

ROYAL STATISTICAL SOCIETY WILLIAM GUY LECTURE

HOW CAN STATISTICS PROTECT US AGAINST CLIMATE CHANGE?

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

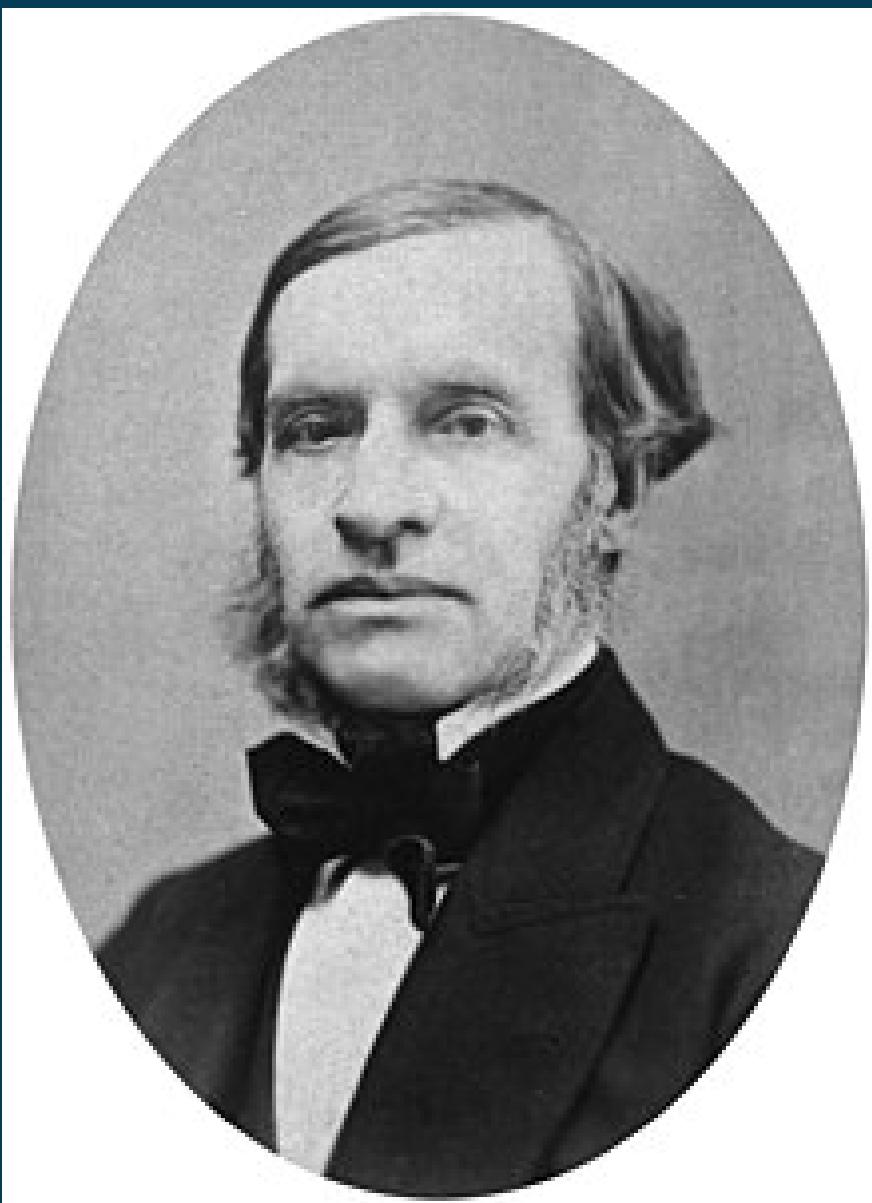
Eleanor D'Arcy
Lancaster University

“

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

William Augustus Guy



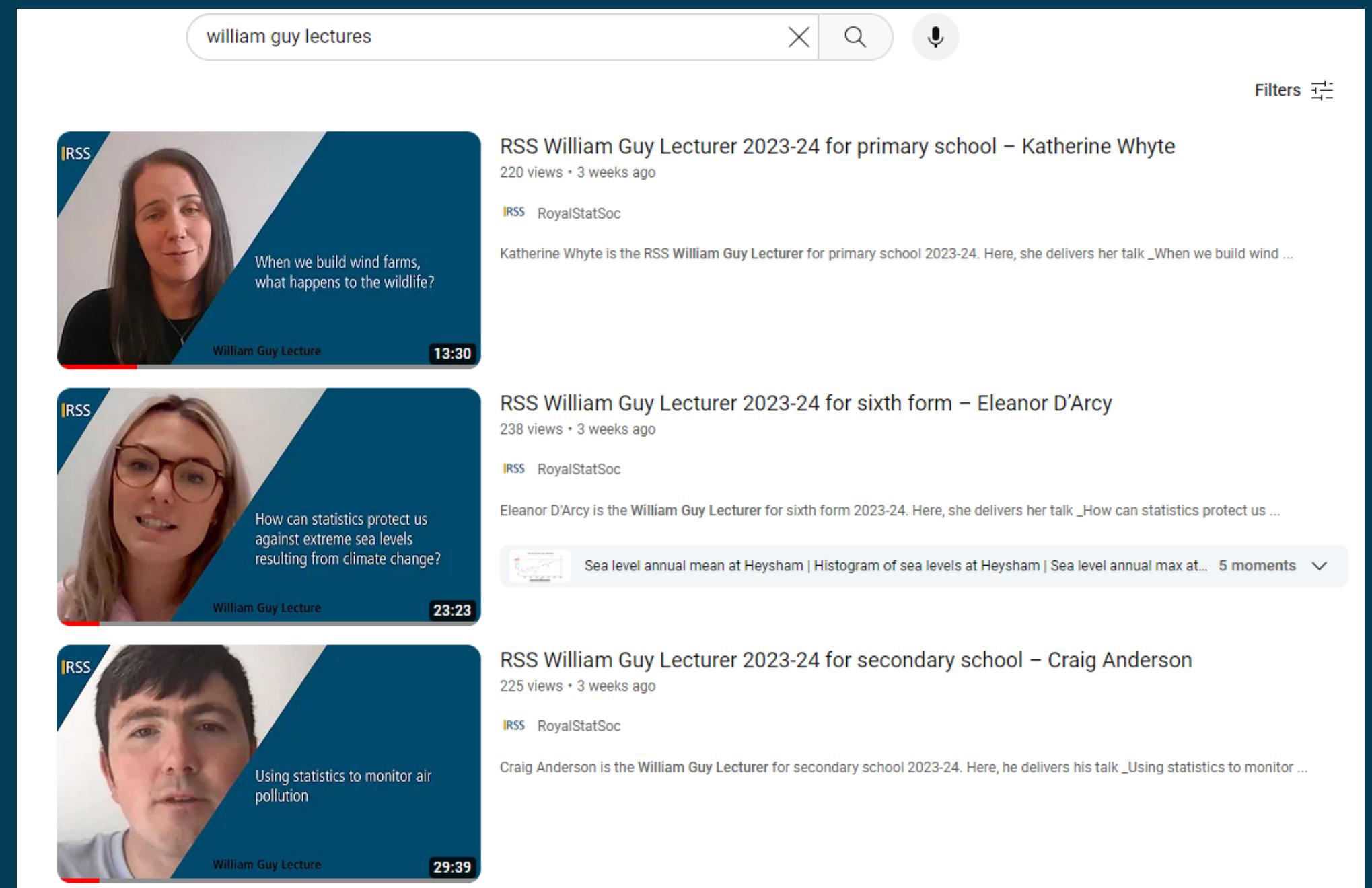
- Medical statistician
- RSS president 1873-1875
- Guy medals are awarded to distinguished statisticians for important work
- First Guy lecture given in 1999
- Three WG lecturers are appointed each academic year

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



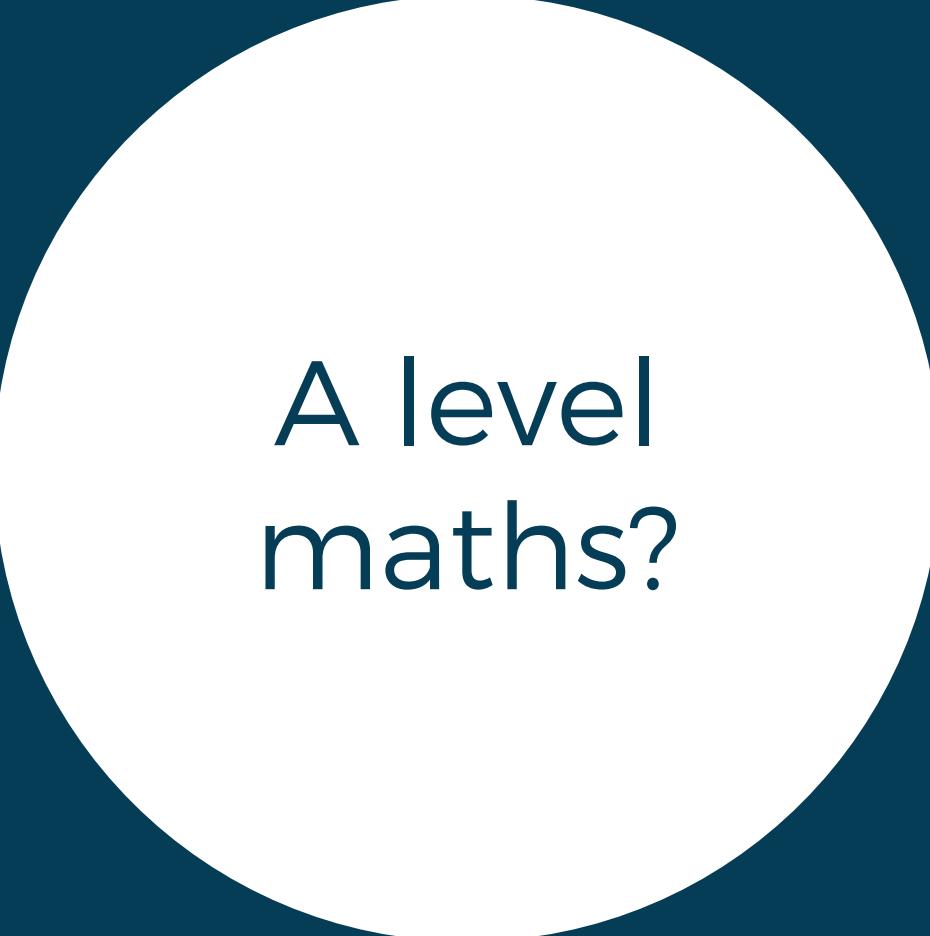
All of our lectures are on YouTube...



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ABOUT YOU

Eleanor D'Arcy
Lancaster University



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

Eleanor D'Arcy
Lancaster University



what is a PhD?



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

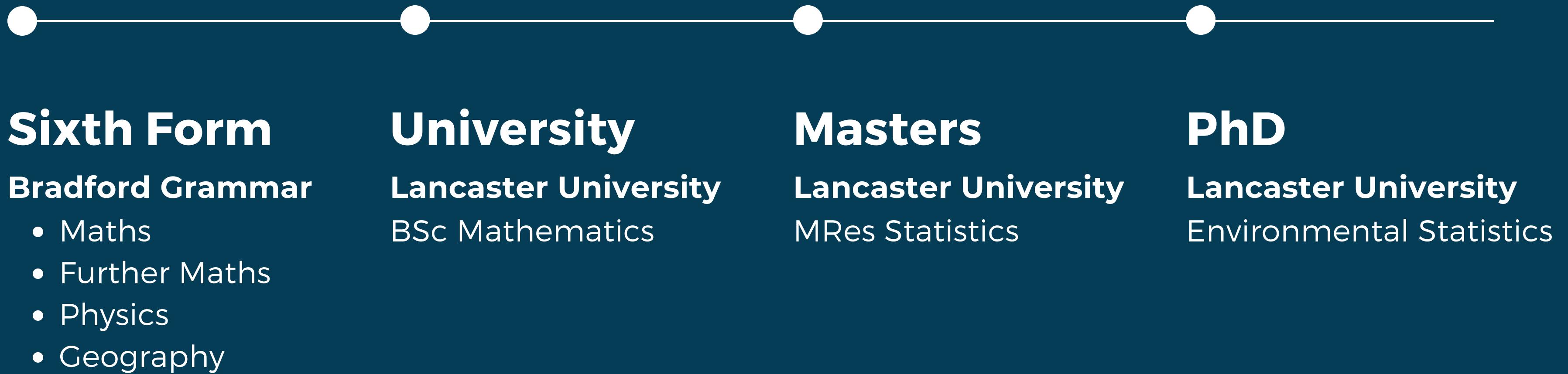
You get
paid

Present
research at
conferences

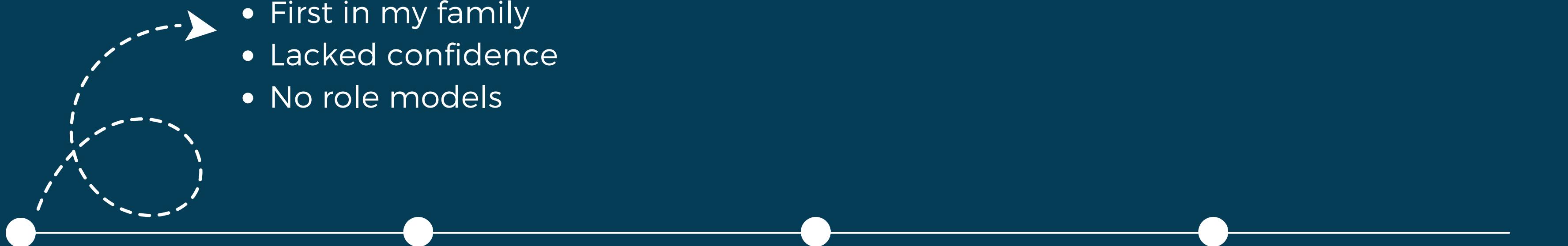
You're a
doctor!



