

ROYAL STATISTICAL SOCIETY WILLIAM GUY LECTURE

# HOW CAN STATISTICS PROTECT US AGAINST CLIMATE CHANGE?

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Eleanor D'Arcy  
Lancaster University

# Agenda

- 01 RSS William Guy Lectureship
- 02 About you
- 03 About me
- 04 Statistics
- 05 Statistical Modelling
- 06 Extreme Sea Level Estimation

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# WILLIAM GUY LECTURESHIP

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Lancaster University

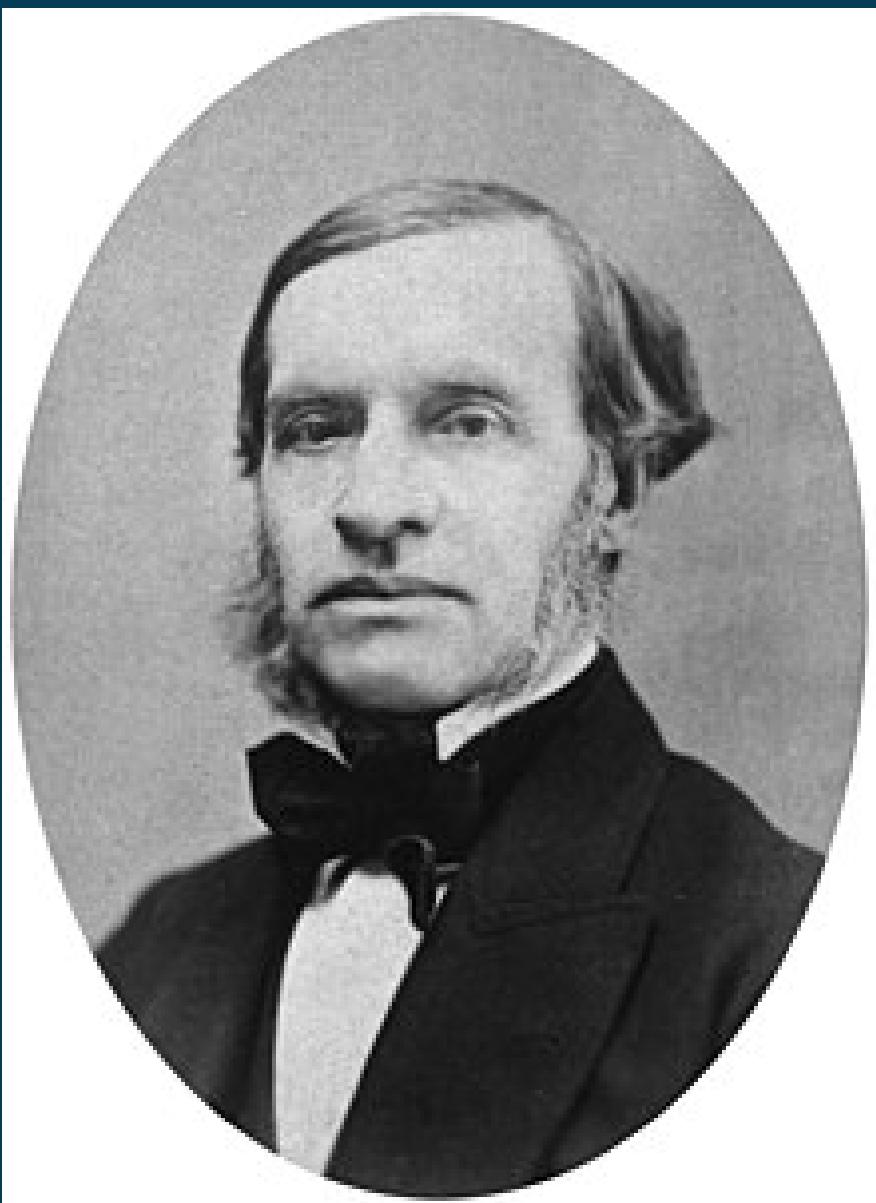
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THE RSS WILLIAM GUY  
LECTURERS ARE PRESTIGIOUS  
VOLUNTEER ROLES INTENDED TO  
CELEBRATE THE IMPORTANCE OF  
ENGAGING WITH SCHOOLS AND  
INSPIRING CHILDREN ABOUT  
STATISTICS FROM AN EARLY AGE.

ROYAL STATISTICAL SOCIETY

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# William Augustus Guy



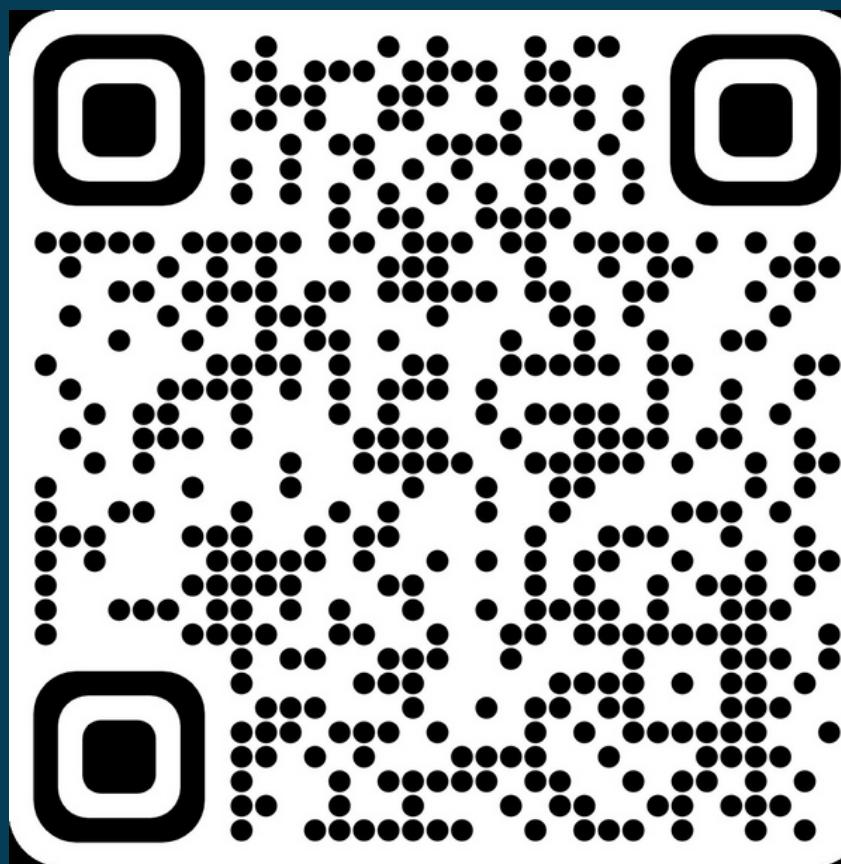
- Medical statistician
- RSS president 1873-1875
- Guy medals are awarded to distinguished statisticians for important work
- First Guy lecture given in 1999
- Three WG lecturers are appointed each academic year

# William Guy Lecturers 23/24

- Theme: *Environmental Statistics and Climate Change*
- Katherine Whyte (primary schools):  
*When we build wind farms, what happens to the wildlife?*
- Craig Anderson (secondary schools):  
*Using statistics to monitor air pollution*



# All of our lectures are on YouTube...



william guy lectures

RSS William Guy Lecturer 2023-24 for primary school – Katherine Whyte  
220 views • 3 weeks ago

RSS RoyalStatSoc

Katherine Whyte is the RSS William Guy Lecturer for primary school 2023-24. Here, she delivers her talk \_When we build wind ...

RSS William Guy Lecturer 2023-24 for sixth form – Eleanor D'Arcy  
238 views • 3 weeks ago

RSS RoyalStatSoc

Eleanor D'Arcy is the William Guy Lecturer for sixth form 2023-24. Here, she delivers her talk \_How can statistics protect us ...

Sea level annual mean at Heysham | Histogram of sea levels at Heysham | Sea level annual max at... 5 moments

RSS William Guy Lecturer 2023-24 for secondary school – Craig Anderson  
225 views • 3 weeks ago

RSS RoyalStatSoc

Craig Anderson is the William Guy Lecturer for secondary school 2023-24. Here, he delivers his talk \_Using statistics to monitor ...

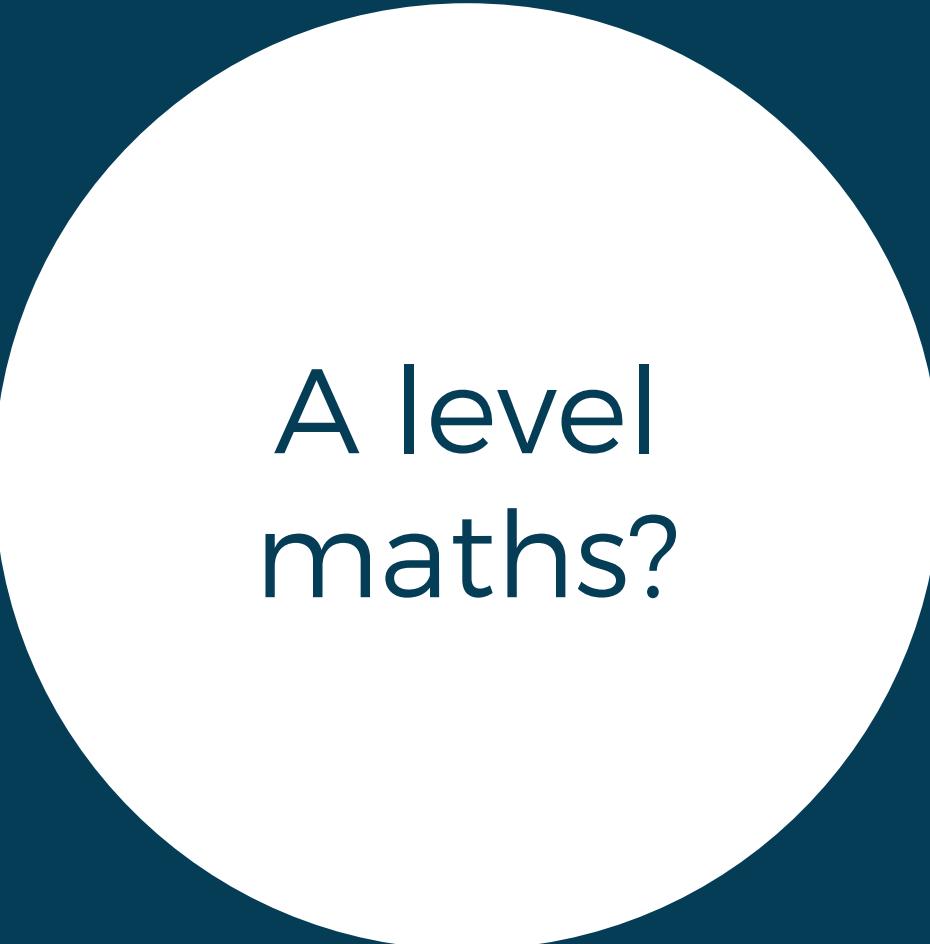
Filters

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# ABOUT YOU

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A level  
maths?

A level  
maths?

Statistics?

A level  
maths?

Future  
career?

Statistics?

A level  
maths?

Future  
career?

Statistics?

University?

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# ABOUT ME

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Eleanor D'Arcy  
Lancaster University

# What is a PhD?



- PhD: Doctor of Philosophy
- The highest level of academic qualification you can achieve.
- Normally takes 3-4 years of full-time work to complete.
- You'll research and write a thesis offering an original contribution to your subject.



# What is a PhD?

Independent research project

Personal development

Publish research

Based at a university

Work closely with an academic

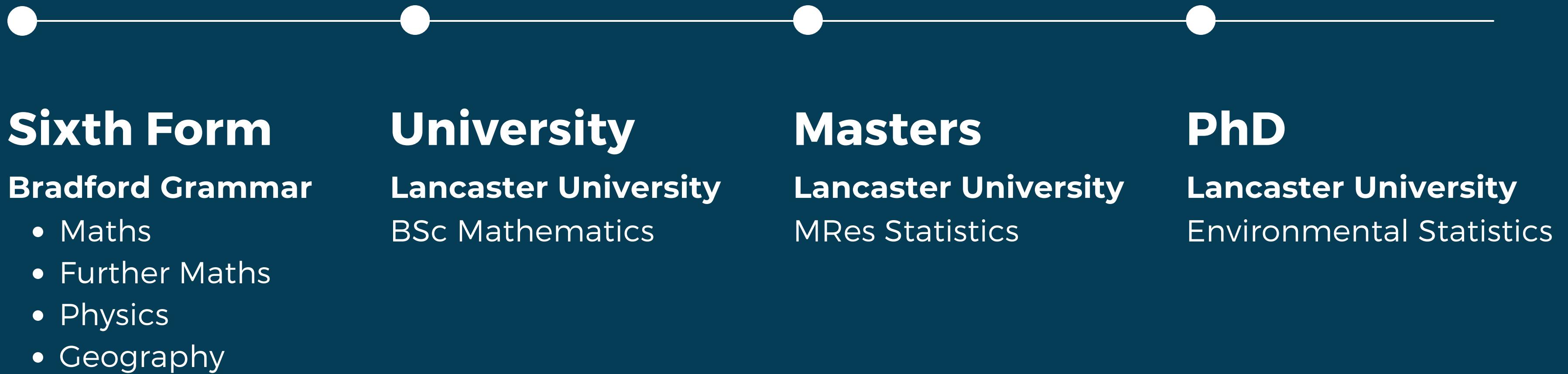
You get paid

Present research at conferences

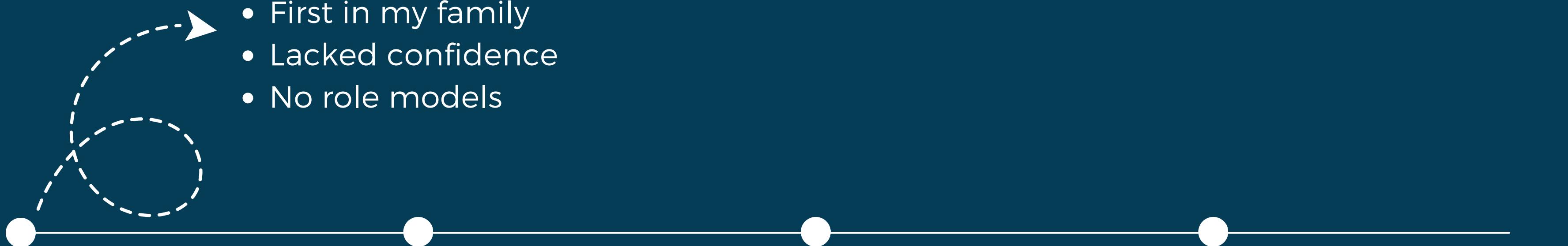
You're a doctor!



