that some of descriptions on Japanese soil datasets will be moved to Supplement to reflect the comment from the referee #2, including text for revisions shown above.

* P 18369, agricultural activity. Key to SOC modeling is a reliable estimate of below-ground carbon inputs to soil. How was this estimated? Later it is referred to Shirato et al. (2004) for two out of nine land use types but details are needed here. Table 1 provides some overview but from this it cannot be inferred how inputs were estimated and to what extent belowground inputs were considered at all.

- Belowground carbon input estimation for agricultural lands (PD, UP, OC, and MG) is based on proportion of below ground biomass against yield of agricultural crops reported in literatures. As shown in detail in Supplement C in original manuscript, for crops like rice, wheat, and vegetables, the variable RS2Y (proportion of residues by weight against yield, dry weight basis) in Equation C1.1 includes residues of both above- and below-ground biomass. Whereas for orchards, manure crops, and forage, the variable BG2Y (proportion of below ground biomass against yield in dry weight) in Equation C1.2.2, and RSBGCA (below ground biomass residue input to soils per a unit cropping area in a year) in Equation C1.2.3 and C1.2.4 takes account the belowground carbon input. We agree with the referee that explanation on the belowground carbon input estimation should be shown in body text also. The following text will be added in line 22 in page 18370 of original manuscript;

"Belowground carbon input was estimated based on the proportion of below ground biomass against yield of agricultural crops reported in literatures. Selected equations and parameters used in DTK are shown in the Supplement."

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* L 16. MG was estimated according to the text; why is manure input for MG zero in Fig. 2 (year 1980)?

- The sum of manures applied to PD, UP, and OC estimated for this year based on the questionnaire to farmers almost (referred as AP) equaled to (slightly exceeded) the mass of total available manure estimated by the number of livestock etc.

* P 18376, paragraph 3.4. For future SOC the response of NPP to climate change is an important driver. How was this considered for the scenarios presented here?

- The response of NPP to future climate change is not taken into considerations in the scenarios. Our approach to estimate organic carbon input to soils employs a sort of simple book-keeping approach based on agricultural statistics on yield etc. without any sub-module to deal with the effect of climate changes on yield in future. We acknowledge that the response of NPP to climate change is an important factor that should be taken into account to investigate future SOC stock change. We discussed whether any sub-module should be developed and implemented in the scenario calculation, however, concluded that such work would have to be conducted in a full implementation of uncertainty analysis using Monte Carlo simulation. This requires a major upgrade of our simulation system that has been undertaken but would take us some time to complete. As the first option we would like to only indicate the following statement for readers to judge strong and weak points in the outcome of our study;

"The response of NPP to future climate change is not taken into considerations in the scenarios. The lack of measure to take account it in our current approach would become a shortcoming in our estimation for SOC stock changes in future with different future climate scenarios.

- As the second possible option, we can challenge to 1) upgrade our simulation system so that it will be capable of running a number of simulations for Monte-Calro Simulation, 2) create a set of probability distribution functions for parameters in agricultural activ-

ity estimation including those in a new sub-model to be added in the system to take account the response of NPP to future climate change. This will take us some time to complete, and require re-construction of the manuscript. We leave this as an option to be considered for recommendation and decision by the referee and the editor.

* P 18380, l 19 ff. After reading this sentence I wonder what the alternative explanation for SOC changes might be? Section 4.1. should be more clearly structured with putting the two main mechanisms and their importance in the beginning.

