

Research Centre for Marine Sciences and Climate Change

Climate Change and Coastal Defence

Eur Ing Terry Hedges

Department of Engineering

University of Liverpool

January 2008

Structure of Presentation

- ❖ Introduction
- ❖ Hazards, Exposure and Risk
- ❖ Coastal Defence
- ❖ Wave Overtopping
- ❖ Concluding Remarks

Introduction

- ❖ The capital value of assets at risk in England and Wales from **river or coastal flooding** or from **coastal erosion** is approximately **£250 billion**. Areas at risk due to **inadequate drainage under extreme rainfall** (as occurred in England in Summer 2007) may add very significantly to this figure.
- ❖ Without flood and sea defences, the average annual economic damage in England and Wales would be more than **£3.5 billion**. In practice, insurance companies pay out around **£1 billion** annually ... but this figure appears to be rising. It was considerably higher in 2007.

Introduction

- ❖ Even so, the **true costs are much greater than the sums paid out by insurance companies**, because some households and businesses are not insured or are underinsured. In addition, the costs of emergency measures and repairs to infrastructure fall on central and local government.
- ❖ Furthermore, there are ‘hidden’ costs to society, such as **increased health care costs** due to sickness and stress-related illnesses. Days are also lost from work due to the need to deal with **disruption**. And there may be damage to important environmental assets.

Hazards, Exposure and Risk



Source: www.cefic.org

- ❖ A **hazard** exists where an object, a substance or a situation has an ability to cause harm.
- ❖ The **exposure** is the extent to which the likely recipient of the harm can be influenced by the hazard.
- ❖ For harm to occur - or for there to be a **risk** - there must be both a hazard and exposure to that hazard.

Hazards, Exposure and Risk

- ❖ What do we mean by risk?

Risk =

Probability of an event * Consequence if it occurs.

- ❖ If there is a low probability or little consequence, then there is only a small risk.
- ❖ In undertaking a risk assessment, we can adjust the **acceptable probability of failure** to account for different consequences. When there are potential fatalities or likely damage to utilities, then there should be a low probability of occurrence. In contrast, if damage is limited to grazing land or only involves the temporary closure of minor roads, then the probability of failure can be set much higher.

