An Introduction to the Environment Agency’s extreme offshore wave, water level and wind conditions data sets, transformed to nearshore for events covering up to the 10000 year extreme coastal event, available to all for use in local studies

Otherwise known as “State of the Nation” (SoN)

Niall Hall
National Coastal Modelling & Forecasting
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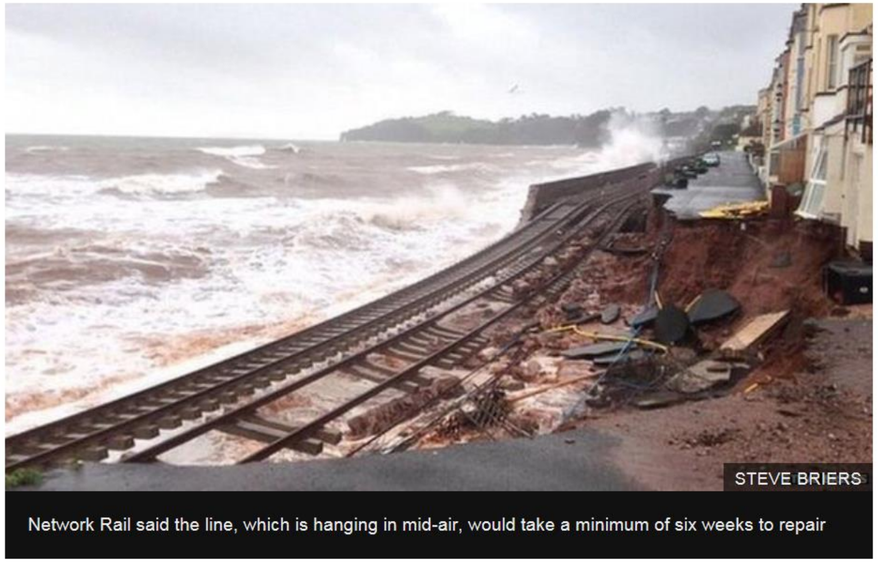
A viewing of the “other” EA looped presentation on this subject will help with and understanding of the motivation behind these outputs. If you haven’t seen that already, please do try to find time later on in the day.

Storms & subsequent damage caused through the winter of 2013 – 2014 resulted in a need to re-run the EA National Flood Risk Assessment (NaFRA)



Dawlish, Devon

https://www.bbc.co.uk/news/uk-england-26062712

Boston, Lincolnshire

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Humber, South Bank

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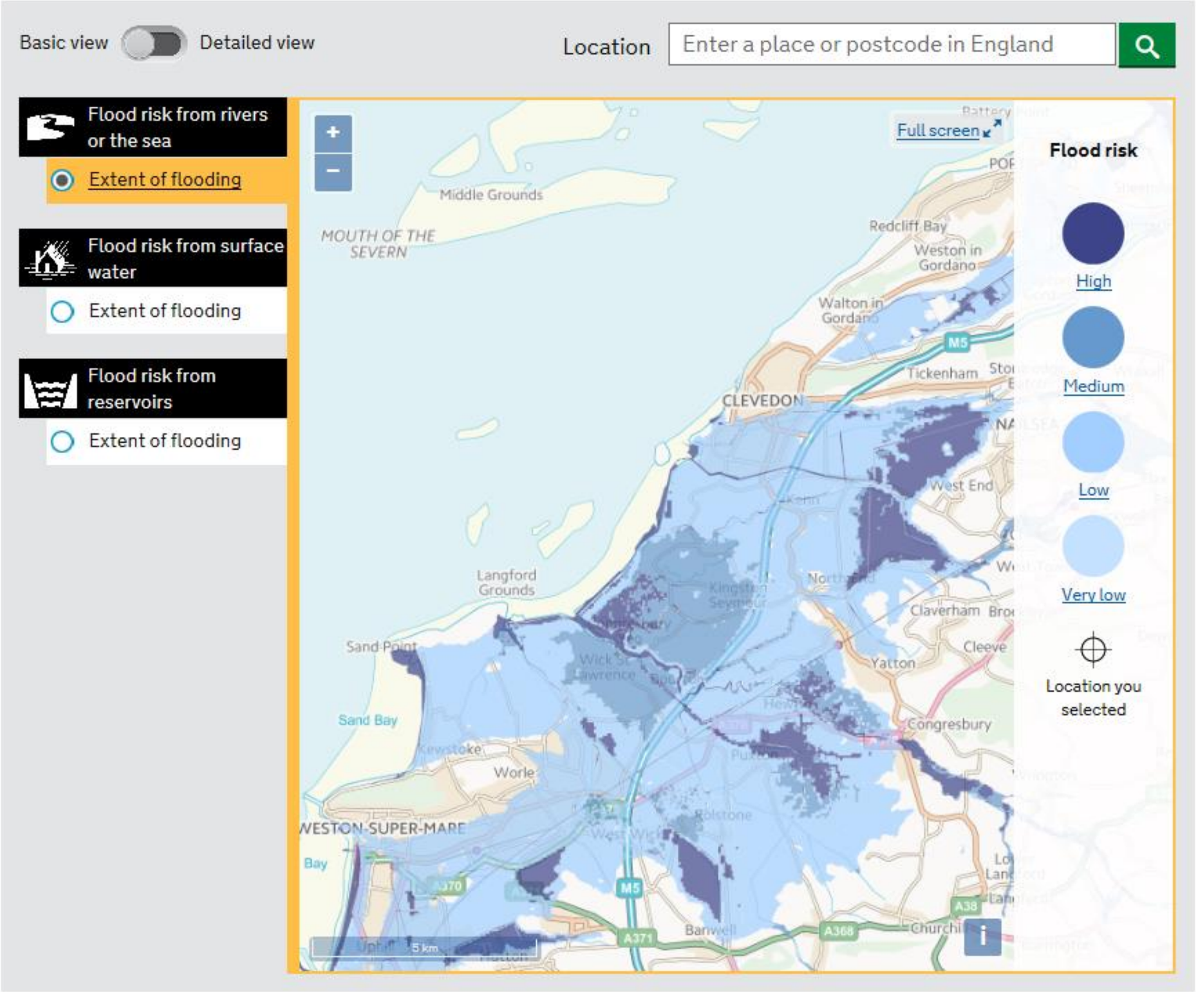
The National Flood Risk Assessment (NaFRA) is an assessment of flood risk from rivers and the sea for England and produced using local data and expertise.

