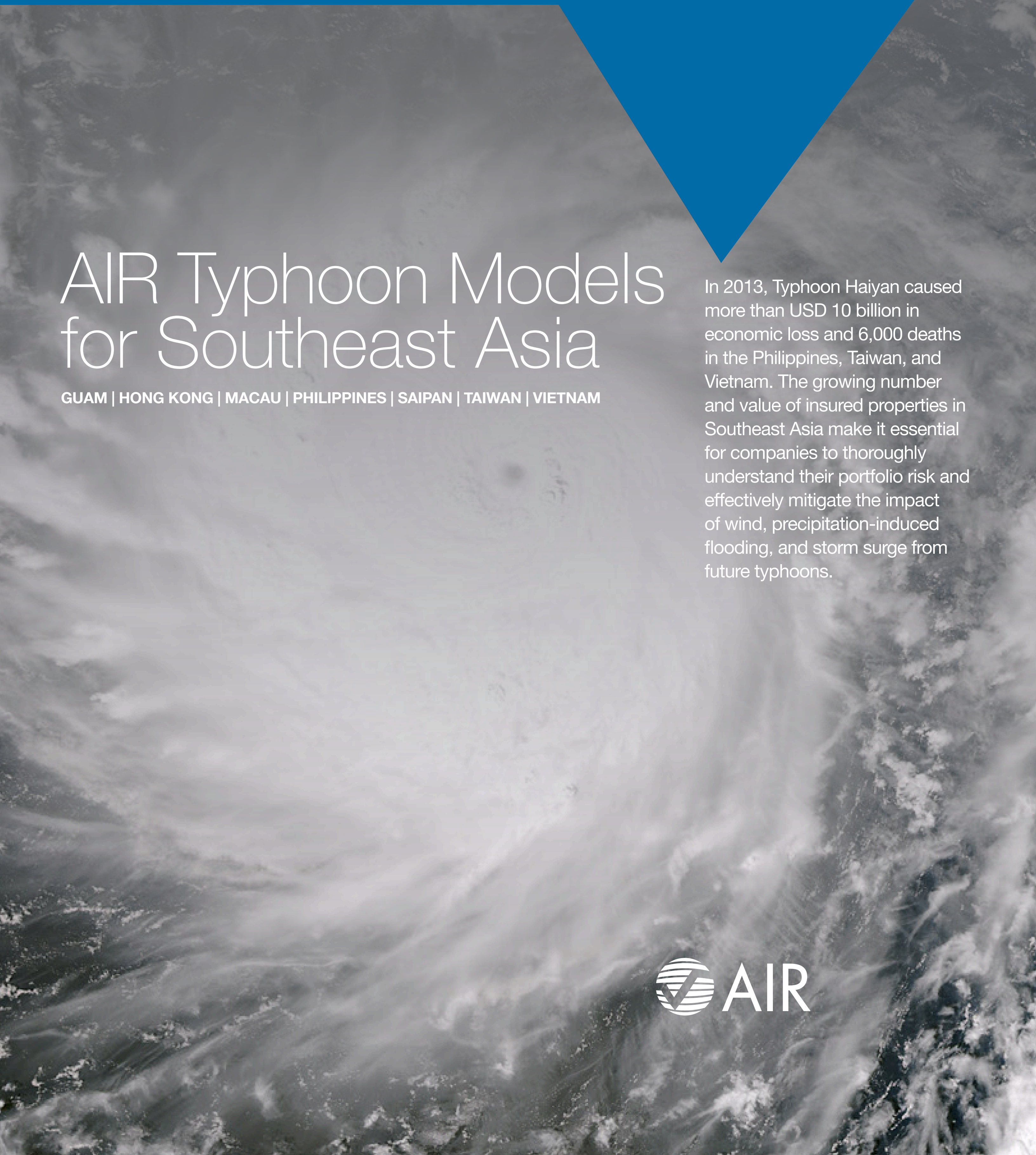
AIR Typhoon Models for Southeast Asia

GUAM | HONG KONG | MACAU | PHILIPPINES | SAIPAN | TAIWAN | VIETNAM

In 2013, Typhoon Haiyan caused more than USD 10 billion in economic loss and 6,000 deaths in the Philippines, Taiwan, and Vietnam. The growing number and value of insured properties in Southeast Asia make it essential for companies to thoroughly understand their portfolio risk and effectively mitigate the impact of wind, precipitation-induced flooding, and storm surge from future typhoons.

