Discussion of Royal Statistical Society meeting on Statistical Aspects of Climate Change

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I found both papers very interesting but would like particularly to discuss the one by Clarkson and co-authors.

One particular focus is the "zero probability problem", that with a negative shape parameter, it's possible for some observed event to be assigned probability 0 by an extreme value analysis. This problem has been known for some time, but has been given particular focus by papers of the "World Weather Attribution" group, see e.g. [3, 6]. The authors' solution, a combination of peaks over threshold analysis and random parameters, is perfectly reasonable, but an alternative is simply to switch to a Bayesian approach as a more realistic recipe for handling uncertainties in the parameter estimates. As far as I know, Coles and Powell [2] were the first authors to make this argument for events of very low probability.

Going beyond their analysis, I'd like to comment on the broader climate context. In July 2022, many parts of the UK suffered extreme heat. To take a specific data point, on July 19, Heathrow Airport, recorded a daily high temperature of 40.2°C (104.4° F). Much of the subsequent discussion has concerned the probability of such an extreme event, in the present climate but also in the past and future.

The approach I am currently developing involves an associated "climate" variable — in this case, summer mean temperature anomalies from a region of western Europe (Figure 1). Climate model runs (CMIP6) were used to characterize the distribution of this regional mean from 1850-2100, and then combined with an extreme value analysis to estimate the probability of an annual maximum temperature at Heathrow exceeding 40°C (Figure 2). The results show that the present probability of this event is about seven times larger than it was in the 1950s; under any scenario it will increase sharply in the future, but there is a big difference between essentially uncontrolled greenhouse gases (ssp585) and the kind of emissions that might result with realistic controls (ssp245). This is the kind of result I would choose to discuss with our political leaders.

On a more technical level, I believe the extreme value analysis could be improved by taking advantage of spatial dependence among stations [1, 5, 4].

I thank the RSS for the opportunity to contribute this discussion.

References

[1] E. Casson and S.G. Coles. Spatial regression models for extremes. *Extremes*, 1:449–468, 1999.

[2] S.G. Coles and E.A. Powell. Bayesian methods in extreme value modelling: A review and new developments. *International Statistical Review*, 64:119–136, 1996.

[3] Sjoukje Y. Philip, Sarah F. Kew, Geert Jan van Oldenborgh, Wenchang Yang, Gabriel A. Vecchi, Faron S. Anslow, Sihan Li, Sonia I. Seneviratne, Linh N. Luu, Julie Arrighi, Roop Singh, Maarten van Aalst, Mathias Hauser, Dominik L. Schumacher, Carolina Pereira, Marghidan, Kristie L Ebi, Rémy Bonnet, Robert Vautard, Jordis Tradowsky, Dim Coumou, Flavio Lehner, Michael Wehner, Chris Rodell, Roland Stull, Rosie Howard, Nathan Gillett, and Friederike E L Otto. Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada June 2021. *Earth System Dynamics (under review)*, https://esd.copernicus.org/preprints/esd-2021-90/ (reference checked October 7, 2022), 2021.

[4] Mark Risser. Nonstationary Bayesian modeling for a large data set of derived surface temperature return values. *https://arxiv.org/abs/2005.03658*, 2020.

[5] B Russell, M. Risser, R.L. Smith, and K.E. Kunkel. Investigating the association between late spring Gulf of Mexico sea surface temperatures and US Gulf Coast precipitation extremes with focus on Hurricane Harvey. *Environmetrics*, 31(2):e2595, 2020.

[6] Mariam Zachariah, Robert Vautard, Dominik L. Schumacher, Maja Vahlberg, Dorothy Heinrich, Emmanuel Raju, Lisa Thalheimer, Julie Arrighi, Roop Singh, Sihan Li, Jingru Sun, Gabriel Vecchi, Wenchang Yang, Sonia I. Seneviratne, Simon F. B. Tett, Luke J. Harrington, Piotr Wolski, Fraser C. Lott, Mark McCarthy, Jordis S. Tradowsky, and Friederike E. L. Otto. Without human-caused climate change temperatures of 40°c in the UK would have been extremely unlikely. https://www.worldweatherattribution.org/wp-content/uploads/uk-heat-scientific-report.pdf (posted July 28, 2022; reference checked October 7, 2022). 2022.

