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Geoscientific Model Development Discussions

Interactive comment on "Reproducing complex simulations of economic impacts of climate change with lower-cost emulators" *by* Jun'ya Takakura et al.

Anonymous Referee #1

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Summary: The authors present a hierarchy of emulators, which progressively take in more comprehensive input data and have more complicated internals. They show that even linear or quadratic functions of global mean temperature (OLS1/OLS2) provide reasonable estimates of aggregated economic damages, and attribute this to its straight-forward relationship with heat-induced mortality, which dominates the aggregate. For the economic impacts in more complicated sectors, however, more sophisticated emulators perform better. While the present method seems useful, it is not clear to me how the authors envision others will use it– and I do not think they have adequately made their case why others should.

General Comments: This manuscript was a pleasure to read and thoroughly interesting- I commend the authors on their great work! My only comment is that the authors provide no direct evidence of "reducing the implementation and computational costs" of impact calculations (this may be obvious to some expert readers, but not all).

On implementation cost: While running the authors' emulators requires no sector-specific knowledge, interpreting the emulators' results does require domain-specific knowledge (as evidence by some of the nuanced discussions of the limitations of the method in this manuscript). Similarly, many users might wish to re-train the emulators based on different GCMs or IAMs, which again would likely require domain-specific knowledge.

On computational cost: The authors claim, without much evidence, that the computational cost of the emulators is overall much less than the computational cost of the base simulations. They mostly attribute this to the computational cost of the geophysical simulations, and mention that the economic sector models are typically more inexpensive- they even propose a hybrid approach where geophysical impacts are emulators then fed into sector-specific economic simulations. However, there are no specifics about the compute time or memory constraints of any of the methods.

On line 365, the authors state: "While computational cost of emulation is small in the calculation (prediction) phase, even by the most complex emulator used in this study (on the order of milliseconds), the availability of input variables in context-specific. For example, the cost of preparing or generating sub-yearly regional climate variables should also be considered".

I understand why the authors focus on the "prediction" phase, but it would be useful to know more specific about the computational cost of the "training" phase of each emulator, as well as the "preprocessing" phase. In particular, I would recommend the authors make a table of the required for each of these three phases: storage space (e.g. for raw input data) and CPU/GPU configuration and runtime. While I agree with the authors

that using the pre-trained emulators presented by the authors has a negligible computational cost compared to running a full GCM/IAM simulation, it is not clear to me that the entire process of developing-training-running an emulator is more inexpensive.

Is the primary product of this paper a pre-trained "out-of-the-box" emulator that the authors want authors to use? Or is it the method that other authors can follow to develop their own? This should be clarified in the text.

Specific Comments: - I appreciate the authors sharing their code publicly, but would recommend they at least include a README file with instructions on how to run the emulators. It was not obvious to me how I would replicate their analysis based on the files in the Zenodo directory. If the authors want their emulator to be widely used as an alternative to IAMs, I would recommend publishing it with documentation in a version-controlled and public-facing repository, e.g. on Github/Gitlab.

- line 250: the authors should mention here that the performance for aggregated impacts is only good because– based on Supplemental Figure 3 of their 2019 paper– they are dominated (>90%) by heat-related excess mortaility and occupational health costs, which themselves have high performance when just the global-mean temperature is used. This context is quite important and may not be obvious to readers. This is mentioned on lines 299-301 of the discussion, but even then referring to these are the "main contributors" feels like an understatement, given that they represent about 90% of the impacts in almost all scenarios.

- line 329-331: How do we know that such overfitting or "leakage" does not affect other sectors? Should we not also be cautious about other results of the model?

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