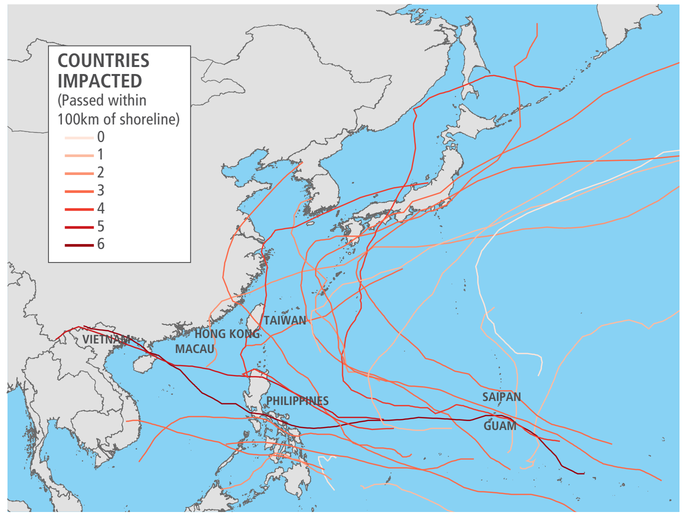


AIR

Damage from typhoons is the most frequent cause of property loss in Southeast Asia. The Northwest Pacific Basin hosts more than 25 tropical cyclones of tropical storm strength or greater per year on average—one third of all global tropical cyclone activity. The AIR Typhoon Models for Southeast Asia—part of AIR's Northwest Pacific Basinwide Typhoon Model—provide a probabilistic approach for determining the likelihood of losses from typhoon winds, precipitation-induced flooding, and storm surge. The models incorporate cutting-edge science that best reflects the current understanding of the behavior of tropical cyclones in the basin, as well as the latest engineering research into the response of local construction. Loss experience from the Southeast Asia insurance market was used to validate model results.

Robust Catalog Leverages Data from Leading Regional Organizations

The models share a large catalog of simulated events that appropriately characterizes the frequency, track, and other meteorological aspects of potential future storms. To create this catalog, AIR scientists utilized historical track data provided by leading regional organizations, including the Japan Meteorological Agency (JMA) and the Shanghai Typhoon Institute (STI), as well as wind and



The majority of storms during the 2012 Northwest Pacific typhoon season impacted more than one country.

A COMPREHENSIVE APPROACH TO ASSESSING REGIONAL RISK

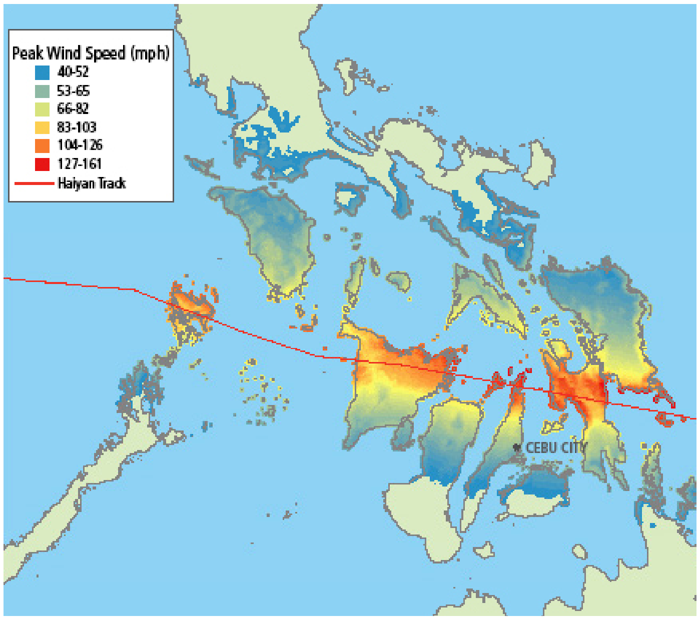
Today, insurers and reinsurers operating globally need the ability to quantify the risk to policies and portfolios that span multiple countries—particularly in the Northwest Pacific Basin, where, given the configuration of landmasses, more than half of all landfalling typhoons affect more than one country.

