

Internal Model – Advanced Uses

Choices, results and capabilities
of flood risk models for
financial risk carriers

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Foreword

One of the key Solvency II principles is that insurers' internal capital models must be embedded at the heart of risk and capital evaluation and they must be used as a key input to a wide range of business and strategic decisions. One particular area of challenge/opportunity for the industry is consistently identifying the capabilities that insurers will need to support uses of the model that go beyond solvency calculations, as well as finding ways to share best practices.

This case study is one of a series that is being published following research by our 'Flexibility and Advanced Uses of Internal Models' IMIF workstream and provides a practical perspective of the modelling capability requirements and choices for insurers in order to effectively manage flood risk in their portfolios. The booklet also explores how flood risk models can support capital models and ultimately key capital management decisions, such as reinsurance needs. I would like to thank Raphael Borrel for his leadership of that workstream, our author Sebastian Rath and NN-Group for agreeing to share their experience in this field.

The publication of this paper is timely because the UK insurance market is about to bring about 350,000 homes in the most flood prone areas of the country into the scope of Flood Re, a government initiated reinsurance scheme. This will reshape the process of insuring UK flood risks, with significant implications for modelling, understanding and communicating flood risk across the insurance industry, and for models and claims administration systems. Also in November 2015, the COP 21 United Nations Conference on Climate Change, taking place in Paris, will again raise the profile of extreme climate risks, including catastrophic flood risks, associated with global temperature increases. The risk and insurance industry must equip itself to provide robust and innovative responses to these changes, which includes having effective and integrated modelling capabilities.

The Internal Model Industry Forum (IMIF) has produced a series of documents, that can be found on the IRM's website, offering guidance and sharing best practice on the validation and use of insurers' internal risk models. We are a market-wide initiative aiming to ensure that these models create value for the business beyond regulatory compliance.

José Morago

IRM Chairman and Founder of the IMIF

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Introduction

The IMIF work-stream on 'Flexibility and Alternative Uses of Internal Models' was set up to allow insurance firms to share insights on how they use internal risk models for business purposes beyond Solvency II compliance, and how these various uses are communicated and embedded into the business.

Internal risk models can potentially provide helpful input or support to a range of business decisions and processes but it is vital that their use is appropriate and their limitations – and the impact of these limitations - properly understood by all those involved. This requirement extends beyond the risk modelling team to any part of management that might use or rely on the models, and also potentially to other interested parties like board members, regulators and investors.

A recent survey conducted by IMIF asked firms how those involved with these wider business decisions understood the limitations of the internal model. The results – shown in Chart 1 below - showed that there is significant scope for better understanding.

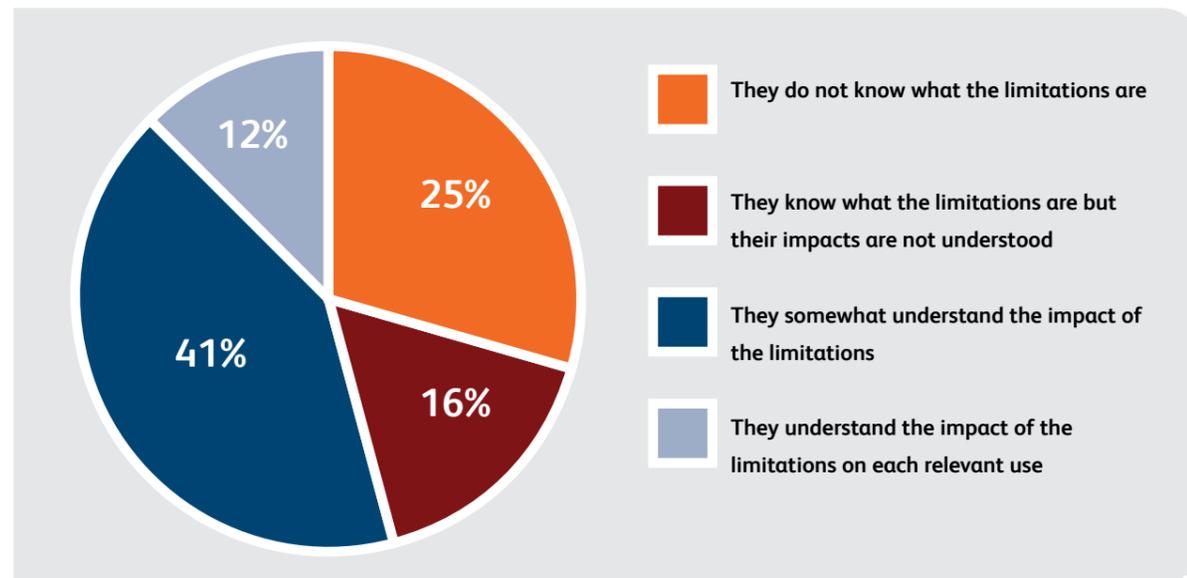


Chart 1: To what degree are the impacts of the limitations of the model on its intended use understood by all required business decision makers? (Source: IMIF 2015)

To assist in this matter this work-stream intends to publish a number of case studies that will highlight:

- Model capabilities and functionalities that can be built to enable specific model uses
- Model limitations, and their impact on the model use, on the reliability of the consequent management information and on managing the resulting implications and
- Practical examples of the uses of internal models.

Ultimately, this work-stream will draw the key points from these case studies to publish a booklet to provide general guidance on using models for different purposes. It will also provide a framework to document the model use, and its limitations at use level. This will be available from the IMIF's web page¹.

¹ www.theirm.org/knowledge-and-resources/thought-leadership/creating-value-through-internal-models/documents-and-resources.aspx

Insurance industry uses of internal models

A survey conducted by the IMIF found a wide variation in how firms were using internal model outputs to drive business decisions for different processes. The results are summarized in Chart 2 below.