# My Journey



# My Journey



## Sixth Form

**Bradford Grammar**

- Maths
- Further Maths
- Physics
- Geography

## University

**Lancaster University**

BSc Mathematics

## Masters

**Lancaster University**

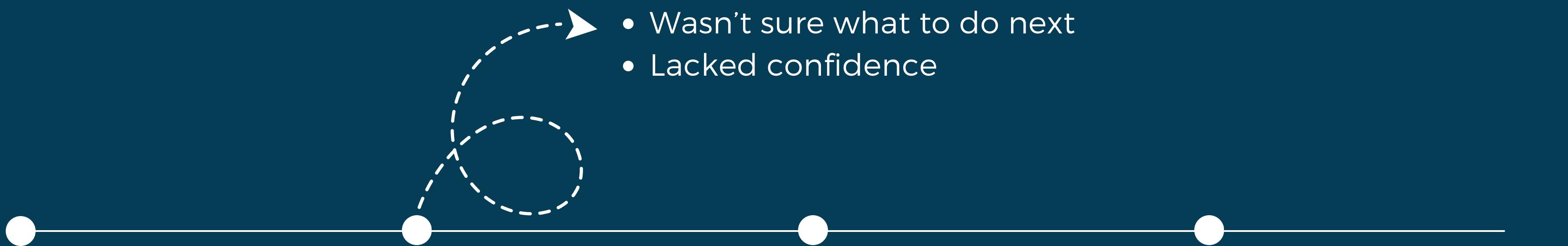
MRes Statistics

## PhD

**Lancaster University**

Environmental Statistics

# My Journey



## Sixth Form

**Bradford Grammar**

- Maths
- Further Maths
- Physics
- Geography

## University

**Lancaster University**

BSc Mathematics

## Masters

**Lancaster University**

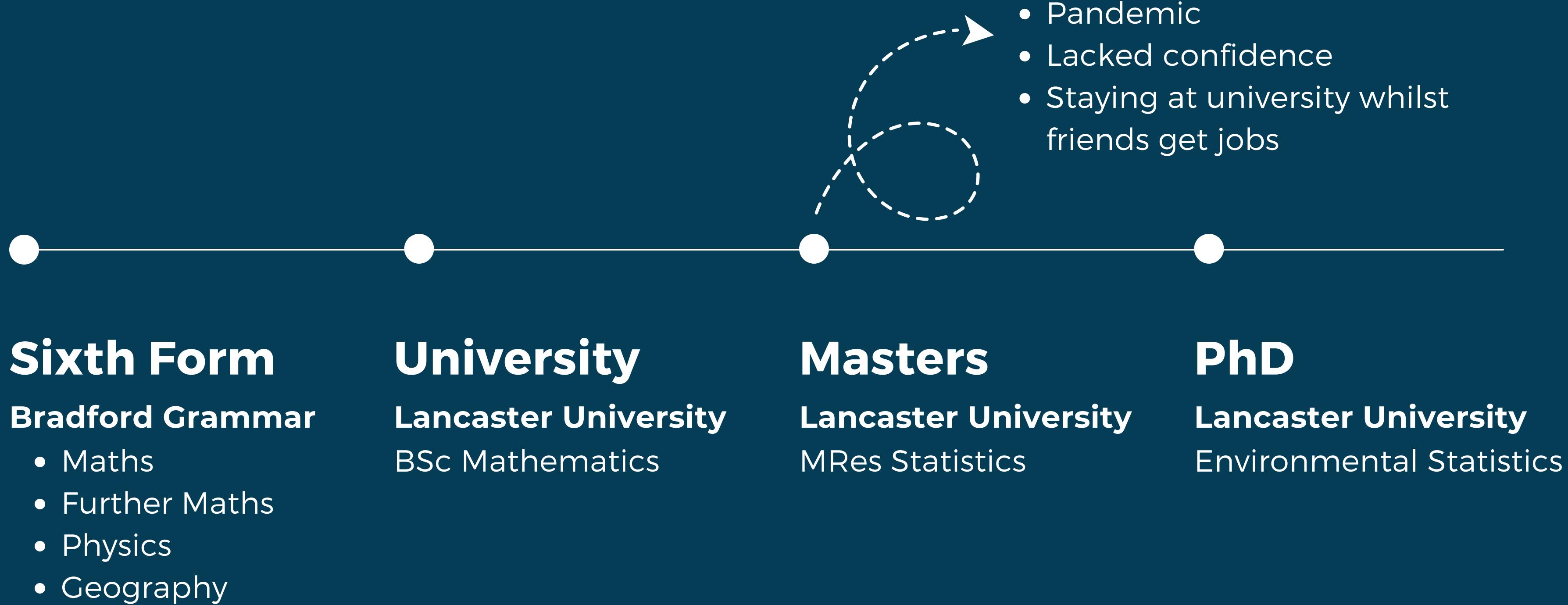
MRes Statistics

## PhD

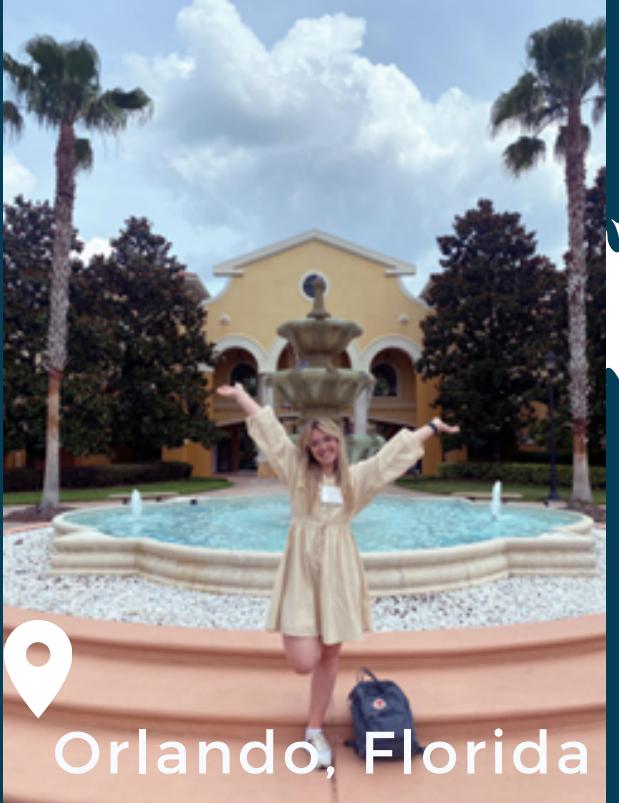
**Lancaster University**

Environmental Statistics

# My Journey



# Conferences and Travel



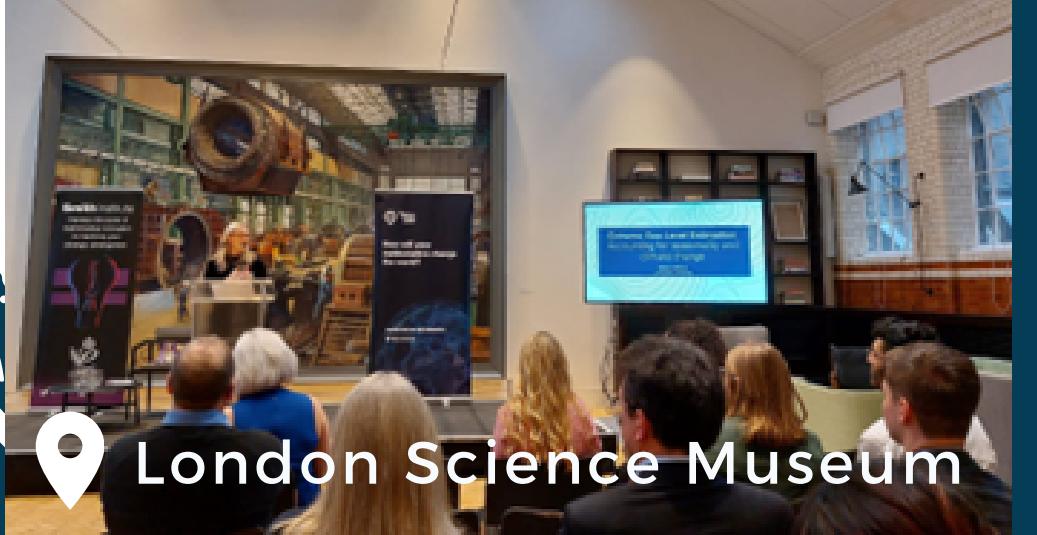
Orlando, Florida



Milan, Italy



Houses of parliament



London Science Museum

# Other Opportunities

## Outreach

William Guy  
lecturer

Teaching  
students

Visit local  
schools

## EDI

Womens+  
network

Athena Swan  
representative

Student  
support  
groups

Organise  
conferences

Visit  
industry

Present  
work to  
different  
audiences

## Research impact

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# STATISTICS

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Lancaster University

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STATISTICS IS A BRANCH OF  
APPLIED MATHEMATICS THAT  
STUDIES AND MANIPULATES DATA.  
THIS INVOLVES THE COLLECTION,  
DESCRIPTION, ANALYSIS, AND  
INFERENCE (DRAWING  
CONCLUSIONS FROM DATA).

JIM CHAPPELOW

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# STATISTICS

Health care departments

Budgeting and finance

Educational data

Medical records

Weather forecasting

Business statistics

Neuroscience

Record of production goods and services

Population record

Machine learning

Stock market data analysis

Computer Science

Data science

Travel and tourism

Sports

Clinical trials

Information technology

Quality department of a company

Robotics

Political campaigns

Transportation

Sales tracking

Pandemic analysis

Artificial intelligent devices

Research and analysis

Cryptocurrency

# Common Statistics

## Mean

The average of all of the data

## Median

The middle number, when in order

## Mode

The most common number

## Example

10, 5, 5, 6, 3, 3, 9, 4, 7, 7, 3

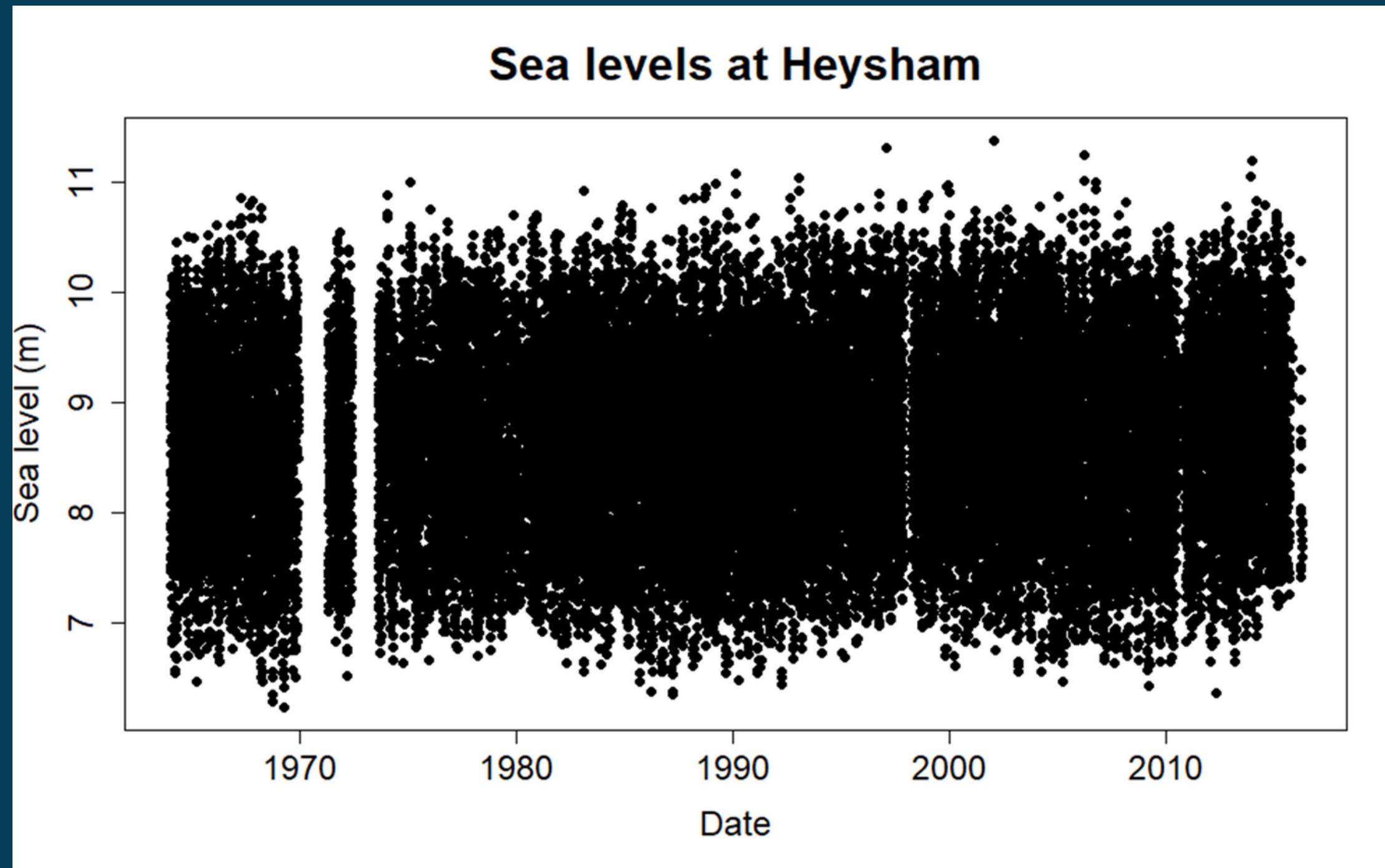
- Mean:  $(10 + 5 + 5 + 6 + 3 + 3 + 9 + 4 + 7 + 7 + 3)/11 = 6.3$
- Median: 3, 3, 3, 4, 5, **5**, 6, 7, 7, 9, 10
- Mode: 10, 5, 5, 6, **3**, **3**, 9, 4, 7, 7, **3**