My Journey



My Journey



Sixth Form

Bradford Grammar

- Maths
- Further Maths
- Physics
- Geography

University

Lancaster University

BSc Mathematics

Masters

Lancaster University

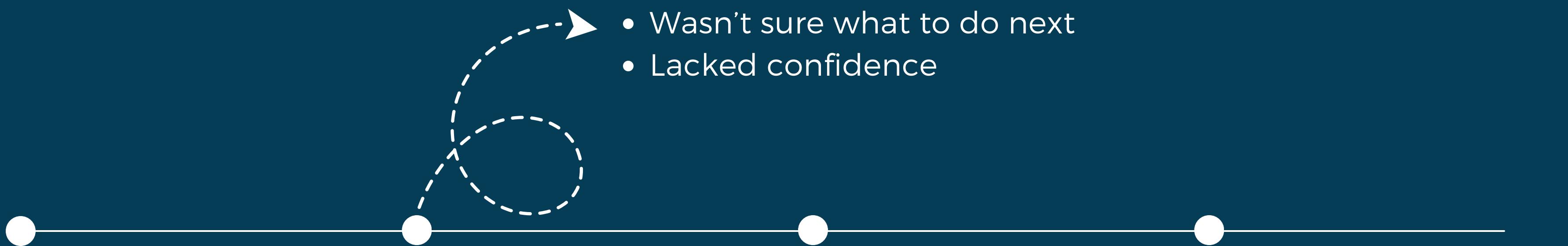
MRes Statistics

PhD

Lancaster University

Environmental Statistics

My Journey



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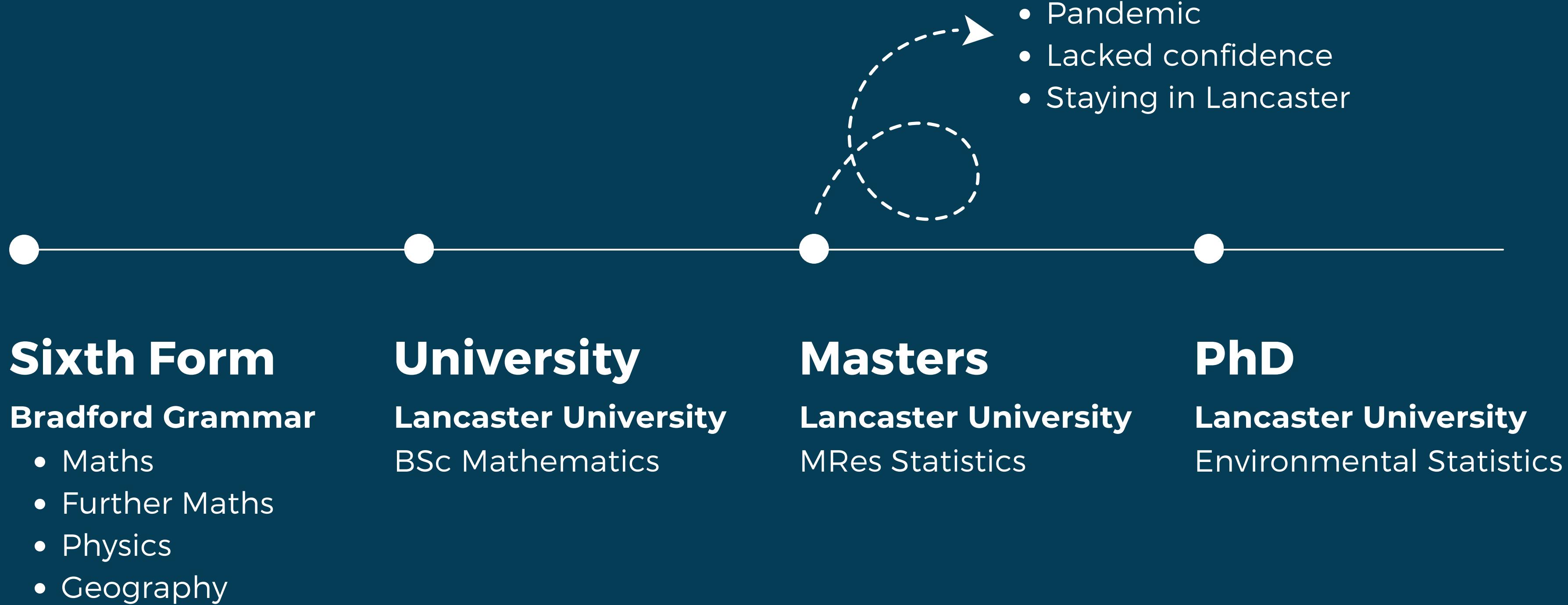
MRes Statistics

PhD

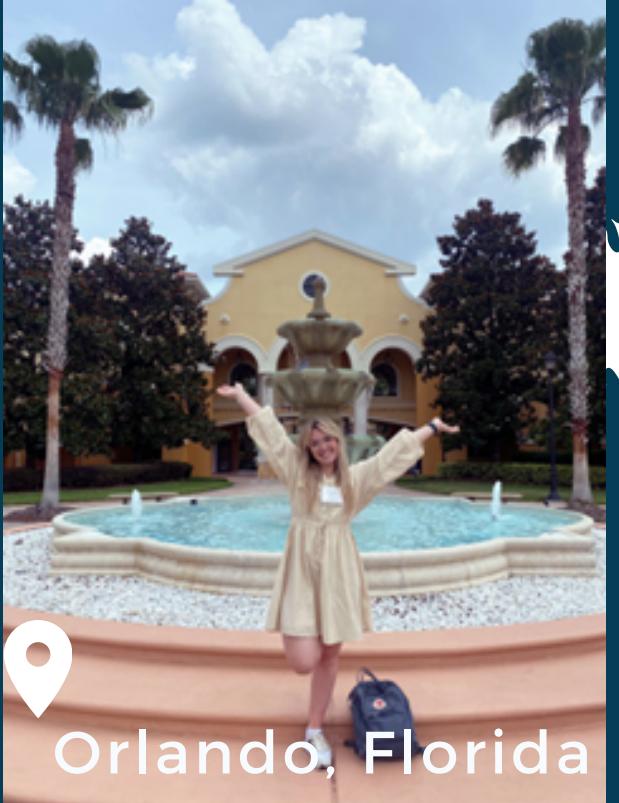
Lancaster University

Environmental Statistics

My Journey



Conferences and Travel



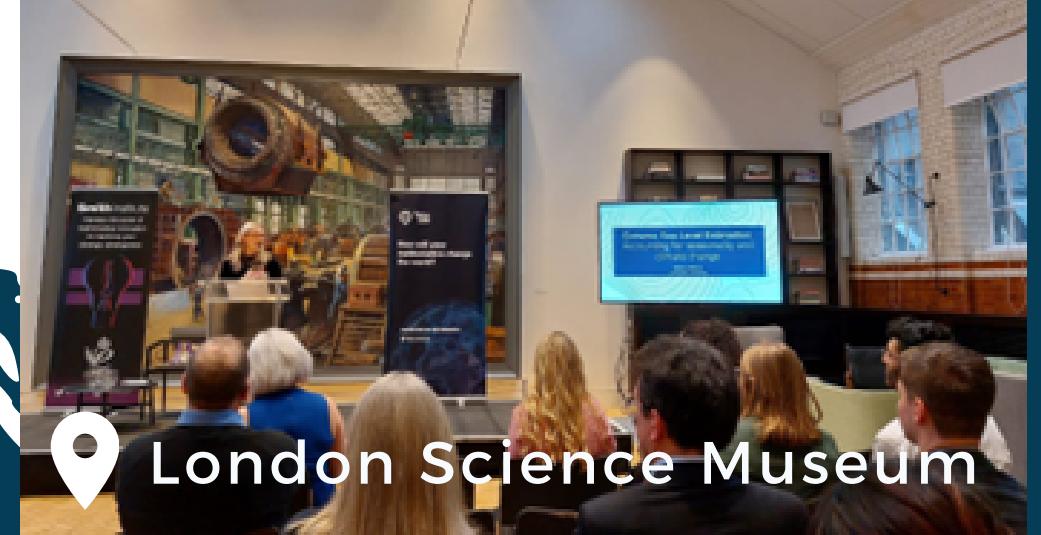
Orlando, Florida



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

Eleanor D'Arcy
Lancaster University



1. What is statistics?

2. Where is statistics used?



“

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

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

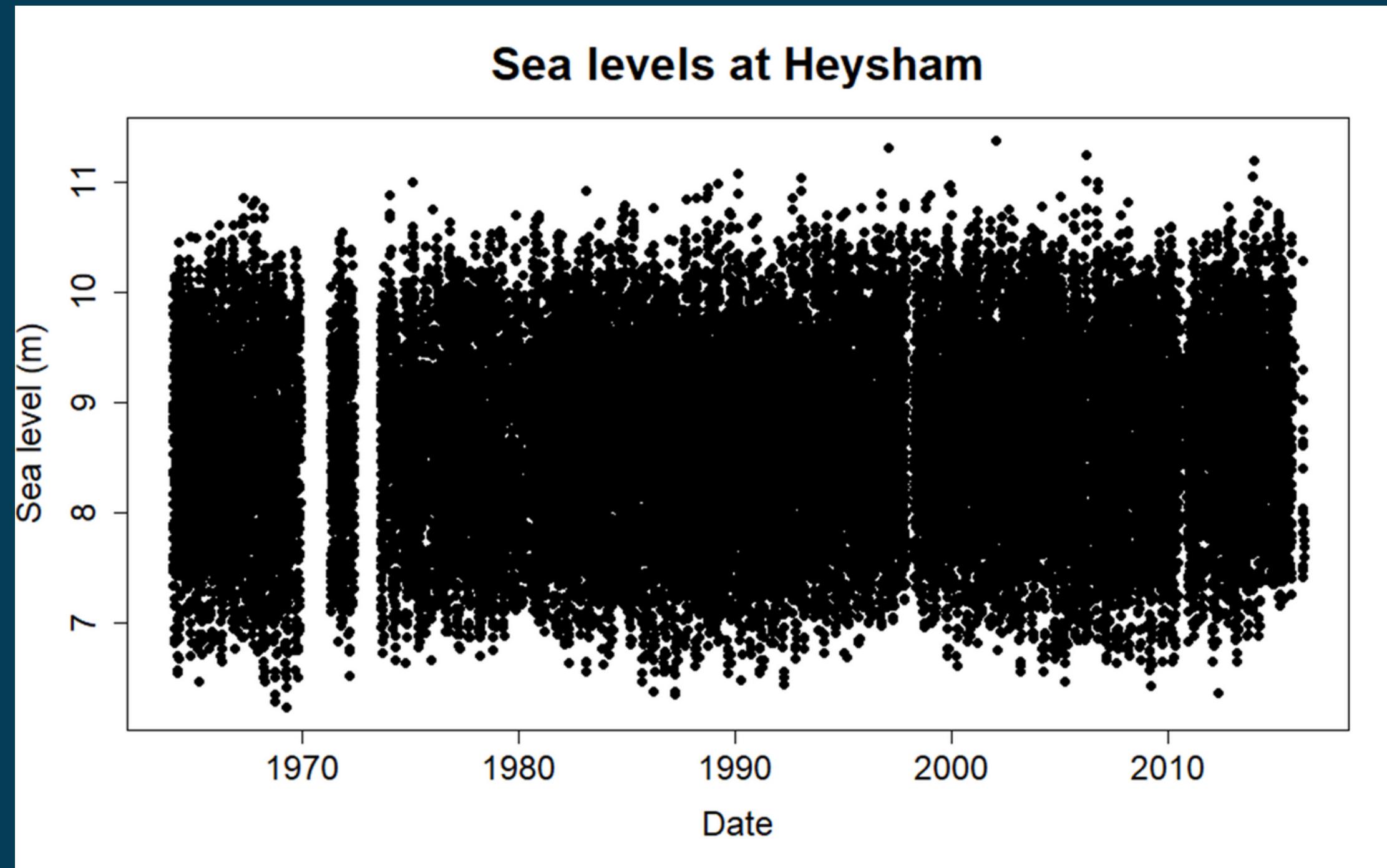
- Mean: $(10 + 5 + 5 + 6 + 3 + 3 + 9 + 4 + 7 + 7 + 3)/11 = 6.3$
- Median: 3, 3, 3, 4, 5, **5**, 6, 7, 7, 9, 10
- Mode: 10, 5, 5, 6, **3**, **3**, 9, 4, 7, 7, **3**

Data

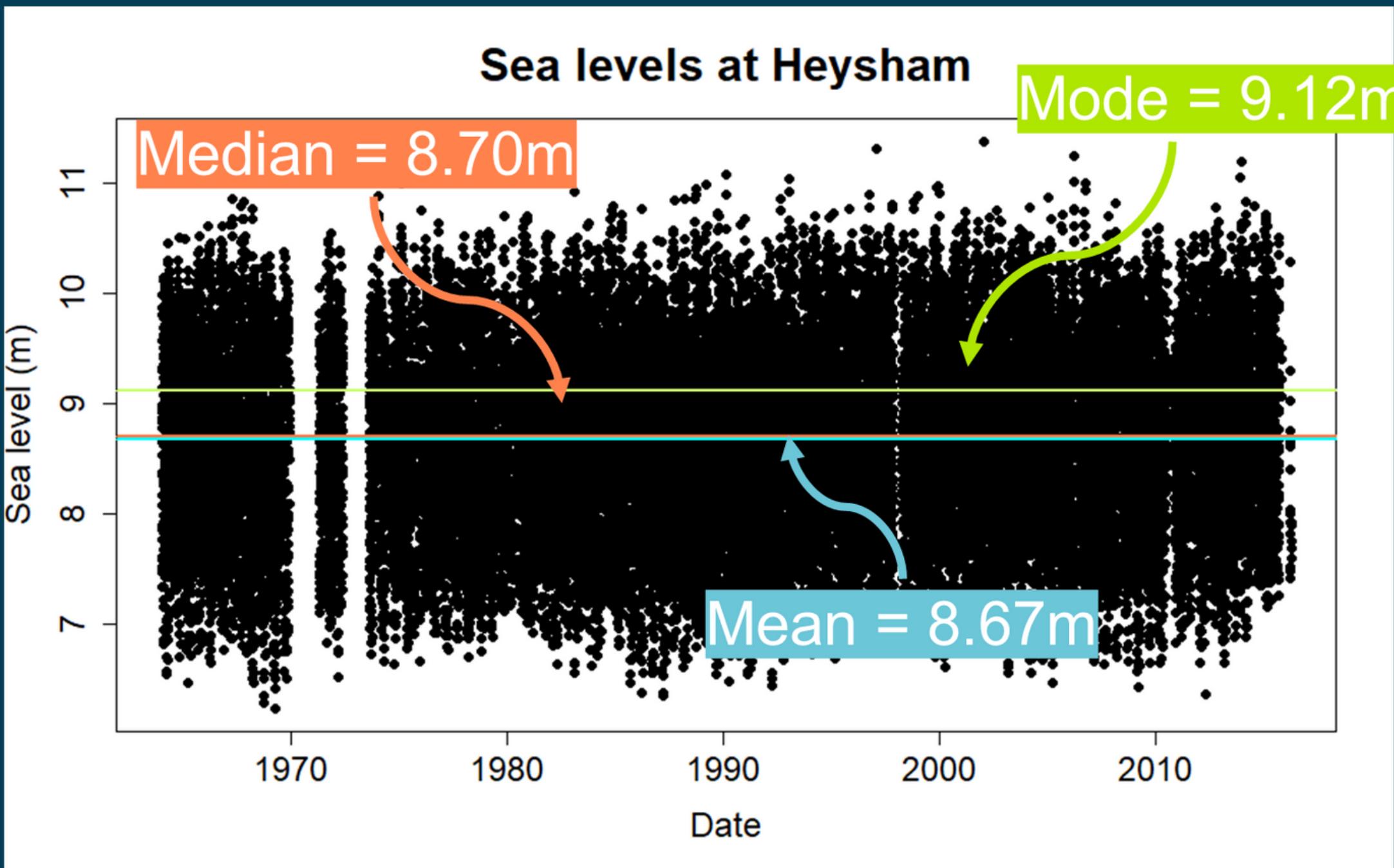
- Sea level observations
- Heysham - North west England
- 2 nuclear power stations
- 50 years of data = 438,300 observations

