Probabilistic modelling of big spatio-temporal climate data for quantifying future changes in compound events.

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Met Office

Future changes in compound events using climate model data

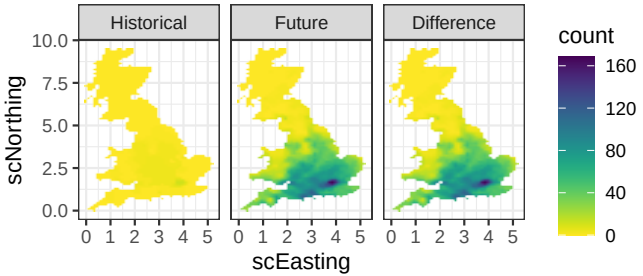
- Question: "What is the change in the chance that (mean) daily temperature will exceed 24°C for 3 consecutive days in the UK"?

- E.g., daily summer data from UKCP RCM (single run) over two 11-year periods (1985-1995 and 2065-2075),

- Is the difference significant?

- Are the periods long enough?

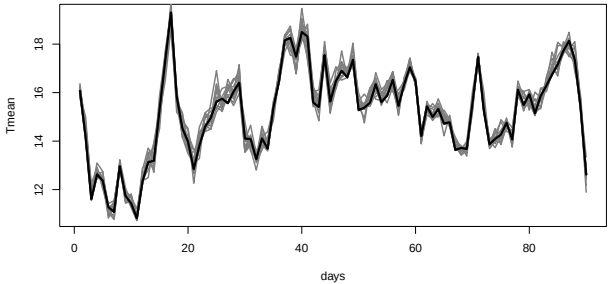
- Are there sufficient occurrences of the event?



Statistical modelling for describing climate model output

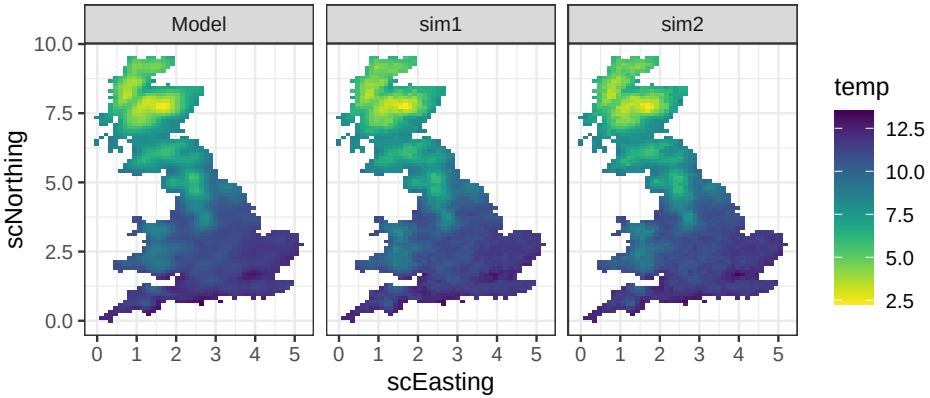
- Can use statistical modelling to capture the behaviour of the weather variables with a probability distribution.
- The probability distribution should capture **correlation in space and time**, so that the resulting simulations retain the characteristics of the climate run.

- We can then simulate from this distribution to address the issue.
- E.g., historical summer 1990:
  Black: model run
  Grey: simulations



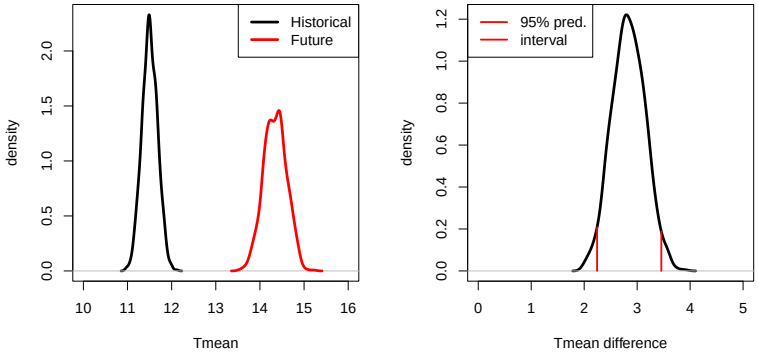
Statistical modelling for describing climate model output

- In space, 9th day of summer 1990:



Quantifying changes

- Can use these distributions to quantify differences, e.g. in mean temperature of the 9th day of summer of 1990 and 2065:

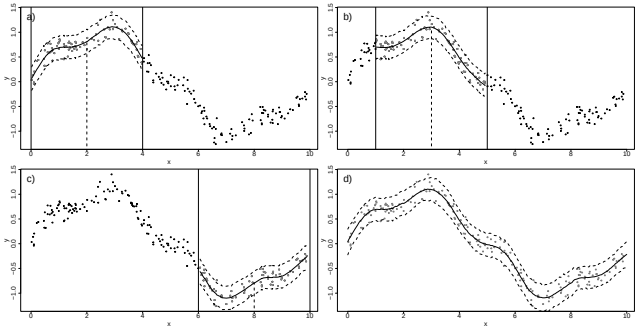


- Bayesian simulation-based inference means we can compute changes in any quantity of interest.