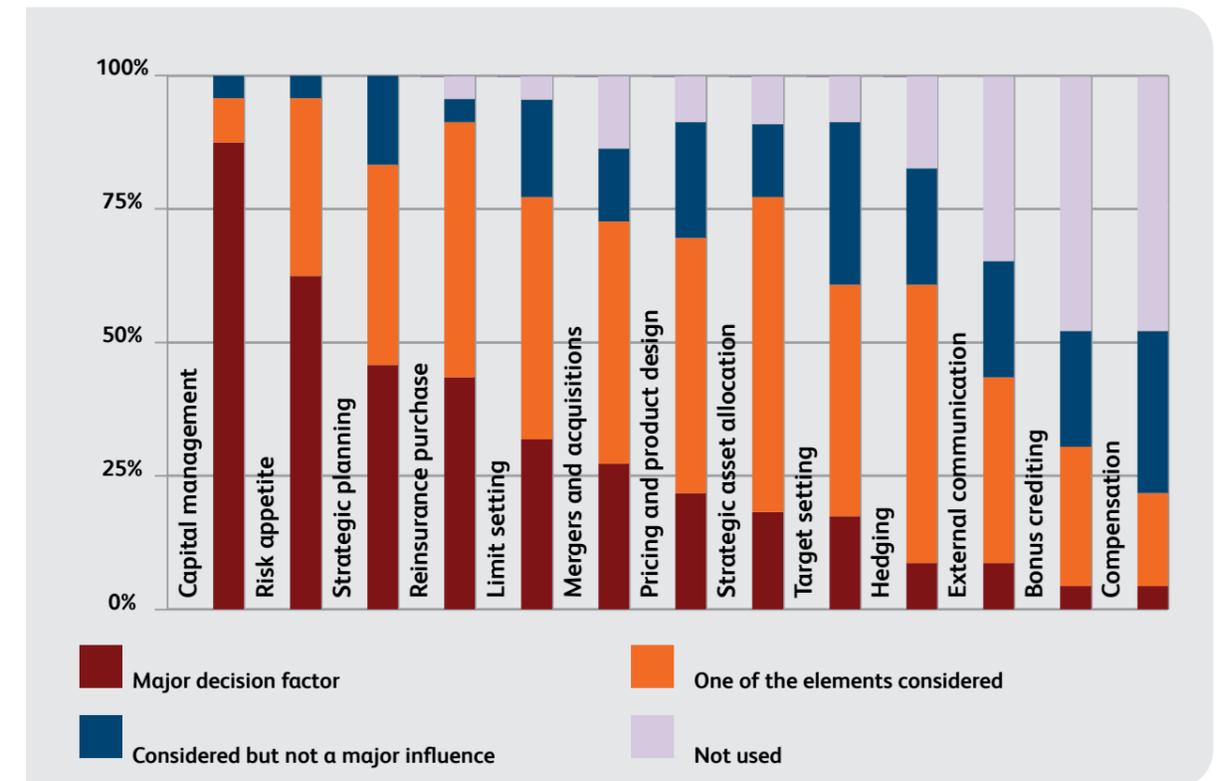
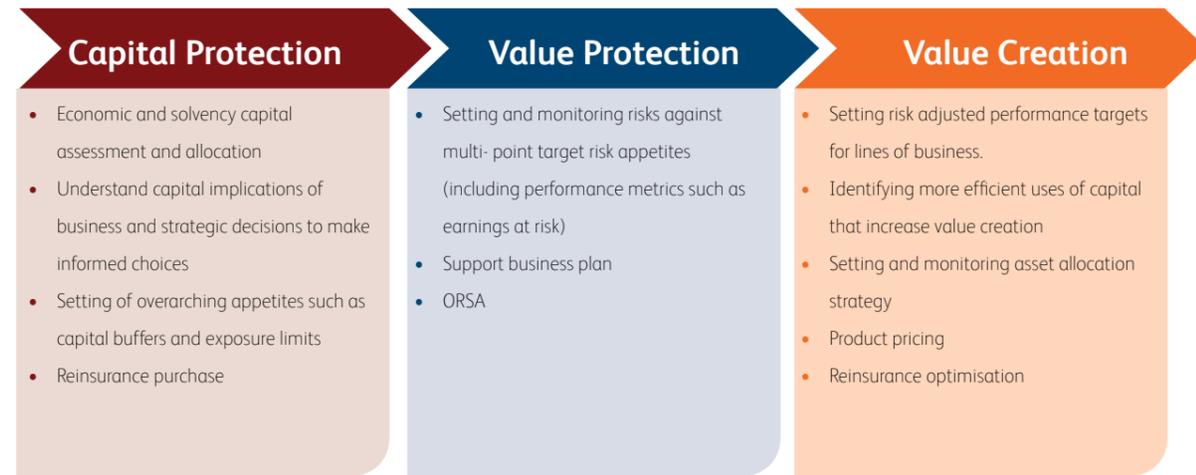


Chart 2: Rating of the importance of uses of the model in decision making (Source: IMIF 2015)

- The survey indicated, as we would expect, that most insurance firms use their internal models to drive business decisions aiming at protecting capital. This encompasses activities such as the allocation of solvency capital and the setting of over-arching risk appetites.
- The survey also showed that market leading insurance companies increasingly use their internal models for more advanced uses which can protect and add value for the business.

