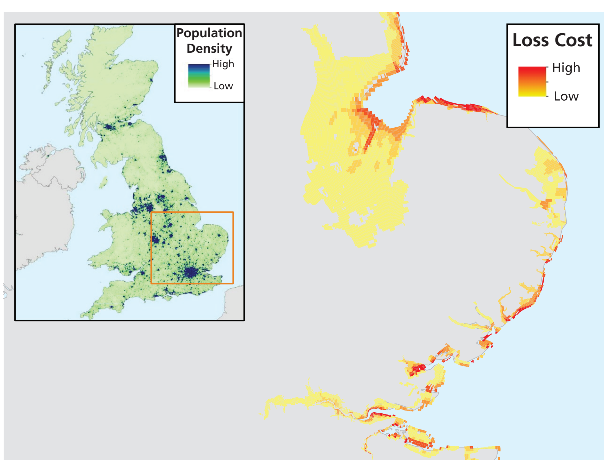
# The AIR Coastal Flood Model for Great Britain

The North Sea Flood of 1953 inundated more than 100,000 hectares in eastern England. More than 24,000 properties were damaged, and 307 people lost their lives. At the time, damage was estimated at GBP 50 million. Were a similar storm surge to occur today, losses would be in the billions. With 10% to 15% of coastline less than 5 metres above sea level, the UK is one of the countries in Europe most vulnerable to coastal flooding.


AIR

Although coastal defences and warning systems have been systematically improved since 1953, the population and exposure at risk have multiplied—and the level of protection is not uniform. Although the North Sea Flood remains the most damaging storm surge on record, companies should not consider it an exceedingly rare level of loss. In fact, more damaging scenarios are possible. Furthermore, with areas of the east coast slowly subsiding, the likelihood of another major coastal flood is growing.

As UK insurers and the government continue to work together to ensure that flood insurance remains affordable and available to homeowners at high flood risk, the insurance industry must assess the risk, manage exposure accumulations, and plan reinsurance for a highly complex peril.



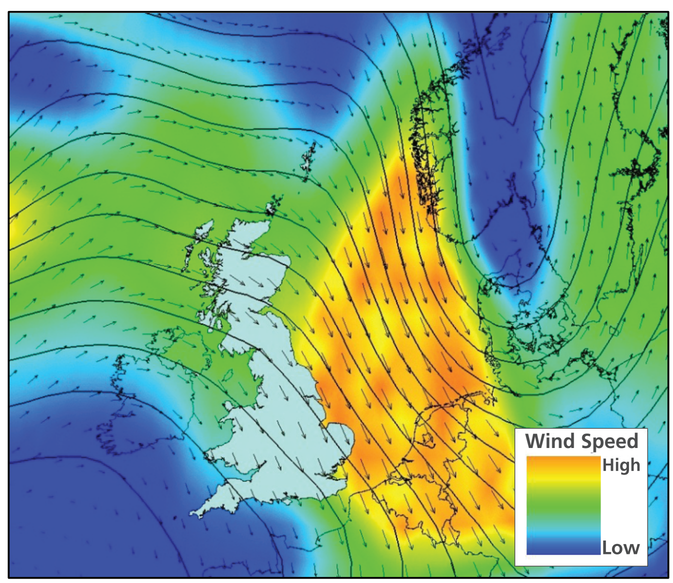

Coastal flood risk (loss costs) in southeastern England; population density of UK (inset)

Companies with a stake in the UK property insurance market need a fully probabilistic approach to assessing coastal flood risk that provides the likelihood of losses of any given size. This approach captures the many complexities inherent in the flood peril, the property damage that can result, and the ultimate insured loss. By using advanced numerical weather prediction and hydrodynamic modelling technology, the AIR Coastal Flood Model for Great Britain, which includes extreme events that exceed the scope of historical experience, allows companies to assess and manage their risk from coastal flooding.

## A Comprehensive View of Coastal Flooding Risk

The most damaging coastal floods are caused by the coincidence of large wind-driven surges and regional high tides. In the North Sea, surges pushed ahead of southward moving extratropical cyclones enter the progressively shallower and narrower approaches to the Strait of Dover. As a result, the east and south coasts of the UK experience the highest frequency of coastal flooding in the country.

The AIR model uses advanced numerical weather prediction (NWP) and hydrodynamics to consider multiple combinations of storms, tide levels, and sea defence effectiveness to develop a realistic catalogue of flood events. Because storms and tides are produced by different mechanisms and may combine in a random fashion, the model includes thousands of possible interactions at different points along the coast.




Representative pattern of a coastal flood-producing storm in the North Sea

NWP, which uses mathematical models of the atmosphere and oceans to predict regional weather patterns, enables the AIR model to more accurately represent the complex time-dependent, three-dimensional structure of damaging storms. State-of-the-art hydrodynamic modelling is used to simulate coastal water flow, enabling robust estimates of the volume of water displaced and its impact upon coastal areas.

