HR Wallingford
*Working with water*

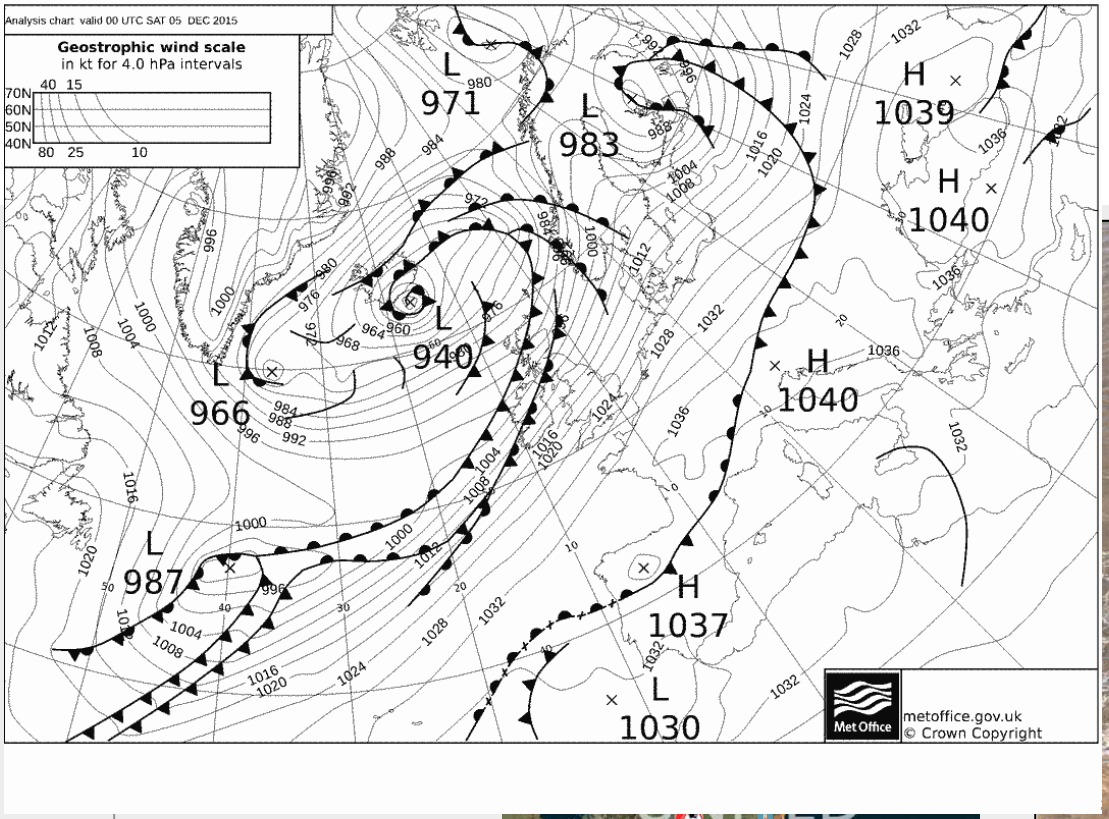
# A multivariate extreme value analysis for the design of coastal structures in England

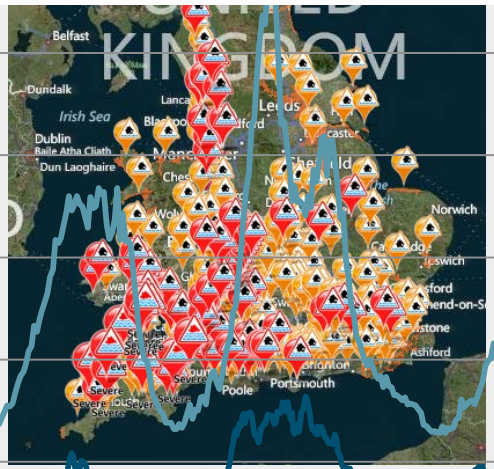
## The State of the Nation Flood Risk Analysis

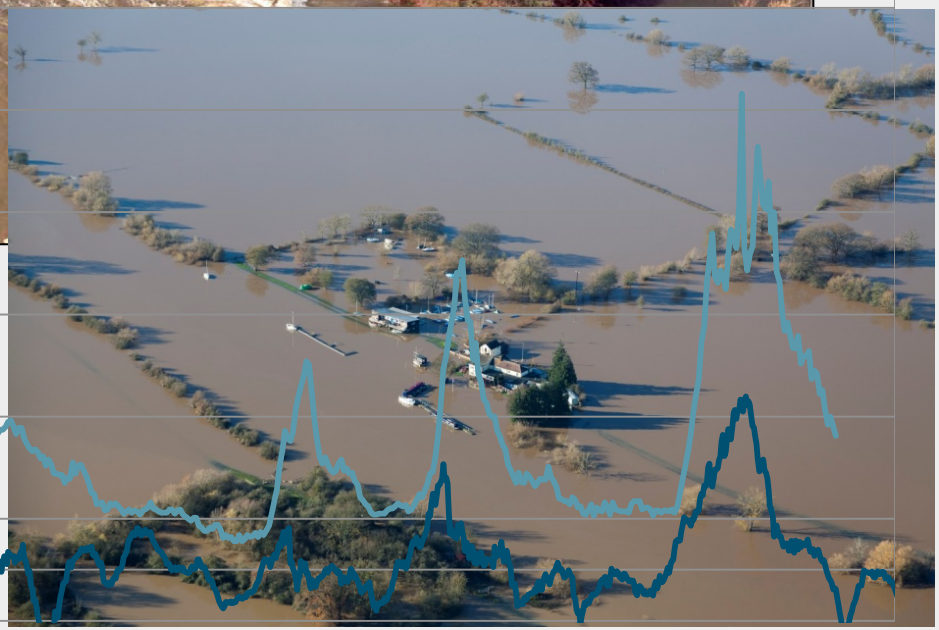
Challenger Society Meeting 19/20th October 2016