To provide a consistent and comprehensive view of risk to companies with regional portfolios, AIR has developed a unified basinwide catalog shared by all modeled countries in the Northwest Pacific basin. The catalog enables seamless risk assessment for multi-country policies and portfolios, an approach of critical importance to global companies.

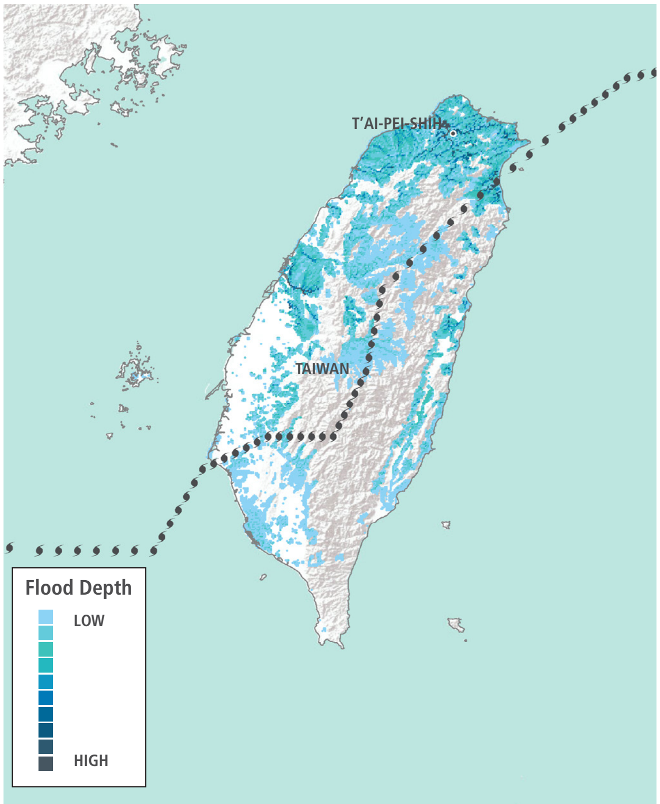
precipitation data from the Automated Meteorological Data Acquisition System (AMeDAS), NOAA's Global Summary of the Day (GSOD), and the Tropical Rainfall Measuring Mission (TRMM), and satellite imagery from Digital Typhoon. Based on this comprehensive data set, the AIR model features a 10,000-year catalog containing 293,235 simulated events ranging from tropical storm strength to Category 5 on the Saffir-Simpson Hurricane Wind Scale.

Wind Hazard Modeling Reflects Latest Research on Regional Typhoon Behavior

Observation data show that the relationship between central pressure and wind speed is unique to each ocean basin. For example, for the same central pressure, typhoons in the Northwest Pacific tend to have lower wind speeds than hurricanes in the North Atlantic. In the AIR model, the generation of a typhoon's maximum wind speed utilizes a central pressure–wind speed relationship that incorporates region-specific data to best reflect the current understanding of winds generated by Northwest Pacific typhoons.



Wind footprint of Typhoon Haiyan, which significantly affected the Philippines in 2013.

