Natural Catastrophes: Flood, Fire & Storm

Special Report 2025

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Introduction

This special report into catastrophe modelling comes at a pivotal time for the market. The paradigm-shifting developments in technology that have touched our everyday lives have made their way into cat modelling, too.

In a digitalised era, with easier access to high-power computing and satellite imagery, there has been a blossoming of innovation that has improved our understanding of cat risks leaps and bounds.

Cat modellers have also been influenced by the trend towards open-source software frameworks, which is helping to democratise cat risk management.

These increased capabilities are coming at the same time as the dynamics of loss from natural catastrophes are changing in the face of urbanisation and climate change.

In this special report, we take a close look at three perils where there have been considerable shifts in risk, along with significant innovations in modelling: flood, hurricane and wildfire.

We hear from cat modellers and exposure managers about their work: where they see the biggest limitations and frustrations, as well as the areas most promising for improvement.

This special report also includes interviews with our three sponsors – Fathom, Reask and Bellwether – about the important work they are doing to help advance cat modelling.

We hope you enjoy reading it as much as we enjoyed putting it together.

Christopher Cundy
Editor

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A shift in the cat modelling landscape

New technologies and the emergence of open standards are revolutionising the catastrophe modelling world, giving users more powerful tools and more choice. Christopher Cundy reports

There have been huge improvements in catastrophe modelling since it emerged as a discipline almost 40 years ago. However, developments in the last five to 10 years have been arguably the most significant, with models becoming more accessible, more accurate and more useful.

The main driver of these trends has been the users – predominantly insurers but increasingly from other sectors – demanding more model-regions covered, multi-model views of risk, transparency and lower costs.

The improvements have been facilitated by leaps in technology, including easier access to high-power computing via the cloud, the availability of more granular information and data from satellites, and advances in statistical analysis, machine learning and artificial intelligence.

James Lay, commercial director at Nasdaq Risk Modelling, a risk modelling platform, says: "In the last three or four years we've seen quite a lot of change: there are more platforms that can access multiple tools and applications in one place; more systems have migrated to the cloud; and the launch of more SaaS offerings."

These latter two are helping to reduce the pain of new software installations, and enable the cat modelling systems to be put into the hands of underwriters and other relevant parts of the business, as well as potentially lowering costs for users.

Lay continues: "The rise of API workflows is another thing that's enabled companies to access a large variety of data and model providers. This was needed really because there's a whole lot of data that people want to leverage."

The proliferation of model vendors in the last few years has also been a notable development. Moody's RMS and Verisk (formerly AIR Worldwide) retain a dominant market position in terms of their platforms and breadth of peril-regions covered, but other modellers have emerged with different approaches and unique skills and technologies.

"I felt the industry was consolidating around a couple of vendors and that was where we were just going to end up. But it doesn't feel like that at all now. It feels like the industry wants to take advantage of companies that have specialist areas of expertise," says Lay.

Dickie Whitaker, chief executive of the Oasis Loss Modelling Framework, an open-source cat modelling initiative which currently has 19 vendors on board, says: "There has been a practical realisation that one firm can't do everything. The strength of all the other vendors is clearly one that can't be ignored."

Ming Li, global head of CAT at reinsurance broker Acrisure, says it is hard to compete with leading model vendors in the peak peril regions like US hurricane and earthquake, and European windstorm. "But when it comes to some of the speciality fields, such as cyber and flood, there are quite a few emerging reputable players. Regional models, such as those tailored for the Middle East and Latin America, have also gained significant traction in the market," he says.

> "There has been a practical realisation that one firm can't do everything. The strength of all the other vendors is clearly one that can't be ignored"
>
> Dickie Whitaker, Oasis Loss Modelling Framework

Open modelling

The flourishing landscape for cat models owes a good deal to the emergence of Oasis and its common framework for modelling, which has enabled innovation and greater accessibility by not tying the models to a particular platform.

According to a cat modelling leader at a major European insurer, who asked to remain anonymous: "We started developing our own models in 2016 and the Oasis Loss Modelling Framework helped a lot to develop our own hazard and vulnerability modules. It gave us a framework to calculate losses and loss distributions, which was an important step. We used it as the basis of our own loss modelling platform, inspired by Oasis, but with more functionality and capabilities that are important for us."

