Actuaries Institute.

General Insurance Practice Committee

Technical Paper: The Use of Catastrophe Model Results by Actuaries

November 2024

Contents

1. Purpose and status of Technical Paper

This Technical Paper has been prepared by the General Insurance Practice Committee (GIPC) to assist Members who are required to provide commentary under either:

a. Prudential Standards issued by the Australian Prudential Regulation Authority (APRA); or

b. Professional Standards issued by the Actuaries Institute,

on estimates of liabilities or prescribed capital that rely to a material degree on the output of catastrophe models relating to both natural peril and non-natural peril risks in general insurance.

This paper is an update to the Technical Paper prepared on this topic dated July 2015. It consolidates detail in the previous version, includes updates in line with current practice in catastrophe modelling, and includes updated references.

The purpose of this Technical Paper is to give Members some tools and approaches which provide ways of gaining comfort around relying on the use of complex models developed by others. While the focus is on specific actuarial regulatory requirements, the approach suggested is equally applicable for non-regulatory uses of catastrophe models or regulatory requirements that may be addressed by a wide variety of parties.

Actuaries may be required to apply judgment when preparing data for modelling, undertaking analysis using models and interpreting model outputs.

The methods of best practice outlined in this Technical Paper are not exhaustive but may provide actuaries who need to use or comment on the output of catastrophe models with guidance in areas for particular focus.

This Technical Paper does not constitute legal advice. Any interpretation or commentary within the Technical Paper regarding specific legislative or regulatory requirements reflects the expectations of the Institute but does not guarantee compliance under applicable legislation or regulations. Accordingly, Members should seek clarification from the relevant regulator and/or seek legal advice in the event they are unsure or require specific guidance regarding their legal or regulatory obligations.

The Technical Paper does not override the requirements in any Professional Standards, Practice Guidelines or other Regulatory Standards that are relevant to this area of work.

Feedback on this Technical Paper from Institute Members is encouraged and should be forwarded to ppd@actuaries.asn.au.

2. Background and scope

This Technical Paper considers the appropriateness of a catastrophe model, data and assumptions used. It looks at some questions the Member could ask, given the purpose for which the modelled results are needed, to gain comfort that the model is a reasonable one to use.

This Technical Paper is not intended to provide information on how to build catastrophe models; rather its purpose is to provide actuaries with guidance on areas that should be considered in determining whether a model or models are appropriate for a particular use.

Catastrophe models rely on input assumptions, many of which may vary over time due to short-term increases in exposure (e.g. an elevated terrorism threat), seasonality, or longer-term climate impacts on the frequency and/or severity of perils. Assessment of the impact of climate change, in particular, is an emerging area with increasing focus, where attention on the medium to long term (typically three years or more) may mean a single set of outputs is not suitable for application for more than a short period of time. Models which allow for this variability introduce greater complexity and uncertainty and while climate change models are not the focus of this Technical Paper, the principles covered in this document may be applied to these more complex projections which become part of the input assumptions into catastrophe models.

While some actuaries are experts in the field of aspects of catastrophe modelling, many are not. In most cases, actuaries will need to rely on the work of others. The aim of this Technical Paper is to provide some tools that a Member could use to assist in gaining comfort in this reliance.

3. Applicable standards and other materials

3.1: Regulatory and professional requirements

There are several aspects of legislative requirements and professional standards where Members are asked to comment on results that are likely to have been produced using catastrophe models. Where Members need to comment on reinsurance programs or capital (e.g. insurance concentration risk charges), they must be familiar with the requirements of the relevant standards.

As at the date of this Technical Paper, the standards listed in Annexure A may require Members working in Australia to assess that catastrophe models are being used appropriately and that they may rely on the work of others in this area.

3.2: Other information sources

Other background materials and publications of interest in this area are listed in the bibliography in Annexure B with links to the documents online. This list is not a complete or comprehensive list and was prepared in October 2024. Other publications, standards or guidance may become available after that date.

Annexure C sets out some catastrophe modelling terms and definitions.

4. Catastrophe model composition

Typical components of a catastrophe model for estimating damage include:

- Exposure data – a database of in-force characteristics of exposure to loss.
- Peril modelling – uses historical data and trends to project hypothetical events with physical characteristics.
- Vulnerability – uses a series of relationships to determine the impact per unit of exposure from the physical peril characteristics.

The combination of peril, vulnerability and exposure is used to determine damage.

Coverage features are then applied to the damage to determine a gross loss after the application of any policy features.

