ROYAL STATISTICAL SOCIETY WILLIAM GUY LECTURE

WILLIAM GUY LECTURE REFLECTIONS

Eleanor D'Arcy
Lancaster University

Agenda

01 Introduction

02 My research

03 William Guy lecture

04 Takeaways

ROYAL STATISTICAL SOCIETY WILLIAM GUY LECTURE

INTRODUCTION

Eleanor D'Arcy
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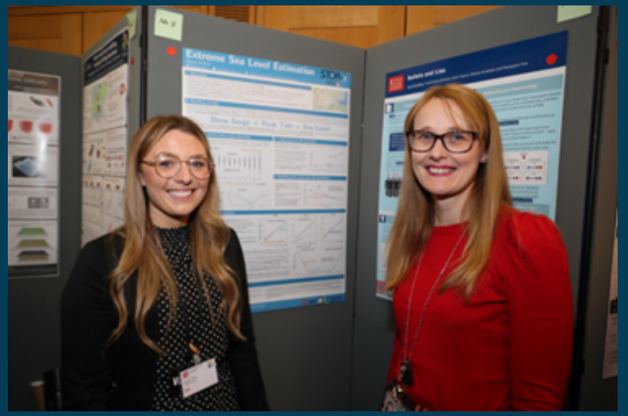
About me

- PhD in Statistics at STOR-i Centre for Doctoral Training, Lancaster University
- PhD in partnership with EDF UK Natural Hazards & Marine Environment R&D team
- Supervisors: Jonathan Tawn (LU) and Dafni Sifnioti (EDF)
- Starting as a Statistician on NCEA programme at the Environment Agency in April
- YSS committee member

Motivations

- Enjoy communicating my research
- Support the RSS aims to encourage young people to consider a statistical career
- Challenge students' preconceptions on what it means to be a mathematician
- Hope that I can be an inspiration/role model for somebody



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MY RESEARCH

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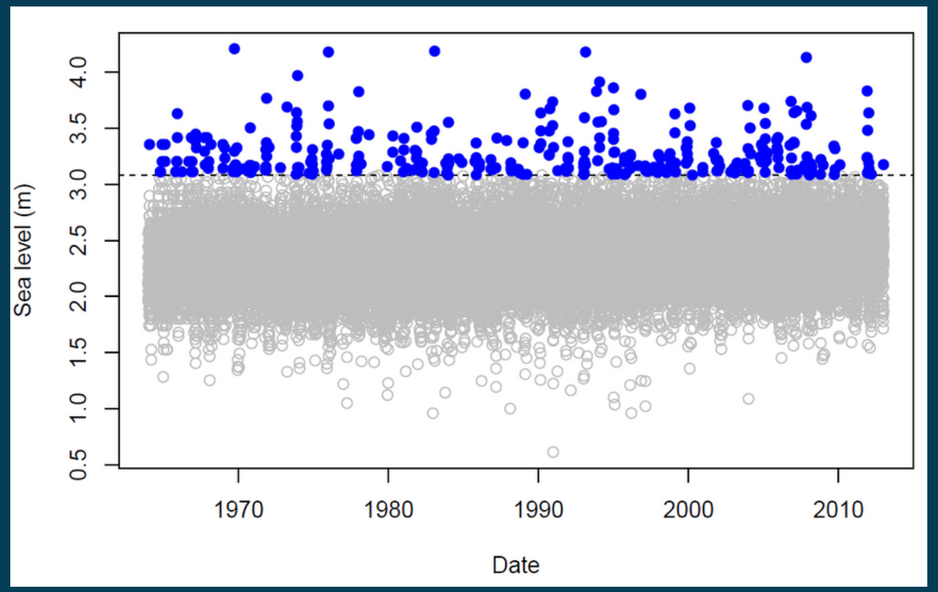
Extreme value statistics



Model exceedances of a threshold u using the **generalised Pareto distribution (GPD)**

$$Y > u,\ Y \sim GPD(\sigma, \xi, \lambda)$$

scale
magnitude

shape
bounded

rate
probability of exceeding the threshold

A **return level** is the level we expect to be exceeded once a year with probability p

- Correspond to return period $1/p$
- Interested in small p

Extreme value statistics

Accounting for Climate Change in Extreme Sea Level Estimation

by Eleanor D'Arcy [1,*], Jonathan A. Tawn [1] and Dafni E. Sifnioti [2]

Modelling Extremes of Spatial Aggregates of Precipitation using Conditional Methods

Jordan Richards[A,B], Jonathan A. Tawn[A], and Simon Brown[C]

A temperature dependent extreme value analysis of UK surface ozone, 1980–2019

Lily Gouldsbrough [a], Ryan Hossaini [a b], Emma Eastoe [c], Paul J. Young [a b]

Inference for extreme spatial temperature events in a changing climate with application to Ireland

Dáire Healy[1], Jonathan Tawn[2], Peter Thorne[3], and Andrew Parnell[1]

On spatial conditional extremes for ocean storm severity

R. Shooter[1] | E. Ross[2] | J. Tawn[3] | P. Jonathan[3,4]

A marginal modelling approach for predicting wildfire extremes across the contiguous United States

Eleanor D'Arcy[1] · Callum J. R. Murphy-Barltrop[1] · Rob Shooter[2] · Emma S. Simpson[3]

INFERENCE FOR EXTREME EARTHQUAKE MAGNITUDES ACCOUNTING FOR A TIME-VARYING MEASUREMENT PROCESS

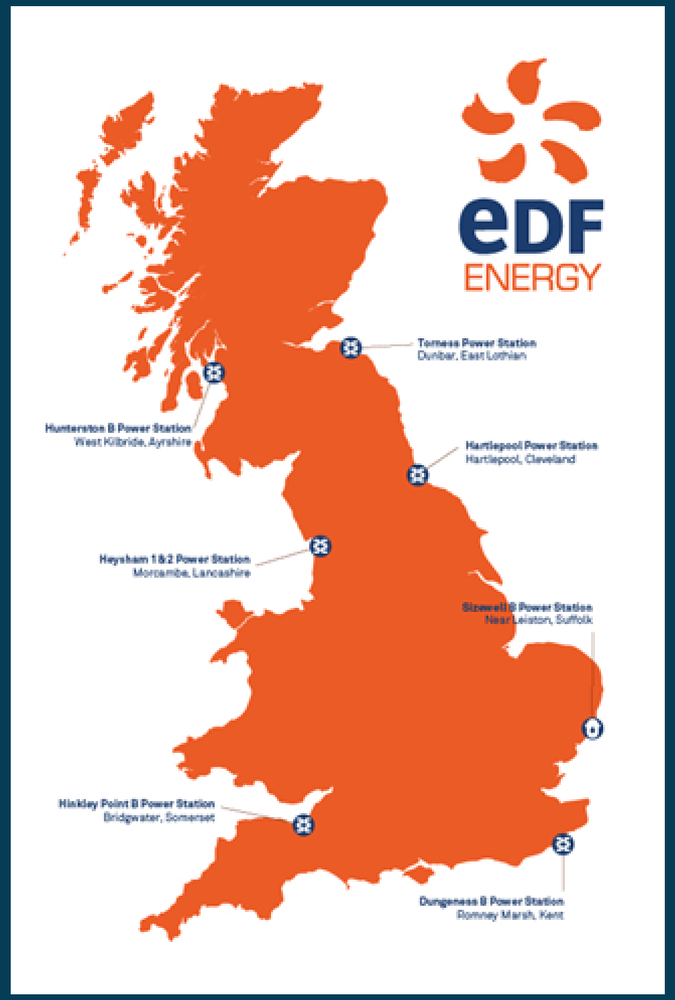
By Zak Varty[1], Jonathan A. Tawn[1,*] Peter M. Atkinson[1,†] and Stijn Bierman[2,‡]