- *We acknowledge that original texts need to be improved with more clear structure as pointed out by the referee. A draft for a revision of Section 4.1 is shown below;*

"The overall trend of the estimates on aggregate SOC stock in agricultural lands in the country showing continuous decrease both in historical and future periods (Fig. 5) indicates that 1) the changes in aggregate SOC stock act as a net source of CO_2 rather than a sink, and that 2) magnitude of the emission of CO_2 will basically decrease over time at long time scale, despite different settings for organic matter input in future scenarios, respectively. The latter statement can also be supported by overall trend in SOC stock-change estimated for a series of decadal periods (Fig. 6) showing smaller magnitudes of the loss of SOC in the later stage in the future period compared with that in the historical period. In addition to these overall trends, in a shorter time scale, however, effects of changes in organic matter input to soils on the aggregate SOC stock-change were found. In the historical period, an increase in the magnitude of aggregate loss of SOC was found, which was attributed to a large conversion of agricultural fields (PD, UP, OC, and MG) to ST or OL (Fig. 2) that lead to decline in the overall rate of organic carbon input to soils, as well as to conversion of PD to UP occurred from 1970's to year 2008 (Fig. 2) that lead to enhancement of SOM decomposition under aerobic conditions. A relatively rapid declines in the loss of SOC were found in early stage of the period with future scenario projections, which were attributed to termination of the land-use conversions from agricultural fields to ST or OT (Fig. 2)."

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* P 18381 l 7. 'archive' should read 'achieve' (?). The whole sentence is difficult to read.

- Yes. It should be 'achieve'. We apologize for mistake. The whole sentence will be revised as following to improve readability;

"The reduction of CO_2 emission by soil carbon sequestration estimated for the scenario MAFF-BP with an increased organic carbon input by intensified rotation in combination with suppressing conversion of agricultural lands to other land-use types were comparable to that of BAU scenario which assumed a relatively lower rate of organic matter input to agricultural fields but with an increased rate of abandoning of the agricultural fields (Figs. 6 and 7)."

* L 22. What is the 'fiscal year' referring to, same as calendar year?

- No. Same as 'business year' or 'financial year'. In Japan, it starts from April and end in March next year.

* L 524-531. These sentences can be omitted.

- We could not identify the above mentioned 8 lines (L 524-531 is probably a miss-typing). If referee mentioned the line 19-26 (8 lines), we agree to omit it.

* P 18382 l 17. I doubt that with the current approach the robustness of the modeling can be evaluated. RothC is a very simple soil carbon model and it is not clear whether its minor response to different climate scenarios is just due to a poor sensitivity of the model to climate variables in general. To factor our direct human influence probably needs a much more sophisticated model framework that also includes vegetation response to climate change as well as a more elaborated soil water sub-model. Also the monthly time step in RothC, which attenuates short term extreme events, speaks against its use for distinguishing direct from indirect human induced influence on SOC.

- In this paragraph we aimed to focus potentials of baseline based accounting, i.e.

comparing a business-as-usual scenario and another future projection, to factor out direct human-induced effect, especially in comparison with a net-net accounting currently being employed in the accounting of SOC stock-changes in land-sector under UNFCCC and Kyoto Protocol. As in the net-net accounting, rather different figures of SOC stock-changes were shown with different climate variables in future. Whereas in the baseline based accounting, the differences were only small. In this respect, we emphasized robustness of the baseline-based accounting, with an aim to provide an evidence to the arena of discussion and selection of the methodology for accounting SOC stock-change in the international agreement framework combating against climate change.

* L 27. It is unclear what the last sentence of the paragraph wants to tell. Maybe omit.
- The sentence was revised as follows;
"There has been arguments that result of baseline based accounting will always be susceptible to how to setup the methodology to draw the baseline. Although, application of process-based model to draw the baseline may contribute to improve fairness and appropriateness, however, transparency in various types of input data preparation must be assured, as we challenged to indicate in this study."

* P 18383 l 25. Is 1.79 Tg CO2 per year meant?
- Yes. Revised as '$\mathrm{Tg\ CO_2\ yr^{-1}}$', also at line 27.

* P 18384. I appreciate it as good scientific practice to always be self-critical with the work we are doing but after reading this paragraph I feel that the authors rise fundamental questions that do undermine their own approach. The same applies for the whole section on uncertainties. Uncertainties are not strictly quantified but discussed in a general way. For example, I wonder why on page 18385 l 17 the authors argue that a full assessment on the uncertainty of input estimates needs to

be implemented but they failed to do so in their study. The reference to Koga et al. (2011) (for manure application) actually underpins how sensitive the conclusion from modeling studies is to parameter uncertainty.

