Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2020-16-AC3, 2020

Earth System Dynamics
Discussions

Interactive comment on "ESD Reviews: mechanisms, evidence, and impacts of climate tipping elements" *by* Seaver Wang and Zeke Hausfather

Seaver Wang and Zeke Hausfather

seaver@thebreakthrough.org

Received and published: 14 December 2020

While we thank Referee 1 for their comments on the manuscript, we strongly believe that criticism of our background and employer are inappropriate in the context of this review. Both of us have relevant academic qualifications to do this work, and have published extensively on related topics. At least in the US, it is not at all unusual for researchers working at academic non-profit organizations to contribute to the peer-reviewed literature.

Furthermore, prior to submission of the document we obtained external evaluation from subject matter experts of each topical chapter to ensure that our review of each can-

Printer-friendly version

Discussion paper

didate tipping element was accurate and up-to-date. These evaluators included those named in the acknowledgements: Sijia Zou, Nicholas Foukal, David Archer, Olivier Gagliardini, Ted Schuur, Dirk Notz, William Boos, Laifang Li, Deepti Singh, Daniel Nepstad, Laura Borma, Beth Lenz, Heidi Hirsch, Tapio Schneider, Jacquelyn Shuman, Adrianna Foster, and Richard Betts.

We have worked to resolve the referee concerns about terminology used in describing tipping elements, and extensively updated all sections of the review to reflect the latest literature (and CMIP6 results) that have been published during the past 9 months since this paper was originally submitted. We hope that in light of these revisions you would be willing to reassess the paper; we feel that there is an important gap in the literature at the moment due to the lack of a comprehensive review of climate tipping elements, and hope to provide it here.

We agree entirely with both reviewers that the proper usage of terminology is fundamental to a constructive review of climate tipping elements. Based on the reviewers' feedback, we have thoroughly revised our use of terminology throughout the manuscript. While the terminology adopted previously was internally consistent within the review, both reviewers have accurately pointed out that the usage conflicted with that employed by Kopp et al., 2016. Both reviewers also highlighted that while earth systems drive climate feedbacks, it is not appropriate to label them as feedbacks per se. Agreeing that these revisions to terminology represent essential prerequisites for satisfactorily improving this review, we have now revised the introduction to utilize terminology fully consistent with that proposed by Kopp et al., and revisited the manuscript text, figures, and tables throughout to ensure that the same terminology is utilized throughout the article.

We do however contend that the classification of some tipping elements as "imminent" possesses value in the context of ongoing anthropogenic forcing. Of course a tipping element is not intrinsically imminent or distant, but when considering current rates of greenhouse gas emissions and land use change, it is useful for a review like this to

highlight tipping elements for which current levels of forcing are rapidly approaching critical thresholds.

We agree with the reviewer on the usefulness of better qualifying initial reports on OSNAP array measurements, and have moderated these statements while also adding the following sentence: “However, the time series of observations from this new monitoring array remains quite short, with continued measurements likely necessary to further substantiate these findings.” We do note however that the physical oceanography community is taking this new research finding quite seriously, and while the new measurements are not fully conclusive given high AMOC variability on short timescales, it would not be an exaggeration to note that Lozier et al., 2019 is prompting researchers to reassess the contribution of LSW formation to AMOC.

We have also added additional discussion to further point out that the OSNAP results are hardly the only evidence of a weaker role of Labrador Sea convection in the AMOC, with prior findings from field deployment of RAFOS floats and Lagrangian modeling both raising questions regarding the strength of this linkage (Zou and Lozier, 2016).

In addition to addressing the reviewers’ feedback and comments, we have furthermore considerably updated the body of the revised manuscript to incorporate recent new literature related to each sub-topic that has been published since this review was originally submitted, as well as other relevant literature brought to our attention.

The AMOC: In addition to the above-mentioned changes to the section on the AMOC, we have added several recently-published findings on the lack of a distinct trend in the AMOC’s measured and estimated in recent decades, while also incorporating new modeling analyses showing stronger 21st century weakening of the AMOC in many CMIP6 models.

Marine methane hydrates: We have updated Table 2 with results from the latest Global Methane Budget paper (Saunois et al., 2020) and referenced a handful of recent relevant additional publications. Upon reflection we have also opted to include a passage

on the diverse body of work quantifying and discussing methane fluxes from the East Siberian Arctic Shelf, as while such seepage is neither climatically significant nor the result of anthropogenic forcing, the topic has remained sufficiently proximate to the subject of potential climate impacts from methane hydrates to warrant a concise mention.