Nigel Tozer

# The State of the Nation Flood Risk Analysis

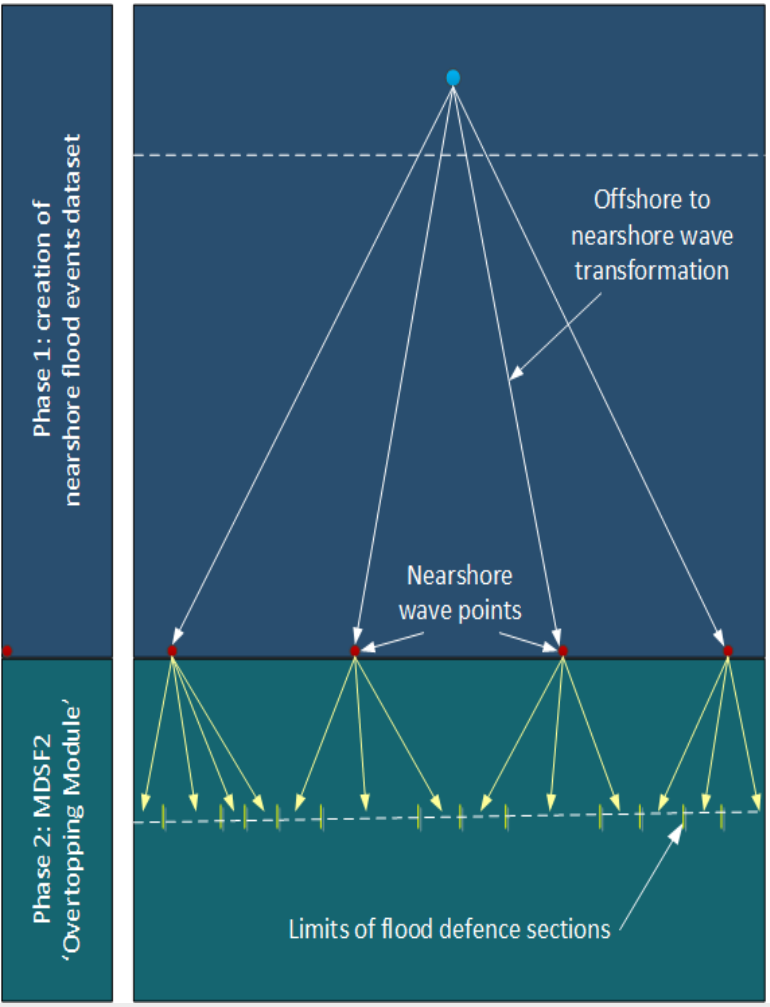


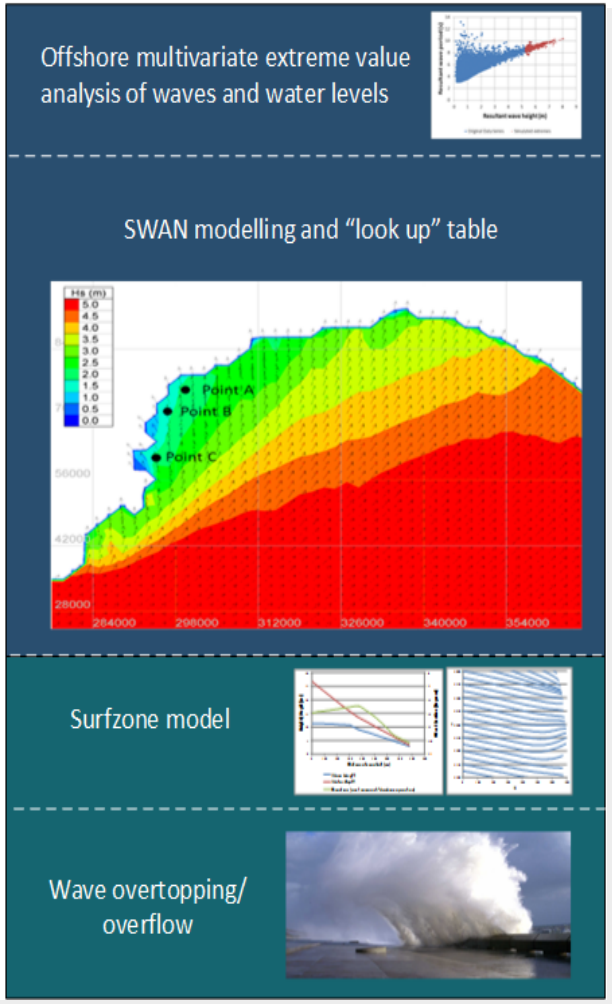



# Overview of the modelling system




1) Multivariate extreme value analysis

2) SWAN wave model emulator

3) Surfzone model

4) BAYONET overtopping model

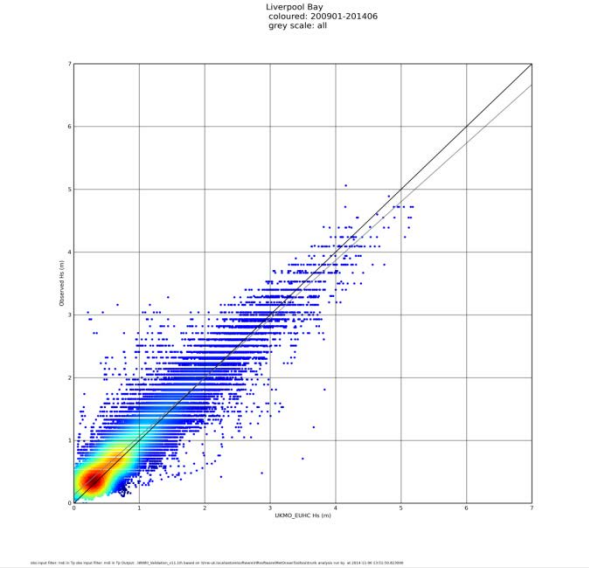
# Sources of waves and water levels

## Water levels:

Observed water levels from tide gauges + EA Coastal Boundaries (Extremes and skew surge)