It shows the chance of flooding from rivers and the sea, taking into account flood defences and the condition they are in, presented in flood risk likelihood categories. We update it using the Modelling & Decision Support Framework (MDSF2) software.



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With a National re-run of NaFRA required

We were presented with an opportunity

To improve the data & methodologies underlying the NaFRA process

… Particularly with regard to how we derive our coastal forcing mechanisms

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Coastal Flood Risk Analysis

- **Offshore multivariate extreme value modelling**: Wave, wind and sea level data have been extrapolated to extreme values using an extreme value model. The model has been fitted and then used to stochastically generate a large sample (10,000 years) of peak wave, wind and sea level events.
- **Offshore to nearshore wave transformation modelling**: The stochastically generated offshore sea condition data have been transformed to the nearshore using SWAN 2D wave model.
- **Surfzone and overtopping model**: The stochastically generated data at the nearshore points has been translated to overtopping rates. This comprised 1D surfzone modelling using SWAN 1D to transform the data to each structure and then wave overtopping modelling using BAYONET

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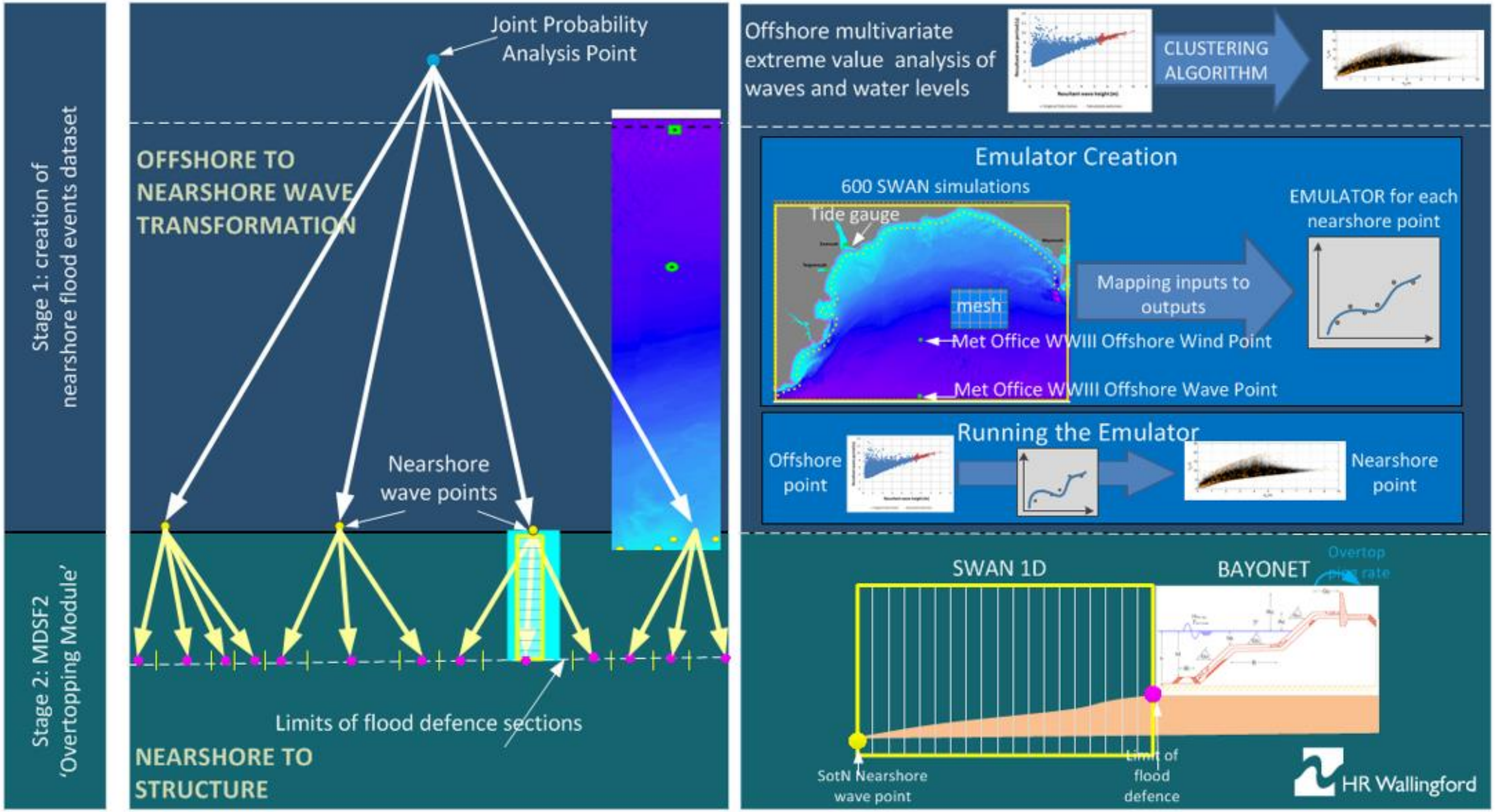
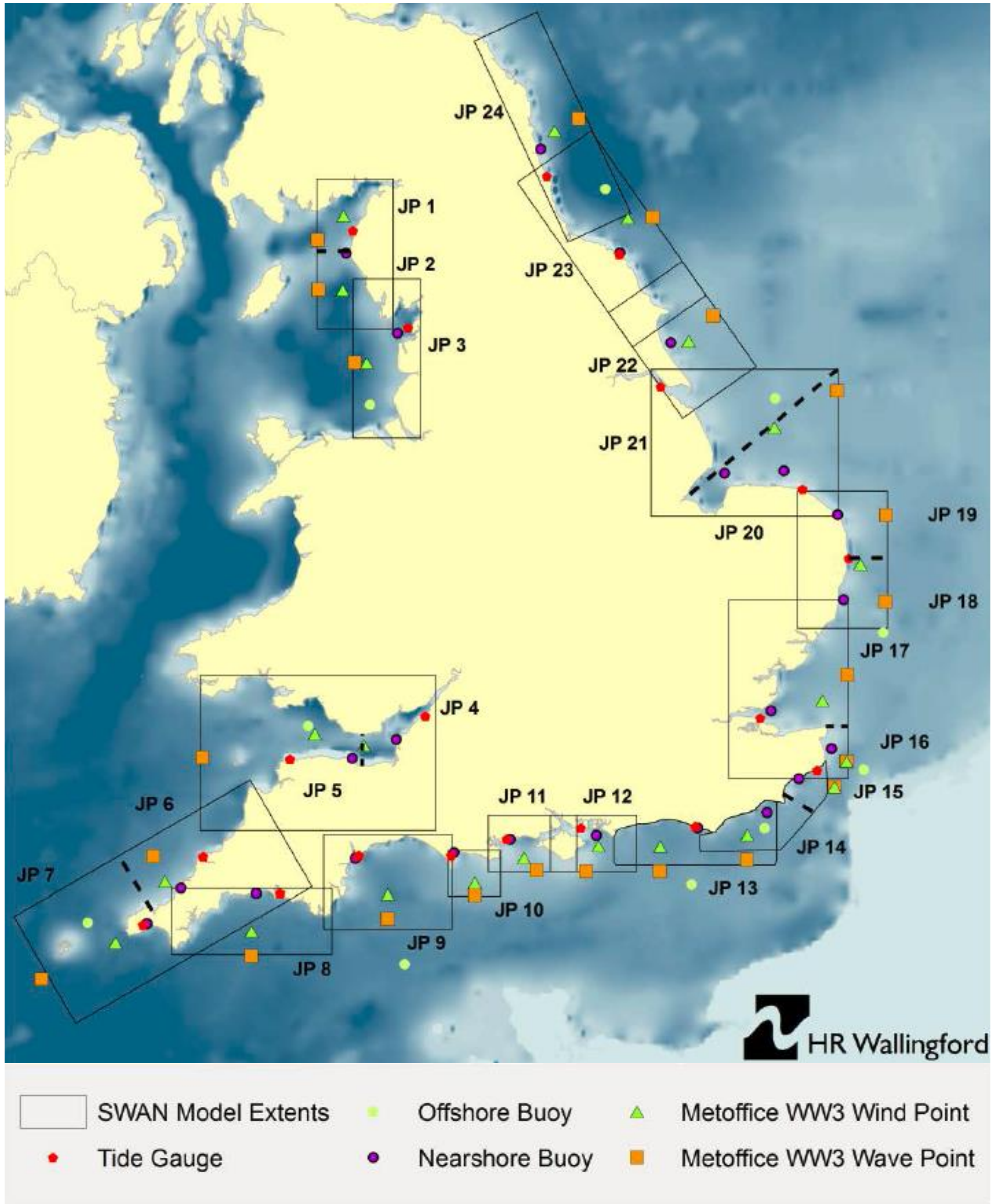


Figure 4.2: Overview of the main components of the SoN coastal boundary methodology

