[General comment]

This paper describes the downscaling algorithm to generate the gridded data from the regional data calculated by the Global Change Assessment Model. After the explanation of the algorithm, methods of the downscaling evaluation and the sensitivity analysis is described, and finally, the result is evaluated.

Downscaling technique is one of a main topic of climate simulation, this paper will be helpful for understanding the concepts and ideas of this technique. Description of the downscaling algorithm and evaluation methods is so detailed and polite that readers can easily understand it.

But the analysis results seem to be insufficient to show usefulness and advantage of this model. In addition, some more detailed descriptions and modifications seem to be required for better understanding.

We thank the reviewer for his helpful, thorough review of the manuscript. We discuss the suggested changes below and detail their implementation.

[Major comments]

<The result of parameter sensitivity test>

Evaluation of parameter sensitivity summarized in Fig.5 is main topic of this paper. The result, as the author said, is dominated by mainly base year and grid resolution, and sensitivities of other parameters are relatively low. The problem is that, under the default value of base year (1800) and resolution (0.25), the result in Fig.5 can be interpreted that the reproductivity is not so good and this poor reproductivity cannot be improved by changing of any other parameters.

Therefore, I strongly recommend to recompute the parameter sensitivity under the practical base year (1900 or 1950) and resolution (0.25) setting, and redraw the Fig.5in appropriate color scale without base year and resolution to show the sensitivity of other parameters clearly.

We now perform the sensitivity analysis with the 1900 base year, and made the sensitivity to most parameters more visible by reducing the colormap range. To avoid having two colorbars, we kept the sensitivity to base year and resolution in the same figure, with a text box indicating the metric value when it is out-of-range. The original script to generate the figure had an error, and the results for the sensitivity to base-year are now different. The discussion was updated as follow:

"The historical downscaling of LULC change starting from the 1900 base-year is presented in Figure 5. Europe had already acquired most of today's cropland extent by 1900, but all other regions experienced a substantial increase in cropland area, both in the form of intensification (e.g. India) or expansion (e.g. North America). The downscaling algorithm leads to a spatial 2005 cropland distribution that is in general agreement with the HYDE data, yet lacking their smooth patterns (e.g. North America, India in Figure 5b,c). However, this smooth aspect seems to be an artifact of the HYDE data when compared to the MODIS data (Figure 5c and Figure 7a).

The performance metric generally ranges from 0.3 to 0.7 according to the region and configuration considered (Figure 6), indicating that the downscaling allocates fairly well the changes in cropland area (the metric is bound from -1 to 1). Performance and

sensitivity to the downscaling parameters are quite different between tropical, temperate and boreal regions, indicating that LULC dynamics differ and cannot be captured by a single downscaling configuration. Overall, however, sensitivity to the intensification versus expansion ratio and to the relative contribution of kernel density are the strongest, suggesting the importance of proximity to pre-existing agricultural areas for the allocation of new crops. The performance of the downscaling is also clearly influenced by the base-year, especially in the case of tropical regions, and, expectedly, by the aggregation of the output LULC to coarser resolution."

The author shows only the result of crop, but it seems to be insufficient to insist that the downscaling algorithm is really useful. I think that it is necessary to show the result of other land use, at least, the forest case that strongly affects on carbon cycle. Author mentioned about results of parameter sensitivities at P11, L19-L23, but this explanation seems to be too simple. A more detailed description is desired after there-calculation and re-drawing.

The evaluation for forest change is now provided in supplementary material and discussed in the text:

"Performance was also evaluated for the downscaling of forests (Figure S2), which is a critical aspect for many environmental studies (e.g. carbon cycle, biodiversity). The results are mostly relevant for the tropical biome, where the evaluation shows similar patterns of sensitivity to those of croplands. Both temperate and boreal biomes experienced relatively little forest change from 1900 to 2005."

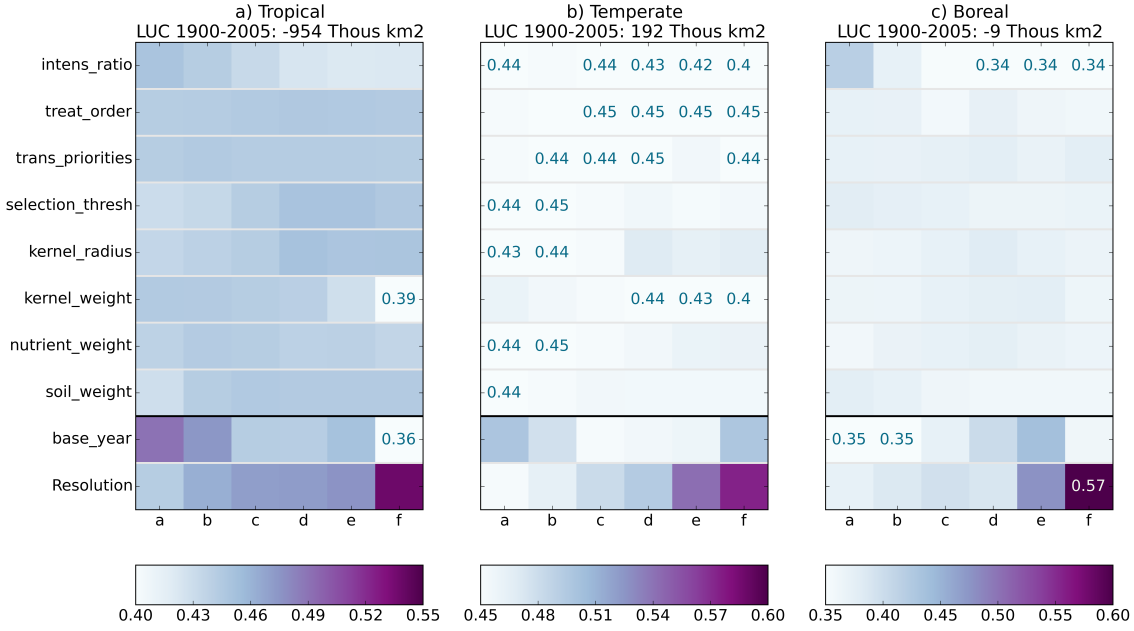

Figure S2. Results of the performance and sensitivity analysis for forests.

