AIR Inland Flood Model for Great Britain

The year 2012 was the UK's second wettest since record-keeping began—only 6.6 mm shy of the record set in 2000. In 2007, the UK experienced its wettest summer, which resulted in 165,000 insurance claims of approximately GBP 3 billion. Flood is a top natural hazard in the UK with 5 million homes at risk.

AIR

With growing numbers of properties in flood-prone areas, the insurance industry must assess the risk, manage exposure accumulations, and plan reinsurance for a highly complex peril.

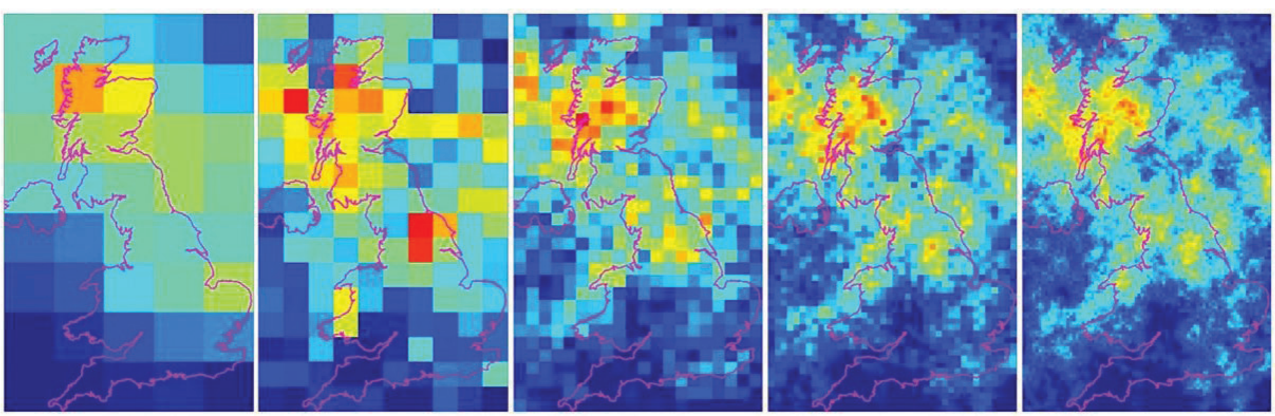
While detailed maps are available to identify floodplains and pinpoint properties at risk, they do not enable probabilistic risk assessment. Nor do they account for risk to properties located off the floodplain—which accounted for a significant share of the claims from the floods of 2007.

Companies with a stake in the UK property insurance market need a fully probabilistic approach to assessing inland 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.

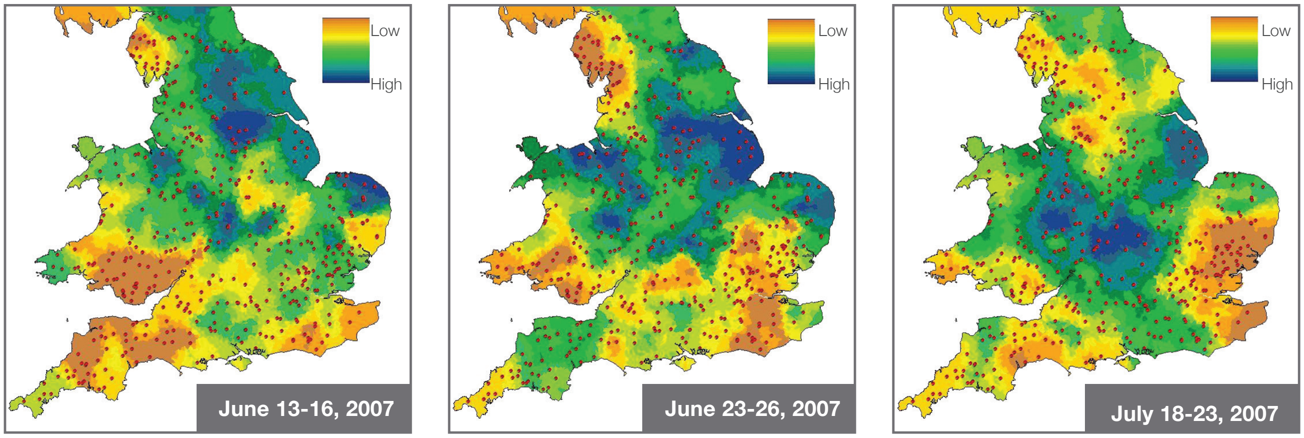
By capturing flood risk on a 10-metre resolution digital terrain model—including multiple sources of floodwater, land cover and antecedent soil conditions, man-made flood defences, and the ultimate impact of floodwaters of varying depth on properties of varying construction and occupancy—the AIR Inland Flood Model for Great Britain is designed to meet the risk management needs of companies pricing and underwriting flood risk in Great Britain.