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



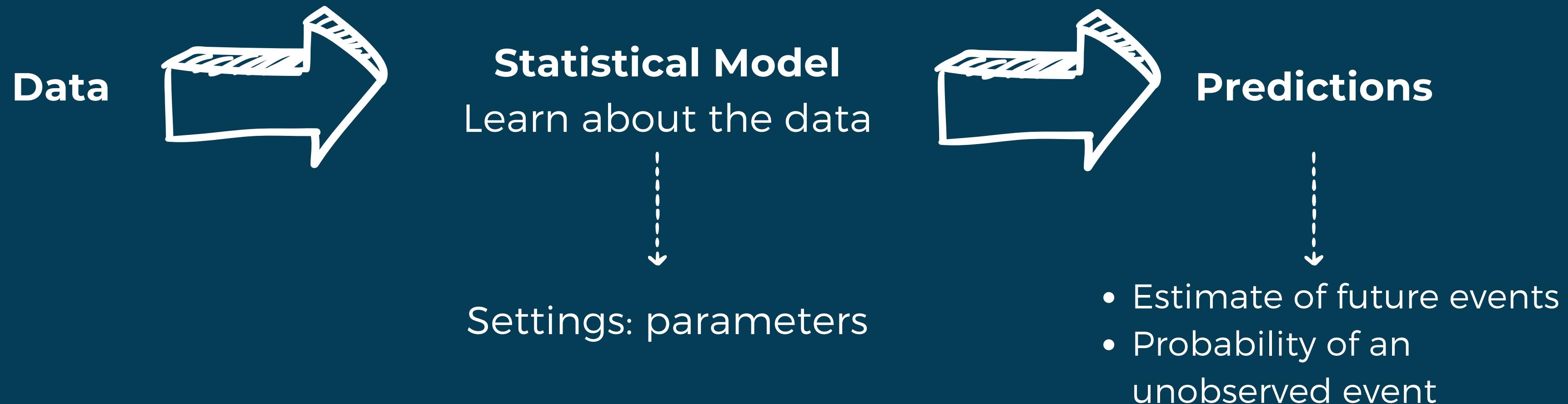
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STATISTICAL MODELLING

Eleanor D'Arcy
Lancaster University

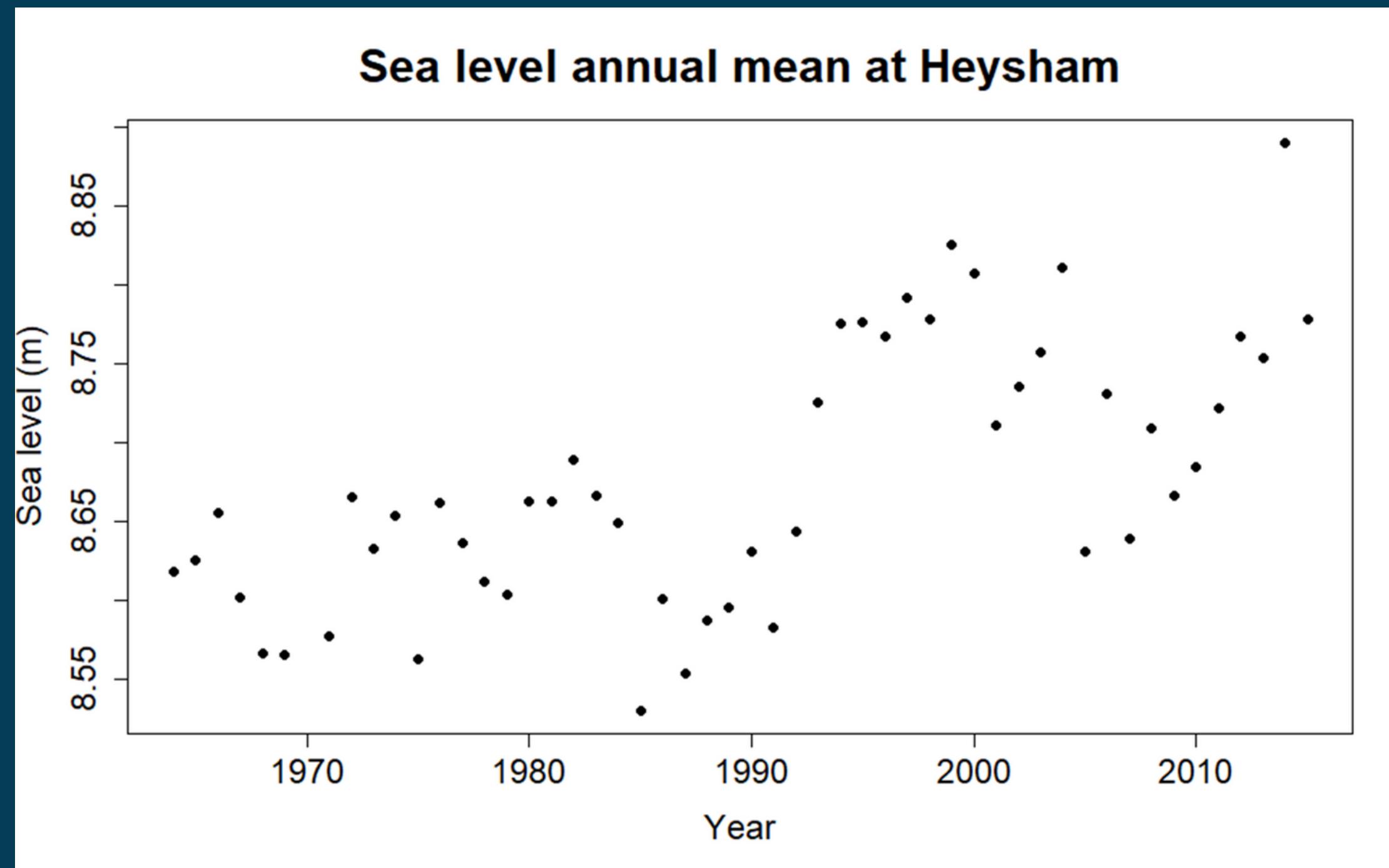
What is a statistical model?