For the users of the traditional cat modelling services, there are obvious plusses in accessing different views of risk, or models for previously unmodelled perils. But there are hurdles to adoption.

James Lay, Nasdaq

Matthew Jones, Fathom

Jessica Turner, MS Amlin

Jessica Turner, head of exposure management, at speciality re/insurer MS Amlin, says: "There's definitely a place for the newer third-party model vendors. One of our challenges to adopting them comes down to platforms. Our cat modellers are trained to use certain tools and systems, so anytime you bring in a new model, it requires time and effort."

She adds the link-up between Moody's RMS, Oasis and Nasdaq (see article on pages 16-17) which will enable Oasis-based models to be run on the Moody's RMS platform, "is going to be helpful for us".

The link-up also mitigates the problem of data incompatibility, which has been another barrier that has helped Moody's RMS and Verisk keep their grip on the market.

Nasdaq's Lay explains: "The industry is beholden to proprietary exposure data formats that have been established over the past 30 years or so. As a user of cat models, you're faced with this task of translating one data format into another in order to run the model in question."

The Nasdaq system automates the task of translating data between formats, so users are able to switch easily between models to get different views of risk. This is a tremendously useful feature for cat modellers, to help them understand the peril better, as well as the strengths and weaknesses of different models.

Technology developments

Advancements in cat modelling have come hand-in-hand with the availability of more powerful computing.

Matthew Jones, chief product officer at flood modelling firm Fathom, says what firms can do today simply wasn't realistically possible with yesterday's technology.

"We couldn't have thought a decade ago about releasing a global probabilistic flood model at any reasonable resolution. It was in the founders' minds when they formed Fathom, but there was never a possibility of doing it back then because the compute [power] just wasn't there," he says.

"Compute definitely plays a factor in how good models are, how high resolution they are, the comprehensiveness, the way models can use sampling rather than making statistical assumptions about distributions," he says, adding: "To some extent, flood modelling isn't so much a modelling problem any more – it's a data problem."

In this regard, he says machine learning and AI can "change the dial on the quality of the input datasets". Particularly for flood modelling, knowing the exact location of a property or an industrial facility that's being insured, and the elevation and surrounding landscape gives a more accurate picture of risk. Developments in satellite imaging and the availability of open-source elevation mapping have proved a great help in this respect, but for situations where the satellite imaging fails – for example, if the building is obscured by trees – Jones explains that Fathom has used machine learning techniques to fill in the gaps.

New technologies and datasets have enabled one of the biggest paradigm shifts in cat modelling – the emergence of models based on the physics of perils such as hurricane, rather than historical data.

At tropical cyclone modelling firm Reask, which uses this physical approach, its chief science officer Thomas Loridan explains: "The way models were built in the past was probably the best that could be done at the time and it was a fantastic innovation. But now we've got so many more tools that we can revisit the problem. The big things are the availability of earth system data, global climate data, the ease of implementation of machine learning algorithms and also computing power. We can reconstruct really granularly what happens around the hurricane."

His thoughts are echoed by the anonymous European cat modeller, who says: "In the insurance world 10 years ago, few people knew what ECMWF [European Centre for Medium-Range Weather Forecasts] or ERA5 [ECMWF's global reanalysis data] meant. Today, there is more and more open-source meteorological data that is easy to download and use (thanks to Copernicus CDS), and we have the IT capabilities and supercomputers to do very intensive calculations. Having access to all these has helped a lot to develop natcat modelling techniques, capabilities and models."

Technology, of course, never stands still and the anonymous cat modeller says there are developments that look promising for cat modellers. "I have some hope that the data-driven numerical weather prediction model initiatives started by the likes of Google DeepMind and NVIDIA FourCastNet will change the way that natural catastrophe modelling can be done. Those models will allow you to simulate 10,000 years of hurricanes very quickly, so maybe it will allow us to update models very frequently. In a changing climate, this is very interesting."