Extreme sea levels

Consequences of coastal flooding:

- Loss of life
- Damage to property and infrastructure
- Coastal erosion
- Displacement of people
- Loss of habitats and ecosystems

The Office for Nuclear Regulation are interested in **10,000 year return level** estimates



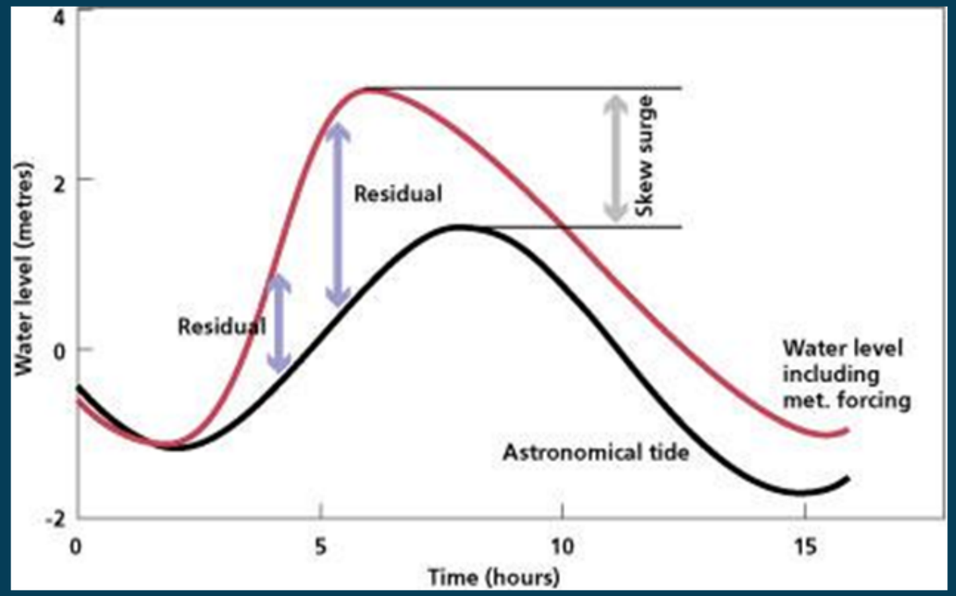
Sea level components

Tides

- Predictable rise and fall of the sea surface
- Can be well predicted far in advance

Storm surge

- Short term sea level changes caused by the weather
- Not accurately predictable



Maximum Sea Level = Skew surge + Peak Tide

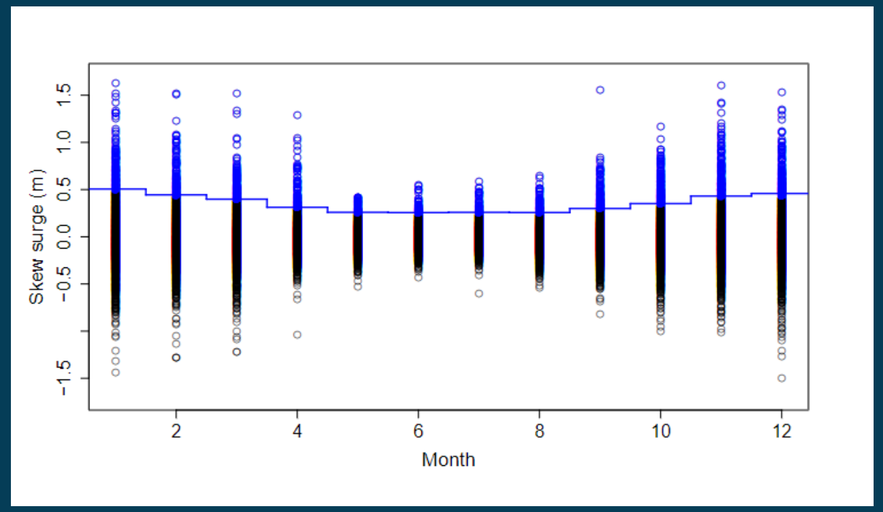
Current methodology

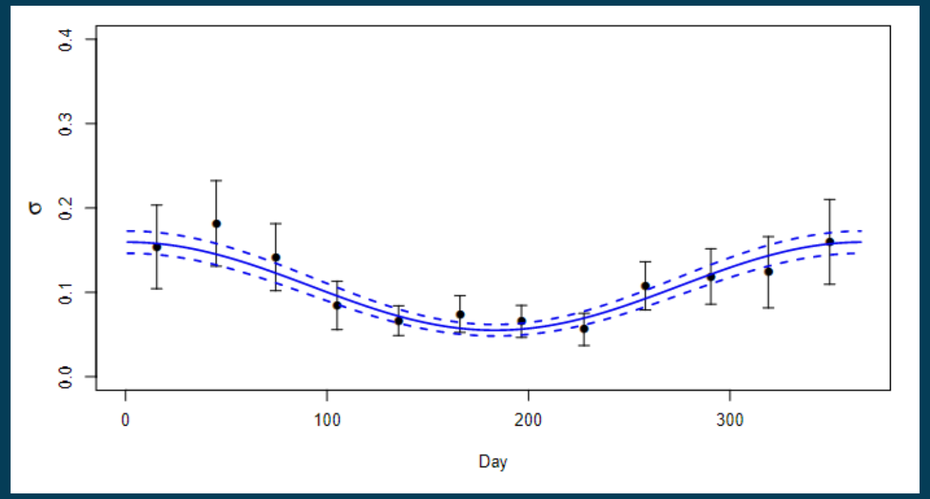
- Skew surges are independent and identically distributed
  - Model extremes using a GPD
- Tides are stationary
- Skew surge and peak tide are independent of each other

Batstone, C. et. al. (2013) *A UK best-practice approach for extreme sea-level analysis along complex topographic coastlines.* Ocean Engineering, 71, pp.28-39.

