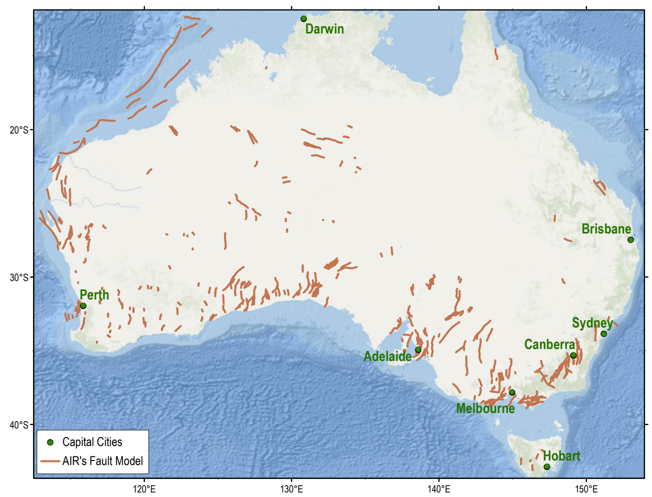
AIR Earthquake Model for Australia

In 1989, an M5.6 earthquake struck Newcastle, New South Wales, damaging 35,000 homes and 3,000 businesses and causing insured losses that rank it among Australia's costliest natural disasters. AIR estimates that if this earthquake were to recur today, it could cost insurers more than AUD 7.3 billion. Companies operating in this market need authoritative tools to identify the risk management strategies that will mitigate the impact of the next catastrophe.

AIR

The AIR Earthquake Model for Australia provides a significant level of detail enabling superior risk differentiation based on factors including seismicity, ground motion attenuation, site soil condition, local design requirements, construction class, occupancy type, building age, and height.



The AIR model uses 391 neotectonic features to constrain the location, upper-bound magnitude, and faulting style of large magnitude stochastic events.

Integrates All Viable Theories of Regional Seismic Activity to Provide a Comprehensive Risk View

Far from the boundaries of tectonic plates, Australia is characterized as a stable continental region, which means data on historical seismicity and active faults are scant. To augment the sparse historical record and capture variation in earthquake risk despite low seismicity, the AIR model makes use of information about neotectonic features (weak zones in the crust or faults ruptured by prehistoric seismic events) that are likely locations for future large earthquakes. Our historical catalog is complete to the end of 2018 with magnitudes homogenized to a common moment magnitude (Mw) scale using different regression relationships that reflect different patterns in the data observed for earthquakes that occurred either before or after 1990.

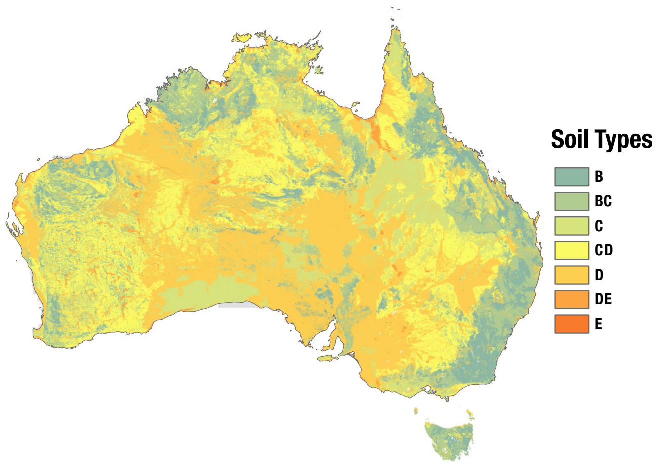
To accommodate uncertainty surrounding the locations of past earthquakes, the model features a background seismicity component, which allows simulated earthquakes to occur anywhere within a seismic source zone, including locations where none have been previously known to have occurred.

Ground Motion Prediction Equations and High-Resolution Soil Data Capture Shaking Intensity at Each Site

The geological environment of western Australia closely resembles that of the central and eastern North American craton (stable continental region). Eastern Australia experienced some uplifting, folding, and volcanism as the continent drifted away from the Antarctic. Therefore, the rock underlying much of eastern Australia is not as old, hard, or cold as the craton in western Australia.

To account for this variability in the geological environment, the model employs two sets of ground motion prediction equations (GMPEs) tailored for western and eastern Australia, respectively. These two sets of GMPEs provide a comprehensive approach to estimating ground motion throughout different areas within Australia. Each set contains the latest GMPEs relevant for eastern and western Australia to better capture the epistemic uncertainty inherent in estimating ground motions in tectonically stable regions.