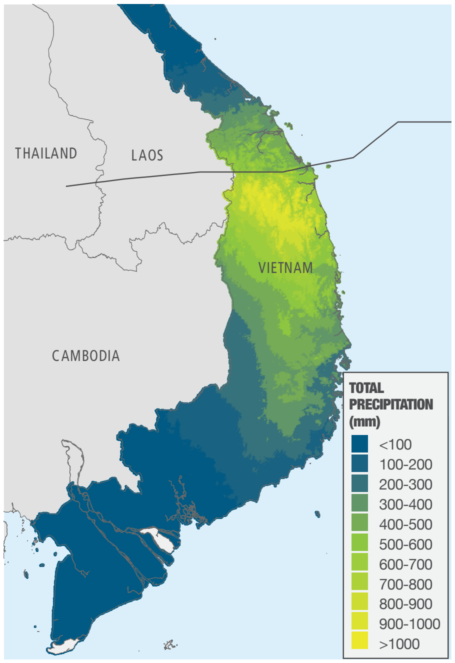


Flood depth and storm track of Typhoon Nari in 2001. Typhoon Nari caused one of Taiwan's most damaging flood events.

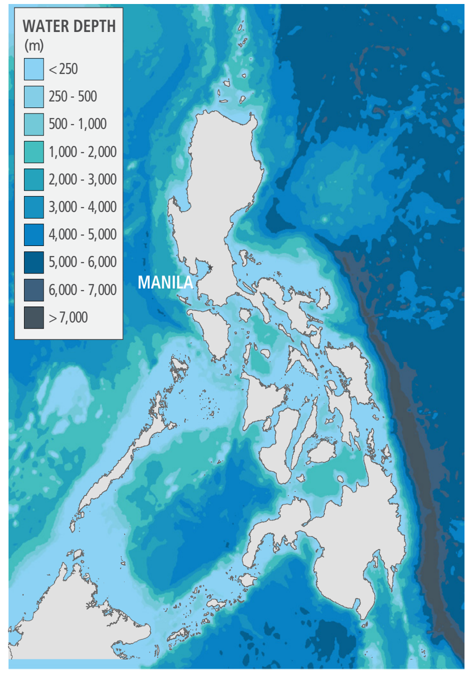
The models' wind field formulation is further supported by the latest available data and scientific literature on the rate of decrease in wind speeds after landfall. Overestimating this rate can significantly underestimate inland losses.

Precipitation-Induced Flood Module Incorporates Detailed Information on Soil Type, Land Use/Land Cover, and Topography

Intense precipitation from typhoons can cause significant flood damage in Southeast Asia. In Taiwan, flood losses are significant, with topographic features leading to enhanced rainfall. Typhoon Nari in 2001 was one of Taiwan's most damaging flood events. Precipitation totals from Nari exceeded 1,000 mm and 50 mm/hr in some parts of Taipei, causing unprecedented levels of flooding. Unlike typhoon winds, which generally decrease as storms move inland, the intensity of storm-related precipitation can actually increase inland. In Vietnam flood is the dominant driver of loss, as typhoon wind speeds tend to be fairly low while rainfall can be significant. Precipitation footprints typically extend for hundreds of kilometers (as opposed to tens of kilometers for wind footprints); thus, even storms that remain offshore can cause flood damage on land.



Accumulated precipitation in millimeters from Typhoon Ketsana (typhoon track in black) in 2009. After passing through the Philippines, Typhoon Ketsana strengthened to a Category 2 typhoon before making landfall in Vietnam, where it caused massive flash flooding.



Bathymetry of the ocean floor surrounding the Philippines. Typhoons typically produce larger storm surges along coastlines with shallow bathymetry than with steep bathymetry.

The AIR models incorporate a dynamic flood module that estimates the severity of flooding and its associated damage. Maximum flood depth is determined using hourly precipitation, which is calculated using a parametric precipitation model developed using TRMM data. The flood module then routes the flow based on soil characteristics, local elevation, and vegetation.

Storm Surge Module Incorporates High-Resolution Bathymetry and Terrain Elevation Data

While little correlation exists between typhoon wind speed and precipitation intensity, storm surge is strongly correlated with wind speed. The size of the wind field is also important, with larger storms producing a larger storm surge.

