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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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Thank you for the thoughtful and constructive comments. I'm happy to take all of these on board. Responding to each in turn:

It's wonderful to know that work is going on to identify relevant impact thresholds for discussion in AR6. I agree identifying meaningful thresholds is not always easy. I think in most cases it takes a fair amount of expert judgment – for example, even in relation to a biophysical threshold such as the limit of human tolerance for heat stress, a judgment has to be made about how many hours of heat and humidity conditions above that limit is to be defined as an instance of 'crossing the threshold', around which estimates of

probability (as a function of time) can be made. I'm happy to give that difficulty more acknowledgement. I suppose one way of saying this is that in almost no case is there a single 'correct' definition of the threshold, and this makes it difficult to choose the one that's most appropriate. At the same time, I'd argue that almost any reasonably defensible choice of threshold is better than no choice at all.

I also agree that many thresholds will be specific to their location, and so not applicable at a national or global scale. A good example of this was once recounted to me by a very experienced climate scientist in the US. After I had outlined to him my argument for taking a probability over time approach, he recalled one time his research team had done that. They had asked a city government what level of extreme rainfall they were worried about. The city government said it was X inches of rainfall over a period of Y hours (I don't recall the numbers, but they gave them), because this was the level that caused the city's sewer system to overflow, bringing faeces floating onto the streets. (That was their non-arbitrary threshold). The research team went away and came back with a plot of the probability of faeces floating in the streets as a function of time. The scientist told me that in all his years of advising this city government, he could not think of any other time when his advice had made such a strong impression. It was a great example of a non-arbitrary threshold, but perhaps not a widely replicable one.

Despite the local specificity of many thresholds, I think a collection of threshold-based risk assessments could add real value to either a national or a global assessment. For example, knowing that several parts of the world could exceed human tolerance for heat stress, that many places could exceed the temperature tolerances for several important crops, and that other places could fall below socioeconomic thresholds of minimum renewable water resources, can greatly enrich our understanding of the scale of the risks facing the world as a whole. There is no need for this information to be aggregated into global-scale metrics, or even for the same thresholds to be used for different regions, for this information to be useful. There may be an issue here that is beyond the scope of this paper, but I wonder whether there is a difference between the value of consistency of measurement for the purposes of advancing scientific understanding, and the value of diversity of measurement for the purposes of informing a risk assessment.

The main difficulty I've mentioned in the initial draft of this paper is the need to start – before doing any science – with a subjective question: 'what is it that we wish to avoid?' The point I'm making here is about the order in which things need to be done. In the heat stress example mentioned in the paper (and presented in this report http://www.csap.cam.ac.uk/projects/climate-change-risk-assessment/) the order was: first, have a policymaker define an issue of concern (environmental conditions exceeding human tolerance for heat stress); second, have an expert in the system of concern (human health) from the WG2 community define a meaningful threshold in relation to that system (X hours above Y degrees WBGT); and last, have an expert in the physical climate from the WG1 community estimate the probability of crossing the threshold as a function of time, for some regions where it looks likely to be a problem. Done this way round, it's quite feasible, but if you start with the WG1 science, it's almost impossible. I'd be interested to know whether you agree.

Regarding global warming thresholds, I'm happy to make an explicit mention of the fact that, as you say, 'there is no such thing as an absolute threshold below which we are safe and above which we are toast'. This is clearly true. I think thresholds with a physical basis are likely to be the most dangerous to cross, and so are particularly important to investigate. Socioeconomic thresholds may perhaps be more amenable to adaptation. What I've called 'experiential' thresholds may have only transient value – they are meaningful only for as long as people have strong memories of the original event. I think it would be going too far to attempt to rank different kinds of thresholds by how 'non-arbitrary' they are, but I agree it is important to distinguish between them, and useful to recognise their different characteristics.

The Gavin Schmidt piece is very good, and makes the point well that there is not just one tipping point in the climate system. It also illustrates the difficulty of defining

meaningful non-arbitrary thresholds in relation to changes in the climate system itself (strictly within WG1 scope), as opposed to thresholds in relation to impacts on people (WG2 scope, to which everything I've said above refers). However, it seems that even the relatively feasible examples are not always communicated as clearly as they could be. Schmidt gives the disappearance of the Greenland Ice Sheet as one of the best examples of a 'point of no return'. The IPCC's Special Report on 1.5°C did helpfully mention that 'these instabilities could be triggered at around 1.5°C to 2°C of global warming', but gave most prominence to the impact-over-time finding that the most likely global sea level rise at 2100 would be around 10cm lower at 1.5°C than at 2°C. It might have been more helpful to compare the probability of triggering disappearance of the GIS at (a sustained) 1.5°C, compared to that probability at 2°C. If illustrated by data such as those underlying figure 13.14c in AR5 WG1, this could perhaps have presented a very powerful picture of the difference in risk between the two levels of warming.