Reinsurance and retrocession features may then be applied to give a net loss after reinsurance or retrocession. Different reinsurance protections may need to be considered e.g. for Australian insurers, standard market placements for non-cyclone perils and the Cyclone Reinsurance Pool (CRP) for cyclone risk[1].

Each step has the potential to introduce significant uncertainty in projected outcomes meaning gross and net loss projections can involve very significant uncertainty.

5. Context in reviewing output of a catastrophe model

It is important to clarify the context in which the model is being considered. Members may be requested or required to assess the catastrophe modelling carried out for a variety of reasons, including but not limited to:

a) regulatory requirements and professional standards (including capital assessment and liability valuation);

b) providing advice on the insurer's reinsurance or reinsurer's retrocession programs; and

c) pricing.

Materiality is a key consideration when reviewing the appropriate use of models and model results. The extent to which the details of a model need to be understood should be consistent with its intended use and the materiality of its outputs to the results. For example:

a. when considering the natural perils vertical requirement of the Insurance Concentration Risk Charge (ICRC), a greater focus on the appropriateness of the models and model results may be warranted where, all else being equal, an insurer chooses to purchase reinsurance to a 1 in 200 year return period, rather than a 1 in 500 year return period;

b. a greater focus on the appropriateness of a model may be warranted where results from that model are more material in key decisions of the business than other models; and

c. when considering the natural perils horizontal requirement of the Insurance Concentration Risk Charge (ICRC), a greater focus on the model results may be required when there is less relevant historical experience to use in setting the estimate.

In cases where there are no models available for a specific peril which will be material to the insurer, the Member may wish to identify these cases and understand the insurers approach to modelling and managing these risks and the associated uncertainties.

[1] The Commonwealth Government's CRP is administered by the Australian Reinsurance Pool Corporation (ARPC).

6. Appropriateness of catastrophe models and results

6.1: Data governance, availability and quality

Good practice requires a governance framework to ensure that the data used is reviewed appropriately, is complete, accurate and consistent and any data limitations are understood. This should involve the following:

a) documentation of the process for transferring data from the insurer's systems to the catastrophe models, and details of any assumptions or estimates used;

b) comparisons over time of the data with the catastrophe model output;

c) processes and controls to ensure data is complete and reconciled against other summaries of exposure data from different sources;

d) summaries of data quality, including risk characteristics and geocoding resolution;

e) understanding of the impact of limitations in the data used, and the possibility of errors in the data; and

f) periodic review by qualified staff who are independent of the data process.

The exposure data used in a catastrophe model is a key input. It should be as complete and accurate as possible. Gaps in the data can impact on the results and understanding such impacts is part of assessing the model's suitability.

It is prudent to interrogate the data prior to the modelling process and perform spot checks on the data as it appears within the catastrophe model. This is particularly the case in relation to the treatment of complex policy and reinsurance terms on large commercial risks.

To understand any gaps and their potential impact on results, the Member may need to have discussions with catastrophe modellers, underwriting and systems/IT as well as review the data itself.

Typical areas of focus include:

a) Classes of business included, how these have been determined and whether each class maps to an appropriate vulnerability and peril for the coverage provided.

b) The level of data aggregation, and whether this is consistent with the application of peril, vulnerability and uncertainty.

c) Whether the insured value is consistent with policy coverage (i.e. does the policy use replacement value or another cover such as a policy limit or average rebuild cost per m^2?). Are values split appropriately by coverage (for example, buildings, contents and business interruption)?

d) Does a lack of granularity in address data and geocoding resolution cause a bias or increase the uncertainty of results? What action is taken for locations which have no address or cannot be geocoded? Which countries are included in the data? Are all country perils covered by the models available?

e) Are all the relevant financial conditions for each policy recorded? These include limits, deductibles, attachments, co-insurance shares, sub limits, peril or site specific restrictions, other aspects of coverage and reinsurance. Have the financial conditions been applied correctly in the model?

f) What risk characteristics have been captured? These include type of construction, occupancy, year property built, number of stories and number of structures.

g) Is the data suitable for the models and perils being considered? Have any assumptions been applied to the data? Are these documented with explanations given for the chosen values? Are there any relevant exposures missing from the data? Have all potential adjustments to the data been considered (for example, treatment of GST/ITC, growth projections, underinsurance and policy benefits)?

h) What changes have there been in the data compared to previous analyses (for example, sum insured, risk count, average sum insured, regional exposures, financial conditions and risk characteristics)? Are these as expected? Has the data been reconciled against systems and other reporting?

It is important to consider the impact that aspects of the data are likely to have on outcomes, particularly in the context of the model's reliances on each field. For example, geospatial exposure data that is not sufficiently detailed combined with a highly-detailed peril model may result in a loss of accuracy if the result is that an incorrect peril or vulnerability is applied.

