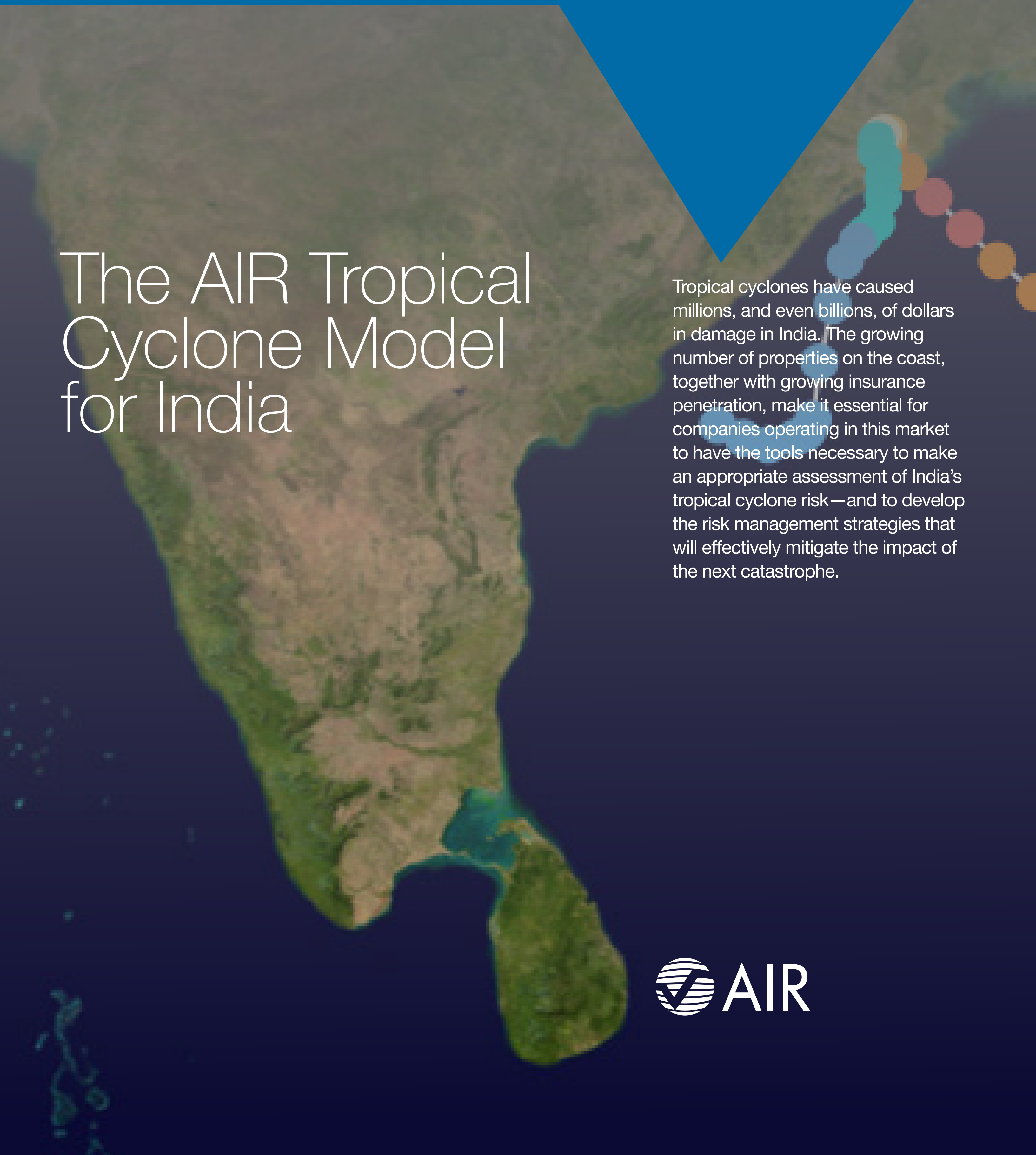


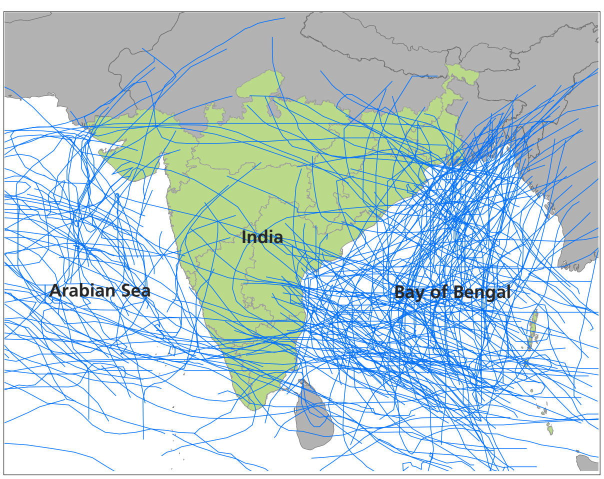
The AIR Tropical Cyclone Model for India

Tropical cyclones have caused millions, and even billions, of dollars in damage in India. The growing number of properties on the coast, together with growing insurance penetration, make it essential for companies operating in this market to have the tools necessary to make an appropriate assessment of India's tropical cyclone risk—and to develop the risk management strategies that will effectively mitigate the impact of the next catastrophe.

