Recommendations for producing visualisations about climate projections for non-expert audiences

Astrid Kause[1,2], Wändi Bruine de Bruin[1,3,4]

Fai Fung[5], Neil Kaye[5],Jason Lowe[3,5]

1 Centre for Decision Research, Leeds University Business School

2 Sustainability Research Institute, University of Leeds

3 Priestley International Centre for Climate, University of Leeds

4 Department of Engineering and Public Policy, Carnegie Mellon University

5 Met Office

Acknowledgements: This project was supported by the Models To Decisions Network, which is sponsored by ESRC, EPSRC, NERC, and AHRC. We thank Suraje Dessai, Adrian Hines, Piers Forster, and Andrea Taylor for their input.

Project summary: In the UK, the greatest threats from climate change include heavy rainfall and flooding. According to the UK Climate Change Risk Assessment 2017, flood damage to UK businesses and communities cost as much as £1 billion per year. Stakeholders from industry and government therefore face important decisions about preparing for future climate change, even if they may not have a background in climate science. Communications and visualisations about climate projections that are designed to inform decisions about climate change adaptation, may be too complex for non-expert audiences (Lorenz et al., 2015; Taylor et al., 2015). We conducted interviews in which end users viewed commonly used climate data visualisations. End users were individuals working at water companies, local councils, environmental charities, media outlets and as infrastructure consultants. Most were professionally responsible for making decisions about climate change and adaptation, and did not necessarily have a background in climate science. We identified variations in interpretations and potential misunderstandings of the presented visualisations. We then sought recommendations from the graph design and risk communication literature that could be implemented to address these potential misunderstandings. Here, we present these recommendations, which should be useful for improving communications about climate projections to general non-expert audiences.

Recommendation 1: Avoid expert terminology and acronyms

Our interviewees were confused by terms such as "business as usual" when reading about emissions scenarios, and acronyms for climate models. Similarly, some lacked understanding of statistical terms, like "probabilistic estimates", "PDF" and "boxplots".

> Example quote: "*I don't understand what the RCP8.5 means. I can only assume that it means it's one of the projections that they're using, perhaps this business as usual scenario, but it's confusing and over complicated maybe*."

Recommendation 2: Explain statistical terms

When presented with communications about probabilistic modelling data, interviewees wanted to know more about the meaning of terms such as "probabilistic estimate" or "percentile".

> Example quote: *"And then the – all the language around, in the next sentence, the projections are probabilistic, the 50th percentile is a central estimate, that makes sense, then it talks about values are very unlikely to be greater than 90th percentile and less than 10th percentile. I'm not sure sort of – unless you're saying that the 90th percentile and the 10th percentile are definitions of very unlikely, then I'm not sure where – why that language is included."*

Recommendation 3: Use consistent time periods with clear justifications

In climate projections, future change is often communicated through comparisons to past time periods. Our interviewees thought that it was not always clear why past time periods were chosen as a comparison period, or which future time period was projected. They found it especially confusing when past and future time periods differed in length (e.g. 30 years versus 20 years).

> Example quote: *"So the first thing is that it's against a long-term average, which is from 1981 to 2010. So I'm thinking, what's the difference between this and actually pre-industrial?"*

Recommendation 4: For communicating change in rainfall, display absolute change in millimetres rather than relative change in percentages, and provide baseline values

Interviewees indicated that projections of relative percent change in rainfall were confusing, and did not always understand concepts of 'positive' or 'negative' change. It was unclear how much one percent actually represented in millimetres, because they lacked information about baseline values.

> Example quote: *"… what does it actually mean in terms of how much dryer or how much wetter it is? It feel like it's - for a specialist audience this will mean something because they already know the background and they already know how much rainfall there is and they would know how much 20% would really matter to various things … what does this actually mean in amount of rainfall rather than the difference?"*

Recommendation 5: Match visualisations with associated text

Interviewees requested a better match between visualisations and associated text. Terms that appear in the visualisation should be explicitly referred to and explained in the text. Captions, headers, and main text should use consistent wording. They will also be easier to understand if they are presented closer together.