Hazards, Exposure and Risk

❖ People



Hazards, Exposure and Risk

❖ Road traffic



New Brighton, UK

Hazards, Exposure and Risk

❖ Property



Hazards, Exposure and Risk

- ❖ Infrastructure – marinas and harbours



Newlyn, UK

Hazards, Exposure and Risk

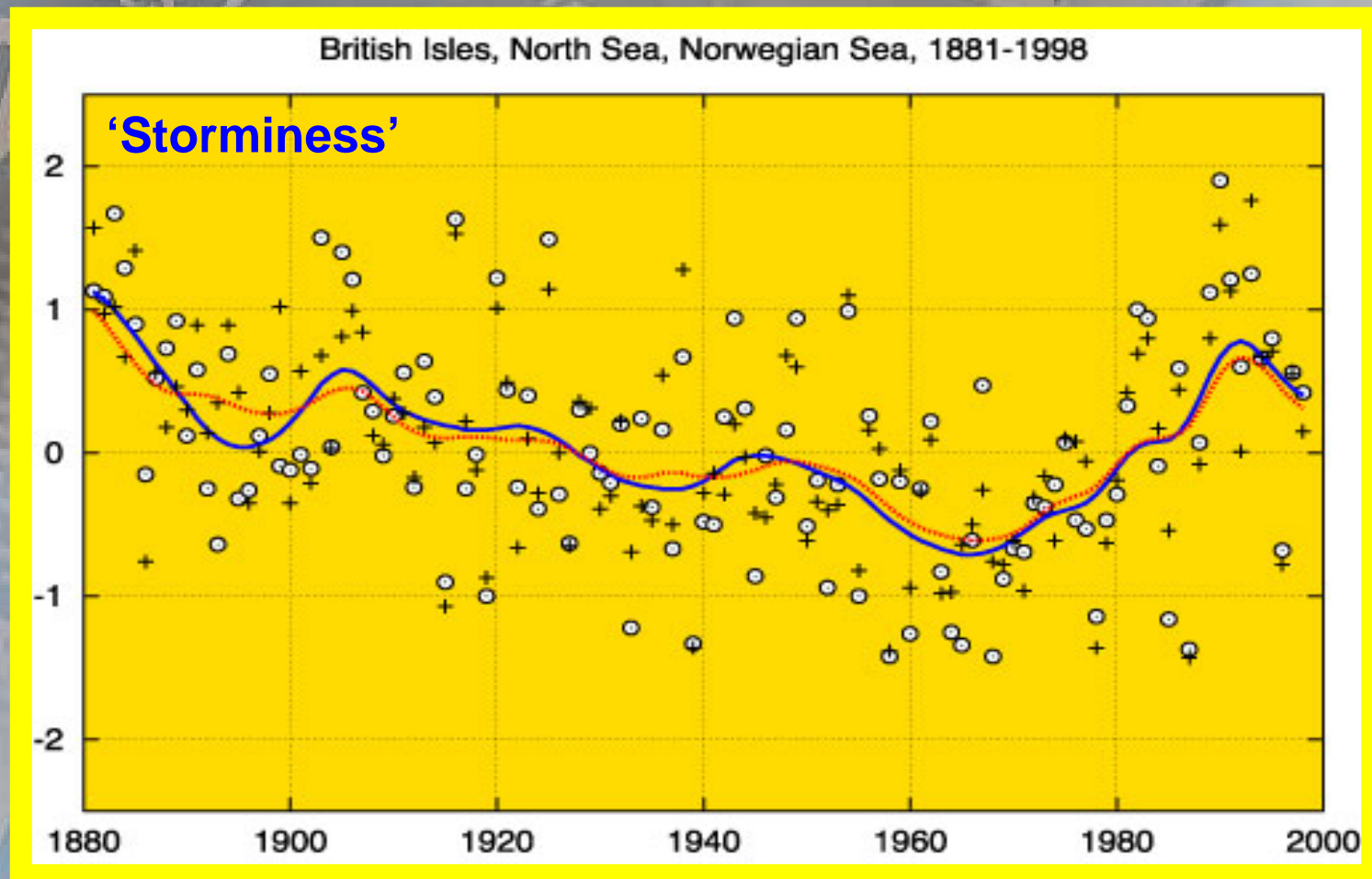
❖ Infrastructure – railways



Hazards, Exposure and Risk

- ❖ The hazard of rising sea levels is compounded by the possible threat of increased storminess associated with global warming.
- ❖ The observed storminess in the area of the British Isles, North Sea and Norwegian Sea over the last 100 years does show long-term variations. But present sea states are probably similar to conditions experienced about 100 years ago.

Hazards, Exposure and Risk



(from http://www.clivar.org/science/extreme_examp.htm
after Alexandersson et al., 1998, GAOS, 6, 97-120)

Coastal Defence

- ❖ So, in terms of storminess, we may now only be back to where we were at the start of the last century.
- ❖ But over the last 100 years or so, there has been considerable development along the coast...



Coastal Defence



- ❖ Clearly, we must be more careful in allowing development. Why was it necessary to locate this gas terminal right on the coast?

Coastal Defence

- ❖ Sea defences are expensive!
- ❖ Construction costs may range from around £2M/km for a simple earth embankment with a stone revetment to £20M/km for a concrete structure such as the new seawall and associated environmental works in Cleveleys, north of Blackpool.
- ❖ Is this the best way to use public funds? Or would the money be better used in schools and hospitals, and on the salaries of university lecturers?

Coastal Defence

- ❖ Sometimes we may decide to protect property by armouring the coast...