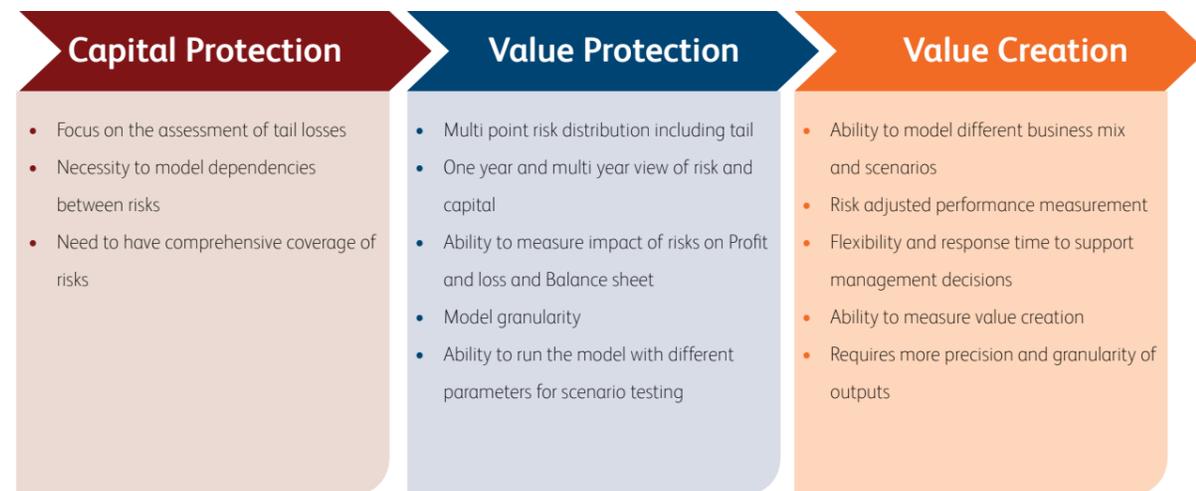
We can trace a progression of key uses of internal models that indicates three increasing levels of maturity, moving from capital protection, through value protection to value creation:



Supported by its survey and case study results, the work stream concluded that the current status quo for uses of internal models is bound by constraints that can be generalized as follows:

- The level of reliance that the management of a firm will place on a model is largely dependent on the level of maturity of this model.
- The uses of an internal model are expected to vary according to the scope, capabilities and limitations of the model.

The table below provides examples of key capabilities that can typically be expected for different model maturity levels together with the typical uses of the model.



In this case study, Dr Sebastian Rath from NN-Group outlines considerations of model choice and model use in the context of the insurance and reinsurance of flood risk. This case study demonstrates how internal models can be used for value creation.

Flood Risk

Flood risk is one of many risk drivers modelled in a (re) insurer's Internal Model. Flood risk is commonly associated with risks relating to rivers flooding their floodplains. It also comprises risks from excess water on areas commonly labelled off-floodplains, causing local flooding further away from rivers that may be resulting from heavy rain events. Lastly, some storm surges combine with river flood events and are therefore modelled together where feasible and necessary. Flood risks in its broader context in an insurer's portfolio are part of natural catastrophe risks, to which other risks belong, including for example storms and earthquakes.

The scope and purpose of this case study is to outline considerations on model choices and model use, primarily from the view of a (re)insurer. This entails a discussion on the use of model results together with an assessment of today's requirements on model capabilities with an outlook to future trends in managing flood risk, within the catastrophe risk and capital management framework of globally active risk carriers.

This case study explains insurance modelling considerations to a wider audience that is increasingly getting involved in discussions on catastrophe risk modelling capabilities. It explains current and future peril modelling challenges, and details where model design and model use can be part of optimisation strategies and risk transfer solutions. It addresses selected aspects that are subject to regulatory market supervision. It provides insights into flood risk management trends from an insurers view for major markets and trends, some aiming at managing peak flood risk exposures, others at giving sound credit to flood resilience programmes. As such this case study takes the view that the insurance sector has now reached a point where globally coordinated activities are actively being aligned to support and incentivise investment initiatives addressing climate change, aimed at improving awareness, catastrophe risk mitigation and risk resilience. In this context, flood events are recognised as dominant global risk drivers for civic society and also reflected to some degree in insurance portfolios, primarily of developed insurance markets.



Considerations on Model Choices and Model Use

Any part of an organisation involved in modelling flood risks will face similar, quite fundamental questions: Are there any suitable models available? If so, are they of sufficient quality and performance for the anticipated use? And if so, what are the necessary criteria supporting the choice for using or continuing the use of such model? And where neither availability nor such considerations can be met, what are the necessary model components and processes required to bridge a gap in flood risk modelling capabilities appropriately?

Availability, resolution and accuracy are key model features determining the use of models. The availability of high-resolution flood risk models remains restricted to selected countries and global regions. Many regions remain without sufficiently appropriate (or any) model coverage when considering today's suite of insurance catastrophe risk models provided by external catastrophe risk model vendors/brokers. This may leave capability-gaps across a risk carrier's Internal Model and its capital management processes. In such circumstances, simpler models or modelling techniques need to be deployed, validated and justified, to account for insured flood risk exposures.

Not only does today's off-the-shelf-availability of flood risk models remain limited for commercial risk carriers, brokers and other institutions involved in flood risk transfer. The supply of new generations of insurance flood risk models is still in the process of embedding new market typical capability requirements regarding performance, calibration, benchmarking, validation and ability to model insured exposures with their granular flood risks. Additionally, model development trends are accelerating and converging over the last decade with the development of distributed computing power and industrialised approaches to large scale modelling. Furthermore, regulation started shaping the modelling process and its transparency for model users, notably



the Solvency II model validation requirements for users of external catastrophe risk models. Lastly, trends for insurance regulation are focussing in new ways on insurance customers as well as the sustainable development of society, including the approaches taken towards achieving protection against climate risk and natural hazards³. A milestone that can be considered as a further catalyst across these accelerating trends is the UN climate change conference in Paris in November 2015⁴.