6.2: Assessing the appropriateness of a model's use

In order to ensure a model is 'fit for its intended purpose', the Member may need to consider the following:

a) Whether the model adequately represents the hazard risk? This may include sense checks of the AAL and OEP curves relative to historical losses and aggregate limits of cover.

b) An assessment of the reasonableness of model input assumptions and inclusions.

c) Whether all relevant perils are covered by the model and when these were most recently assessed?

d) Whether all relevant lines of business are covered by the model?

e) Whether all geographic regions where the insurer writes business are represented in the model?

f) Whether adequate allowance is made for all relevant financial terms and conditions (for example, per site / per policy / per event limits and deductibles and inuring reinsurance)?

g) Is the model granular enough to reflect changes in underwriting policy? For example, a postcode-based cyclone model may not reflect an insurer's focus on reducing exposure in parts of particular postcodes.

h) Where specific information is unknown, how is 'unknown' data treated within the model and is it material?

i) Is the model calibrated to local conditions?

(i) Consider that vulnerability functions may have been adopted from other countries and whether this could be a material issue.
(ii) Does the model adequately take into consideration historical changes in building codes?

j) For relevant perils, how are the impacts of climate change allowed for in the model calibration? Should any adjustments be made to model input assumptions as a result?

k) Consider whether model construction and documentation increases the risk of inappropriate results being produced?

(i) Consider the extent to which the model has been reviewed by suitably qualified experts.

(ii) Is the model sufficiently documented and supported to enable a clear understanding of its functioning?

(iii) Are model upgrades appropriately delivered with appropriate explanations for any changes?

Consider approaches to test whether a model is 'fit for purpose' and to assist in illustrating the uncertainty and variability within and between different catastrophe models. This could include:

a) Comparison to other vendor model results, high level sense checks, and the major drivers of model differences.

(i) Consideration should be given both to the differences in the AAL and to any variation in losses along the OEP curve of the return period(s) of focus.

(ii) Comparisons may be undertaken for the relevant geographic regions and exposure types (classes of business) and the relativities in the model results across different regions and exposure types.

(iii) Attempts should be made to understand any significant differences in model results, especially if the differences may materially impact user decisions.

b) The sensitivity of the modelled losses to changes in key parameters (for example, occupancy type, construction class, year built, building height etc) should be tested, documented and, if possible, compared to other vendor model results and historical event data where available.

c) Reference to other independent sources can assist in forming a view as to the appropriateness of key model assumptions, including:

(i) relevant scientific research;

(ii) opinions from suitably qualified experts; and

(iii) relevant industry organisations.

d) Comparison to historical events.

(i) Has the model been calibrated to historical events? How have historical losses been adjusted to account for changes in exposure including inflation, changes in building standards, changes in sums insured and population density? What is the current industry loss estimate for historical events? What return period is implied for the historical events based on the model results?

(ii) How does the frequency of events with certain characteristics (for example, magnitude for earthquake events) compare to historical events, both nationally and by region?

6.3: Validation of model results

Once model results are obtained, the factors listed below may be useful when considering the appropriateness of specific modelling results for a given portfolio.

a) Are the results plausible from a macro perspective? What does the insurer's OEP imply for the industry-wide OEP based on the company's market share and an assumption that the market share is a similar proportion of the catastrophe loss?

b) Are the results consistent through time? Are the year-on-year changes in model results adequately explained by movements in exposure, model or assumption changes?

c) How do the results compare with historical experience?

d) Reverse stress testing can be undertaken; that is, select a specific large modelled event and consider the event in terms of the reasonableness of the number and geographic spread of claims given the geophysical characteristics of the event.

e) How do the modelled loss results compare to realistic disaster scenarios that have been developed either internally or by external industry bodies or agencies?

f) If more than one model has been used, has the potential for 'overlap' been considered and dealt with appropriately? This is particularly relevant when considering weather-related perils, such as hail and storm, which may include elements of both wind- and water-related damage.

The Member should assess the completeness of any model they are relying upon. The following list provides typical components that may not have been allowed for (at all or adequately) in modelled results. Additional adjustment factors may need to be applied to the model outputs where insufficient allowance has been made for matters such as:

a) Demand surge or post loss inflation;

b) Underinsurance;

c) Loss adjustment expenses;

d) Additional living expenses / business interruption. Is this cover offered and, if so, has it been appropriately dealt with in the model?

e) Additional benefits over and above the sum insured (for example, removal of debris and professional fees).

f) Input tax credits (if not already allowed for in the input data).

g) Secondary perils, such as storm surge, liquefaction and fire following earthquake.

h) Adequate growth factors (between the exposure in-force date(s) to the period under consideration) have been applied to exposures or modelling results and the appropriateness of implied assumptions embedded in the way these growth factors are applied.

i) Classes of business which, whilst not generally captured within the models, still expose the insurer's balance sheet (for example, marine and agriculture).