Source: HR Wallingford

SWAN 2D model domains and locations of joint probability data sets



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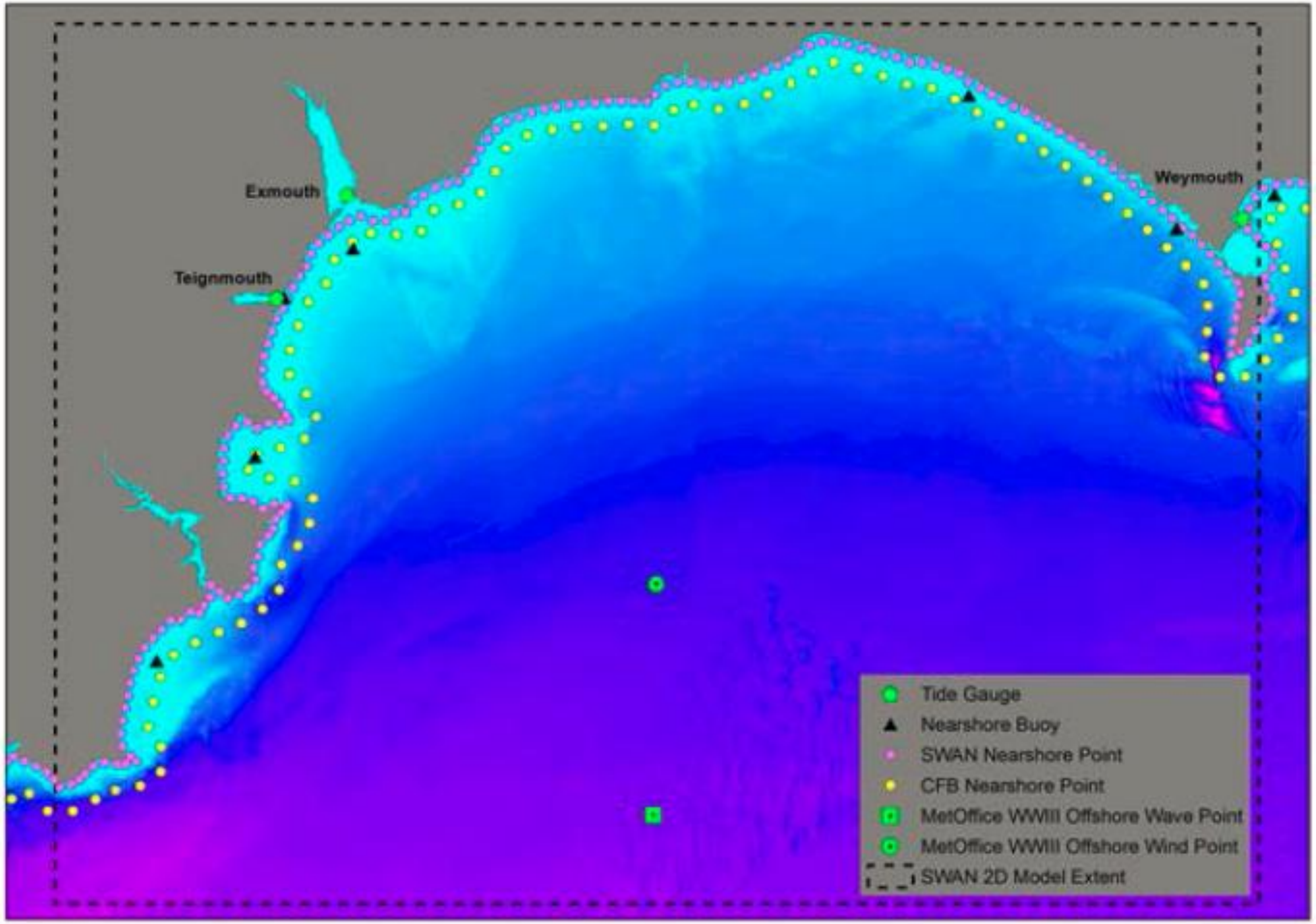
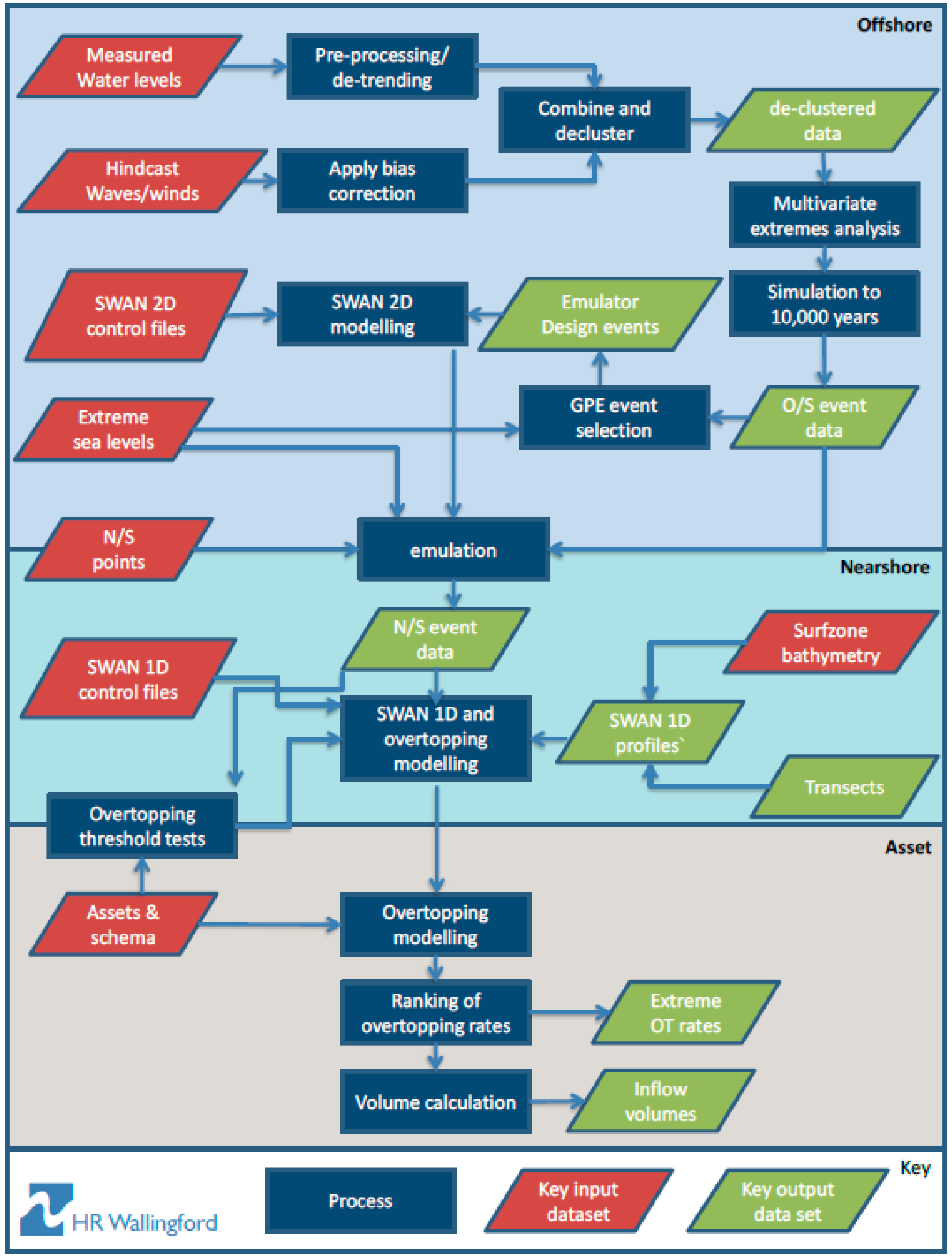
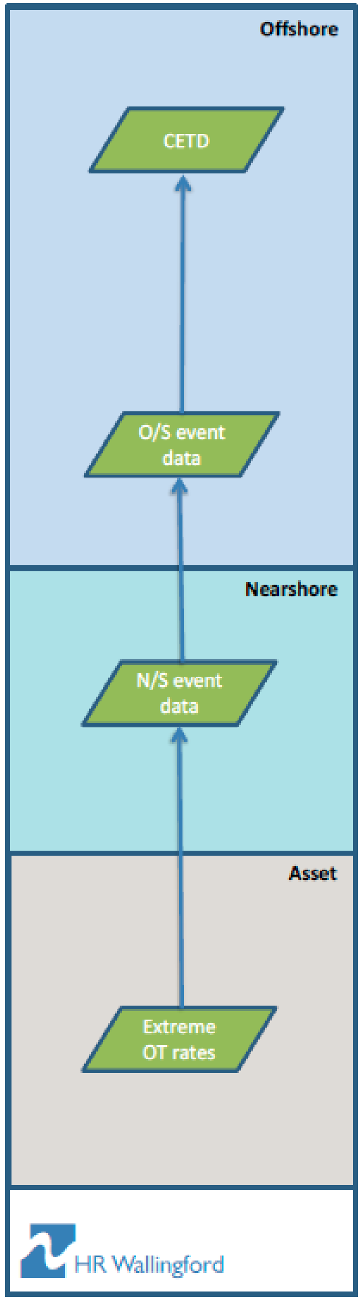