## Waves:

Met Office WWIII Hindcast





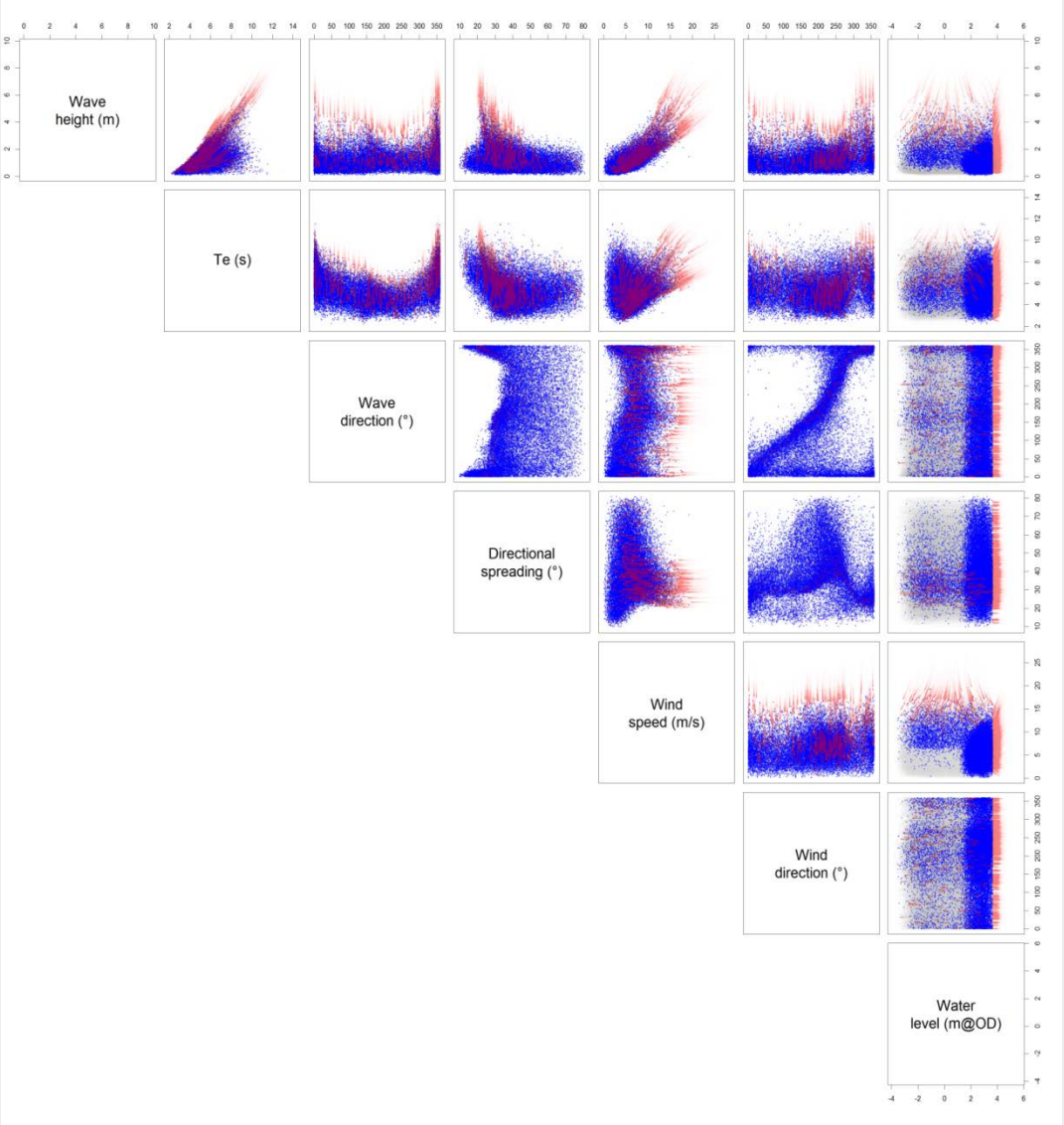
 

# Multivariate Extreme Valued Analysis

Concurrent offshore time-series of

- Water level $WL$
- Significant wave height $H_s$
- Wave period $T_e$
- Wave direction $\theta$
- Wind speed $U$
- Wind direction $\theta_U$
- Directional spreading $DSpr$

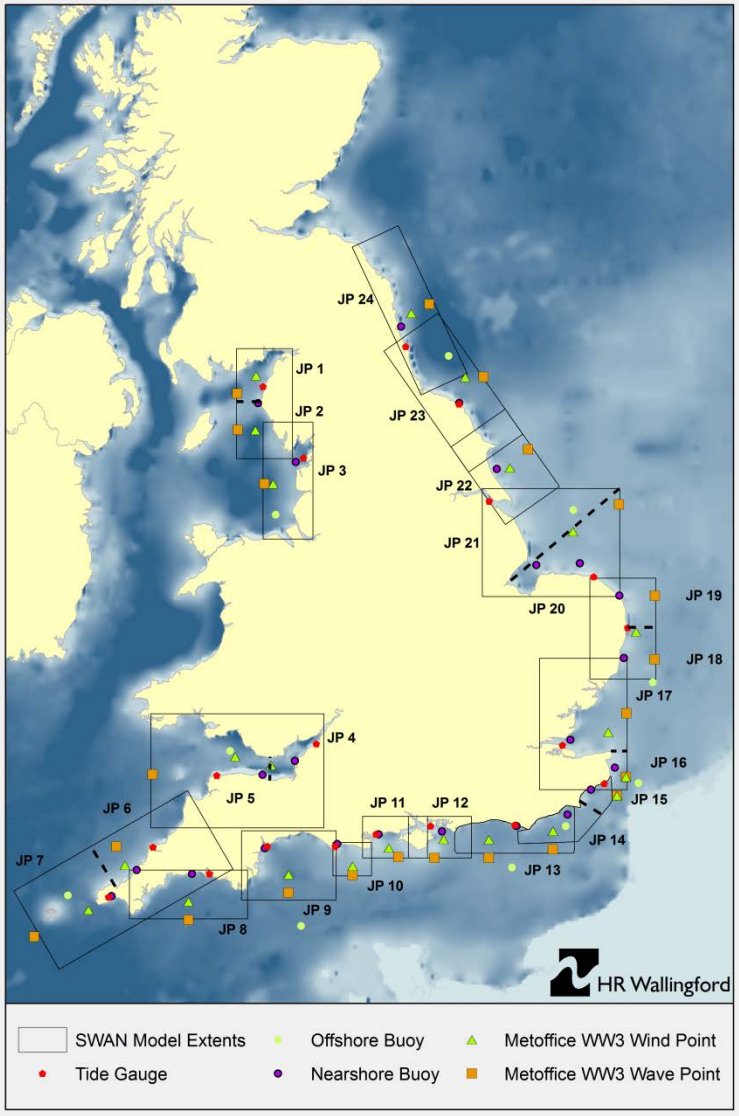
- Method accounts for dependencies between all variables