6.4: Combining results from multiple models

Where multiple models are available for the same peril and location, model results may be combined by weighting the two models. This process results in a new model with additional input parameters being the weights assigned to, or the process by which model results are combined. These assumptions also need to be assessed, noting that they also may add to, rather than reduce, result uncertainty.

7. Understanding and documenting uncertainty

Due to the multiple levels typically comprising catastrophe models, there is potential for compounding uncertainty across modules relating to exposure, vulnerability and both the frequency and severity of peril components. This can be further exacerbated by the application of insurance or reinsurance structures to model results and any related basis risks that those structures introduce.

A good understanding of the key sources of uncertainty, and clear communication of the model result limitations, is necessary to reduce the adverse impact of uncertainty on decisions.

The Member should consider the level and implications of uncertainty in results being relied upon and document this qualitatively, including the key risks and the most significant sources of uncertainty.

Model results may also be subject to uncertainty due to limitations in the model itself, including non-modelled uncertainty.

Different sources of uncertainty may be more relevant for smaller vs larger loss events. Loadings for demand surge will typically be greater for large loss events, for example, and may be nil for small losses.

The use of tail probability outputs can further increase the impact of underlying uncertainty, where there are fewer observed or projected events.

External uncertainties can arise from the quality of the data being fed into the model, but also include the use of "switches" (model option settings) that might not be set appropriately for the analysis at hand.

Other methods of illustrating uncertainty have already been highlighted including:

a) comparison of different vendor models;

b) sensitivity analyses;

c) reference to other independent sources, such as scientific research; and

d) comparison to historical events – i.e. how well did the model predict the actual losses?

Scenario testing can also assist in identifying and prioritising sources of uncertainty in model results.

Prudential and professional standards require uncertainty to be highlighted and, where possible, quantified or illustrated. APRA has indicated the need for insurers to understand the uncertainty in their catastrophe modelling and its subsequent use. Documentation of any analyses carried out to understand uncertainty can help to inform and assist all parties in having a common understanding.

In assessing whether the process for identifying and managing uncertainty is adequate, appropriate analysis undertaken by others may be utilised.

7.1: Quantifying uncertainty

Some models attempt to quantify uncertainty around the loss quantity only, which is usually referred to as 'secondary uncertainty'. Approaches to this vary by model vendor, with some generating a distribution around a mean loss, and others having different loss values for the same event. These approaches recognise that, for a given event, the actual loss can vary depending on a number of factors including:

- the hazard (for example, a similar earthquake may generate different levels of surface ground shaking);
- the vulnerability of buildings (for example, similar types of buildings may have been constructed to varying levels of quality); and
- the quality and detail of the risk data used in the model.

These methods should be noted when selecting models for analysis and interpreting results.

Having results from several models may help to understand the uncertainty surrounding the models for a particular peril. However, it is not necessary to obtain results from multiple models~~,~~ to have an informed view of the catastrophe risk or the uncertainty surrounding a given model.

One approach considers each aspect of the modelling. The steps are:

a) Create a list of uncertainty items that could be considered.

b) Assess each item in the raw list considering its potential materiality and the ability to quantify a possible adjustment. If practical, this should be done consulting various experts. This step will help identify the most material items and create a reduced list containing only these items.

c) Items on the reduced list then need to be assessed to determine the best adjustment method and a suitable value or range of values. This should be done by consulting experts and potentially other sources of information. There could be a simple post-modelling PML loading to allow for demand surge, or a total sum insured increase prior to modelling to account for underinsurance. As some data adjustments need to occur before modelling, the uncertainty discussions need to be addressed early in the process.

d) The impact of various exposure data uncertainties can be assessed with sensitivity studies. An alternative catastrophe model or historical experience can be used to quantify the impact of certain secondary perils (such as fire following earthquake, or storm surge following cyclone).

e) Claims experience, especially for major events, can help highlight key items of uncertainty relevant for the portfolio. Analysis of claims and implementation of lessons learnt will improve management and understanding of uncertainty over time.

Annexure D includes a sample list and commentary to help illustrate this approach.