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



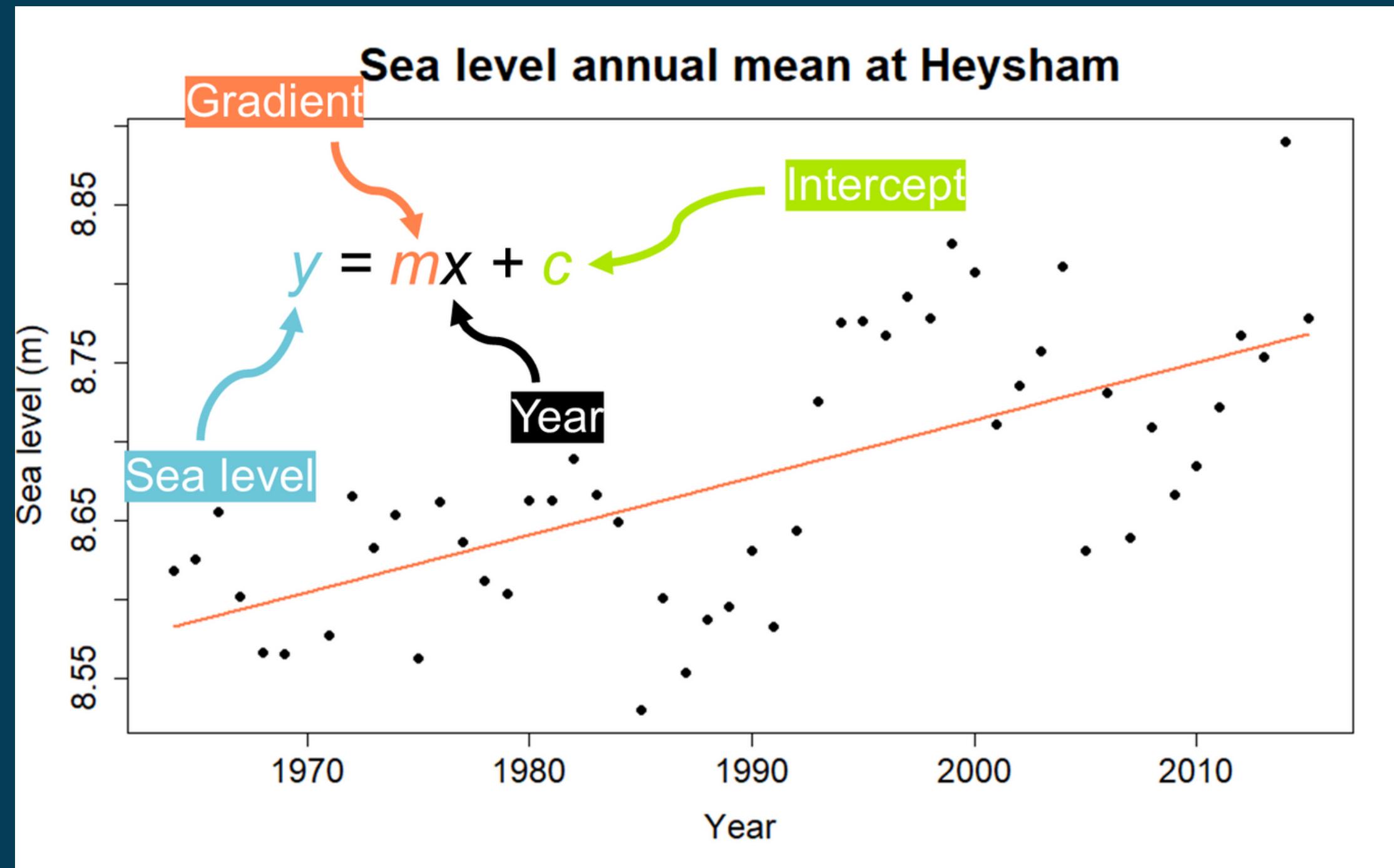
Linear Models

Input: Annual mean sea levels



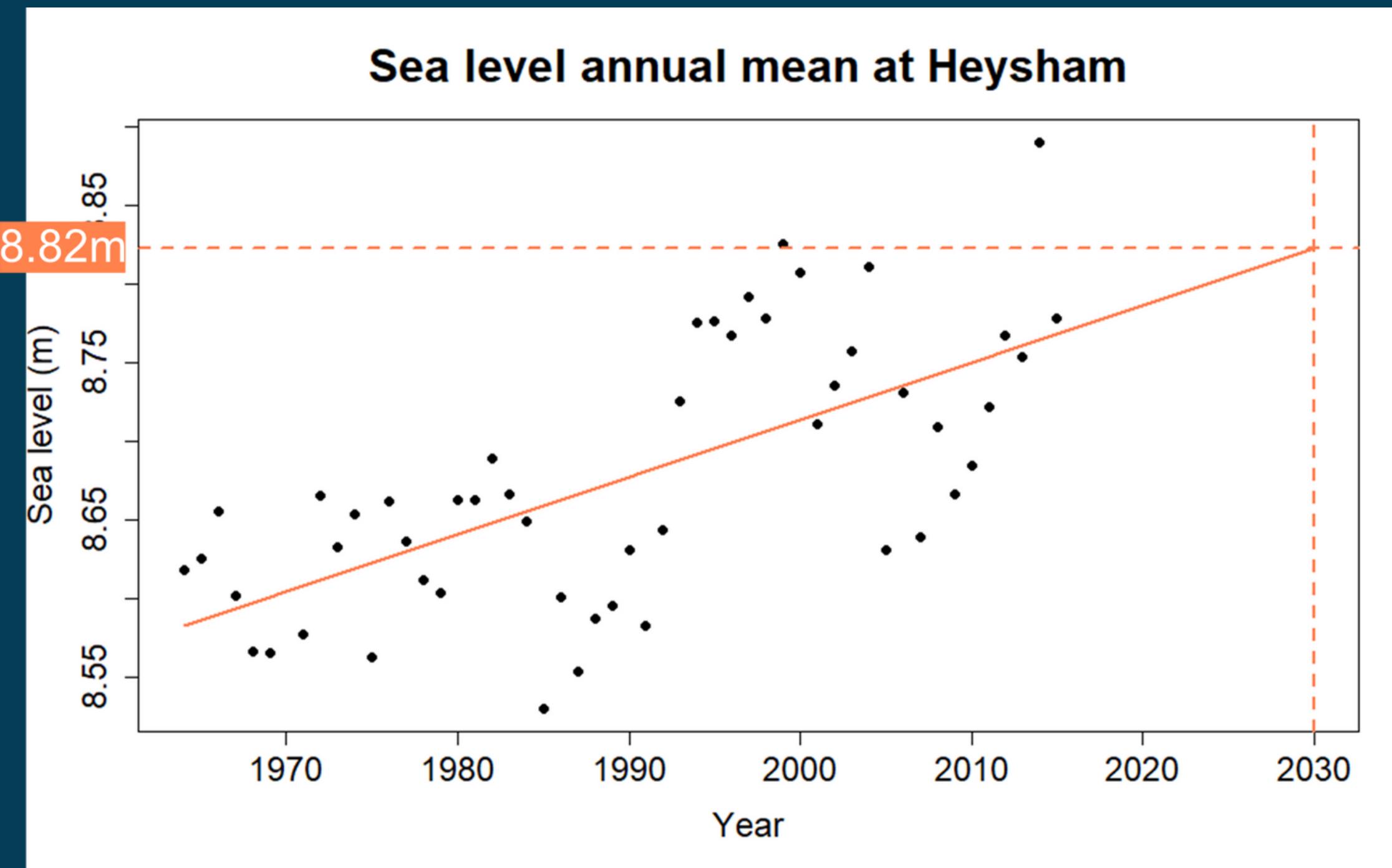
Linear Models

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



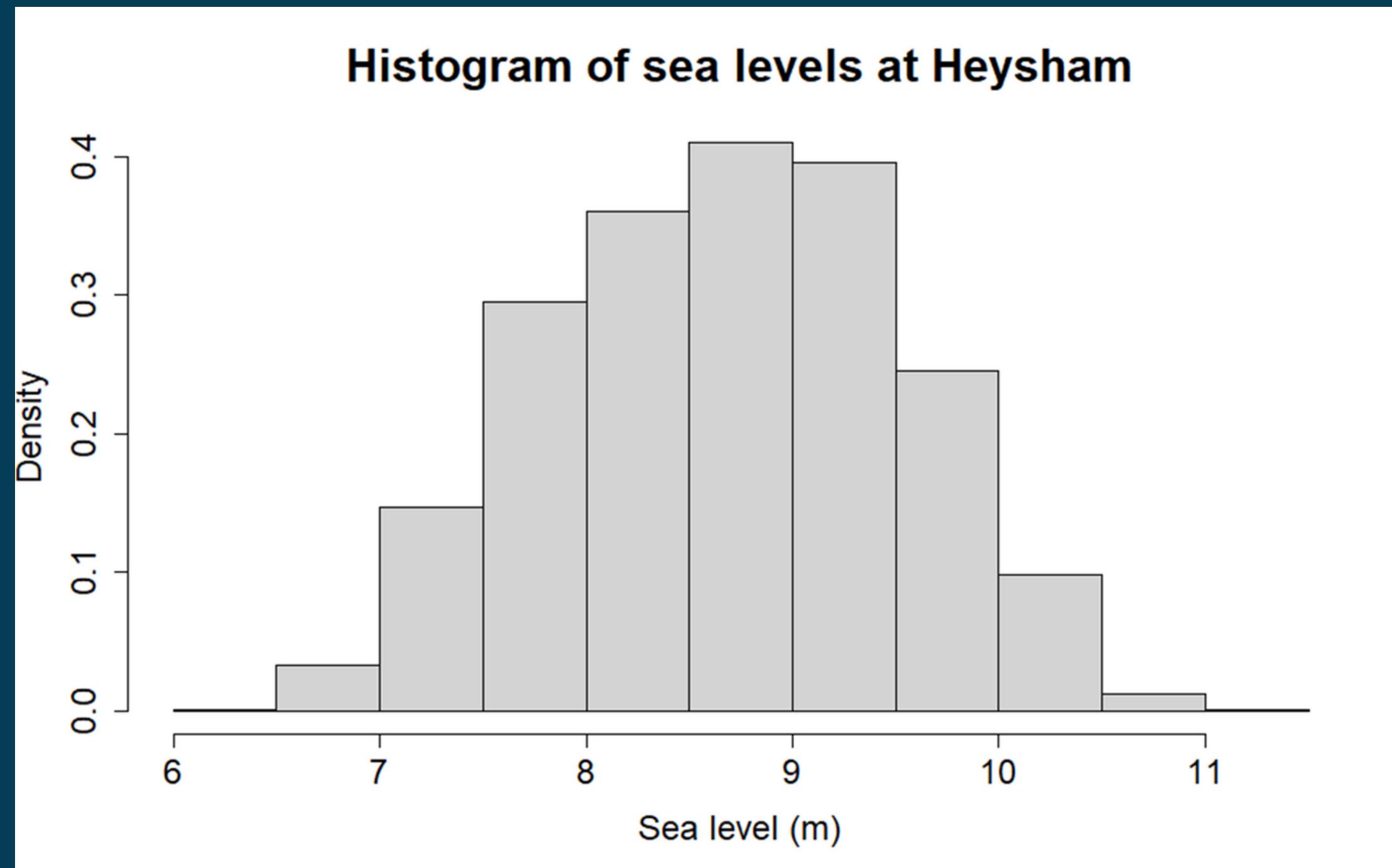
Linear Models

Output: Prediction of sea level in a future year



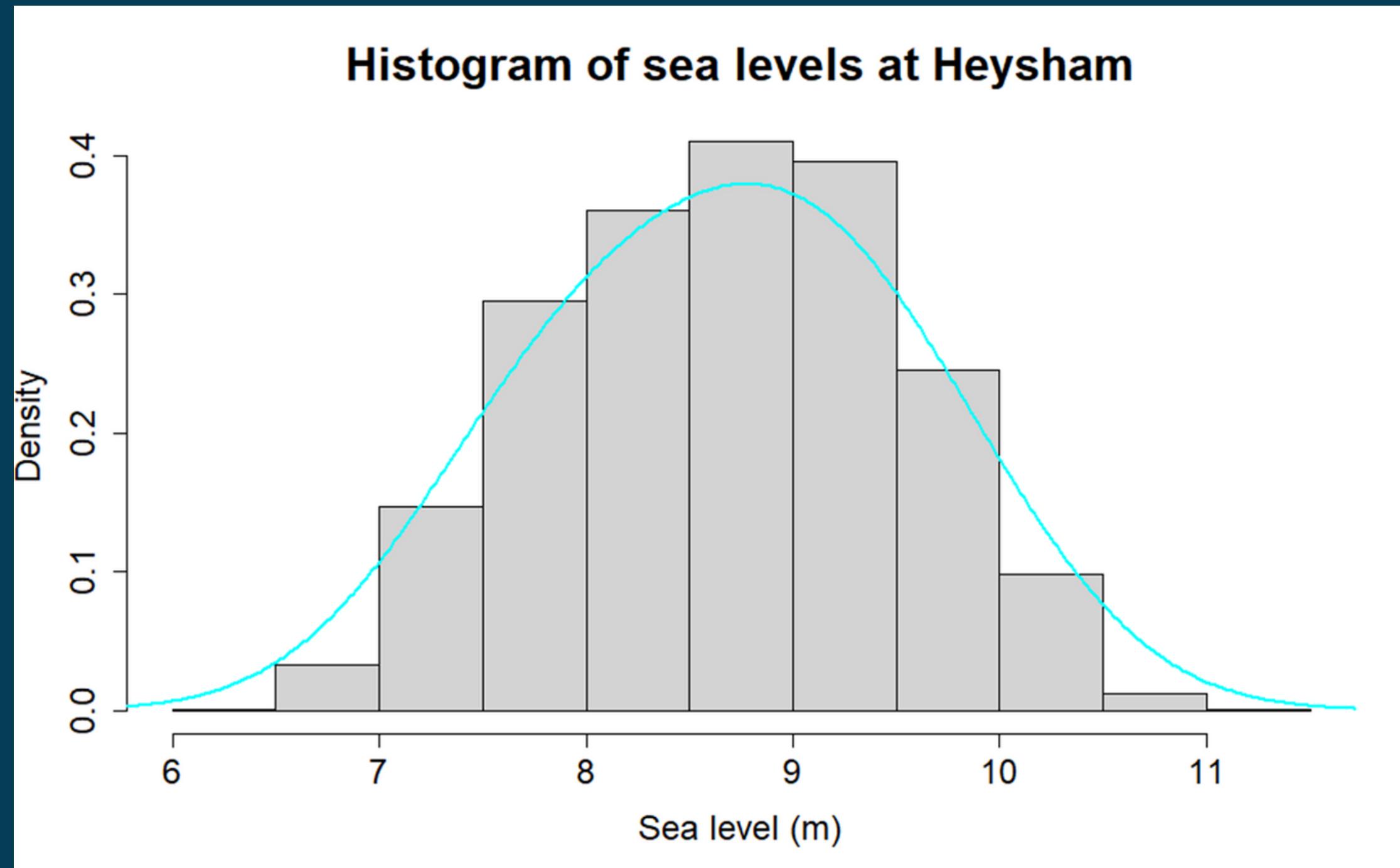
Probabilistic Models

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



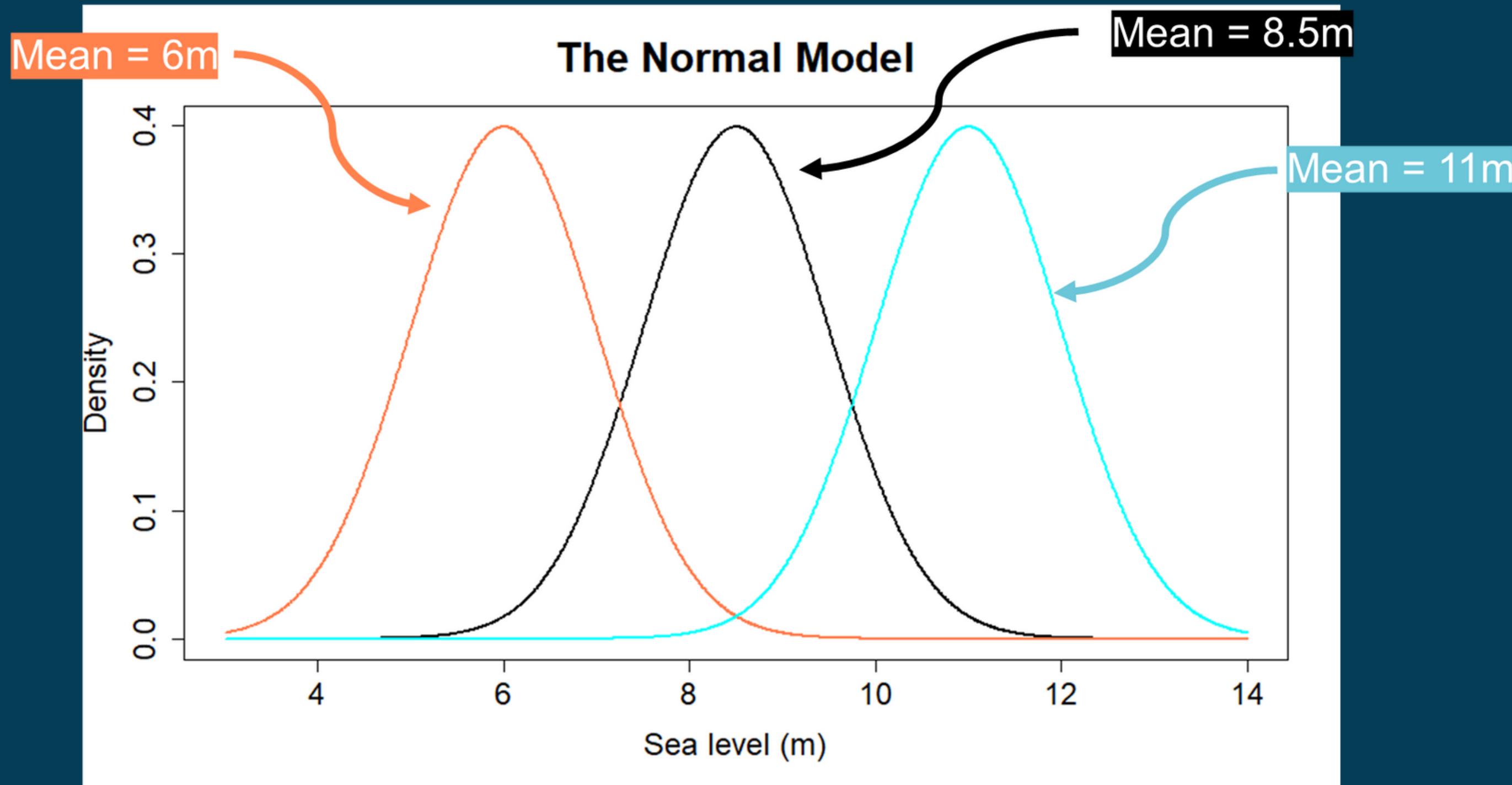
Probabilistic Models

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



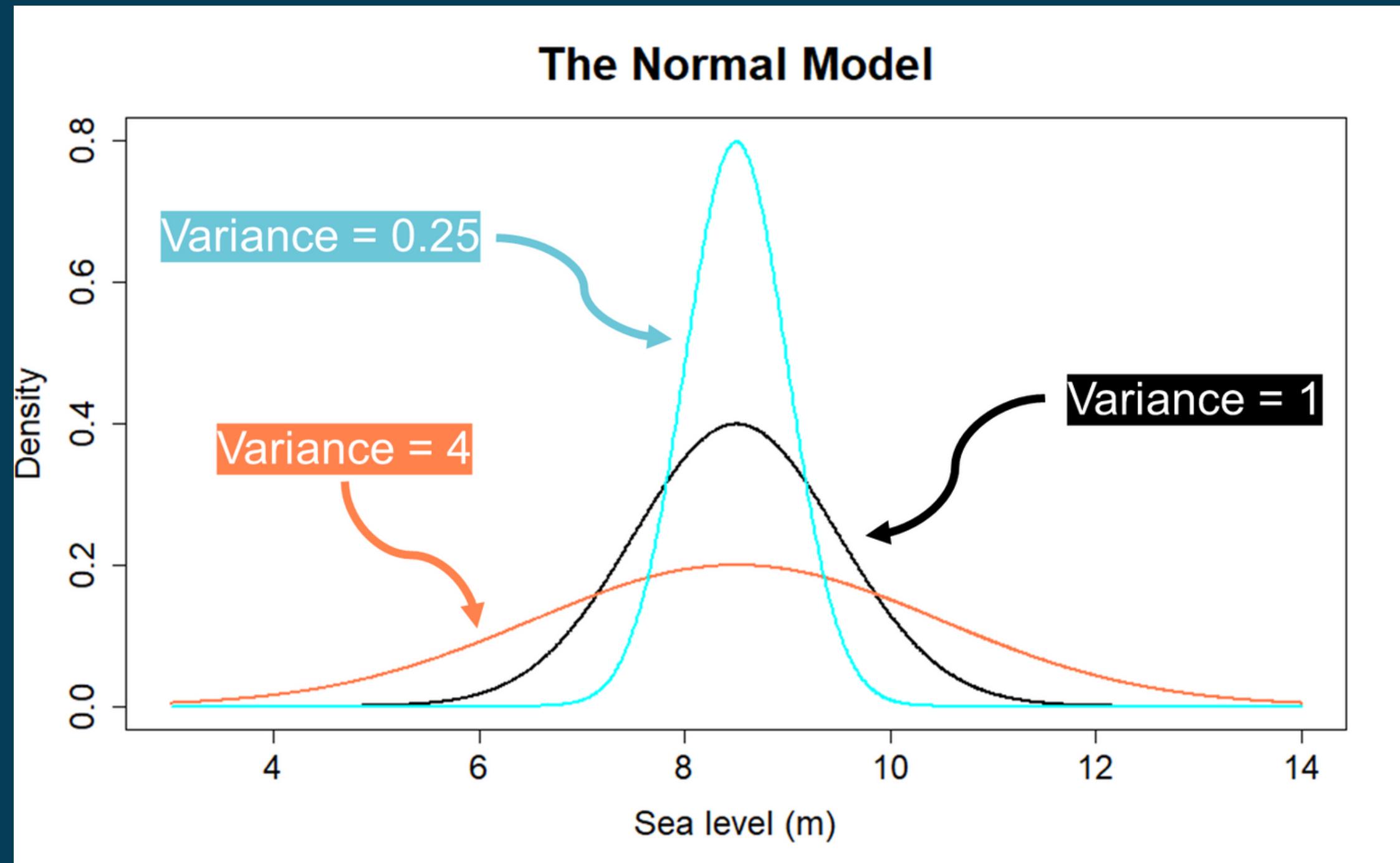
