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Earth System Dynamics
Discussions

Interactive comment on "How Robust is Your System Resilience?" *by* Mehran Homayounfar et al.

Anonymous Referee #2

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The present manuscript focuses on the relevant concepts of 'robustness' and 'resilience'. The authors revisit the concepts and aim for their proper quantification as well as study the connections between them. In doing so, they present an analytical framework based on a stylized dynamical model [proposed by Muneepeerakul and Anderies (2017)] that realizes a conceptual framework for socio-ecological systems [coupled infrastructure systems (CISs)] to formulate the setting for their proposals and analyses presented in the manuscript.

The authors set forth the boundaries of conditions for the sustainable operation of the aforementioned system. The system may collapse by crossing one of the two boundaries relating to: - a scenario where there is an over-arching requirement of investment for maintaining the infrastructure, such that there is not enough revenue

from the system. In this case, the system may be abandoned for an alternative one, - a scenario where the non-trivial equilibrium state of the system is unstable representing unsustainable maintenance of public infrastructure.

The authors define the measures of robustness and resilience relating to the above boundaries and study the connections between these measures. This reveals certain trade-offs between robustness and resilience of the system, which they relate to choices of certain policies implemented by social agents (e.g., taxation and investment in public infrastructure), internal stresses and external disturbances of the dynamical model considered.

The scope and results of the manuscript are potentially interesting and motivating. The authors hint at the potential implications of their results in 'understanding the interplay between social dynamics and planetary boundaries', whereby crossing the latter may drive the system to undesirable regimes. In this regard, the trade-off between robustness and resilience of a system can be particularly useful for assisting decision makers in governing and/or managing CISs. However, the presentation of the results in the manuscript needs improvement. In my opinion, the article is still premature for publication, but may definitely be considered after an appropriate revision. Also, the authors themselves have realized that variance (as used in the present version of the manuscript) is not an apt measure of robustness since it weighs above mean and below mean values of resilience equally. Thus, further discussion may be postponed until the revised results are presented in the subsequent version of the manuscript.

Specific comments:

1. The authors may consider rephrasing the title to: 'Robustness and Resilience - Quantification, Connections and Trade-offs' to have it more precise and well-rounded.

2. Page 2, line number 13: At this point, the authors may add references to more latest approaches in this direction (in addition to the suggestions by Anonymous Referee #1), such as that taken by - Mitra et al. (2015), An integrative quantifier of multistability in

complex systems based on ecological resilience, Scientific Reports, 5, 16196.

3. Page 3, line number 19: Why are these two conditions referred to as 'boundaries'? Please motivate or rephrase the terminology.

4. Page 3, line number 25: Why only the distance to the boundaries is considered as an effective measure here? What about the overall dynamics of the system within the phase space, or what about engineering resilience?

5. Page 5, line number 17: What is the reasoning behind choosing the ranges of uncertainties in 'g' and 'w' that the authors have used in the manuscript, namely, [75, 125] and [0.75, 1.75] respectively? Please state, if there is any physical reasoning underlying the above choice in order to motivate the reader about the same.

Technical comments:

1. Page 2, line number 16: Please abbreviate SESs prior to their use at this point and thereafter.

2. Page 3, line number 8: Please insert an appropriate reference here ;).

3. Page 3, line number 12: 'of' which 'the' key variables...

4. Page 4, line number 14: Is the Routh-Hurwitz stability criterion being referred to here? If yes, the necessary correction should be made along with the inclusion of a reference in this regard.

5. Page 9, line number 14: The word 'brief' should read as 'briefly'.

6. Page 9, line number 16: 'Eq's (1, 4 and 5)' should read as 'Eqs. (A1, A4 and A5)'.

7. Page 9, line number 22: The comma after 'Muneepeerakul and Anderies' is unnecessary.

8. Page 9, line number 25: The equation number '(A2)' should be indented properly within the same line.

9. Page 10, line number 2: Which Fig. 1 do the authors refer to here - of the manuscript under consideration or that of Muneepeerakul and Anderies (2017)?

10. Page 10, line number 3: 'The' should not be capitalized.

11. Page 10, line number 13: 'Replicator' should not be capitalized.

12. Page 10, line number 24: 'Eqs. 1, 4 and 5' should read as 'Eqs. (A1, A4 and A5)'.

13. This is a general comment concerning all the figures presented in the manuscript. The resolution of all the figures has to be substantially improved in the revised version of the manuscript. The 'x' and 'y' labels of the figures should be made larger in certain figures as well as the sizes of the texts associated with the colour bars in certain figures where they appear.

14. Figure 1: What do the stars represent?

15. Figure 2: What do the colours in Figure 2(a) represent - the standard deviation (\mu_system)? Otherwise, how are the standard deviations in this figure represented?

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