8. Realistic Disaster Scenarios (RDS)

RDS are one way to quantify catastrophic loss potential and manage catastrophic exposure in a consistent way, by running detailed specified scenarios. They have been used in other markets for many years (Lloyds introduced pre-defined event scenarios for managing agents in 1995) and include both natural peril and non-natural peril events.

An individual RDS can be based on an actual past event, or an event similar to an actual past event, or a completely theoretical event based on knowledge of the potential hazard (for example, any event from a catastrophe model event set, or a potential event not within the event set).

A RDS can provide a company with an alternative practical method of stress testing in a way that is more easily understood by Boards and others within an insurer. It can enhance thought processes around the particular risk.

A RDS can consider events beyond the primary impact, such as increased post-event costs (demand surge) or an increased possibility of reinsurer default.

A specific RDS event typically has the following details:

a) a definition of the physical event, with a map showing the footprint or impacted locations;

b) the assumed industry insured loss (this could be split by line of business or include other classes of business, if material;

c) an estimated return period of the event, defined either in terms of industry loss or the physical characteristics of the event; and

d) average loss defined as a proportion of exposure with differing ratios by class of business and by geographical location.

Other details could be provided (for example, where applicable, a catalogue of major infrastructure that may be affected by the event).

The events should be selected to represent material catastrophic risks to the insured or industry.

RDS could also consider multiple events within a short timeframe.

The event scenarios should be regularly reviewed and updated to ensure they continue to represent material catastrophe risks.

RDS can be stress tested, as that contain damage assumptions which can be varied within realistic ranges. This is a practical deterministic way to consider secondary uncertainty, although this represents only one component of overall uncertainty.

9. Other matters

9.1: Considerations outside the model

The following points~~,~~ highlight items beyond the model that may be important for determining the accuracy of model outputs:

a) Are factors that influence secondary perils or uncertainty able to impact the PML? This includes the impact of climate cycles or other periods of elevated risk frequency or severity.

b) If an opinion on the calculation of reinsurance recoverables in relation to any component of the Insurance Concentration Risk Charge is in scope, it is essential for the reinsurance contract wording to be available and reviewed.

c) All clauses in the contract can have a large practical impact on the estimated net PML, including the hours clause where the impact of two events occurring in quick succession should be considered.

d) Does the reinsurance contract apply equally to all perils at all levels? Are there any restrictions on cover or growth in regions?

e) Are there any per risk or per location limits in the reinsurance contract that could materially impact the horizontal cover?

f) Does the PML allow for the possibility of aggregation of perils under the hours clause (for example, often cyclones subsequently cause flooding and could be a single proximate cause under the hours clause).

g) Does the insurer’s natural perils vertical requirement in its ICRC allow for sufficient growth and planned portfolio changes?

h) Has the aggregate risk been based purely on model output, and does this cover all perils? If it is based on experience, has an allowance been made for perils where there were low or minimal losses over the experience time horizon? If based on exposure, does it allow sufficiently for multiple events in a year? Is cover able to be eroded by smaller events?

i) Does the natural perils horizontal requirement in its ICRC calculation consider a planned change in mix (for example, lines of business or geographical locations) and could this have a material impact?

9.2: What is not modelled

One key question when considering catastrophe model output is whether all relevant perils are represented in the results. In some cases, there may not be a model available, but the peril exists.

For risks other than home and commercial property – including motor (large hail risk), aviation and some marine risks (large cyclone risk) – there are additional challenges related to the issues of time-variable value, location, as well as specific risk themes relevant to those types of risks and their vulnerability. In many of these lines of business, there are specific issues that need consideration. For these lines of business, dependent on the materiality, simpler approximations may be appropriate, such as using:

- “percentage captured” based on premium income, and load catastrophe data accordingly, per peril; or

- more sophisticated techniques, depending on the level of confidence in the existing data and its level of overall completeness.

Any such approximations have limitations which will impact modelling results.

It is unlikely to be possible to develop a single methodology for capturing non-modelled perils. If this is a potentially material exposure, then understanding the method and parameters that were used in the modelling is important.

9.3: Further considerations

Additional simulation error may appear when catastrophe modelling results are used within an economic capital model to simulate potential losses in the optimisation and analysis of reinsurance and capital. Since the extreme events of focus in catastrophe modelling occur with low probability (in relative terms), the variability around estimates due purely to simulation error needs to be assessed and managed when using such results. In economic capital models, a sufficiently large number of simulations should be run to reduce this error. Also, in some situations it may be appropriate to allow for correlation or other dependency structures between different perils.

When comparing results from modelling undertaken at different times, it is useful to compare differences in the figures and identify the cause of changes. In addition, it is also beneficial to compare the results between different classes of business and by different geographical regions in relative terms. That is, a comparison may be made of the PML by return period as a proportion of total modelled sum insured for each grouping, as a reasonableness check to ensure the results make sense in relative terms from one grouping to another.