Other factors influencing the storm surge threat include bathymetry (underwater topography and ocean depth) and astronomical tide. A given typhoon will typically produce a larger storm surge along a coastline with shallow bathymetry than one with steep bathymetry. Background astronomical tide level—that is, the water height that would have been observed in the absence of a storm—influences the total water level seen during a tropical cyclone event. Through the use of high resolution bathymetry and terrain elevation data, the model simulates storm surge from its inception to its farthest extent inland. In addition, the hydrodynamic storm surge module explicitly captures wave effects. Storm surge is modeled in Hong Kong, Taiwan, and the Philippines, where there is the greatest risk from this important sub-peril.

Damage Functions Provide Robust View of Wind, Precipitation-Induced Flood, and Storm Surge Risk

AIR engineers have developed peril-specific functions for 116 different construction classes and 116 occupancy classes in Southeast Asia. Further highlights of the vulnerability module include:

— Damage functions that support a variety of specialized risks, including marine cargo, marine hull, builder's risk, large industrial facilities, warehouses, auto, and two-wheeled vehicles, as well as the conventional risks, such as residential, commercial, industrial, government, and agricultural buildings.
— Separate damage functions by different coverage types (buildings, other structures, contents, time element) for the wind, precipitation-induced flood, and storm surge perils
— Damage functions that vary by building height, construction, and occupancy, year built, and location of the property

- Unique set of damage functions for "tall" buildings (30 stories and higher)
- Damage functions that account for the duration of winds, as well as peak wind speed
- Flood damage estimation that accounts for existing flood mitigation systems, including levees, tunnels, canals, and drainage systems, etc.
- Method for estimating business interruption that varies by occupancy and accounts for business characteristics (e.g., resiliency, the ability to relocate), building size, and complexity
- Damage functions that capture variability in regional wind vulnerability due to building codes, their enforcement, and local building practices
- For buildings with unknown attributes—such as height or construction—damage functions account for differences in regional building inventories

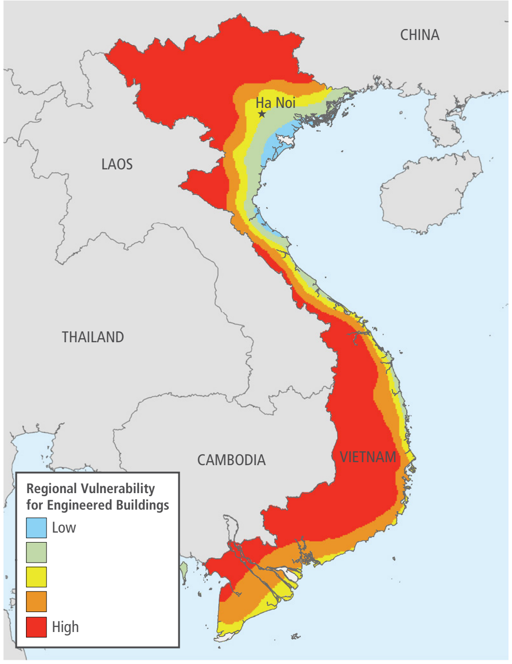
Leveraging AIR's Detailed Industry Exposure Databases

AIR's industry exposure databases (IEDs) for Guam, Hong Kong, Macau, Philippines, Saipan, Taiwan, and Vietnam consist of the latest available information on risk counts, building characteristics, and construction costs, at a 1-km spatial resolution. By using a wide variety of local sources, the IEDs capture the characteristics of properties at a high level of detail. The benefits and uses of AIR's IEDs are numerous. They provide a foundation for all modeled industry loss estimates, and risk transfer solutions, such as industry loss warranties that pay out based on industry losses, rely on the IED. And based on industry exposure weights by line of business, aggregate CRESTA exposures are automatically disaggregated to a 1-km grid during analysis. The IEDs are also used to distinguish building stock variations at a regional level when creating damage functions for buildings with unknown characteristics.

Validating Insured Losses Using Company Loss Data

To produce realistic and robust model results, AIR builds its models from the ground up, validating each component independently. AIR modeled wind speeds, precipitation totals, and storm surge, for example, are validated against observation data from actual storms.