AIR

Robust Catalog Captures the Full Range of Potential Cyclone Experience

The Indian subcontinent divides the North Indian Ocean basin into two seas: the Bay of Bengal to the country's east, and the Arabian Sea to its west. While tropical cyclones take a wide variety of tracks around India, they are four times more likely to originate in the warmer waters of the Bay of Bengal than they are in the Arabian Sea. The AIR Tropical Cyclone Model for India features a catalog of more than 55,000 simulated storms whose wind field and track parameters reflect the full range of potential North Indian Ocean basin cyclones across the entire modeled domain.

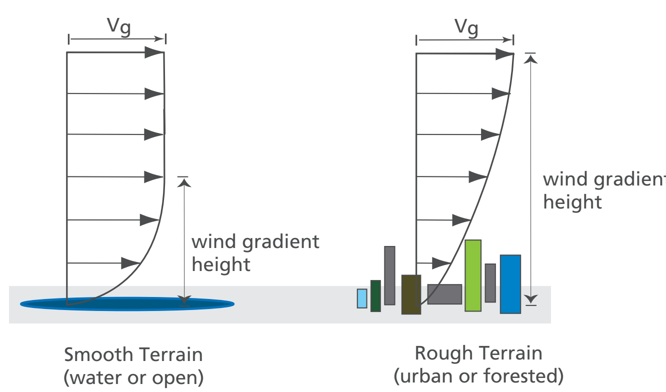


Greater tropical cyclone activity occurs in the Bay of Bengal compared to the Arabian Sea.

India's extensive coastline is at risk from both landfalling and bypassing tropical cyclones. Bypassing storms can cause significant damage when they track up long stretches of the coast, delivering damaging winds to coastal exposures and heavy precipitation and flooding hundreds of kilometers inland. The AIR Tropical Cyclone Model for India captures the risk from both wind and flood—a critically important feature given that both perils are covered in standard residential and commercial policies.

High-Resolution Land Use/Land Cover Data Captures Directional Effects on Surface Wind Speeds

To capture surface winds with realism, the model must account for the impact of the surrounding terrain. Winds arriving at a site directly from the Bay of Bengal, for example, will be faster than winds that had to travel first over forested or urban terrain. Using the latest satellite-derived high-resolution land use/land cover and elevation data, the AIR model captures the effects of surface friction on wind speed. It does so for eight wind directions: east, north, northeast, northwest, south, southeast, southwest, and west.



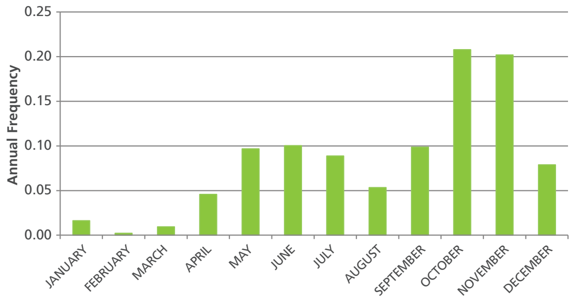
Winds arriving from across the smooth, open ocean will travel faster than winds that have previously traveled across rough or urban terrain. (Source: Cook, 1985)

> "The AIR cyclone model for India is quite comprehensive and is outstanding for risk evaluation."

Dr. A. Meher Prasad, Engineer and India risk expert, peer reviewer of the AIR model.

BI-MODAL CYCLONE SEASON

Interrupted by the India Summer Monsoon, the North Indian basin has two peaks in annual tropical cyclone activity: pre-monsoon (May/June) and post-monsoon (October/November). Midsummer monsoon winds propel strong wind shear over the basin, which inhibits tropical cyclone development and intensification.



The North Indian Ocean basin exhibits two peaks in the seasonal distribution of tropical cyclone activity.

