The AIR Severe Thunderstorm Model for Australia

Billion dollar losses from severe thunderstorms are no longer a rare occurrence in Australia. The 2014 Brisbane hailstorm and the 2010 hailstorms in Perth and Melbourne each broke the billion dollar mark, and the 1999 Sydney hailstorm—the costliest natural disaster in Australia's history—would cause nearly AUD 4.6 billion in insured losses if it were to recur today. The AIR Severe Thunderstorm Model for Australia provides a countrywide, comprehensive view of risk by sub-peril never before available for this region.

AIR®

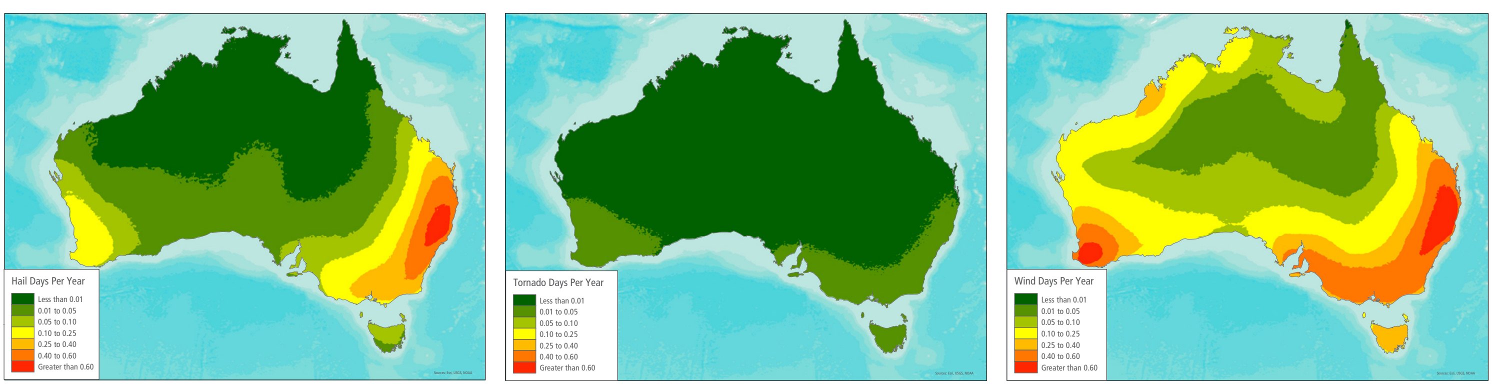
In Australia, severe thunderstorms occur more frequently and cost more annually than any other atmospheric peril; they account for one-third of the costliest natural catastrophes in Australia from the past 50 years, according to the Insurance Council of Australia (ICA). Loss potential is increasing as property replacement values rise in the densely populated cities of Adelaide, Brisbane, Canberra, Melbourne, Perth, and Sydney, and the number of insurable exposures continues to grow as development expands into previously unpopulated areas.

The industry's first comprehensive severe thunderstorm model for the country, the AIR Severe Thunderstorm Model for Australia explicitly captures all three sub-perils—hail, tornado, and straight-line wind—nationwide to help companies assess and manage the risk. Because aggregate losses from severe thunderstorms can result in extreme volatility in financial results, a robust and highly granular view of the risk is critical for organizations to make risk management and mitigation decisions and develop resilience strategies.

An Innovative Way to Model Storm Occurrence

The AIR model utilizes historical data from Australia's Bureau of Meteorology (BOM) Severe Storms Archive, which comprises storm reports from a trained weather spotter network. But because the data depend on eyewitness reporting, they contain an inherent bias.

To compensate for reporting bias in the historical data, AIR employed a hybrid physical-statistical method to "smart smooth" the BOM reports to physically realistic locations, including areas that may not have experienced major activity in the brief historical record. Smart-smoothing blends Climate Forecast System Reanalysis (CFSR) data—which includes information about atmospheric conditions conducive to severe thunderstorms—with BOM storm reports data. This technique results in a spatially complete catalog of simulated events and gives companies a more accurate view of their severe thunderstorm risk.



These three maps show the model's annual spatial distribution for all hail, tornado, and straight-line wind "hits," respectively. The key specifies how many occurrences there are per year in a particular location.

Accounting for Highly Localized Effects

Thunderstorm weather systems can last for several days and affect multiple states, but the individual tornadoes, hail swaths, and straight-line wind swaths (the “sub-perils”) that make up an outbreak may last for just minutes and affect highly localized areas. To capture the localized effects, AIR developed high-resolution event footprints specific to each sub-peril.

