We thank both referees as well as the editor for their time and care in handling this manuscript. In this point-by-point response, our original responses to the referees have been left in blue text, and the new responses with specific changes are in green.

We again thank the referees and editor for their careful consideration of the manuscript. Our updated January 2022 responses are in magenta. We further address the reviewer 2 comment 2, and in the manuscript, we have also added a new figure 4 and discussion about this figure, demonstrating that the overshoot asymmetry can be predicted by a model's previously-published reported values of ZEC. This additional figure relates to that specific reviewer's comment, as it shows that there is a high degree of consistency between emissions-forced and concentration-forced ESM runs, even under negative emissions, as well as a consistency in Earth system dynamics between zero and negative CO_2 emissions. We thank both the reviewer and editor for the opportunity to respond further to this point, which we believe substantially strengthens the argument in the manuscript.

Reviewer 2 (Victor Brovkin) Comments:

2) Second, there are limitations of concentration-driven runs in analysis of TCRE (Fig. 3). Emissions in these runs are not purely anthropogenic but ESM-inferred emissions. Using monotonously increasing CO_2 scenarios is all right, but when concentrations start to decline, one can do wrong conclusions about temperature-cumulative emissions relationship if interactive carbon cycle is ignored. It is counter-intuitive: after cessation of fossil-fuel emissions in IAM scenarios, ocean naturally continues to take carbon, and ESM-inferring approach would count this ocean uptake as continuing anthropogenic emissions. Really confusing! This limitation must be discussed in depth for Fig. 3.

We will add further discussion of this in revision. However, the point that the reviewer makes here isn't necessarily true, so long as the climate emulator used by the IAM that prescribes the concentration trajectory for a given scenario is doing a good job of emulating the Earth system. For example, in the zero-emissions condition that the reviewer refers to, the atmospheric CO_2 concentration will decline in accordance with the continued ocean carbon uptake. Because ESM-inferred emissions are calculated based on the change in time in the integrated carbon summed across the land, ocean, and atmosphere together, an atmosphere-to-ocean carbon flux should not lead to any inferred anthropogenic emissions at all. If the IAM and ESM were to disagree on the relative amount of ocean and land uptake in response to the forcings, then the atmospheric CO_2 concentration would not reflect the ESM fluxes, and the inferred emissions from the ESMs would deviate from those generated by the IAM and used to construct the scenario, and this is why we compare these quantities against each other in fig. 2a-b.

We have added a new paragraph discussing this point, which reads:

"As these scenarios are concentration-driven rather than emissions-driven, the uncertainty due to carbon cycle processes shows up in figure 3 as a horizontal divergence between ensemble members, rather than a vertical divergence as it would appear in an emissions-driven scenario. However, the self-consistency between the climate and carbon cycles that results from the inferred-emissions approach, as well as the qualitative consistency between the models and the emulator that was used to translate scenario fluxes to atmospheric CO_2 concentrations in the scenario specification, together ensure that the behavior will be similar between concentration-driven and emissions-driven dynamics, even under these extreme scenarios with either very high or net negative emissions."

In the newest version, we have added further detail on this point. In the methods section, we have added another paragraph detailing the logic:

Since the method for inferring compatible fossil fuel emissions from a concentration-driven ESM simulation is based only on conservation of mass, it is equally valid for net positive and net negative CO2 emissions scenarios. However, if the ESMs disagree on the rate of land or ocean carbon uptake with the representation of land and ocean carbon uptake in MAGICC7 used to construct the CO2 concentration timeseries, this disagreement will result in differences between the ESM-inferred and the scenario-specified CO2 emissions. By comparing the ESM-inferred and scenario-specified emissions, we can determine whether any systematic differences between the ESM and MAGICC7 net carbon sinks exist.

Also, we have added another sentence to the paragraph that we had added above, noting that the fact that the ZEC, which is based from emissions-forced runs, predicts the asymmetry in the temperature-cumulative emissions curve, where the emissions are diagnosed from concentration-forced runs, for the overshoot scenario provides further evidence that this comparison can be made.

The consistency between the model dynamics that are concentration-forced here and those of the emissions-forced runs from ZECMIP (MacDougall et al., 2020) further supports the argument that temperature-cumulative emissions relationships between concentration-forced and emissions-forced experiments are comparable even under strong net negative CO_2 emissions.