A Complete View of Great Britain Flood Risk

The AIR Inland Flood Model for Great Britain incorporates a river network extending more than 300,000 km. For on-floodplain flooding, a hydraulic model is employed to explicitly model stream links with a contributing area of more than 10 km². Off-floodplain flooding is modelled according to the physical properties of more than 15,000 smaller catchments.



To develop a catalogue of highly realistic simulated storms, historical weather data is downscaled to a high spatial and temporal resolution using numerical weather prediction (NWP) technology.



In this example using the 2007 floods, each prior event's impact on the antecedent conditions of the following event is captured through the runoff coefficient.

A More Realistic Approach to Rainfall Simulation

Drawing on its expertise in numerical weather prediction (NWP), AIR has developed an innovative and sophisticated rainfall generation module that produces realistic and statistically robust rainfall patterns over space and time. The process preserves the rainfall intensity distributions (for example, one-hour and 24-hour rainfall accumulations) at each location. The result is a 10,000-year catalogue of realistic fine-scale simulated storm events over England, Wales, and Scotland.

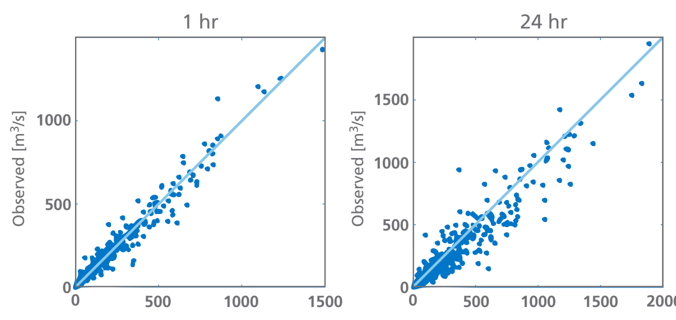
The model captures all types of storm systems—from large-scale events affecting the entire country to highly localized thunderstorms—and preserves patterns of historical frequency of each type over time.

Proper Assessment of Antecedent Conditions is Critical

Flooding is more likely to occur when soils are already saturated and cannot absorb additional water. Thus the amount of prior rainfall (or snowmelt)—referred to as antecedent conditions—is of critical importance in modelling flood risk.

AIR takes a hybrid statistical-physical approach to determining the proportion of total rainfall that cannot be absorbed by underlying soils and is instead transformed into surface runoff, ultimately finding its way to the river network. This runoff coefficient, as well as the initial river flow prior to each event, known as the baseflow, are drawn from distributions dependent on highly localized soil properties, land cover, and topography—and are conditioned on preceding rainfall events.

Surface runoff is routed downstream along the river network using the Muskingum-Cunge flood routing scheme. The physically based flood routing module also accounts for the river cross-sectional shape and captures the mitigating effect of lakes and reservoirs on the flood peaks. More than 4,000 reservoirs and lakes are modelled explicitly as a part of the flood routing module.



Validation of modelled annual flood peaks with observed data from more than 600 gauging stations across Great Britain.