# Data

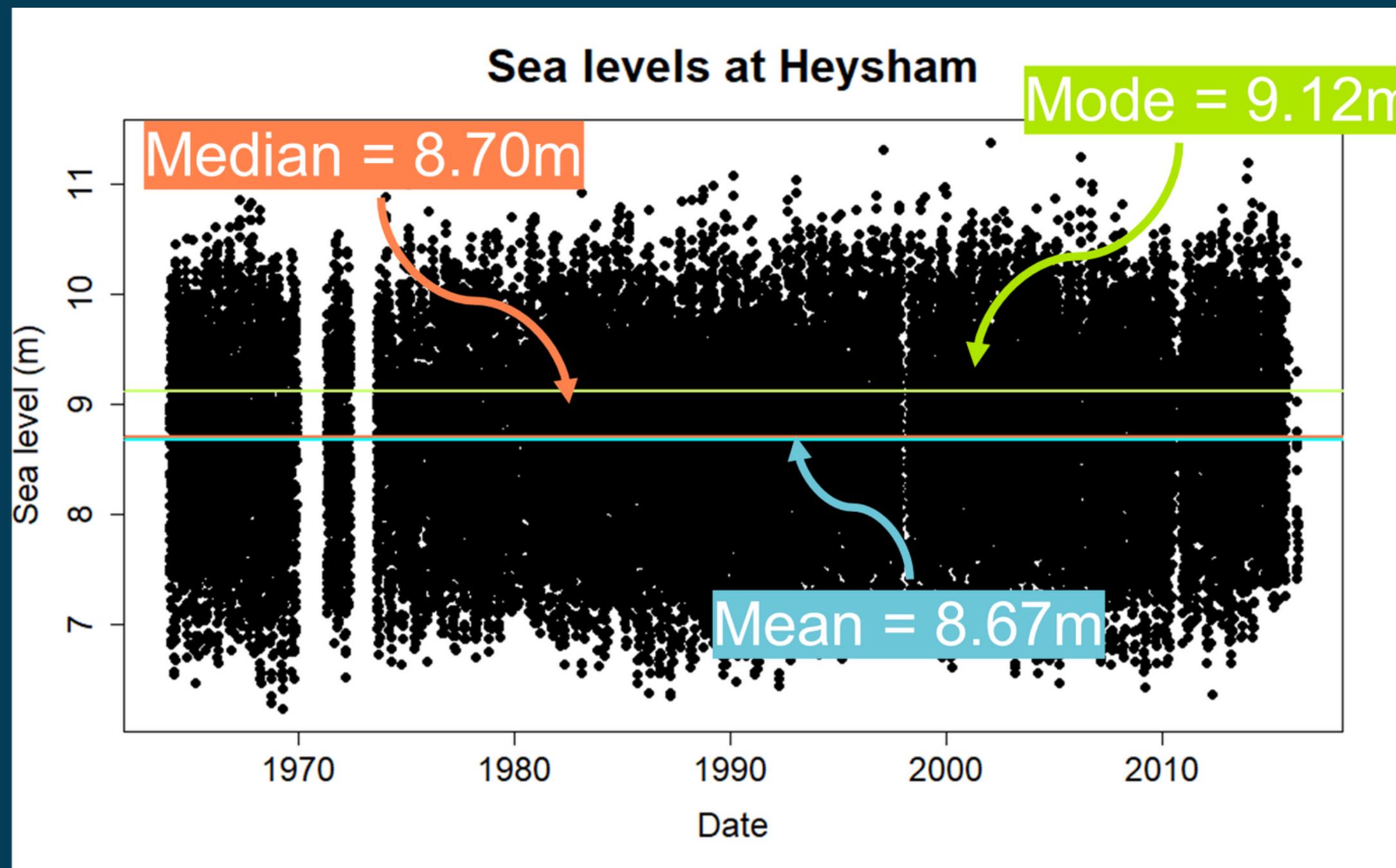
- Sea level observations
- Heysham - North west England
- 2 nuclear power stations
- 50 years of data = 438,300 observations

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



# Mean/Median/Mode



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# STATISTICAL MODELLING

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Lancaster University

# What is a statistical model?

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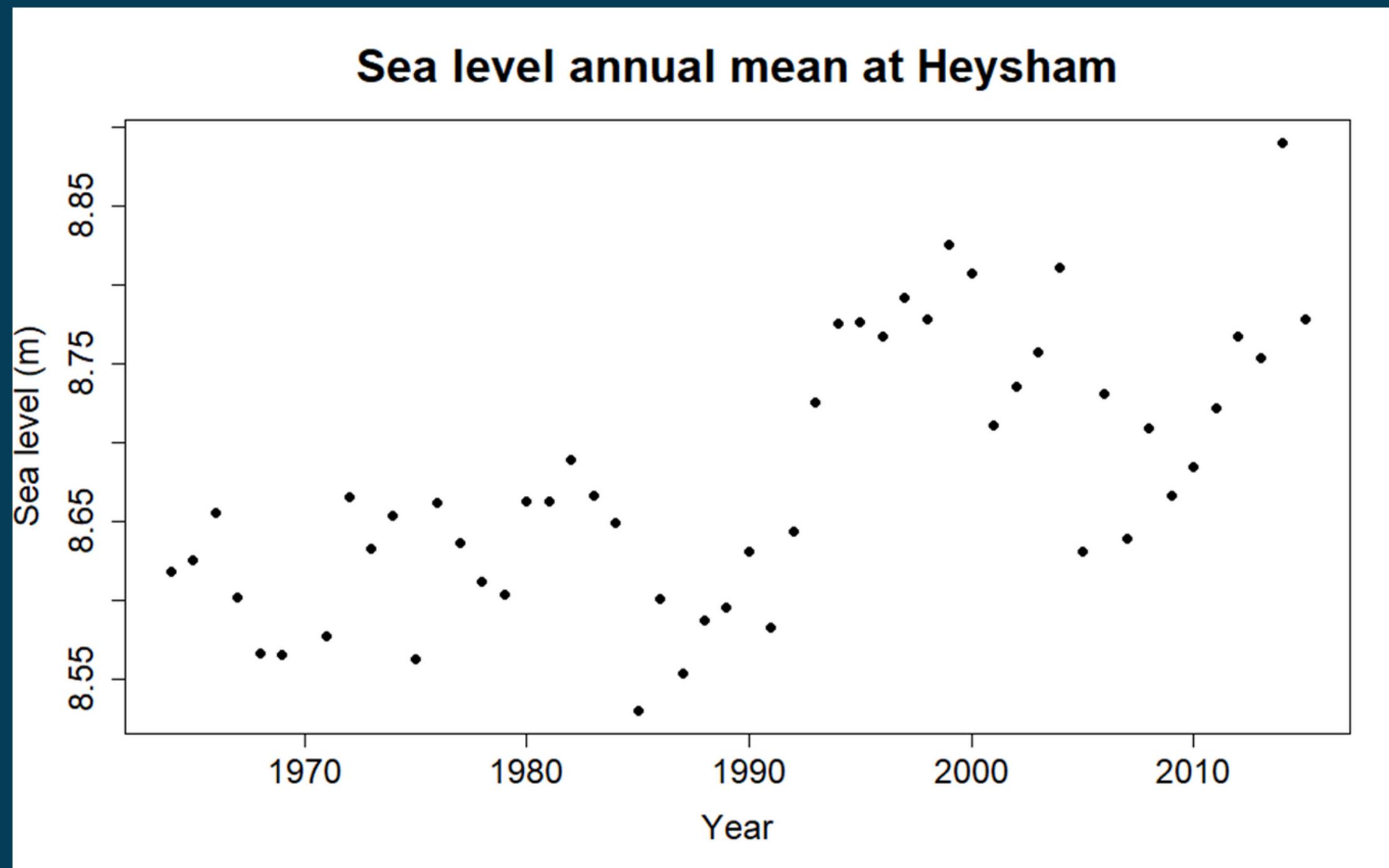
The goal of a statistical model is to provide us with insights and help us make informed decisions using the available data.

