The importance of combined extreme events for nuclear regulation

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The Fukushima Nuclear Disaster

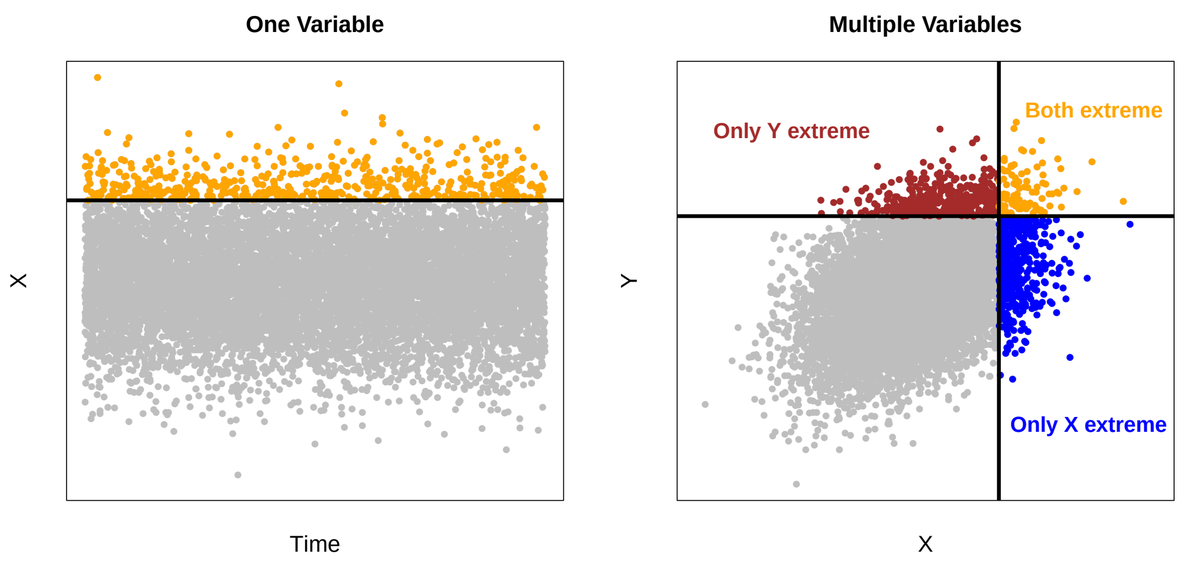
- On March 11th, 2011, the combination of **two extreme events** (earthquake and tsunami) caused a meltdown at the Fukushima Daiichi nuclear power plant.

- The event exposed **critical weaknesses** in the Japanese regulatory framework. In particular, little consideration had been given to the **joint occurrence** of both hazards.
- Good nuclear regulatory practices now consider the impact of joint extreme events.

Extreme Events

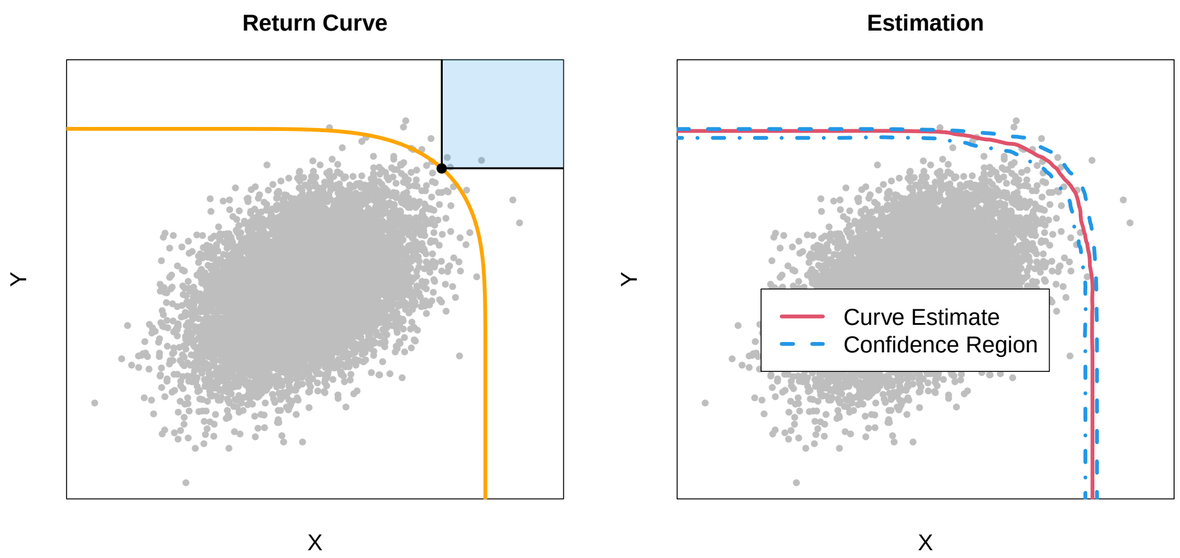
- When considering just one variable, defining what is 'extreme' is straightforward (i.e., the big values).
- However, when considering multiple variables simultaneously, there is no fixed definition of a **joint extreme** event.
- **Return curves** provide a means to quantify joint extreme events and assess their impact.
- Let X and Y represent two variables and p represent a very small probability. Return curve defined by the set