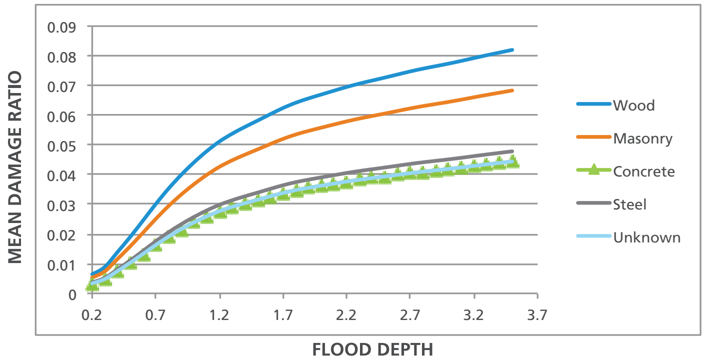
## Flood Volume Model Determines Depth and Extent of Coastal Flooding

The height and volume of the storm surge, the state of the tide, and the performance of any sea defences determine the amount of water that comes ashore. The topography and elevation of the coastal landscape prescribe where that water will go and the depth of the flooding that will be experienced. To determine flood patterns the model estimates flood volumes and then redistributes them over high resolution local topography.

The most common types of coastal flooding—water passing through and around property but not remaining at great depth, water standing for a long period, and the high velocity inundation that can destroy buildings very close to the coastline—are all modelled.

## Accounts for Secondary Risk Modifiers and Time Element Damage

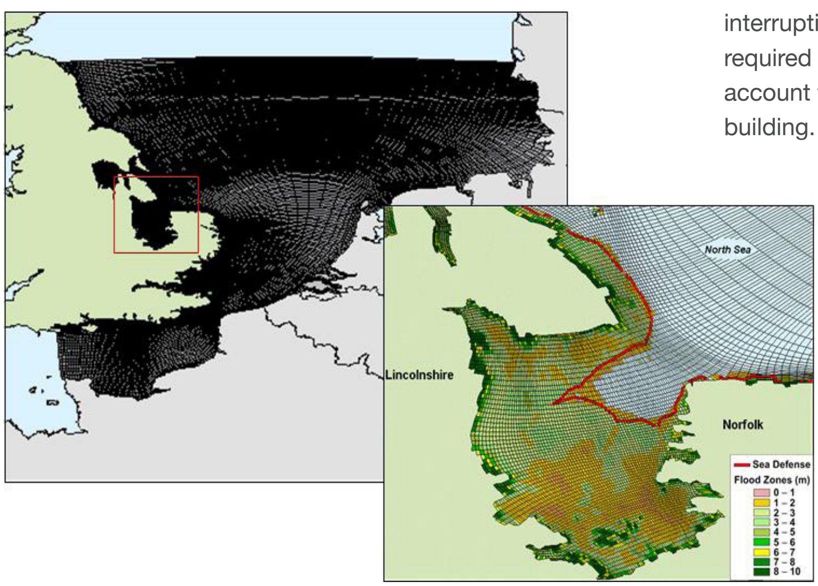
The model reflects the best available information regarding flood damageability and includes the latest research from engineering analyses and findings from published damage surveys and those conducted by AIR. The amount of damage that a building will suffer depends principally on the depth and duration of inundation and on the building construction and occupancy type. Secondary risk modifiers, such as floor of interest and basements, are explicitly modelled.




Sample building and building component damage functions for a high street shop

To estimate damage to buildings and contents caused by coastal flood, the AIR model incorporates damage functions that vary by occupancy, construction, and height. For commercial properties, the model's damage functions use a component-based approach to capture the relative vulnerability of different building components, including building, fixtures and fittings, and services, as well as their contribution to total replacement value.

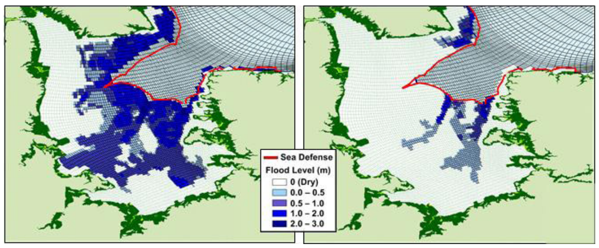
Time element damage functions account for alternative accommodation and related expenses and business interruption losses. The model accounts for the time required for drying and cleaning the property, which can account for a significant share of the time to re-occupy a building.