Because BOM and CFSR do not provide footprint dimensions, the model groups events that are close in space and time using clustering algorithms developed by AIR to create realistic individual outbreak patterns—patterns that would not be possible using random sampling alone. AIR’s event footprints, whose realistic size and shape are based on historical observation rather than on an artificially imposed grid size, are the key to the model’s ability to generate robust tails of the exceedance probability curve.

Daily Simulation Captures Large and Small Loss-Causing Events

The AIR model simulates daily severe thunderstorm activity based on historical occurrence rates and local and seasonal weather patterns. The daily simulation enables the model to capture both the large outbreaks that produce insured losses in excess of AUD 10 million—the ICA threshold for a catastrophic event—and smaller events that may last only one day, but that could still impact a company’s portfolio on an aggregate basis, or a more rural portfolio on an occurrence basis.

AIR offers 10,000- and 100,000-year stochastic catalogs. The availability of more simulated events, along with smart-smoothing, allows for a more granular view of the risk, making the model ideal for use in ratemaking and underwriting. In addition, the model features eight historical events and four Extreme Disaster Scenarios.

Sub-Peril—Specific Damage Functions Reflect Unique Damage Mechanisms

Because hailstorms, tornadoes, and straight-line windstorms inflict damage differently, the model’s damage functions are sub-peril–specific to provide the most accurate estimates of loss. For both straight-line winds and tornadoes, damageability is modeled as a function of the 3-second gust wind speed. Hail damage is a function of hail impact energy, which takes into account storm duration, the density

Top: Blue tarps cover half the roofs pictured due to damage from the 1999 Sydney hailstorm (Source: Commonwealth of Australia (Geoscience Australia) 2015). Bottom: This property suffered severe damage from straight-line wind.

of individual hailstones, the distribution of hailstone sizes within an area, and the accompanying wind speed.

The model’s damage functions are based on engineering analyses of constructions practices, Australia and New Zealand building code design requirments, lessons learned from damage surveys, as well as claims data analyses, including industry loss data from the the ICA. Detailed analyses of these claims data also reveal that the uncertainty around the mean damage is also sub-peril–specific, a feature captured in the model. Touchstone® allows companies to analyze results for each sub-peril individually, as well as for all three sub-perils combined, thereby giving further insight into a highly complex risk.

Reflecting Regional and Temporal Variations in Vulnerability

The model's damage functions incorporate findings from AIR's comprehensive study of the adoption and enforcement of building codes throughout the country, changes in building materials and construction practices, structural aging and mitigation features, as well as other factors that affect vulnerability. Year-built modifiers provide highly granular differentiation of vulnerability across states/territories and time.

Other highlights of the AIR model's vulnerability module include:

- Support for 44 construction classes and 110 occupancies for hail, tornado, and straight-line wind
- Use of year built and building height to further differentiate vulnerability
- Damage functions for personal automobiles, commercial automobiles (car dealerships), and large industrial facilities for each sub-peril
- Unknown damage functions vary by CRESTA to account for the regional distribution of building stock

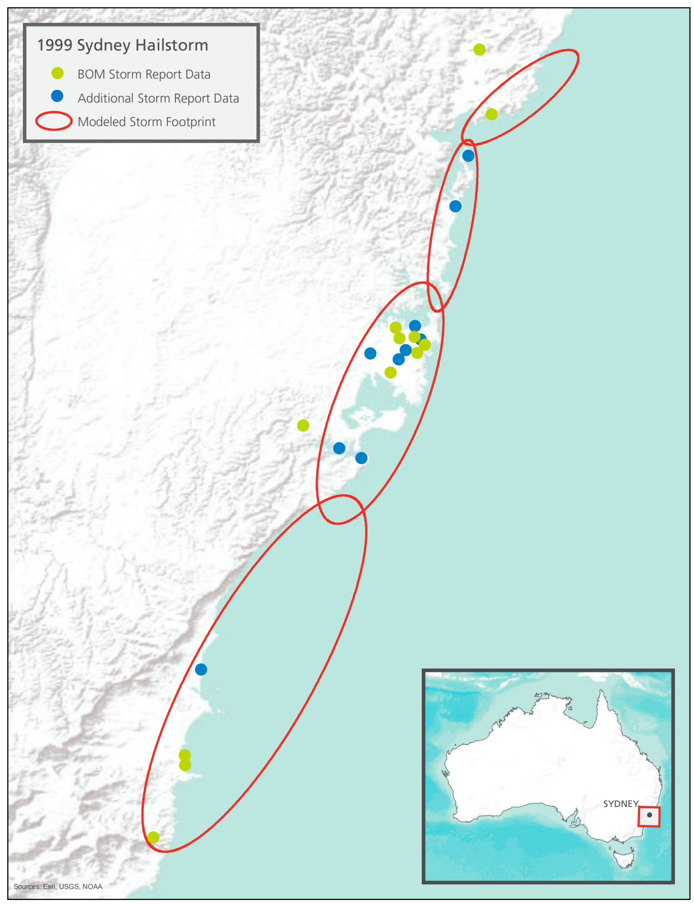
Leveraging AIR's Detailed Industry Exposure Database for Australia

