Earth System
Dynamics
Discussions

Interactive comment on "Differences in carbon cycle and temperature projections from emission- and concentration-driven earth system model simulations" *by* P. Shao et al.

Anonymous Referee #3

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Authors compare the globally-averaged atmospheric CO2 concentration [CO2] and temperature from concentration- and emission-driven versions of eight ESMs that contributed results for the esmHistorical and esmrcp85 experiments to CMIP5. The results for esmrcp85 experiment have already been analyzed by Friedlingstein et al. (2014) and Hoffman et al. (2014) and I am trying to find exactly what new science does this manuscript contributes. One new idea that is put forward by the authors is the use of ln[CO2] instead of [CO2] in calculating the temperature-[CO2] feedback parameter that was introduced by Friedlingstein et al. (2006). Authors also suggest that ln[CO2] instead of [CO2] should be used in the carbon-climate feedback analyses. While both these suggestions make some sense, the rest of the manuscript somehow doesn't ap-

pear to be the right medium to convey this trivial point since the authors do not themselves perform any carbon-climate feedback analyses. The fact that the additional [CO2] spread in emissions-driven RCP 8.5 scenario leads to higher uncertainty in simulated temperature change for the RCP 8.5 scenario for year 2100 has already been highlighted in Friedlingstein et al. (2014). Besides, the manuscript does not appear to present any comprehensive or new analysis so as a reader I haven't learned anything new. In addition, the manuscript would benefit significantly from basic equations that would introduce the reader to how concentration- and emissions-driven simulations actually work. Finally, it appears the annual cycle of [CO2] for the CanESM2 model is calculated incorrectly or the data downloaded from the CMIP5 archive and used by the authors was corrupted. The correct amplitude of the annual [CO2] cycle from CanESM2's third ensemble member of the esmHistorical experiment is shown in Figure 1.

Other comments

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Line 2, Abstract. " . . . using all eight Earth System Models . . .". What does "all" mean here. Did only eight ESMs contribute to CMIP5.

Line 6, " . . . differences in 2100 vary from −19.7 to +207.3 ppm in emission-driven ESMs.". Please be explicit and say difference compared to concentration driven runs.

Lines 12-14, " . . . while the [CO2] seasonality is simply neglected in concentration-driven ESMs, suggesting the urgent need of ESM improvements in this area." Yes, the CO2 annual cycle is important but why is it urgent. In my mind, the largest uncertainty in ESMs is how the terrestrial carbon cycle responds to increasing CO2.

When reading the abstract a reader does not know how α' is different from α.

Lines 24-25. "This partitioning can be simulated using Integrated Assessment Models (IAMs) (Van Vuuren 25 et al., 2011a) or sophisticated earth system models (ESMs)."

What about observations, don't they tell us anything about this partitioning.

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Lines 7-8. "IAMs were used to provide the atmospheric carbon concentration ([CO2]) trajectories that were then used by climate models to assess the physical science basis of climate change". Replace "carbon" with "carbon dioxide". The later part of the sentence seems to come straight from the IPCC web site and thus reads a bit weird.

Lines 16-18. "The diagnosed cumulative emissions are mostly contributed by the carbon-concentration feedback that is about 4.5 times larger than the carbon-climate feedback (Arora et al., 2013)." This sentence seems totally out of place and does not follow from the sentences before.

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Lines 26-28. " . . . the separation of the carbon–climate and carbon–concentration feedbacks requires additional simulations (e.g. the simulation with 1% increase of [CO2] per year; see Arora et al., 2013)." 1% per year increasing CO2 simulation by itself doesn't allow to calculate the two feedbacks but rather its fully, biogeochemically and radiatively coupled versions do.

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Lines 25-26. " . . . and Arora et al. (2013) gave an initial analysis of the CMIP5 emission-driven runs with a brief introduction to some of the ESMs used here". NO, the Arora et al. (2013) manuscript analyzes concentration-driven simulations.

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Lines 8-9. "The emissions of other greenhouse gases and aerosols are treated as externally specified in both types of simulations.". In CO2 emissions-driven simulation, generally concentrations of other GHGs are specified together with emissions of aerosols.