Acrisure's Ming Li says the availability of granular data and new data science technologies have lowered the barrier to entry. "For us, it is a blessing, as you have more choices of which one you use. But it is also a curse because you have to evaluate and compare models to decide which one is working the best!"

How secondary perils came to dominate the conversation

Re/insurers have long studied the world's primary natural catastrophe perils, tropical cyclones and earthquakes. However, secondary perils are increasingly overshadowing these massive hazards, with important implications for the sector. Martin Assmann reports

Ask five re/insurers to define a secondary peril, and you'll likely end up with six different interpretations. The debates range from nuanced discussions over modelling capability, to whether large-scale events like floods are "primary" or "secondary".

But the definitions do share some common themes. The Cambridge Institute for Sustainability Leadership frames them as events with lower impact, often triggered by other perils, and poorly modelled. Swiss Re describes them as more frequent but moderate in severity.

The issue today is that secondary perils are rapidly becoming primary: both in terms of generating severe losses, and in the way they are being modelled better.

Rising impact

Catastrophe risk modelling has traditionally centred on primary catastrophic events – which most people accept are tropical cyclones (hurricanes) and earthquakes – given their sheer scale, dominance over insurance losses and public attention. However, insured losses from secondary perils are surging.

The Insurance Information Institute reports that over the last decade in the US, secondary perils have caused more losses than primary perils and have grown 50% faster (see Figure 1).

Munich Re's global report on 2023 natcat losses cited $95bn of insured losses, of which $58bn, or 61%, was attributed to a traditional secondary peril: severe convective storms.

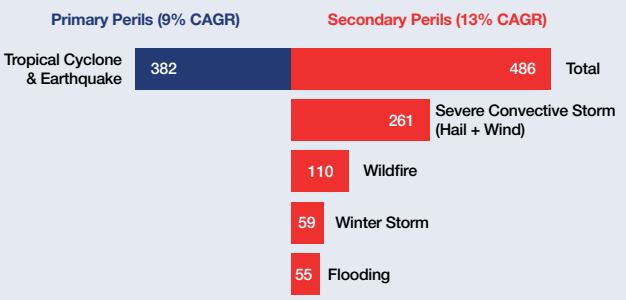
Swiss Re's data (see Figure 2) shows the rising contribution to insured losses from secondary perils, particularly severe convective storms, floods and wildfires.

The impact of climate change

Tobias Grimm, climate expert at Munich Re, says the upward trend in insured losses "is strongly influenced by increasing exposed values". This is linked to urbanisation and the trend for more homes being built in vulnerable locations, such as on the coast or near forests at risk from wildfire.

But the nature of the perils is changing, too. As global temperatures rise, conditions conducive to severe convective storms and flooding are becoming more prevalent. The Intergovernmental Panel on Climate Change (IPCC) warns that without substantial mitigation efforts, extreme weather events are expected to increase, raising exposure for insurers.

Figure 1: US natural catastrophe losses by peril, 2013-22 ($bn)



Source: Insurance Information Institute/Zesty AI. CAGR based on five-year moving average

The IPCC has established clear links between climate change and the increasing severity of many natural disasters, while the effect on frequency can vary, depending on the event type and region.

For example, rising global temperatures are exacerbating drought conditions, leading to more frequent and intense wildfires. Sea level rise, driven by melting ice sheets and thermal expansion of oceans, is amplifying coastal flooding risks. Warmer sea surface temperatures are providing more energy for tropical cyclones, resulting in more powerful hurricanes.