Normal Model

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

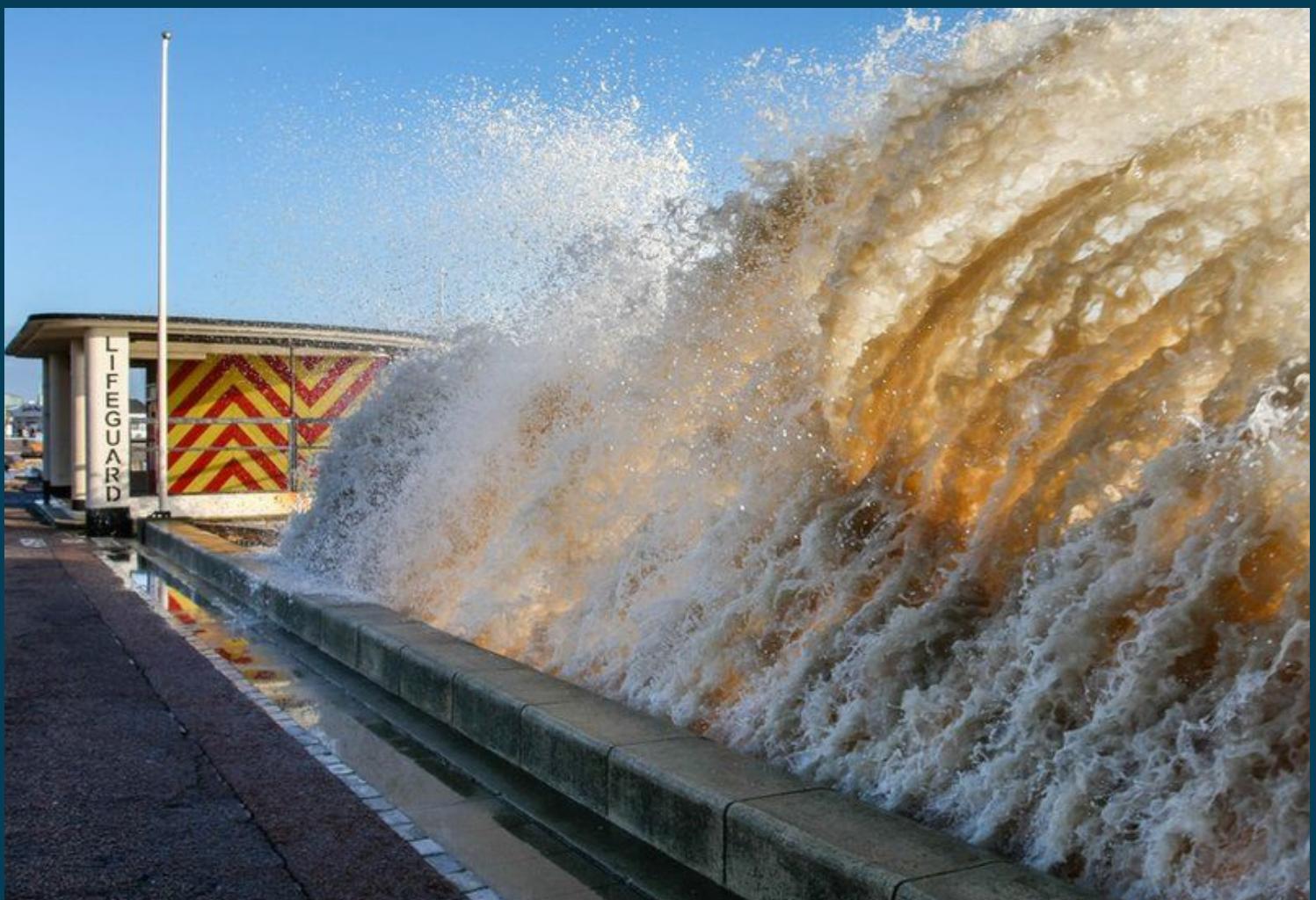
Eleanor D'Arcy
Lancaster University

Motivation

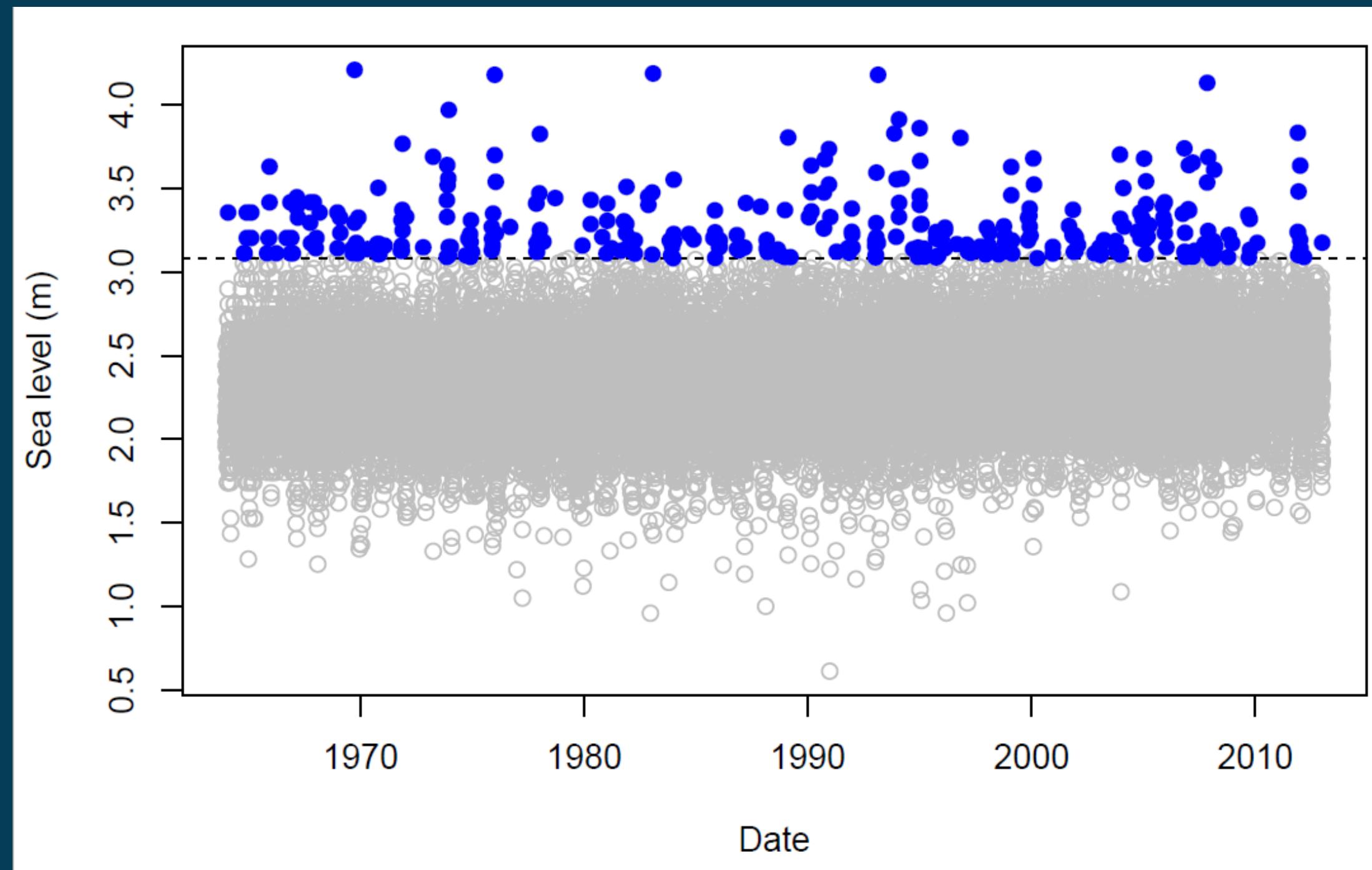
The risk of coastal flooding is increasing due to climate change and sea level rise.

Consequences of coastal flooding:

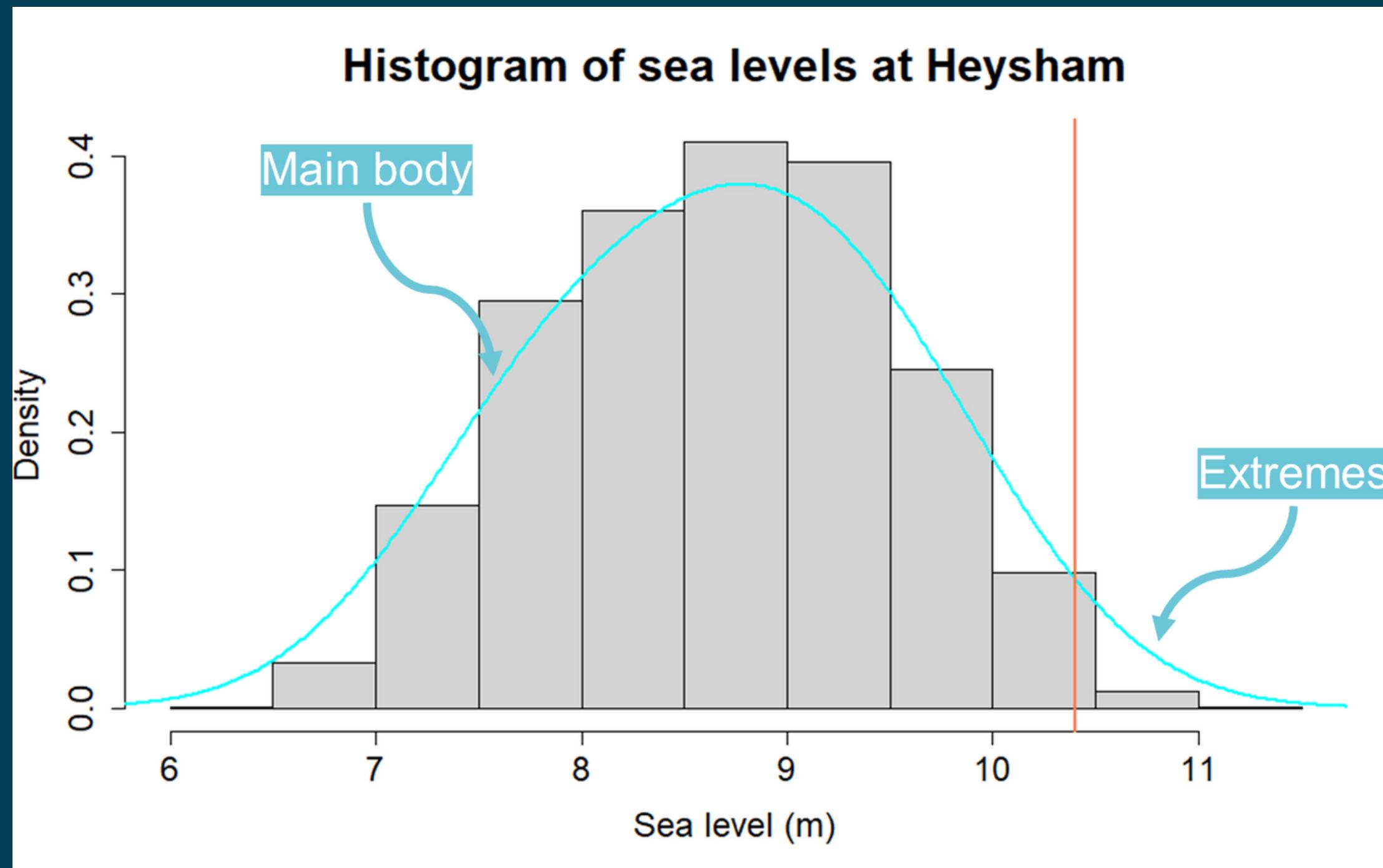
- Loss of life
- Damage to property and infrastructure
- Coastal erosion
- Displacement of people
- Loss of habitats and ecosystems



Extremes



Extremes



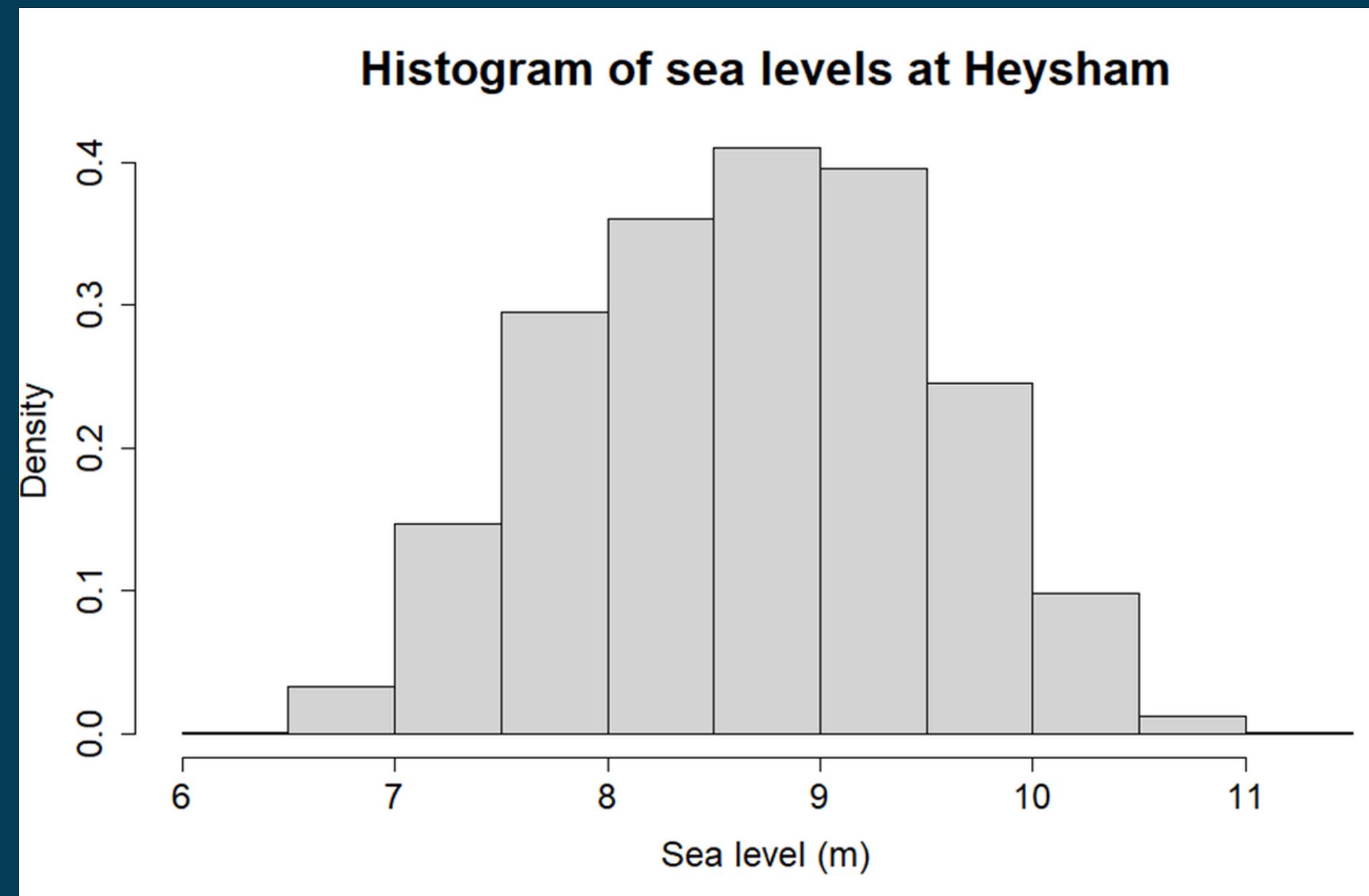
Statistics and Engineering



Statistics and Nuclear



How high should we build a sea wall?