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Lines 9-10. "The accumulated differences by 2100 over land are close to or slightly greater than those over ocean in all ESMs (Fig. 3b and c)" What do Figures 3b and c has to do with this sentence which appears to talk about carbon.

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Lines 9-11. "Based on mass conservation in the earth system, the total anthropogenic carbon emission can be computed as the sum of changes in the three carbon pools (atmosphere, land, and ocean)." Equations always help. The manuscript, in its current form, does not include any equations that would introduce the reader to the basic C budget.

Lines 21-22. " . . . while the large positive differences in CanESM2 and CESM1-BGC are due to their higher climate-carbon cycle feedback than the IAMs . . .". Something is amiss here and this doesn't seem to be the right justification. CanESM2 and CESM1-BGC have very different carbon-climate feedbacks because CanESM2 doesn't have a N cycle coupled to its C cycle, where as CESM1-BGC does.

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Line 21-22. Please reword the vague phrase - "The global warming spreads from 3.11 to 5.47K . . ."

Lines 23-22. Please reword this sentence or break it into smaller chunks. It is difficult to follow this sentence.

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It is unclear how authors have calculated their α in equation (1).

References

Friedlingstein, P., Meinshausen, M., Arora, V. K., Jones, C. D., Anav, A., Liddicoat,

S. K., and Knutti, R.: Uncertainties in CMIP5 climate projections due to carbon cycle feedbacks, J. Climate, 27, 511–526, doi:10.1175/JCLI-D-12-00579.1, 2014.

Hoffman, F. M., Randerson, J. T., Arora, V. K., Bao, Q., Cadule, P., Ji, D., Jones, C. D., Kawamiya, M., Khatiwala, S., Lindsay, K., Obata, A., Shevliakova, E., Six, K. D., Tjiputra, J. F., Volodin, E. M., and Wu, T.: Causes and implications of persistent atmospheric carbon dioxide biases in Earth System Models, J. Geophys. Res.-Biogeo., 119, 141–162, doi:10.1002/2013JG002381, 2014.

Friedlingstein, P., et al.:Climate-carbon cycle feedback analysis: results from the C4MIP model intercomparison, J. Climate, 19, 3337–3353, doi:10.1175/JCLI3800.1, 2006.

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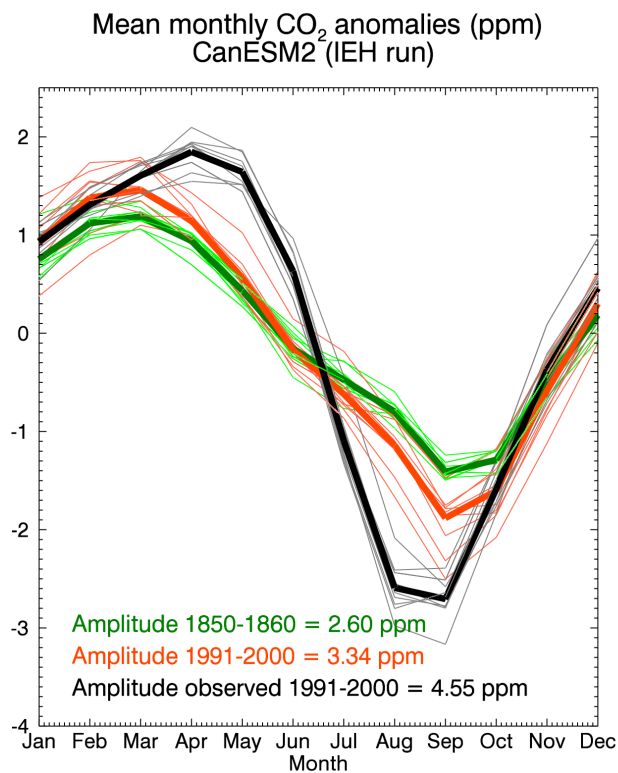
Fig. 1. The annual cycle of mean monthly CO2 anomalies from CanESM2's 3rd ensemble member of the CMIP5 esmHistorical simulation. Thin lines are individual years and the thick line their mean.