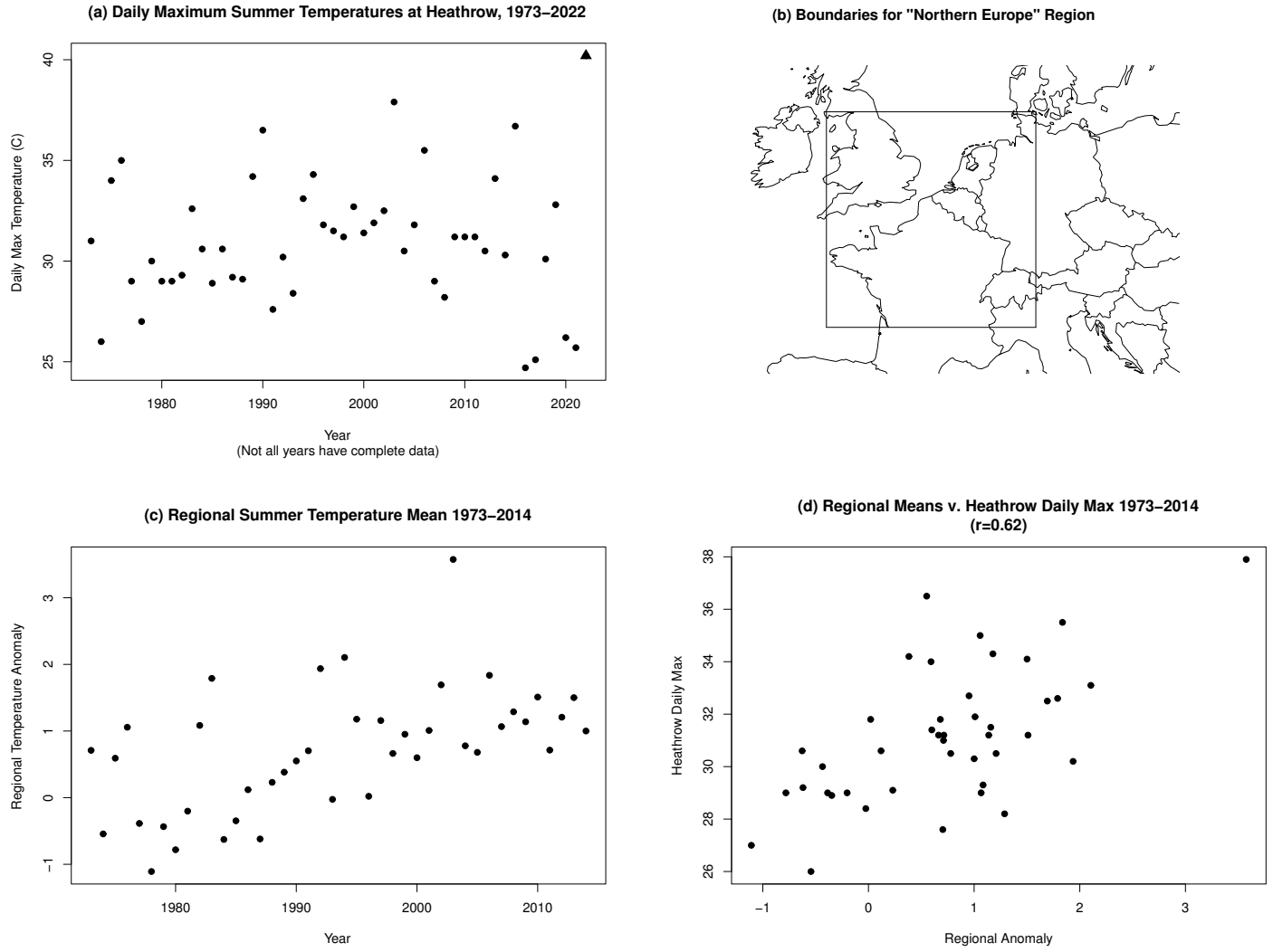

Figure 1. (a) Annual maximum temperatures at Heathrow; triangle represents 2022 value. (b) Region of Northern Europe used to define regional summar means. (c) Regional summer means by year. (d) Regional summer means plotted against Heathrow annual maxima.

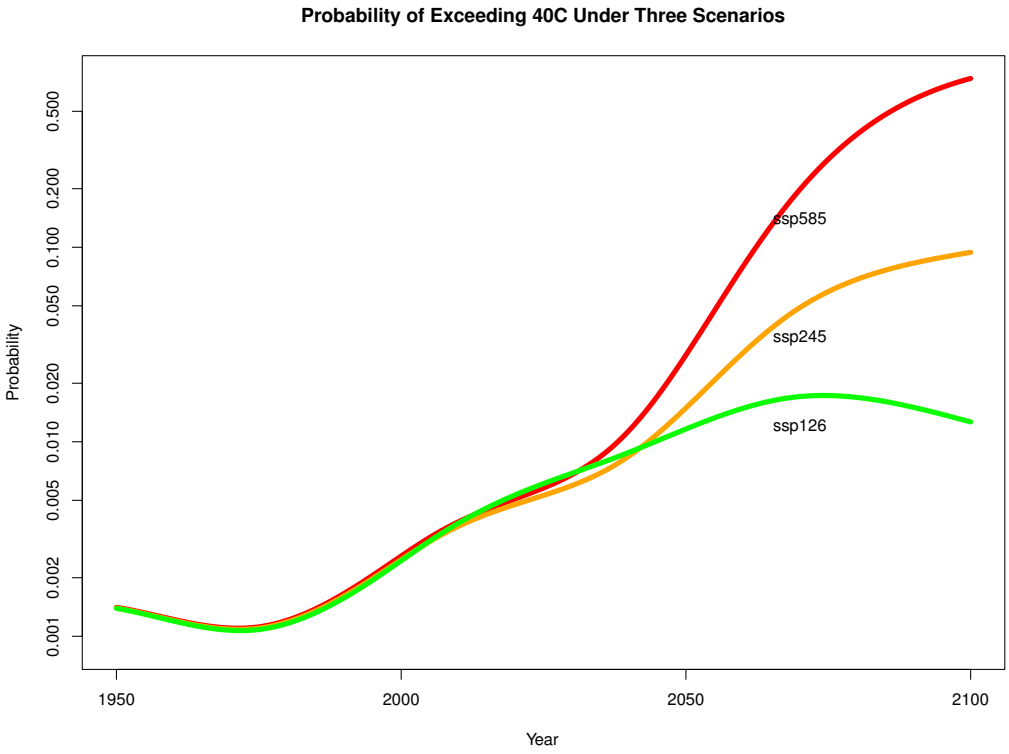

Figure 2. Estimated probability that the annual maximum temperature at Heathrow exceeds 40°C, calculated from historical model runs (1950–2014) and from three emissions scenarios (2015–2100).