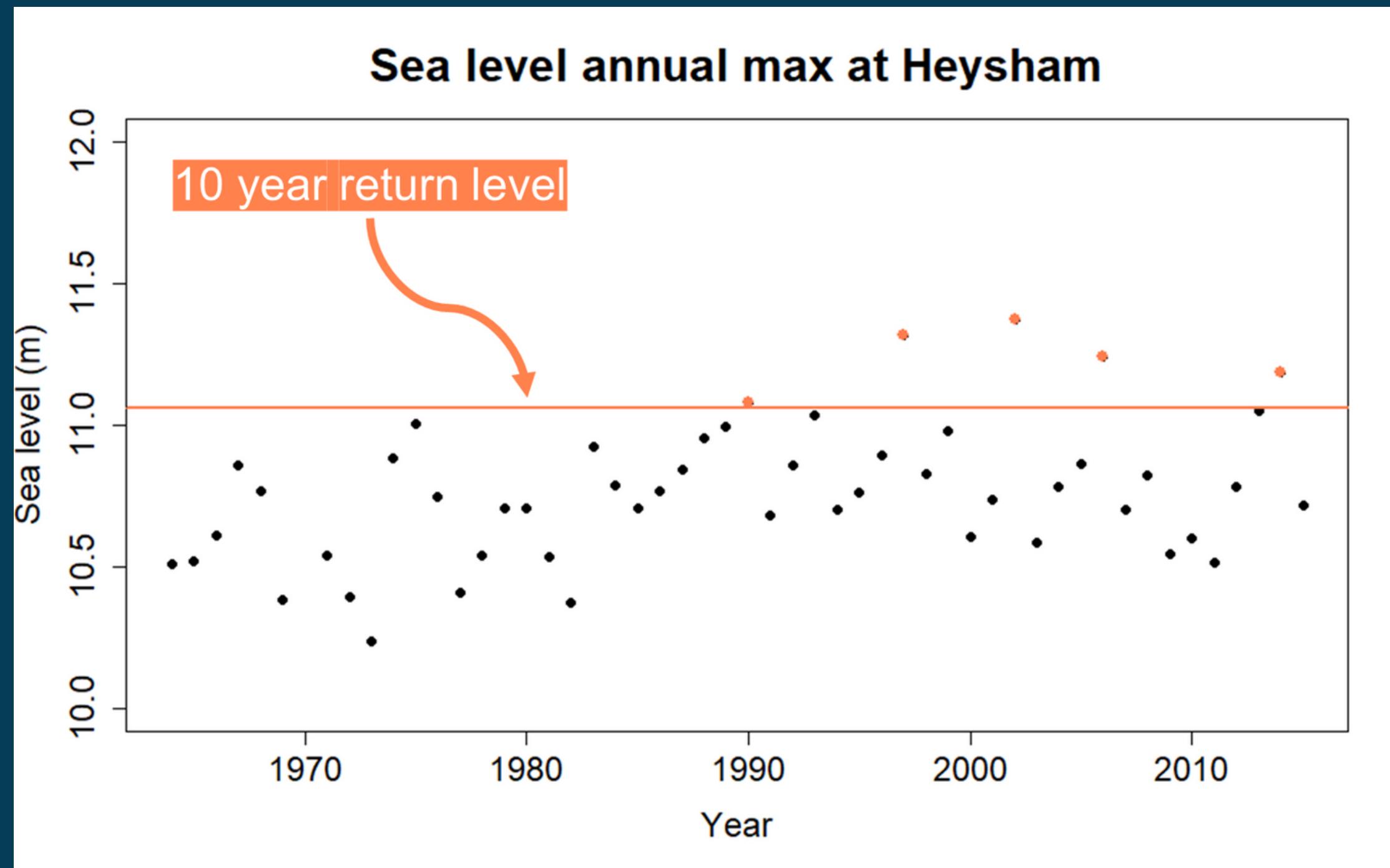


Return Levels

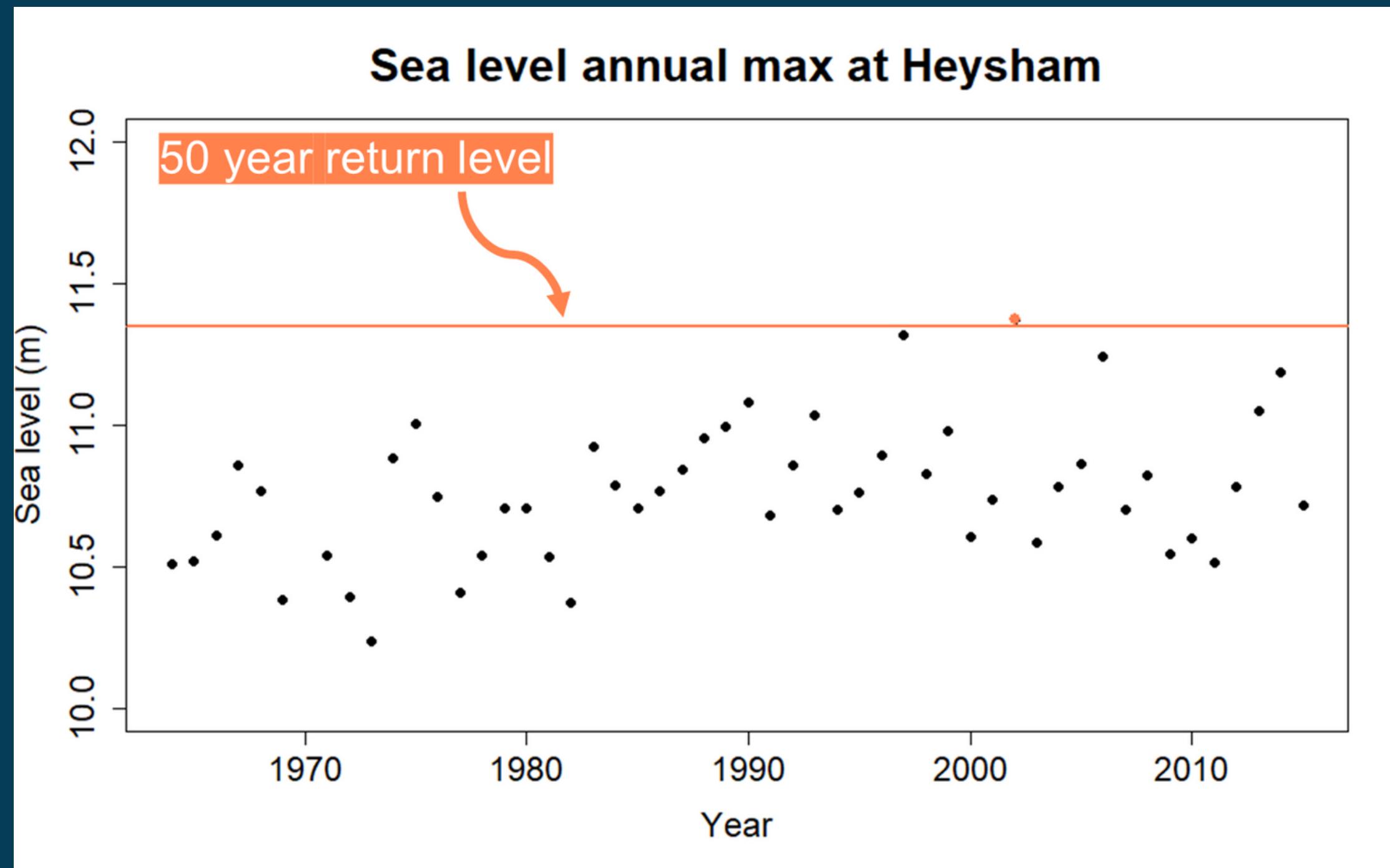
Level we expect to be exceeded once a year with probability p

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

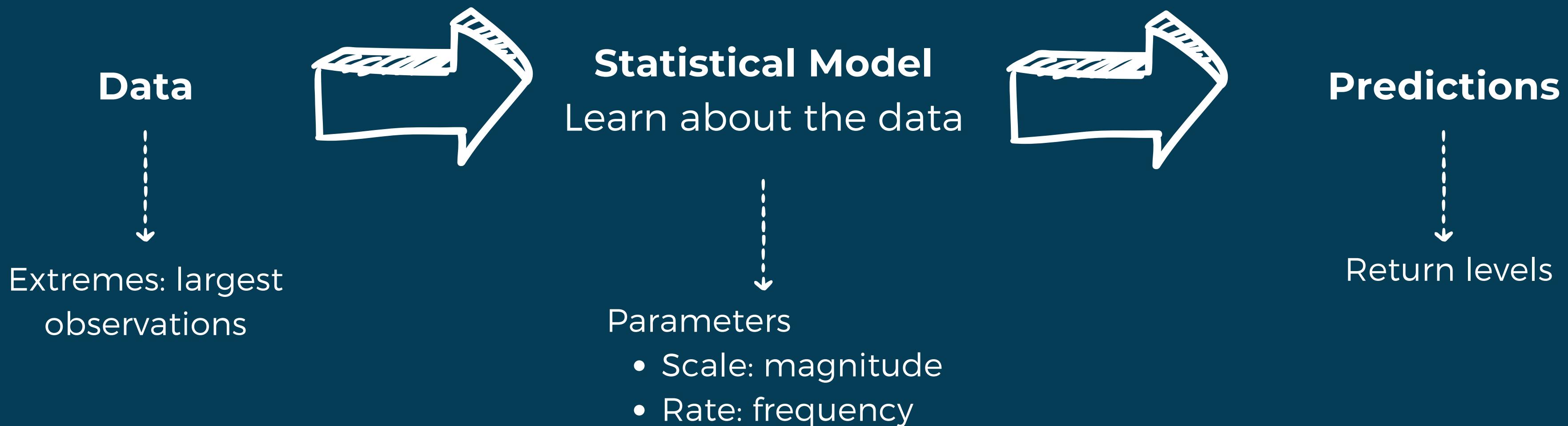
Return Levels



Return Levels



Can statistical modelling help?