Aim: Correct these and estimate extreme sea levels

Skew surge seasonality



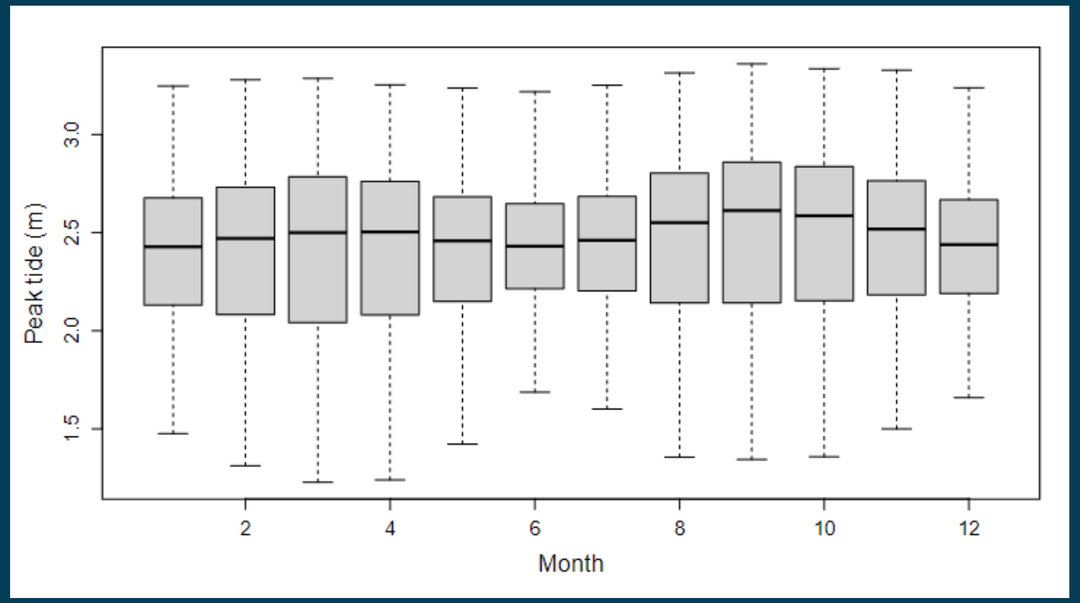


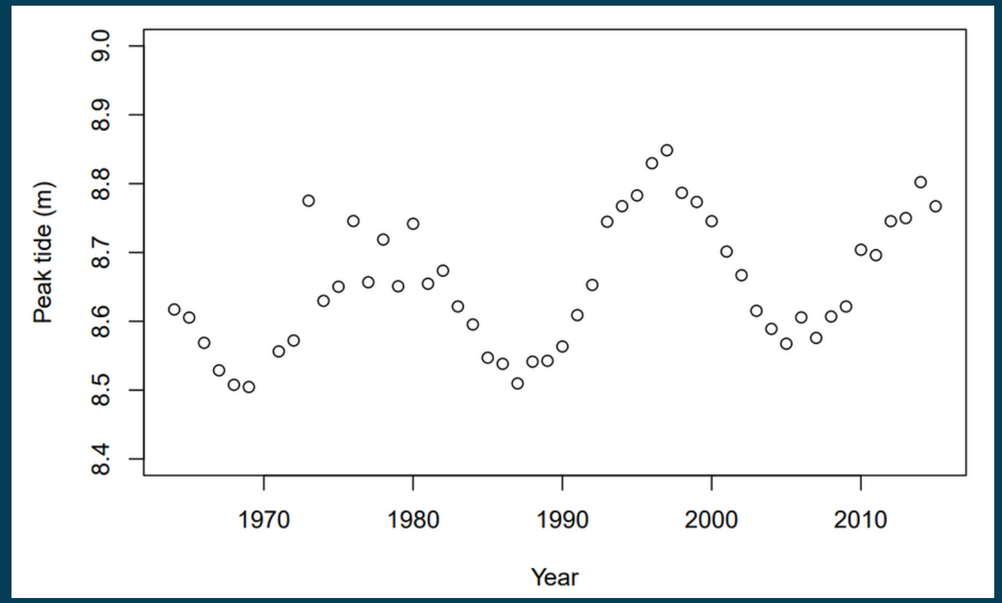
- Monthly threshold
- For non-extremes, we use the monthly empirical distribution
- For extremes, we use a non-stationary GPD

$$Y \sim GPD(\sigma_d, \xi, \lambda_d)$$

$$\sigma_d = \alpha_\sigma + \beta_\sigma \sin\left(\frac{2\pi}{365}(d - \phi_\sigma)\right)$$

Peak tide seasonality





Note: Tides are deterministic so don’t require modelling

SS-PT dependence

- Can be assumed as independent at most sites
- Extreme skew surges tend to occur on lower peak tides
- For extreme skew surge,