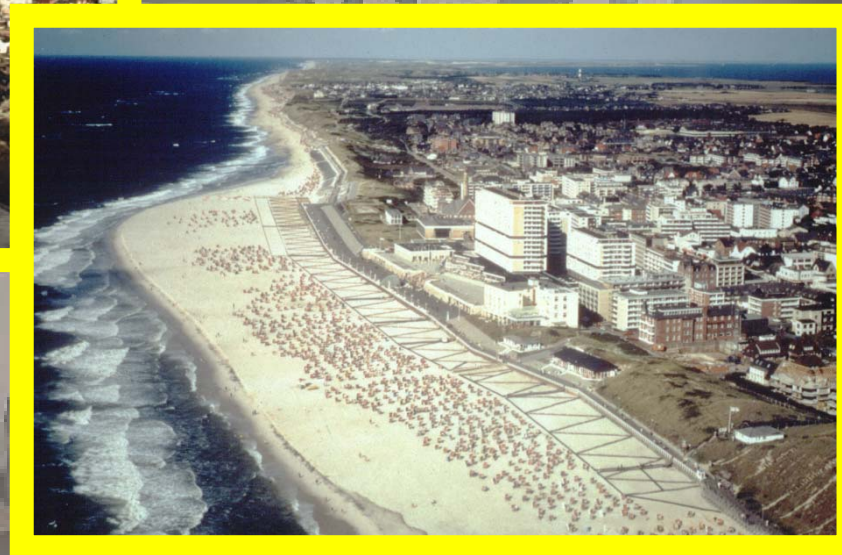
Coastal Defence

- ❖ Sometimes we may choose to mimic nature by creating artificial headlands and reefs, rather than building seawalls...



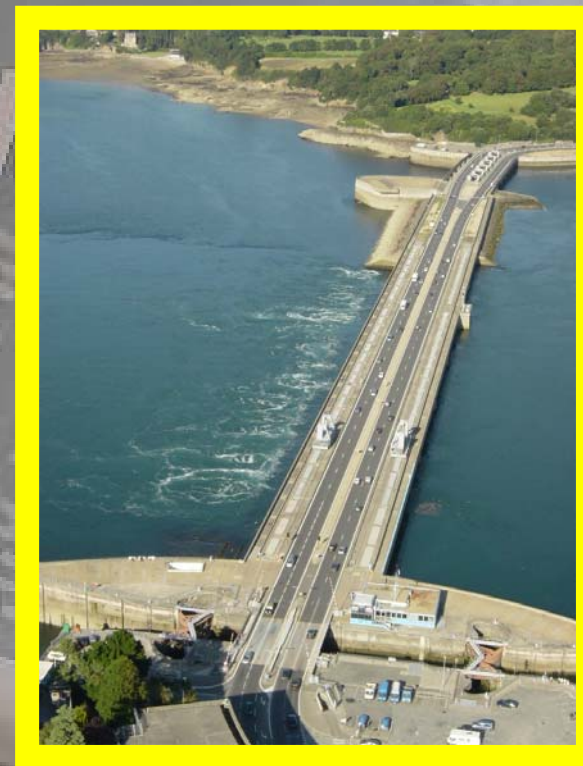
Coastal Defence

- ❖ Sometimes we may choose to nourish existing beaches or create new ones...



Coastal Defence

- ❖ We can close off estuaries with barrages. Besides providing defences against the sea, we might use them for power generation...



Wave Overtopping

- ❖ Now, we'll look at one particular problem: wave overtopping. How do we model the phenomenon?
- ❖ We must note that **models are only an aid to thinking, not a substitute for thought.** They involve simplifying assumptions. They must be calibrated/validated, often with limited data.
- ❖ Modelling natural phenomena is particularly difficult. How do we obtain the data? How long will we have to wait for suitable data? How accurate will the data be?
- ❖ **“Prediction is very difficult, especially if it's about the future.”** (Niels Bohr, Danish Nobel Prize-winning physicist, 1885-1962.)