Flood Component Incorporates Detailed Information on Soil Type, Land Use/Land Cover, and Topography

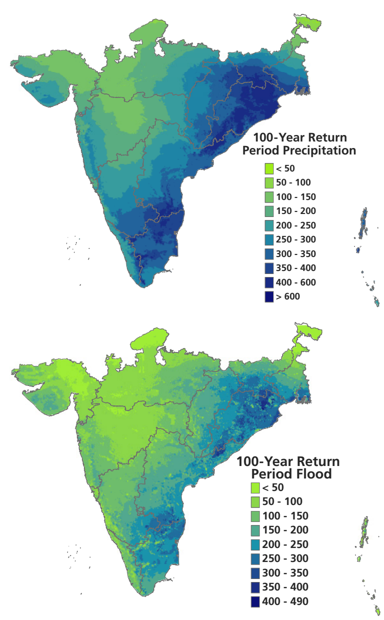
Unlike tropical cyclone winds, which generally decrease as a storm moves inland, precipitation intensity and the related flood hazard can actually increase. As such, precipitation-induced flooding can be a major driver of insured loss from India cyclones.

The AIR model employs a separate module that is used to determine the spatial distribution of accumulated runoff. Using data about storm size, intensity, and rainfall characteristics, the model captures an hourly precipitation footprint at each location over the entire duration of the storm. Slower moving storms subject locations to higher rainfall totals; thus even weak-wind storms can result in extensive flooding if they have a slow forward speed.

The redistribution of rainfall depends on soil type, land use/land cover, and slope—all of which determine what fraction of precipitation is absorbed. If the soil is sandy, a higher fraction will percolate down than if the soil is clay. Similarly, if the land is forested, more precipitation will be absorbed than in a paved urban environment. All else equal, less precipitation will be absorbed on a sloped surface than on one that is flat. The precipitation that is *not* absorbed is then transported downhill in the direction of the steepest gradient.

Leveraging AIR's Detailed Industry Exposure Database for India

To generate reliable estimates of industry losses, the AIR model incorporates a comprehensive, high-resolution industry exposure database (IED) that includes residential, commercial and industrial properties. AIR builds the IED by compiling detailed information about risk counts, building attributes and replacement values, as well as information on standard policy terms and conditions from a collection of local sources, including India's Central Statistics Office, the Insurance Regulatory and Development Authority, and the India Central Public Works Department. Because raw exposure data can vary in resolution, AIR employs a sophisticated algorithm to disaggregate all risk counts to a 1-km grid. When detailed, location-specific exposure data is not available, companies can leverage the IED using AIR's detailed modeling capabilities to disaggregate their coarse resolution data to a higher resolution that accurately reflects the spatial distribution of industry exposures.



Using high-resolution data on land use/land cover, soil type, and topography, the model translates (top) precipitation to (bottom) accumulated runoff, or flood. (Source: AIR)

Separate Damage Functions for Wind and Flood

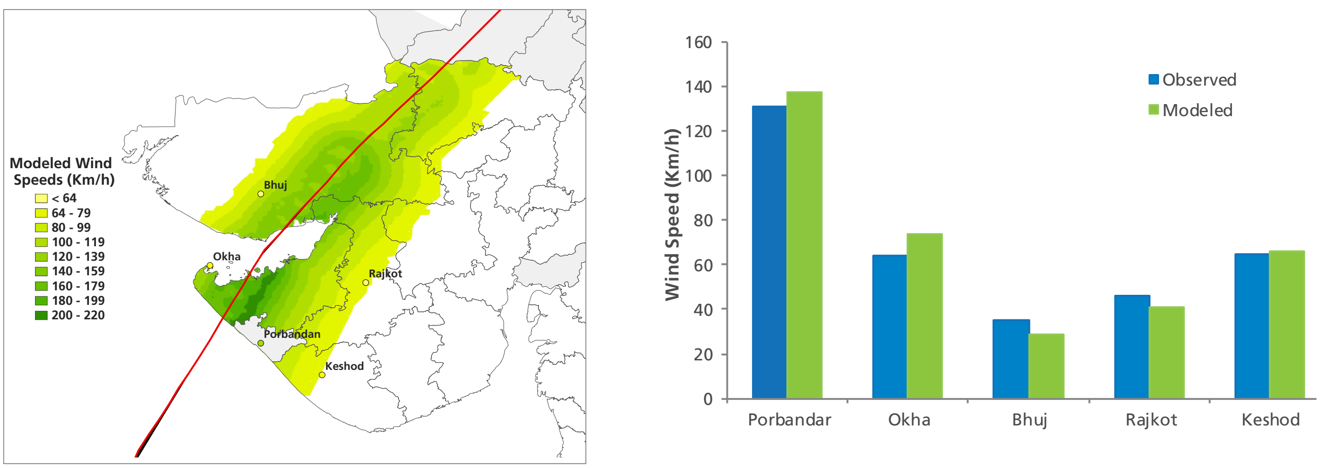
Damage functions capture the relationship between the hazard and the vulnerability of affected structures. The model incorporates separate damage functions for the wind and flood perils, as well as by coverage (buildings, contents, and time element); damage functions vary by construction, occupancy, and height. For buildings with unknown construction, occupancy, or height characteristics, the model employs weighted averages of known vulnerability functions based on the regional distribution of these characteristics.

