



Aerial photograph of a coastal landscape with green fields and a yellow coastline.

[http://www.aon.com/austria/products-and-services/
reinsurance/attachements/impact_forecasting_global_2008.pdf](http://www.aon.com/austria/products-and-services/reinsurance/attachements/impact_forecasting_global_2008.pdf)
(retrieved 11 November 2016)

IMPACT FORECASTING

Global Model Coverage

Aon RE GLOBAL

IMPACT FORECASTING and ELEMENTS

Impact Forecasting, LLC, a wholly owned subsidiary of Aon Re Global, is a catastrophe modeling center of excellence whose seismologists, meteorologists, engineers, mathematicians, finance, risk management and insurance professionals analyze the financial implications of natural and man-made catastrophes around the world.

Impact Forecasting provides best-in-class catastrophe modeling insight to Aon Re Global clients. Impact Forecasting's detailed loss model, Elements, is an open-box model that allows full transparency. Elements gives users the ability to adjust frequency assumptions, have their own loss experience loaded into the model through custom damageability curves, and receive the benefit of an investment of more than 14 years and \$120 million in the creation of this world-class suite of catastrophe models. Elements is the only model that is completely open for review, as well as the only model that has been developed to allow easy modification of assumptions and report generation.

North American Models

Impact Forecasting has developed a robust suite of models for a wide variety of perils in North America. This includes the first western United States brush fire model, the first terrorism model available post-9/11, and the first deterministic riverine flood model.

United States Peril Models

- > Earthquake and Fire Following Earthquake
- > Hurricane
- > Offshore Oil Platform (Gulf of Mexico)
- > Storm Surge and Coastal Flooding using state-of-the-art SLOSH research
- > Tornado / Hail
- > Terrorism

- > Workers' Compensation / Life for Earthquake and Terrorism

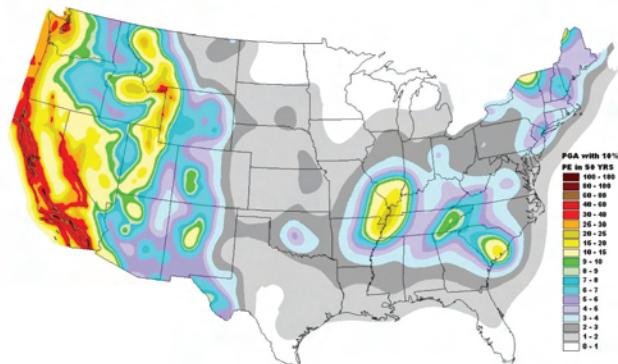
- > Multi-Peril Crop
- > River Flood
- > Western Wildfire

Canada Peril Models

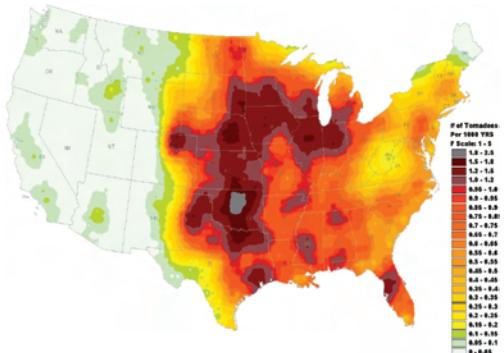
- > Terrorism: Property and Workers' Compensation / Life

U.S. EARTHQUAKE MODEL

The earthquake model for the United States considers faulting along both established faults and earthquake locations spread over a broad area. Along with established faulting along the San Andreas in California, earthquake faulting sources exist for the New Madrid region, Cascadia in the Pacific Northwest, and Charleston region in South Carolina. Earthquake hazard models also exist for the Hawaiian Islands, Caribbean region, and Alaska. The hazard model accounts for the latest research provided by the United States Geologic Survey (USGS). For example, the model includes the latest research earthquake modeling from the USGS, including modeling of crustal events using the "Next Generation Attenuation" relations and updates to the Cascadia hazard in the Pacific Northwest. Vulnerability modeling for building, contents and interruption damages are generated using state-of-the-art engineering processes.



