THE UNIVERSITY *of* EDINBURGH
Centre for Statistics

CFS RESEARCH DAY

Modelling extremes and causal inference in the context of geoscience and climate change data[†]

Centre for Statistics

https://centreforstatistics.maths.ed.ac.uk

6 December 2022

[†]Organized by Nicole Augustin, Amanda Lenzi, Gabi Hegerl.

Program:

- 11:00 - 11:05 Nicole Augustin (School of Mathematics) - Welcome
- 11:05 - 11:25 Sjoerd Beentjes (School of Mathematics)
- 11:25 - 11:45 Simon Tett (School of Geosciences)
- 11:45 - 12:05 Emiko Dupont (University of Bath)
- 12:05 - 12:45 Speed talks (participants give short talks to introduces themselves)
- 12:45 - 13:45 Lunch
- 13:45 - 14:25 Speed talks
- 14:20 - 14:40 Andrew Schurer (School of Geosciences)
- 14:40 - 15:00 Ioannis Papastathopoulos (School of Mathematics)
- 15:00 - 15:20 Mark Naylor (School of Geosciences)
- 15:20 - 16:45 Breakout discussions & Coffee break
- 16:45 Breakout groups report back + CfS seed funding (https : //centreforstatistics.maths.ed.ac.uk/cfs/project − funding)

Effects of causes vs causes of effects

Sjoerd Beentjes

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Abstract: It is often possible to estimate "effects of causes" from sufficiently rich observational data. Here, one seeks to emulate the setting of a randomised controlled trial that could, at least in principle, be set up to estimate the causal effect. However, not all causal questions can be answered from experimental studies. Examples include attribution (e.g., what fraction of deaths are due to a specific exposure?), necessity (e.g., was it the aspirin that cured my headache?), or the identification of "causes of effects" more generally. Expressing such questions mathematically requires the probabilistic analysis of counterfactuals. In this talk, I will discuss some results and examples from the causal attribution literature.

Event Attribution or how much did human activities change the probability of an extreme event?

Simon Tett

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Abstract: Event attribution aims to estimate after a damaging extreme event occurs how much human driven climate change has modified the probability of the event. I will outline some approaches to doing this, provide some examples and then consider "loss and damage".

Spatial confounding and spatial+

Emiko Dupont

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Abstract: Spatial confounding is an issue that can arise when regression models for spatially varying data are used for effect estimation. Such models include spatial random effects to account for the spatial correlation structure in the data. But as spatial random effects are not independent of spatially dependent covariates, they can interfere with the covariate effect estimates and make them unreliable. Traditional methods for dealing with this problem restrict spatial effects to the orthogonal complement of the covariates, however, recent results show that this approach can be problematic. Spatial+ is a novel method for dealing with spatial confounding when the covariate of interest is spatially dependent but not fully determined by spatial location. Theoretical analysis of estimates as well as simulations show that bias, in this case, arises as a direct result of spatial smoothing and, moreover, that it can be avoided by a simple adjustment to the model matrix in the spatial regression model.

Joint work with Simon Wood and Nicole Augustin.

Disentangling the effect of volcanic eruptions on extreme climate events

Andrews Schurer

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Abstract: Explosive volcanic eruptions can inject a massive amount of sulphur dioxide into the stratosphere which can have a fast and pronounced impact on climate. Globally the effect is to cool the surface of the planet and on average cause a global drying. They can also substantially affect the likelihood of getting extreme climate events. In this talk I will show results for an idealised set of climate model experiments with and without a huge volcanic eruption. These show that some areas of the globe can see an increase in the likelihood of centennial drought events by a factor of fifty while the likelihood of 5-day precipitation centennial events can either increase or decrease by similar amounts depending on location.

The talk will then focus on the European summer of 1816 which has often been referred to as a 'year without a summer' due to anomalously cold conditions and unusual wetness, which led to widespread famines and agricultural failures. The cause has often been assumed to be the eruption of Mount Tambora in April 1815. We apply event attribution methods to quantify the contribution by the eruption and random weather variability to this extreme European summer climate anomaly. By selecting analogue summers that have similar sea-level-pressure patterns to that observed in 1816 from both observations and unperturbed climate model simulations, we show that the circulation state can reproduce the precipitation anomaly without external forcing, but can explain only about a quarter of the anomalously cold conditions. We find that in climate models, including the forcing by the Tambora eruption makes the European cold anomaly up to 100 times more likely, while the precipitation anomaly became 1.5–3 times as likely, attributing a large fraction of the observed anomalies to the volcanic forcing. This study demonstrates how linking regional climate anomalies to large-scale circulation is necessary to quantitatively interpret and attribute post-eruption variability.

Joint work with Nicolas Freychet and Gabi Hegerl.

Changes in the distribution of observed annual maximum temperatures in Europe

Ioannis Papastathopoulos

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Abstract: In this talk, we will present statistical methods for detecting and quantifying changes in the distribution of the annual maximum daily maximum temperature (TXx) in a large gridded data set of European daily temperature during the years 1950-2018. Several statistical models are considered, each of which models TXx using a generalized extreme value (GEV) distribution with the GEV parameters varying smoothly over space. In contrast to several previous studies which fit independent GEV models at the grid box level, our models pull information from neighbouring grid boxes for more efficient parameter estimation. The GEV location and scale parameters are allowed to vary in time using the log of atmospheric CO2 as a covariate. Changes are detected most strongly in the GEV location parameter with the TXx distributions generally shifting towards hotter temperatures. Averaged across our spatial domain, the 100-year return level of TXx based on the 2018 climate is approximately 2^oC hotter than that based on the 1950 climate. Moreover, averaged across our spatial domain, the 100-year return level of TXx based on the 1950 climate corresponds approximately to a 6-year return level in the 2018 climate.

Joint work with Graeme Auld and Gabriele Hegerl.

A Bayesian approach to short and long term earthquake forecasting using inlabru

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Abstract: Earthquake hazard maps in space and/or time provide a rational basis for long-term hazard mitigation and shorter term operational forecasting respectively. Both require the determination of optimal combinations of model input parameters, and a realistic estimate of the uncertainties involved. While Bayesian methods are well suited to the problem, the construction of posteriors using random sampling (e.g. MCMC) is prohibitively slow for fitting the complex spatio-temporal point process models required, particularly if the parameters are strongly correlated and we wish to include many relevant spatial covariates, such as maps fault maps, or satellite-based deformation rates. The Integrated Nested Laplace Approxima- tion (INLA) offers a potential solution to this problem, because it was designed exactly to handle large spatial models with a range of spatially varying covariates and strongly correlated parameters. This work has required we implement a self-exciting Hawkes process within inlabru in order to model the aftershock process. Here, we present examples of how this approach can be used for time-independent and time-dependent seismicity forecasting.