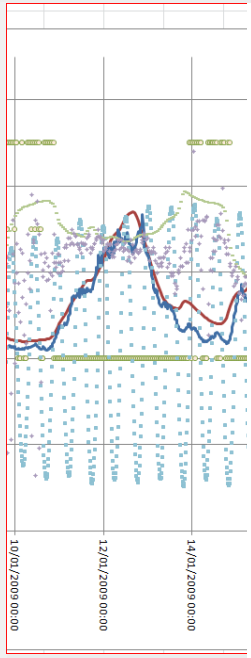


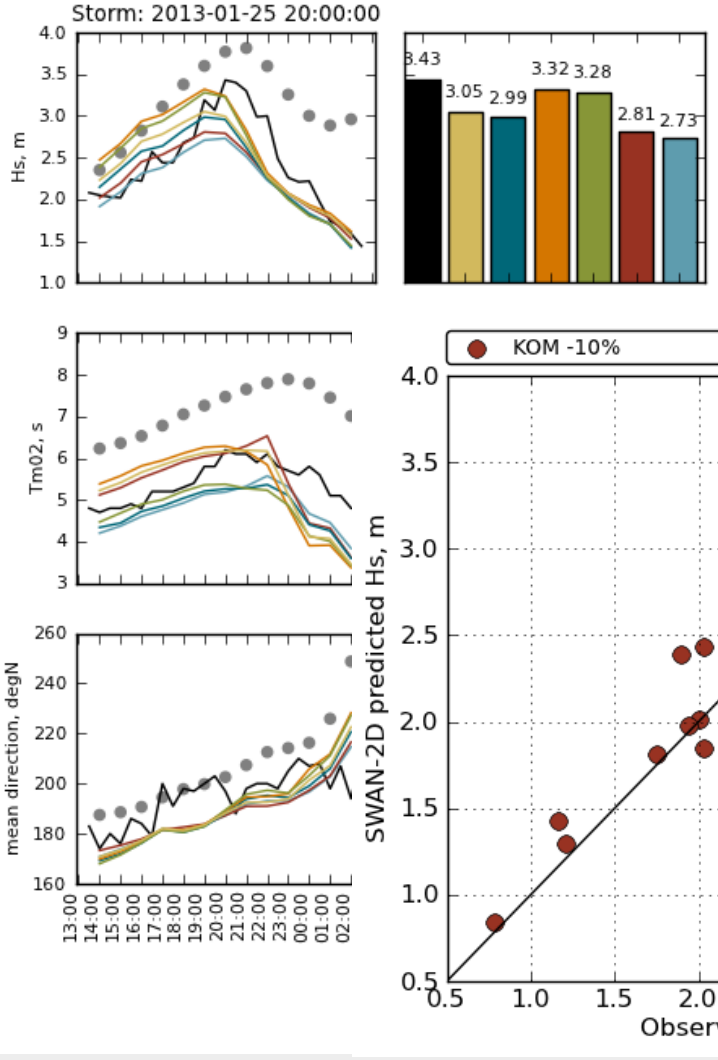

Heffernan, J. E. and Tawn, J. A. (2004). *A conditional approach for multivariate extreme values (with discussion).* Journal of the Royal Statistical Society, Series B (Statistical Methodology) 66 (3): 497–546.

# SWAN model calibration / validation

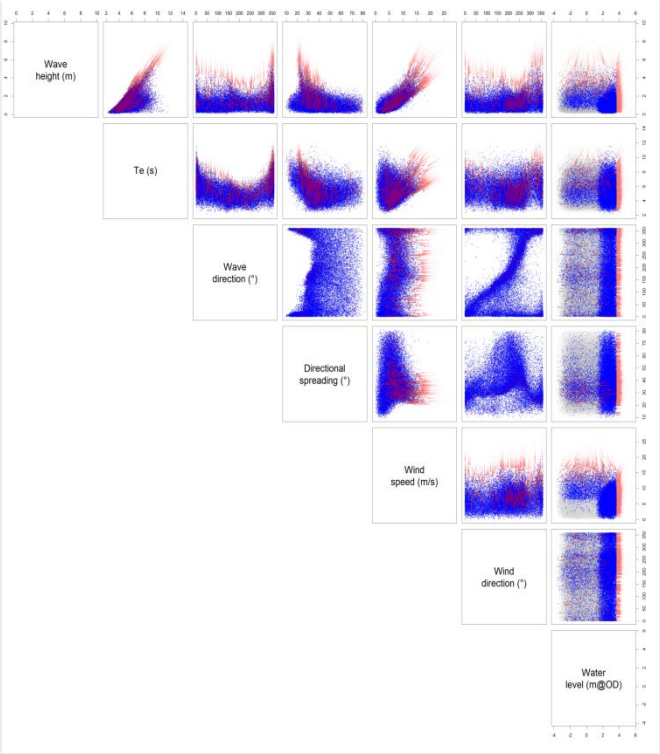


# SWAN Emulation




Gaussian Process Emulator

MDA + Radial Basis Function

Models trained using 500 SWAN model runs

Provides a more accurate fit to the dataset with fewer training runs than a standard look-up table approach.