$$Y \sim GPD(\sigma_{d,t},\ \xi, \lambda_{d,t})$$

- Relationship changes throughout the year

SS-PT dependence

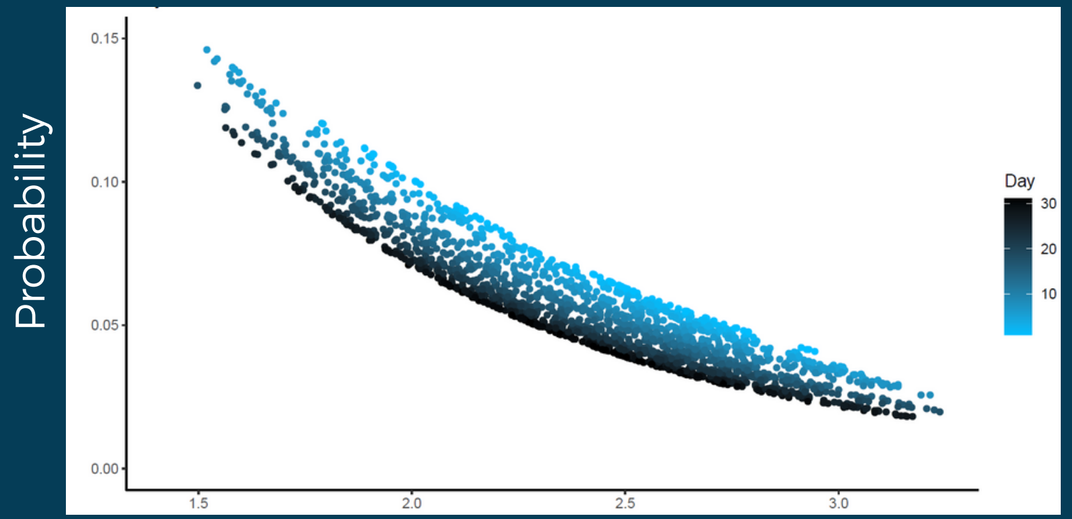
standardised tide

logit-link function

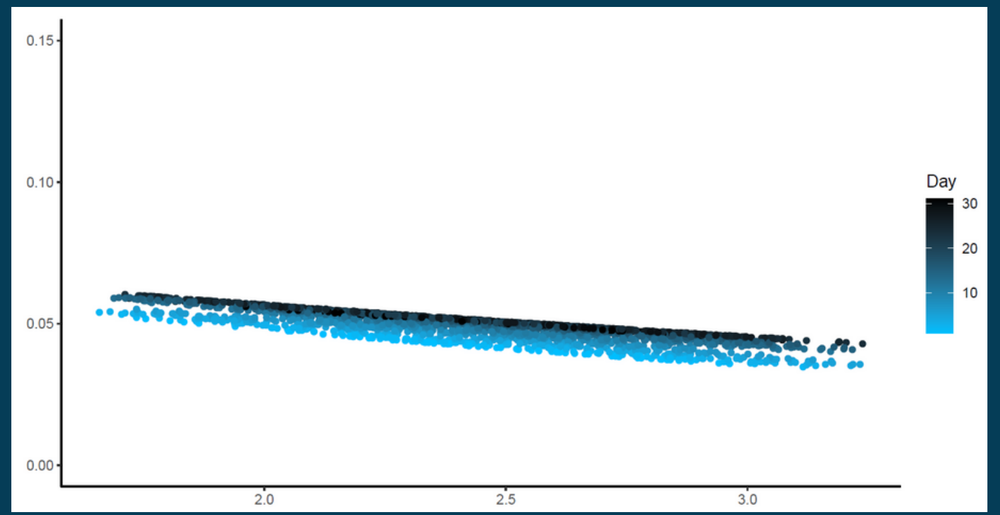
$$g(\lambda_{d,x}) = g(\lambda_d) + \tilde{x}\left[\alpha_\lambda + \beta_\lambda \sin\left(\frac{2\pi}{365}(d - \phi_\lambda)\right)\right]$$

day in year

May



December

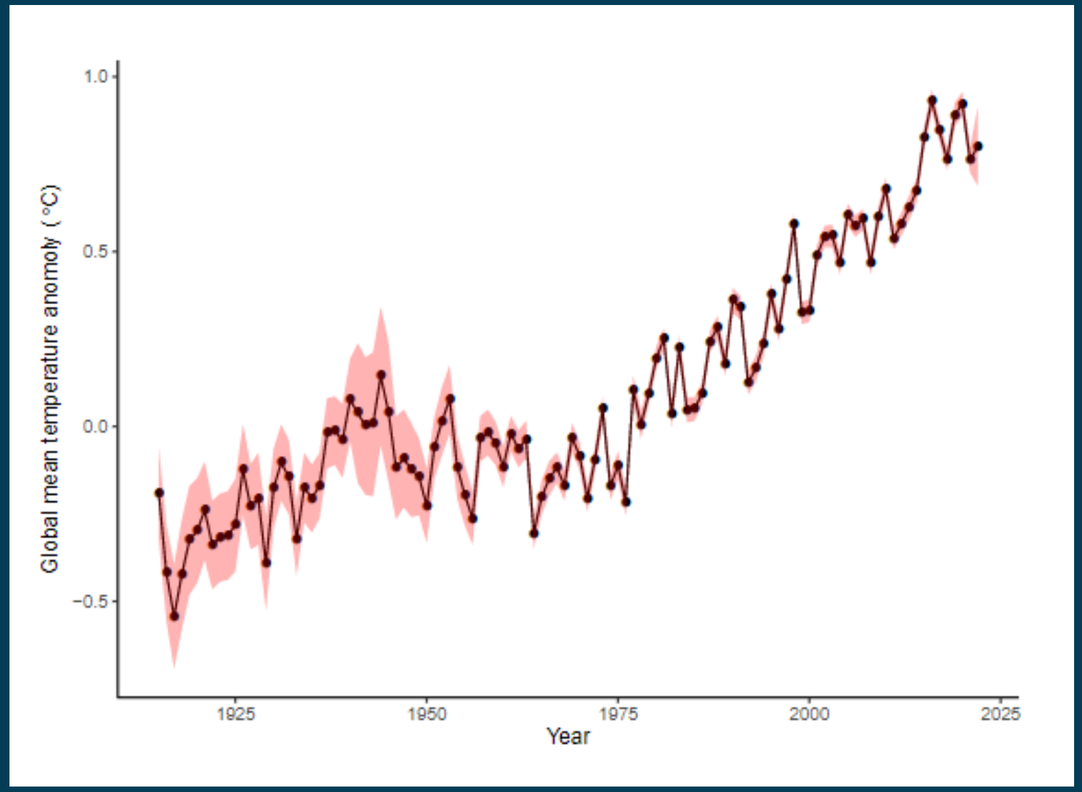


Climate change

Investigate changes at extreme levels as opposed to mean sea level rise

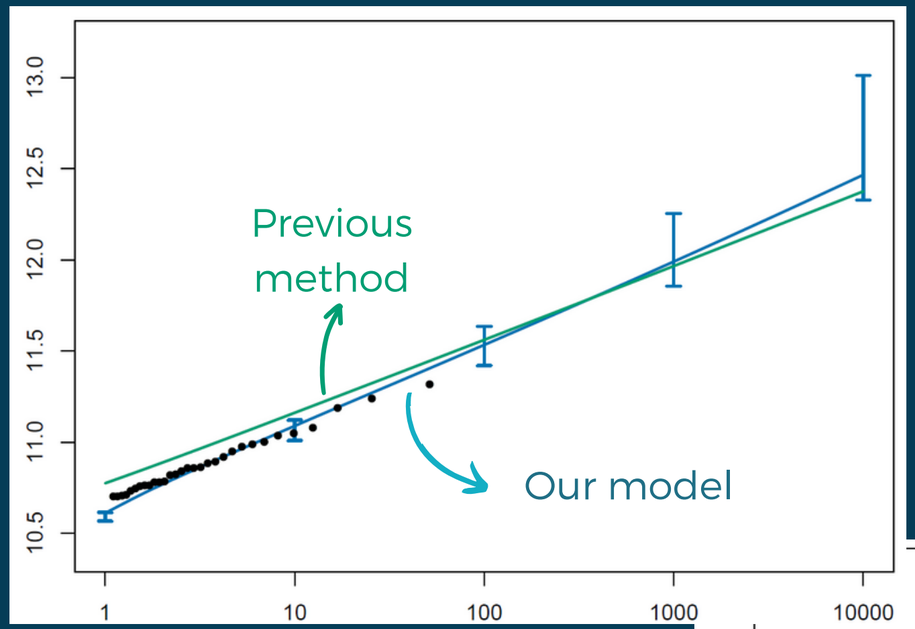
- Magnitude of extreme events is not changing
- Occurrence of extreme events is changing

$$g(\lambda_{d,x,k}) = g(\lambda_{d,x}) + \sum_{s=1}^{4} \delta_s GMT_k \mathbb{1}_{d \in \mathcal{S}_s}$$