U.S. TORNADO / HAIL / SEVERE WINDS MODEL



SPECIALTY CLASS MODELING

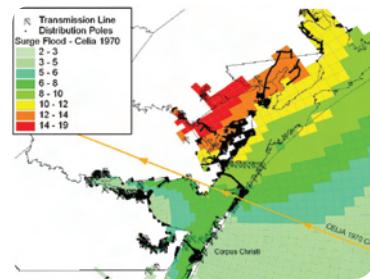
Our experts also employed specialty class modeling for unusual construction classes such as marine craft and electric transmission and distribution lines. Marine craft classes for various hull construction and boat length and are detailed in unique vulnerability classes. We also considered wind vulnerability modeling for transmission and distribution wire stock for electric utility assets.

U.S. COASTAL STORM SURGE AND INLAND FLOODING MODELS

Hurricane storm surge and inland flooding due to riverine inundation are two flood risk models in Impact Forecasting.

COASTAL STORM SURGE

Impact Forecasting modeled flood risk due to coastal storm surge from tropical cyclones, using a robust approach that considers various physical criteria, such as coastal sea water depth (bathymetry), temporal effects of the hurricane life-cycle, and local site conditions (30 meter resolution DEM elevations relative to mean sea level). We determined life-cycle modeling of the hurricane path and effects, using the same software technology employed by the National Hurricane Center (SLOSH). We calibrated vulnerability due to flood inundation against known depth-damage functions provided by the U.S. Army Corp of Engineers and recent hurricane experience for Hurricane Katrina.



INLAND FLOODING RISK

Impact Forecasting modeled inland flood risk due to river inundation for a suite of deterministic scenarios. A full probabilistic suite of inland flood events is scheduled for release in July 2008. The USGS survey provided historical river network gauge station data; in addition, thorough exposure mapping is available using DFIRM (digital flood insurance rate maps) from FEMA.



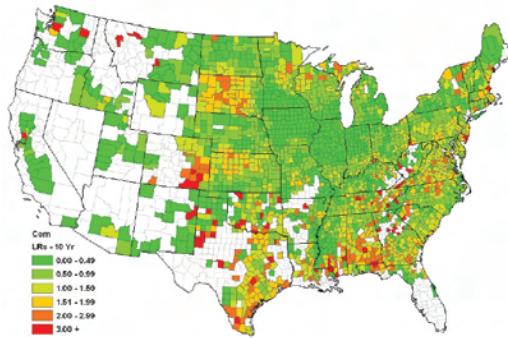
U.S. WESTERN WILDFIRE MODEL

Wildfire has become a phenomenon with large catastrophic outbreaks of fires across California and the western United States in recent years. We obtained historical wildfire data from the U.S. Forest Service and the CalFire. Our fire modeling considers: locations of historical fire perimeters; the effects of fuel loading due to timber, brush, or grassy fuels; and effects of slope conditions on suppression. Loss reporting includes consideration of multi-day duration and multi-event distance effects.



U.S. MULTI-PERIL CROP MODEL

The U.S. multi-peril crop model considers loss effects on agricultural crop insurance products due to variations in yield and revenue. Loss modeling includes consideration of crop yield effects due to variations in meteorological conditions in temperature and precipitation. Robust reporting features include the ability to provide guidance in USDA RMA reinsurance fund allocations.



TERRORISM MODELING

The Impact Forecasting terrorism model considers the consequences of various terrorist attacks against potential terrorism targets. Various attack types include both traditional blast due truck bombs and improvised explosives and unconventional attacks due to chemical, biological, radiological, and nuclear methods (CBRN). Target categories include high-profile commercial structures, sports stadiums, governmental buildings, military bases, chemical warehouses, petrochemical processing plants, utilities, and others. Flexible assumption options and "what-if" type reporting allow complete transparency in loss outcomes.

Terrorism models exist for the United States, Canada, Australia, United Kingdom, France and South Africa.



WORKERS' COMPENSATION AND LIFE MODELING

Impact Forecasting has developed models for workers' compensation or life risks due to earthquake or terrorism perils. Liability payouts are determined by exposure to death or injury from earthquake and terrorism occurrence. For earthquake peril, death and injury risk due to structure collapse is quantified. For terrorism peril, death and injury risk are modeled upon likely attack modes such as traditional explosive blast or unconventional attacks such as CBRN.

