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Interactive comment on “Path dependence of climate and carbon cycle response over a broad range of cumulative carbon emissions” by T. Herrington and K. Zickfeld

Anonymous Referee #2

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Summary: Herrington and Zickfeld provide a clearly structured and well-written study which describes and discusses how the transient climate response to cumulative carbon emissions (TCRE) varies with the amount of cumulative carbon emissions and the annual rate of carbon emissions. Besides TCRE, they also look at the potential proportionality of other earth-system components to cumulative emissions of carbon. They find that TCRE declines with higher cumulative emissions and with the emission rate.

Overall the manuscript provides a nice and clear overview of the experiments and describes all results in accessible and balanced language.

There are a few aspects in which the manuscript could be further improved, on the

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one hand by connecting it better to the literature, and, on the other hand, by possibly extending a bit of the analysis. These two aspects are discussed in a bit more detail below.

General comments:

1) Better connection to the literature

The authors have already done a great job in citing and framing their results. However, this connection could be even better. For instance, while the authors cite many studies which suggest that global temperature remains approximately constant for centuries to millennia after CO₂ emissions cease, there is also a recent study which indicates that this should not necessarily be the case (Frölicher et al, 2014). It would be good to cite this study, and discuss possible implications. This is related to the other connection which I would like to see being more elaborated. While the text already mentions the study by Krasting et al (2014), and highlights that they find different results, it would really helpful to discuss why the authors think this is the case. It appears that both studies cited above use a much more detailed ocean representation. A few lines which discuss this would be welcome.

2) Possible extension of analysis

It is a pity that the lowest cumulative emission budget used on this study already brings temperatures to above 2°C relative to preindustrial levels. If computation time permits, I would therefore be strongly in favor of adding a case with, for example, 775 GtC cumulative emissions.

Specific comment:

1) Page 755, line 7: I'm puzzled by the statement "The finding of path independence of thermosteric sea level rise over century timescales is similar to the findings of other studies" with a reference to Bouttes et al. (2013). The abstract of that paper reads: "Whereas surface temperature depends on cumulative CO₂ emissions, sea level rise

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due to thermal expansion depends on the time profile of emissions." To me this reads like sea-level rise is actually dependent on the path that is followed. Please clarify.

References:

Bouttes, N., J. M. Gregory and J. A. Lowe (2012). "The Reversibility of Sea Level Rise." *Journal of Climate* 26(8): 2502-2513. Krasting, J. P., J. P. Dunne, E. Shevliakova and R. J. Stouffer (2014). "Trajectory sensitivity of the transient climate response to cumulative carbon emissions." *Geophysical Research Letters* 41(7): 2520-2527. Frolicher, T. L., M. Winton and J. L. Sarmiento (2014). "Continued global warming after CO₂ emissions stoppage." *Nature Clim. Change* 4(1): 40-44.

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