Connecting climate models to community needs

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It is increasingly being recognised that although there is a need to anticipate future climate change so that we can respond to it with forethought, a 'predict then act' approach to climate adaptation might not be appropriate as plans that seem optimal under one future scenario might come to be regretted if future conditions are different to what was projected (Johnson, 2021). Yet, climate models have already generated so much information about the potential futures of our planet that climate scientists are now grappling with how to continue storing all the data (Baker et al., 2016). We need to reflect on how such information can inform climate action in ways that are meaningful and not maladaptive, and this requires a conversation about what climate models are, what information they can provide, and how to make it 'usable' (Dilling and Lemos, 2011) for communities.

Though there exists a spectrum of tools of varying complexity that could be described as climate models, often when people refer to 'climate models', they are referring to state-of-the-art global climate models that feed into IPCC Assessment Reports. These models work by dividing the world into 3-dimensional grid boxes, and calculating the flows of energy and moisture between boxes, and correspondingly, the resulting climate variables like temperature and precipitation.

Climate models need to be fed information about what the concentration of greenhouse gases in the atmosphere are going to be in the future in order to model the response, and this commonly comes a set of scenarios. Representative Concentration Pathways (RCPs) (van Vuren et al., 2011) were used in the Coupled Model Intercomparison Project Phase 5 (CMIP5), the modelling effort that fed into the IPCC Fifth Assessment Report. These pathways of future climate forcing were designed to be compatible with a range of different possible futures, rather than being consistent with a specific set of policies. The latest modelling from CMIP6 has started to use Shared Socioeconomic Pathways (SSPs) (O'Neill et al., 2014), in which future climate forcing scenarios *are* underpinned by specific narratives about potential futures (Figure 1). At the moment, cumulative emissions and emissions under stated policy goals track RCP 8.5 most closely (Schwann et al., 2020). But by quantifying the impacts associated with this scenario, we're dynamically altering the probability attached to it; in essence, having this information about the future creates potential to change it.

