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Discussions

Interactive comment on "Telling the boiling frog what he needs to know: why climate change risks should be plotted as probability over time" *by* Simon Sharpe

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I'm grateful for these helpful comments.

I realise I should have made clear, and will do in amending the paper, that I'm not proposing that all climate science should be done this way. Clearly, if John Tyndall hadn't been interested in the molecular physics of radiant heat, and if a century's-worth of scientists after him hadn't pursued fundamental research into the physics of the climate and all the workings of the Earth's systems, then policymakers wouldn't have any questions about climate change for any scientists to answer. I have a deep respect for fundamental research, and recognise it as the foundation that makes any

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Discussion paper

policy-related inquiries possible. It's right that most science should be science-led.

I am in complete agreement with the reviewer's conclusion that a 'substantial rebalancing' towards the approach I'm advocating – not a complete conversion – is what would be appropriate and valuable. My concern is that within the vast body of research being done on climate science, not enough is being done with the express intent of informing risk assessment. To give an example: when I served on the UK's delegation to approve the Summary for Policymakers (SPM) of the AR5 Working Group 2 report on Impacts, I was surprised that mention of research finding that heat and humidity conditions could potentially exceed the limits of human physiological tolerance for heat stress was not being included in the SPM. I asked the lead authors whether they doubted the validity of this research finding. They said no, and that if anything, it probably understated the risk – but the rule was that a finding could only be mentioned in the SPM if it was supported by at least two separate pieces of research. And of the more than 12,000 scientific papers cited in the WG2 report, only one had asked whether a warming planet might at some time, in some places, become too hot for people. (Meanwhile, I found WG2 cited nine studies that looked at the impacts of climate change on ski resorts in Europe, and thirteen studies that considered the impacts on European grape growing and wine production.)

I agree that even when research is done for the purpose of informing risk assessment, it is unlikely to be a simple process of scientists answering policymakers' questions. It is more likely to need a dialogue to arrive at a shared understanding of what is possible, knowable and relevant to people's interests.

The point about uncertainty is really important. It's fair to say that the simplest approach to estimating probabilities of specific climate impacts will be through the use of computer model ensembles, and there are undoubtedly risks to this. The graphs of global temperature increase shown in Figures 2 and 3 of this paper were produced with models that did not incorporate earth system feedbacks; other work by the same authors [1] has shown that when these feedbacks are incorporated, the estimated probability

of a given degree of temperature increase is substantially higher, within a wide range of uncertainty. As the actuaries wrote in our climate change risk assessment report [2], models are imperfect, and a factor that is important in determining risk should never be excluded from consideration simply because it cannot be quantified.

Having said that, I don't think the proposed approach – of assessing the probability of crossing a non-arbitrary threshold of impact as a function of time – necessarily implies using a model, or even making quantified estimates. The IPCC AR5 WG1 Chapter 12 on 'long-term climate change: projections, commitments and irreversibility' included a table [3] showing the estimated likelihood of specific abrupt and irreversible changes in the climate system occurring during the 21st century. These likelihoods were estimated using expert judgment, and were expressed in terms such as 'very unlikely', 'possible', and 'likely' instead of being quantified. The table would have been consistent with the approach I'm proposing if it had indicated how these likelihoods could change as a function of time or global temperature increase. To the extent that such a time-dependent assessment could have been supported by the science, it would have been useful.

Unquantified and judgment-based estimates of probability are common in other areas of risk assessment. A good example is counter-terrorism, where the UK government uses five 'threat levels' to indicate the likelihood of a terrorist attack in the UK [4]. These are: Low - an attack is unlikely; Moderate - an attack is possible but not likely; Substantial - an attack is a strong possibility; Severe - an attack is highly likely; Critical - an attack is expected imminently.

In situations where there may be great danger, expert assessments such as these can be useful despite their deep uncertainties. I think the important thing is to use the best available information (whether quantified or not) to give the fullest possible assessment of the risk.

What I think this means for the recommendation about research funding is that it should

be driven not so much by the need to answer specific questions, but by the need to rigorously assess specific risks. If the purpose of a research call is understood to be risk assessment, then it should be carried out in accordance with general principles and best practice of risk assessment, which should include as a priority the robust consideration of uncertainty assessments.

As mentioned above, this is only proposed as an approach for some research calls, not for all of them. And I agree, it is not a panacea.

References

[1] Lowe, J.A. and Bernie, D., 'The impact of Earth system feedbacks on carbon budgets and climate response', Philosophical Transactions of the Royal Society, Vol 376 Issue 2119 (2018) https://royalsocietypublishing.org/doi/full/10.1098/rsta.2017.0263

[2] Hare, D., 'An Actuarial Perspective' in King, Schrag, Zhou, Qi and Ghosh, 'Climate Change: A Risk Assessment' (2015) pp20-21 http://www.csap.cam.ac.uk/links/13/1032/

[3] Table 12.4 on p1115 of Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner, 2013: Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter12_FINAL.pdf

[4] UK Government, 'Terrorism and national emergencies' https://www.gov.uk/terrorism-national-emergency

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