> "I'm very impressed with AIR's flood model. There is major innovation—notably in the rainfall representation—and I am certain that it will be fit for purpose and probably out compete others very quickly."

Dr. Stuart Lane, Professor of Physical Geography at Durham University, a member of the AIR Inland Flood Model for Great Britain peer review team.

Hydraulic Modelling Determines the Relationship between Water Flow and Flooding Elevation

A physically based hydraulic model transforms river discharge—which is the output from the flood routing module—to water level, or elevation. This step is critical for assessing inundation depth at each location of interest for each event. The AIR model accounts for the effect of tide for river reaches in the tidal zone.

The hydraulic model used in the AIR Inland Flood Model for Great Britain is HEC-RAS, a widely used hydraulic engineering application. Inundation depths are derived using the Ordnance Survey's Land-Form PROFILE® digital terrain model—a database with 10-metre horizontal resolution and 0.1-metre vertical resolution.

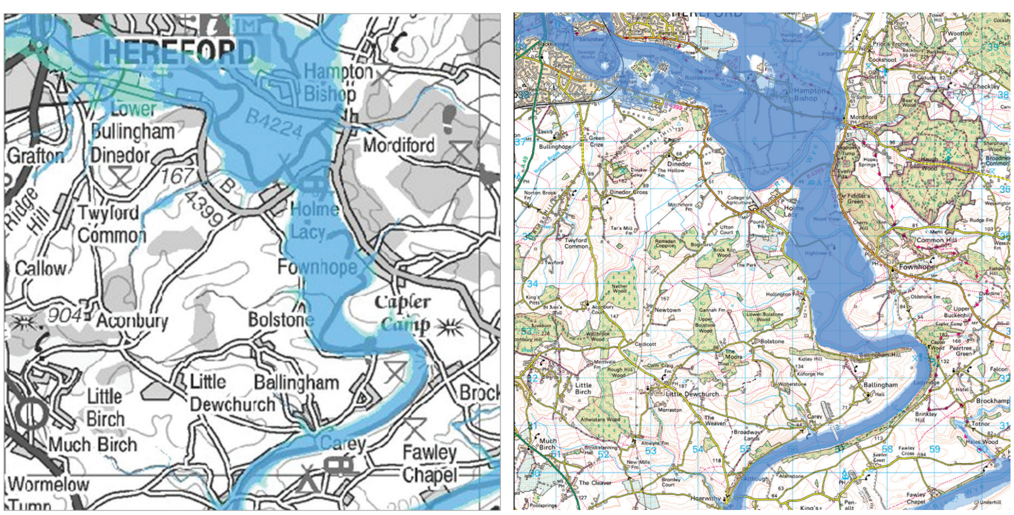
The Hydraulic Model Accounts for Flood Defences—Including Dams, Levees, and Gates—and Their Possible Failure

Flood defences play a critical role in protecting properties within the floodplains of Great Britain. Embankments and flood storage areas are represented in the terrain data sets and are explicitly modelled.

The failure of flood defences is modelled probabilistically. For each link, detailed characteristics of its flood defences—such as standard of service, type, condition, and grade—are estimated from high resolution data sets. These parameters are verified against the latest national flood defence database, and then are used to construct fragility curves to estimate flood defence failure. The probability of flood defence failure is sampled per link, per event. Without proper treatment of flood defence failure, modelled losses can vary by as much as an order of magnitude.

Off-FloodPlain Flooding is a Major Source of Insured Losses

With approximately 50 percent of the losses from the 2007 floods occurring off-floodplain and much of that loss occurring in highly exposed urban areas, AIR developed an explicit model for off-floodplain loss estimation. The off-floodplain model accounts for such factors as elevation, runoff, drainage backups, and facility ageing at each modelled location.



AIR modelled 100-year flood extent compared with Environment Agency flood extent near Hereford at River Wye.