AIR also validates from the top down, comparing modeled losses to industry loss estimates and company data. Modeled losses for the AIR Typhoon Models for Southeast Asia have been validated against actual claims data, as well



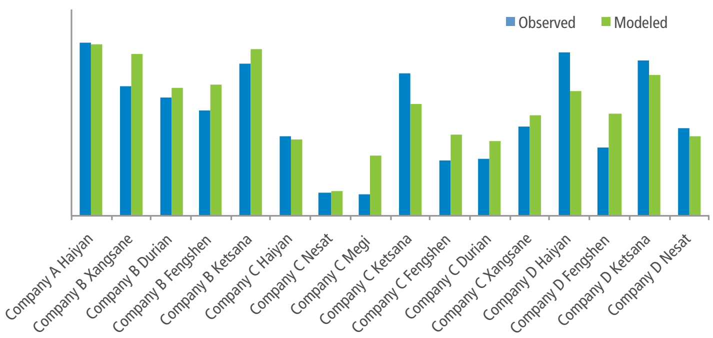
Regional wind vulnerability of engineered buildings in Vietnam.

as loss information available from major brokers, reinsurers, and reports from governments. AIR's comprehensive approach to validation confirms the reasonability of modeled loss estimates and that the final model output is consistent with both basic physical expectations of the underlying hazard and is unbiased when tested against historical and real-time information.

Separating Wind, Precipitation-Induced Flood, and Storm Surge Flood Losses for More Accurate Model Results

Touchstone® allows users to input separate policy conditions for wind, flood, and storm surge, and obtain separate loss estimates for the three sub-perils.

PHILIPPINES COMPANY BOOKS VALIDATION



Modeled losses for select events compare well to observed losses based on individual company data.

Model at a Glance

Modeled Perils	Tropical cyclone winds and their duration, precipitation-induced flood, and storm surge
Stochastic Catalogs	All seven modeled countries/territories are part of the unified Northwest Pacific basinwide 10,000-year catalog, which includes 293,235 simulated tropical cyclones. Four Extreme Disaster Scenarios are also provided, as are 40 historical events.
Modeled Lines of Business	Residential, commercial, industrial, agricultural, as well as specialized classes such as marine cargo and hull, builder's risk, infrastructure, warehouse risks
Supported Construction and Occupancy Classes	— 116 construction classes are supported for wind, precipitation-induced flood, and storm surge — 116 occupancy classes are supported for wind, precipitation-induced flood, and storm surge
Industry Exposure Databases	— Contain risk counts, building characteristics, and construction costs at a 1-km spatial resolution — Provide a foundation for all modeled industry loss estimates
Unknown Damage Function	When detailed exposure data (e.g., construction type or height) is unavailable, the models apply an "unknown" damage function that takes into account regional building inventories at sub country level.
Supported Policy Conditions	The models support a wide variety of location, policy, and reinsurance conditions that are specific to each modeled country.

Model Highlights

— Unified basinwide catalog of 293,235 simulated tropical cyclones provides a comprehensive view of Northwest Pacific typhoon risk, essential for global companies that underwrite policies and manage portfolios spanning more than one country
— Capture the unique meteorological characteristics of storms that make multiple landfalls, including precipitation-enhancing effects that can cause significant flood losses even in the absence of strong winds
— Explicitly model tropical cyclone winds, precipitation-induced flooding, and storm surge
— Incorporate central pressure–wind speed relationship specific to the Northwest Pacific
— Precipitation is modeled hourly, and the resulting runoff is routed using a dynamic overland flow module and local land characteristics
— A hydrodynamic storm surge module explicitly captures wave effects
— Account for flood mitigation systems
— Account for damage to building, contents, and business interruption losses from wind, precipitation-induced flood, and storm surge
— Support the modeling of specialized risks, including large industrial facilities, warehouses, marine cargo, marine hull, auto, builder's risk, and two-wheeled vehicles
— Carefully validated using observations from past events, industry-reported loss, and company claims data
— Touchstone enables users to easily run wind, precipitation-induced flood, and storm surge scenarios and can distribute aggregated exposure data down to a high resolution grid based on distributions in AIR's detailed industry exposure database

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