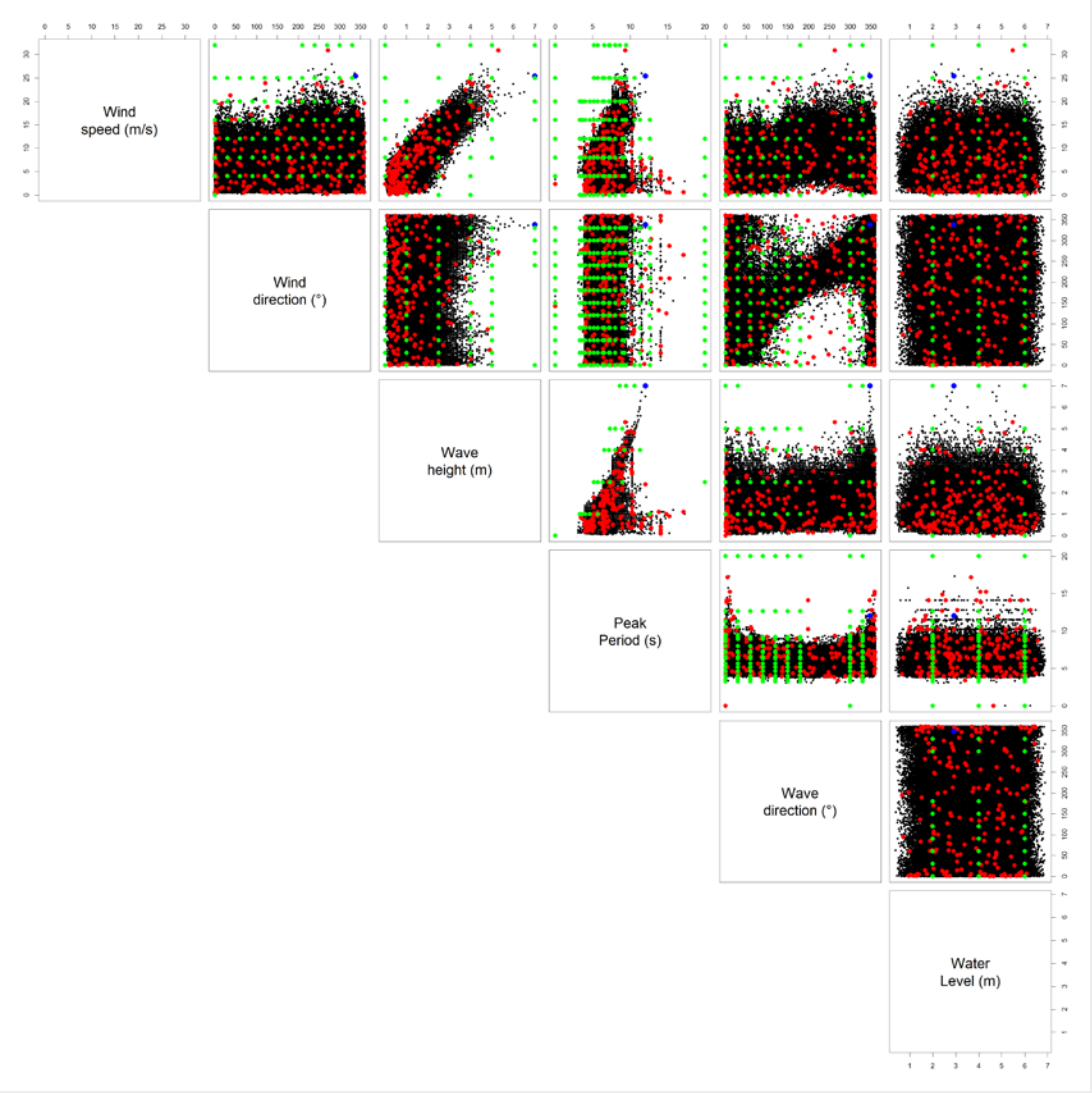
- **1/2million events x 24** is lots of SWAN model runs
- Traditional “look up” table approach ~**10,000 x 24** – still a lot

**IH Cantabria - Camus, P., Mendez, F.J. and Medina, R., 2011. A hybrid efficient method to downscale wave climate to coastal areas. Coastal Engineering, 58(9): 851-862.**