ChatGPT



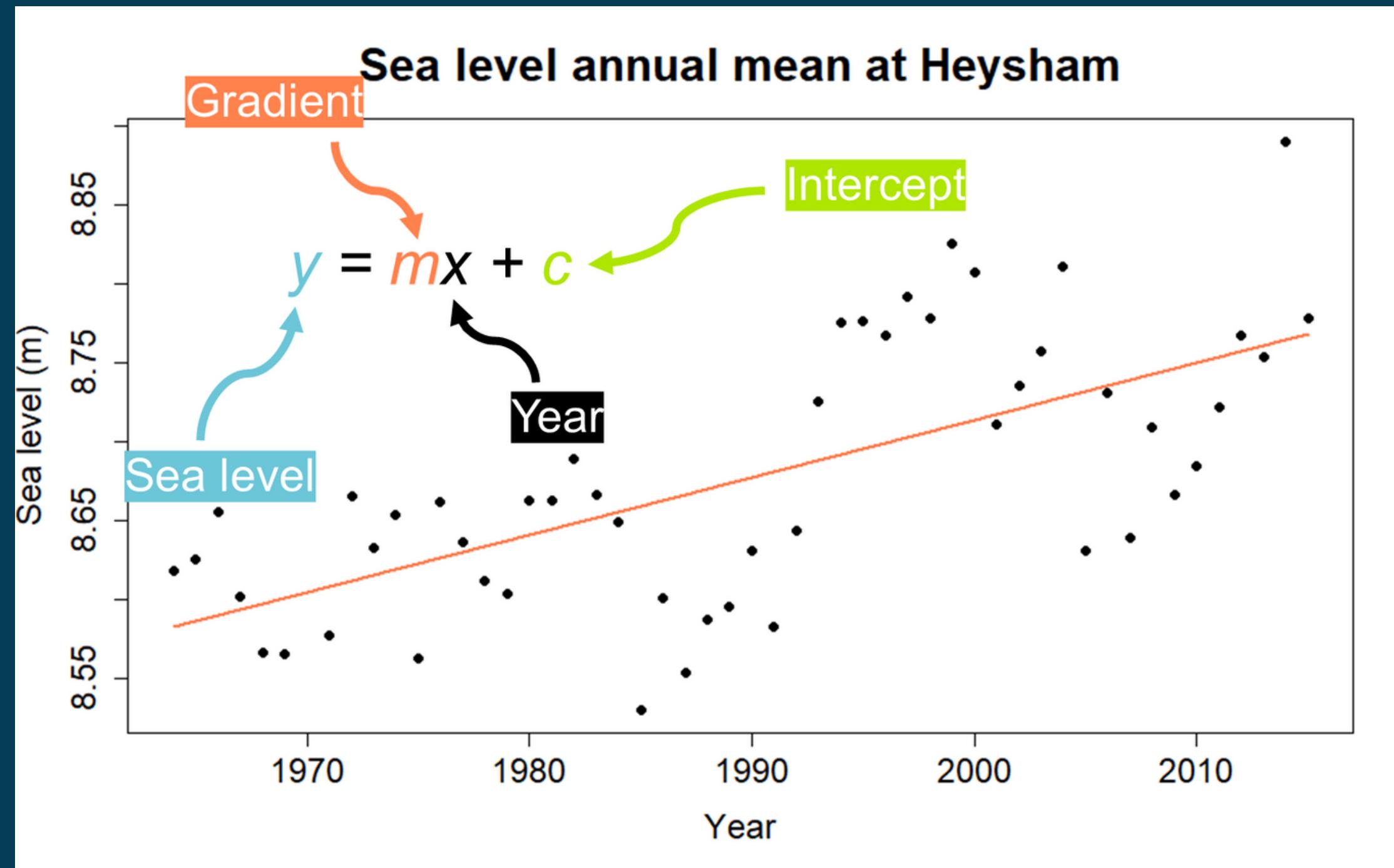
# Linear Models

Input: Annual mean sea levels



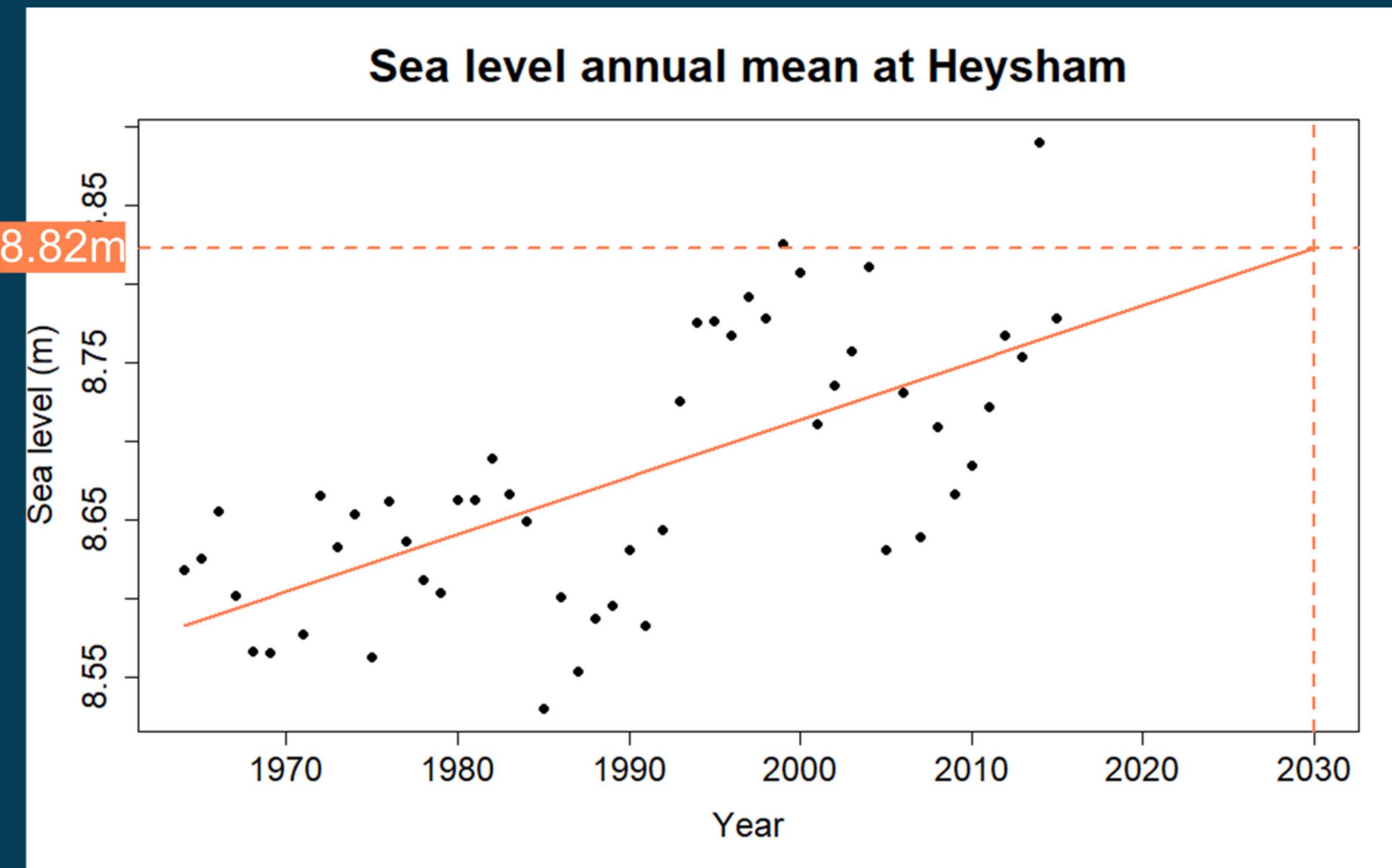
# Linear Models

Model: Use a straight line to represent the relationship between two variables



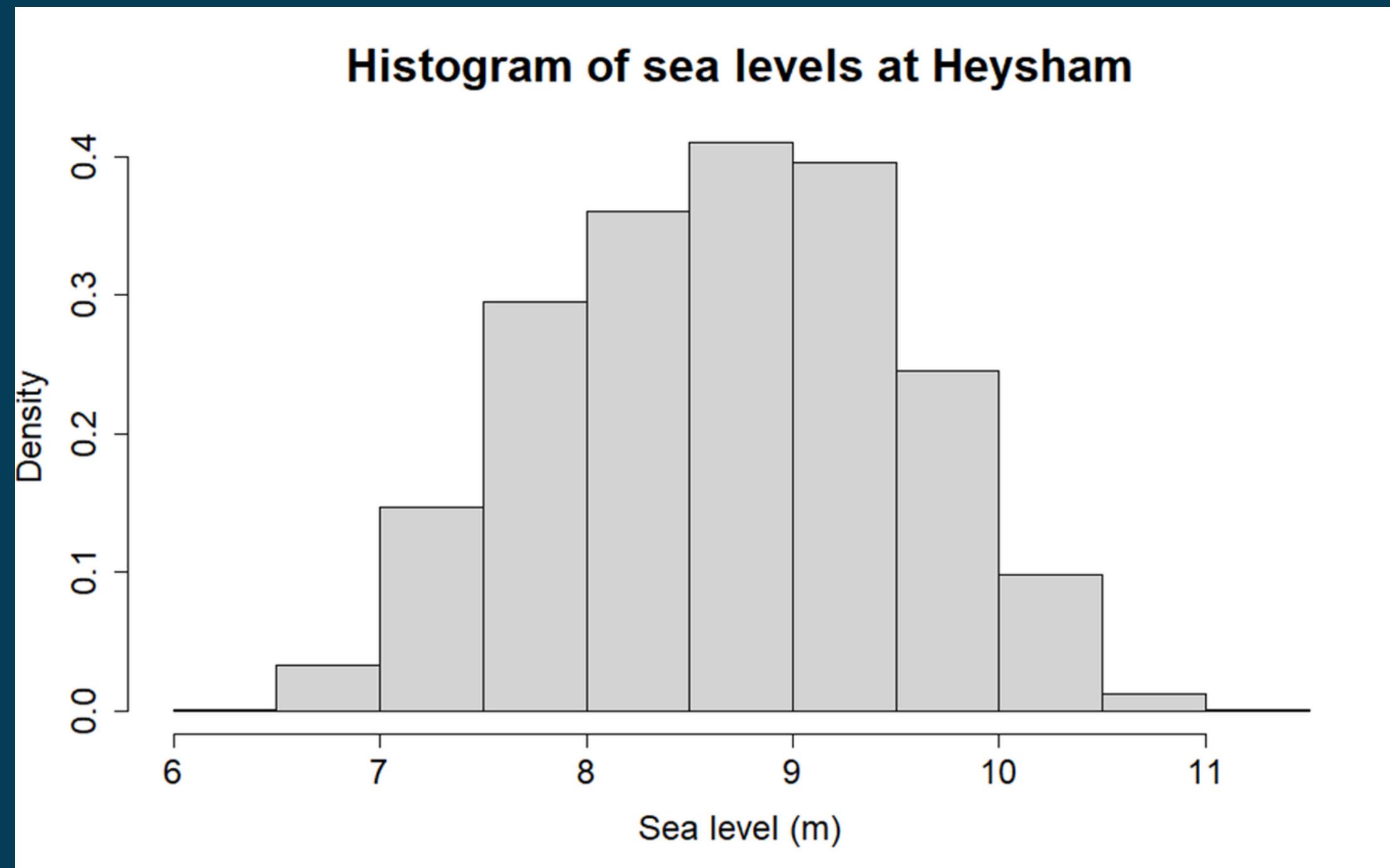
# Linear Models

Output: Prediction of sea level in a future year



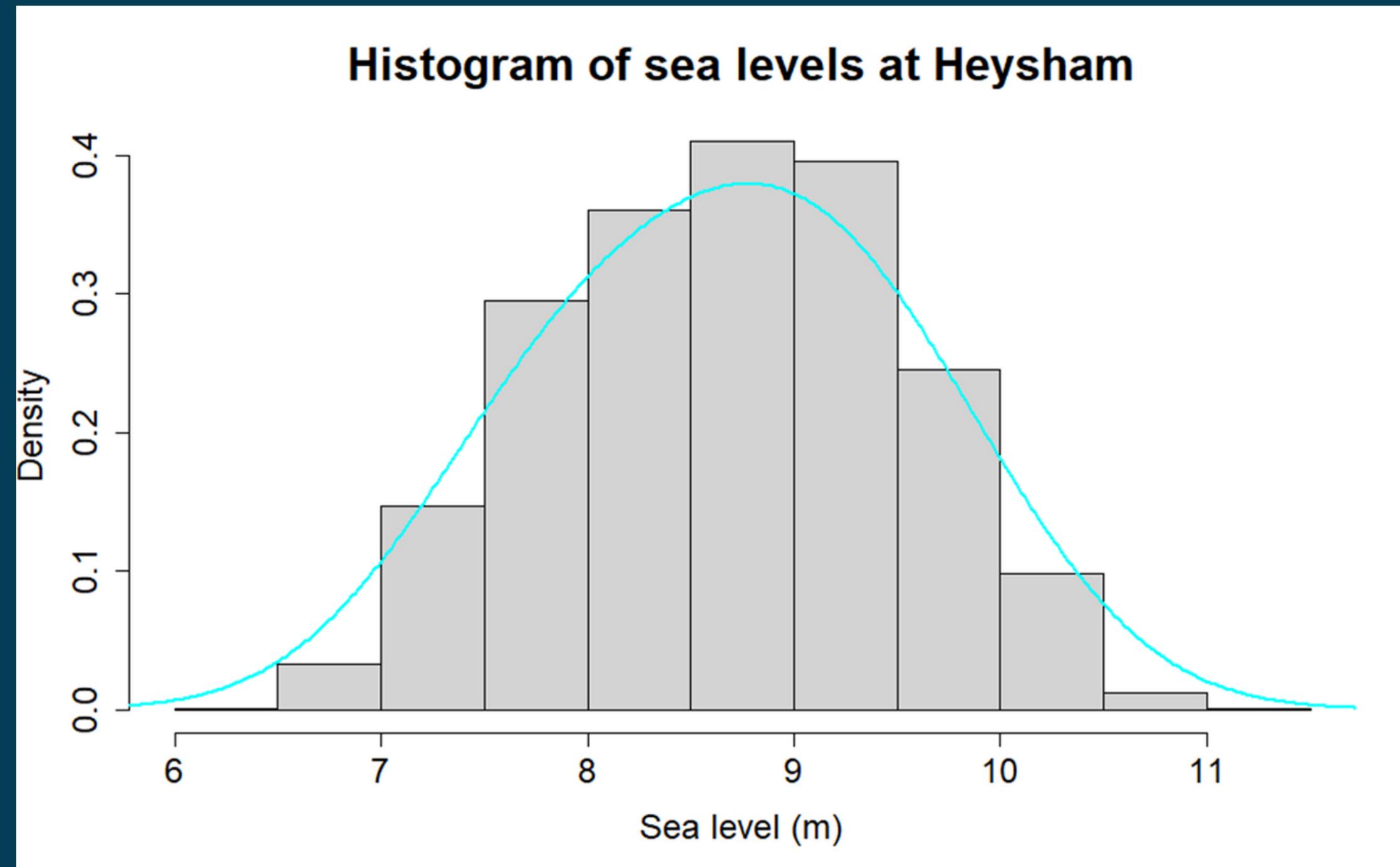
# Probabilistic Models

Input: All of the observations (as a histogram for visualisation)



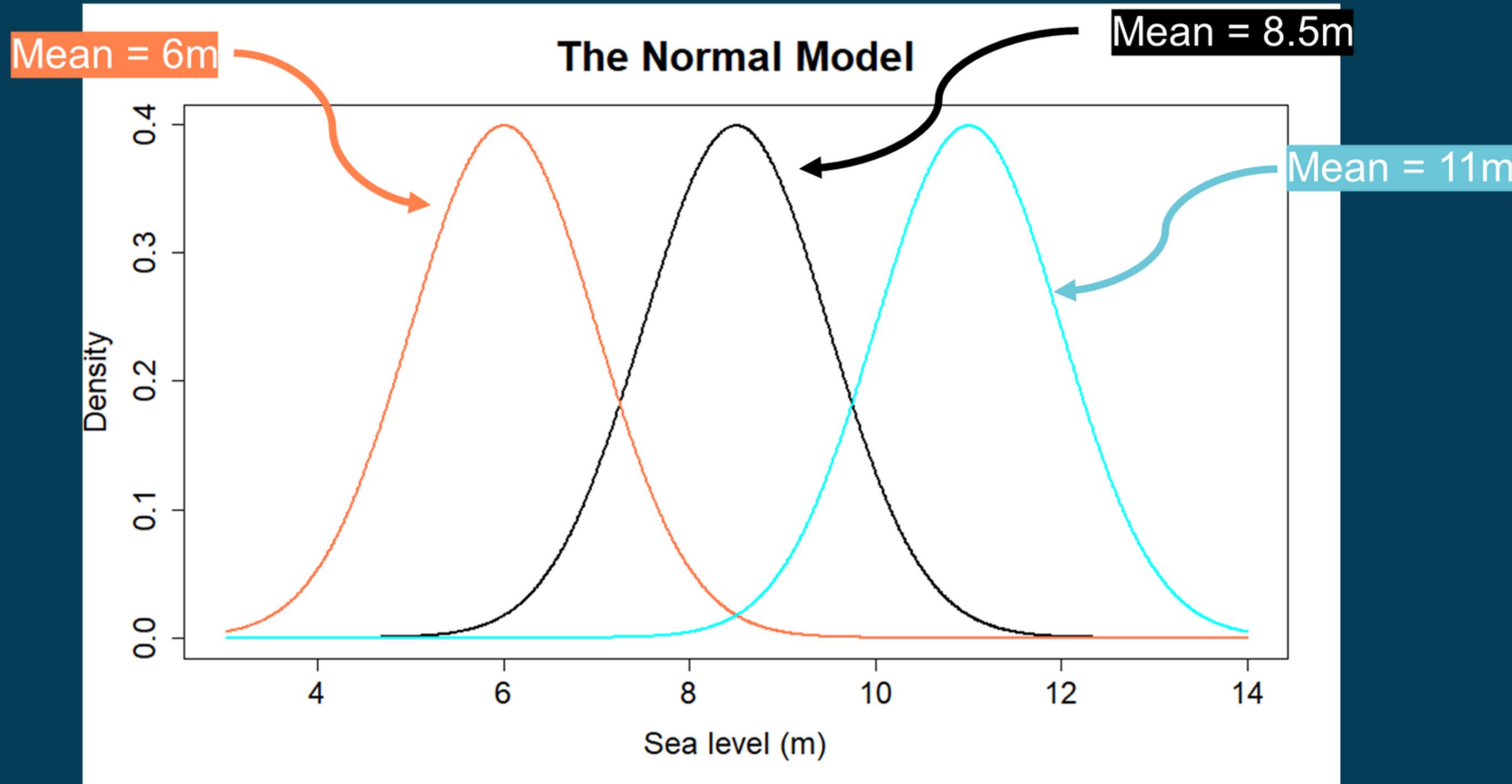
# Probabilistic Models

Model: Tells us about the likelihood, or the probability, that we will observe each value in our data.



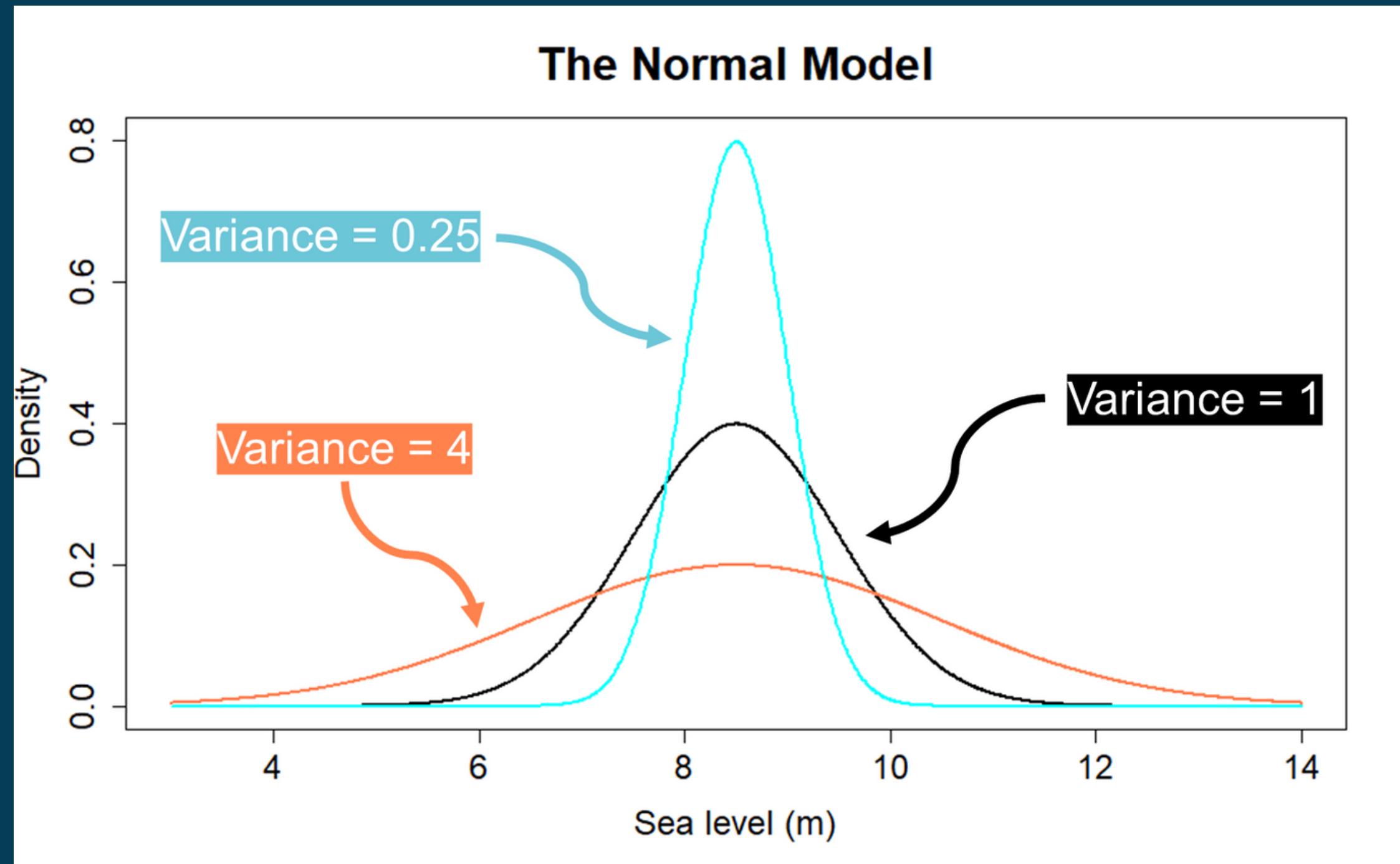
# Normal Model

Setting 1: Mean



# Normal Model

Setting 2: Variance



“

**ALL MODELS ARE WRONG, BUT  
SOME ARE USEFUL.**

**GEORGE BOX**

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# EXTREME SEA LEVEL ESTIMATION

