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Comment on esd-2020-85

Anonymous Referee #2

Referee comment on "The potential for structural errors in emergent constraints" by Benjamin M. Sanderson et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2020-85-RC2, 2021

General Comments

Sanderson et al provide discuss the nature of emergent constraints (ECs), particularly the potential role of structural errors in driving uncertaints in ECs. Overall, I found it difficult to know what to do with this paper. While the material is clearly presented and interesting to read, it feels more like a review article or a perspective, rather than a journal article. The discussion is generally qualitative and/or speculative, and I'm still not quite sure what the main takeaways are. The quantitative analysis in the paper is limited to Figure 1, which shows the relationships between a number of previously published ECs, and Figure 2, which uses the simple energy balance models to illustrate different kinds of ECs identified in the paper. The former has been covered in more detail in papers led by Caldwell, Bretherton and Schlund, while the 2-layer energy balance model has been extensively discussed by Geoffroy et al, Armour, and Lutsko & Popp (some of these papers are cited in the present manuscript). Without more novelty or substance, it is difficult to recommend publication, although I enjoyed reading the manuscript.

Moving forward, the authors might want to think of ways to deepen their analysis. One approach might be to develop a mathematical framework or procedure for identifying and speaking about structural errors in emergent constraints. Alternatively, they could focus in on a particular kind of emergent constraint and probe the structural assumptions used by this kind of emergent constraint in more depth. For example, they could dig into the cloud schemes responsible for the process-based constraints on ECS (e.g., the Sherwood, Brient and Zhai constraints) to really understand the underlying structures. A template could be the recent paper by Thackeray et al, which investigates the snow albedo feedback over multiple generations of climate models, including its relationship to the well established emergent constraint on the feedback.

References:

Armour KC (2017) Energy budget constraints on climate sensitivity in light of inconstant climate feedbacks, Nature Climate Change, 7, 331-335
Bretherton, C. and Caldwell, P.: Combining Emergent Constraints for Climate Sensitivity, Journal of Climate, 33(17), 7413–7430. 2020
Caldwell, P. M., Bretherton, C. S., Zelinka, M. D., Klein, S. A., Santer, B. D. and

Sanderson, B. M.: Statistical significance of climate sensitivity predictors obtained by data mining, Geophysical Research Letters, 41(5), 1803–1808, doi:10.1002/2014gl059205, 2014.
Caldwell, P. M., Zelinka, M. D. and Klein, S. A.: Evaluating Emergent Constraints on Equilibrium Climate Sensitivity, Journal of Climate, 31(10), 3921–3942. 2018
Geoffroy, O., Saint-Martin, D., Olivié, D. J. L., Voldoire, A., Bellon, G. and Tytéca, S.: Transient Climate Response in a Two-Layer Energy-Balance Model. Part I: Analytical Solution and Parameter Calibration Using CMIP5 AOGCM Experiments, J. Clim., 26(6), 1841–1857, 2013a.
Geoffroy, O., Saint-Martin, D., Bellon, G., Voldoire, A., Olivié, D. J. L. and Tytéca, S.: Transient Climate Response in a Two-Layer Energy-Balance Model. Part II: Representation of the Efficacy of Deep-Ocean Heat Uptake and Validation for CMIP5 AOGCMs, Journal of Climate, 26(6), 1859–1876. 2013b.
Lutsko, N. J., & Popp, M. (2019). Probing the sources of uncertainty in transient warming on different timescales. Geophysical Research Letters, 46, 11367– 11377
Schlund, M., Lauer, A., Gentine, P., Sherwood S. C. and Eyring, V. (2020) Emergent constraints on equilibrium climate sensitivity in CMIP5: do they hold for CMIP6? Earth Syst. Dynam., 11, 1233–1258.
Thackeray, C. W., Qu, X., & Hall, A. (2018). Why do models produce spread in snow albedo feedback? Geophysical Research Letters, 45, 6223– 6231.

Technical Corrections:
-The title is vague: "On Structural Errors in Emergent Constraints", and again makes it hard to know what the main takeways are.
-In the first sentence of the introduction, I'm not sure it's right to state that higher CO2 concentrations are a "boundary condition which has yet to be realized". Increasing CO2 concentrations doesn't enter the boundary conditions, it adds a forcing term. So I would describe climate forecasting as an initial value problem, rather than a boundary condition problem.
-The paper claims that the Cox and Sherwood D constraints are well correlated with each other. But in fact the correlation co-efficient is only 0.31 (~10% of the variance explained).
-Typo at L610: "wider constrained range wider"
-L654: In terms of multi-metric approches, the authors may wish to cite the "cloud-controlling factor" approach (see Klein et al for a recent review) which has recently shown promise for constraining cloud feedbacks.

References:
Klein S.A., Hall A., Norris J.R., Pincus R. (2017) Low-Cloud Feedbacks from Cloud-Controlling Factors: A Review. In: Pincus R., Winker D., Bony S., Stevens B. (eds) Shallow Clouds, Water Vapor, Circulation, and Climate Sensitivity. Space Sciences Series of ISSI, vol 65. Springer, Cham.