Note that we removed the 32 region sensitivity plots as they were not of much support to the results and discussion.

<model description>

Model overview is described in section 2.1. But the description is totally insufficient. For example, the phrase "the terrestrial modules" (P2, L28) suddenly

appears in the section title. Before this section, the author mentioned about "GCAM" and reader did not be given any information about module structure of GCAM. The phrase "Over the spin-up period" (P3, L13) is also the same. The readers not familiar to GCAM cannot prefigure the existence of spin-up period. For better understanding of GCAM and downscaling system, at least, the whole structure of GCAM and the computational flow should be shown in some figures.

An overview of the GCAM model is now part of the main manuscript, complementing the introduction paragraph and giving more details on the representation of the terrestrial biosphere. There is a figure showing the structure of GCAM and the overall computational flow (Figure S1) in supplementary materials, which we suggest to leave there given the more detailed description now part of the manuscript.

<configuration of chapters>

Both downscaling methods and evaluation method are described in section 2. But these methods are essentially different and both are respectively important, and, despite the importance, section number indent seems to be too deep.

Therefore, I think that it is better to separate the description of the downscaling method and evaluation method and summarize the evaluation method and results into new section. Also, model overview is important and is required more detailed description as mentioned above.

As a result, it is preferable to modify the structure of chapters as follows.

before	after
1 Introduction	1 Introduction
2 .1 Overview of the terrestrial	2 Model Overview
2.2 Downscaling method	3 Downscaling algorithm
	4 Evaluation and sensitivity analysis
2.3 Downscaling evaluation and	4.1 method
3.1 Evaluation and sensitivity	4.2 results
	5 Future projections
2.4 Configuration for future projection	5.1 Objective and configuration
3.2 Future land use change scenarios	5.2 results

Thanks! We updated the manuscript with the proposed structure.

<Introduction>

This is a model description paper, so originality is not required so strongly. But generality of the problem and solution is also important for scientific and technical progress, and should not be ignored even in a model description paper.

The author mentioned that spatial resolution is a technical challenge (P2, L11), but only from this explanation, reader cannot judge how this challenge has generality on climate science. Therefore, I ask a presentation of previous studies and an explanation of more detailed background of this study.

The paper clearly lacked a paragraph introducing the importance of land use change projections for environmental studies, which we now address in the revised paper:

"LULC change is a key component of environmental change studies. More than 50% of the terrestrial biosphere has now been transformed to urban areas, croplands or rangelands by anthropogenic activities (Ellis, 2011). Estimates of the carbon budget from historical LULC change range from 12.5% to 33% of all anthropogenic carbon emissions depending on the time period and method considered (Houghton et al., 2012). These emissions combined to LULC-induced albedo and moisture dynamic alterations are a significant – albeit poorly constrained - climate forcing (e.g.Brovkin et al., 2013; Mahmood et al., 2010; Pongratz et al., 2010). The array of LULC changes impacts extends to many other environmental aspects, including biodiversity, freshwater resources and air quality (Foley et al., 2005), hence the importance of projecting future land use scenarios for impacts assessments."

Regarding the issue of spatial resolution, this is really a problem specific to GCAM, and can't be much more discussed than it is. We illustrate the sub-regional, non-regular spatial scale of the terrestrial component in GCAM (the combination of the 32 regions and 18 AEZs), present the approach developed to downscale GCAM LULC to a grid for the IPCC 5th assessment (Hurtt et al., 2011), and discuss the need for a GCAM-specific, flexible downscaling tool.

[Minor comments]

P2,L19: Meaning of the brackets (Kraucunas et al., 2014) is not clear.

Corrected

P2,L31: Correspondence of the brackets is wrong.

Corrected

P3,L13: Does " (1700-2005)" have a specific meaning? If so , description is required. If not, it is an extra information.

This was removed with the mention to the spin-up period (see former comment).

P3,L29: land use and land cover -> LULC

Done

P4,L15-L19: This paragraph should be moved to "Data availability" section.

Done

P6,L16: The code can easily be modified.... If it is so easy, why do not you do so?

We had to stop developing at some point, as there are many other additions that would be of interest for some users and applications (e.g. adding other constrains, having other regional or AEZ-specific parameterizations, etc). It wouldn't be an instant edit to the code though, so we removed "easily".

P8,L2: Sect. 1.2.3.2 -> Sect. 2.2.3.2.

Sorry about that, this was now changed according to the new structure of the manuscript.

P24,Table 7: This table summarizes the parameters about a key topic of this paper. So, it is desirable to show all information without omission. Authors should not expect that readers are so diligent as to refer to supplementary material while reading a paper.

The tables have been moved from supplementary to the main manuscript (Table 8 and 9).