

Probability and Statistics

Dr. Lee Fawcett

Modelling Environmental Extremes

South Tyneside College, April 27th 2012

1 Introduction

1 Introduction

- Who I am

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- Who I am
- What I do

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2 Statistics of Extremes

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3 Mathematics & Statistics at University

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- Any scientific experiment requires the analysis of data
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- Although the questions can become complex, the solutions almost *a/ways* involve simple ideas of probability and statistics!

Are wholegrains *really* that good for you?



How can my pigs gain weight more quickly?



Statistical modelling of extreme weather has a very practical motivation: **reliability**.

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Anything we build needs to have a good chance of surviving the weather/environment for the whole of its working life.

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Rainfall: Flooding in North–West England, 2009



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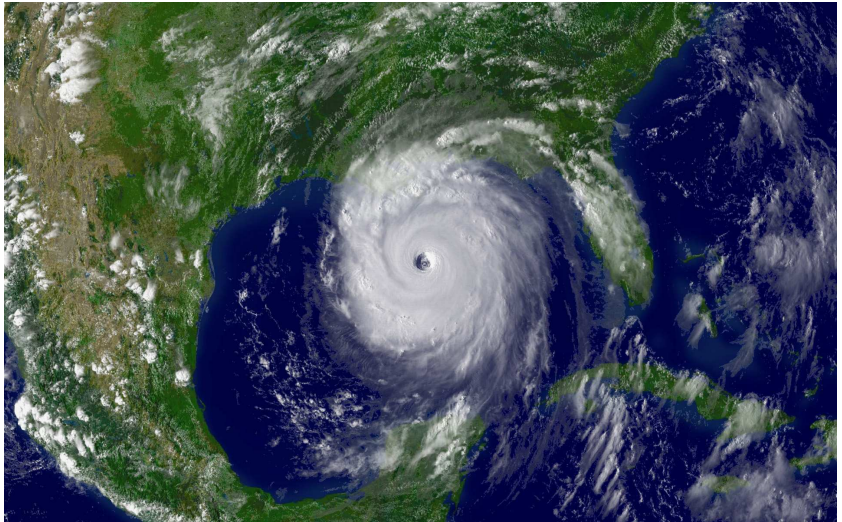


- £100 million worth of damage
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- Massive transport disruption

Drought: sub-Saharan Africa



Sea-surge: Hurricane Katrina, 2005



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www.KatrinaDestruction.com

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Hurricane Katrina: Some facts

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Billed as the “storm of the century” – just a few weeks later, **Hurricane Rita** battered Texas and Louisiana.

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Consider sea-surges in New Orleans. Suppose measurements are taken offshore in the Gulf of Mexico once every *day*.

Since we're interested in the extremes, we select the maximum value for each *year*, and throw the rest away!

Hands-on: Part A

Shown below are these **annual maxima** for the years 1955–2004 (inclusive).

6.0	2.6	2.1	4.3	4.1	4.5	9.2	5.9	5.0	4.5
6.9	4.8	2.2	3.4	5.7	2.6	4.2	4.2	5.6	11.8
8.3	4.8	3.0	3.4	12.8	3.7	5.5	3.0	3.1	9.1
4.0	13.3	5.5	11.0	4.8	5.1	3.2	3.9	3.3	3.4
4.5	1.7	2.7	2.9	12.4	7.9	9.7	5.0	11.8	3.8

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3. What is wrong with the probability in question 2?

It suggests that we will *never* see a sea-surge in excess of 14 feet. We are trying to work out the probability of something more extreme than has ever happened before!

The mean of our data is **5.5 feet**; the standard deviation is **3.1 feet**.

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X : Annual maximum sea surges (in meteres)