It may be beneficial to identify peak drivers of the PMLs in terms of classes of business, individual perils and geographical region. The sensitivity of the ‘all perils’ whole of portfolio PML to results from key peak groupings should be considered.

Although the return period relevant for the natural perils vertical requirement in the ICRC, and for reviewing reinsurance is often 200 years, it may be prudent to review the model results above this return period. For example, does the PML “flatten out” after 200 years or does it rise sharply beyond that point? The results of such review may indicate a need for further analysis and/or review of reinsurance and capital adequacy.

Annexure A: Regulatory and professional requirements

a) **GPS 320** (Actuarial and Related Matters) – January 2024 – APRA (GPS 320);

b) **GPS 116** (Capital Adequacy: Insurance Concentration Risk Charge) – July 2023 – APRA (GPS 116) - https://www.legislation.gov.au/F2023L00672/latest/text ;

c) **Professional Standard 102** (Financial Condition Report) – March 2021 updated October 2024 - Actuaries Institute (PS 102); and

d) **Professional Standard 302** (Valuations of General Insurance Claims) – March 2023 updated October 2024 – Actuaries Institute (PS 302)

APRA publications

While neither a professional nor prudential standard, APRA has provided some guidance[2] on better practice in Financial Condition Reports (FCRs).

APRA has commented that better practice in FCRs includes:

i) separate discussion of the Probable Maximum Loss (PML) and the reinsurance arrangements, including discussion of the uncertainty in the PML;

ii) discussion on risks and limitations regarding catastrophe modelling, as well as commentary on ranges of model outcomes based on different input assumptions and reasonableness checks against historical events;

iii) clear statement of reinsurance arrangements, including retention, upper limit, defined coverage, reinsurers involved, reinstatements and downgrade clauses;

iv) discussion of the process for selecting the structure of a reinsurance program and resulting catastrophe cover; and

v) providing an actuarial opinion, as well as stating facts on the suitability and adequacy of the reinsurance arrangements and identifying gaps in process or areas for improvement.

APRA has also provided the following guidance:

1. APRA "Prudential Practice Guide GPG 116 – Insurance Concentration Risk", March 2013 (GPG 116) - https://www.apra.gov.au/sites/default/files/GPG-116-Insurance-Concentration-Risk-March-2013_2_0.pdf

2. APRA's reinsurance requirements and the use of insurance linked securities, August

[2] "An assessment of the suitability and adequacy of reinsurance arrangements, including the documentation of reinsurance arrangements and the existence and impact of any limited risk transfer arrangements, and whether the reinsurance arrangements are sufficient to cover the Probable Maximum Loss defined in GPS 116": APRA (2013): Letter to Industry: Catastrophe Risk Governance.

2023 - https://www.apra.gov.au/apra%E2%80%99s-reinsurance-requirements-and-use-of-insurance-linked-securities%C2%A0

3. APRA "Letter to industry: Catastrophe Risk Governance", 19 December 201 - https://www.apra.gov.au/sites/default/files/Letter-insurers-and-groups-catastrophe-risk-governance-19-December-2013.pdf

Annexure B: Bibliography

The list below was compiled during the preparation of this Technical Paper and was applicable at the time of issuance. Standards will change over time so check the latest versions are referred to and that the standards remain applicable.

1. Actuarial Standards Board "Catastrophe Modelling (for All Practice Areas), July 2021 http://www.actuarialstandardsboard.org/asops/actuarial-standard-of-practice-no-38-revised-edition/

2. European Insurance and Occupational Pensions Authority centre of excellence for catastrophe modelling https://www.eiopa.europa.eu/tools-and-data/centre-excellence-catastrophe-modelling-and-data_en

3. Association of British Insurers resources on catastrophe modelling https://www.abi.org.uk/search/?q=catastrophe+modelling

4. Lloyds of London, Catastrophe Modelling and Climate Change, - https://www.lloyds.com/news-and-insights/risk-reports/library/catastrophe-modelling-and-climate-change

5. London Market Association (LMA), Catastrophe Modelling Guidance for non-catastrophe modellers, June 2013 https://www.lmalloyds.com/lma/finance/Cat_Modelling_Guidance.aspx

6. National Association of Insurance Commissioners (NAIC), Catastrophe Modelling Centre of Excellence – https://content.naic.org/research/catastrophe-modeling-center-of-excellence

Annexure C: Catastrophe modelling terms

Specific terms used in this Technical Paper:

a) "Aggregate Exceedance Probability" (AEP)