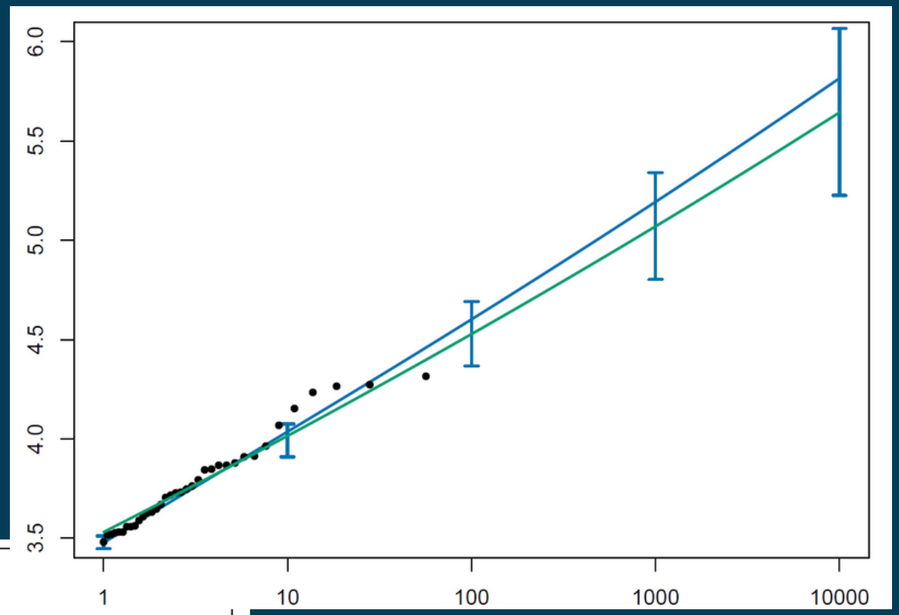


Results

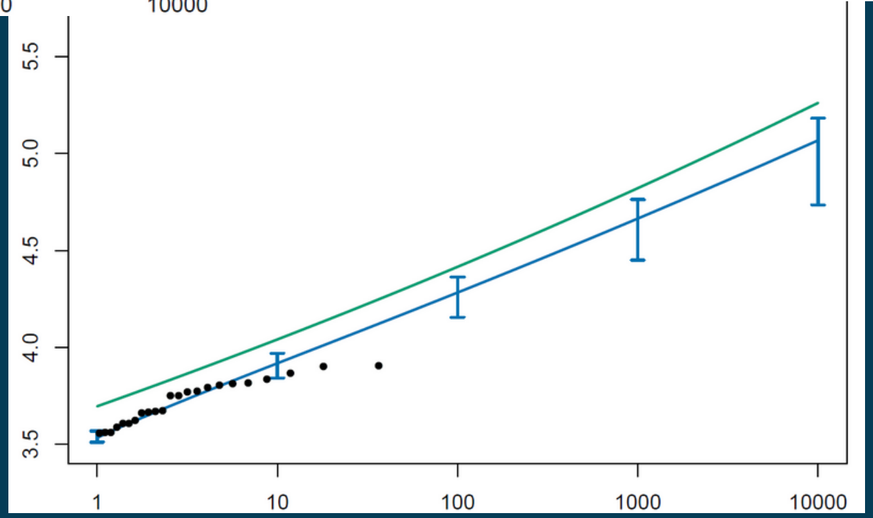
Heysham



Lowestoft

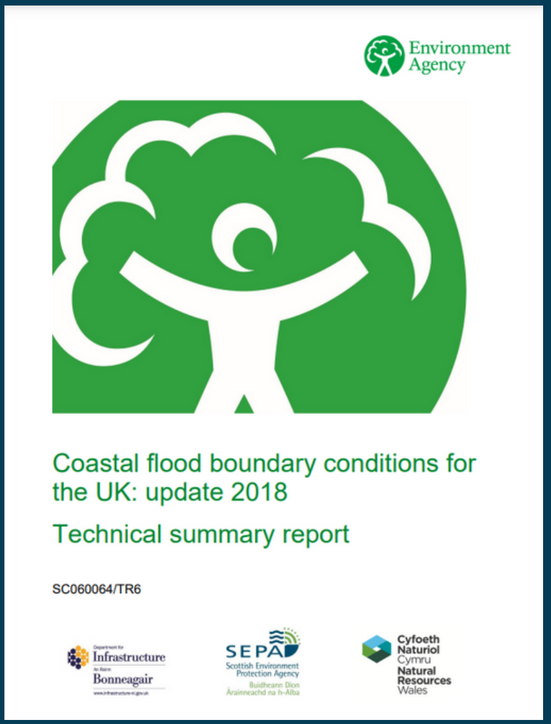


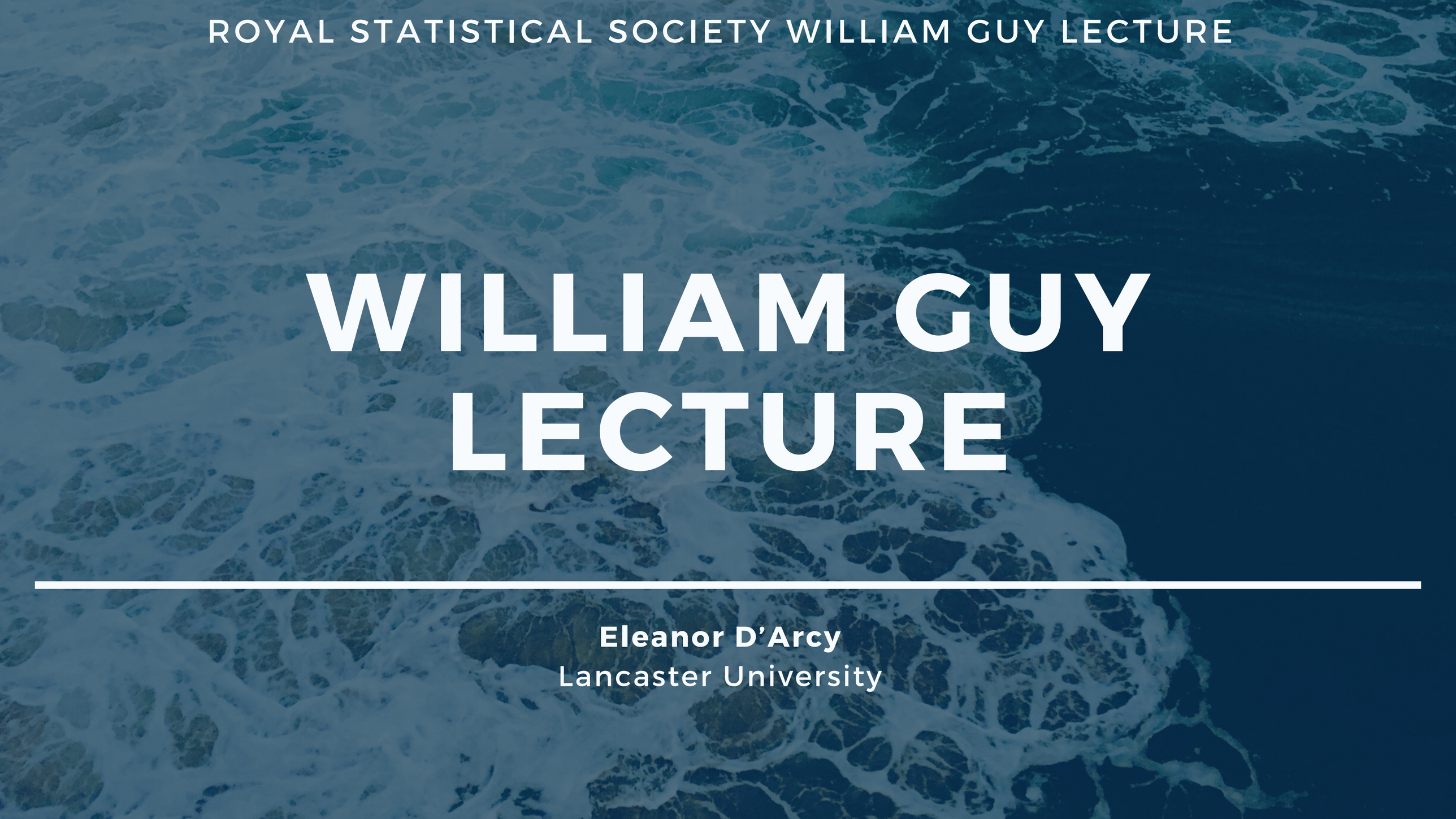
Sheerness



Impact

- Implementation at EDF
- Working with the **Environment Agency** for upgrades in **Coastal Flood Boundary Report**
- Thames Barrier maintenance planning
- Papers
  - D'Arcy, E., Tawn, J. A., Joly, A., & Sifnioti, D. E. (2023). Accounting for seasonality in extreme sea-level estimation. The Annals of Applied Statistics, 17(4), 3500-3525.