Large scale flood risk models developments for the use of financial risk carriers remain critically limited by the exhaustive data requirements and complexity involved in the modelling process. In the first decade of the 21st century national flood models emerged for the UK and Germany. In the current decade the emphasis is on completing European views of flood risks with emphasis on including CEE countries, as well as establishing tested solution for US floods, with regional models launching in Asia. From a prospective model users point of view, the modelled coverage of global flood-prone regions has credibly increased upon successful completion, testing and acceptance of these groups of models. During this process it is likely that the current focus for developing large-scale flood risk models will be less dominated by the larger, developed insurance markets. This would be particularly true once supra-regional weather patterns determining climate trends are modelled so that climate data is more readily exchanged and used as common regional standards. Clearly, this integration is likely to happen in the future and will require time, regulation, as well as significant investment in further collaboration.

Why are insurance flood risk models seemingly more complex and more demanding in their development? Providing accurate high resolution flood models remains amongst the most complex modelling jobs for natural catastrophe modellers and model vendors, with implications on development agendas and model release cycles. Building flood models over large domains such as the US or Europe requires many person-years with significant upfront investment, followed by extensive testing and market acceptance periods. This typically involves managing many terabytes of data across a long series of modelling steps. These including modelling stochastic climate catalogues, deriving weather patterns, performing the rainfall-runoff modelling and river routing, covering groundwater effects, taking into account complex soil and topography data, with all other information relating to insured assets, their vulnerability and propensity to flood loss. This entire modelling chain uses many external data sources, all of which are subject to investment and overhaul cycles. For flood there are two notable examples highlighting the cyclical nature of data and the impact on models: investment cycle into space-based rainfall observation satellites as well as government investment cycles for funding their nation's regional flood defences. Data requirements demand that modelled weather-sets exceed the domain of modelled river catchment areas, which rarely coincide with national boundaries. Furthermore, every modelling step involves

significant assumptions and expert judgement, waging uncertainties, which catastrophe risk modellers consider when validating the use of their models, conveying their views of risk and related uncertainties across the probability-spectrum. Accepting the use of individual models requires an own model validation and acceptance process for catastrophe risk carriers to which early guidance under Solvency II was published, e.g. by the Association of British Insurers⁵.

Where high-resolution flood models are currently not available such that risk carriers can readily use them, adaptations of alternative or simpler models need to ensure that required processes and governance meet the insurers requirements for underwriting, pricing, portfolio and capital management. Where an adaptation of a physical-based model is not an option, this is likely to have some limiting effects in the insurers overall Internal Model. Higher level aggregate modelling may be deemed as viable choice under some circumstances, restricting the physical effects of floods without completely covering all temporal and spatial flood effects and dependencies. For such choice, results are less granular and based on approaches that involve aggregate loss modelling across larger areas, where the aggregation limits a decomposition into event occurrences and granular local characteristics of the flood event. In such circumstances pricing approaches and portfolio management methods may vary, imposing further restrictions on the use of model results within the risk carriers internal model framework. Aspects relating to the interpretation of model results, specifically for portfolio optimisation or optimising reinsurance purchase, are addressed in a separate IMIF case study 'Supporting reinsurance business decisions' available from the IRM website (www.theirm.org).

....providing accurate high resolution flood models remains amongst the most complex modelling jobs....

³ University of Cambridge, Institute for Sustainable Leadership, 5/2015: Insurance Regulation for sustainable development – Protecting human rights against climate risk and natural hazards.

⁴ https://unfccc.int/meetings/paris_nov_2015/meeting/8926.php

⁵ See ABI, 12/2011: Industry Good Practice for Catastrophe Modelling under Solvency II.

Considerations on Model Results

High-resolution large-scale flood models are facilitating the most complete range of model uses and capital management objectives, including:

- Local and regional risk pricing,
- Comprehensive risk accumulation control and management,
- Comprehensive portfolio management; or
- Advanced risk appetite and capital allocation.

The audience of this case study might typically focus on portfolio management of such high-resolution flood models, in which case model users typically analyse their modelled losses and dependency on certain key loss drivers and components. Typical analysis steps for a catastrophe risk model include, by means of example:

- Inherent changes between chosen models versions (for example, from one model version to another, upgraded one);
- Changes to portfolio over time (for example, as annual or quarterly comparison or after major renewal seasons); or
- Variations in loss analysis configuration (for example, the use of aggregation and disaggregation of a model demand surge contribution to loss, or equally the contribution to storm surge to flood losses in relevant coastal regions).

Where a choice can be made between different readily-available, commercial high-resolution flood risk models, the model use is determined by analysis and model acceptance. This typically involves a wide range of comparative analysis steps to benchmark model results. Latest upgrades of leading catastrophe risk modelling platforms now introduce features and tools that simplify and automate such comparative analytics. More efficient tooling supports deeper understanding of trends in portfolio characteristics, particularly around the model calibration and its manifold options used to analyse portfolios. Comparative portfolio analytics require effective modelling, presentation and visualisation of key performance indicators. Insurers, reinsurers and other risk carriers typically consider, by means of example:

- Comparisons of summary event-probabilities,
- Comparisons of annual event-probabilities,
- Event comparisons as validation step in portfolio modelling,
- Average annual loss comparisons at aggregate county and ZIP levels,
- Specific measures expressing risk in the tail of the risk distribution, such as the Tail-Value-At-Risk (TRVAR).
- Scenario analysis for individual events or scenario exercises as part of a risk carrier's Own Risk And Capital Assessment (ORSA);
- Scenario analysis for trend shifts across temporal scales or the probability spectrum, such as climate change;
- Statistical and geographical visualization of the modelled results and their comparisons.

At this stage it is worth noting again that for a large part of the global floodplains the choice of a flood risk model fully supporting such analysis of portfolio characteristics remains very limited. Consequently, considerations on model uses remain restricted within a modern insurer's overall modelling framework as simpler, partial flood modelling approaches are deployed to represent the risk in the overall risk and capital management framework. Some examples for limitations on capabilities are exemplarily addressed in the next section.