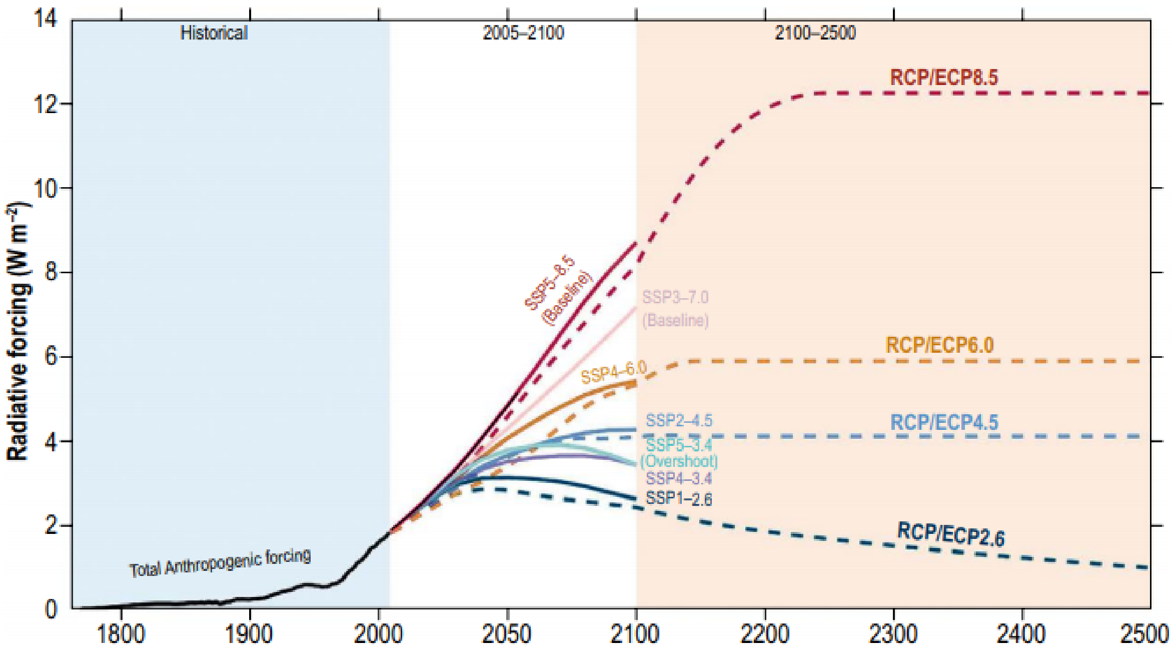

Figure 1: Radiative forcing (W m–2) time series for historical data (1765–2004), and for future scenarios from the Representative Concentration Pathways (RCP; 2005–2100) and their continuation as the extended RCPs (2100–2500), and the Shared Socioeconomic Pathways (SSP; 2005–2100). The RCP scenarios are shown as dashed curves, and SSPs are shown as solid curves ('Marker' scenarios are used). Note the change in x-axis scale for the 2005–2100 interval to give an improved illustration of radiative forcing scenarios during the 21st century.

Source: Abram, N., J.-P. Gattuso, A. Prakash, L. Cheng, M.P. Chidichimo, S. Crate, H. Enomoto, M. Garschagen, N. Gruber, S. Harper, E. Holland, R.M. Kudela, J. Rice, K. Steffen, and K. von Schuckmann, 2019: Framing and Context of the Report Supplementary Material. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)].

In this way, climate modelling results are very different to, say, a weather report. When we are looking at climate modelling runs out to the end of the century, we are not looking at a forecast of what will happen day by day or even year by year, but information about how the climate might respond over the long term to human influence. Some scientists make the distinction between 'predictions' and 'projections' to convey this nuance (Bray and Von Storch, 2009).

Let's say a risk averse decision-maker decides to act with RCP 8.5 in mind, considering it the worst case scenario. They would likely find that different models yield slightly different results for the climate parameters of relevance to them, because modelling centres have built their climate models in their own way. As scientists learn more about the climate system, new components are introduced. Additionally, since some processes, like cloud formation, happen on scales smaller than the boxes used in your average global climate model, climate scientists need to represent the fine-scale process in terms of variables available at the scale of the box. Different schemes for doing this inevitably lead to some differences in what the models say about the future, though the overall message conveyed by climate models is the same – that the climate is warming, and ‘business as usual’ means more warming than in a future where climate mitigation is undertaken (Figure 2).

