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

Anonymous Referee #2

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This paper presents a series of strategies for emulating economic impacts of climate change, progressively adding more explanatory variables and using more complex emulation techniques. The authors consider nine impact sectors under a range of scenarios, considering 5 socioeconomic pathways, 4 climate pathways and 5 climate models (to capture modelling uncertainties). The underlying impacts calculations are complex and cannot easily be performed by non-specialists, therefore justifying the need for user-friendly emulators. The paper was a pleasure to read.

What is the main objective of the paper? Is it to provide a tool for others to use, to provide a methodology for others to apply to their own data, or to use emulation to

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extract understanding of the underlying models? The paper addresses all of these, and abstract presents the main objective as the first "The developed emulators could be used to explore future scenarios related to climate-change policies", but it is not clear how the emulators can be applied at present. What are the likely applications of the emulators, to apply them to another data set, most likely using a different climate scenario (or climate model)? It would be very useful, and appropriate for GMD, if the authors provide documented code in a form suitable for this. For instance an application directory which contains the trained emulators (or code to generate them) and an example input data set, together with detailed instructions how to run the code and construct the input data set.

Relevant to the above, the cross-validation selects input scenarios at random from the 100 combinations (SSP*RCP*model). This is not an especially strong test as the training data will always include some instances of each of the SSPs, RCPs and climate models. A stronger test would be to test under specific LOO assumptions. i.e. How well are the impacts under each RCP estimated from an emulator built only with the other RCPs? How well are the impacts using each climate model estimated by an emulator built only with other climate models? These analyses would give confidence of the applicability to independent climate data, which seems to be where the real power of this approach lies.

The authors use a simple regression fitting. Did they consider building in a stepwise fashion using e.g. and AIC criteria (e.g. stepAIC function in R)? This can significantly reduce over-fitting, especially when there are many inputs, and improve performance under cross-validation. The authors should consider looking at this if, as I suspect, it is straightforward to implement. It may be as simple as adding a line of code e.g.

require(MASS)

model <- lm(output $\sim$ v1+v2+v3+v4+. . . etc) #what you have already?

model <- stepAIC(model) #remove terms that don't satisfy AIC

I was not convinced by the correlation between model fit and impact magnitude (Figure 7 etc). I would like to see these data points labelled by sector. For instance, the largest impacts are heat-related deaths and occupational health. These are both temperature-driven impacts and I would expect them to be easier to emulate because precipitation is more difficult to model and with a more complex spatiotemporal response. Conversely, the most difficult impacts to emulate are fluvial floods and hydropower, which are likely sensitive to the details of the precipitation projections. Related to this, I do not regard the statement that aggregate impacts are easier to emulate as being robust. I suspect this result is a function of the data set, reflecting the fact that the largest impacts are (happen to be?) in those (temperature-dependent) sectors which are the easiest to emulate?

Line 59 should mention Gaussian Process emulators as an alternative to ANN. At least some of the cited references used GPs. This is a widely used emulation approach and has a number of advantages, most notably by estimating the uncertainty of emulated predictions.

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