A measure of the probability that one or more occurrences will combine in a year to exceed the specified threshold. AEP is derived from the sum of losses from all events in a year. This is useful in estimating losses for an annual aggregate cover (stop-loss) or in analysing reinstatement requirements. It is also useful for pricing insurance business as it gives the distribution of annualised catastrophe losses, given that more than one event can occur in the same year. This can be used in determining appropriate catastrophe loads for insurance premiums.

b) "Annual Average Loss" (AAL)

Annualised expected value of losses from catastrophe events.

c) "Catastrophe model"

Catastrophe modelling is the process of using computer-assisted calculations to estimate the losses that could be sustained by a portfolio of risks due to a catastrophic event that has not necessarily occurred, but which is scientifically credible. It draws upon a number of disciplines including actuarial science, engineering, meteorology and seismology.

A catastrophe model typically comprises three modules:

1. **Peril Module:** The Peril Module simulates the frequency and severity of natural phenomenon (events) that could possibly take place using scientific equations and variables to estimate the destructive force at a given location. For example:

   a. for cyclone, the wind speed at any location is a function of central pressure, distance and direction to the eye and forward speed of the storm system; over land, the geographical and topographical features are also considered; and

   b. for earthquake, the amount of ground shaking at any location is a function of magnitude, distance to the epicentre location and local soil conditions.

2. **Vulnerability Module**: The Vulnerability Module combines the event characteristics from the Hazard Module with information relating to the risks exposed to estimate the potential damage caused by the simulated events. Vulnerability functions translate parameters from the Hazard Module into the expected amount of damage, often expressed as a percentage of insured value. The vulnerability function may depend on the risk's characteristics such as its construction, height, roof type, etc.

3. **Financial Module:** The Financial Module translates the estimate of damage from the Vulnerability Module into an insured loss, taking into account the insurance and reinsurance policy's financial terms and conditions such as limits and deductibles.

d) "Demand Surge"

A basic definition of demand surge (sometimes called ‘post loss inflation’) is the definition of the Actuarial Standards Board (US): “A sudden and usually temporary increase in the cost of materials, services, and labour due to the increased demand for them following a catastrophe.” This reflects the definition used in this Technical Paper.

e) “Event set” or “event loss table”

Complete list of all modelled scenarios usually containing a unique event ID, loss and frequency.

f) “Horizontal requirements”

The natural perils horizontal requirement (NP HR) for an insurer that has exposures to natural perils is calculated as:

1. the greater of H3 requirement (the net retention post three 1 in 10 year events) and H4 (the net retention post four 1 in 6 year events) requirement (as defined in paragraphs 29 and 36 of GPS 116 respectively); ***less***

2. Premium Liability (PL) offset (the expected future allowance for natural catastrophe perils allowed for in premium liabilities (if any)) (as defined in paragraph 43 of GPS 116).

   An insurer does not need to calculate both the H3 requirement and the H4 requirement if it is able to demonstrate that one of these amounts is expected to be materially lower than the amount determined for the other.

g) “Insurance Concentration Risk Charge (ICRC)”

The ICRC is the minimum amount of capital required to be held against insurance concentration risks. The ICRC relates to the risk of an adverse movement in the capital base due to a single large loss or series of losses. The ICRC for a general insurer or Level 2 insurance group is the maximum of the following items:

- the natural perils vertical requirement (NP VR), as defined in this annexure;
- the natural perils horizontal requirement (NP HR), also defined in this annexure;
- the other accumulations vertical requirement, relating to the insurer’s accumulated exposure to non-natural peril events. This is defined in paragraphs 44 to 52 of GPS 116; and
- the lenders mortgage insurer concentration risk charge, determined in accordance with paragraph 53 of GPS 116. This part only applies to lenders mortgage insurers.

h) “Loss adjustment expenses;”

The direct and indirect costs associated with assessing and settling claims.

i) “Non-modelled perils”

In Australia, the main six perils of relevance for reinsurance are cyclone, earthquake, bushfire, flood, storm and hail. The various catastrophe model vendors provide widely used systems for modelling tropical cyclones and earthquakes. The perils of bushfire, flood, storm and hail are collectively known as “non-modelled perils”, as vendor modellers do not traditionally provide models for these. Some vendors now have models for some of these remaining perils, but these have not been universally accepted.