The AIR Coastal Flood Model for Great Britain was developed in close partnership with Delft Hydraulics. Left: the model domain and (inset) the Wash and its flood zones

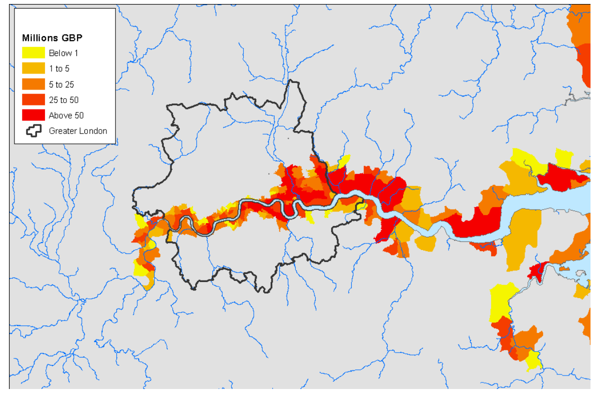
## SEA DEFENCES—AND THEIR POSSIBLE FAILURE

The level of flooding that results from any given storm depends on the behaviour of coastal flood defence systems. Based on storm severity and duration, the model accounts for sea defences being overtopped or failing under extreme pressure.




Example of flood distribution patterns in the flood zone of the Wash, with failed sea defences (left panel) and effective sea defences (right panel)

Some major engineered structures, such as the Thames Barrier, provide a significantly higher degree of protection than a typical seawall or earth embankment.



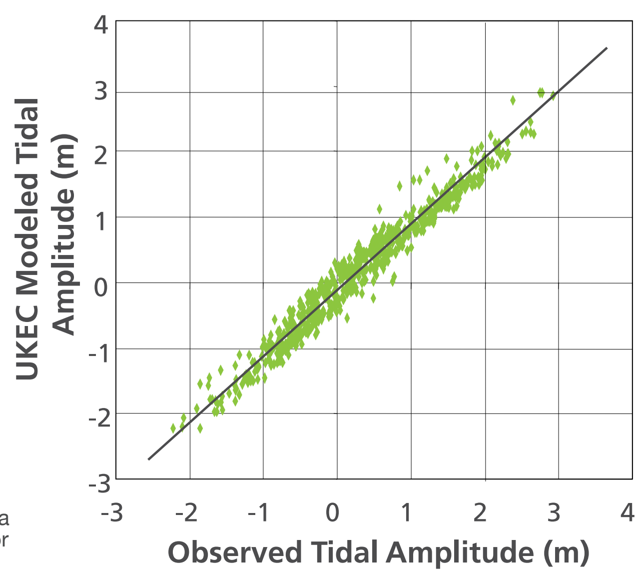

Extreme loss scenario after failure of Thames Barrier

But an extreme scenario in which the Thames Barrier fails could cause significant flooding in London and beyond, all the way to Teddington Lock. Such a scenario could result in insured losses of more than GBP 4.5 billion.

## A Comprehensive Approach to Model Validation

Validation is an essential step in the model development process. To ensure the most reliable modelled loss estimates available, each component of the model has been carefully validated against multiple sources and data obtained on three historical storms: December 11–21, 1982; January 26-February 7, 1983; and February 8–20, 1989.

Empirically computed floodwater volumes, for example, were compared with modelled flood volumes computed on a high resolution (100-400 metre) grid. These comparisons were made for all coastal regions and performed for several different model runs. The model's damage functions incorporate findings from published engineering research and leverage the extensively validated damage functions from the AIR Inland Flood Model for Great Britain.




Modelled tidal amplitudes compared to observed data from near-shore stations for three storms

## Model at a Glance

| | |
|---|---|
| **Modeled Peril** | Coastal flooding caused by storm surge |
| **Model Domain** | Eastern and southeastern coasts of England |
| **Supported Geographic Resolution** | Up to 100-metre |
| **Supported Lines of Business** | Residential, commercial, industrial, agricultural, and municipal |
| **Supported Construction and Occupancy Classes** | 33 construction classes, including caravans (mobile homes); 50 occupancy classes<br><br>Unknown damage function: When detailed exposure data (e.g., construction type or height) are unavailable, the model applies an "unknown" damage function that takes into account country-specific construction characteristics using exposure-weighted averages. |

## Model Highlights

- Combines advanced numerical weather prediction and hydrodynamic modelling technology to create a comprehensive model of surge and tidal dynamics along the UK east and south coasts
- Provides a comprehensive catalogue of storm surge flooding events, which enables a reliable means of determining the full range of potential flood losses
- Uses realistic flood patterns based on elevation data and detailed hydrodynamic simulations to compute peak flood depths
- Fully accounts for the system of sea defences and thousands of possible surge-tide interactions at different points along the coast; defence failure is probabilistically modelled in loss estimation
- Incorporates damage functions for residential, commercial, and industrial assets as well as agricultural buildings and greenhouses (building and non-plant contents)
- Features damage functions created using a component-based approach to capturing the relative vulnerability of individual building components for commercial properties

## ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, AIR Worldwide founded the catastrophe modeling industry and today models the risk from natural catastrophes, terrorism, pandemics, casualty catastrophes, and cyber attacks, globally. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, site-specific engineering analyses, and agricultural risk management. AIR Worldwide, a Verisk (Nasdaq:VRSK) business, is headquartered in Boston with additional offices in North America, Europe, and Asia. For more information, please visit www.air-worldwide.com.



AIR
A Verisk Business