

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

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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

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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.

In focusing primarily on terminology, however, we note that the reviewers have largely omitted to discuss the considerable value of the literature reviews we have presented for each earth system component covered. We point out that we solicited the input and feedback of leading experts in the process of preparing each subsection, in order to ensure that our synthesis accurately reflected the current state of knowledge on each sub-topic.

While our chosen format for this review has produced a long manuscript overall, we point out that each of ten candidate tipping elements as well as a section discussing their potential to interact synergistically is presented in just a few pages - close to the minimum length necessary to provide background upon each sub-topic and associated concepts for non-specialists while still highlighting the key relevant findings and current research directions. Our chosen format thus covers a wider breadth of topics than an individual specialized review paper focusing on a single candidate tipping element, enabling comparison and discussion of potential interactions, while also providing needed detail and depth that the short format of Lenton et al., 2008 or Steffen et al., 2018 would not allow. The lack of any comprehensive review of tipping elements in the literature is a notable gap; numerous members of the research community have reached out to us following the online publication of the pre-print, expressing that they found this review to be helpful and see it as a valuable contribution to the literature.

We strongly disagree with the referee's assertion that this review fails to update the scientific understanding of the tipping elements discussed in Lenton et al., 2008. The review presents significant updates in the state of scientific knowledge driven by new research, referencing a sizable body of recent literature, incorporating feedback from experts in each sub-field, and in some cases directly highlighting shifts in scientific

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opinion on specific candidate tipping elements that have taken place since the publication of Lenton et al., 2008, as is the case for assessing the potential climate impact of marine methane hydrate dissociation and for projecting future changes in monsoon circulation, for instance.

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 changes to the section on the AMOC as detailed in our response to Referee #1, 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 (Saunio 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

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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.

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