Considerations on Model Capabilities

Model validation and acceptance requirements around using flood models analysing portfolio or industry-loss estimates remain complex. They address complexities of the peril model itself, as well as the regional catchment and floodplain representation. In addition, they are clearly and critically influenced by wide-scale uncertainties around future trends in climate, exposure, vulnerability, the many drivers within the flood hazard on-floodplains, off floodplains and in coastal regions exposed to storm surge. Consequently, catastrophe risk models are starting to emphasise more and more clearly the different bands and ranges of uncertainties around their individual modelled loss estimates as well as across the modelled probability spectrum.

Flood risk management is an interdisciplinary activity crossing many stakeholder groups that take uncertainties and model capabilities more and more consistently into account in their decision making, priorities and communications, amongst others

- Traditional insurance, reinsurance and alternative risk transfer solutions,
- Asset management arms of insurers and risk carriers starting to look into the effects of climate change⁶, assessing benefits of sustainability in their investment strategies across circular economies and committing

their groups to binding targets, requiring a deeper integrated framework the evaluation of risk return and risk appetite. Where such frameworks for asset valuation and allocations considerably shift, the asset management thought leadership started addressing related risks under the umbrella terminology of stranded assets;

- Government departments, inter-governmental organisations, local as well as global funding partners aiming to achieve sustainable infrastructure investment or much wider, holistic ambitions; and
- Dedicated local and large scale projects aim to strengthen risk mitigation, risk adaptation and risk resilience with a lasting physical, social, and/or economic impact.

Regional and national regulation impose additional overlays to the interconnected nature of flood risk management. Together they inform considerations on model choices, judging the model's coded reflection on exposures, vulnerabilities and hazard components.

The remainder of this section expands on two trends in the insurance of flood risk management with their specific effects on considerations for assessing flood risk model capabilities, today and in the future.

⁶ For example – Pilita Clark in Financial Times, 24/7/2015: Aviva orders coal companies to clean up.

Trend Towards Pooling of Flood Risks

The formation of Flood Re⁷ in the UK is the most recent European example for natural catastrophe risk pooling. Future risk pooling solutions in other regions of the world are likely to draw on some of its design, implementation features and expertise. As joint not-for-profit venture, sponsored by the insurance industry and the UK government, it is a world-first risk-transfer scheme serving to:

- enable flood cover to be affordable for those households at highest risk of flooding;
- increase availability and choice of insurers for customers;
- create a transitional measure to allow flood insurance to move towards risk-reflective pricing within 25 years; and
- create a level playing field for new entrants and existing insurers in the UK home insurance market.

This specific UK scheme may inspire a wider trend toward exploring the benefit of pooling catastrophe risks, and will lead to a further evolution in future model uses, processes, governance and model capabilities. It deeply drives various uses and model capabilities, and the exchange of those, of which a few examples are:

- the risk carrier's use of location information and exposures across modelling, policy administration and claims management, as well as the government's roles in policy design, regulation and proactive management of social, economic and environmental considerations;
- the production, challenge, use and exchange of detailed and aggregate flood maps for risk pricing, underwriting and portfolio management across a wide spectrum of return periods;
- the challenge to maintain up-to-date analysis capabilities that can readily incorporate future trends such as those by local impacts from climate change; and
- the consistent use for policy design by the scheme, its members and benefactors.

When observing the current status quo and focussing on

necessary trends to achieve global efforts for effective flood pooling using external flood models, either as part or basis of the pooling mechanisms, it is quite clear that the future flood risk management requires an ever tighter alignment of modelling-processes across stakeholders. This will align process and governance requirements, and it is likely to further emphasise consistent model use as well as fair outcomes across all stakeholders and benefactors while taking into account a range of uncertainties:

- current and future impacts on local and regional climate change pattern with their impact on flood frequencies and severities across the insured period. This may require detailed analysis for hours-clauses, seasonal dependency structures or cross-peril dependencies between correlations such as between storms, surges and floods;
- current and future exposure development trends, government policies managing peak exposures and pooling policies critically managing their long-term financial viability, risk appetite and exposure to peak risk concentrations;
- current and future vulnerability and resilience trends for buildings and contents, lines of businesses and coverages.

...the future flood risk management requires an ever tighter alignment of modelling processes across stakeholders....

⁷ For further details, see: www.floodre.co.uk

Trend Towards Emphasising Resilience of Cities

Increasing numbers of impactful initiatives are beginning to emphasise and strengthen resilience and to avoid some financial losses. Such initiatives across all involved stakeholder groups, including many that are supported and driven by risk carriers. This case study focusses on the recently launched programme '100 Resilient Cities'⁸, pioneered by the Rockefeller Foundation and dedicated to helping cities around the world become more resilient to the physical, social and economic challenges that are a growing part of the 21st century. This 100RC-programme supports the adoption and incorporation of a view of resilience that exceeds that of natural catastrophe shocks from earthquakes, fires, floods, etc.. It also addresses the stresses that weaken the fabric of cities on a day to day or cyclical basis. Examples of such stresses that the programme addresses include high unemployment; an overtaxed or inefficient public transportation system; endemic violence; or chronic food and water shortages. By addressing both, the shocks and the stresses, the programme's ambition for cities is to become more able to respond to adverse events, achieving an overall better ability to deliver basic functions in both good times and bad, to all populations.

Programmes such as this one can relatively quickly address experience learnt on a local level. The experience around Hurricane Sandy in 2012 with losses due to storm, storm surge and floods, with further losses due to power outages and business interruption in New York, is only one example for a global megacity as candidates where retrofitting the urban texture to the challenges of climate and flood risk is an obvious topic.

Efforts of such or similar programmes are likely to turn into what could be described as the genuine next challenge for any catastrophe risk model. This challenge will reflect and validate insights of such programmes and assess where credible model updates are required for an enhanced view of catastrophe risk, via the vulnerability or exposure parameterisation.