European / Middle Eastern / African Models

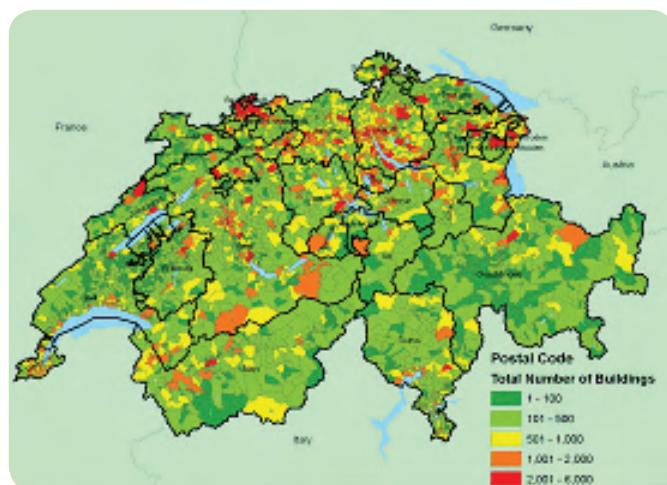
Impact Forecasting has developed a suite of EMEA models, in conjunction with many of the leading universities and research organizations. Impact Forecasting's first priority with EMEA models is to provide insight and modeling capabilities for those regions and perils where robust and credible models are not provided by other modeling firms. This included the development of the first cross-border model for Central and Eastern Europe capturing correlation between neighboring countries, and the first flood models used for pricing risk in the Belgian market. We will further expand this suite of models to meet our clients' specific requirements.

Earthquake	Terrorism	
> Greece	> UK	> South Eastern Europe
> Switzerland	> South Africa	> Romania
> Belgium	> France	> Bulgaria
> Austria	Flood	> Slovenia
> Germany	> Belgium	> Croatia
> Romania	> Germany	> Bosnia-Herzegovina
> South Africa	> Austria	> Serbia
Storm Surge	> Central and Eastern Europe	> Nordic
> Norway	> Poland	> Norway
> Germany	> Czech Republic	> Sweden
> UK	> Slovakia	
> France	> Hungary	

SWITZERLAND EARTHQUAKE MODEL

The Swiss Insurance Association, the Association of the Cantonal Building Insurance Offices and the Federal Office of Private Insurance started an initiative in May 2005 to develop a countrywide earthquake cover for Switzerland. While discussions continue to finalize the details of the form of coverage, the intention is to introduce compulsory insurance cover within the next two years.

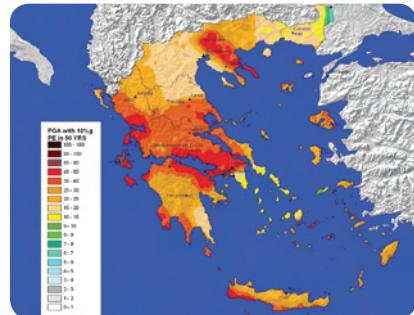
Impact Forecasting has worked with the Swiss Seismological Service at ETH Zurich, leading Swiss earthquake engineer Dr. Wenk and the EDAC group at the University of Weimar led by Dr. Jochen Schwarz to develop a high quality earthquake model based on the best local knowledge available to assess earthquake risk both for the proposed compulsory earthquake insurance scheme and for private insurers.



GREECE EARTHQUAKE MODEL

Aon Re Global's strong market presence in Greece coupled with this new Impact Forecasting model provides clients with a unique ability to understand earthquake risk in Greece, comparing the output from the commercial vendor models AIR, EQE and RMS with the Impact Forecasting model.