Finally, regarding shaded uncertainty bands, I agree this is worth mentioning. I thought I had done so, but hadn't. I'll add this in. A spectacular example of shaded bands showing the range of risk is figure 12.5 from AR5 WG1, which shows the uncertainty around long-term global temperature increase. Within the set of impact over time graphs, I have found these two (AR5 WG1 12.5, and 13.14 as mentioned above) exceptionally useful for communicating the extent of the risks, but have never met another non-scientist who was aware of them – probably because they were not included in the SPM. I can only guess they were excluded from the SPM because they were considered too long-term to be policy relevant, but arguably, since they show the largest risks, they are the most policy relevant of all. I think including long-enough time horizons for the largest risks to be visible in all SPMs could be helpful – and would be consistent with the general principle that a risk assessment should always consider the biggest risks.

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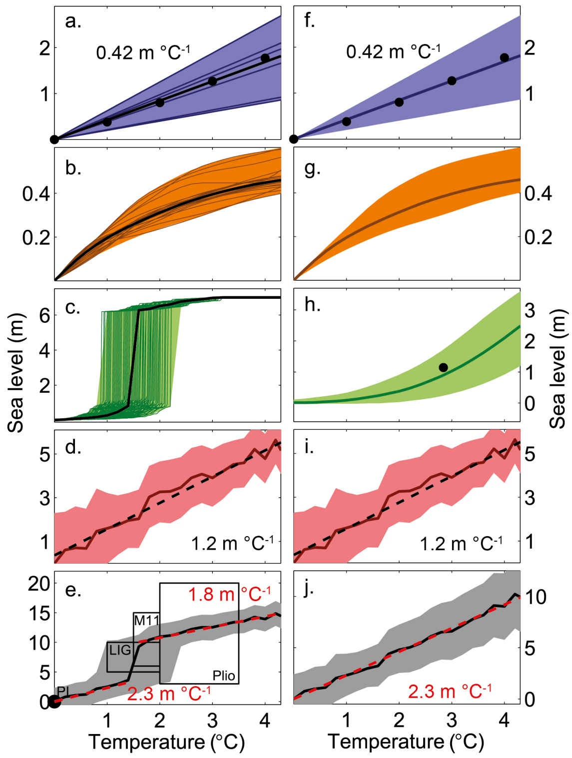

Fig. 1. Figure 13.14 from IPCC AR5 WG1

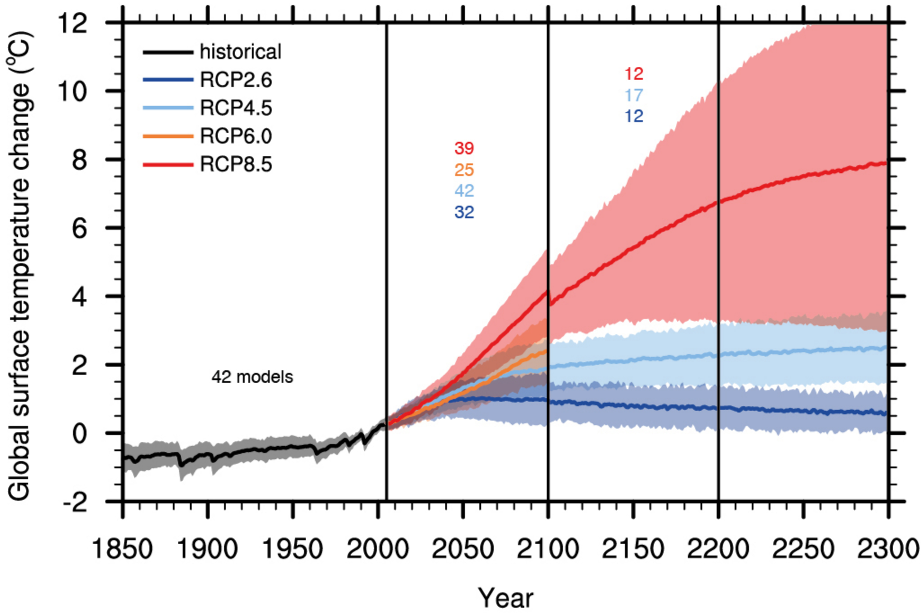

Fig. 2. Figure 12.5 from IPCC AR5 WG1