Wave Overtopping

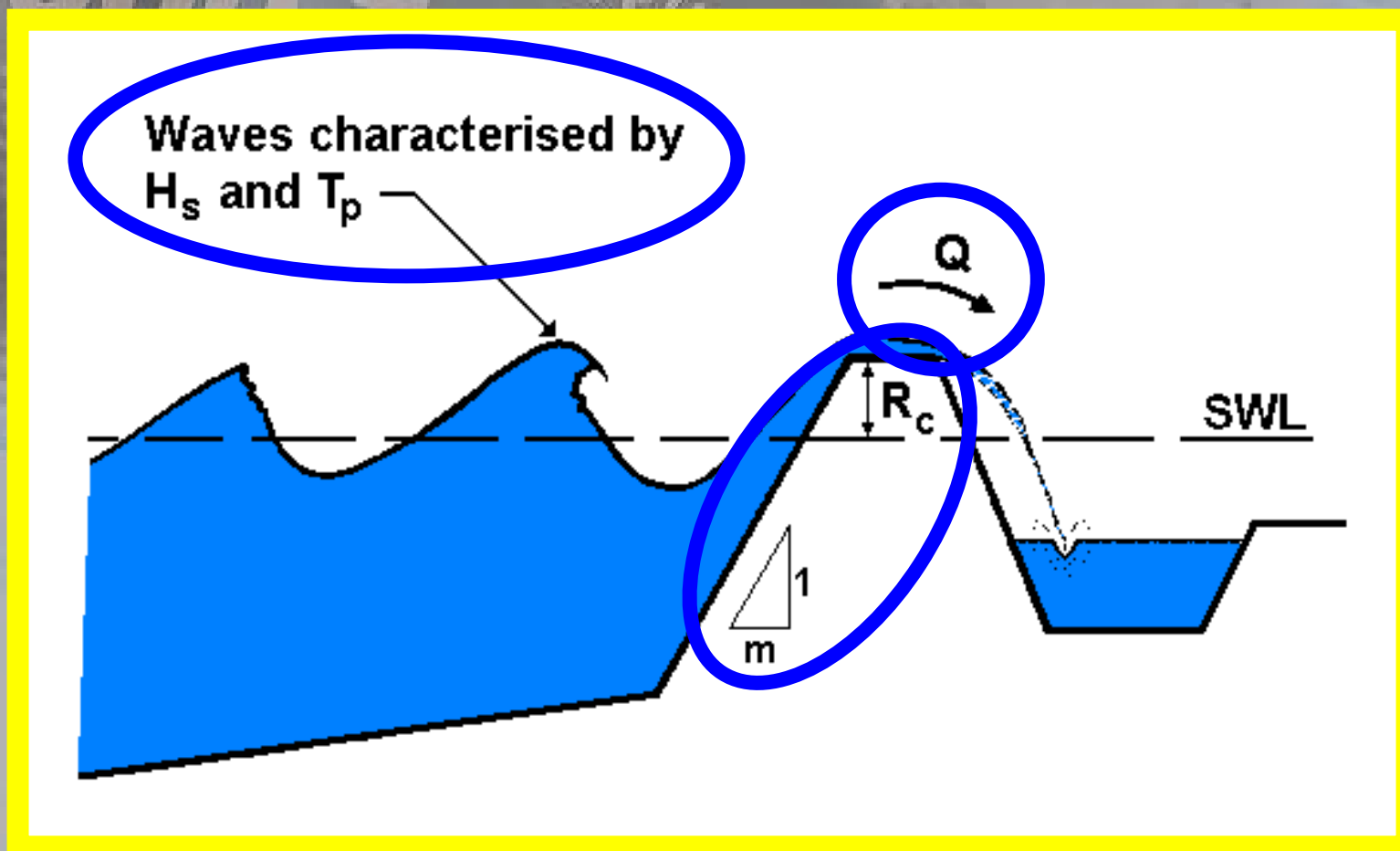
- ❖ The real thing...



(Video)