Damage is Calculated Using a Component-Based Approach

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

Damage functions can be modified to account for flood protection and mitigation measures, if known. Since flood damage is highly dependent on height, AIR's model enables companies to analyse the risk to a specific floor or floors of interest, including basements.

Time element damage functions account for alternative accommodation and related expenses, which are modelled in terms of the number of days of loss of use. 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.

To estimate business interruption losses, specific damage functions were developed that vary by occupancy and account for property damage level, building size and complexity, and business characteristics, such as resiliency and the ability to relocate.

Designed to Meet the Insurance Industry's Flood Modelling Needs

For reinsurance purposes, it is generally accepted that a flood event in the UK is defined in the context of the 168 hour (seven days) collective rule. Regardless of an event's cause, flood losses incurred within a specified geographic area and time frame of 168 hours constitute a single event for reinsurance purposes.

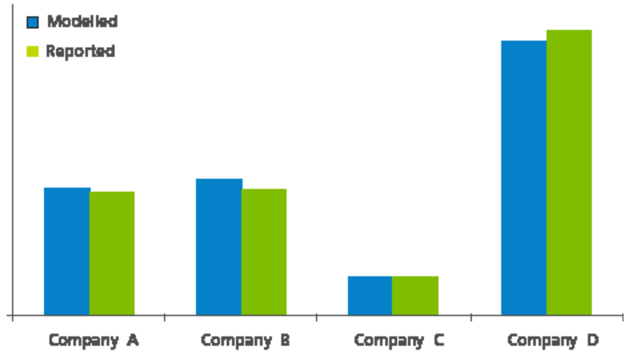
The AIR Inland Flood Model for Great Britain models rainfall events in space and in time to explicitly quantify event duration. The events in the AIR stochastic catalogue generally conform to the 168 hour event duration.

Companies can apply standard UK policy conditions and can use the software to capture a complete view of their UK catastrophe risk by analysing inland flood risk in conjunction with windstorm and storm surge risk.

Validated by Extensive Claims Data and Independent Experts

Losses from the AIR Inland Flood Model for Great Britain have been validated through extensive analysis of both detailed claims data and aggregated data as reported by the insurance industry. Detailed claims data for both personal and commercial lines from the 2007 floods was provided by leading UK insurers, representing roughly 30 percent of the industry exposure.

In addition to AIR's internal model validation, the Inland Flood Model for Great Britain has been thoroughly reviewed by a team of independent flood experts from leading universities, HR Wallingford, and the Centre for Ecology and Hydrology.



The AIR Inland Flood Model for Great Britain has been extensively validated using detailed company claims data from the 2007 floods.

Model at a Glance

Modeled Perils	Inland flooding, both on- and off-floodplain
Model Domain	Great Britain (England, Scotland, and Wales)
Supported Geographic Resolution	From full postcode to lower resolutions, or user-supplied geocodes
Supported Lines of Business	Residential, commercial, industrial, agricultural, and municipal
Vulnerability Module	Building vulnerability varies by occupancy, construction, and height to estimate building and contents damage. Time element damage accounts for time required for cleaning and drying, building complexity, and business resiliency.

Model Highlights

— Incorporates an innovative and sophisticated rainfall generation module that uses the results of numerical weather prediction (NWP) modelling to produce realistic and statistically robust rainfall patterns in space and time, and across seasons

— Features physically based hydraulic modelling of detailed river networks; model results are validated against flood maps and local measurements from various sources

— Accounts for flood defences in routing and hydraulic modelling; defence failure is probablistically modelled in loss estimation

— Explicitly models off-floodplain losses to capture a major source of insured flood losses

— Features damage functions created using a component-based approach to capturing the relative vulnerability of individual building components for commercial properties

— Supports typical event duration clause in reinsurance contracts

— Peer-reviewed by an independent team of experts from leading universities and organizations, including HR Wallingford and the Centre for Ecology and Hydrology (CEH)

— Validated with detailed loss experience data for both residential and commercial lines from the 2007 floods, representing approximately 30 percent of the industry exposure

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.

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