For companies with Construction All Risks/Erection All Risks (CAR/EAR) exposures, the model employs damage functions that capture the time-dependent nature of both the vulnerability and replacement cost of buildings under construction.

Comprehensive Approach to Model Validation

To produce realistic and robust model results, AIR builds its models from the ground up, validating each component independently. For example, the AIR modeled wind speeds and precipitation totals are validated against historical storm data provided by the India Meteorological Department, International Best Track Archive for Climate Stewardship, and Tropical Rainfall Measuring Mission, among other sources.

AIR also validates its models from the top down, comparing modeled losses to industry loss estimates and company data. AIR's comprehensive approach to validation confirms that overall losses are reasonable and that the final model output is both consistent with basic physical expectations of the underlying hazard and unbiased when tested against historical and real-time information.



Modeled wind speeds for the Gujarat cyclone show good agreement with observed maximum wind speed values. (Source: AIR)

A COMPONENT-BASED APPROACH TO MODELING COMPLEX INDUSTRIAL FACILITIES

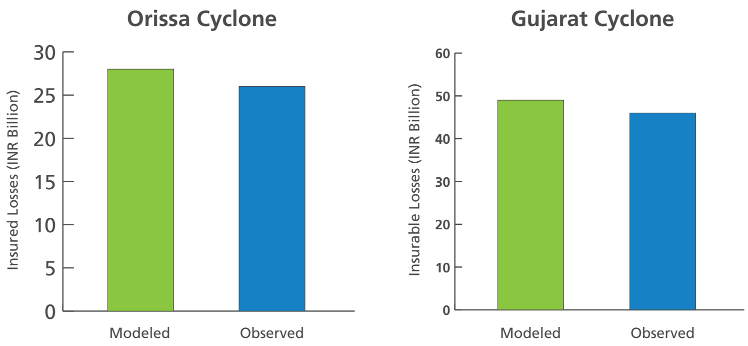
The AIR model employs a component-based approach to estimate potential loss from tropical cyclone winds and flooding to complex industrial facilities. AIR assesses the overall vulnerability of over 60 different facility types (e.g., chemical plants, oil refineries) based on the vulnerability of the individual assets—the components and sub-components—that the facility comprises. The model implicitly accounts for more than 500 distinct industrial components, which have been identified through detailed, site-specific engineering-based risk assessments conducted through AIR's Catastrophe Risk Engineering (CRE) practice.

Supports a Wide Array of Policy Terms and Conditions

The AIR Tropical Cyclone Model for India supports a wide array of policy terms and conditions, including local limits and deductibles, and policy limits and deductibles.

The model takes full advantage of detailed exposure information when available, including the construction, occupancy, age, and height of each structure, location-specific geographical characteristics (e.g., land use/land cover, elevation, and topography) and geological information (e.g., soil type and permeability). It also takes advantage of local insurance policy and reinsurance treaty terms.

Companies with aggregate-level exposure can make use of AIR's high-resolution IED to disaggregate their data for detailed catastrophe analyses.



As a final test in AIR's comprehensive model validation process, modeled losses are compared against reported losses for historical storms at an industry level. Here modeled insured losses are compared against reported losses for the Orissa Cyclone, and for the Gujarat Cyclone, modeled insurable losses are compared to insurable losses derived from reported economic losses.

Model at a Glance

Modeled Perils	Tropical cyclone winds and precipitation-induced flood
Supported Geographic Resolution	CRESTA/state, district, 6-digit postcode resolution, and can accept user-specified latitude/longitude
Stochastic and Historical Catalogs	Number of events in the stochastic catalog: 35,242 Historical events available: Andhra Pradesh (1990), Gujarat (1998), Orissa (1999)
Supported Lines of Business	Residential, commercial, industrial, and CAR/EAR
Vulnerability Module	Separate wind and flood damage functions for 19 construction types and 114 occupancy classes estimate losses to buildings, contents, and time element coverages. Accounts for the impact of height and year of construction on building vulnerability.

Model Highlights

For more information regarding AIR's Tropical Cyclone Model for India, please contact your AIR representative.

- Peer-reviewed model provides coverage for 16 states on the Indian subcontinent, accounting for tropical cyclone activity along both the Arabian Sea and Bay of Bengal coastlines
- Incorporates the latest land use/land cover data to capture the directional effects of surface friction
- Explicitly models precipitation-induced flood losses by assessing the accumulated run-off from a storm's precipitation totals
- Directly accounts for the effect of wind duration on damage
- Provides separate damage functions for the wind and flood perils, by coverage; damage functions vary by occupancy, construction, and height
- Damage to large industrial facilities modeled using an objective, engineering-based, component-level approach
- Supports damage estimation to residential, commercial, and industrial buildings under construction

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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