- Firstly, main reasons why we could not have managed to conduct a full assessment on the uncertainty analysis on agricultural activity were 1) development of a set of probability distribution functions for parameters in agricultural activity estimation, as well as preparation of computation system for Monte Carlo simulation for the activity estimation (i.e. migration from spread-sheet calculation software to database or other relevant system), had not been completed yet, 2) a technical barrier to make our country-scale SOC stock change simulation system capable of running a large number of simulations for Monte Carlo simulation. Migration of the system into a large-scale server computing system had been undertaken, but was not ready for use.

We understand the point raised by the referee and consider we need to explain our standpoint.

With regard to the SOC stock-change at country scale we focus 1) its estimates for future, 2) its nature as temporal CO_2 storage (appearance of peak sequestration, time course of sequestration etc.), and 3) the factors affecting to it.

With regard to the 1st subject, and also the 2nd subject to a lesser extent, readers would rate it as having shortcomings and leaving room for interpretation due to a lack of a full uncertainty analysis. Even so, we think still assessment on the subject 3, and to some extent the subject 2, can produce useful output if questions are selected and asked carefully to avoid difficulties derived from the lack of a full uncertainty analysis. For example, we employed scenarios of future land-use change and future climate to have rather exaggerate and contrasting settings to highlight what factors need to be taken into account to challenge to give estimate for a country-scale SOC stock change, and to provide useful implications to policy makers.

With regard to the subject 1, we showed estimates on SOC stock based only on a set of mean values of parameters without dealing with their probability distribution. Validity of SOC stock-change estimates on each future scenario, and, in particular, the

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difference among several future scenarios, will be recognized only if the probability distribution of parameters and hence prediction uncertainty are small. We have a standpoint that it is important to reflect the outcome of the study done by Koga et al. (2011) *into discussions in our manuscript, and not to overemphasize the quantity of the future estimate itself (subject 1), especially for a better support for decision making of policy makers and stakeholders at this stage.*
At current, the work to include a full uncertainty analysis on agricultural activity, and if feasible, on initial SOC level setup, is undertaken, and its prospective outcome will be summarized as individual work for review. Based on the outcome of Koga et al. (2011)*, we think inclusion of full uncertainty analysis as well as realistic estimation on manure input will become a sort of standard or minimum requirement for any regional or country-scale SOC stock-change estimation. In this regard, we will be pleased to challenge to include a full uncertainty analysis for this manuscript (especially for 2nd paper for future estimation), and ask for recommendation, decisions and directions of referee and editor, as it will take some time to complete such work.*

Response to Referee #2

* General comments
* This paper reports a newly developed system for assessing soil organic carbon sequestration in Japanese agricultural lands and results of its application (some scenario analyses). The authors collected and combined various datasets, and tried to include as much detail as they can into the system. I think their trial is interesting and worth publishing. However, partly because of this complicated assessment system and experimental settings, this paper is not readable and concise.
* I would suggest further improvement of this paper in terms of readability and conciseness.
- *We acknowledge that the original manuscript has room for improvement as the*

referee pointed out. We will split the manuscript into two papers to improve readability and conciseness. The structure and contents will be as follows;
Paper 1: Simulation for historical period plus validation based on soil monitoring data.
Paper 2: Simulation for future with scenarios.
Also this idea is in accordance with suggestion from the referee #1.

* Specific comments
* Some of the datasets they showed were not with reference. It is better to show the data source (e.g. web page or reports, etc). In any event, I do not think details about Japanese datasets are needed for international readers; it might be an option to move these details to the Supplement.
- Citation and reference for '(Nihon Dojo Kyoukai , 2006)' will be added in the part describing two sub-datasets 'Daihyou danmen chousa' and 'Kanni danmen chousa' in 'Chiryoku hozen kihon chousa' dataset.
- Details of Japanese soil datasets will be shown in Supplement as suggested by the referee. Please note that description on analytical procedures used to determine soil organic carbon concentration in each dataset (e.g. wet/dry-combustion method, wet-oxidation method, or no such information is available) will be added (probably in body text) corresponding to comments from referee #1.