The modeled ground motion also accounts for local soil conditions, which can dramatically alter the intensity and frequency content of surface ground shaking at the location of a risk. AIR has used geological maps and geotechnical data to develop soil classification maps at various scales—including resolutions as fine as 100 meters in the most populated areas.

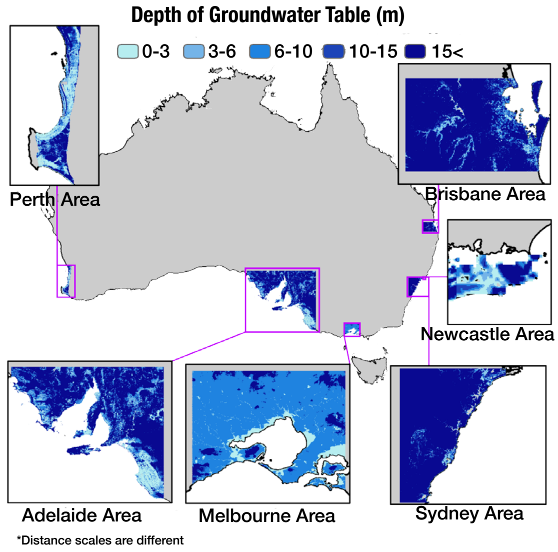


Enhanced soil maps with resolutions as fine as 100 meters in metropolitan locations help to accurately capture the effect of site amplification.

Advanced Liquefaction Modeling for Coastal Areas of High Exposure Concentration

Liquefaction occurs when soil saturated with water is shaken violently and temporarily loses its strength. It becomes unable to support the weight of buildings above it, causing them to tilt or even topple over. Differential settlement as liquefied soil shifts can break buried utility lines and float pipelines and ducts to the surface.

The AIR model features a liquefaction module covering areas of high exposure concentration along the coasts. The potential for liquefaction depends on soil properties near the surface and the amount of saturation due to groundwater depth. Input data for modeling liquefaction includes soil classification maps and maps of groundwater depth developed by AIR using water well log data from local agencies and high-resolution topographic data.



Groundwater depth data were developed from borehole logs and hydrological models for five liquefaction-modeled areas in Australia.

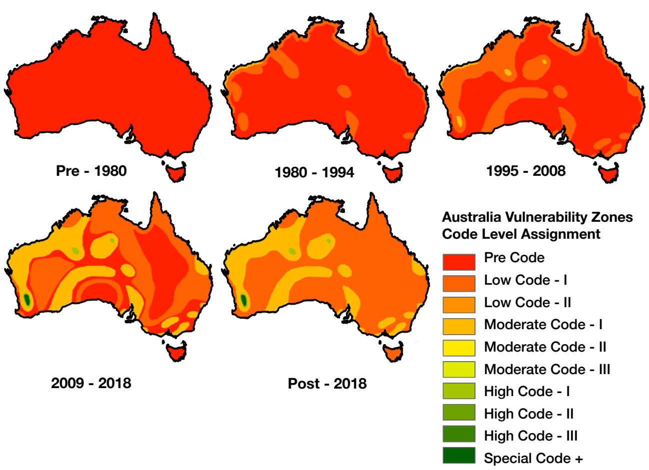
Damage Functions that Capture Regional Differences in Vulnerability

The vulnerability of Australia's building stock can vary regionally due to differences in building codes and preferred construction practices based on climate and historical earthquake and tropical cyclone experience. The AIR model supports 127 distinct construction classes and 114 unique occupancy classes. The vulnerability of buildings is further refined by height class (low-rise, mid-rise, high-rise, and tall) and by the year in which they were built.

Vulnerability has changed with the emergence and ongoing revision of building codes governing prescribed earthquake and wind loading. To account for this, buildings are classified in the AIR model into five seismic design code levels from minimal earthquake resistance to a more robust level of structural design. As a result, AIR damage functions for any given construction and occupancy class can vary based on these seismic design code levels which are determined by a building's location and the year in which it was built

MASONRY VENEER CONSTRUCTION: A POPULAR CONSTRUCTION FOR HOMES IN AUSTRALIA

Masonry veneer, one of the construction classes supported by the model, comprises 35% of the single-family dwellings across Australia, with significant popularity in the southeastern part of the country. It uses wood frame stud walls as the lateral force resisting system, accompanied by a nonstructural unreinforced masonry veneer linked to it with clips or ties. Forces and deformations can be transferred between the masonry veneer façade and the structural wood framing during ground shaking. Given the substantial weight and brittle nature of the masonry veneer, this type of construction is much more vulnerable than wood frame housing with lighter exterior cladding.