  - D'Arcy, E., Tawn, J. A., & Sifnioti, D. E. (2022). Accounting for climate change in extreme sea level estimation. Water, 14(19), 2956.
- R package: *https://github.com/eleanordarcy/ESLestimation*





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Lancaster University

Key themes

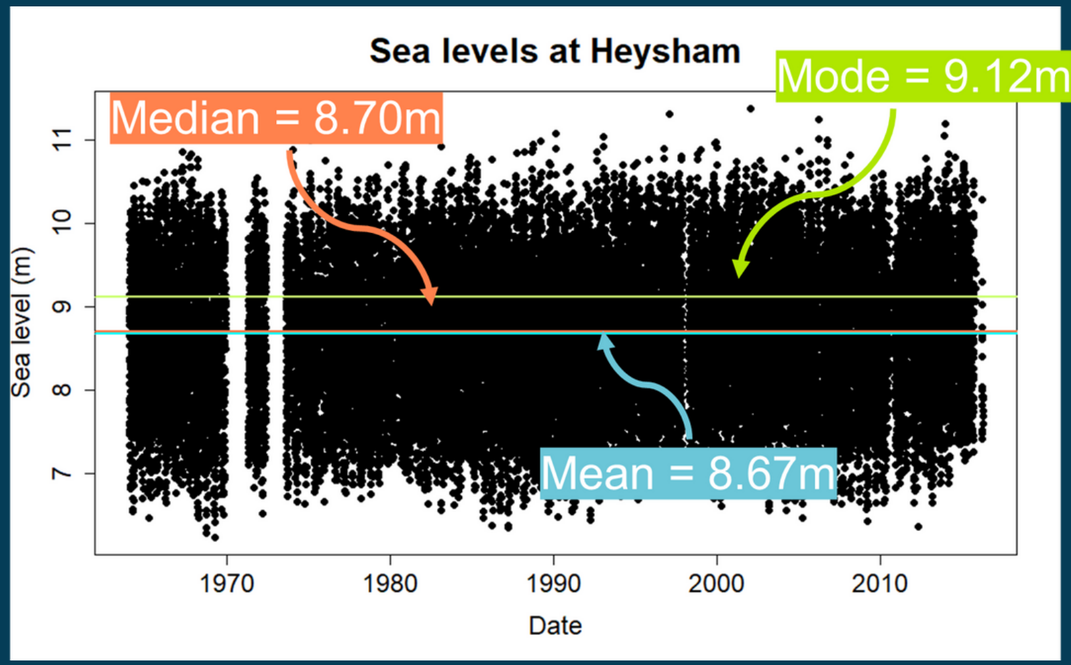
- **01** What is a PhD?
- **02** My journey
- **03** Data
- **04** Statistical modelling
- **05** Collaboration