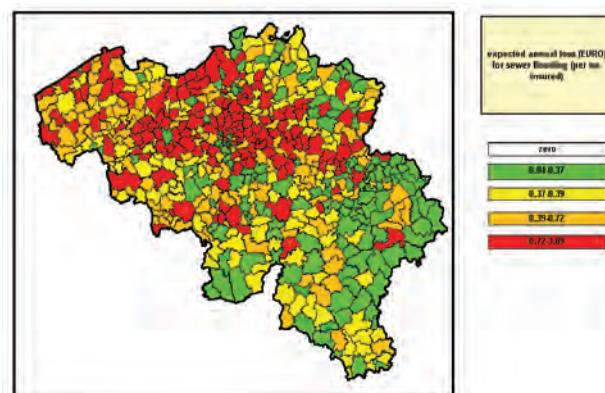
Aon developed this model to provide an open environment professional solution to assess catastrophe risk / reinsurance cover in Greece. In collaboration with Impact Forecasting, a team of Greek scientists including seismologists, geologists, engineers and insurance professionals developed this model, which provides the most up-to-date view of earthquake risk in Greece. The model includes a comprehensive industry exposure database that gives Aon Re Global and our clients a strong understanding of the mix of exposures.



BELGIAN NATURAL HAZARD RISK PRICING MODEL

As of March 1 2006, coverage of natural hazards has become a compulsory part of the standard fire insurance in Belgium. Impact Forecasting has been the first to develop a flood and earthquake model that allows insurers to estimate the expected frequency of flood losses for their portfolio as well as the annual average loss at a specific address for a given property type. Development of the model started in 2000 and it is now widely used within the Belgian insurance market to support the pricing of the risk, as well as for reinsurance calculations.

To develop the flood model, Impact Forecasting worked with Dr. Patrick Willems, senior researcher at the Hydraulic Department of the K.U.Leuven. In the June 2008 release the flood hazard maps compiled by the Walloon authorities are also integrated for users who are licensed to use these data. These maps embody an extensive and comprehensive R&D effort on flooding frequency and spatial extent. Dr. Thierry Camelbeeck, leading seismologist at the Royal Observatory of Belgium, provided input with regard to the seismic zones and upper-bound magnitude to setup the earthquake model. Assumptions on the seismic vulnerability and building typology were influenced by earlier R&D work performed by Impact Forecasting for Servizio Sismico Nazionale. Prof. Daniele Veneziano at MIT (Boston, Massachusetts) is an international expert on natural hazards and helped put together and review the methodology for both hazard types.



AUSTRIA AND GERMANY EARTHQUAKE MODEL

In 2006, the Austrian government in conjunction with the insurance association launched the HORA initiative to map flood and earthquake risks across the country. Aon joined the project as initial partner being responsible for the earthquake part.

The outcome is an open model based on a newly derived earthquake catalog (created by GFZ Potsdam and ZAMG Vienna) and regionalized damage functions (created by Bauhaus University Weimar) taking into account typical building stock as well as ground conditions.

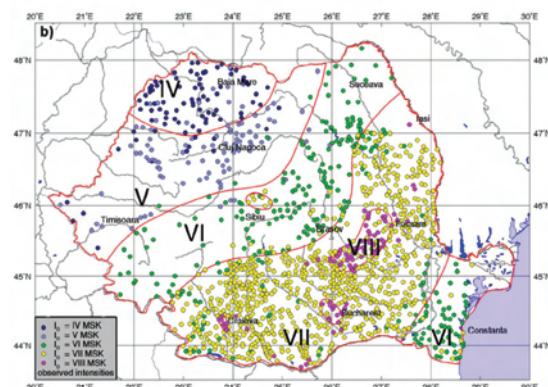
The hazard catalog covers Austria and surrounding areas up to 300km around Austria. The approach has been extended to South-West Germany.

ROMANIA EARTHQUAKE MODEL

Romania is one of the most seismically active countries in Europe, mainly due to deep earthquakes in the so-called Vrancea zone. The Vrancea source zone accounts for more than 95 percent of the released seismic energy in the country with the strongest earthquakes reaching magnitudes of almost $Mw = 8$ and causing large damages (local intensities up to IX X).

Instead of the usual radially symmetric pattern, the intensity distribution of the Vrancea intermediate-deep earthquakes is characterized by a kidney-shaped pattern. This anomalous intensity distribution implies the need to use an attenuation function that does not merely depend on distance to the epicenter and hypocentral depth. Aon therefore commissioned the GeoForschungs-Zentrum (Potsdam) with the elaboration of a new attenuation relationship for the intermediate-deep earthquakes in the Vrancea zone that realistically reproduces the observed pattern.