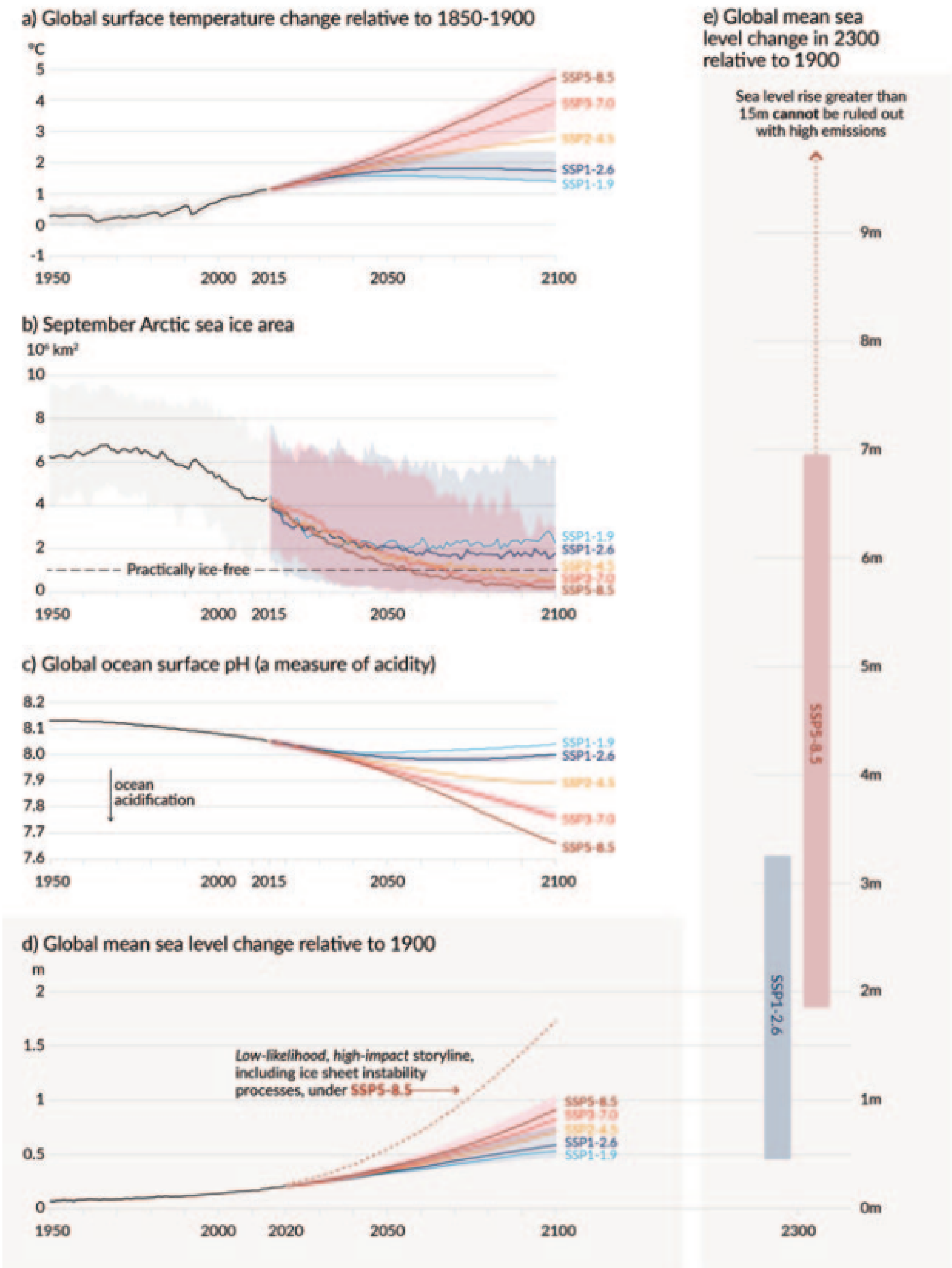

Figure 2: Human activities affect all the major climate system components, with some responding over decades and others over centuries.

Source: IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press

Here, our hypothetical decision-maker might be tempted to pick one of the models available, but to do this would overlook the inherent variability of the climate system. If you run the same model multiple times, you would likely get slightly different results on account of this. Working with a range of models gives a better sample of plausible pathways, which can help to fuel our conversations about climate adaptation and think through the robustness of options that might be on the table.

At this point, our hypothetical decision-maker might be troubled by the lack of granularity in global climate model projections. While the size of the grid boxes used for global climate modelling varies, those used in the Coupled Model Intercomparison Project Phase 5 (CMIP5) averaged roughly 2 degrees latitude by longitude (footnote: https://portal.enes.org/data/enes-model-data/cmip5/resolution) , though this is always improving. But that's far too coarse to capture a small island like Mauritius, for example, which may be labelled as an ocean gridcell in a global climate model. Climate adaptation tends to be a local endeavour, given that hazards, vulnerability and adaptive capacity tend to interact in context-specific and place-based ways, so there is a mismatch here between the scale at which global climate models produce information and the scale at which climate information is needed for adaptation decision-making.

Dynamical downscaling or regional climate modelling can be used to generate regional insights, and involves running a climate model similar to the ones used at global scale over a limited area. The reduction in domain area frees computational resources that can be aimed at increasing the resolution of the simulation. The regional climate models are capable of giving us helpful insights into what the challenges of our future climate might be, but again, we must take care not to treat their outputs as predictions.

As with global climate models, there are a range of regional climate models that could be applied and so the uncertainty attached to the eventual outputs widens, as it is usually not feasible to apply every combination of possible models. There will inevitably be a modelling 'path not travelled', so to speak. Additionally, each model needs to be assessed relative to present-day observations to understand how well it captures the key climate statistics of the place decisions are being made; models that perform well for one location and metric (e.g. average rainfall) may not retain that skill for another metric (e.g. extreme rainfall), which could have implications for how we interpret future scenarios from that model (Foley and Kelman, 2018). When these caveats are taken into account, downscaling may work out as a costly investment for limited added value, but interviews with decision-makers suggest a tendency to equate enhanced resolution with greater reliability (Webber, 2017).