“



• Climate change
• Sea level science

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SOME ARE USEFUL.**

GEORGE BOX

Oceanographers



Seismologists



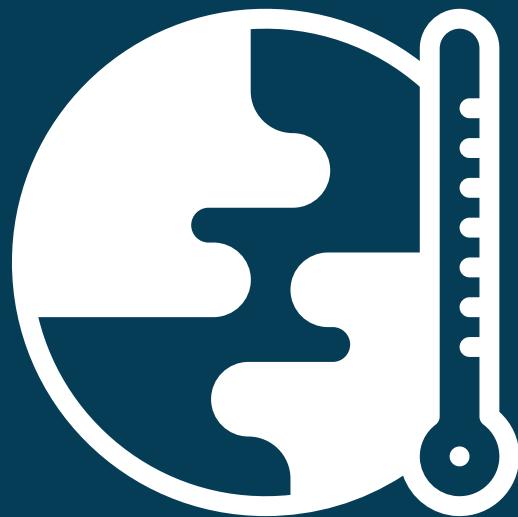
Statisticians



Meteorologist

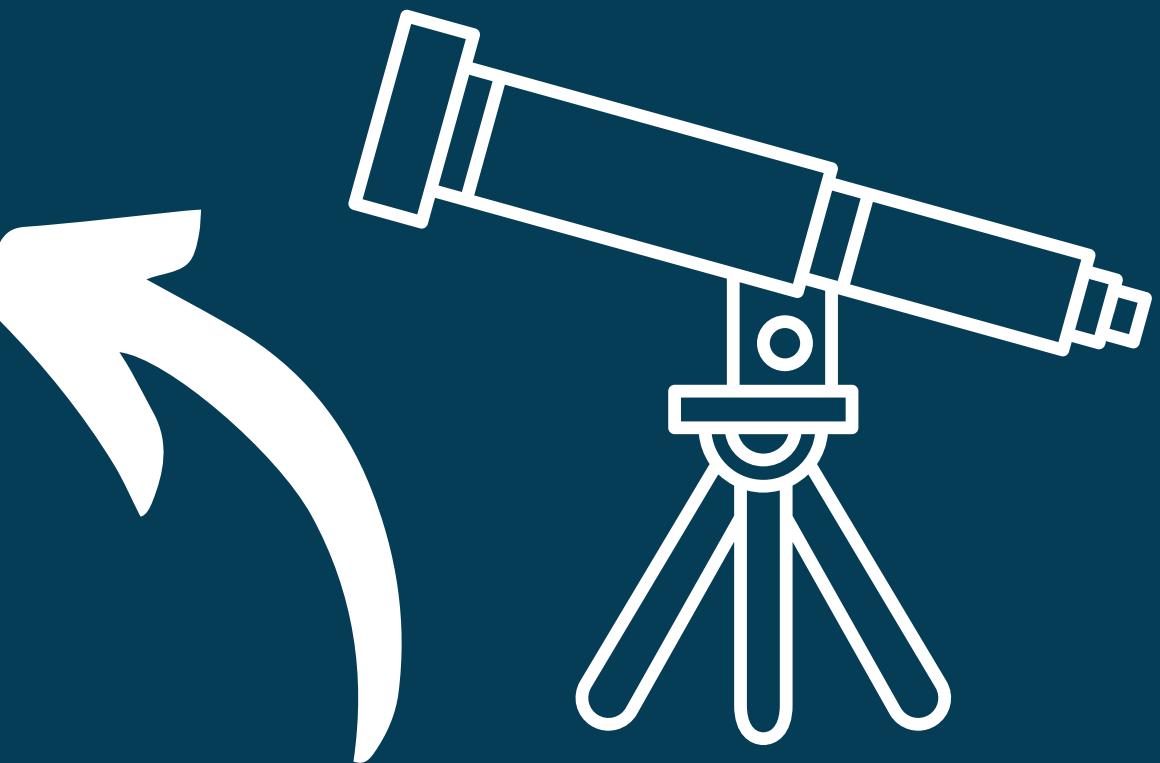


Hydrologist



Climatologist

Predictable rise and
fall of the sea surface
driven astronomically

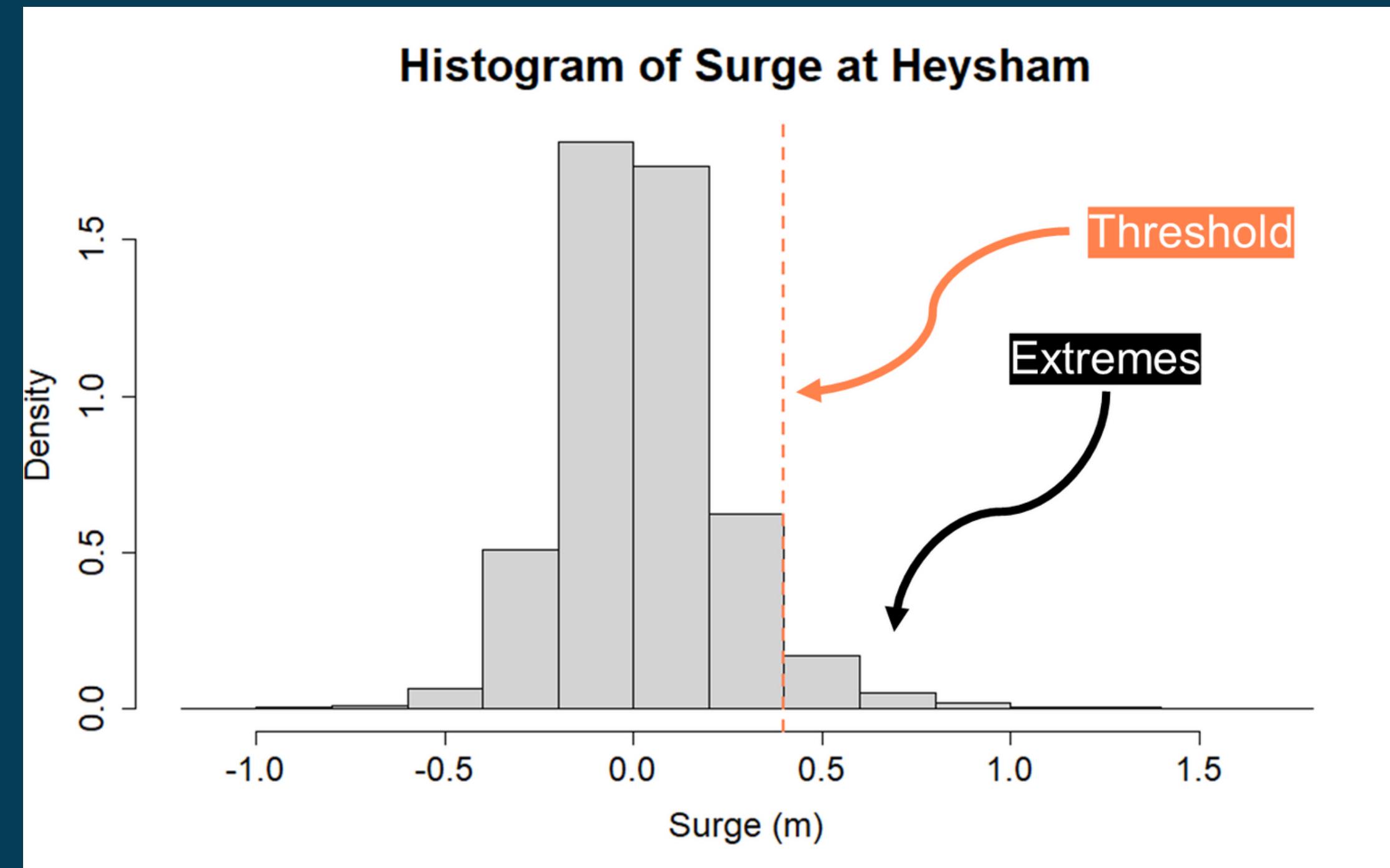


Sea level = Tide + Surge

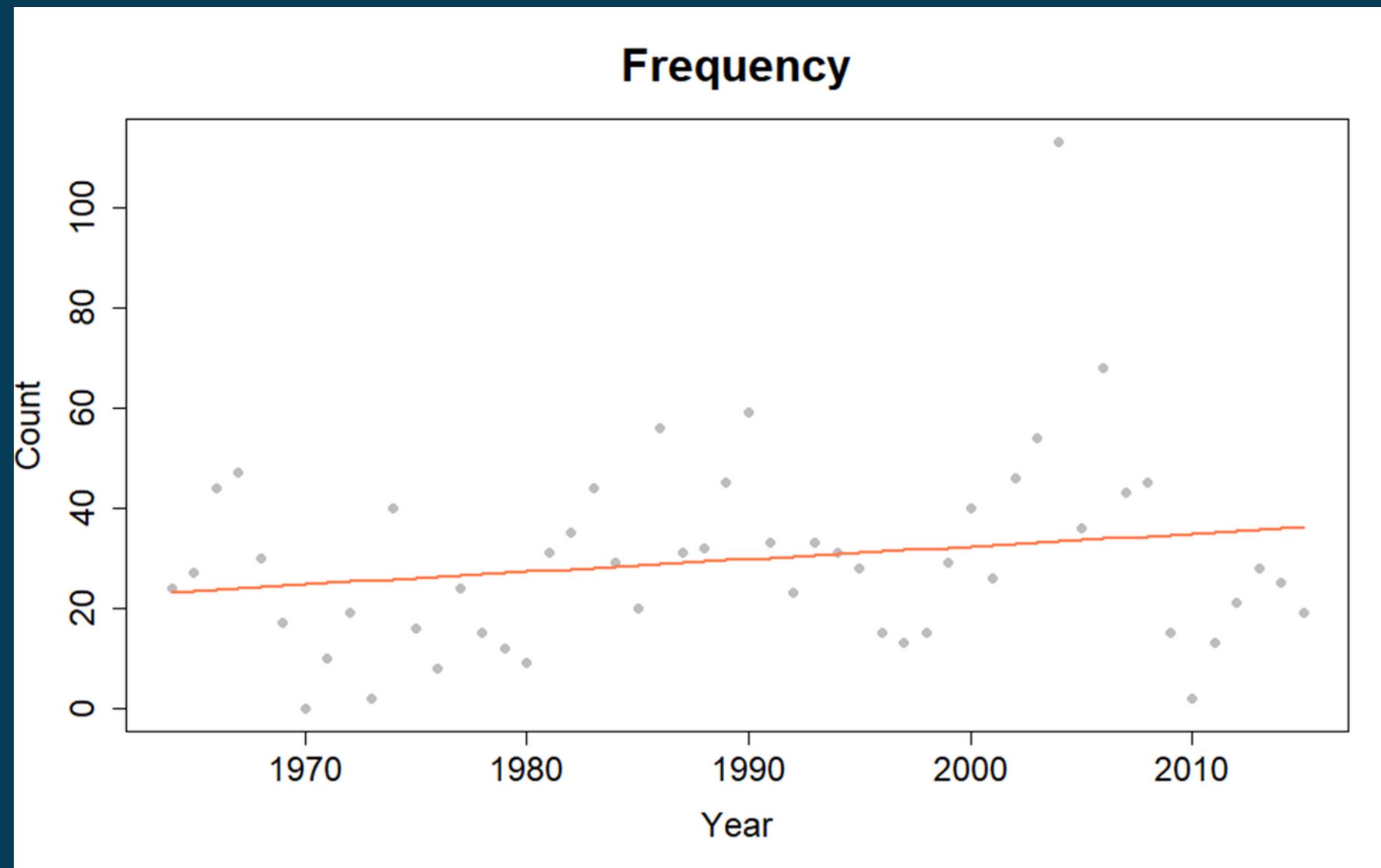


// ⚡ Short term sea level
changes caused by weather

