

Rate-induced tipping in natural and human systems

Reviewer 1 Responses

We are grateful for the constructive reviewer comments received on our manuscript. These comments are repeated below in italic type. Our responses are coloured blue and given in normal type. New text copied from our revised manuscript is presented in quotations.

Response to Reviewer 1

The authors submitted a great, concise review of the phenomenon of rate-induced tipping and showcase it nicely using conceptual models from ecology, climate, and powergrids. I very much enjoyed reading this. The authors accomplished to explain rate-induced tipping in a very accessible manner while being technically fully accurate and still giving sufficient details to allow for an easy reproduction of the examples. The authors might want to take into account some of the very minor comments below; but the manuscript could also be accepted as is I think.

Some minor comments / questions / suggestions (and most are really very minor):

- l6: “an instability that occurs when external forcing varies across some critical rate” - to me it seems this could be misunderstood, maybe “varies faster than some critical rate”

Agreed, we will make the change as suggested.

- l11: I wouldn’t necessarily say that the “changes” are referred to as “tipping points”, the latter are rather the points (in forcing or time) at which such changes occur?

*Yes, indeed this was an oversight on our part, we will make the following revision “The points in time, or the level of forcing, at which such changes occur are commonly referred to as *bifurcation-induced tipping points*.”*

- l19: I think that the seminal paper by Stocker Schmittner (<https://www.nature.com/articles/42224>) should be cited here as well - to my knowledge this is the first paper describing rate-induced tipping effects, at least in the climate context

Thank you we will add this reference in the suggested location

- l52: replace “vanishing” by “sufficiently small”? Also in the next line, “instantaneously” to “fast enough”?

Changes will be made as suggested

- l76: istability → instability

Thank you, we will correct this

- Fig.3: is the axis of (c) logarithmic?

Yes it is indeed logarithmic, we will add the following to the caption “... note the logarithmic scale for the rate parameter.”

- l109: could this sentence be simplified?

*We will simplify this sentence by splitting it into two, writing “However, the added possibility of R-tipping, combined with the symmetric return forcing (see Methods for further details), means that *multiple critical rates* can arise for return forcing profiles with the same peak level. These multiple rates emerge due to the competition between the slow approach rates required to avoid R-tipping and the fast return (and approach) rates required for safe overshoots.”*

- l125: the system has too much inertia?

*The system has too much inertia for the forcing but agree this can be phrased better and so will make the following revision “Then, for even higher rates (the green region to the right of the upper part of the vertical Fold line), both B-tipping and R-tipping upon return can be prevented since the **system processes are not sufficiently fast** to react to a short forcing impulse.”*

- l164: cite some more papers, including some of the older ones, on AMOC collapse here as well?

We will make revisions to the text that will include additional older references.

- Fig.4: show additional panel similar to the one in Fig.5c here as well?

We will create an additional Figure showing the tipping diagrams for the plant-herbivore and AMOC models and provide accompanying text. We believe that adding two panels to the current Figure 4, which already contains 6 panels, will contain too much information for a single figure.

Niklas Boers