

The storm of the century!

Promoting student enthusiasm for applied statistics

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RSS Conference: Manchester, September 2016

Motivation

- New undergraduates often have a rather dim view of Statistics
- At Newcastle: Courses in **Clinical Trials, Big Data, Financial Modelling, Environmental Extremes...**

"We can finally see the relevance of this subject!"

- Outreach & recruitment visits to local schools/colleges:

"Boring boring boring. Wish this [Statistics] wasn't part of my maths course at school"

"All we seem to do is flip coins and roll fair six-sided dice"

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Aims

- Use real-life data on climate extremes to **bring to life** parts of the school curriculum in Probability & Statistics
- Topics covered:
 - ▶ Relative frequency probability (Age 11+)
 - ▶ Interpreting probability (Age 11+)
 - ▶ Basic statistical modelling and extrapolation (Age 11+)
 - ▶ The Normal distribution* (Age 16+)
 - ▶ Non-standard probability models* (Age 11+)
 - ▶ Transposition of formulae* (Age 14+)
- Demonstrate the **practical application** of the subject, including its use in other subject areas
- Promote **enthusiasm** for the subject and encourage students to think about **further study**

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ITV News @itvnews · 6h

Plane leaves East Midlands Airport in front of tornado [itv.co/1pQRzDS](https://www.itv.com/news/1pQRzDS)



Part 1: Statistics of extremes - motivation



Part 1: Hurricane Katrina - summer 2005



- Annual maximum wave heights (AMWH) reached 14.4 feet
- Referred to as the **storm of the century**
- Some data on AMWH ('55-'04):

8.5	8.9	9.1	8.9	8.4
9.7	9.1	9.6	8.7	9.3
9.6	9.3	8.7	9.0	8.8
8.9	8.9	12.2	7.8	7.7
8.3	8.1	7.3	6.8	6.7
7.3	7.6	8.2	8.6	9.8
9.5	7.4	7.3	10.2	10.3
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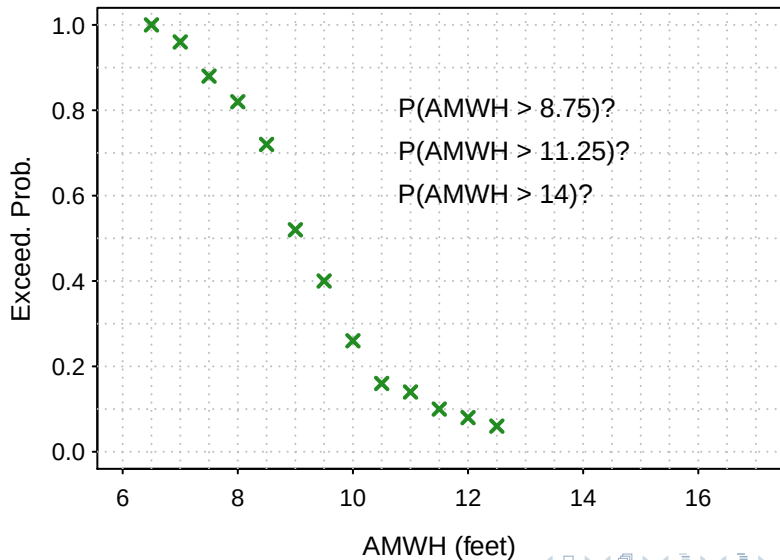
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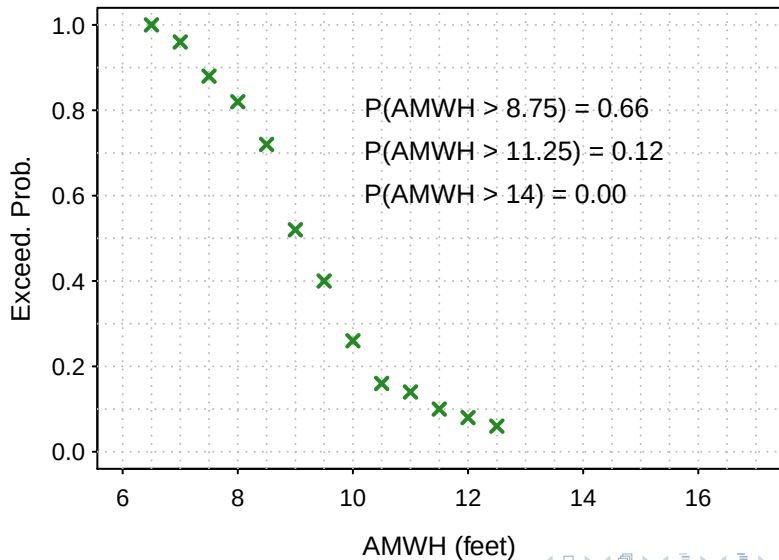
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Part 2: Relative frequencies