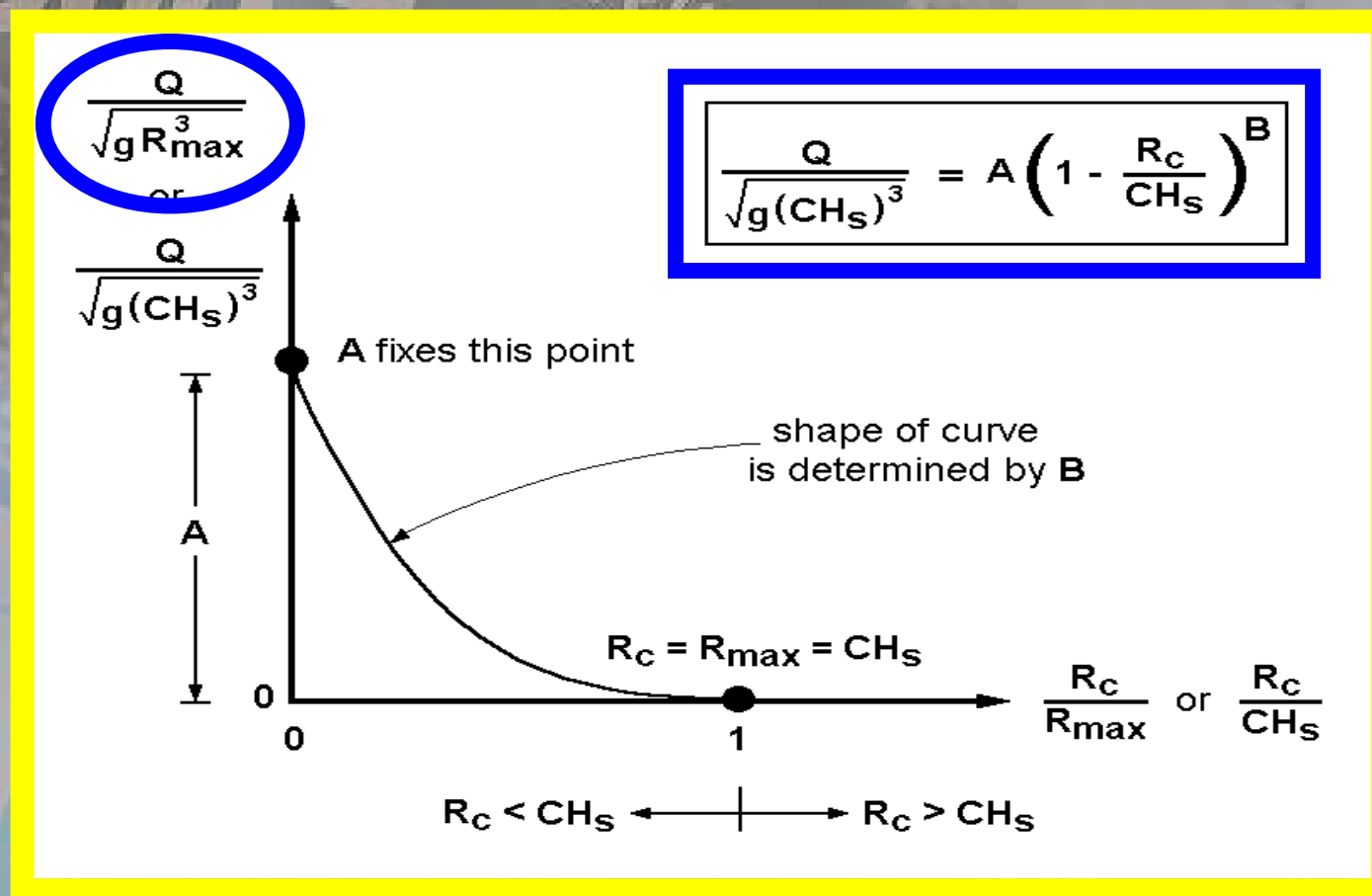
Wave Overtopping

- ❖ ... and here is how we characterise the reality:



Wave Overtopping

- ❖ Our model can be visualised as follows:



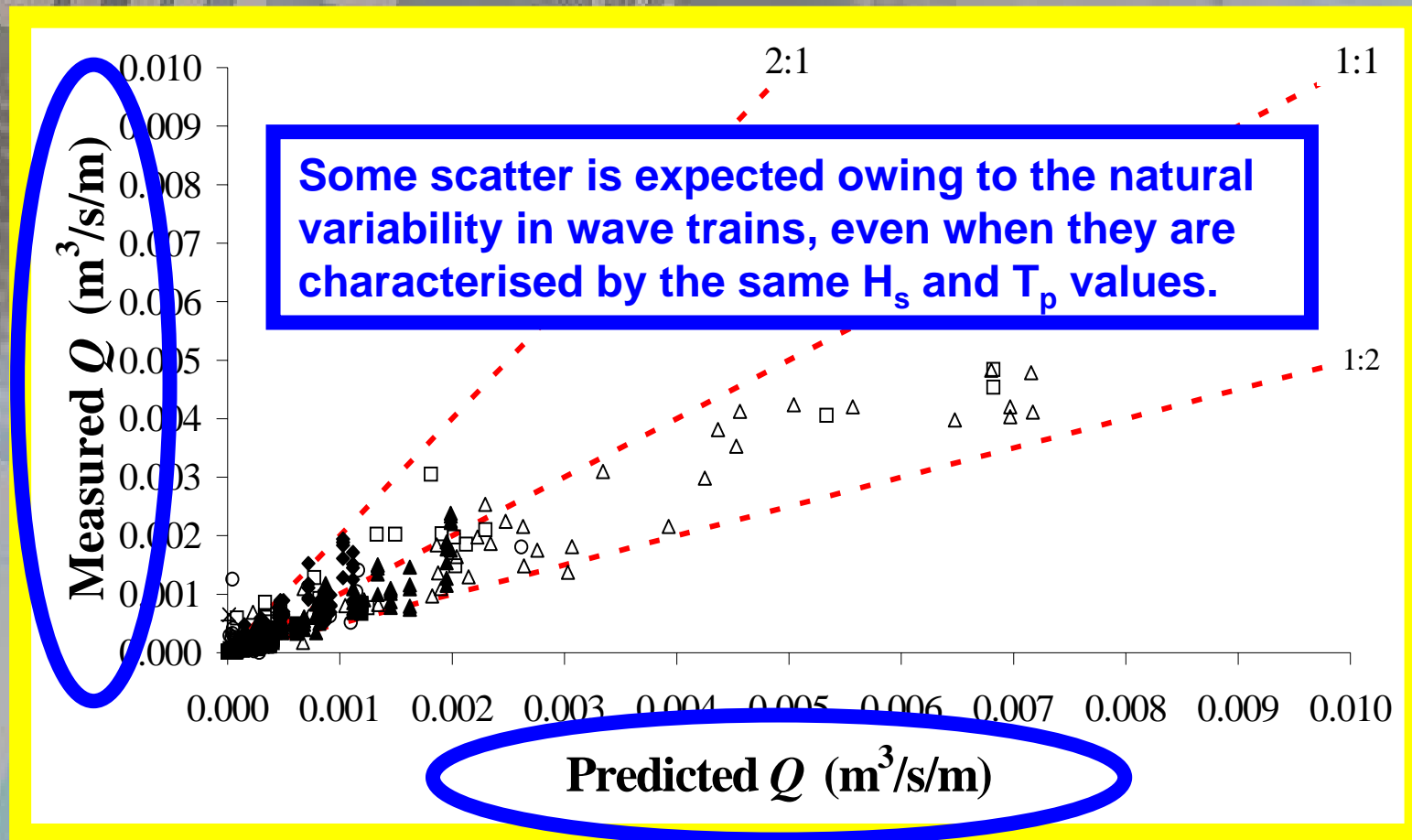
Wave Overtopping

- ❖ As with all other models, the new expression had to be calibrated/validated.
- ❖ We have used physical model data from HR Wallingford and Kansai University.



Wave Overtopping

❖ Hedges and Reis (1998, 2004) model:



