

## ***Interactive comment on “Earth system responses to cumulative carbon emissions” by M. Steinacher and F. Joos***

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This is a nice, timely paper addressing the issue of linearity between cumulative emissions and a range of climate and ocean variables. The authors also quantify the equilibrium climate sensitivity (ECS) and transient climate response response. For surface temperature this linearity is by now well established (if maybe not completely understood), for other variables not. The main contribution of the paper is that it sets out to investigate this in a structured way with an constraint model ensemble and a large set of emission scenarios. This allows the authors not only to address scenarios uncertainty but also model, response uncertainty. However, it takes several readings to get this message across to the reader, and the paper may benefit from some clear rephrasing of the goals and the steps to approach that. Perhaps a flow chart after figure 1 could

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do that. For instance section 3.1 is entitled climate response to an emission impulse, whereas really the objective is to see whether, using IRFs the response of any variable X is linearly related to the emission pathway. Keeping the reader fixed to that ultimate goal helps the readability. In general the paper is very densely written with little attention to helping the reader stay focussed on the key questions. Some rephrasing and additional lines would be easy to insert, but turn the paper into a real scientific paper rather than a report.

Other comments

Title. It may be worthwhile to insert the word linearity somewhere in the paper. Abstract L 3 is rather than are L4 response rather than responses (and is rather than are) L11 replace in steric by a steric P9841 L10-28. I would prefer to see this paragraph at the end of the introduction. P9846 l 1-3. How much cooling is effected by this assumption, and how does this effect the climate sensitive further down in the paper. This is an important issue, and while the authors appear to be aware of it, they skip over it a little too lightly. P9846 l21 definitions P9847 L21. I do not quite understand why the weighing with the model scores is performed here. I understood that you do that in the first steps, so is this really necessary? Or is it double weighting? P9853. L14. It may be better to use the verb used than ran in the case of the scenarios and refer to Steinacher et al (2013) P9853 L 28-29. I cannot see how the AME scenarios fit in 3c. Do you mean 3b? similarly on 9854 l 14-17. P9861. L 17-20. It may be worth to have a look at van de Werf and Dolman, Earth Syst. Dynam. Discuss., 5, 529-544, 2014

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