Both trends discussed here, the developments in model

⁸ For further details, see: www.100resilientcities.org



uses and the upgrading of model capabilities, have already started to influence existing catastrophe risk modelling frameworks. On the one hand, new open-source modelling frameworks emerge, on the other hand the established catastrophe risk model vendors are starting to offer access for external models into their overall modelling platforms. This shall achieve efficiencies, particularly on the exposure, hazard and aggregation modelling challenges. Consequently, these efficiencies should lead to firmer views and challenge on risk-distributions within their overall uncertainty-spectrum. For now it remains clear that a formidable integration challenge remains, with quite a number of steps towards fully leveraging emerging insights from such initiatives into the daily modelling and decision making chains in flood risk management at insurers, reinsurers, in insurance linked securities or cat-bond transactions, or across governmental and regulatory bodies. In this process the emphasis should be on clarity in the design of scenarios, and their comparison across the probability spectrum of losses.

Model Capabilities

Following the considerations for these two specific trends, the tables below provide a range of selected model capabilities that could be deemed as important to inform model choices, or model development potentials, as well as uses within the Internal Model and capital management framework of risk carriers:

Capabilities	Description	Comments
Gross loss curve	Model needs to be able to simulate a complete and appropriate distribution of gross losses explicitly. The climatology of the loss catalogue needs to cover geographies completely and adequately, it may also reflect annual seasonality.	For the purpose of risk pricing and portfolio management, the flood risk model should be suitable to provide complete input into the risk carrier's Internal Model, such that further modelling, e.g. of reinsurance treaties, can explicitly model net losses. As input for any Internal Model, an appropriate gross curve should be the basis before netting down. Where annual seasonality cannot be considered, the limitations for certain contract arrangements, including hours clause or analysis of trigger points may limit sophisticated internal model users aiming for a specific treaties terms or capital optimisation tasks.
Frequency – Severity	Cat-risk model should feed into Internal Models with their simulated number of claims (frequency) and claim size (severity) across a series of events.	Internal Models that only simulate loss ratios or aggregate claims are not be able to apply per risk Excess of Loss (XoL) treaties. A frequent and practical approach is to split attritional and large claims, where only the large claims portion is modelled on a frequency-severity basis (as XoL-treaties typically cover large and catastrophe claims).
Reconciliation; P&L Attribution	Reconciliation between cat-risk model, Internal Model, reporting in financial statements and business plan	In order to aid the communication of any loss, risk or capital analysis, modelled cat loss numbers need to be able to reconcile, between modelled lines of business, between entities, between gross and net levels and their various diversification levels. Having the ability to look through underlying assumptions in modelling flood risk is, amongst others, an important objective of the ORSA.
Full range loss curve	The availability of the full range of simulated gross and net results are required to be able to perform detailed reinsurance analysis and are commonly required for catastrophe risks such as floods	While capital setting under the European Solvency II regime focuses on the 99.5th percentile, managing flood risk from an insurer's perspective focusses on more than one particular percentile. Analysis typically requires several simulated results. As a minimum, there will need to be a comparison of the mean results, the 99.5th percentile, and other percentiles used for flood risk zoning, pricing and as part of monitoring the risk appetite. Reinsurance purchase or pooling mechanisms may require further consideration.

Capabilities	Description	Comments
Granularity	Flexible grouping of lines of business	Flood risk models, such as other catastrophe risk models, have to support group lines of business within the same major / minor lines, within the same country and in total for a particular business entity, e.g. for aggregate reinsurance purchase, reporting, aggregation and allocations in capital models.
Link to risk appetite	Accumulation control within risk appetite framework	The management of underwriting activities, providing cover for flood losses, involves accumulation controls ensuring that the total limits written remain within the corporate risk appetite which is linked to the capital management of the insurance undertaking as part of their risk management, reporting and regulatory supervision process.
Dependency	Dependency between risks and lines of business	The dependency between catastrophe risks is required when regional loss analysis is performed and the impact on risk appetites and capital is determined (both tail and core of the distribution events). The dependency structure between exposed lines of business is necessary when catastrophe model results are utilised to manage exposure hot spots in an insurance portfolio, check global cat-reinsurance strategy and thus the overall capital management strategy.
Benchmarking	Flood risk pricing and soundness of view of risk	The exchange, comparison and analysis of various models supports determining commercially sound pricing of flood risks. Establishing best views on regional catastrophe risk profiles in a climate that is more and more accepted to change regionally in the future can explain some uncertainties. This ensures that risk carriers manage their exposure to extreme risks, informing their validation and regulatory approval processes and avoiding systemic risks that could arise due to partially incomplete or outdated views of risks.

Model Limitations

When considering catastrophe model limitations, the Principle of Proportionality has to be observed as results may be more spurious and the time (and cost) of further development of model skills may outweigh the benefits. A range of common limitations are set out below and have been discussed in further industry guidance papers⁹.