$$\{(x, y) \mid \Pr(X > x, Y > y) = p\}.$$



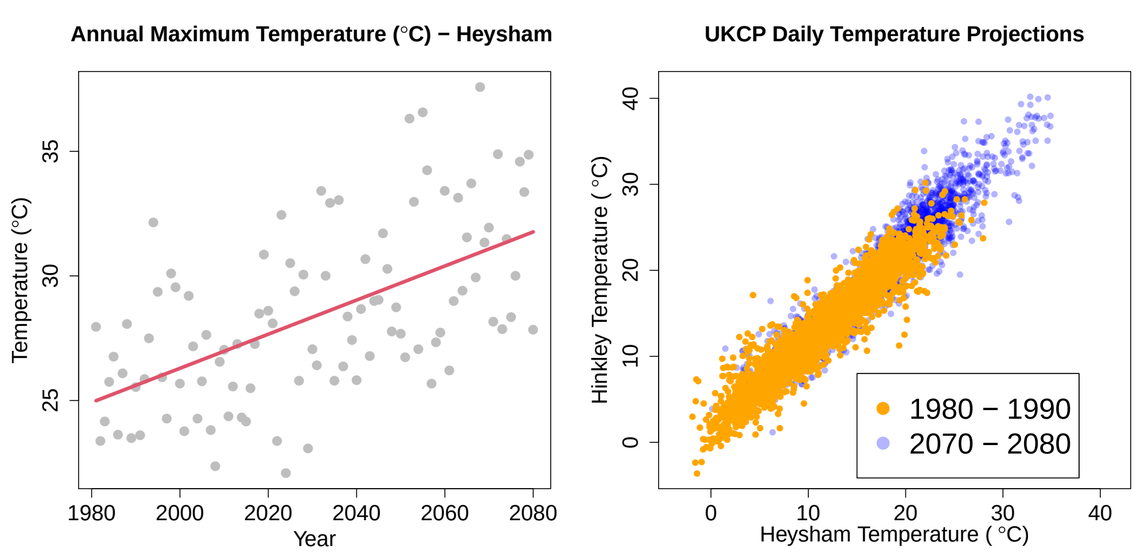
Return Curves

- We have developed **novel estimation techniques** [1] for return curves which **outperform** existing methods.
- This allows us to estimate curves corresponding to **1-in-10,000 year events** - the required standard for nuclear facilities in the UK.



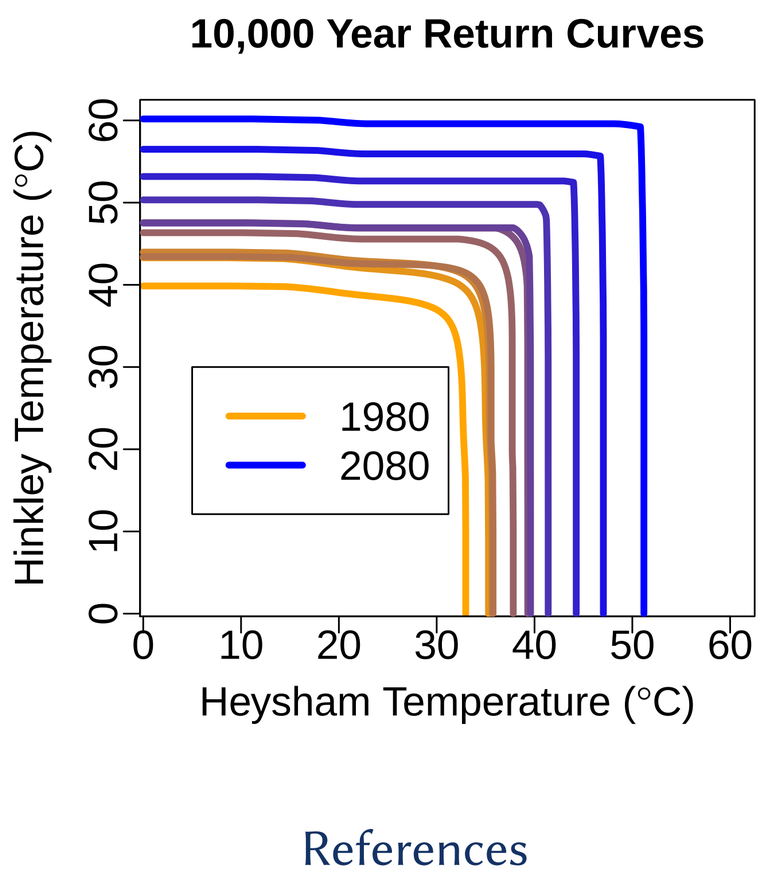
Incorporating Climate Change

- Environmental datasets relevant to nuclear sites exhibit complex trends due to **climate change**.
- This results in return curves that are **changing in time**.
- We have proposed state-of-the-art statistical techniques [2] that allow climate change **trends** to be **captured in curve estimates**.



Return Curves Estimates for Future Climates

- Using data from the **UK Climate Projections** [3], we apply our methods to obtain return curves up to the **year 2080**.
- Can observe clear trends within their **shape** and **magnitude**.
- Such curves allow us to analyse the impact of **future joint extreme events**, helping to **improve** international **nuclear regulatory practices**.



References

[1] Murphy-Barltrop, C. J. R, Eastoe, E. F. and Wadsworth, J. L. (2021). On the Estimation of Bivariate Return Curves for Extreme Values. *Preprint*

[2] Murphy-Barltrop, C. J. R and Wadsworth, J. L. (2022). Modelling non-stationarity in asymptotically independent extremes. *Preprint*

[3] Met Office (2021). 2018 UK Climate Projections (UKCP18).

Acknowledgements

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