AIR has developed a high-resolution industry exposure database (IED) for Australia that is based on the latest available information on risk counts, building characteristics, and construction costs from a wide variety of local sources. The benefits and uses of AIR's IED are numerous. It provides a foundation for all modeled industry loss estimates. Risk transfer solutions, such as industry loss warranties that pay out based on industry losses, rely on the IED. Using AIR's detailed modeling application, companies can also leverage the IED for Australia to disaggregate the exposure data in their own portfolios to a highly detailed level for improved loss estimates.

The IED is also used to estimate damage functions for exposures with one or more primary building features missing—for example, when the building occupancy is known, but theconstruction material and/or building height is missing. The model uses regional building inventory data to estimate the damage functions for risks with unknown features as a weighted average of damage functions for buildings with known features and weights calculated from the regional demographics of the building stock, leveraged from the IED. Each CRESTA in Australia has damage functions that account for regional differences in the building stock.

Comprehensive Approach to Model Validation

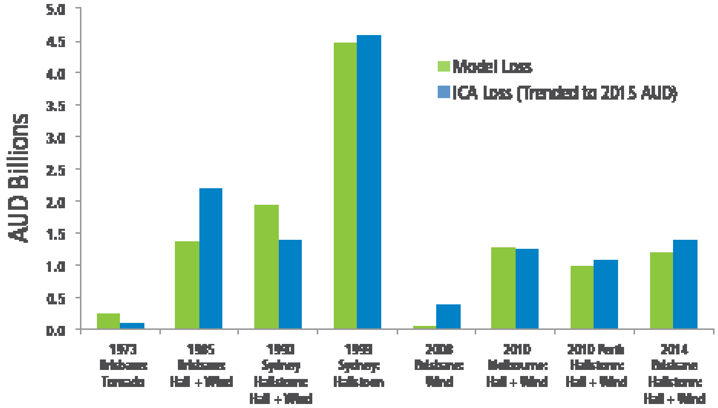
The AIR Severe Thunderstorm Model for Australia is carefully validated against actual loss experience. However, validation is not merely limited to final model results. For example, the annual frequency and seasonality of hail, tornado, and straight-line wind events is validated against historical data (e.g., lightning and storm reports) and published studies. The efficacy of the model's damage functions was validated through the analysis of claims data and damage surveys conducted in the



The modeled footprint of the 1999 Sydney hailstorm aligns well with storm report data from the Bureau of Meteorology and additional sources, showing good agreement between historical and modeled events.

aftermath of severe thunderstorms, including those conducted by the Cyclone Testing Station (CTS) at James Cook University, and information leveraged from AIR's other existing Australia models.

Modeled losses are extensively validated against loss data from organizations and companies, including the ICA, BOM, and published reports. In the figure, sample model losses for the model's eight marquee events are compared to trended ICA losses.



Modeled losses for the model's eight marquee events in Australia show good agreement with reported losses.

Model at a Glance

Modeled Perils	Hail, tornado, and straight-line wind
Model Domain	Continental Australia and island of Tasmania
Stochastic Catalogs	10,000- and 100,000-year all-events catalogs, eight historical events, and four Extreme Disaster Scenarios (EDS)
Supported Geographic Resolution	Touchstone and CATRADER®: Country, state/territory, CRESTA, and postal code levels
Supported Construction and Occupancy Classes	– 44 construction classes and 110 occupancies for hail, tornado, and straight-line wind – Automobile and cars in dealerships – Large industrial facilities
Industry Exposure Database	– 1-km grid resolution – Detailed representation of residential, commercial, and industrial building stock

Model Highlights

— Integrates statistical modeling with the latest meteorological research
— Captures the highly localized effects of straight-line winds, hail, and tornadoes
— Daily simulation captures the impact of both large and small loss-causing events
— Sub-peril–specific damage functions developed based on claims data, latest scientific research, post-disaster damage surveys
— Accounts for regional and temporal variations in sub-peril vulnerability—which capture the local building practices and characteristics (such as age and height)
— Unknown damage functions vary by CRESTA to account for the regional distribution of building stock
— Features sub-peril–specific damage functions for large industrial facilities and automobiles
— Validated against historical loss data from government and industry sources

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.