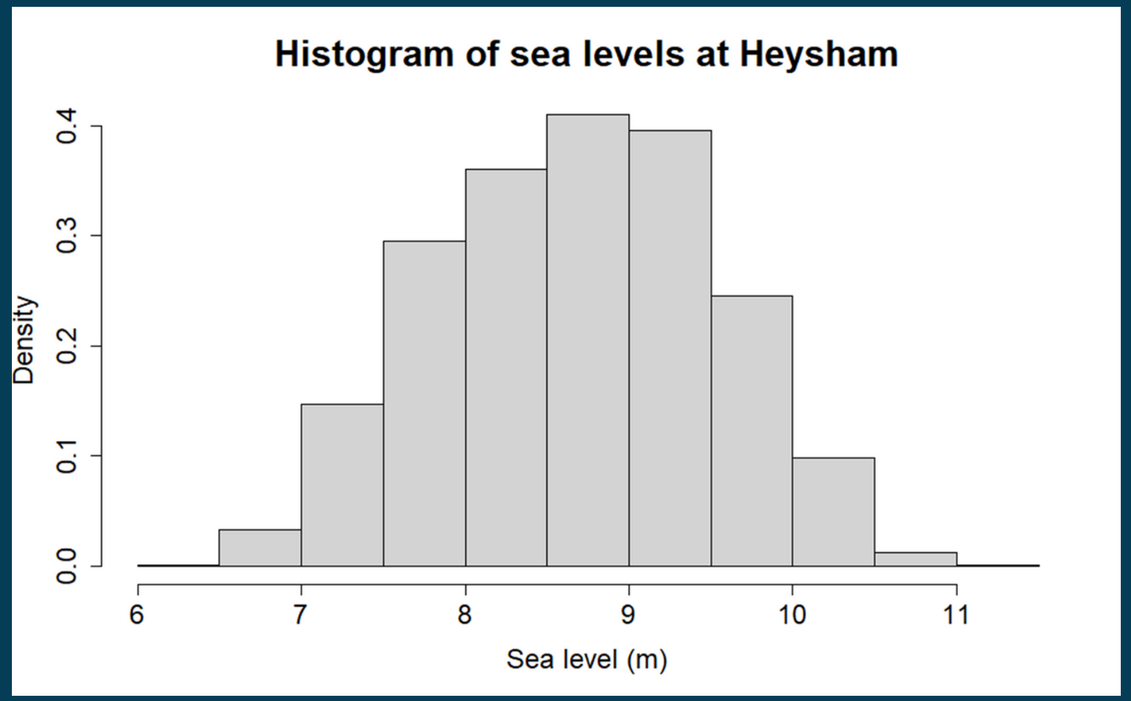
Data

- Sea level observations
- Heysham - North west England
- 2 nuclear power stations
- 50 years of data = 438,300 observations

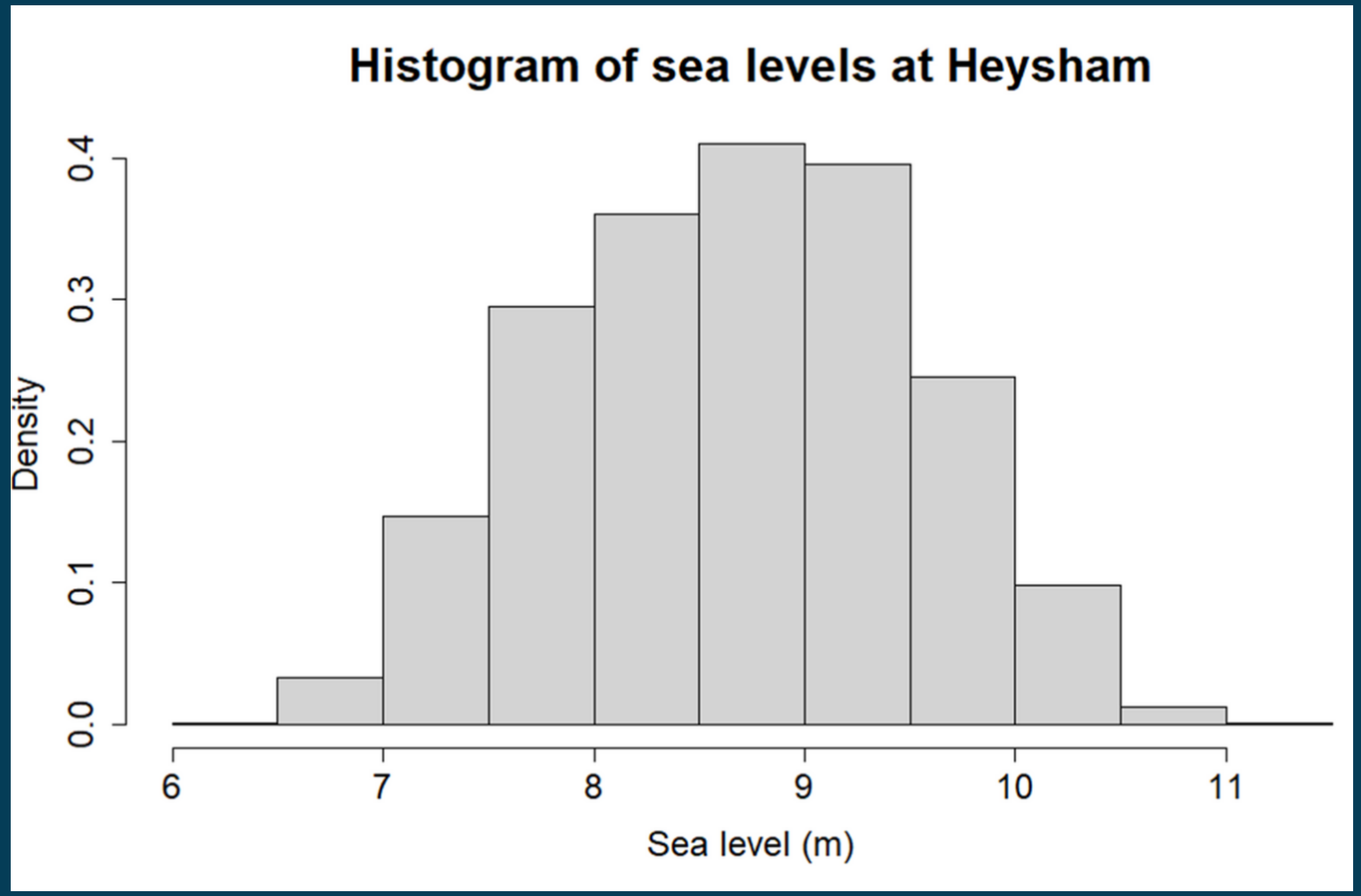
```
Port:                P050
Site:                Heysham
Latitude:            54.03167
Longitude:           -2.92042
Start Date:          01JAN1984-00.00.00
End Date:            31DEC1984-23.00.00
Contributor:         National Oceanography Centre, Liverpool
Datum information:   The data refer to Admiralty Chart Datum (ACD)
Parameter code:      ASLVZZ01 = Surface elevation (unspecified datum) of the water body
  Cycle    Date       Time       ASLVZZ01     Residual
 Number yyyy mm dd hh mi ssf           f            f
     1) 1984/01/01 00:00:00      6.6560       0.4254
     2) 1984/01/01 01:00:00      5.2320       0.5192
     3) 1984/01/01 02:00:00      3.9860       0.6589
     4) 1984/01/01 03:00:00      3.2240       0.8236
     5) 1984/01/01 04:00:00      2.8080       0.8140
     6) 1984/01/01 05:00:00      2.8360       0.5795
     7) 1984/01/01 06:00:00      3.9330       0.5015
```