Data Limitation	Link to Model Capabilities	Comments
Limited ability to reflect up-to-date effects of global economic growth, inflation, regional climatic vulnerabilities and effects on losses together with regional, national and supra-national policy responses.	Gross Loss Curve	<p>Inherent drivers and trends for the overall spectrum of uncertainty are manifold. They will either require to upgrade model views in the future or to superimpose scenario analysis on existing model results.</p> <p>Inflation affects lines of businesses differently, and therefore requires consideration with economic and other offsetting effects.</p> <p>Overall the impact of climate change is likely to increase the cost of insurance¹⁰ for the current exposure without taking mitigating or resilience effects into account.</p>
Limited ability to model flood risks for small lines of business, sub-sections or new risks aspects separately	Granularity	<p>Claims and premium experience are often aggregated into groups of risks that have homogeneous characteristics. This means that model users are not able to distinguish between risks within the same group and as such these small lines of business or sub-sections cannot be modelled separately. A practical solution to this is to assume that the sub-portfolio of interest is a fixed proportion of the risk group it is in. Otherwise, scenario tests are typical approaches to perform tests that can be included within the ORSA or added as bolt-on in a Realistic Disaster Scenario (RDS) within the model.</p>
Incomplete calibration of climate, flood frequency and severity	Frequency / Severity	<p>A sound understanding of the existing model calibration is mandatory before choosing approaches to address gaps. The loading for existing gaps may well be non-linear and therefore involve extensive testing and communication of assumptions. A commonly established mechanism in dealing with inherent ambiguity of research and science are expert elicitation processes, aiming to draw out a clearly articulated basis for certain points in the model performance.</p>
Un-modelled or insufficiently modelled flood regions and flood peril aspects and dependencies	Gross Loss Curve	<p>Un-modelled perils, regions and secondary loss effects can materialize as significant actual claims. Where not sufficiently addressed as part of the Internal Model they result in an incomplete view of flood risk. This can impose challenges when seeking the required adjustments to the view of risk and to ensure that risk management decision, risk appetite and capital are well managed. Common approaches used to account for such gaps include a loading through expert judgment supported by scenario testing.</p>

Typical Modelling Limitations	Link to Model Capabilities	Comments
Inability to model cross-country exposures or dependencies consistently.	Reconciliation; P&L	<p>For parts of the global floodplains there is currently still insufficiency modelling capability for financial risk carriers to choose from, if any. Hence, exposures in neighbouring flood risk exposed regions or countries cannot be consistently modelled. This provides a gap and consistency challenge.</p> <p>Floods are determined by geographic catchment boundaries and may require careful consideration around hours-clause effects. A broad-brush loading-approaches across readily modelled countries to address modelling gaps may have clear limitations and may not be sensible in some cases.</p>
Systematic gap between dynamics risk (weather/flood) forecasting and the calibration of catastrophe risk models based on historic event sets with expert judgement to include future trends	Dependency; Benchmarking	<p>Any newly observed catastrophe risk event is seemingly always somewhat different that those that we aim to capture in our catastrophe risk models. While this comment may be obvious as it describes the difference between real events and stochastic models, the future of complex large scale flood-models will at some point in time be coupled more systematically to large scale weather modelling, and at that point in time also offer some additional model features closing this gaps to some degree.</p>



⁹ For example: Association of British Insurers, 04/2014. 'Non-modelled risks: a guide to more complete catastrophe risk assessment for (re)insurers.' Freely available at www.abi.org.uk.

¹⁰ Keith Wade, in The Economist, 21/7/2015: Climate change and the global economy: growth and inflation.

Conclusion

Using flood risks as an example, this paper demonstrates today's practical challenges in managing and modelling catastrophe risk in our real world. It explains how this translates into requirements, capabilities and limitations relating to an insurer's use of internal capital models. This paper seeks to establish guidance as well as help in understanding and communicating today's modelling and its limitations. This process underpins the important transfer of risks from extreme events from an individual to an insurer, from an insurer to a reinsurer and from reinsurers to the wider capital markets.

The philosophy of Heraclitus of Ephesus is captured in just two words: 'panta rei'. His statement 'everything flows' implies that everything is constantly changing, from the smallest grain of sand to the stars in the universe. He implies that objects ultimately are figments of one's imagination. Only change itself is real, which he describes as constant flux, like the continuous flow of a river which always renews itself.

When using models to reflect nature's true complexity and in order to secure the financial security of individuals and their activities, a common understanding and language is required that does not hide behind model complexities or the regulatory language of the financial service sector. To engage policy holders, interest groups, academia, insurers, investors and their respective decision making bodies a certain transparency around the use of models, and their current construction, is inevitably required, above all to be able to adapt those models for future change in due time.

Common access to clear definitions for the ambitions and limitations of model functionalities are becoming ever more essential in a globalising financial services market. For insurers under Solvency II, such definitions should be to a level of detail sufficient for Internal Model design. Where model requirements or functionalities are limited or unfeasible, modellers should declare how such limitations affect each use of the model, and in manner that can be easily understood by the model users. As described in the IMIF booklet "The validation cycle: developing sustainable confidence and value", such processes should be supported by an independent model validation cycle, providing assurance on the fitness for purpose of the model. An ongoing feedback loop between users and owners of the model should be available and monitor, and to the extent feasible, mitigate the limitations.

The foundation of insurance activities rests on sound risk-research, demands the most appropriate form of modelling, and implies a constant exchange of knowledge, starting with the information to policyholders, requiring wide ranges of management decisions and finally involves reporting to regulators. This involves the underwriting functions, as well as the independent model validation functions. And in such framework, a model change or upgrade turns out to be what it should be: another well-controlled adaptation to changing perceptions of risks in our dynamic world.

Authors:



Dr. Sebastian Rath, Principal Insurance Risk Officer, responsible for the international risk management of NN-Group (formerly ING)¹. Sebastian previously built commercial catastrophe risk models, managed and advised on portfolio risks across the entire risk management spectrum, from hazard modelling, re/insurance pricing to capital market risk transfers and catastrophe risk model validation under Solvency II. Throughout his career he worked closely with catastrophe risk model vendors and many UK and European insurers. He published market guidance with the Association of British Insurers, drawing on his in-house and consulting experience with global insurance groups. He regularly speaks on catastrophe risk and capital management and through his work maintain strong ties across EU insurance regulators. As part of promoting thought leadership he is affiliated with UNESCO-IHE in Delft², Netherlands, shaping the development of global flood risk reliance programmes.