So, what meaningful role *can* climate models play in informing climate adaption, which inevitably involves local decision-making? Arguably, a helpful starting point is for communities themselves to establish what constitutes ‘difficult’ weather, and use climate models to understand how those types of events may change in magnitude, frequency or duration in the future. A standardised set of metrics is helpful for climate modellers seeking to compare simulations, but those numbers may not resonate with the public without connection to the local context. A more meaningful discussion might be had by replacing ‘number of days with more than 20mm of precipitation’ with reference to a memorable surface water flooding event, for instance. Participatory community mapping and timelines provide frameworks for synthesising these local knowledges, not just of climate trends and events but of how communities have responded to them in the past, which has social and cultural dimensions. Robust decision-making could then be applied to find flexible adaptation actions that bring benefits under a wide range of climate futures and non-climate decision criteria (Bhave et al., 2013).

Such an approach would require engaging in a more nuanced way with the intersection between weather and climate. Understandably, the climate science community has concerns about weather and climate being conflated, realising that to the non-expert (or climate denier), cold weather and snowstorms are hard to reconcile with a warming planet (Gibbens, 2019). But as Hulme (2016, p.4) argues, climate can be thought of as “an idea which mediates between the human experience of ephemeral weather and the cultural ways of living which are animated by this experience”. Statistics render the ‘idea’ visible, and context-relevant statistics may illuminate potential incompatibilities between the sensory experience of weather in a destabilised climate, and existing ways of living.

Tailoring projections to specific adaptation problems or local contexts may help (Tang and Dessai, 2012), but it is important to be realistic about what can be accomplished here. Generating climate model projections requires time, money, and expertise, and these resources are coordinated at the international level out of necessity to target scientific questions within specific timescales. So, the work of boundary organisations of the science policy interface is often about translating projections that have been or will be produced, rather than fundamentally changing *how* they will be produced. As such, the complexities and uncertainties outlined above can continue to hamper usability, even when end-users have been involved in co-designing decision support tools, as in the case of the UK Climate Projections (Kirchhoff et al., 2013).

Another challenge of the community-led approach is that weather and climate are, in part, socially constructed. Recollections of notable extreme weather events shift or are lost over time. Historical sources can help to provide a long term picture of societally-relevant weather and climate impacts. For example, Walshe et al. (2020) find that many interviewees in Mauritius have the impression that cyclones cannot happen in November or April, but archival materials show that they have. Similarly, McAneny et al. (2017) use archived correspondence between Rarawai Sugar Mill on the Ba River in Fiji and the mill’s former owner, the Colonial Sugar Refining Company to reconstruct a 122-year time series of river flooding. These historical insights and reconstructions could be used in conjunction with climate models, or on their own to catalyse important conversations about disaster preparedness and climate adaptations which might need to be put in place.

Climate models are a valuable tool, but work best in conjunction with local data, especially for contexts like small islands where the current crop of climate models cannot meaningfully represent local topography due to limitations of resolution. And even if the granularity with which this kind of data can be delivered were not an issue, we would also need other kinds of data to unpack the social and cultural dimensions of climate change. Emphasising climate models and computational tools alone runs the risk of devaluing local knowledge and stories, which need to be incorporated into our responses to the climate crisis to ensure solutions are culturally sensitive and tailored to community needs. By blending 'old' data like historic records with 'new' kinds of data like climate models, we can get a fuller sense of not just the challenges ahead but crucially, how communities might meet them.

Note

The author presented a related talk at the UNDP Archipelagic and Island States Forum event *The Scholars Space: Innovative Response to Climate Change in Island and Small States*. You can view the talk, titled 'Making sense of 'old' and 'new' data in island and small state contexts' here: https://www.youtube.com/watch?v=f5Ys0_u7DLo&feature=youtu.be

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