This new attenuation relationship, together with an updated earthquake catalogue (Grünthal and Wahlström 2007) and vulnerability functions that are specific to the country will be integrated into the Impact Forecasting earthquake model for Romania. This new state-of-the-art model is expected to be released before the end of 2008.



RIVER FLOOD MODEL FOR CENTRAL AND EASTERN EUROPE AND NORDIC REGIONS

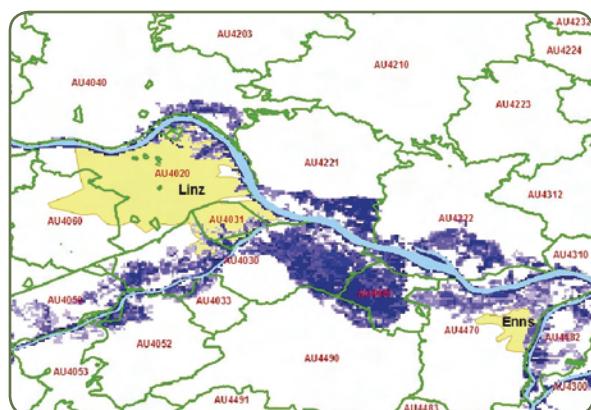
Flood continues to be a topic of concern to insurers, particularly in Europe. In response to the severe flooding in Europe in 2002 Impact Forecasting created the first cross-border model covering Austria Hungary, Czech Republic, Slovakia and Poland. The stochastic event set of floods used in this model cover the entire region, rather than each country individually and thus accounts for correlation in damages between countries. To develop this model, Impact Forecasting worked with hydrological consultant Hydro-GIS Ltd. The initiative was led by Dr. Harvey Rodda (Hydro-GIS), who previously worked on the RMS UK river flood model and later with Peter Brett Associates where he worked on both UK river flood assessments and on a Czech Republic flood model. Local hydrologists were engaged to build up a flood history database and to understand local data issues.

The flood scenarios consider both rainfall driven floods as well as those influenced by snow-melt. The model also takes account of local river defenses and includes a significant number of breach scenarios.

The EDAC group led by Dr. Jochen Schwarz at the Bauhaus University of Weimar in Germany developed specific flood damage functions for a range of building types (construction, height, age etc). This work included an analysis of a large database of actual flood claims from recent events in Germany and Austria.

Recently the model has been further extended to South Eastern Europe covering Romania, Bulgaria and the entire Danube basin (Croatia, Slovenia, Bosnia-Herzegovina and Serbia). The extension is fully integrated with the original CEE model such that the cross-border flood potential is correctly quantified.

A similar model has been also developed for Sweden and Norway, again covering both countries simultaneously. In the Nordic model also the possibility of storm-surge floods along the Norwegian coastline is accounted for.

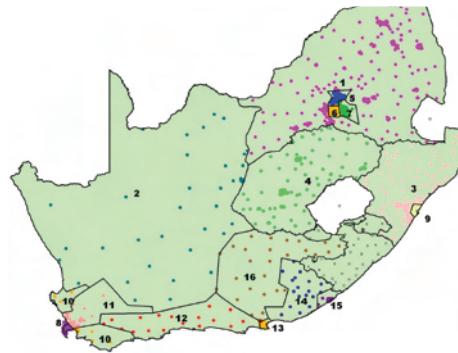


South Africa and Asia Pacific Models

SOUTH AFRICA EARTHQUAKE MODEL

While South Africa is less seismically active than other regions, it has experienced at least five events with a magnitude six or greater since 1800. In fact, in 1969 a Richter magnitude 6.3 earthquake northeast of Capetown virtually destroyed Tulbagh leaving many homes and businesses in ruin.