* This paper includes a lot of abbreviations, which for me makes the paper less readable. I recommend to reduce the use of the abbreviations if possible.
- Agreed. Changes will be made, as listed below for some examples;
1) Names for land-use types will be expressed using full names without using abbreviations (e.g. PD, CL, OC, MG, etc. used in original text).
2) Names for land-use change scenario; URB -> Urbanization, ABN -> Abandoning.
3) Names for datasets and soil survey; BSSFC -> 'basic survey for soil fertility conservation', BSEMP -> Basic Soil Environment Monitoring Project.

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4) Name of toolkit for agricultural activity estimation; DTK -> its full name 'Dojo-tanso-kun' or other alternative expression.
In case some figures need to employ abbreviations they will be explicitly explained in figure caption.

* The amount of discussion is too much. I think the authors can shorten the discussion.
- As we will split the manuscript into two, volume of the discussions will be reduced apparently. In addition, several paragraphs in the discussions will be removed, for example;
Page 18381 Line 19-26: Will be removed.

* Figures:
* Labels should start with a capital letter (e.g. year -> Year).
* Can you improve the captions? Current captions are confusing. For example, if I understand correctly, the same line type with the same color was used for both observed (1970-2008) and BAU. I think the observed and predicted should be shown with different line type.
* I do not think the background color is essential for the figures.
Above mentioned points have all been revised. Please see example of revised figures in this document.

* Technical corrections (typing errors etc).
* Page 18360, line 19: with reduction -> with reduction of ??
Revised.

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Koga, N., Smith, P., Yeluripati, J. B., Shirato, Y., Kimura, S. D., and Nemoto, M.: Estimating net primary production and annual plant carbon inputs, and modelling future changes in soil carbon stocks in arable farmlands of northern Japan, Agr., Ecosyst. Environ., 144, 51–60, 10.1016/j.agee.2011.07.019, 2011.

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Prag, A., Hood, C., and Barata, P. M.: Made to Measure: Options for Emissions Accounting under the UNFCCC., Climate Change Expert Group Paper No. 2013(1), OECD/IEA. available at: http://www.mitigationpartnership.net/oecd-2013-made-measure-options-emissions-accounting-under-unfccc (last access: 03 Mar 2014), 2013.

Shirato, Y., Hakamata, T., and Taniyama, I.: Modified Rothamsted Carbon Model for Andosols and its validation: changing humus decomposition rate constant with pyrophosphate-extractable Al, Soil Sci. Plant Nutr., 50, 149–158, 10.1080/00380768.2004.10408463, 2004.

Takata, Y., Ito, T., Ohkura, T., Obara, H., Kohyama, K., and Shirato, Y.: Phosphate adsorption coefficient can improve the validity of RothC model for Andosols, Soil Sci. Plant Nutr., 57, 421–428, 10.1080/00380768.2011.584510, 2011.

Note on figures

Both revised and original data were shown in Fig. 3 - Fig. 6 in this document for the purpose of comparison.
However, for manuscript for revision, only revised data will be used.
Two new figures have been prepared to be added for manuscript for revision,

Figure Captions

Fig. 1 (NEW)
Diagram on decision tree applied to determine 9 different land-use types based on existing geographical dataset on land-use and vegetation.

Fig. 2 (NEW)
Procedures to create spatially-explicit future land-use map based on the latest land-use map data and target values of the area of each land-use type.

Fig. 3
(Fig. 5 in original manuscript, with revised and original simulation output, including some modification)
Simulation output on changes in soil organic carbon stocks in agricultural lands in Japan with different scenarios on future agricultural activity, land-use change, and climate. Solid and dashed line indicate future agricultural activity scenario BAU and MAFF-BP, respectively. Gray and black colour indicate scenarios on future land-use change pattern ABN (abandoning) and URB (urbanization), respectively. Results with different future climate scenarios, FGOALS B1 and MIROC-H A1B, are lined-up horizontally.