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Part 3: A probability model

- Some history on the development of **extreme value theory** is given, including the work of **Emil Julius Gumbel**
- The **Gumbel model** is then presented as

$$P(X > x) = 1 - \exp \left\{ -\exp \left[-\left(\frac{x - \mu}{\sigma} \right) \right] \right\}.$$

- ▶ We explain that μ and σ are location and shape parameters, and here $\hat{\mu} = 8.636$ and $\hat{\sigma} = 1.275$
- ▶ Where appropriate, we discuss the exponential function
- ▶ We explain that X is shorthand notation for our variable (AMWH here) and x is any observation on this variable (e.g. 8.75, 11.25 or 14)
- Using a scientific calculator, or our *Shiny* app, we then demonstrate the Gumbel model

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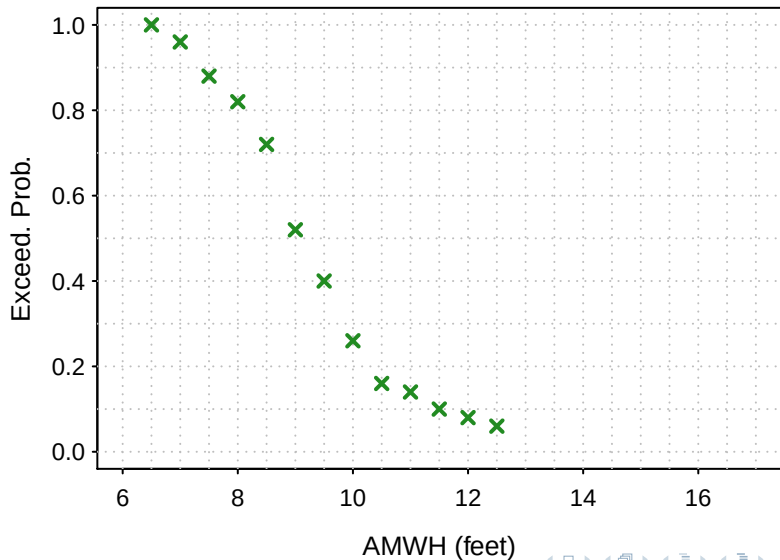
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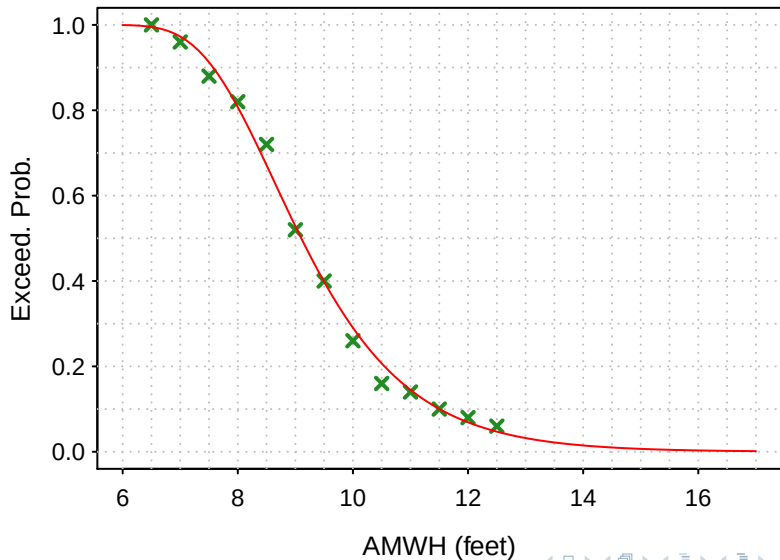
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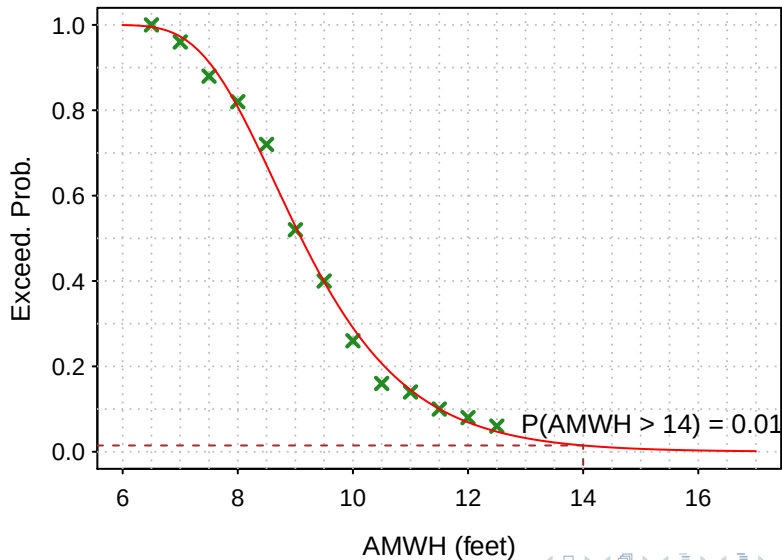
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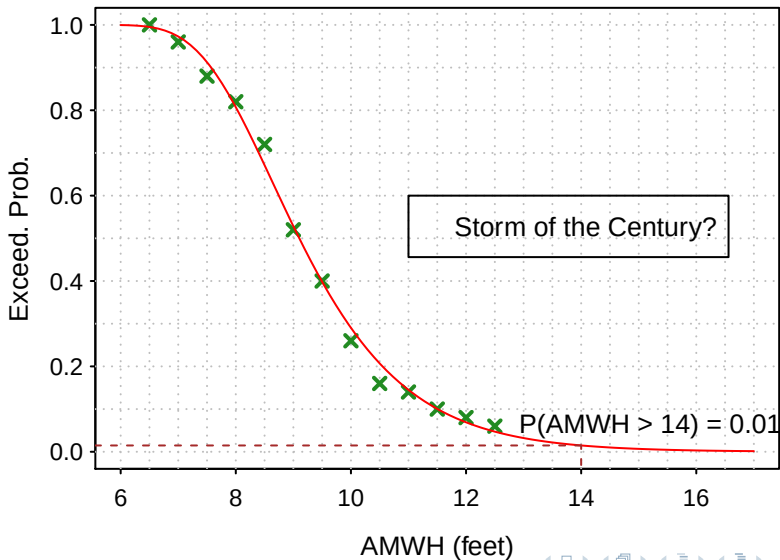
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Part 3: Model comparisons