Impact Forecasting is therefore developing a seismic model also for this region. Specific to South Africa is that both natural seismic activity and mine related seismic activity occurs. To better understand their space-time-magnitude distribution, a M.Sc. study is started at the mining engineering department of K.U.Leuven. The study will be supervised by Dr. Jozef Van Dyck (Impact Forecasting) and Dr. Andrzej Kijko, leading seismologist at the Council of Geosciences, Pretoria. Jan Wium, professor at the University of Stellenbosch and chairman of the commission responsible for the Seismic Building Code in South Africa, has agreed to assist in the studies of existing building stock and vulnerability.



ASIA PACIFIC

Impact Forecasting has been developing models in Asia Pacific since the release of the Australian probabilistic cyclone model in 1997. Pioneering the use of catastrophe analysis for reinsurance purposes, the Impact Forecasting models have been used to provide valuable insight to our clients, and have led the way in educating the insurance industry in this region.

Australia Peril Models

- > Tropical Cyclone
- > Earthquake
- > Bushfire, Flood, Thunderstorm and Hail
- > Terrorism

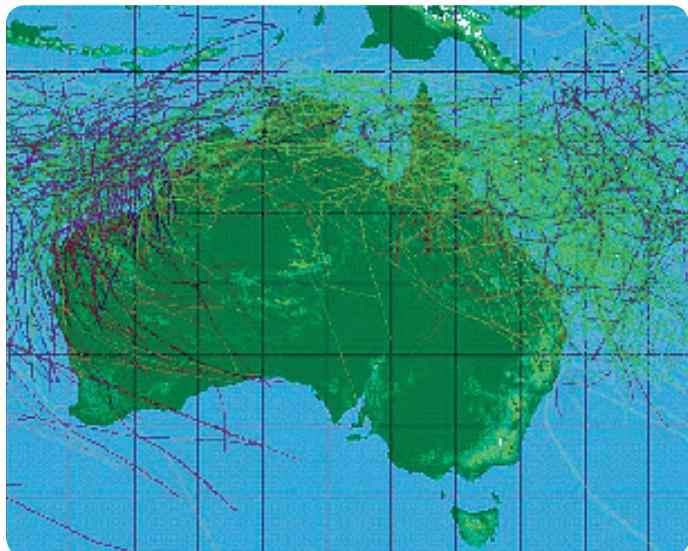
Japan Peril Models

- > Earthquake
- > Typhoon

New Zealand Peril Models

- > Earthquake

AUSTRALIA CYCLONE MODEL



Aon Re derived its Cyclone model from historic track information from the Bureau of Meteorology historic event database. We spent substantial effort in cleaning the database, for instance, by double-checking the records with the Queensland Weather Services.

A series of 100km segments running parallel to the coast, each roughly 50 km offshore, have been defined as gates. Cyclones are simulated starting through any of these gates, but following track patterns with characteristics similar to cyclones in the historic database – such as the distribution of central pressure, the eye movement speed, the eye radius and the storm direction of movement. Cyclones tracks are simulated until the storms fade away, either over land or sea.

Wind speeds at each location at each point in the event are determined using a proprietary wind model developed by Daneshvaran and Gardner (2001). This approach provides a method for accurately estimating wind speeds for an entire linear segment of a track between two time-based snapshots. This means that the Impact Forecasting model can calculate wind speeds during run time, rather than referencing a grid of wind speeds that were pre-generated and included in the software package for a fixed set of events.

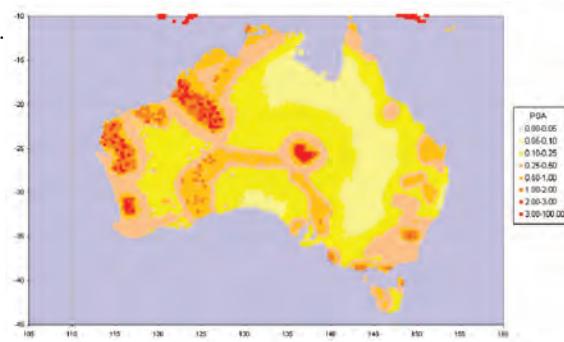
The wind speeds from the model are adjusted to take account of terrain and topography, using a database of adjustments created through analysis of the Australian Surveying and Land Information Group (AUSLIG) 1:25k scale ortho-photos for major cities and land coverage maps for the remainder of Australia.