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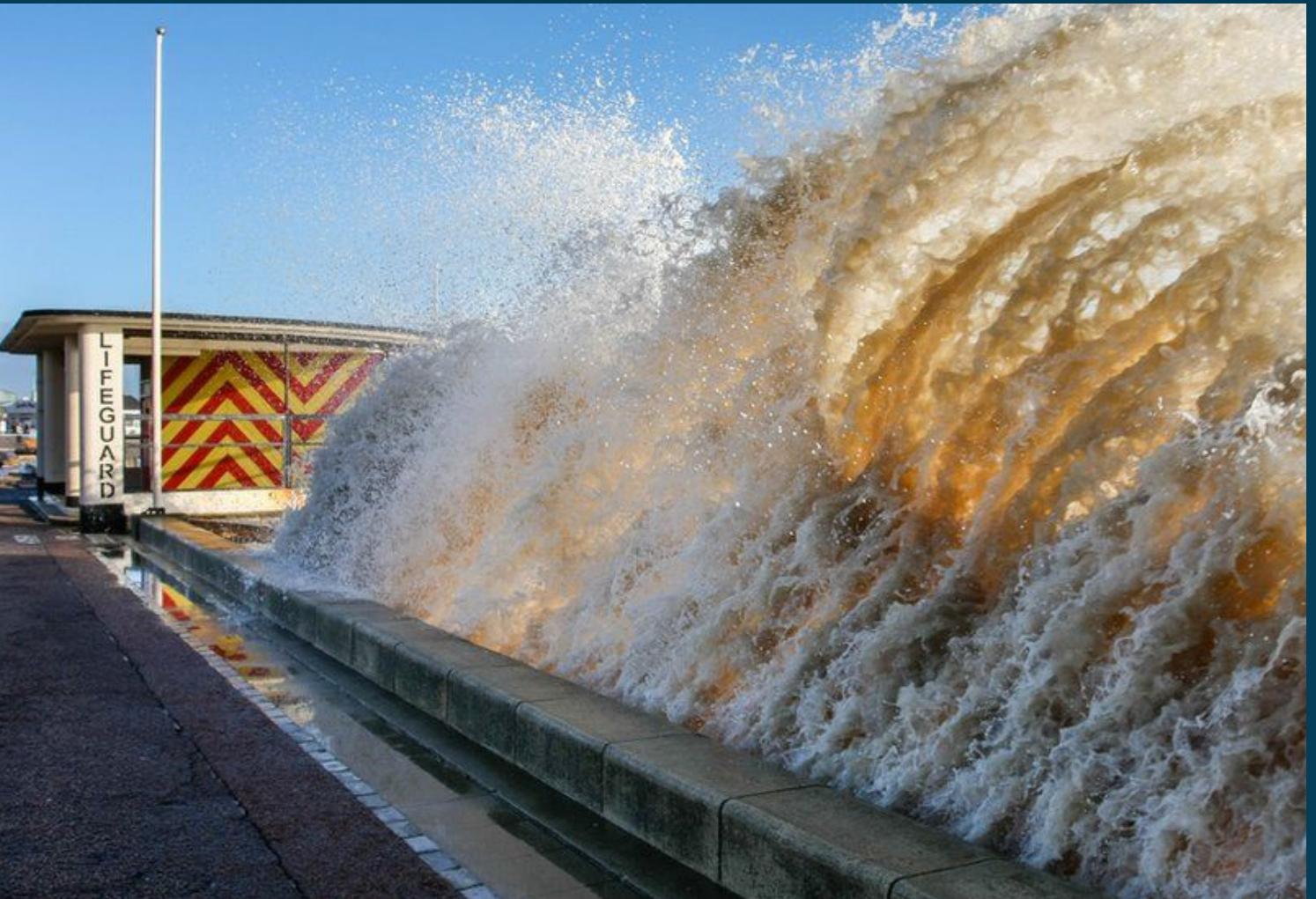
Eleanor D'Arcy  
Lancaster University

# Motivation

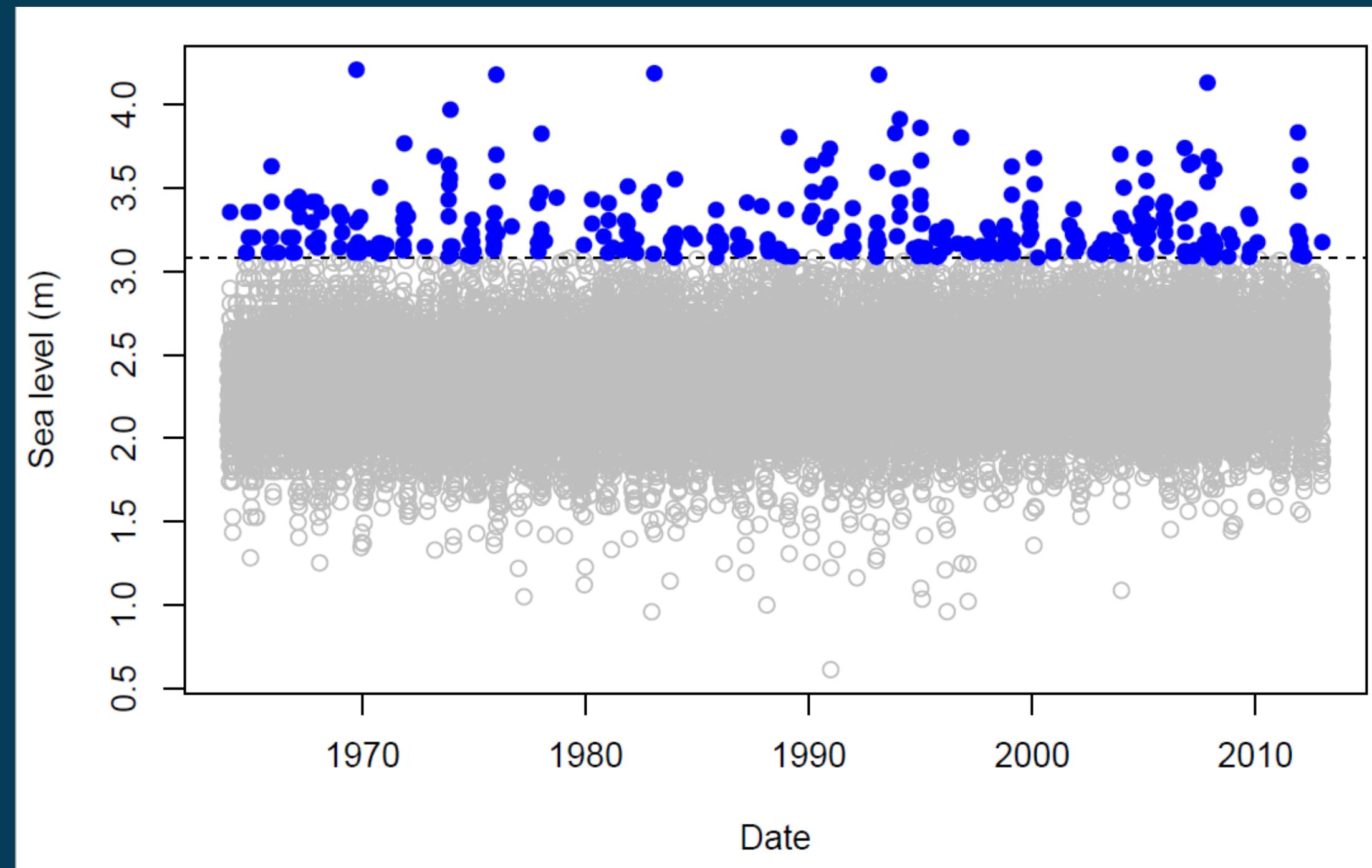
The risk of coastal flooding is increasing due to climate change and sea level rise.

Consequences of coastal flooding:

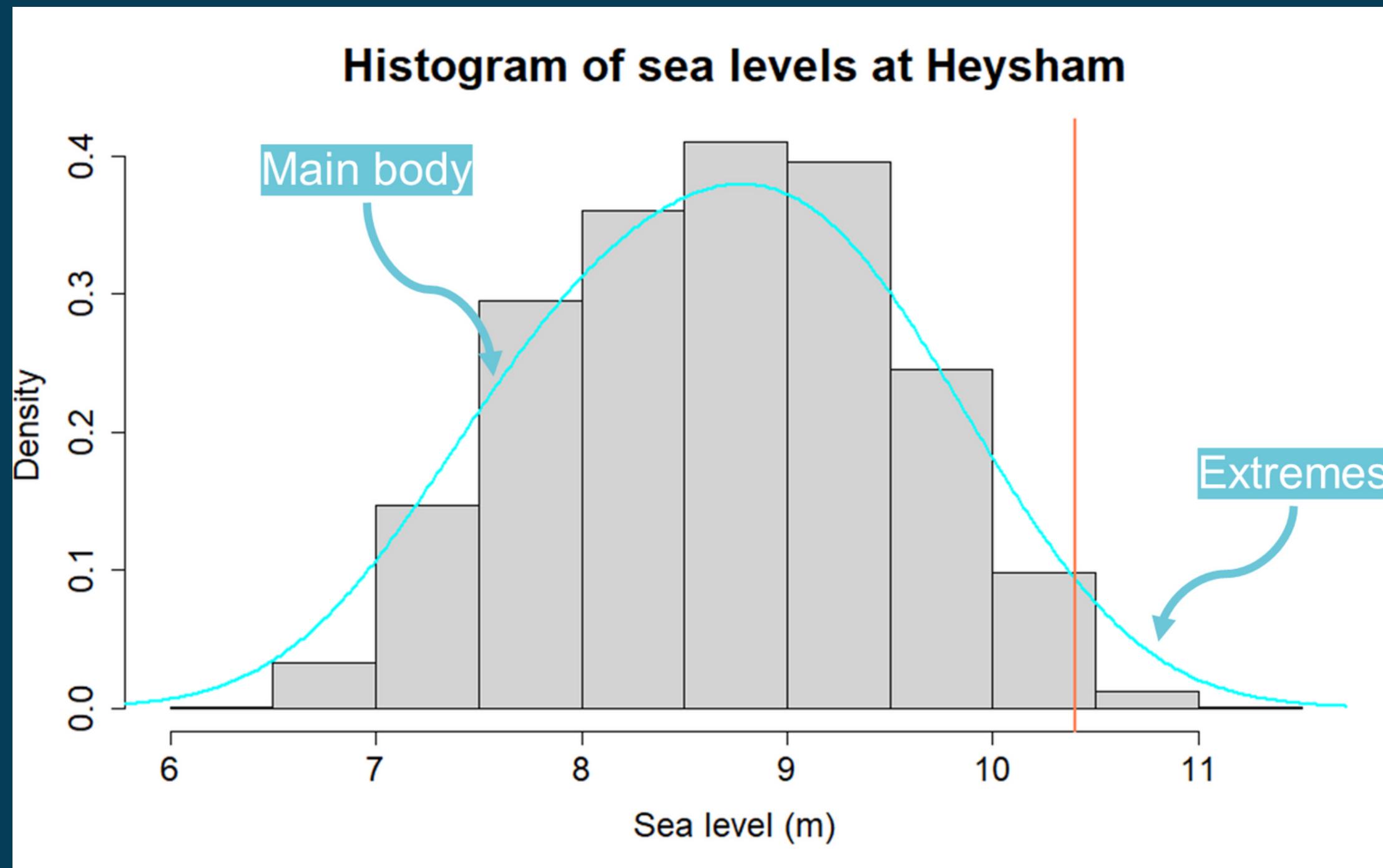
- Loss of life
- Damage to property and infrastructure
- Coastal erosion
- Displacement of people
- Loss of habitats and ecosystems



