RESEARCH BRIEF

Managing Physical Climate Risk: Leveraging Innovations in Catastrophe Risk Modelling

THE GENEVA ASSOCIATION

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Over the last 30 years catastrophe loss modelling (Cat models)—arguably the first InsurTech offering in the form of innovative tools— has revolutionised the (re)insurance industry's capacity to assess, price and manage risks of extreme events for property/catastrophe business and has provided a shared common language for risk transfer applications.

Today, the value of Cat models has also been recognised across many other sectors and users, leading to various derivatives of these models that are supported by development professionals, the financial sector and national to local governments, in making risk-based decisions. Cat models, conditioned on rapidly advancing Earth observations and climate change models, offer the opportunity for (re)insurers and other sectors to assess physical risk of climate change with a forward-looking approach building on the Financial Stability Board's Task Force on Climate-related Disclosure (FSB-TCFD) recommendations.

The expansion of Cat models for the (re)insurance industry has been 'demand-led.' With rising demand for Cat risk analytics from (re)insurers as primary drivers, a number of other factors have also contributed to the expansion of Cat models since the 1980s, including: (i) scientific progress on understanding of natural hazards and their characteristics (meteorological, hydrological, climatological and geological); (ii) engineering research and testing relating to impacts of hazards on the built environment; (iii) progress with geographic information systems; and (iv) various government-based initiatives and an increasing number of industry-academic partnerships.

Evolution of Cat models by peril, geography, application and provider since 1980s

By region and peril: The growing demand for insurance and reinsurance solutions in high-income countries with mature insurance markets has been the primary driver for steady expansion of Cat model coverage by peril and geography.

Perils

- Hurricane
- Earthquake
- Extratropical cyclone
- Severe thunderstorm
- Coastal flooding
- Inland flood
- Agriculture and wildfire
- Severe hailstorm
- Man-made perils
- Liquefaction
- Tsunami
- Landslide
- Rainfall-induced flooding

Regions

- U.S.
- Europe
- Japan
- Canada
- Australia
- New Zealand
- South America
- The Caribbean
- Southeast Asia
- China
- India

By provider: A variety of stakeholders are engaged in Cat model development, including three prominent Cat modelling commercial vendors, large insurance and reinsurance companies, reinsurance brokers and increasingly small specialised enterprises.

Source: The Geneva Association

By application: Beyond (re)insurance, Cat models are used in a variety of applications with potential for further expansion to other sectors

- (Re)insurers in property/ Cat business, development planning
- Agricultural insurance
- Financial and capital markets
- Public-sector disaster risk management
- Development planning
- Managing natural infrastructure

By multi-lateral Cat modelling partnerships and platforms: Emergence of industry-led and other international partnerships and platforms is providing new opportunities for coordinated engagement of scientists, risk modellers from the insurance industry, governments, academia and non-governmental organisations around the world.

These include:

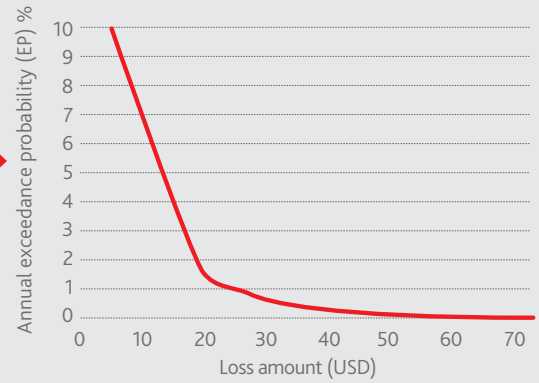
- (Re)insurance industry-led multi-lateral partnerships and platforms.
- Risk modelling initiatives of international organisations inspired by or leveraging Cat modelling.

The development of Cat models followed a series of insolvencies linked to a number of major catastrophes in the U.S. and Europe in the 1980s. For the past several decades, Cat models have served the (re)insurance industry well, facilitating a strong risk analysis and management culture as well as portfolio management practices of property risks throughout the industry value chain. Over the years, the (re)insurance industry's reliance on Cat models has increased to the point that in some jurisdictions the regulators require Cat models to be officially certified for use in the market.

Cat models are built on four key components

Hazard module	Exposure module	Vulnerability module	Financial module
Assesses the level of physical hazard across a region considering factors such as the topography, soil type, land use and built-in environment	Estimates of the location and event response characteristics of exposure.	Estimates the physical damage on the asset at risk, expressed in terms of a certain percentage loss of value to the exposure.	Monetises losses of the physical damages; estimates of insured losses are computed using insurance policy terms and contract structures.

Summary example results of an EP analysis



Stochastic event generation defines the hazard phenomena by simulating thousands of catastrophic events in time and space, based on historical hazard data.

Source: The Geneva Association

Effective development and utilisation of Cat models requires in-depth understanding of the underpinning assumptions, intended usage, and model limitations. There is much more that could be done to extend the value of Cat models for the (re)insurance industry. This requires a collective endeavour across (re)insurers, brokers, and model vendors not only to benefit further from the current framework but also to extend the Cat models' capabilities. Seven key issues need to be considered.