We adapted the vulnerability functions in this model from U.S. vulnerability databases and compared them with the Australian Building Code specifications. The damage functions represent the various combinations of 21 different construction materials and allow for differences in construction pre- and post-1980. In addition, the model incorporates the varying codes levels in different regions of Australia, both due to the Australian Wind Code (AS1170.2-1989) and for other city-applied codes in places such as Darwin.

The model has previously been calibrated against a range of historic Australian events. Demand surge can be modeled in the Impact Forecasting Australia cyclone model.

AUSTRALIA EARTHQUAKE MODEL

The Impact Forecasting model is an exact implementation of the methodology the method outlined in Gaull et al. (1990). It is a simple yet reliable model where all parameters are known. The attenuation relationships are defined for Western Australia, South-Eastern Australia and North-Eastern Australia. As part of the model validation, exhibits in the paper were compared to the



measurements produced by the Impact Forecasting system for each of MMI, PGA and Peak Ground Velocity (PGV).

AUSTRALIA EARTHQUAKE MODEL CONTINUED

The model provides adjustment to the earthquake attenuation through a model of the effects of various types of rock and soil, implemented at the postcode level of resolution. Soil characteristics were determined for the Australian continent using geomorphic map data from the Generalized Geology of the World and Linked Databases.

Impact Forecasting developed damage functions to determine losses for each location as a function of post-soil-adjustment hazard. The damage functions, developed for analysis in the United States, represent a wide range of construction age, material, design building code, region and lateral force resisting system.

Representative Australian damage functions were chosen from this database based on a review of the Australian Building Code specifications outlined in AS1170.4-1993. In selecting the damage functions, we determined that the design code produced structures that were of reasonable construction compared to international standards, but specific earthquake-related safety measures in Australia were not required to be included. The design code is representative of a region with minimal earthquake hazard, as opposed to more hazardous regions such as New Zealand.

In total, there are 17 different construction types available under the PGA approach. With three coverage types, two code levels in Australia and three age bands, there are more than 300 damage functions available for Australia. Validation of the Impact Forecasting earthquake model included a review of the industry losses from the 1989 Newcastle earthquake.

The Impact Forecasting model is the only Australian earthquake model to incorporate simulation of demand surge. The model can also be used to simulate human injuries and deaths for use in analysis of workers' compensation or life insurance portfolios, as well as property. The individual events simulated generate losses to each of these three exposure types, thus allowing the combined risk to insurers from all three classes to be determined.

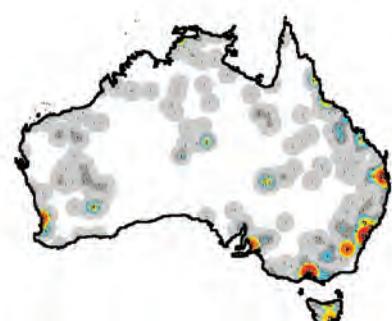
AUSTRALIA BUSHFIRE, FLOOD, THUNDERSTORM AND HAILS MODEL

Aspects of catastrophe modeling that are considered fundamental are the so-called "Other Perils" – all the possible losses due to natural hazards, with the exception of Earthquake and Cyclones. Understanding the losses derived from these perils is critical for any business, especially when determining retention levels on excess of loss reinsurance programs.

Impact Forecasting has developed a unique statistical model based on the ICA Loss losses from small but rather frequent losses for an Australian portfolio.

AUSTRALIA TERRORISM MODEL

In August 2003, Aon Re announced that it had built the first property and casualty terrorism exposure loss model specifically for Australian insurers, large employers and property owners.



The model details more than 2,000 high-profile targets across Australia, including commercial, government, infrastructure, transport, education and public places. It considers a range of potential attack modes, including conventional explosives, biological and chemical weapons.

NEW ZEALAND EARTHQUAKE MODEL

We constructed the New Zealand earthquake model as a component of Minerva, a Catastrophe Model / DFA system developed for the New Zealand Earthquake Commission (EQC). The main Hazard component was developed in conjunction with independent experts, Dr. David Spurr and Dr. Russell Kent, under the supervision of Aon employees Impact Forecasting embodied two principal types of model, source zone and smoothed seismicity, in its model.

