Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2019-90-RC2, 2020

Earth System Dynamics
Discussions

Interactive comment on "What could we learn about climate sensitivity from variability in the surface temperature record?" *by* James Douglas Annan et al.

Anonymous Referee #2

Received and published: 20 February 2020

General comments:

Annan et al study whether the variability can constrain sensitivity in an idealized two-box model setting. They find it works well for lower values of sensitivity although loses power for higher values (around 5K). They also report that using the forced response in addition can constrain estimates further. It is well written and seems to be technically correct. I have a few questions listed below and some minor suggestions for ease of comparison with previous work.

Specific comments:

- Ranges are reported in the 5-95% interval. It would be great to see the 33% to 66% for comparison with the IPCC ranges particularly in the abstract, as was done in Cox et al (2018).
- Section 3.1, p.6, lines 25-30. Is the increasing uncertainty in estimated sensitivity due to the larger timescales in the higher sensitivity models relative to the length of the time series which is fixed at 150 years? If climate sensitivity scales proportionally with timescale then the 1K sensitivity has 10 times greater effective sampling for a finite length record. Is this what's going on here?
- Section 4, p. 11. There are other deterministic forcing factors uniform in amplitude and phase across all the CMIP GCMs (and the real Earth system) not present in the two-box model simulations. These deterministic forcing factors could further separate and discriminate the model sensitivities in addition to the IPCC annual forcing timeseries. Examples of such factors are the diurnal and seasonal cycles of solar insolation. Even though these forcings (and responses) are averaged over when using annual GMSAT, there might still be traces of it in the responses (at least in the more complex and nonlinear CMIP model responses and the real world) and this could act to further help reveal the sensitivity. This is not considered in the ideal model scenario and would be interesting to test in the two-box.
- section 4, p. 12. Worth noting that there are differences between forcing from well mixed GHGs and aerosol forcings. Well mixed GHGs tend to act uniformly over the globe while aerosol forcing is quite geographical. You're not going to be able to compare the effects of aerosol forcing with well mixed GHG forcing in a box model, at least in a simple way.

Technical corrections:

- line 25: The usual approach to integrating stochastic differential equations is the Euler-Maruyama method to simulate the correct variance on the random variable. If the timestep is 1 unit (as it appears here) it shouldn't make any difference but is worth noting for the reader.
- Table 1: Would be good to get all the parameters in the same units as Geoffroy et al (2013a) for direct comparison (particularly C_m and C_d in W yr /m^2/K). I'm aware these are not standard SI units, but just like kWhrs, they are *much* more convenient to calculate with. It would also be good to list the resulting timescale ranges τ_f and τ_s for the same reason.

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