Seven key factors for Cat models

Methodologies

Traditionally, have relied on statistical techniques using empirical (observed) historical data of physical events

Data requirements, hazard, exposure and vulnerability

- Limited availability of historical data is a key challenge
- Quality of hazard and exposure data fed to models determine the quality of model output

Standards and interoperability

Lack of model standards and interoperability significantly burdens model users

Regulatory issues

Cat models and/or their users are subject to regulatory control in a handful of jurisdictions around the world

Open framework and open source versus restricted

Challenges related to open framework, open source versus restricted data and methodologies persist

Model validation and uncertainty estimation

Model validation is critical and resource-intensive for Cat model developers and model users

Resource requirements

Development and utilisation of Cat models is a multi-disciplinary and resource-intensive process

Source: The Geneva Association

Improvements and expansions in Cat modelling could not only benefit existing (re)insurance users but also a wider group of stakeholders from private and public sectors and the international community.

Opportunities for expanding Cat models for shaping the future of disaster and climate risk management

Expanding (re)insurance applications

- Business interruption
- Contingent business interruption
- Inclusion of other non-physical damage-related loss factors
- Cascading effects and interdependencies of hazards (secondary perils)
- Cascading impacts of interacting natural and technological hazards
- Critical infrastructure failures
- Solving the protection gap in vulnerable low-income countries

Public sector applications

- Emergency, preparedness and response operations
- Cost-benefit analysis of preventive and risk reduction measures
- Improving risk understanding and communication
- Development planning

Integration of physical climate risks into core business, investing strategies and financial systems

- Financial sector (banks, asset managers, rating agencies, etc.)
- At the company level, compliance and reporting of climate risk for different sectors

Redefining risk with a systems-based thinking to reshape risk management

- 'Models of models', e.g. global social-natural-economic systems such as water-energy-food nexus, agricultural planning and food security, urban systems

Source: The Geneva Association

The usefulness of Cat models to the (re)insurance industry and wider society could be even further enhanced with new climate modelling and observational capabilities, as well as emerging technologies (e.g. supercomputers, cloud sourcing, deep learning, visualisation, engineering and materials science).

Leveraging latest climate science and modelling, specifically:

1) Leveraging observations of earth's climate system at an unprecedented scale
2) Incorporating latest understanding of climatic regimes and interconnectivities in the weather patterns
3) Advancements in seamless forecasting, from minutes to decades
4) Earth system simulations ('synthetic data')
5) Nested models within climate change scenarios

New developments in the supply chain for construction, control systems for monitoring thresholds, and other engineering advancements for enhancing vulnerability and exposure functions.

Big data, satellite and remote sensing, wearable devices, computational advancements, artificial intelligence and neural networking techniques, along with predictive analytics, are tools that, as they mature, will undoubtedly be co-opted into the new generation of risk models, which will be developed over the next few years.

Recommendations for the way forward

1

Further leverage and enhance current Cat modelling methodologies and tools

To some extent it can be said that models make markets. In turn, markets are also needed to stimulate investment in the current commercially driven Cat model paradigm. We recommend a call for action to (re)insurers, brokers, model vendors, the development community and the public sector in the following areas:

i. Extend existing models to address current limitations and gaps, e.g. business interruption and contingent business interruption and supply chain modelling, economic demand surge, and loss adjustments expenses;

ii. Drive for interoperability;

iii. All stakeholders should scale-up ambition for global coverage of natural peril models for every country, across high-, middle- and low-income countries;

iv. Set expectations of transparency and uncertainty quantification in model design and limitations, while remaining sensitive to considerations for intellectual property;

v. Improve risk communication of model outputs and related model uncertainty amongst users;

vi. Agree on and develop a uniform international exposure data standard to enable transparency, comparability and acceptance of results and allow for efficient use of Cat models.

2

Embed latest climate science in Cat models and explore opportunities for improving modelling of physical climate risk with a forward-looking approach taking into consideration climate change scenarios

While a highly complex issue, integration of the latest climate science, earth system simulations ('synthetic data') and nested models within the Global Climate Models into Cat models could potentially be a game changer to evolve Cat modelling towards a forward-looking approach.

Such enhanced models could be critical for integrating climate physical risk into core business, financial systems and investment applications (linking to FSB-TCFD recommendations).

Building on the international scientific cooperation in climate science and modelling, this offers the opportunity to extend the Cat loss model value proposition to also support new climate insurance product offerings, both now and for the future.

3

Consider 'models of models' and embrace a systems-based thinking for development of the next generations of Cat models

The usefulness of Cat models to the (re)insurance industry and wider society could be even further advanced if connections are made to models in other domains and fields of study. The overarching benefit of coupling models would be to better understand feedback loops and cascading effects within and across sectors (e.g. the water-energy-food nexus). Cat models, extended to reflect climate-conditioned future scenarios, could provide new insights and support policy, planning and decision-making.