Illustration showing Spatial location of datasets including nearshore points





Key input datasets and processes

Variable	Source	Comment
Sea levels time series	NTSLF National Class “A” Tide Gauge Network supplemented with additional processed EA tide gauge data	Class A tide gauges are supplemented with records from other EA tide gauges
Sea levels extremes	Coastal Flood Boundaries Study (CFB)	EA, NRW, SEPA & RANI study that provides amongst other things, extreme sea levels at 2km resolution around the UK coast
Offshore wave	WaveWatch III hindcast	Hindcast run by the Met Office. Model grid is 8km resolution for a timespan from Jan 1980 to Jun 2014 (Includes 2013/14 winter storms). Some locations have been corrected for bias following comparison with measured datasets
Wind conditions	WaveWatch III hindcast	As wave but no bias correction
Bathymetry offshore	SeaZone TruDepth	Approx 30m resolution, July 2014 download
Bathymetry nearshore	2m resolution combination of EA LiDAR, multi-beam and single beam surveys from Channel Coast Observatory	Compiled by EA Geomatics

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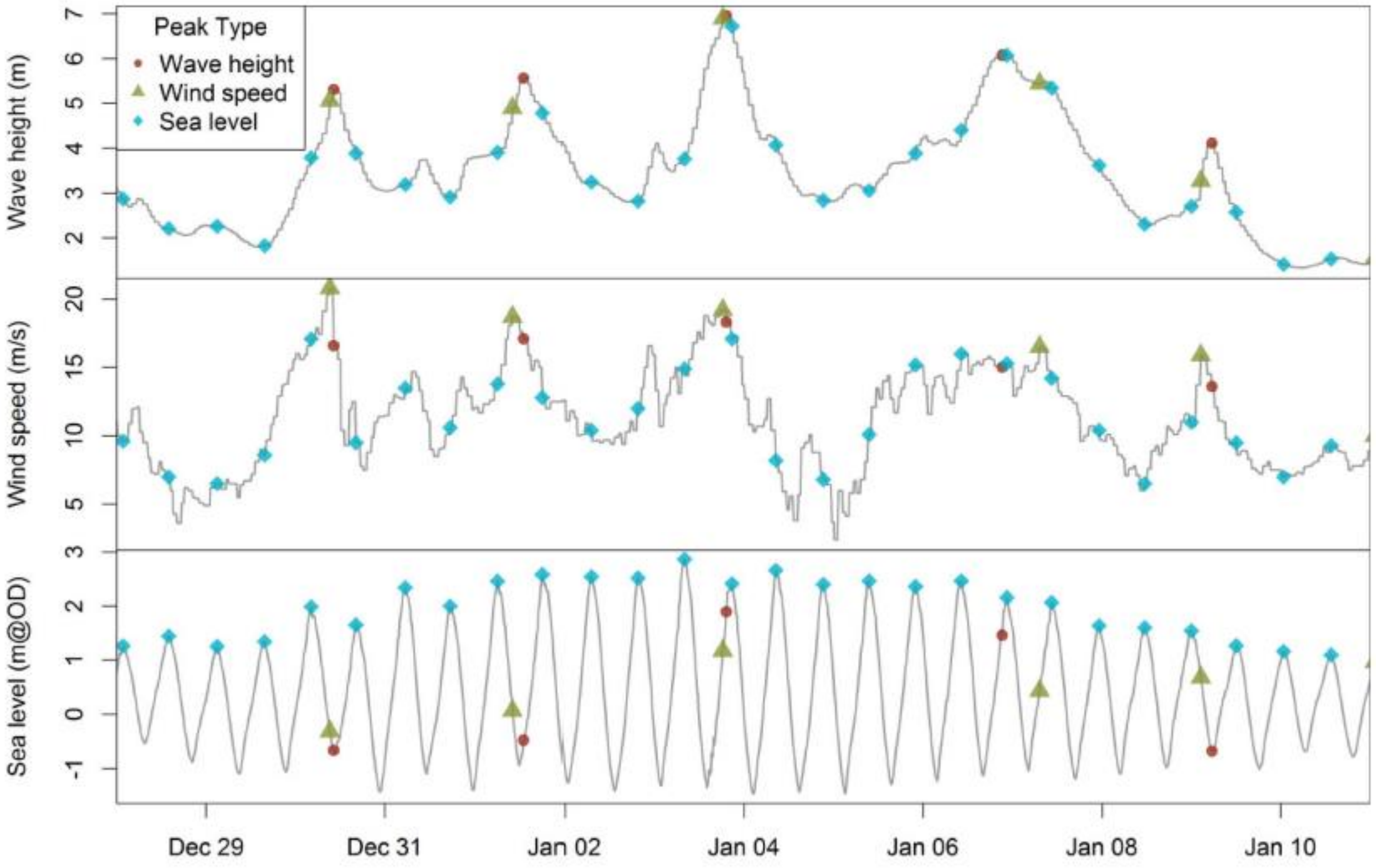
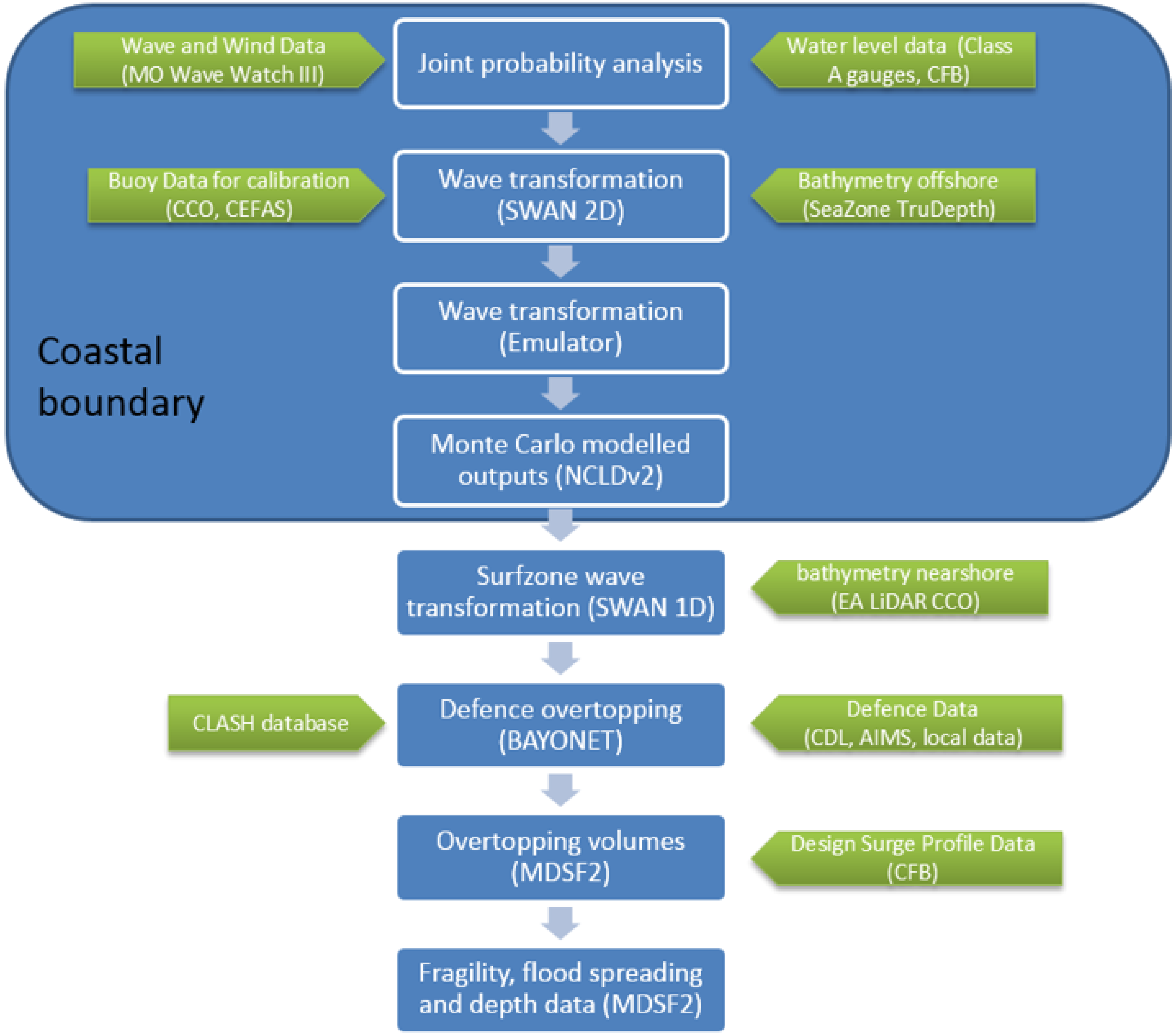
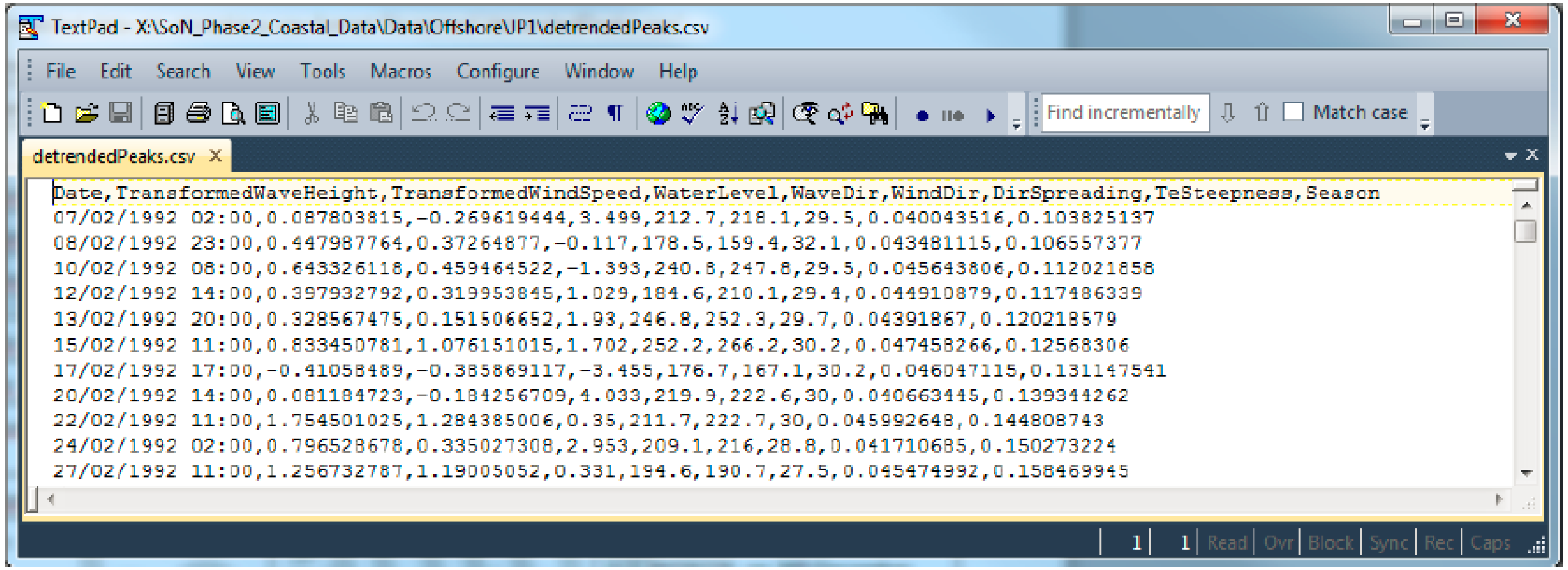
So what does this all look like ?