	Probability that AMWH exceeds		
	8.75 feet	11.25 feet	14 feet
Relative frequency	0.66	0.12	0
Gumbel model	0.599	0.121	0.011
Normal model	0.653	0.105	0.001

Discussion points

- Is the Normal distribution appropriate here?
- Do you trust the relative frequency estimates?
- The values in these tables are estimates. We really need some sort of 'margin of error'...
- Think about climate change. How might this mess things up?

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Part 4: Structural design

A new sea wall is to be built to protect the city of New Orleans against future flooding. How tall should this sea wall be to protect against the wave height we might expect to see, on average, once every 500 years?

Discussion points

- Do you know where to start?
- Does this help: $P(\text{AMWH} > ?) = \frac{1}{500}$?
- Rearrange the following to make ? the subject:

$$1 - \exp \left\{ -\exp \left[- \left(\frac{? - \mu}{\sigma} \right) \right] \right\} = \frac{1}{500}.$$

- Margin of error?

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Evaluation

- These activities have been used many times in schools and colleges in and around Newcastle
- The activities are usually well-received by students/teachers
- At our recent '**sixth form conference**', as a result of our hands-on sessions:
 - ▶ 65% of attendees said they were more likely to consider applying to Mathematics/Statistics courses at University
 - ▶ 75% of attendees said they would be more enthusiastic about their school study of Mathematics/Statistics
- Some more comments from student participants in the past:
 - "Ticked the boxes for me, I like to see how the stuff we learn can be used in the real world"*
 - "I didn't realise maths and geography could be used together, they're my two favourite subjects at school"*
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Thank you... questions?

- The activities in “The storm of the century!” have been automated via a dedicated *Shiny* app
- If you'd like to play with this, or take a look at the handouts/slides used in the talk, visit my webpage:

<http://www.mas.ncl.ac.uk/~nlf8/outreach/>

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