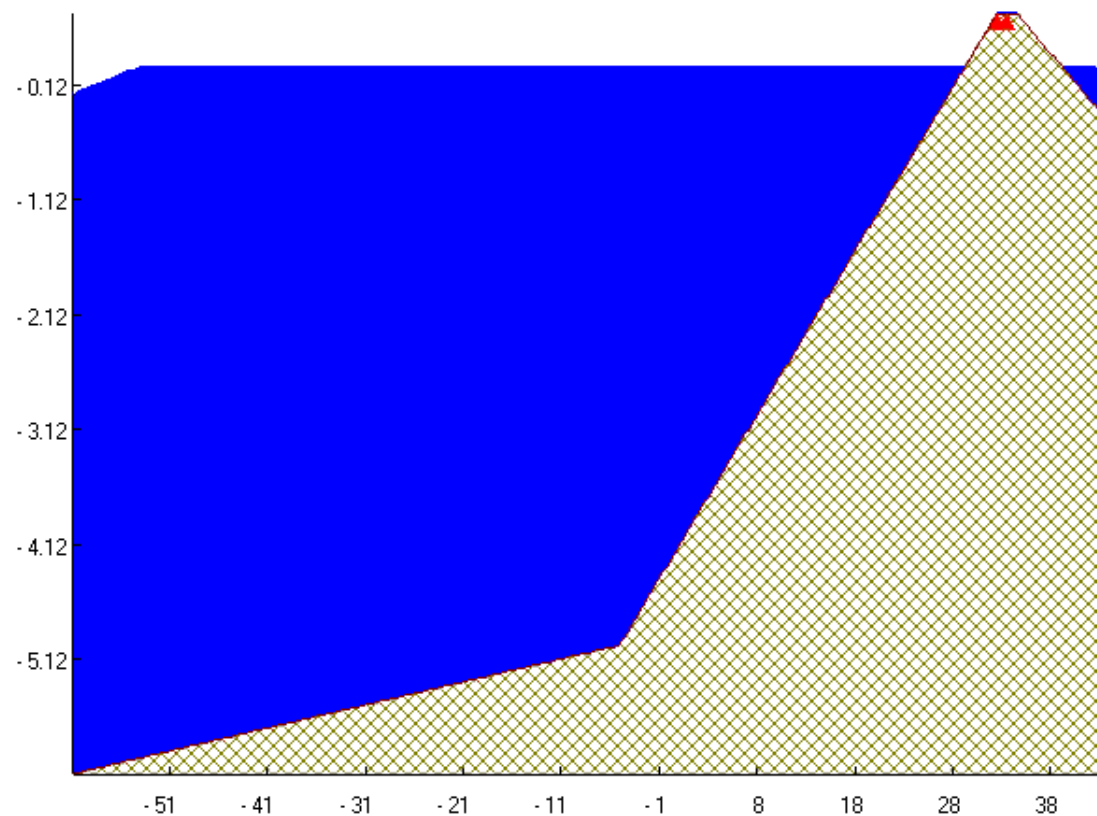
Concluding Remarks

- ❖ **Climate change is imposing increasing threats along coasts, both from rising sea levels and increased storminess.**
- ❖ **Civil engineers employ a wide variety of coastal defences, ranging from the use of concrete, steel and rock in seawalls to nourishing beaches with sand and stabilising them with vegetation.**
- ❖ **Restricting the financial and negative environmental impacts of sea defences is important to governments and the general public, who wish to be protected from the damaging effects of the sea whilst still remaining free to enjoy its visual and other benefits.**

Concluding Remarks

- ❖ The accuracy provided by the Hedges and Reis model in predicting overtopping rates is allowing its use as part of the **National Flood Forecasting (and Warning) System**.
- ❖ The model has been adopted by the Environment Agency, North-East Region, to warn of overtopping of sea defences along the coast from Berwick-upon-Tweed to the Humber.
- ❖ But work continues on the development of even more advanced models...

Concluding Remarks



(Video)

Finally...

- ❖ Thank you for your attention. Are there any questions?

... oh!, and many thanks to:

- ❖ Dr Maria Teresa Reis (LNEC, Portugal)
- ❖ Prof Hajime Mase (DPRI, Kyoto University, Japan)
- ❖ Dr Keming Hu (Royal Haskoning, UK)
- ❖ Alan Williams (Coastal Engineering UK Ltd, UK)
- ❖ Kevin Keating (Faber Maunsell, UK)
- ❖ Simon Lewis (Mouchel Parkman, UK)
- ❖ Dr Peter Hawkes (HR Wallingford, UK)
- ❖ David Blackman (Proudman Oceanographic Laboratory, UK)