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Interactive comment on “The carbon cycle in the Australian Community Climate and Earth System Simulator (ACCESS-ESM1) – Part 1: Model description and pre-industrial simulation” by R. M. Law et al.

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We thank the reviewer for their comments. Each comment is addressed below with the original review in italics and our responses in normal font.

This is an important study describing the behavior of the Australian Community Climate and Earth System Simulator (ACCESS) for pre-industrial simulations of the coupled global carbon climate system. The paper is well suited for publication in GMD however there are a number of short comings to the paper in the current form. The main concern

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is in the assessment of the CABLE land carbon simulations. While the paper contains a long history of the development of the CABLE model with many references to the various versions of the model and input files, the comparisons between the model versions provides no assessment of the simulated carbon cycle against other models or against observations.

This paper was always intended to be part 1 of a two part study. Unfortunately delays in getting part 2 (Ziehn et al.) submitted have made this paper more difficult to assess and we apologise for this. Part 2 presents the historical simulation for this model and particularly for the land carbon, part 2 is where we compare against observations and other models. We have rewritten the introduction (especially the final paragraph) and the first paragraph of section 4 to try and be clearer about the scope of this paper, noting that aspects of the ocean carbon can be more easily assessed against observations from a pre-industrial simulation while comparisons of land carbon against observations are easier under present-day conditions. Part 2 has now been submitted and will hopefully be available online shortly.

The lack of systematic model evaluation results in a limited framework for the reader to assess the usefulness of the model for historical or projected future climate carbon simulations.

We have aimed to provide complementary analysis across part 1 and part 2 of the study and have chosen to focus in part 1 on the equilibration of land carbon fluxes and pools and on variability. The sensitivity of the model to interannual variations in temperature and precipitation may be useful in understanding how the model responds to future changes in temperature or precipitation. We will make that link clearer in our revised manuscript. We will also check the comparability of our pre-industrial carbon sensitivity to temperature and precipitation with that seen in present-day observations and models (e.g. Fig 6.16, Ciais et al., WG1 AR5 Chapter 6, 2013).

The description and evaluation contain unnecessary detail in some areas such as page

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8 lines 1 to 16.

The page 8 description is part of documenting changes between CABLE1.8 and CABLE2.2.3 in the context of ACCESS1.3 to ACCESS1.4 model differences. While this detail is useful for providing a link back to the ACCESS1.3 published model version we agree it is a distraction from the main ACCESS-ESM description and hence propose to move this material to an appendix.

The climate assessment of the various versions of ACCESS on page 17 is particularly complex and uninformative. It requires the reader to assess a range of unknown models against each other without any observations to assess model bias and variability.

The aim was to demonstrate that there was little difference in our physical climate model simulation from the previously published ACCESS1.3. We agree that the figure was complex and propose to move it to the appendix, replacing it in the main text with a figure focussed around the difference in land temperature between our two ACCESS-ESM1 configurations and how both relate to observations. For the ocean, assessment of the physical climate will now focus on ACCESS-ESM1 rather than ACCESS1.4 and on fields that are most relevant to carbon.

The land carbon assessment comparing the prescribed LAI version of the model against the prognostic carbon model investigates the relative differences in the terrestrial carbon cycle of the models but misses more fundamental metrics. In the introduction the authors refer to two important studies for assessing land carbon simulations and their fluxes to the atmosphere (Anav et al. 2013 and Shao et al. 2013). The paper could be greatly improved by simplifying the model description and the carbon cycle evaluation using the framework and metrics found in these papers. This would provide much needed objective assessment of the ACCESS model against other earth system models and global estimates of the terrestrial carbon cycle.

Our part 2 paper (Ziehn et al) contains many similar assessments to Anav et al and Shao et al, since those assessments rely on model simulations of the present day pe-

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riod. In particular Ziehn et al plot the seasonality of regional GPP and LAI similar to Fig 9 and Fig 11 of Anav et al, and provide timeseries of land temperature and precipitation comparable to Fig 1 and 2 of Anav et al. Global total carbon fluxes are compared with other models based on the data presented in Shao et al, Fig 2 and carbon pools are assessed against the analysis in Todd-Brown et al., (Biogeosciences, 10, 1717-1736, 2013). We have not attempted to reproduce the summary metrics presented in Fig 18-21 in Anav et al., because they would be time consuming to reproduce (being relative across models) and we do not believe they would add significantly to our model assessment.

In many parts of the paper the authors digress into thought experiments about the lack of carbon conservation or unusual behavior in the model but provide no metrics or statistical relationships to support these hypotheses.

As noted by the other reviewers, the lack of carbon conservation is important to understand and explain. We will describe an example transect which illustrates the relationship between rainfall and low leaf carbon. We also now note how the mismatch between leaf carbon pool and LAI leads to issues with the relative magnitude of simulated GPP and leaf respiration. The limited regional extent of the carbon conservation problems will be noted, and the impact on NEE will be illustrated through a supplementary figure.

Therefore in order for this paper to be ready for publication I would recommend the authors simplify the model description down to the relevant information and then provide a systematic assessment of the carbon cycle model against other CMIP5 models and global carbon cycle estimates.

A restructure of the paper to move less relevant model description and assessment to the appendix should help improve the relevance of the main text. For ocean carbon, comparison with other CMIP5 models and global carbon cycle estimates is appropriate for this paper describing the pre-industrial simulation while for land carbon, these com-

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parisons are best undertaken for the historical simulation and hence are presented in the second part of this study (Ziehn et al.).

Interactive comment on Geosci. Model Dev. Discuss., 8, 8063, 2015.

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