The AIR model captures the temporal and spatial variation in the vulnerability of buildings in Australia through five age bands: pre-1980, 1980-1994, 1995-2008, 2008-2018, and post-2018. These bands reflect the revision, adoption, and enforcement of relevant building code updates.

A Component-Based Approach to Modeling Large Industrial Facilities

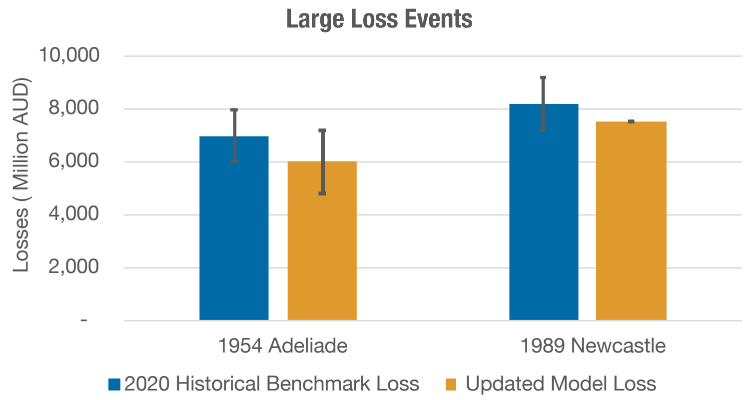
Damage functions for more than 400 individual industrial facility components—including tanks, flares, boilers, cooling towers, and conveyor systems—are aggregated to obtain damage functions that represent the vulnerability of large industrial facilities at the facility-level. These damage functions are developed using weights that reflect the proportion of each component's contribution to total replacement value of the facility. This component-based approach provides reliable assessment of not only the physical damage to the facility but also business interruption losses, which depend heavily on the interactions between the facility components.

Leveraging AIR's Detailed Industry Exposure Database for Australia

AIR has developed a high-resolution industry exposure database (IED) for Australia based on 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. Furthermore, risk transfer solutions, such as industry loss warranties that pay out based on industry losses, rely on the losses obtained by analyzing the IED. Using Touchstone®, companies can also leverage the IED for Australia to disaggregate the exposure data in their own portfolios to a highly detailed level for more realistic loss estimates.

A Comprehensive Approach to Modeled Loss Validation

Each individual model component has been independently validated against multiple sources and data from historical events. For example, the seismicity component is validated against the catalog of historical events, the ground motion intensity module is compared against ground motion recordings, simulated liquefaction has been compared against observed occurrences of liquefaction, and modeled damage ratios have been validated against damage experience in published reports. In addition to these component-level validations, the loss estimates produced by the AIR Earthquake Model for Australia for past earthquakes have been validated against loss reports for historical events in Australia.



AIR's modeled losses for select earthquake events in Australia show good agreement with reported losses. (Vertical bars depict variation in reported losses from multiple sources.)

Model at a Glance

Modeled Perils	Ground shaking from earthquakes and liquefaction
Model Domain	Continental Australia and island of Tasmania
Supported Geographic Resolution	1-km grid
Supported Construction Classes and Occupancies	127 construction classes; 114 occupancy classes 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 CRESTA-specific construction characteristics
Industry Exposure Database	Provides a foundation for all modeled industry loss estimates; can be leveraged to disaggregate exposure data to a highly detailed level for improved loss estimates; includes selected large industrial facilities (IFMs)

Model Highlights

— Includes thoughtfully developed relationships to consistently homogenize various earthquake magnitude scales to moment magnitude

— Employs neotectonic faulting, an innovative approach to capturing earthquake hazard in a relatively seismically stable region such as Australia

— Utilizes the latest high-resolution soil maps to capture the effect of site amplification on ground motion

— Employs two sets of GMPEs that have been tailored to the distinct attenuation properties of eastern and western Australia, based on the latest research for both stable continental and active regions, considering both locally sourced and globally available data

— Includes a liquefaction module, covering areas of highest exposure concentration along the west, south, and east coasts of Australia

— Contains a suite of damage functions that has been vastly expanded to support numerous construction and occupancy classes

— Damage functions are also region-specific to capture spatial and temporal variations in vulnerability across Australia resulting from evolving seismic and wind design requirements

— Extensively validated vulnerability functions have been compared against published research and observed damage from historical earthquakes

— Complete model has been comprehensively validated against observed intensity, damage, and loss data from various historical events

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 incidents. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, longevity modeling, 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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