Fig. 4
(Fig. 6 in original manuscript, with revised and original simulation output, including some modification)
Changes in SOC stock in agricultural area in Japan under different future climate projections (FGOALS B1 and MIROC-H A1B; lined up vertically) and future land-use change scenarios (ABN and URB; lined up horizontally). Solid and broken line indicates agricultural activity scenario BAU and MAFF-BP, respectively. Horizontal line indicates SOC stock change rate at year 1990 (mean of year 1985–1995; -1.22 and -0.81 Tg C yr-1, in original and revised estimates, respectively).
Data in original and revised version of the manuscript are shown in gray and black colour, respectively.

Fig. 5
(Fig. 7 in original manuscript, with revised and original simulation output)

Rate of apparent soil organic carbon stock changes in different land-use and period during year 1980–2008 and those projected for period after year 2008 with different future scenarios of climate (FGOALS B1 and MIROC-H A1B, lined-up horizontally) and combinations of agricultural activity (BAU and MAFF-BP) and land-use change pattern (ABN and URB) (lined-up vertically). PD: paddy fields, CL: croplands; OC: orchards; MG: managed grasslands; FL: forest lands. WL: wetlands; ST: settlements; OL: other lands. The rate is expressed as 10 yr mean value. Positive and negative values on vertical axis indicates gain and loss of soil organic carbon stock, which are equivalent to CO_2 removal from and emission to the atmosphere, respectively.

Fig. 6

(Fig. 8 in original manuscript, with revised and original simulation output)

Relative changes in SOC stock in agricultural lands in Japan obtained by baseline-based accounting defined as differences in estimated changes in SOC stock between two different future agricultural activity scenarios, MAFF-BP and BAU, with regarding BAU as baseline scenario (i.e. MAFF-BP minus BAU). Negative and positive value on vertical axis indicates relative removal and emission, respectively, of CO_2. Solid and broken line indicates the estimations with future climate scenario MIROC-H A1B and FGOALS B1, respectively. Ocher and light blue colour indicate results with future scenario on land-use change pattern ABN (abandoning) and URB (urbanization), respectively.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/10/C9063/2014/bgd-10-C9063-2014-supplement.pdf

Interactive comment on Biogeosciences Discuss., 10, 18359, 2013.

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Table 1. Revised estimation on initial soil organic carbon stock for agricultural lands (paddy fields, upland crop fields, orchards, and managed grasslands) in year 1970 and its comparison with the original estimate. Note that soil organic carbon stocks shown in Fig. 3 are estimates for land included in simulation, which includes land other than agricultural lands (e.g. settlements) in year 1970.

Version	SOC (M tC)	Area (M ha)	SOC($tC\,ha^{-1}$)
Original	482.17	5.49	87.8
Revised	438.95	5.49	79.9