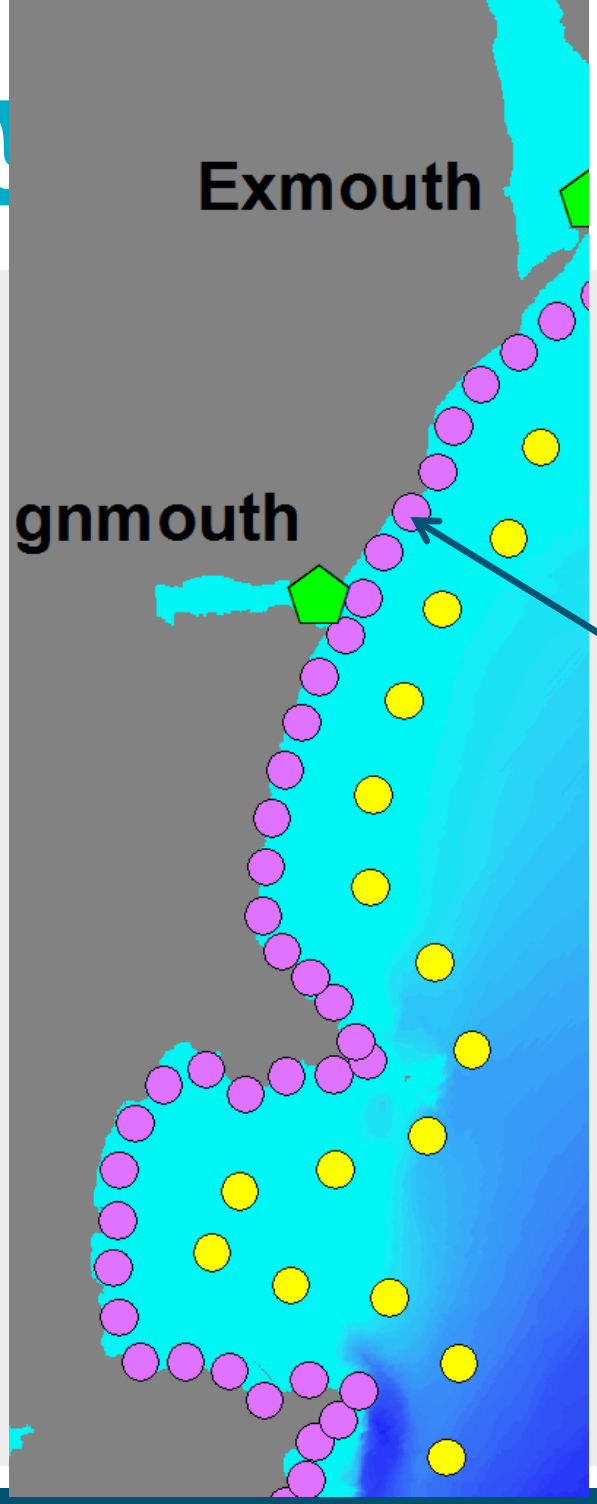
# Example of the Maximum Dissimilarity Algorithm

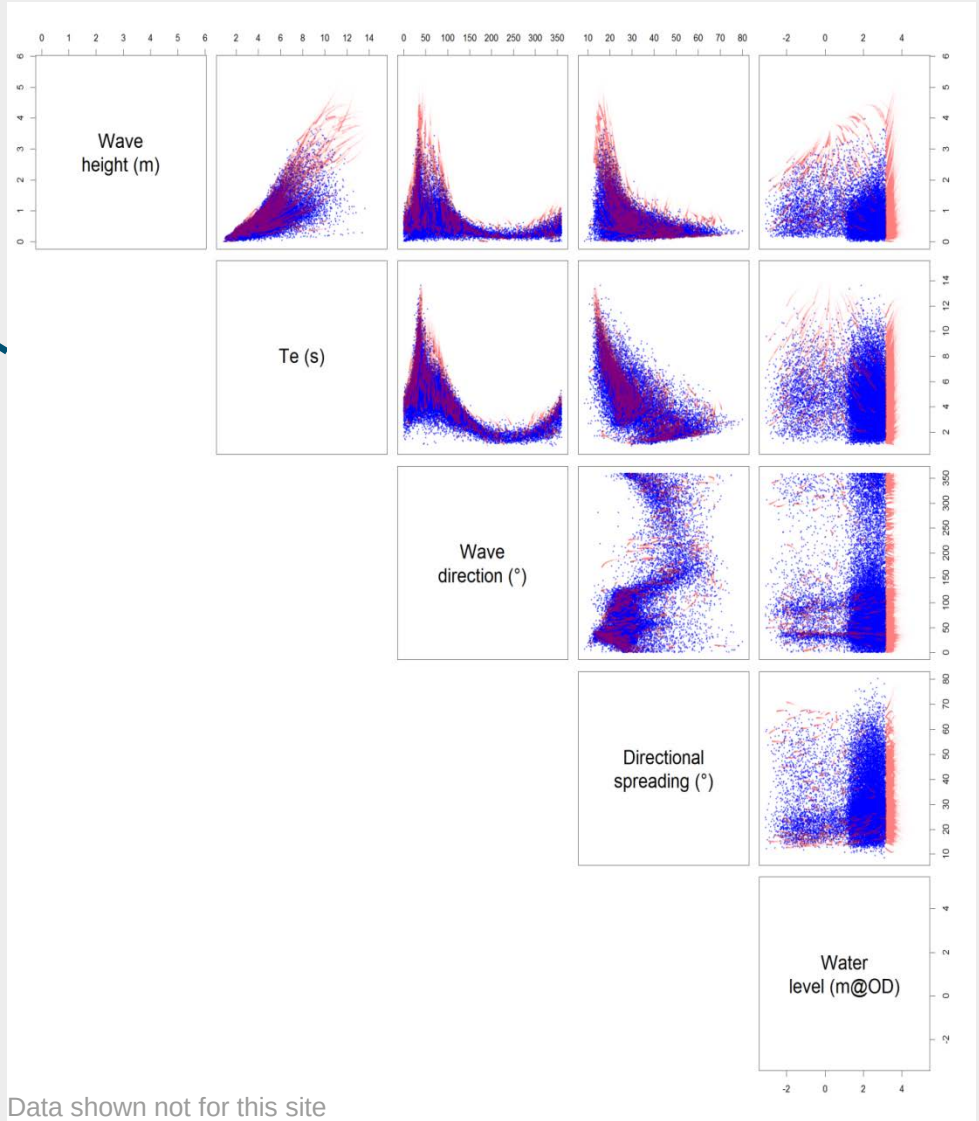
- Full set (Black)
- Regular Grid Points ~ 10000 (Green)
- MDA points – 200 (Red)