Source zone is an older type of model and defines earthquakes in terms of time, magnitude, location and depth on a 10 km grid size. It divides the country into zones of uniform earthquake occurrence characteristics. Smoothed seismicity is a combination of distributed grid values of seismicity based on historical data for smaller more common earthquakes. The Impact Forecasting model simulates approximately 27,000 earthquakes based on area source. Fault-based methods use geological data reflecting occurrence and magnitude characteristics for the larger rare earthquakes. The model simulates 3,850 earthquake events on 156 faults.



Impact Forecasting uses the Campbell (1997) attenuation model, primarily developed for California, as regarded as one of the most robust models in terms of general application. It is typical of modern attenuation models that the complete model is designed to provide spectral information, peak ground acceleration and peak ground velocity based on local soil characteristics, and assumes a fault source, which takes into account fault type and geometry. Earthquakes are assumed to be in the crustal layer, and for universal use the Campbell model must be used in conjunction with a subduction zone attenuation model.

For subduction earthquakes, Impact Forecasting uses the Youngs et al. (1997) attenuation model, a model specifically developed for subduction earthquakes based on extensive data from subduction earthquakes around the Pacific Rim. The model differentiates between subduction slab earthquakes and subduction interface earthquakes, and differentiates between rock and deep soil.

The authors indicate that the relationships are appropriate for moment magnitudes greater than five and distances from 10 to 500 km from the rupture surface. In the Campbell model strike slip faults and normal faults are treated the same, and oblique strike slip faults are assumed to be intermediate between reverse faults and strike slip faults in their effect.

The model differentiates between hard rock, soft rock and firm soil with depths greater than 10m. It is not applicable to shallow soil and soft soil. The attenuation functions and soil adjustments used by the Impact Forecasting model are some of the most advanced anywhere in the world, with the Minerva earthquake model winning British Insurance Industry awards for its innovation.

JAPAN EARTHQUAKE MODEL

Modeling and understanding earthquake risk in Japan is complex. The Japanese insurance market typically relies on "black-box" catastrophe models, which impede users' understanding and confidence in the results generated because insurers are unable to customize the risk factors contained within them to suit their individual portfolio needs.

In response, Impact Forecasting has created its own model for Aon Re Japan, a fully transparent portfolio management tool, providing an independent view of risk. The Impact Forecasting model is open, data driven and modular. This unique open software design gives the user unprecedented access to significant modeling functions, including:

- > Various portfolio disaggregation options
- > Portfolio representation to individual site resolution
- > A choice of attenuation rules, both Japan specific and international
- > Scenario parameters including location, magnitude, depth, strike / dip angles, point and click fault selection and pre-defined historic earthquakes
- > Active fault parameters
- > Japan specific vulnerability models

Dr. David Spurr, a leading earthquake engineering consultant was a key contributor working closely with government research organizations and universities to use the latest data and information in the model including the time-dependent probabilities for all major fault systems.



DELIVERING VALUE TO CLIENTS

Impact Forecasting's client-focused approach ensures we develop modeling solutions driven by our clients' needs, focusing on new perils and territories where an adequate modeling solution is not currently available. Key benefits of our models include:

- > Tailored to each specific country
- > Uses the latest local knowledge and research
- > Completely open and transparent to our clients
- > Provides greater insights into the sensitivity of results to data and model assumptions
- > Covers all lines of business and coverage including business interruption

REGIONAL HEADQUARTERS – AON RE GLOBAL

AMERICAS (GLOBAL HQ)

Chicago, IL USA

t: +1 312 381 5300

f: +1 312 381 0160

ASIA PACIFIC

Singapore

t: +65 6221 8222

f: +65 6532 2977

EUROPE, MIDDLE EAST, AFRICA

Paris, France

t: +33 1 5875 7300

f: +33 1 5875 7777

UNITED KINGDOM

London, United Kingdom

t: +44 20 7623 5500

f: +44 20 7216 3826



200 East Randolph Street, Chicago, IL 60601
t: +1.312.381.5300 | f: +1.312.381.0160 | www.aon.com