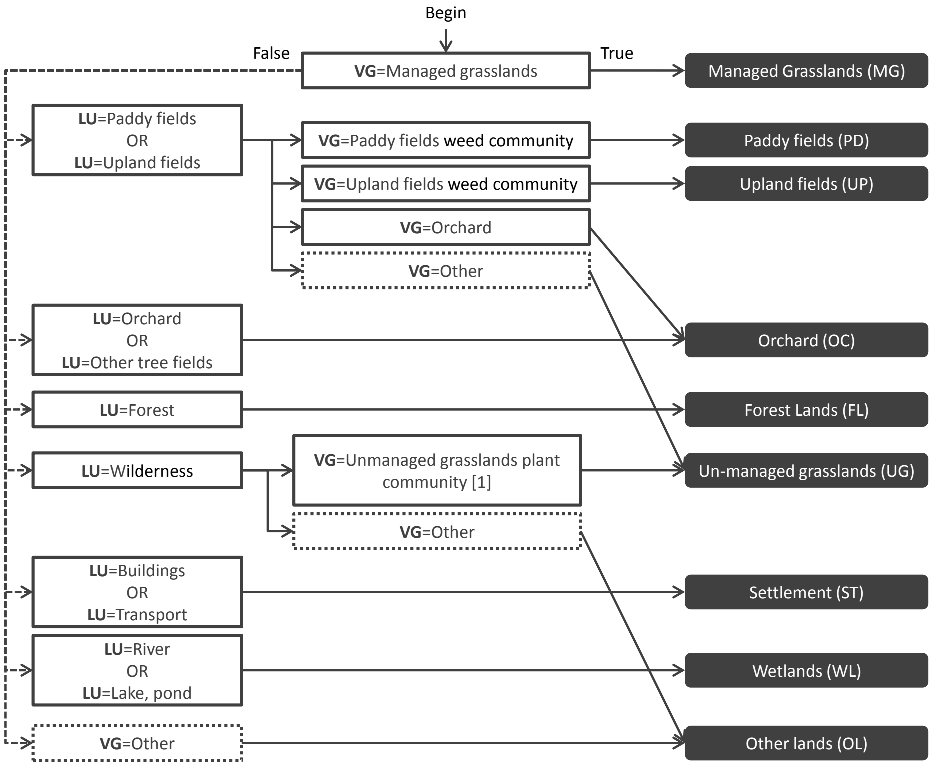

Fig. 1.

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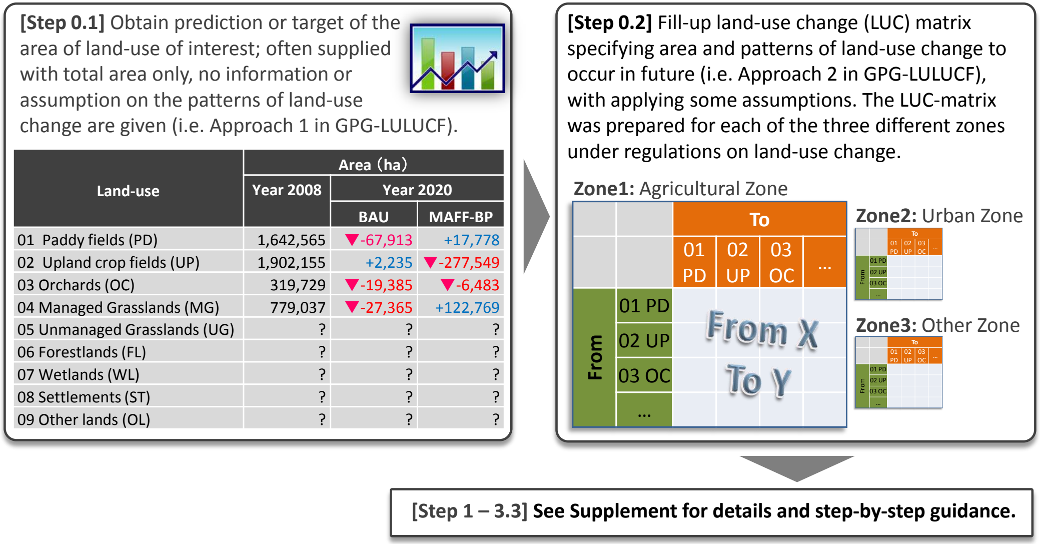

Fig. 2.