# Extremes



# Extremes



# Statistics and Engineering



# Statistics and Nuclear

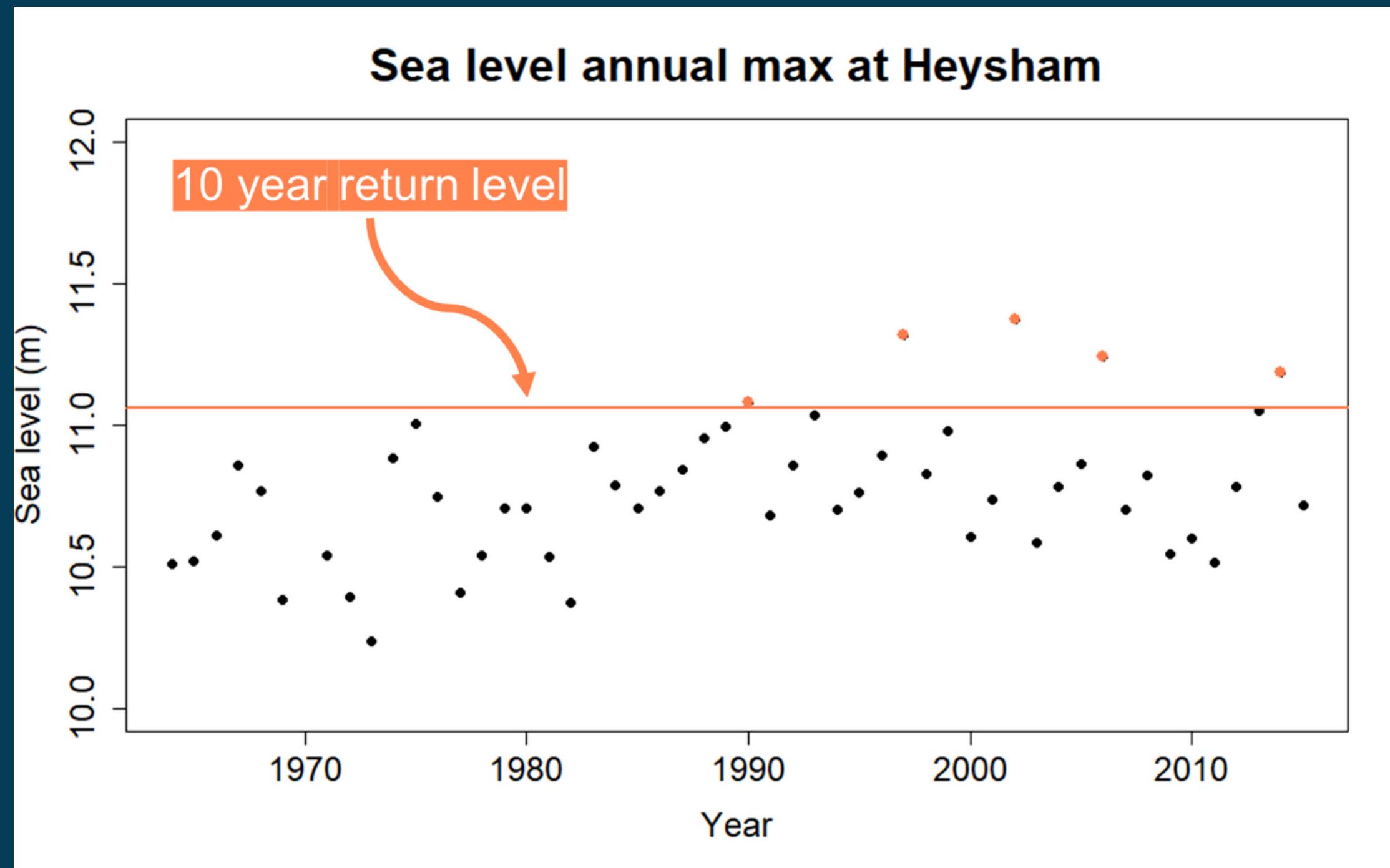


# Return Levels

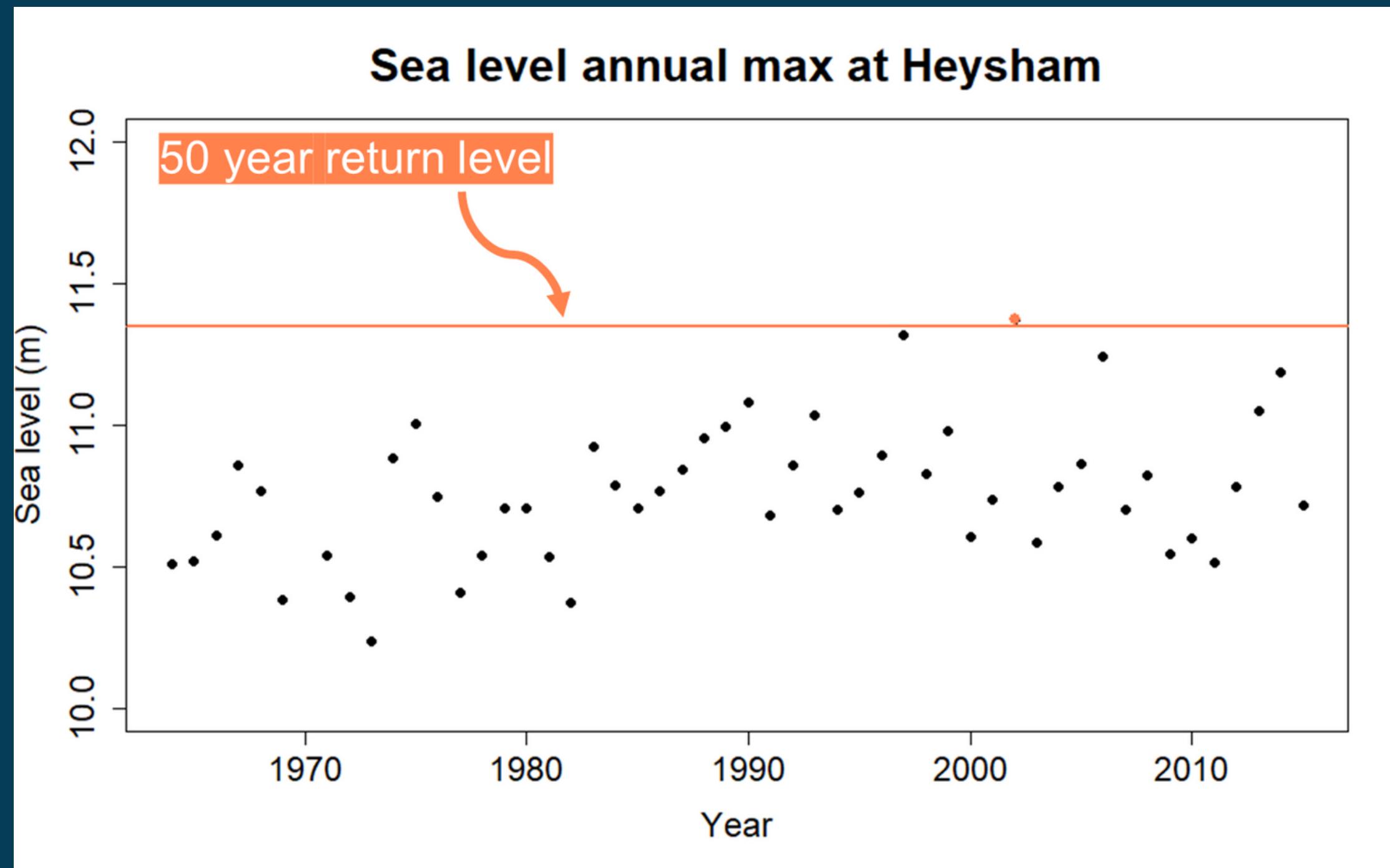
Level we expect to be exceeded once a year with probability  $p$

- Correspond to return period  $1/p$
- E.g.  $p = 0.1$  corresponds to 10 years
- ONR require accurate estimates for 10,000 year RL ( $p=0.0001$ )

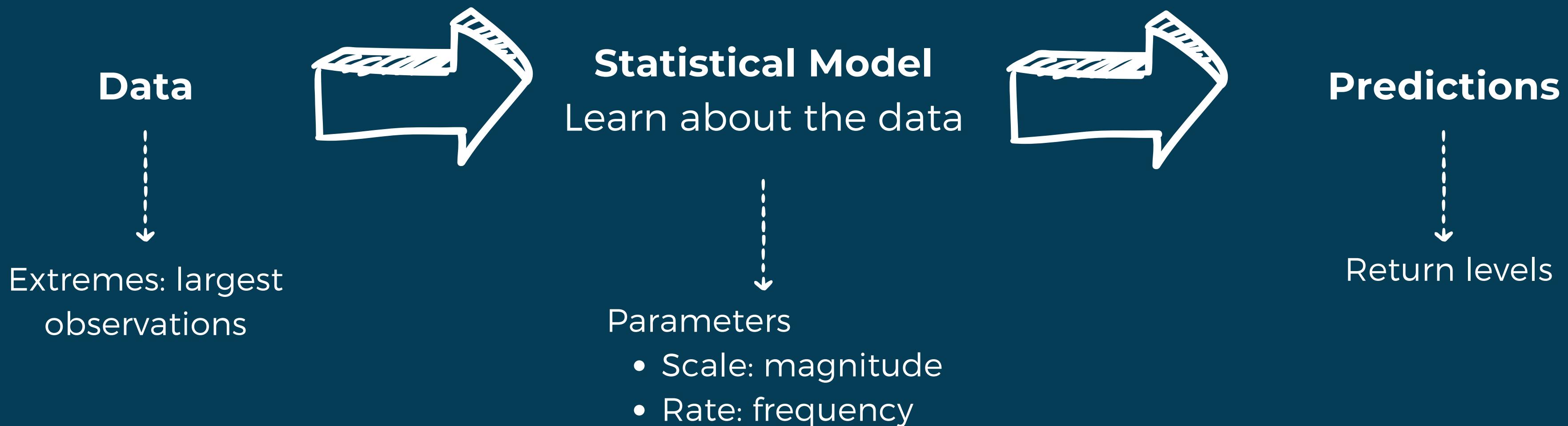
# Return Levels



# Return Levels



# Can statistical modelling help?



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• Climate change  
• Sea level science