> Example quote: *"it says that the map shows annual percentage difference from the long term, 1981 to 2010 average and the average between – so if you're saying that's also looking at post-2061. Those years aren't written on the maps at all."*

Recommendation 6: Make relevant features most salient

Our interviewees were often unable to identify the features of the visualisations that were most relevant for understanding the main message. Visualisations about climate projections should be designed such that the most relevant features draw the most attention, by increasing their sizes and selecting salient colours.

> Example quote: *"I find that the plot details box thing on top is quite prominent. I think that would be better placed elsewhere, maybe to help the reader concentrate on the actual data instead of the computer output, really."*

Recommendation 7: Communicate one simple message per visualisation

Interviewees noted that visualisations about climate projections tended to contain too much information, for example about different seasons, multiple emissions scenarios, or multiple probabilistic thresholds. Understanding will be improved by presenting one visualisation for each key message, and removing distracting 'visual clutter' that does not pertain to the main message. If there is more than one key message, perhaps more than one visualisation is needed.

> Example quote: *"I think there is an awful lot of information on these that is presented in a way that I'm not used to seeing. So I'm trying to understand actually what the graph is framed about and I think the track of observed rainfall helps you to put that into context …"*

Recommendation 8: Test communication materials

Before disseminating communication materials, we recommend conducting think-aloud interviews with intended audience members so as to assess whether they find the visualisations understandable and useful. Such interviews may also identify confusion and misunderstandings, as well as design strategies for avoiding those. If time and funding permits, additional survey-based experiments with larger samples can be used to systematically test whether new visualisation designs are better than old ones.

Further reading

Alhadad, S. (2018). Visualizing Data to Support Judgement, Inference, and Decision Making in Learning Analytics: Insights from Cognitive Psychology and Visualization Science. Journal of Learning Analytics, 5(2), 60–85. https://doi.org/10.18608/jla.2018.52.5

Ali, N. & Peebles, D. (2013). The effect of Gestalt laws of perceptual organization on the comprehension of three-variable bar and line Graphs. Human Factors, 55, 183-203.

Bruine de Bruin, W., & Bostrom, A. (2013). Assessing what to address in science communication. Proceedings of the National Academy of Sciences, 110, 14062-14068.

Fischhoff, B, Brewer, N.T., & Downs, J.S. (2011) Communicating Risks and Benefits: An Evidence-Based User's Guide (Food and Drug Administration, Washington, DC).

Garcia-Retamero, R., & Cokely, E. T. (2017). Designing Visual AIDS That Promote Risk Literacy: A Systematic Review of Health Research and Evidence-Based Design Heuristics. Human Factors, 59(4), 582–627. https://doi.org/10.1177/0018720817690634

Harold, J., Lorenzoni, I., Shipley, T. F., & Coventry, K. R. (2016). Cognitive and psychological science insights to improve climate change data visualization. Nature Climate Change, 6(12), 1080–1089. https://doi.org/10.1038/nclimate3162

Lorenz, S., S. Dessai, P. M. Forster & J. Paavola (2015). Tailoring the Visual Communication of Climate Projections for Local Adaptation Practitioners in Germany and the UK. Philosophical Transactions A, 373, 1-17. http://rsta.royalsocietypublishing.org/content/373/2055/20140457.article-info

McDowell, M., Rebitschek, F. G., Gigerenzer, G., & Wegwarth, O. (2016). A Simple Tool for Communicating the Benefits and Harms of Health Interventions: A Guide for Creating a Fact Box. MDM Policy & Practice, 1(1). https://doi.org/10.1177/2381468316665365

Shah, P., Freedman, E.G., & Vekiri, I. (2005). The comprehension of quantitative information in graphical displays. In P. Shah (Ed.) & A. Miyake, The Cambridge Handbook of Visuospatial Thinking (pp. 426-476). New York, NY, US: Cambridge University Press.

Taylor, A.L., Dessai, S., & Bruine de Bruin, W. (2015). Communicating uncertainty in seasonal and interannual climate forecasts in Europe. Philosophical Transactions A, 2055, 1-16. http://rsta.royalsocietypublishing.org/content/373/2055/20140454

Zikmund-Fisher, B. J., Fagerlin, A., & Ubel, P. A. (2010). A demonstration of "Less Can Be More" in risk graphics. Medical Decision Making, 30(6), 661–671. https://doi.org/10.1016/j.immuni.2010.12.017.Two-stage