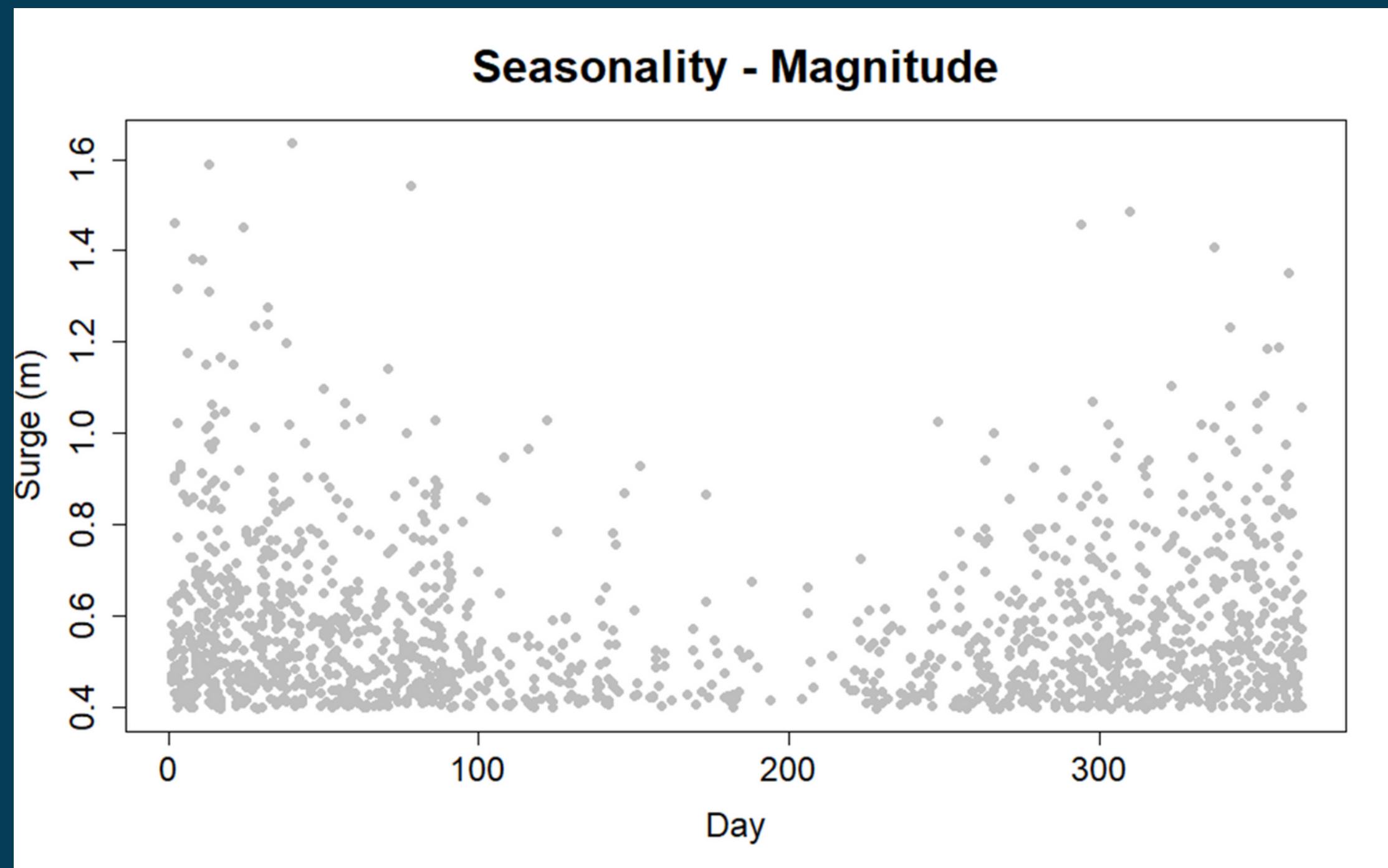
Modelling surges

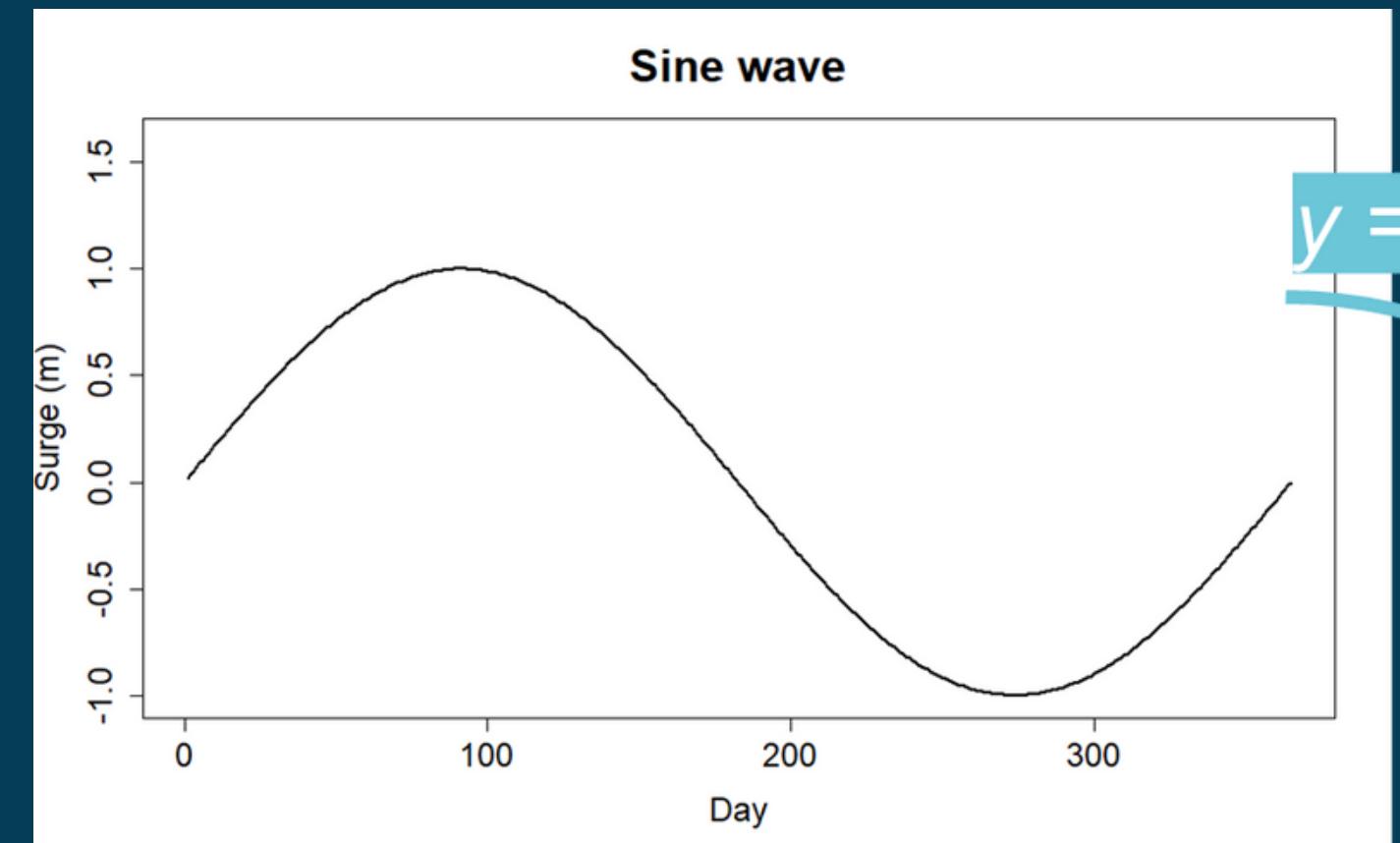


Climate change effects

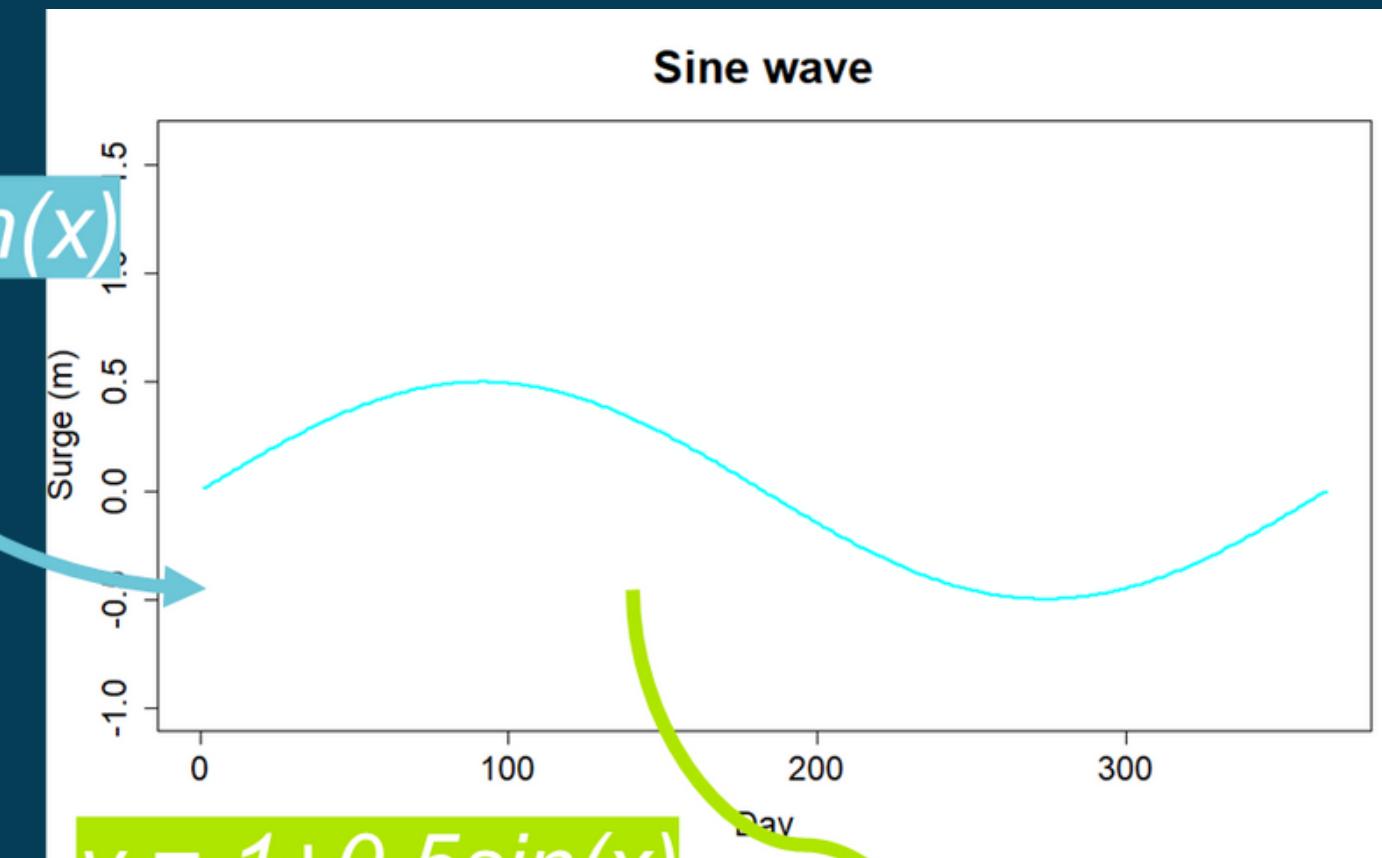


Seasonal effects

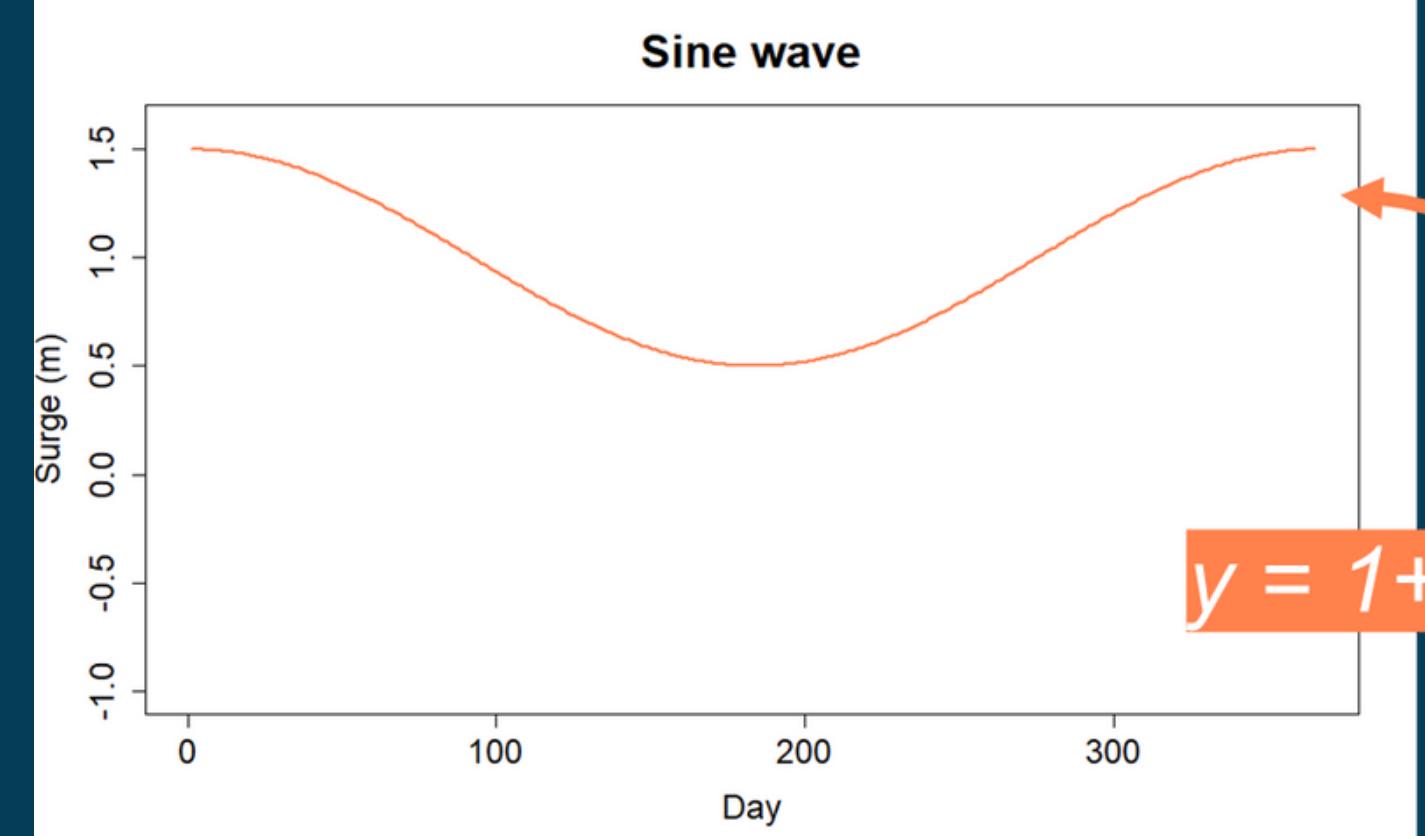




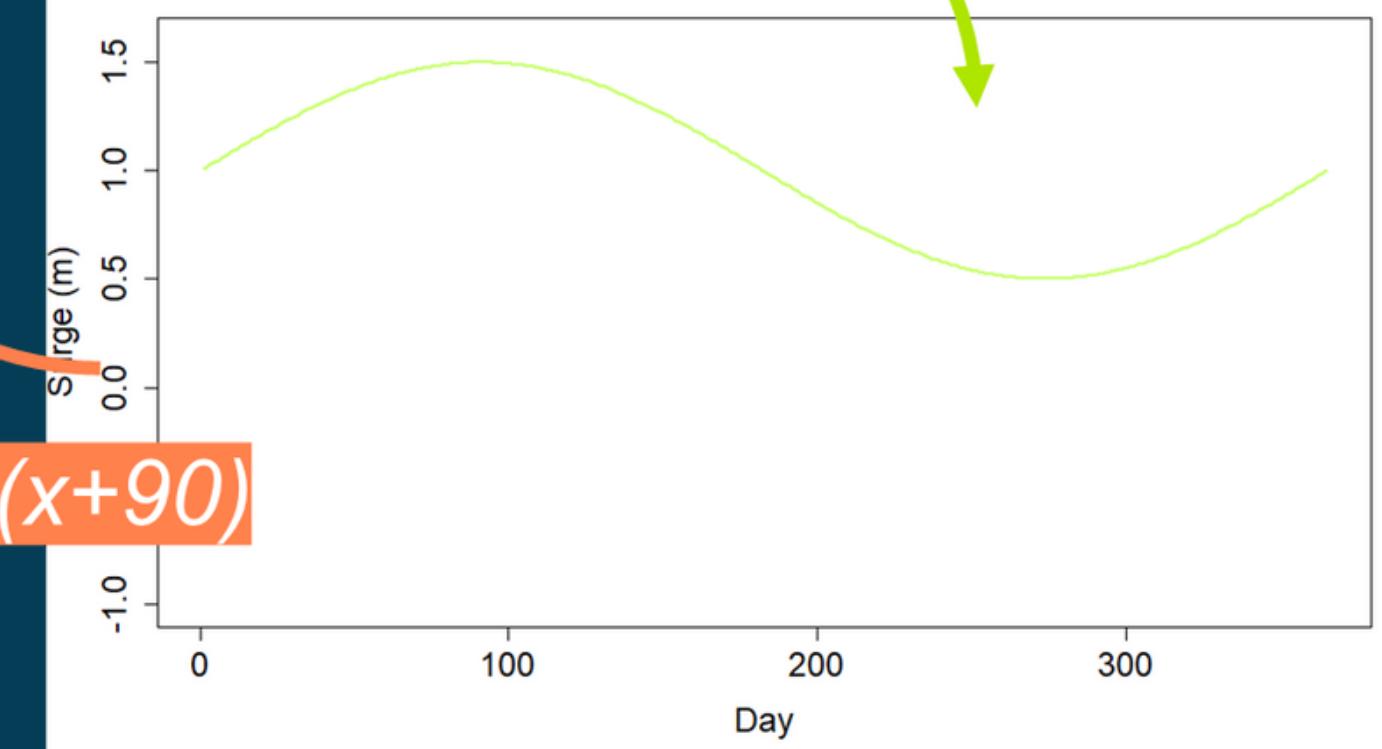
$$y = 0.5\sin(x)$$



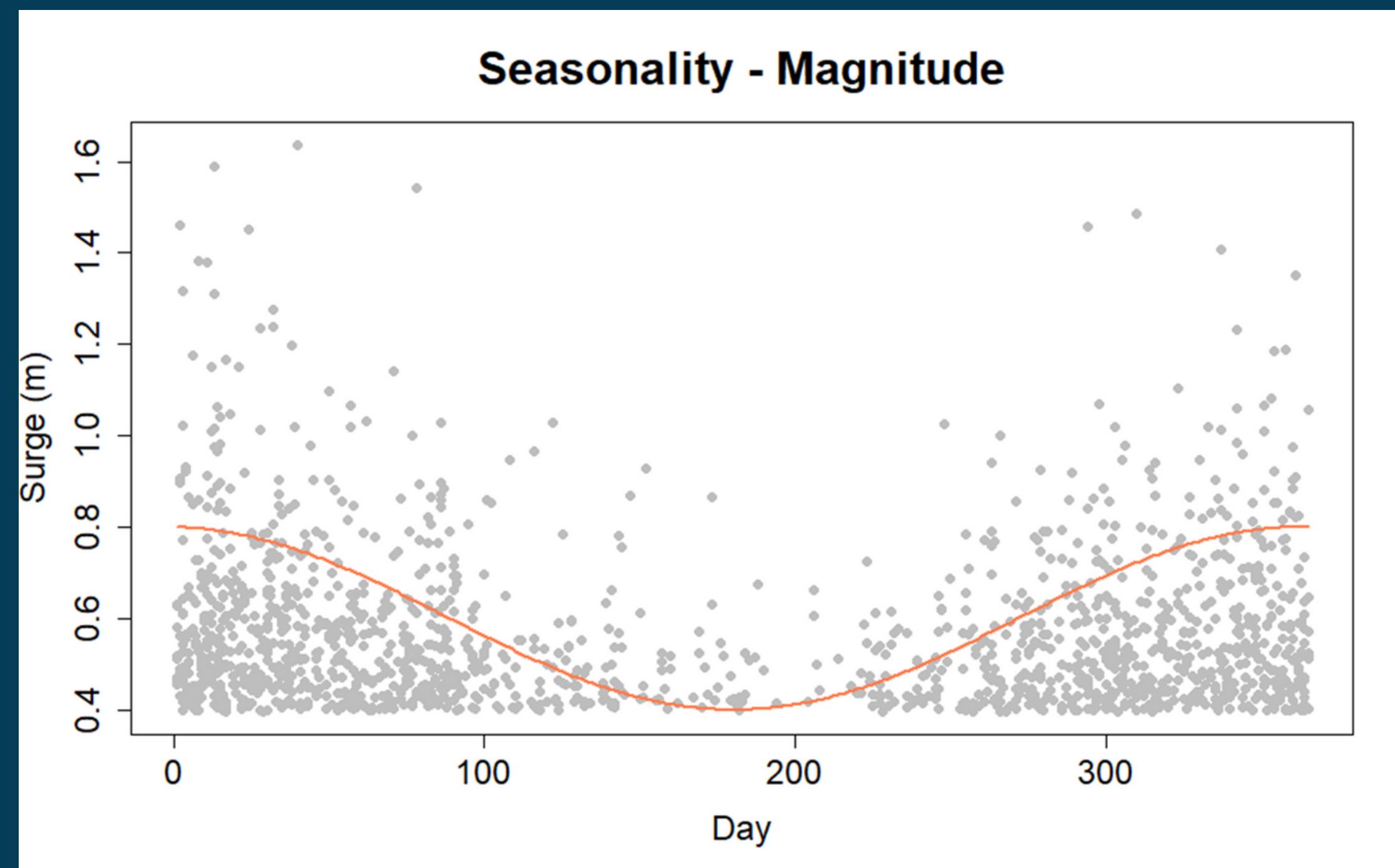
$$y = 1+0.5\sin(x)$$



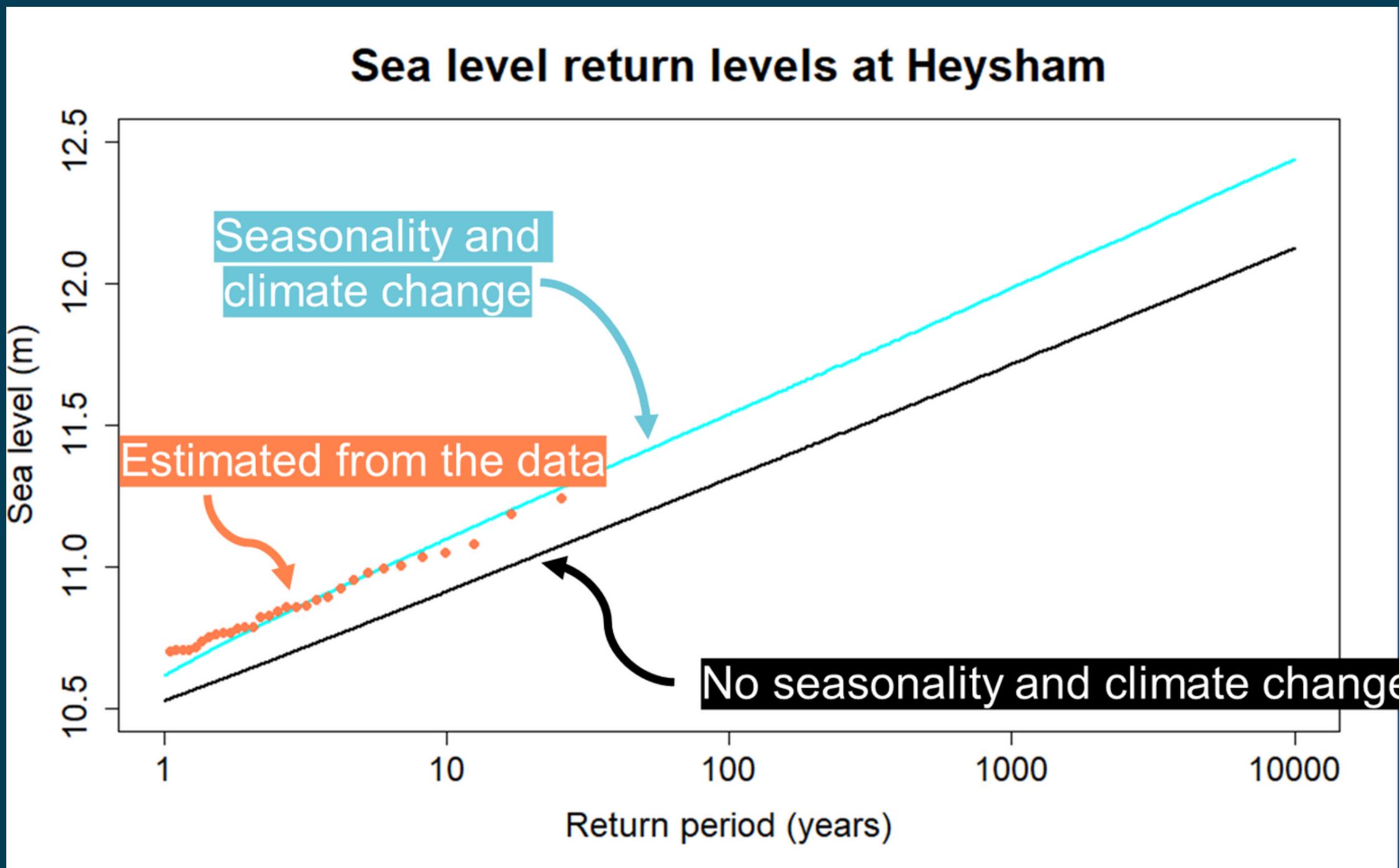
$$y = 1+0.5\sin(x+90)$$



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

Eleanor D'Arcy
Lancaster University