**ALL MODELS ARE WRONG, BUT  
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GEORGE BOX

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Oceanographers



Seismologists



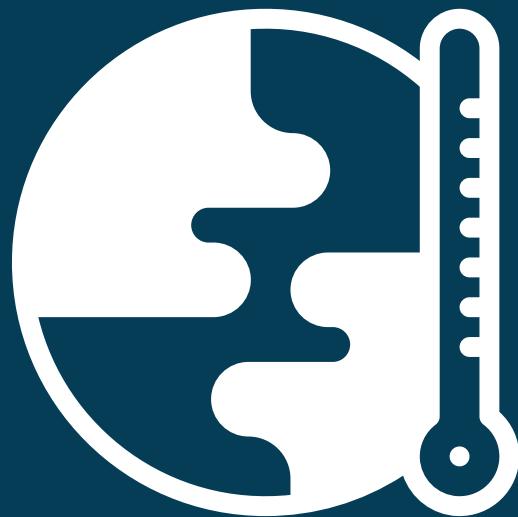
Statisticians



Meteorologist

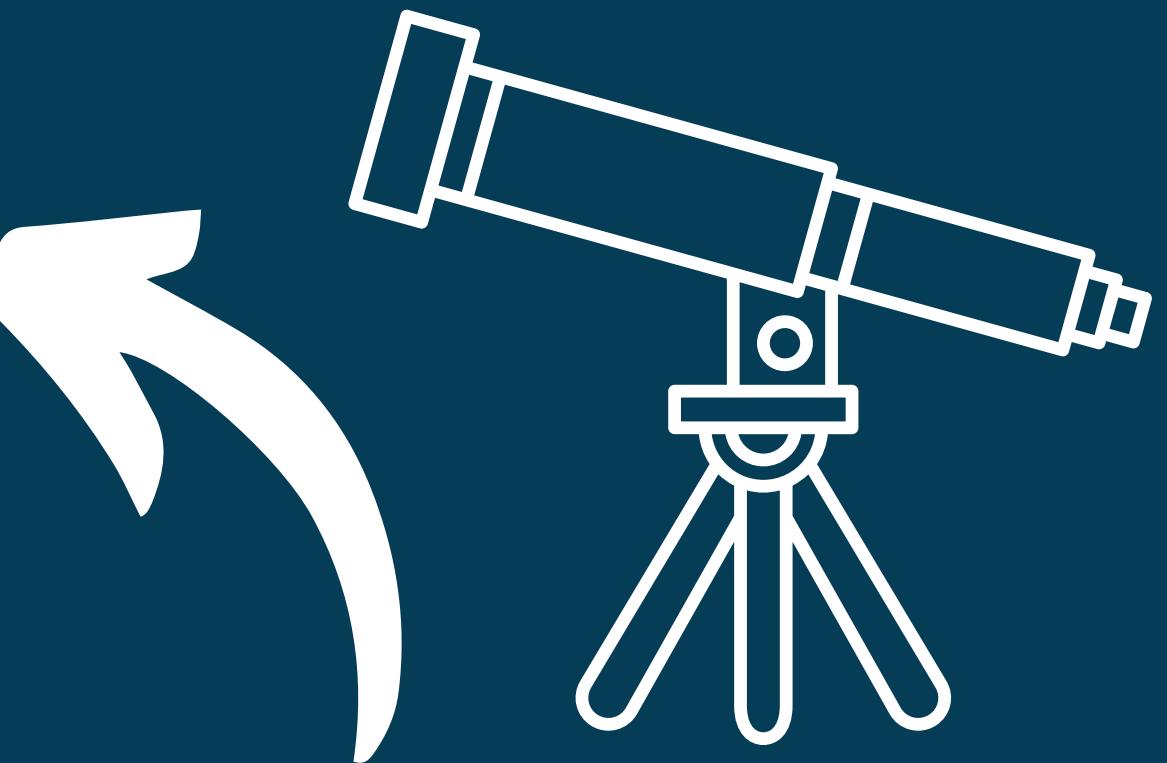


Hydrologist



Climatologist

Predictable rise and  
fall of the sea surface  
driven astronomically

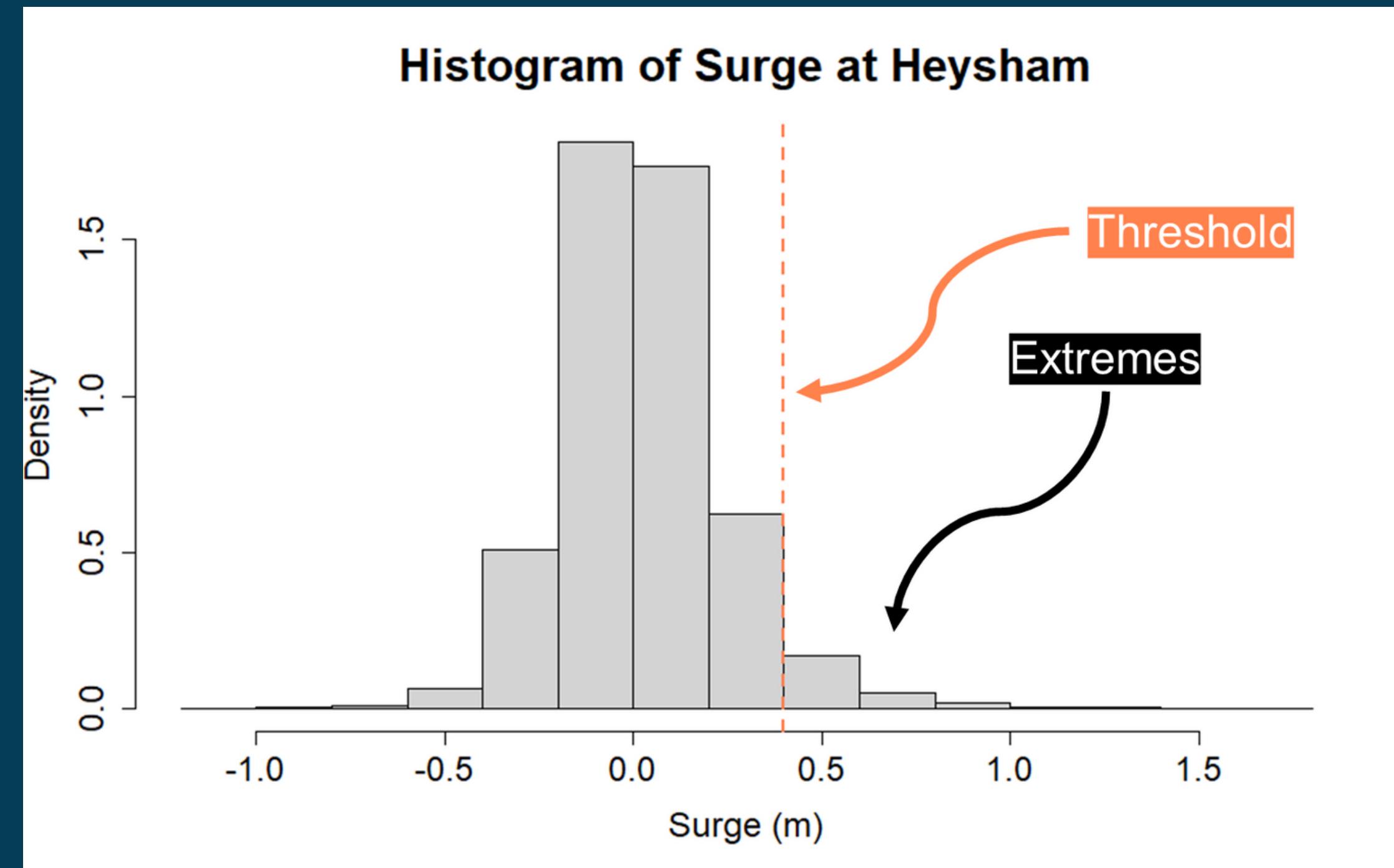


**Sea level = Tide + Surge**

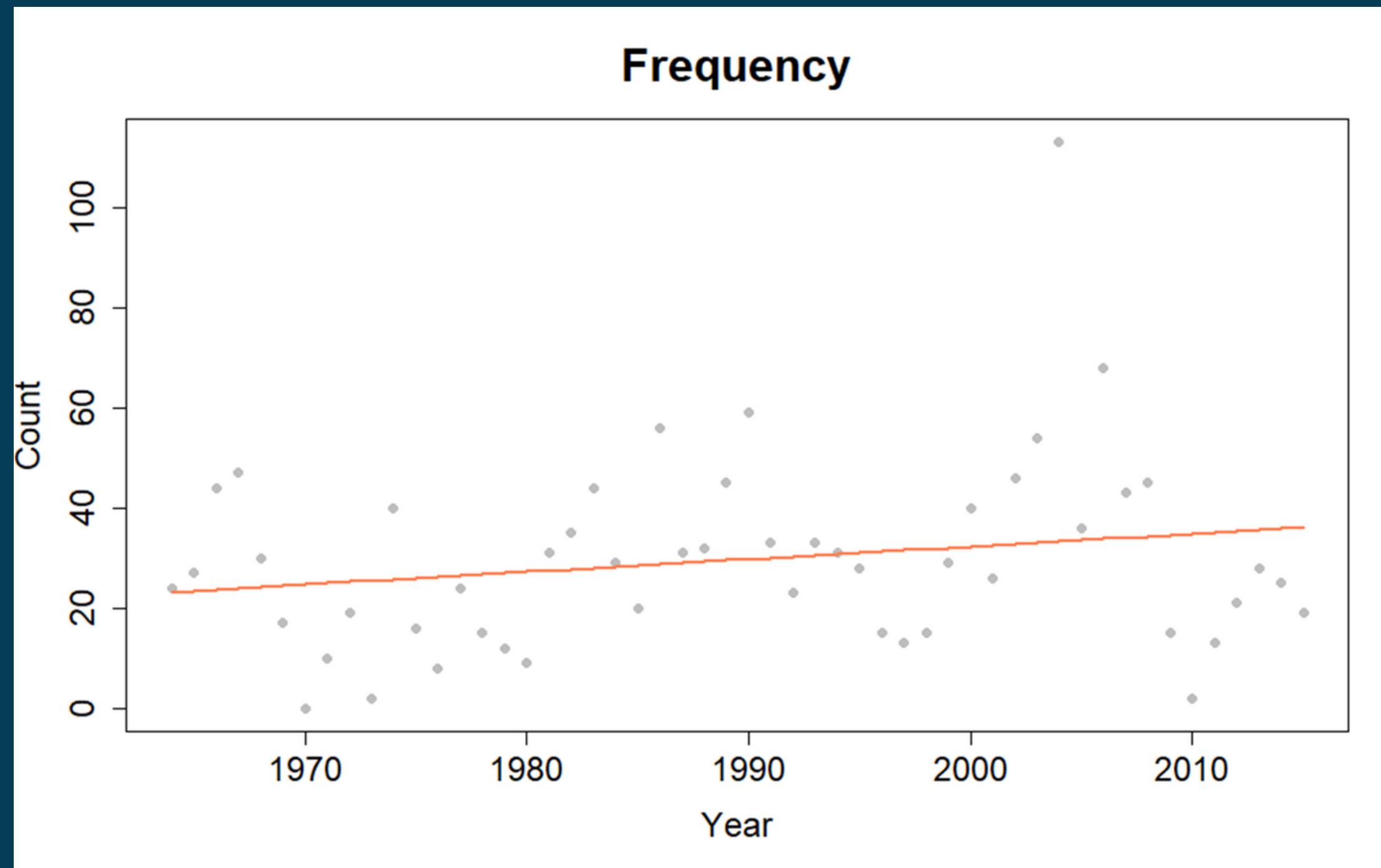


// Short term sea level  
changes caused by weather

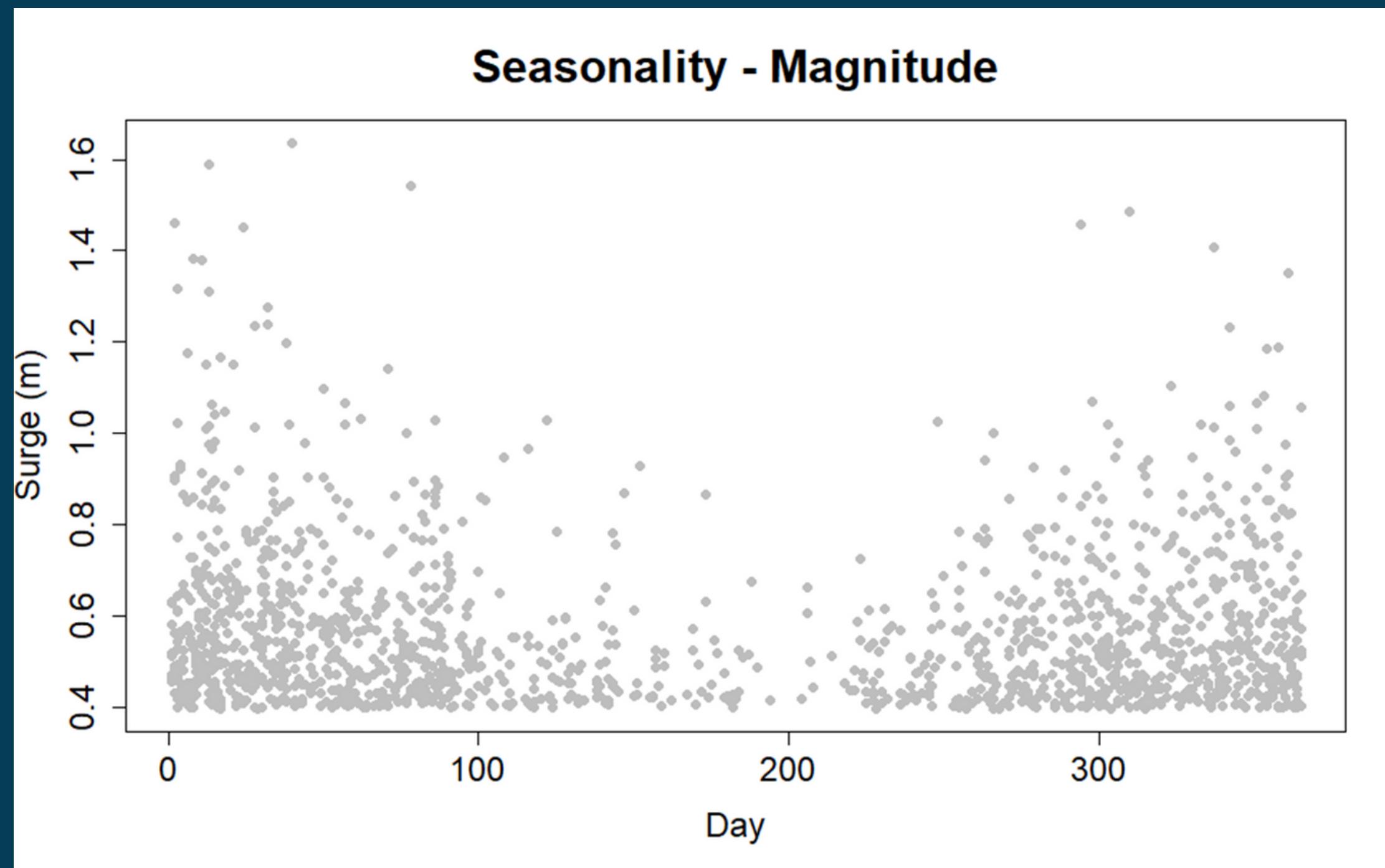
# Modelling surges

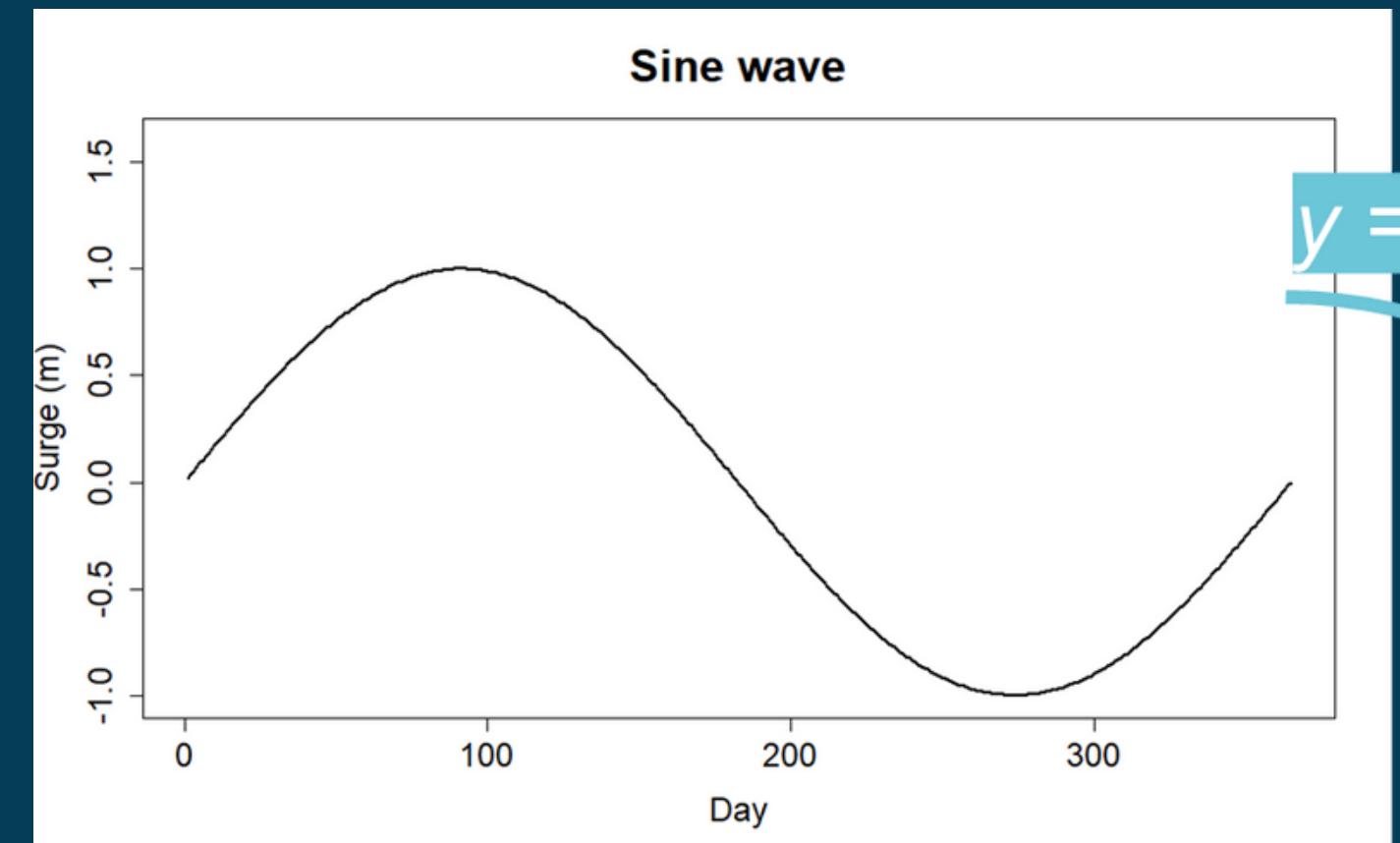


# Climate change effects

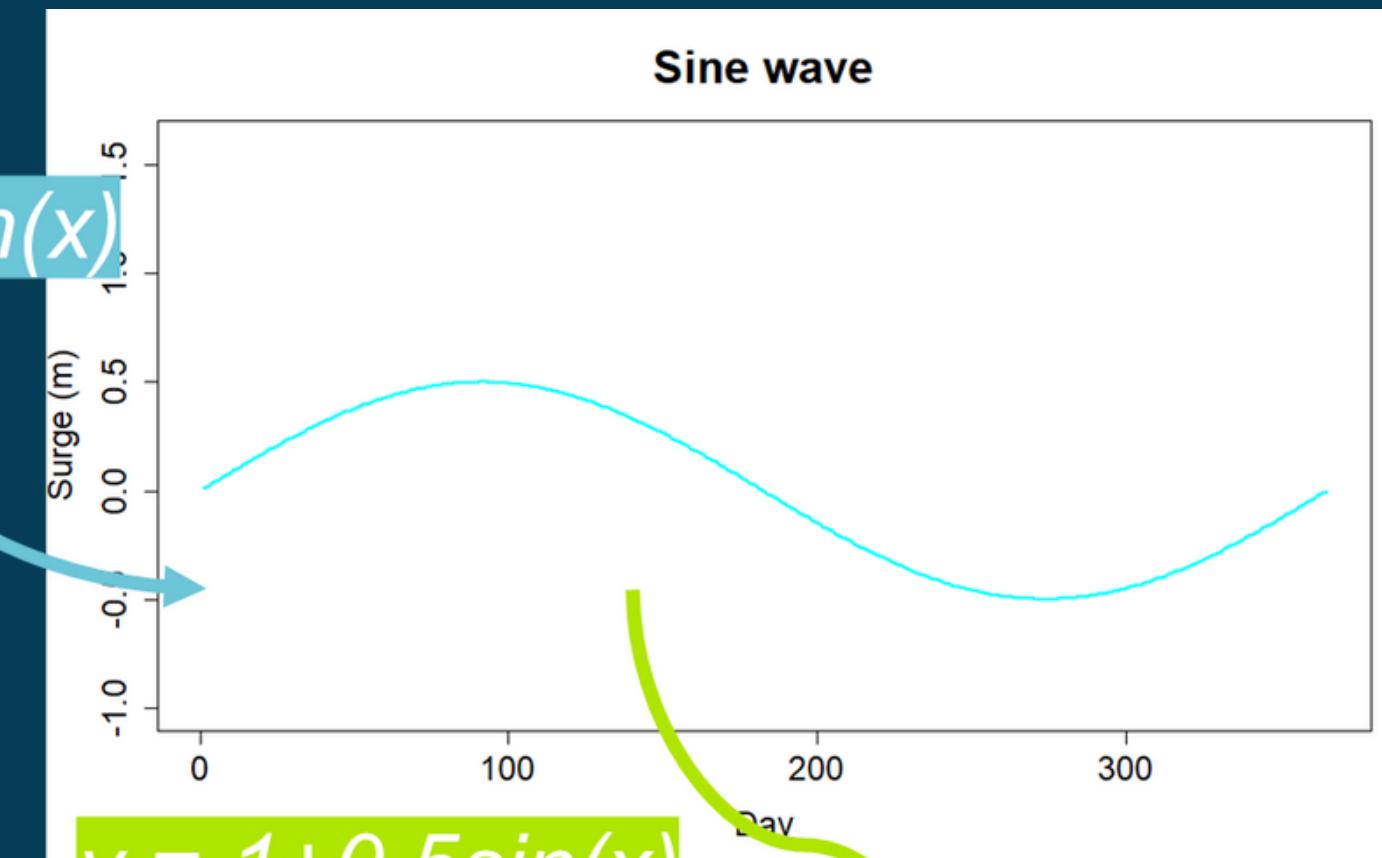


# Seasonal effects

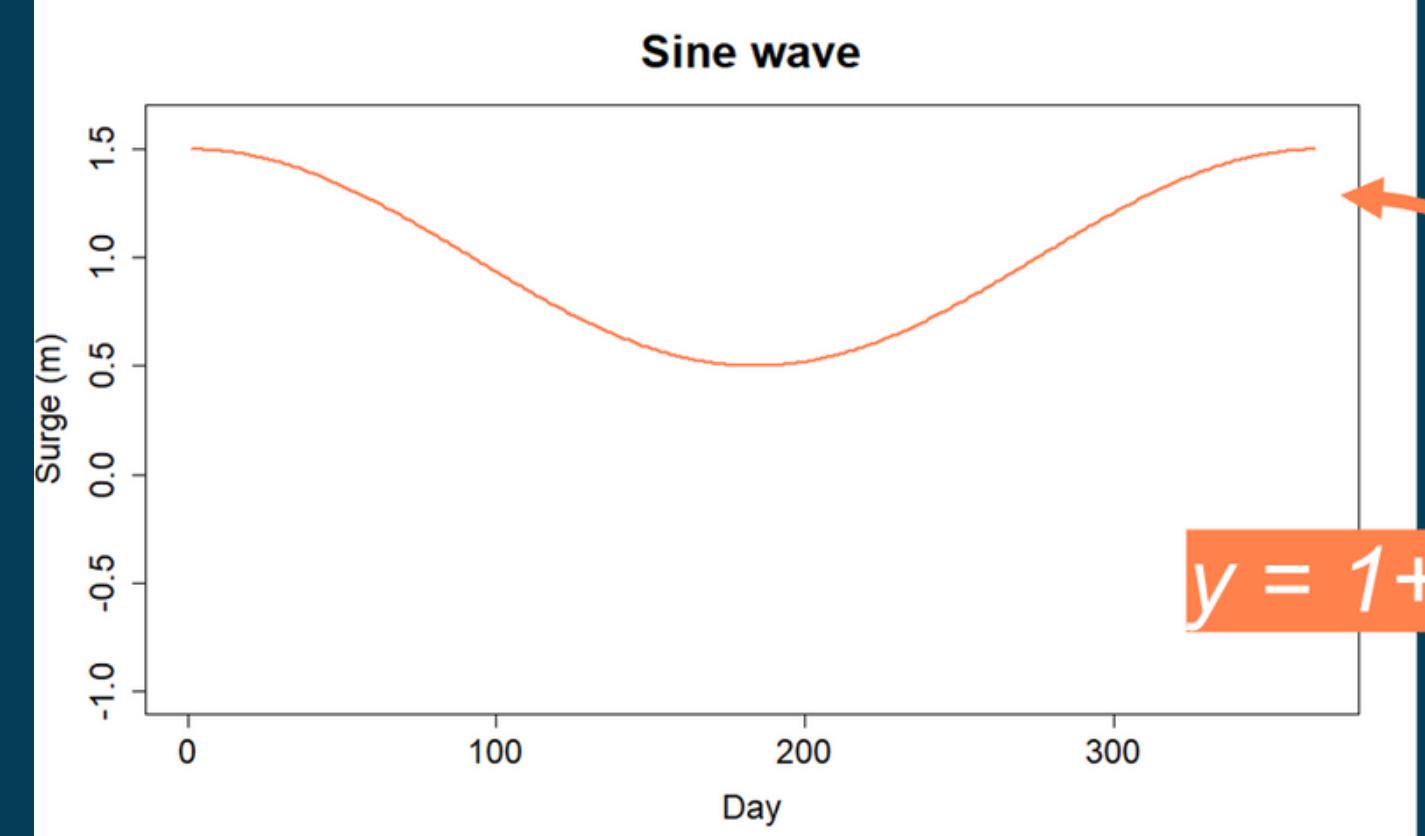




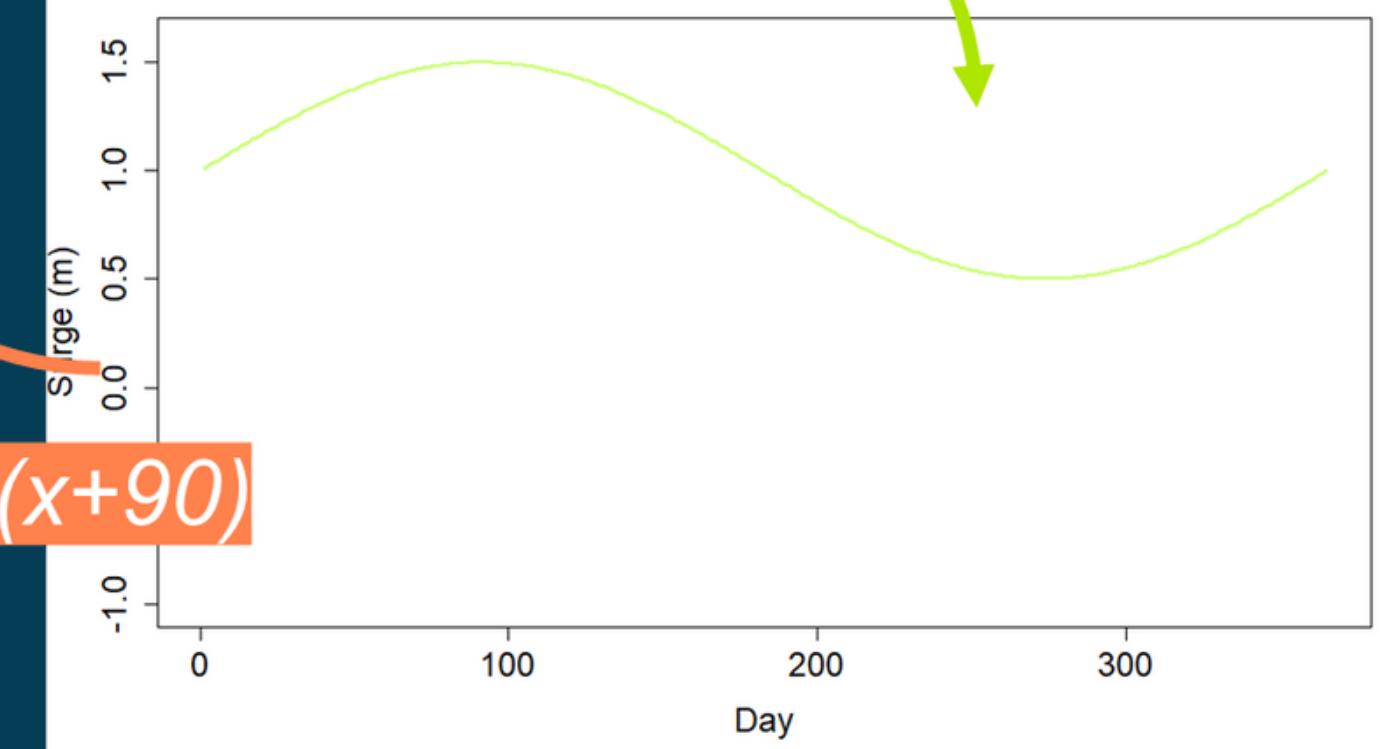