Statistical framework

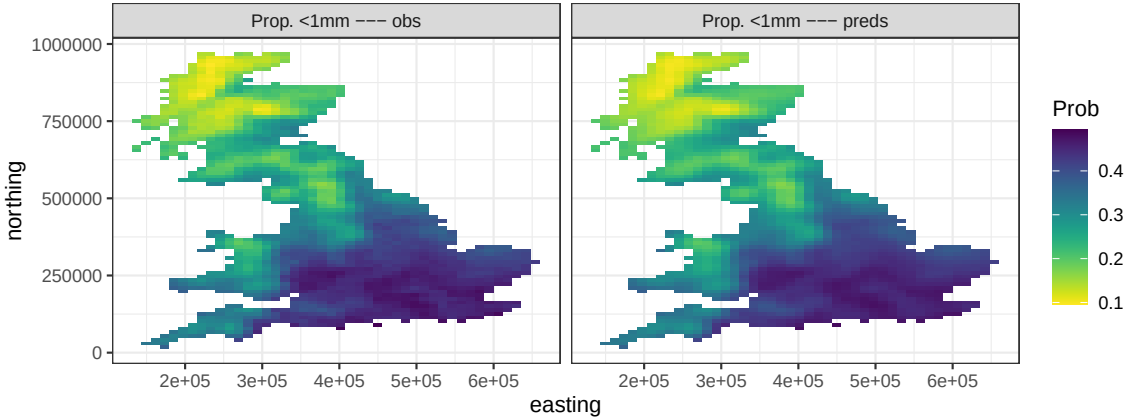
- We employ a Generalised Additive Model (GAM) in moving space-time windows to balance flexibility and scalability,
- in conjunction with Gaussian copulas to capture the cross-dependence (e.g. temperature and precipitation).

- Bayesian inference is used to fully quantify uncertainty.
- GAMs are penalised in each window to avoid over-fitting the data.



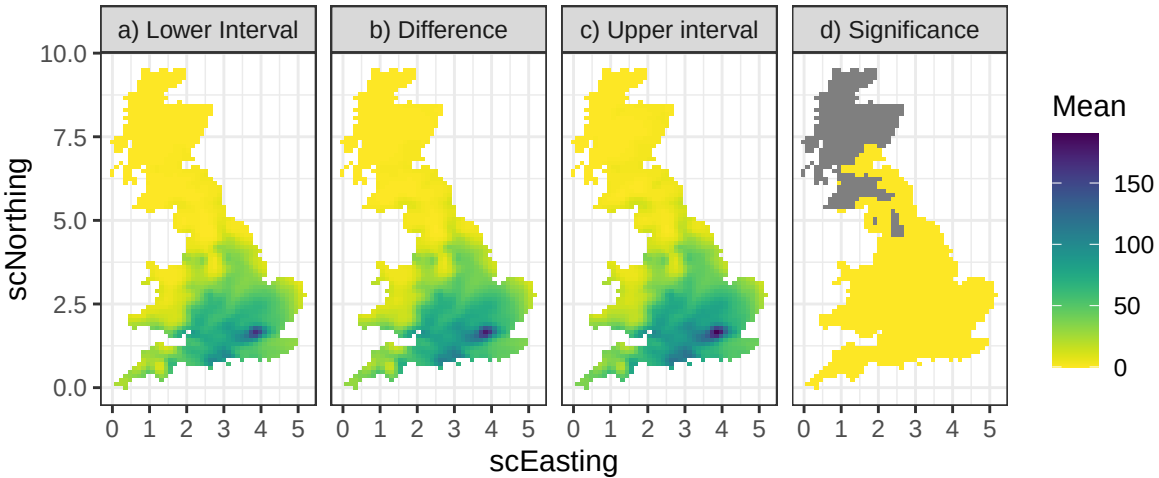
Is the probability distribution well captured?

- Probability of rain being below 1mm.



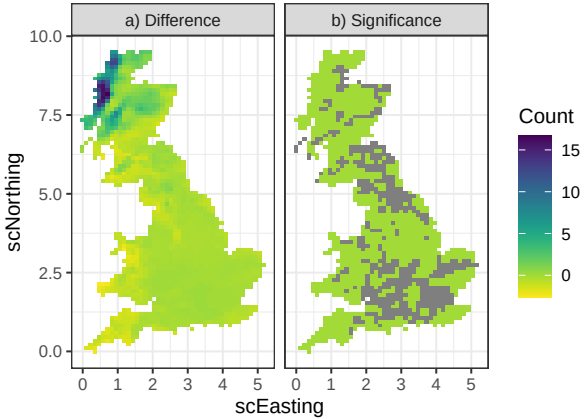
Changes in compound hazards

- "What is the change in the chance that (mean) daily temperature will exceed 24°C for 3 consecutive days in the UK"?

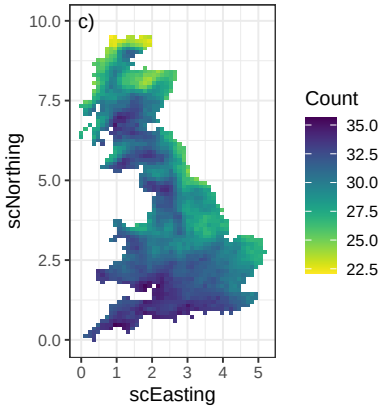


Changes in compound hazards

- Seasonal average number of minimum daily temperature exceeding 10°C and relative humidity exceeding 90% for two consecutive days (high chance of potato blight).



- Seasonal average number of warm-dry days, defined as days where mean temperature exceeds its historical period mean and precipitation is below its historical period mean (index of heat and drought risk).



Main message

Statistical (probabilistic) modelling can be used to robustly quantify future changes in compound events. Method here is:

- flexible;
- paralleliseable and scalable;
- Bayesian, so uncertainty fully quantified,

Thank you!
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