# SWAN Emulator output

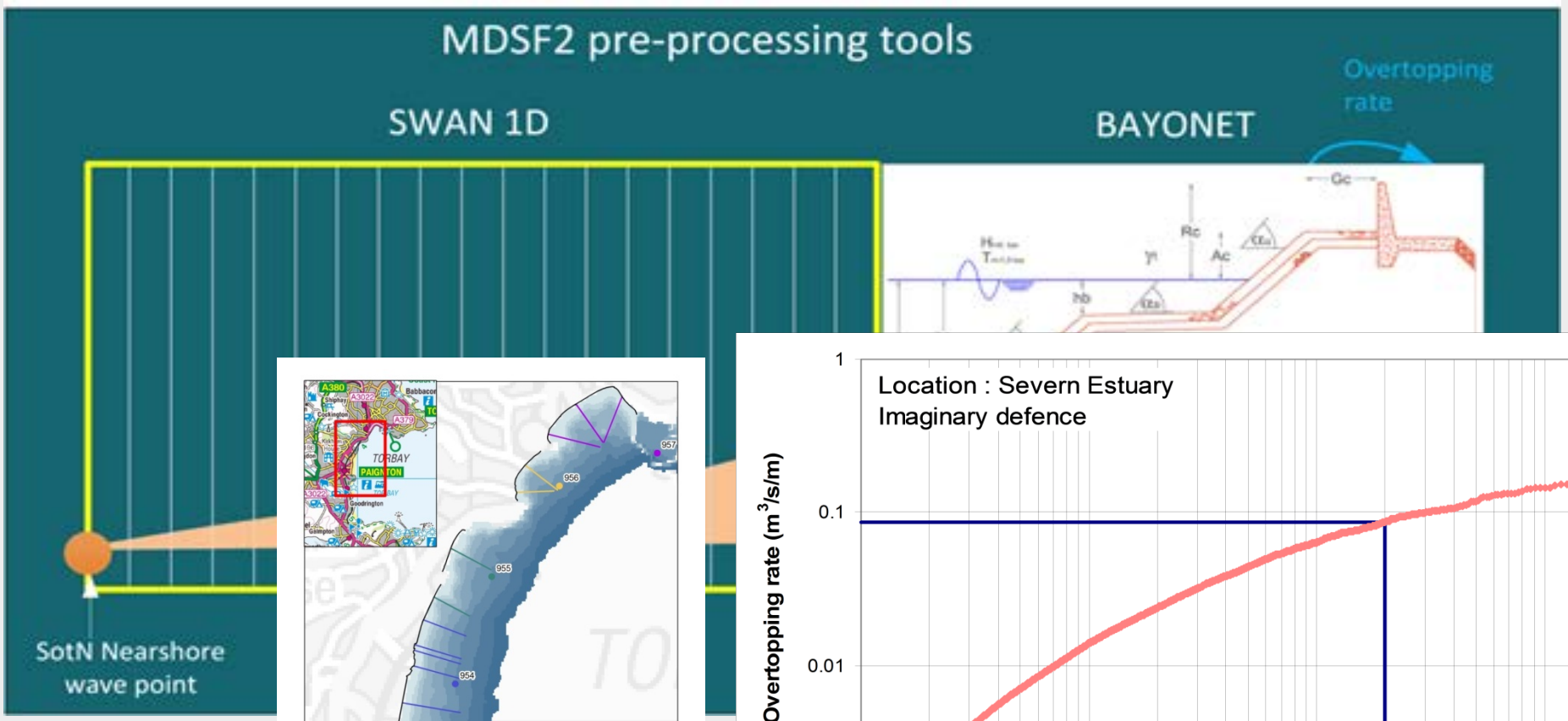



Data shown not for this site

# EA Modelling and decision support Framework MDSF2







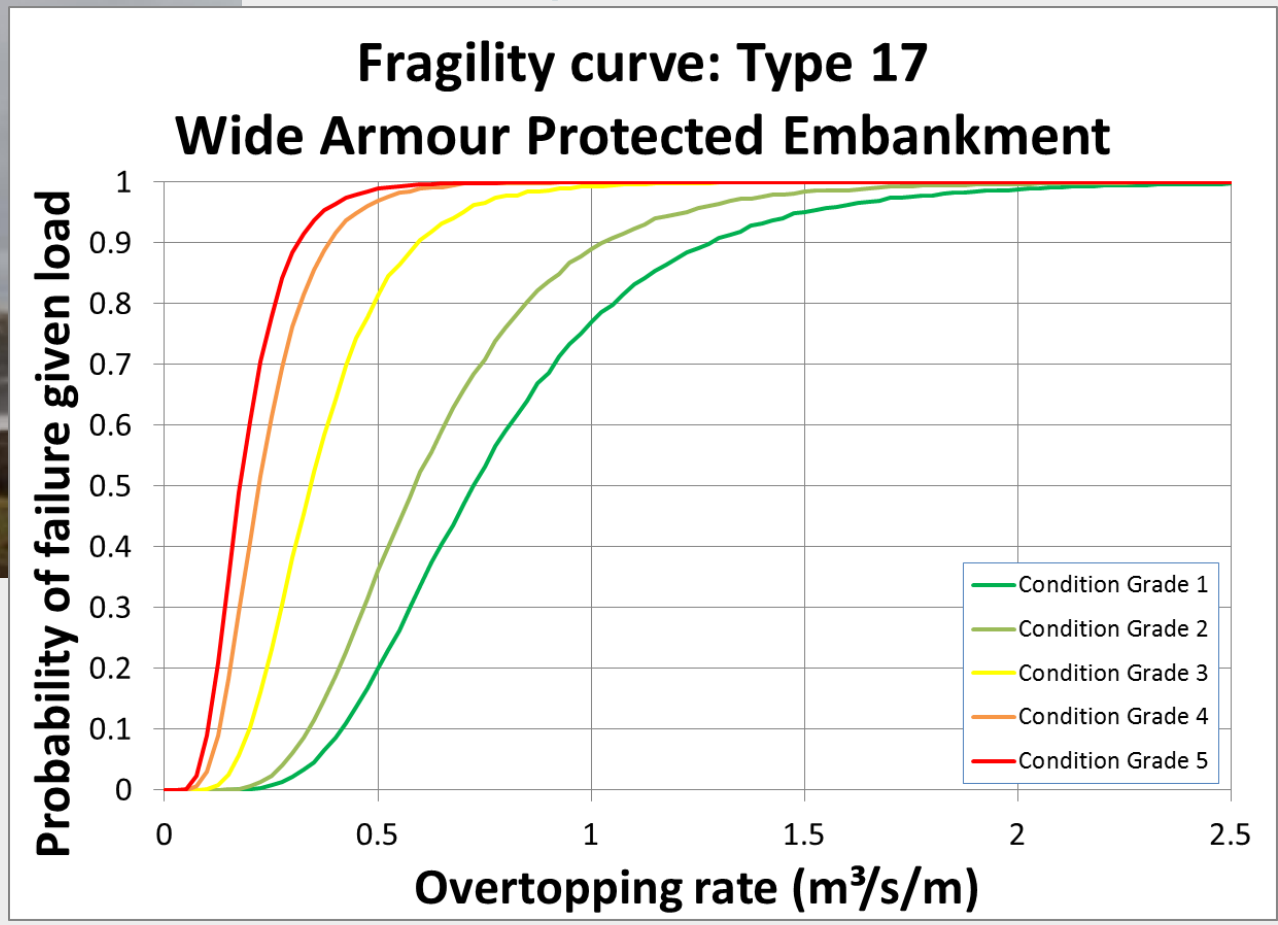


# Consideration of breach is important

5th December 2013, Seal Sands. RAF repair coastal revetments

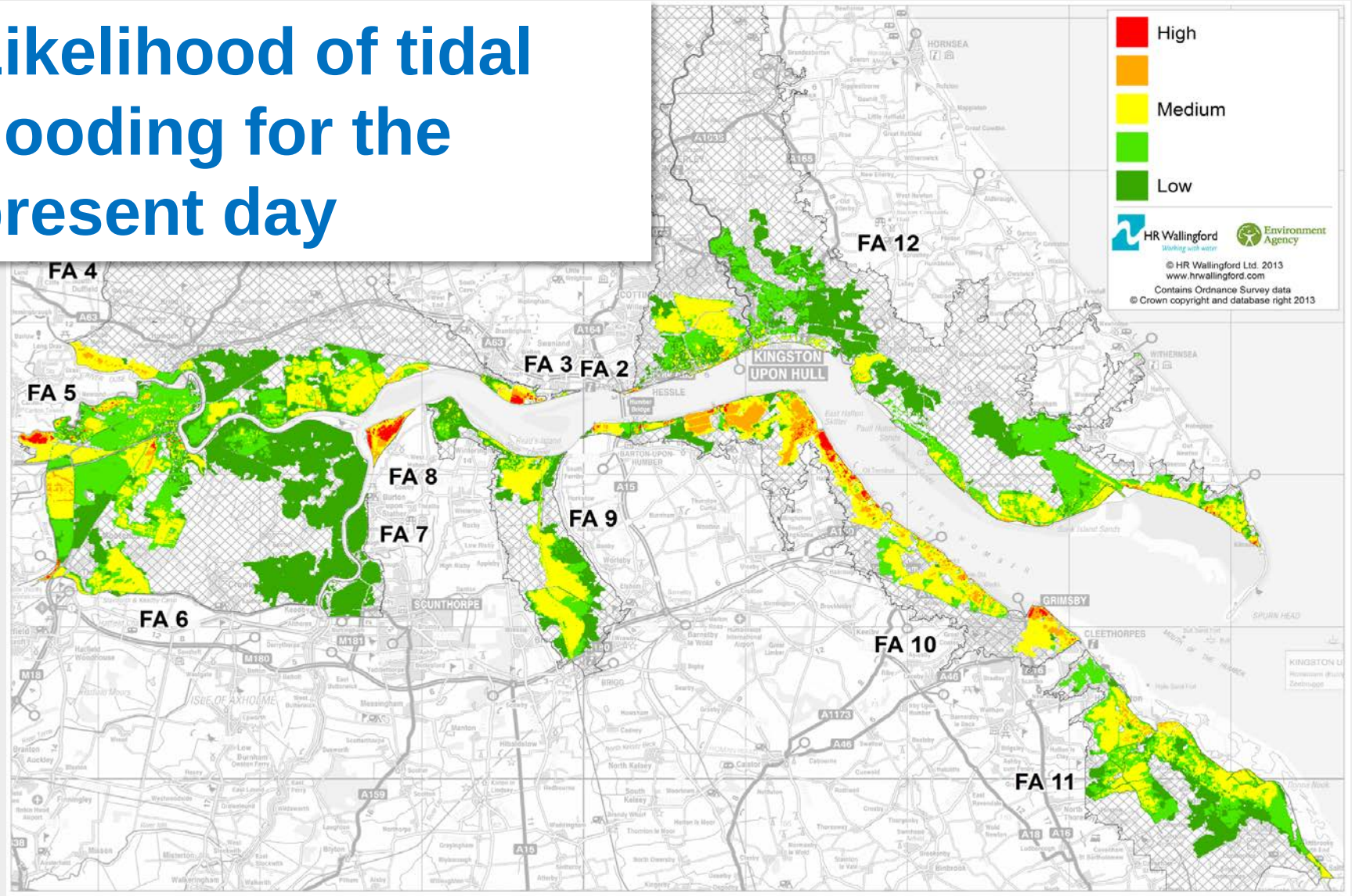
Consideration of breach via fragility curves is an important aspect in risk assessment



# Flood Inundation

## Likelihood of tidal flooding for the present day



# Summary and future work

Developed and applied robust methodology for coastal flood risk analysis for every defence in England

Uses a range of sophisticated analysis tools and models

Includes an update to MDSF2 that will be applied by the EA

Has potential applications in e.g.

- Future climate change analysis
- Flood forecasting
- Design of coastal structures
- Spatial correlation of events
- Planning optimal asset management
- Sensitivity to morphological change

# Acknowledgments

Environment Agency,

Met Office,WaveNet,

Channel Coast Observatory,

HR Wallingford (SoN Team)

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Any Questions?

 