$$y = 0.5\sin(x)$$



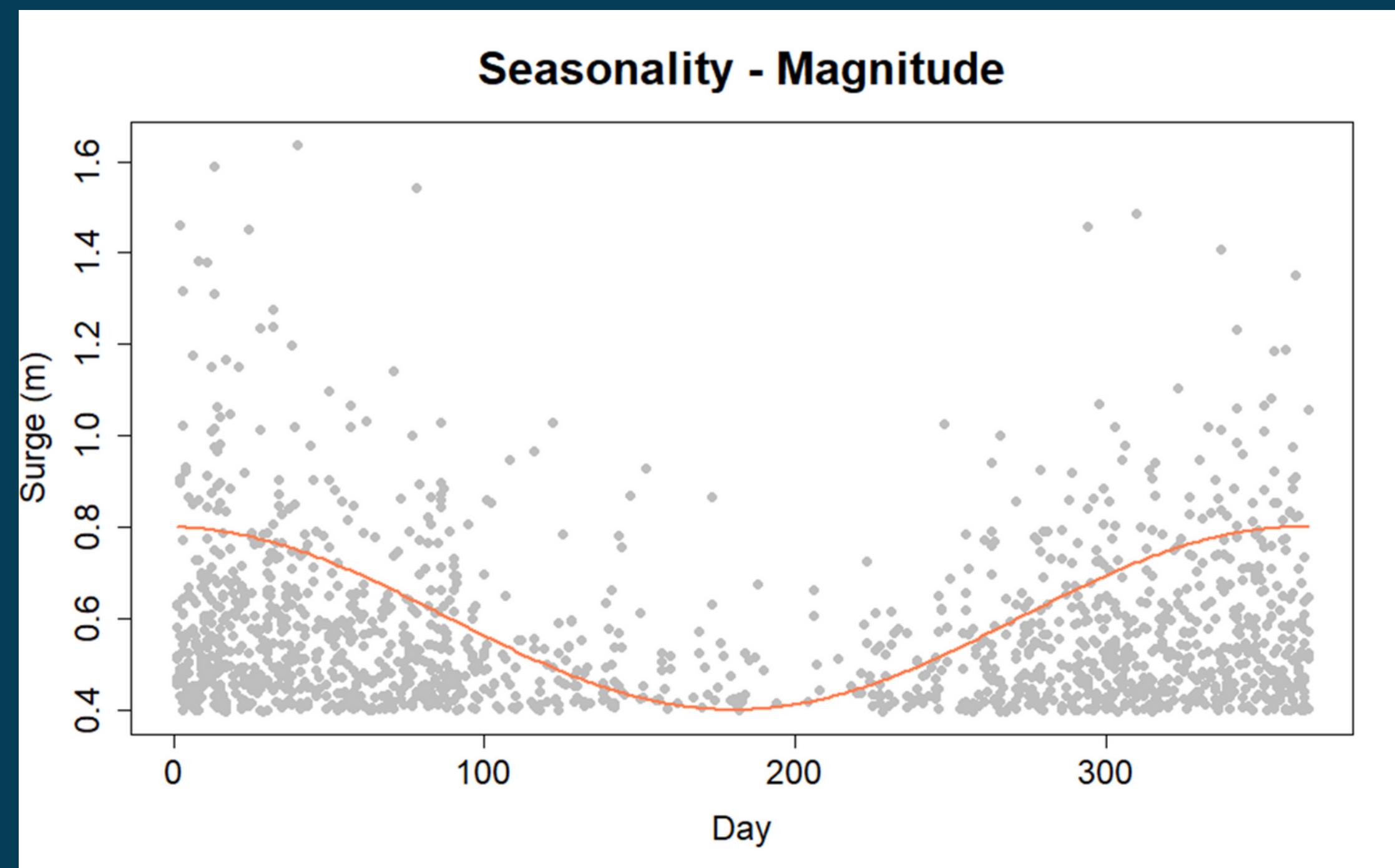
$$y = 1 + 0.5\sin(x)$$



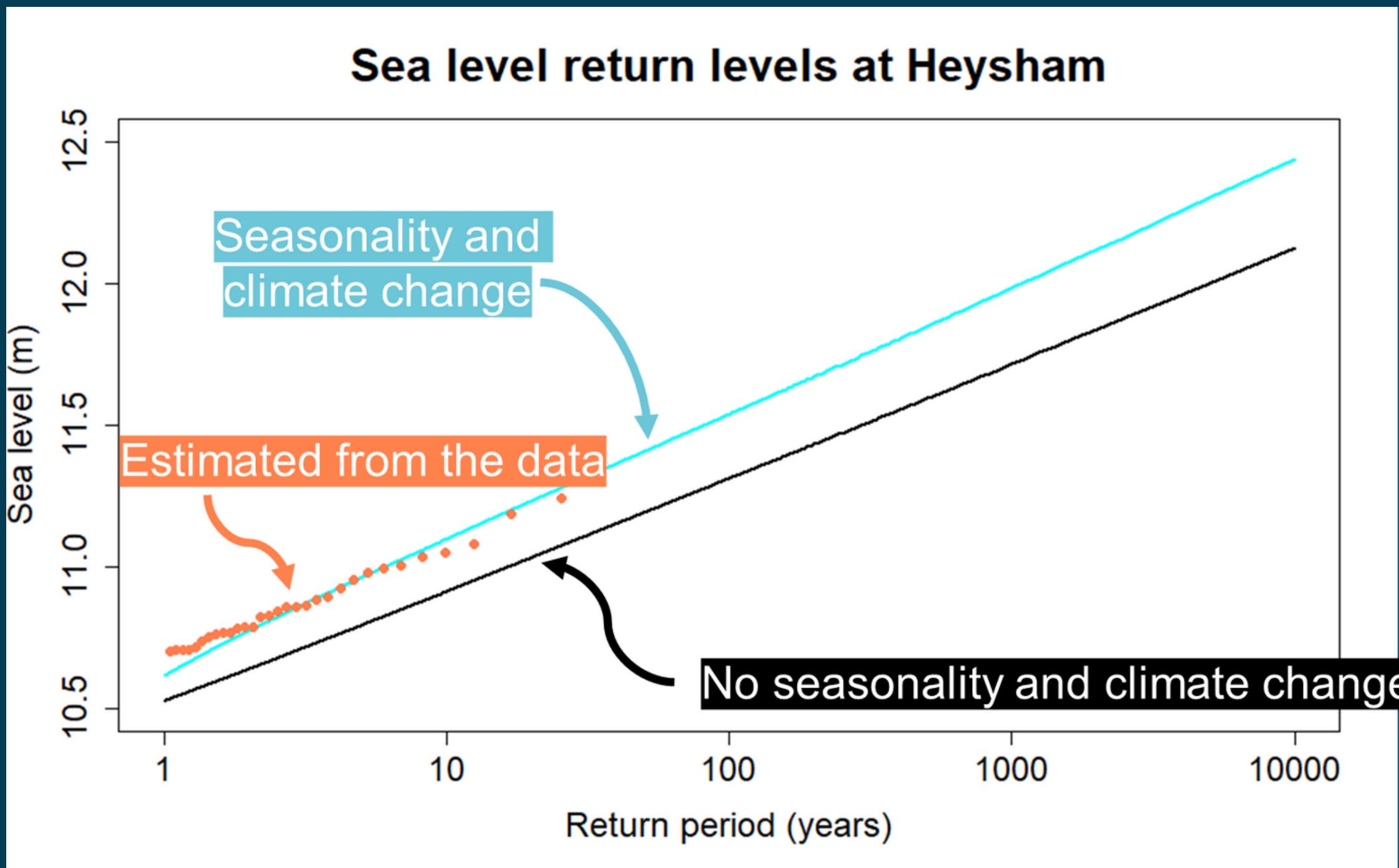
$$y = 1 + 0.5\sin(x+90)$$



# Seasonal effects



# Results - Return levels



# Summary



## Statistical modelling

- Linear models
- Probabilistic models
- Extreme value model
- Trigonometric models

## Statistics and the wider community

- Collaboration with oceanographers and climatologists
- Return level estimates for coastal defence engineering
- Statistics for the nuclear industry

# What next?

- Implementation at EDF
- Working with the Environment Agency for upgrades in Coastal Flood Boundary report
- Thames Estuary 2100 plan



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THANK YOU AND  
GOOD LUCK

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Lancaster University