Wave and Wind Data (MO Wave Watch III)
Joint probability analysis
Water level data (Class A gauges, CFB)
Buoy Data for calibration (CCO, CEFAS)
Wave transformation (SWAN 2D)
Bathymetry offshore (SeaZone TruDepth)
Wave transformation (Emulator)
Coastal boundary
Monte Carlo modelled outputs (NCLDv2)
Surfzone wave transformation (SWAN 1D)
bathymetry nearshore (EA LiDAR CCO)
CLASH database
Defence overtopping (BAYONET)
Defence Data (CDL, AIMS, local data)
Overtopping volumes (MDSF2)
Design Surge Profile Data (CFB)
Fragility, flood spreading and depth data (MDSF2)

Field name	Units	Description
Date	Date time	The date and time of the event
TransformedWaveHeight	m	The de-trended significant wave
TransformedWindSpeed	m/s	The de-trended wind speed
WaterLevel	m(ODN)	The level of the water surface
WaveDir	Degrees north	The wave direction
WinDir	Degrees north	The wind direction
DirectionSpreading	Degrees	The one-sided directional width of the wave spectrum
TeSteepness	Dimensionless	The wave steepness, calculated using Te
Season	Dimensionless	A value from zero on 31st Dec to 0.99726776 on 30th Dec. Used for de-trending the data on seasonality



Offshore data De-trended Peaks

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Field name	Units	Description
Date	Date time	The date and time of the event
WaterLevel	m(ODN)	The level of the water surface
WaveHeight	m	Significant wave height (Hs): the mean of the highest third of the wave
TpWaveFreq	s	The wave frequency (1/Tp)
DirSpreading	Degrees	The one-sided directional width of the wave spectrum
Te	s	Wave energy period: the variance-weighted mean period of the one-dimensional period. Variance density spectrum
Tm	s	Mean wave period: the mean of all wave periods in a time-series
Tz	s	Zero crossing period: the mean time interval between upward or downward zero crossings
WaveDir	Degrees north	The wave direction
WindSpeed	m/s	The wind speed
WindDir	Degrees north	The wind direction
Tp	S	Peak wave period: the period corresponding to the peak spectral frequency
TeSteepness	Dimensionless	The wave steepness, calculated using Te
Season	Dimensionless	A value from zero on 31st Dec to 0.99726776 on 30th Dec. Used for de-trending the data on seasonality

Offshore data

Event data
Lower peaks

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Offshore data
Event data
Samples

Field name	Units	Description
WaveHeight	m	Significant wave height (Hs): the mean of the highest third of the wave
WindSpeed	m/s	The wind speed
WaterLevel	m(ODN)	The level of the water surface
WaveDir	Degrees north	The wave direction
WindDir	Degrees north	The wind direction
TpWaveFreq	s	The wave frequency (1/Tp)
DirSpreading	Degrees	The one-sided directional width of the wave spectrum
TeSteepness	Dimensionless	The wave steepness, calculated using Te
Season	Dimensionless	A value from zero on 31st Dec to 0.99726776 on 30th Dec. Used for de-trending the data on seasonality
Te	s	Wave energy period: the variance-weighted mean period of the one-dimensional period. Variance density spectrum

The “lower peaks” dataset shown on the previous slide contains the non-extreme peak events drawn from the concurrent time-series observation data where-as the “samples” dataset contain the synthesised extreme events

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There are then similar datasets to cover:

- The nearshore points for use in SWAN 1D
- The points at the toe for application to the overtopping calculations

- Plus bathymetry and asset data (Broad scale)

Application guidance for local flood risk analysis

- The key datasets available can be applied in different ways, these range in the level of rigour and there are related time and cost implications
- It is important to note that these datasets were developed for NaFRA which is focused on calculating flood risk which in turn is defined as the product of probability and consequence
- This is a probabilistic framework approach not deterministic, therefore can be considered a truer risk based approach

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Application guidance for local flood risk analysis

- SoN data described here may be applied in the context of local flood studies
- Typically flood studies of this nature use more traditional deterministic (non-risk based) approaches

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Application guidance for local flood risk analysis

Limitations of traditional deterministic assessments:

- The probability of the event is defined by the sea conditions – these do not relate to the Annual Exceedance Probability of overtopping nor to the flooding response and associated consequence
- Only a limited number of discrete events, defined in terms of specified annual exceedance probabilities of sea conditions, are considered. This does not facilitate a risk-based analysis, which requires a wider range to be considered
- Probabilities of breaching are not quantified and evaluated and hence, where these are non-negligible the associated risk is not evaluated

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Application guidance for local flood risk analysis

It is envisaged that SoN data can help overcome “SOME” of these limitations within local flood studies. Therefore two approaches have been identified that differ in the level of robustness and rigour:

- Robust analysis
- Simplified analysis

Application guidance for local flood risk analysis

Robust analysis

Undertake flooding analysis for each event in the nearshore dataset (NCLD). Each event is run through the modelling chain from the nearshore to the toe and overtopping for each flood defence asset. Its possible to use fast empirical methods to filter out events that give negligible overtopping. This gives event specific overtopping rates for each asset along the coastal frontage.

Application guidance for local flood risk analysis

Simplified analysis

To reduce the flood simulation computational burden, and avoid simulating all of the events, a simplification can be introduced. This takes the form of an assumption that overtopping rates for flood defences within the system being considered, are fully dependent. Or in other words if one defence experiences a particular event all defences in that system will experience the same overtopping rate

Other related reading

HR Wallingford
Working with water

Multivariate extreme value modelling of sea conditions around the coast of England

Ben Gouldby[1], David Wyncoll[1], Mike Panzeri[1], Mark Franklin[2], Tim Hunt[2], Dominic Hames[1], Nigel Tozer[1], Peter Hawkes[1], Uwe Dornbusch[2] and Tim Pullen[1]

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Abstract

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