Ice-sheet collapse: we have updated this section with recently-published relevant literature examining critical thresholds, positive feedbacks, and tipping behavior for both the Antarctic and Greenland Ice Sheet, including a new study reporting preliminary 2100 SLR projections from ISMIP6. We have also added passages on paleoclimate studies assessing historic ice sheet extent and response under past climates, on atmospheric forcing of Antarctic ice shelves, on ocean forcing of the GIS, and on the wide uncertainty range of future sea-level rise projections associated with ice-sheet loss.

Permafrost thaw and carbon release: Numerous additions. Deeper discussion of resiliency and vulnerability of different permafrost landscapes. Inclusion of additional discussion of changes to northern Arctic hydrology and associated implications for mineralization of permafrost organic carbon. Addition of a passage detailing limitations of current climate models' representation of permafrost dynamics. More detailed discussion of feedbacks between temperature-induced promotion of plant growth and permafrost thaw. Specific updates to literature reflecting the latest Global Methane Budget, initial assessments of CMIP6 performance, and other relevant new papers.

Boreal forest ecosystem shifts: Further discussion of competing feedbacks due to shifts in plant productivity/respiration and composition of boreal vegetation in response to changing climate and fire regime.

Stratocumulus cloud deck evaporation: Addition of a single new reference by the same research group exploring the mitigation potential of solar geoengineering upon this climate tipping element.

Coral reef biodiversity collapse: Addition of some relevant recent papers of interest.

Amazon rainforest dieback: Presentation of updated findings on current rates of deforestation, carbon loss, and forest degradation. Inclusion of new regional studies incorporating results from CMIP6 models, as well as addition of a passage detailing ongoing developments in hydraulic modeling of the response of plant physiology to water stress.

Monsoons: Added discussion of projected changes in monsoon rainfall under CMIP6 models.

Loss of summer Arctic sea ice: Addition of a relevant paper describing CMIP6 Arctic sea ice modeling results, along with some other relevant recent literature.

Zou, S. and Lozier, M. S.: Breaking the linkage between labrador sea water production and its advective export to the subtropical gyre, J. Phys. Oceanogr., 46(7), 2169–2182, doi:10.1175/JPO-D-15-0210.1, 2016.

Saunois, M., Stavert, A. R., Poulter, B., Bousquet, P., Canadell, J. G., Jackson, R. B., Raymond, P. A., Dlugokencky, E. J., Houweling, S., Patra, P. K., Ciais, P., Arora, V. K., Bastviken, D., Bergamaschi, P., Blake, D. R., Brailsford, G., Bruhwiler, L., Carlson, K. M., Carrol, M., Castaldi, S., Chandra, N., Crevoisier, C., Crill, P. M., Covey, K., Curry, C. L., Etiope, G., Frankenberg, C., Gedney, N., Hegglin, M. I., Höglund-Isaksson, L., Hugelius, G., Ishizawa, M., Ito, A., Janssens-Maenhout, G., Jensen, K. M., Joos, F., Kleinen, T., Krummel, P. B., Langenfelds, R. L., Laruelle, G. G., Liu, L., Machida, T., Maksyutov, S., McDonald, K. C., McNorton, J., Miller, P. A., Melton, J. R., Morino, I., Müller, J., Murguia-Flores, F., Naik, V., Niwa, Y., Noce, S., O'Doherty, S., Parker, R. J., Peng, C., Peng, S., Peters, G. P., Prigent, C., Prinn, R., Ramonet, M., Regnier, P., Riley, W. J., Rosentreter, J. A., Segers, A., Simpson, I. J., Shi, H., Smith, S. J., Steele, L. P., Thornton, B. F., Tian, H., Tohjima, Y., Tubiello, F. N., Tsuruta, A., Viovy, N., Voulgarakis, A., Weber, T. S., van Weele, M., van der Werf, G. R., Weiss, R. F., Worthy, D., Wunch, D., Yin, Y., Yoshida, Y., Zhang, W., Zhang, Z., Zhao, Y., Zheng, B., Zhu, Q., Zhu, Q. and Zhuang, Q.: The Global Methane Budget 2000–2017, Earth Syst. Sci. Data, 12(3), 1561–1623, doi:10.5194/essd-12-1561-2020, 2020.

Interactive comment on Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2020-16, 2020.

Printer-friendly version

Discussion paper