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Earth System Dynamics
Discussions

Interactive comment on "Relating Climate Sensitivity Indices to projection uncertainty" *by* Benjamin Sanderson

Anonymous Referee #1

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In the present paper the author assesses the relation of different traditional metrics of climate sensitivity to future warming in a simple climate model framework. Ensemble simulations for RCP8.5 and RCP2.6 scenarios with a two timescale thermal response model constrained by observations are conducted. Two commonly used (Effective Climate Sensitivity (EFFCS) and Transient Climate Response (TCR/T140)), and one new proposed (A140) metrics are assessed. The findings are discussed in relation to CMIP5 and CMIP6 data. The study indicates that sensitivities derived from different metrics are time-scale dependent. Residual drift in the control run can substantially affect the significance. In particular, drift may explain that, surprisingly, EffCS is a better predictor than TCR for CMIP RCP8.5 simulations.

General

Simple metrics like EFFCS and TCR are frequently used to, e.g., assess the climate sensitivity of Earth system models. On the other hand, various studies have documented limitations of such simple metrics, which may lead to erroneous conclusions. Thus, assessing the applicability of such metrics is a valuable contribution. A simple model framework, as used in this study, may by an appropriate testbed providing that the applicability of the results can be conclusively demonstrated. In my view, the present study presents some interesting and valuable results. Overall, it is well-written (though the model description may need some improvement, see below), and well-structured. However, I think that major modifications are needed to justify publication. In particular, with regard to a more comprehensive and clear description of the model (see Major 1 & 2), and with regard to the applicability of the results (see Major 3 & 4). In addition, the author may consider few minor points to further improve the paper.

Major

1) I have problems to completely understand the simple model setup. A more thorough description is needed in my view. As far as I understand, the model consists of Eqs. B1 and B2, together with B3 for including a transient forcing. An optimization procedure is applied to estimate the parameters based on a given data set (HadCRUT) and cost functions (B4-B6). However, I do not completely understand how this optimization defines the parameter distribution (the model ensemble), i.e. how is the distribution exactly derived from the optimization, and how do(es) the distribution(s) look(s) like (a Figures of the pdfs may be helpful in this respect)? Furthermore (random order): (i) in L210 it is stated that CO2 concentrations enter the cost functions, but H(t) and D(t) seem to be heat fluxes (L215)? (ii) How do H and D relate to the parameters r1,r2 in B2 (are they the same)? (iii) Are T_p (B3) and P (B1) the same? (iv) How does F (B3) relate to R (B2) (or how are eq. B1 and eq. B2 coupled in the model). (v) How (where) does the non CO2 forcing factor f_r (L208) enters the equations.

2) I'm wondering how important the non-CO2 forcing agents (L207) and the factor f_r are for the results. How much of the variability of the control (present day) climate is

explained by the non-CO2 forcing, and how is the non-CO2 forcing prescribed in the scenarios (it seems that all is represented by a constant f_r)?

3) Not much attempt is made to evaluate/validate the models behaviour under RCP scenarios. So far (as far as I can see) it is only shown that the model reasonably reproduces the HadCRUT data (where it is constraint to), and gives a response within the CMIP range. It would be useful to show that the model can reasonably reproduce the RCP8.5/RCP2.6 response of one particular model if the parameters are constraint by the present day simulation of the same model. This would give more confidence to the obtained results.

4) One main result is that residual drift may explain 'surprising' results regarding EffCS and TCR in CMIP. From Fig. 3 we see that different CMIP models seem to exhibit different magnitudes of residual drift. I'm wondering whether the simple model result regarding the effect of drift can be qualitatively checked by comparing respective simulations.

Some Minor

1) A common question concerning studies utilizing such simplified models is the sensitivity to the particular choice of the model setup. In this respect, the author may like to comment on the sensitivity of the results with respect to the particular choice of the number of timescales (n=2 in B1 & B2). How different would be the results for n=1 (or n=3)?

2) The author introduces a new metric (A140) as an alternative. It would be useful if the author could illustrate the behaviour of A140 (in contrast to EFFCS) for a CMIP data set.

3) In the abstract, the author quantifies the relative errors for T140 and EFFCS in the simple model framework. As these numbers may certainly not be the same for CMIP model, the may not be part of the abstract.

4) f_r appears twice in Table B1

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