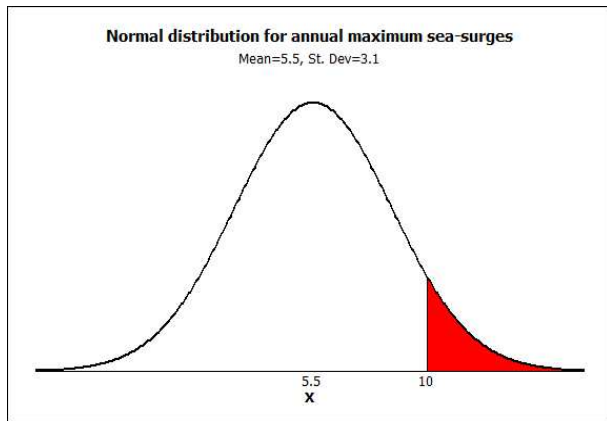
$$X \sim N(5.5, 3.1^2)$$

Hands-on: Part B

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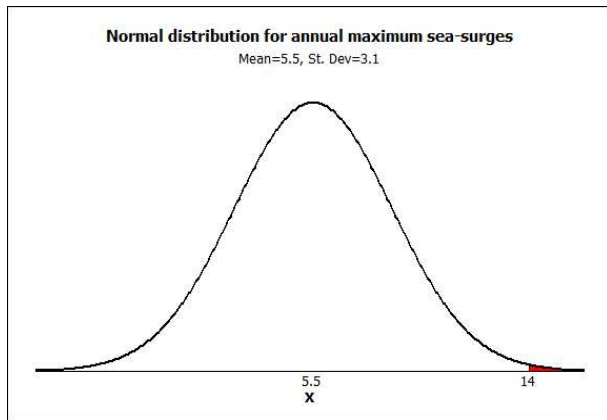
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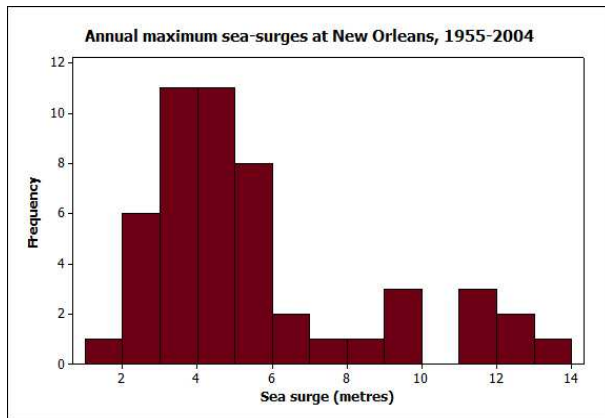
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- ... however, is the Normal distribution appropriate?

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- This could invalidate the Normal distribution calculations!

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In fact, it has been *mathematically proven* to be the *limiting distribution* for extremes!

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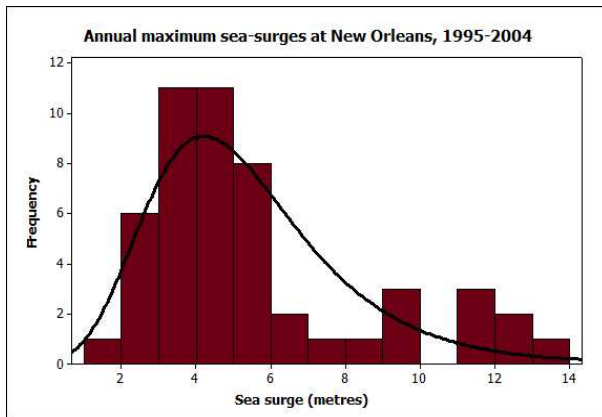
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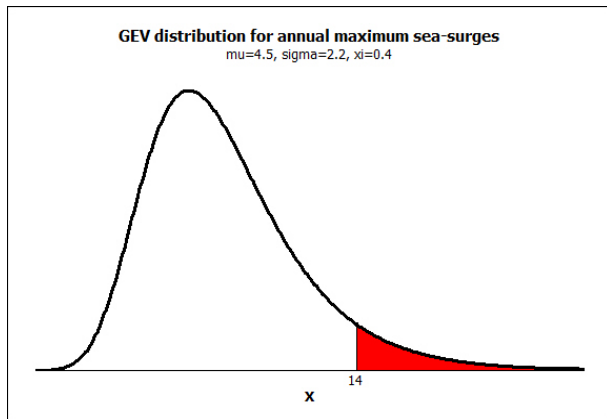
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- The GEV has a mathematical foundation for extremes as well!

3. Much of the levee (sea wall) system protecting New Orleans was destroyed during Hurricane Katrina.

The authorities now want to build a new levee that is tall enough to withstand the once in a thousand year sea-surge.

Using the Normal distribution, how high would the authorities need to build this sea wall?

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$$3.0902 \times 3.1 = ? - 5.5 \quad \text{i.e.}$$

$$9.57962 + 5.5 = ?, \quad \text{so}$$

$$? = 15.08 \text{ feet.}$$

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and that you were told that for our data, $\mu = 4.5$, $\sigma = 2.2$ and $\xi = 0.4$.

Hands-on: Part D

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- What is the MMath?

All done!

Thank you!

Bear us in mind when you make your choices!

lee.fawcett@ncl.ac.uk