Data visualisation

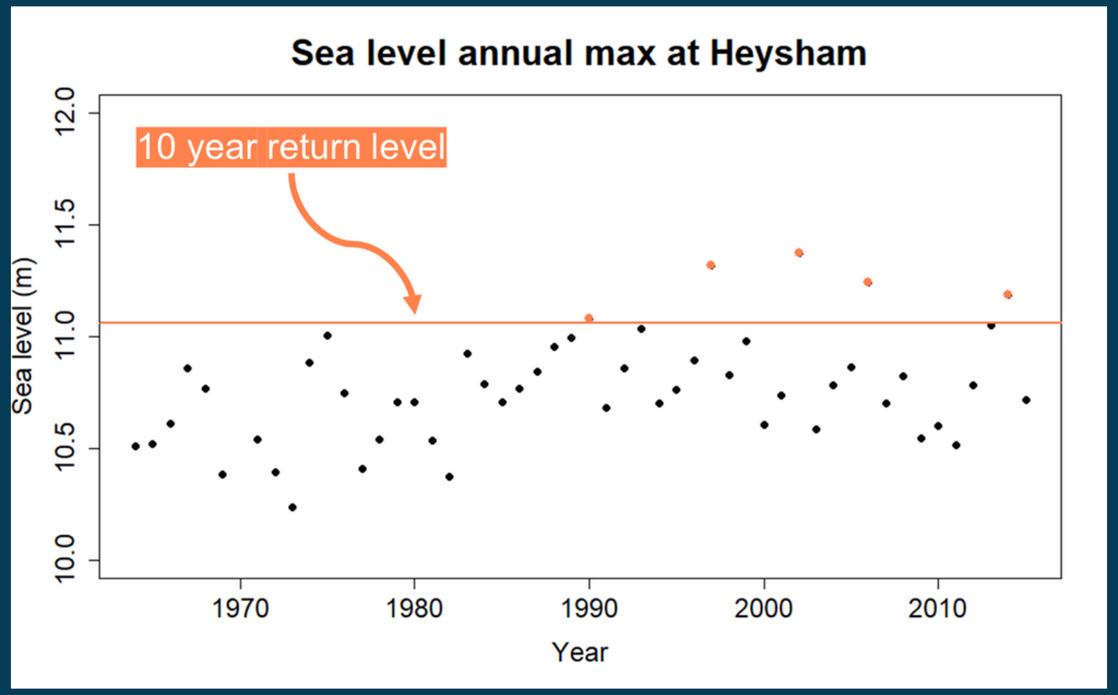


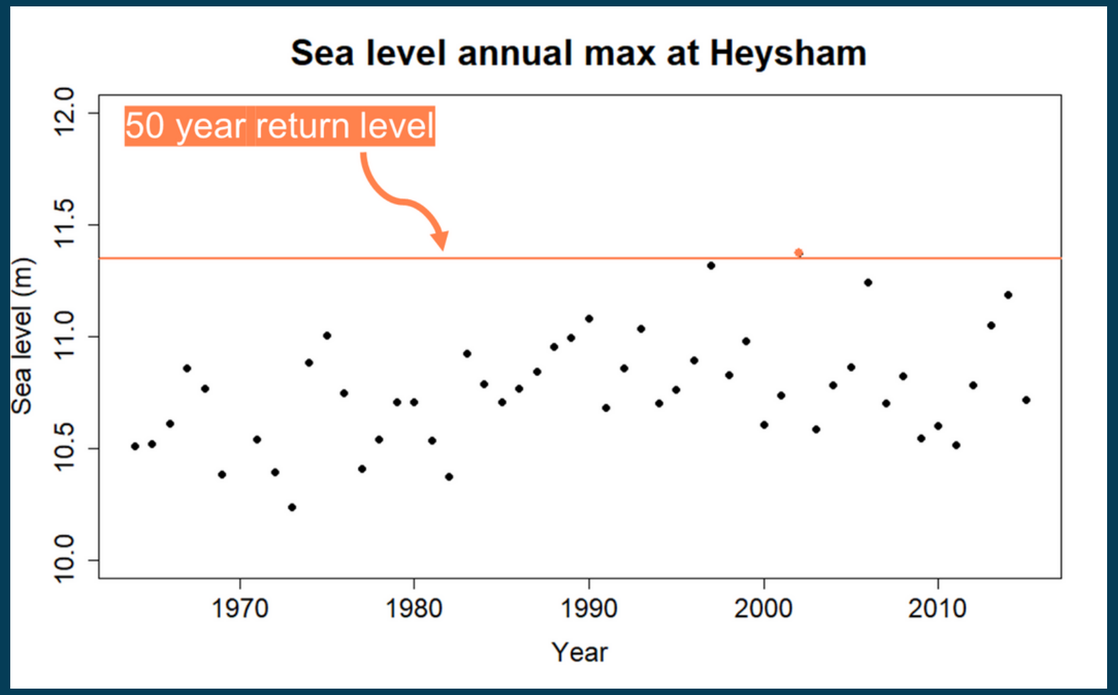


How high should we build a sea wall?



Return Levels

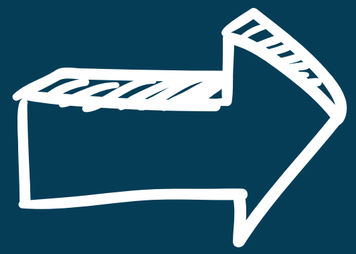




What about the 10,000 year return level?

Can statistical modelling help?

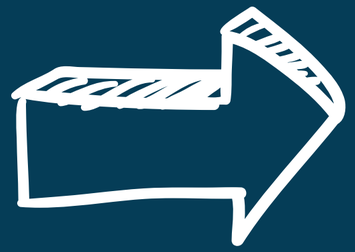
Data



Statistical Model

Learn about the data

Settings: parameters



Predictions

- Estimate of future events
- Probability of an unobserved event

Statistical models

Linear models

Normal model

Harmonics

Extreme value model

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TAKEAWAYS

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Lancaster University

Things that worked

- Being honest about failure
- Being relatable: Maths is hard

- Using real-world data
- Drawing from concepts they learn in class to make it interesting

Reflections

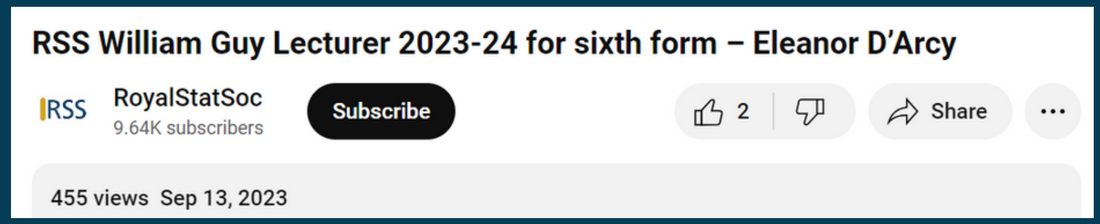
- Pressure and privilege
- Outreach should be valued more
- Direct feedback is limited
- Choosing something that I find interesting to talk about
- Every talk is different

Thank you very much for giving your talk to round of my Taster Day.

I think that it was pitched at the right level and gave the students a real life application of statistics that they could relate to. Often the ‘real life’ examples that they work with are

It was great! Thanks so much for your time to deliver this talk and sharing your own journey of study to hopefully encourage more girls to study Maths at a Higher level! #maths4girls

Thanks again so much for speaking to the sixth form mathematicians at Headington, it was a great way to end our half term and hopefully will inspire many more of them to consider studying maths at university.



THANK YOU, ANY QUESTIONS?

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