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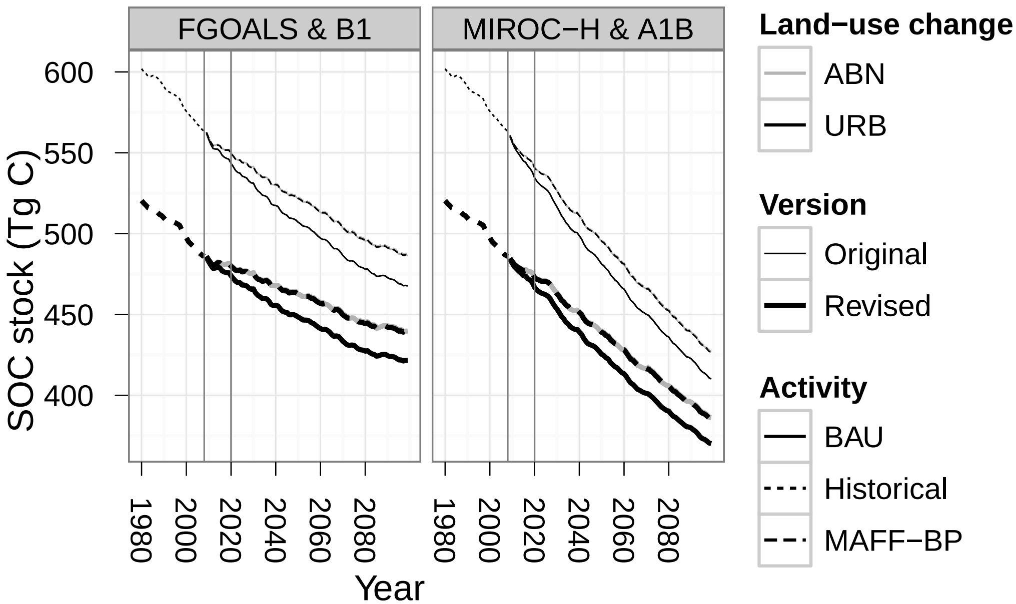

Fig. 3.

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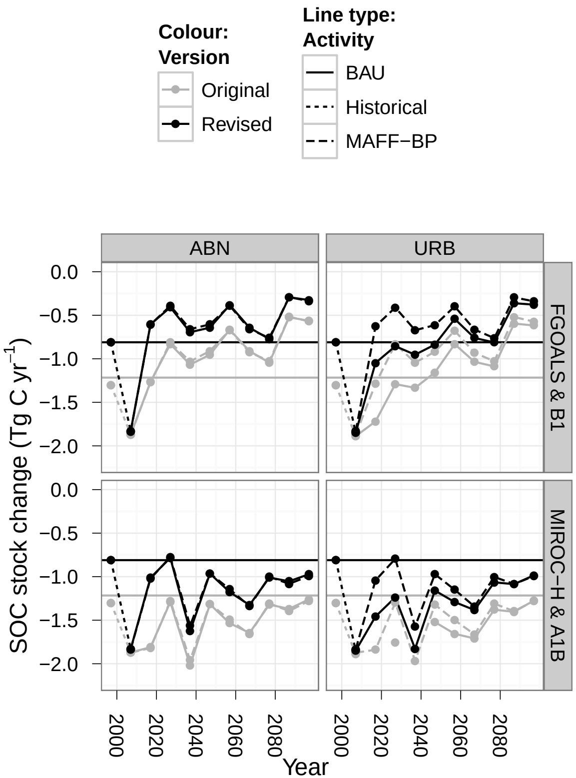

Fig. 4.