More literally and specifically, where certain perils are material to an insurer but not included in its computer-based modelling techniques (that is, literally not modelled), an allowance for losses in respect of these perils would need to be added to the Natural Perils (NP) PML.

j) “Occurrence Exceedance Probability” (OEP)

This is a measure of the probability that a single occurrence will exceed a certain threshold. OEP is derived from the single largest occurrence in a year. This is useful in determining how likely a loss will be ceded to a per occurrence reinsurance layer. This distribution is used in both purchasing and pricing catastrophe risk reinsurance.

The AEP is always larger than or equal to the OEP at a given return period (as more than one event can occur per year).

k) “Probable Maximum Loss” (PML)

This represents the maximum loss that is likely with a given level of probability over a defined time frame (usually annual), such as the one in two hundred PML over the next year (for example, the 0.5% (1/200) loss estimate from the OEP curve). This figure may need to be adjusted to allow for a variety of factors (for example, exposure growth, demand surge, etc), depending on the purpose of the PML estimate.

l) “Return period”

1 divided by the annual exceedance probability giving the expected number of years between events equal, to or greater than, the event for which the return period applies.

m) “Secondary uncertainty”

This relates to the uncertainty in loss given that an event has occurred. Typically, this relates to the precise local intensity of the hazard, and the vulnerability of a property to this hazard.

n) “Underinsurance”

Where the declared replacement value is not sufficient to fully reinstate the building and/or contents. Overinsurance is a similar concept where the declared replacement value significantly exceeds the cover required to replace the insured items. When this Technical Paper refers to underinsurance, the possibility of overinsurance should also be considered.

o) “Vertical Requirement”

The natural perils vertical requirement is the maximum of:

1. the net whole of portfolio loss; and

    1. the net PML less NP reinsurance recoverables,

    both at a stated return period of at least 1 in 200[3].

[3] APRA [2023]: GPS 116, paragraph 21.

Annexure D: Simple sample uncertainty table

The table below is a fictitious example of how uncertainty may be allowed for in deriving a 1 in 200 year PML. This is a simplification and does not necessarily cover all factors that need to be considered (for example, claims handling expenses). The actual adjustments applied will vary depending on an insurer's exposure and circumstances, the models used and various other factors. The adjustments applied may also be different for other severity levels, especially at the lower end of the curve.

The key benefit of this approach is the thought process of considering the different areas of uncertainty and how these may impact the insurer and documenting the outcome.

When combining all individual adjustments, possible correlations should be considered as all sources of uncertainty are unlikely to fully apply for all events. Practitioners should be wary of introducing unintended conservatism if adopting similar approaches.

In the example below, a number of adjustments are made:

1. the sums insured have been increased to allow for suspected underinsurance; and
2. the modelled loss has been adjusted to allow for:
    a) a large proportion of risks with an unknown construction type;
    b) demand surge; and
    c) flood following cyclone.

In the example below, a total adjustment of 27.5% is made to the modelled loss.

Uncertainty Source	Category	Material?	Comment	Proposed adjustment method	Adjustment	
					Data	Modelled loss
Policy Sums Insured	Input	Yes	Suspected underinsurance	Increase building TSI before model run	12%	n/a
Buildings not constructed as stated	Input	Yes	25% of policies have 'unknown' construction	Conduct sensitivity study, adjust modelled loss	n/a	7%
Clean up costs (covered by policies)	Scope	No	Considered immaterial, as government often steps in to clean up after big disaster	n/a	n/a	n/a
Demand surge	Scope	Yes	Quantity based on XYZ study, signed-off by Board	Adjust modelled loss	n/a	15%
Landslides	Scope	No	No significant risk for portfolio		n/a	n/a
Liquefaction	Scope	No	No significant risk for portfolio		n/a	n/a
Looting	Scope	No	No significant risk for portfolio		n/a	n/a
Paying for claims not covered due to reputation risk	Scope	No	No significant risk for portfolio		n/a	n/a

Uncertainty Source	Category	Material?	Comment	Proposed adjustment method	Adjustment	
					Data	Modelled loss
Flood following cyclone	Scope	No		Adjust modelled loss based on relative impact of this sub-peril as per alternative model XYZ	n/a	0.50%
Loss adjusting costs	Scope	Yes	Conducted historical claims analysis and identified range of 1%-5%	Adjust modelled loss	n/a	5%
Tsunami	Scope	No	Underwriting strategy is to avoid coastal areas		n/a	n/a
Meteorite impact	Scope	Yes	Can be material, but believed to be extreme low probability; no allowance applied		n/a	n/a
				Total adjustment	**12.0%**	**27.5%**

For APRA regulated entities, the adjustments applied need to be owned, and understood, by the Board[4].

END OF TECHNICAL PAPER

[4] https://www.legislation.gov.au/F2023L00682/latest/text para. 6.