Raphael Borrel is a member of the IMIF steering committee and leads the 'Advanced Uses of Internal Models' work-stream. He manages the Solvency II Experts Group, a large non-commercial European network of Solvency II interested parties. He is an experienced risk strategy, risk transformation and compliance consultant with over 15 years of experience within financial services. He previously worked within the Lloyd's market, Big 4 consultancies and Aon. He currently focuses on assisting companies to transform their risk management capability through the integration of an enterprise-wide approach, shifting the risk focus to a more strategic and forward looking perspective and driving a significant strengthening in Internal Model capabilities and use.

¹ www.nn-group.com (formerly ING)

² www.unesco-ihe.org

The Internal Model Industry Forum

This document has been produced by the IMIF. IRM set up the IMIF in 2014 to address the key questions and challenges that insurers face in the use, understanding and validation of internal risk models. It is designed to work in a collaborative way to develop and share good practice to ensure that these models add value to the organisation and support regulatory compliance. IMIF now has over 300 members and has run a series of Forum meetings to explore key issues. A number of workstreams are also undertaking research and we aim to publish the results along with other useful resources and guidance.

The IMIF work is led by a steering committee comprising modelling experts from insurers alongside representatives from: Deloitte, EY, KPMG, Milliman, PWC, the Institute and Faculty of Actuaries, ORIC and the Bank of England Prudential Regulation Authority.

As the leading organisation promoting education and professional development in all aspects of risk management, IRM is pleased to be able to support this industry initiative to share good practice

More information about the IMIF and its work can be found on the IRM website:

www.theirm.org

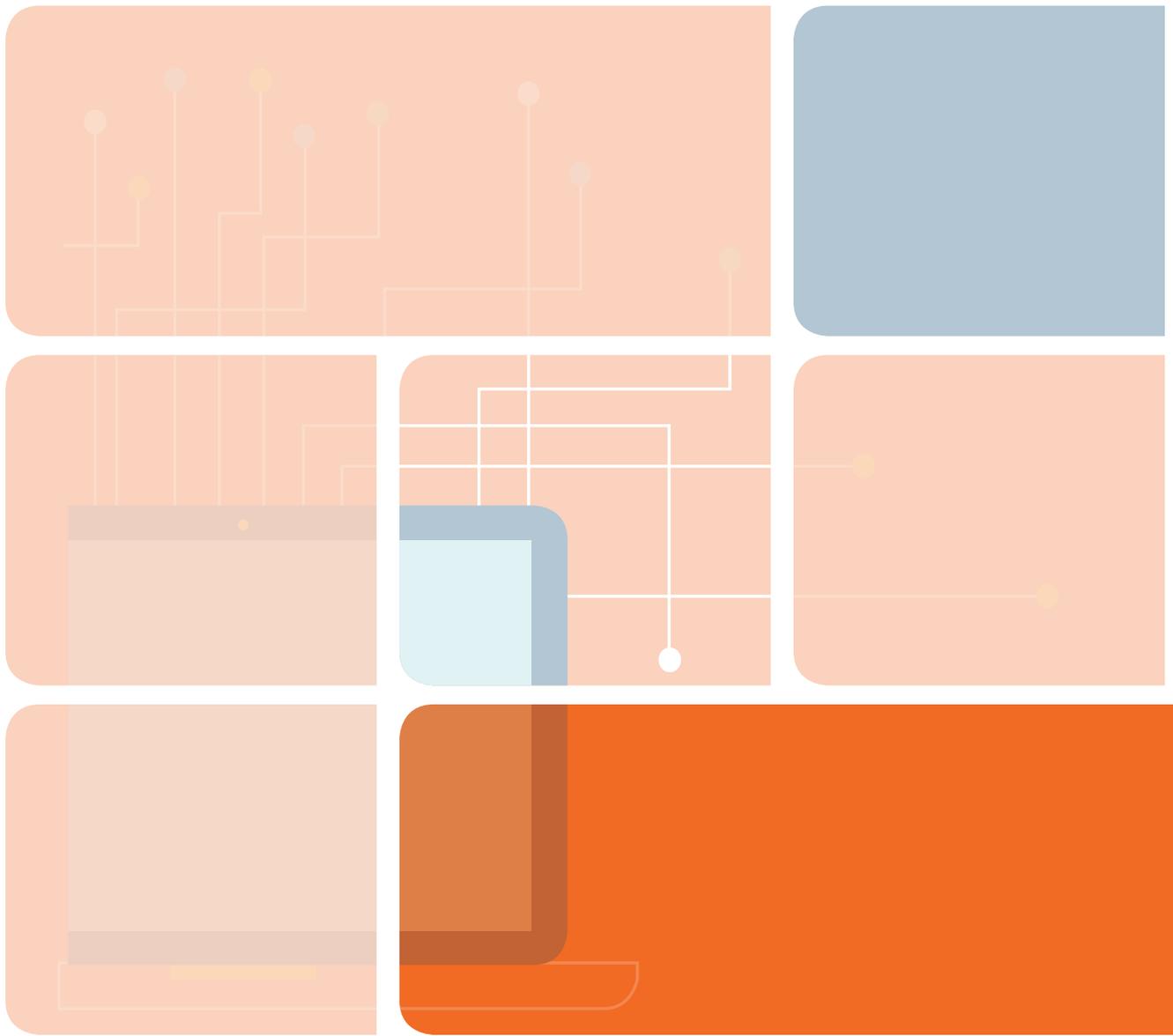
Who are the IRM?

This work has been supported by members of IRM, which has provided leadership and guidance to the emerging risk management profession for over 25 years. Through its training, qualifications and thought leadership work, which includes seminars, special interest and regional groups, IRM combines sound academic work with the practical experience of its members working across diverse organisations worldwide. IRM would like to thank everyone involved in the IMIF project.

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IRM

T: +44(0) 20 7709 9808

E: enquiries@theirm.org

www.theirm.org

Institute of Risk Management

2nd Floor, Sackville House

143-149 Fenchurch Street

London

EC3M 6BN

United Kingdom

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Model
*Industry
Forum*

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