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Earth System Dynamics
Discussions

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

Anonymous Referee #1

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This is an original research article that proposes two novel metrics of robustness and resilience. The authors identify a continual challenge with robustness and resilience: both these properties may require contextualisation. That is, how is robust and/or resilient X to Y. Here, the authors evaluate the relationship between their two novel measures of robustness and resilience. Specifically they explore trade-offs. So not just how does X or Y change as a consequence of changing inputs or assumptions. This has the potential for some significant impact.

The authors in the original submission argue that robustness is the more straightforward property to measure. Since submission the authors have effectively submitted a correction in that they have identified a limitation - or at least undesirable property - of their definition of robustness. Consequently I am not able to evaluate the quantitative

elements of the manuscript. Instead, I consider some general then specific points.

General comments

The work is based on a previously published model. To aid the reader in understanding the model I would suggest reproducing Figure 1 from Muneepeerakul, R. and Anderies, J.M., 2017. Strategic behaviors and governance challenges in socialâĂŘecological systems. Earth's Future.

P7 L4 "She may also be concerned about other system properties, e.g., productivity, user participation, etc. As more dimensions are considered, the set of Pareto- optimal policies grow. In the same spirit as that of the work done here, these other dimensions should be defined rigorously."

This is not a criticism of the manuscript, more of a general observation: defining and including other properties and so adding other dimensions introduces the potential of adding very different measures to the framework. The problem of evaluating "apples to pears". But beyond that there will be unavoidable normative inputs. As the authors note "she may also be concerned about other systems properties". How much which will she concerned? What respective weightings would be given to such concerns? Given freedom to weight different factors, there are potentially a very large number of Pareto-optimal solutions. The authors propose a way to transparently link potentially different properties within a single (or at least well defined) CIS. Explicitly identifying trade-offs is a potentially valuable approach. Rather than address this at the end of the paper Discussion and conclusions, perhaps it could be worked into the paper's main set of motivations?

P7L7 "In the present study, the governance structure, represented by a policy (a combination of ðİŘű and ðİŚę), is fixed. A natural next step is to explore if a policy is allowed to change, how one may improve the resilience and robustness of a CIS and/or alter the nature of their tradeoff."

This is another potential valuable contribution. If one possible impact of this work is to inform policy, then there needs to be an ability to evaluate changes and adaptations of policy in the light of new knowledge. How robustness and resilience changes over time as a consequence of changing policy is a very important research question. I think the authors could argue that in the absence of transparent measure and metrics, attempts to explore adaptive policy may be importantly limited.

Specific comments

"The concepts of "resilience" and "robustness" have grown considerably in popularity as desirable properties for a 20 wide range of systems. Terms like "resilient communities" and "robust cities" have been used more frequently in public discourse."

This requires some evidential support. I also note that some of the key literature is potentially missing. For example, for a discussion on resilience on social-ecological systems, I would expect a reference to material such as Folke, C., 2006. Resilience: The emergence of a perspective for social–ecological systems analyses. Global environmental change, 16(3), pp.253-267. This would help address the first point as this article alone has been cited over 4300 times. Also, more recent work may be required. Holling (1973) is used to initially define resilience. The literature review stops at around 2006/7. Much work has been done since then. Another Folke paper for example: Folke, C., Carpenter, S., Walker, B., Scheffer, M., Chapin, T. and Rockström, J., 2010. Resilience thinking: integrating resilience, adaptability and transformability. Ecology and society, 15(4).

P1 l29 "Robustness may very well be a desirable property of a system, but it seems to come with a price."

The article is importantly about trade-offs. Perhaps also useful to simply point out that this may be an example of no free lunch? Wolpert, D.H. and Macready, W.G., 1997. No free lunch theorems for optimization. IEEE transactions on evolutionary computation, 1(1), pp.67-82.

P2 footnote - I would propose this text is integrated into the main text. Clearly and consistently define all terms.

P2 L16 SES is not defined.

P3 L7 typo: "(cite report of engineers)"

P4 l14 "Routh-Horowitz" this is either a typo "Routh-Hurwitz" or the authors are referring to some other work. In either event, a citation is required here.

Caption text for Figure1 and Figure 2 require explanation of star symbol.

Figure 4 red dots are very hard to see. Also bear in mind that RGB colour blindness may mean it is not possible to discern the difference between the red and blue.

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