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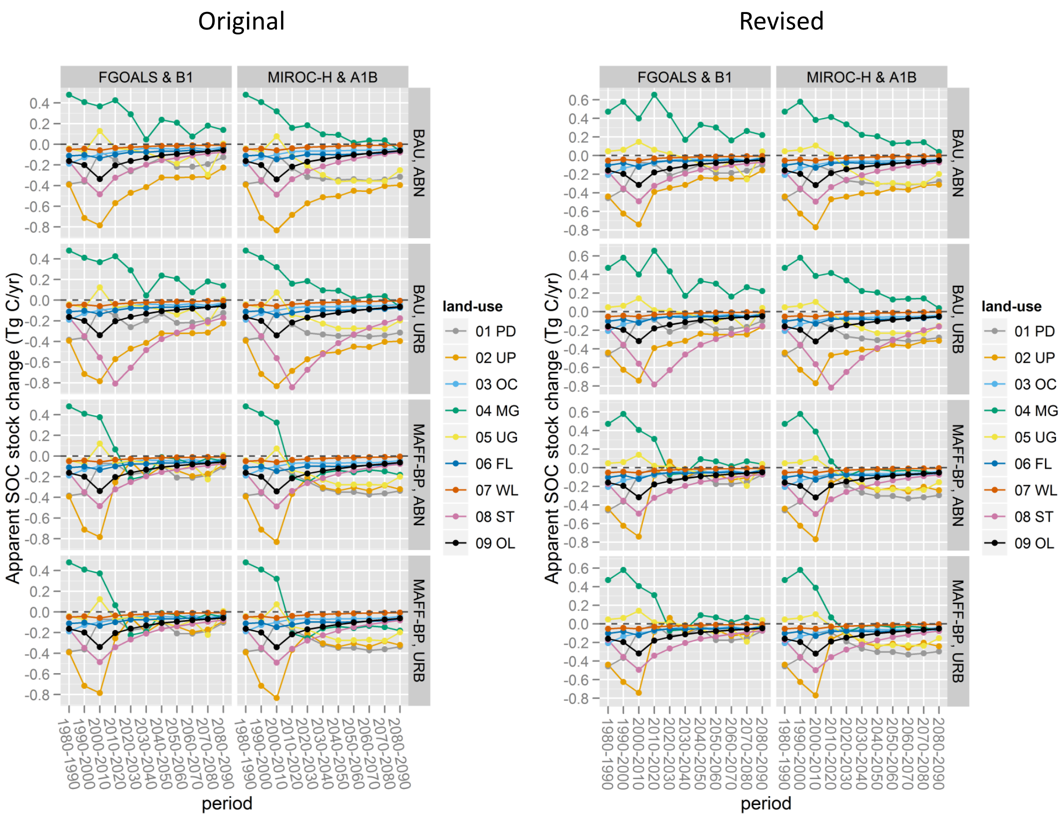

Fig. 5.

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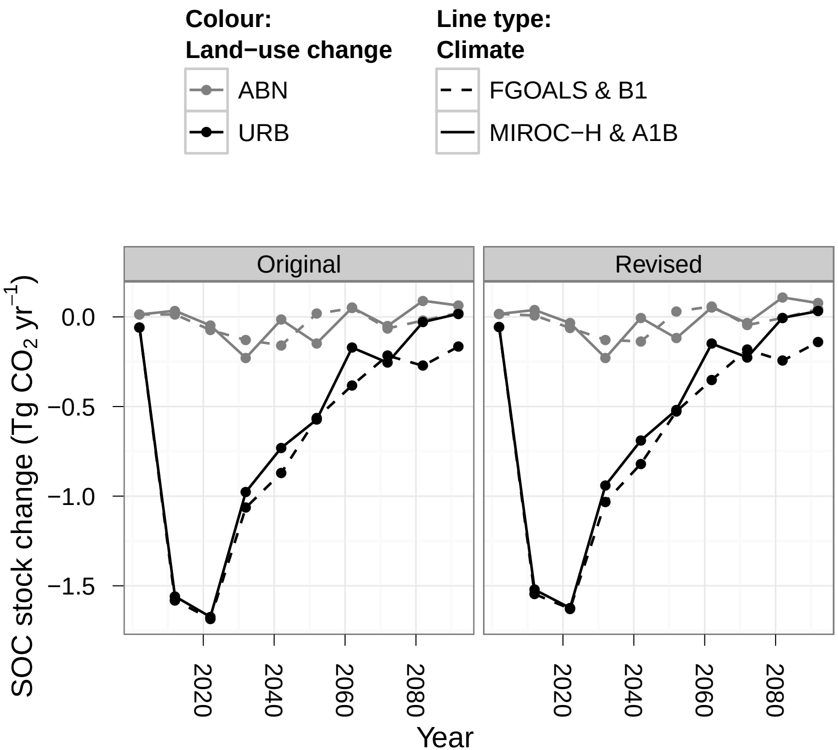

Fig. 6.