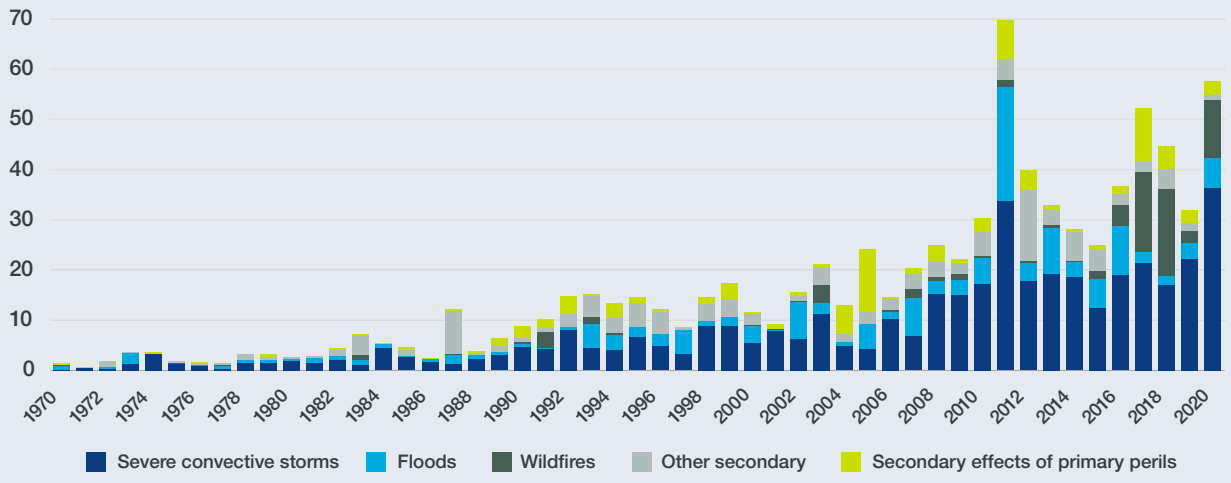
Munich Re's Grimm says: "In the case of these natural hazards, science assumes that climate change has a significant influence on the number and severity."

Understanding how a changing climate affects atmospheric risks is a key challenge for cat modellers trying to understand exposures to hurricane and the key secondary perils.

Technological innovation

Unlike hurricanes or earthquakes – which impact wide areas in a broadly similarly way – secondary perils often produce highly localised damage.

Figure 2: Global insured losses from secondary perils by peril types, 2000-2020. ($bn at 2020 prices)



Source: Swiss Re Institute

For example, a wildfire can reduce one house to ashes while leaving its neighbour with only smoke damage. A roof or vehicle in an area with stronger wind gusts during a hailstorm may experience more damage than those shielded by trees or buildings nearby that might escape relatively unscathed. Similarly, in flood scenarios, a difference of a metre in elevation can mean the distinction between devastation and no loss at all.

Historically, this level of detail has been impossible to model, as the data and computing power simply wasn't available – hence one of the definitions of a secondary peril as one that is unmodelled or poorly modelled. But nowadays, with access to cloud computing and granular earth observation data, modellers can create a high-resolution picture of hazard and exposure.

Sarah Russell, managing director at mapping and spatial analysis firm Bellwether that sits within X, the innovation arm of tech giant Alphabet, says high-resolution models are essential for quantifying localised impacts, such as pinpointing flood risks or predicting wildfire spread patterns.

By integrating data from sources like satellite imagery and meteorological forecasts, these models provide insurers with more accurate risk profiles and a clearer picture of geographic risk distribution, enhancing underwriting strategies. This has obvious benefits in terms of making it possible to model secondary perils, but hurricane and earthquake modelling also benefits from this more granular approach.

Wildfire exemplifies the evolving nature of secondary perils, Russell explains. "Wildfire is significant in the overall cat risk space for a few reasons: it's growing in urgency and intensity across wider geographies, perhaps no longer a 'secondary peril'; it's a challenging peril to model well because the data inputs, including vegetation, change all the time; and finally, because few folks have been able to understand deeply how fire risk is correlated across a portfolio."

Reinsurance

The rise of secondary perils is having profound impacts beyond discussions around modelling. In aggregate, perils such as severe convective storm might be regularly matching hurricane in terms of annual losses, but there are very many more storms in a year than hurricanes. For insurers buying reinsurance, this has become a major challenge. Reinsurers have been pulling back from covering the higher-frequency lower-severity events, instead focusing on extreme scenarios involving primary perils. So while insurers can obtain reinsurance cover for tail losses, it has become harder to find cover for aggregate losses at an efficient price.

Given reinsurance underpins much of the primary insurance market's capacity to take on risks, it is vital that modelling of secondary perils improves, so that insurers can manage their earnings volatility, and hopefully tempt reinsurers back into the market.

Future outlook

As secondary perils become better modelled and continue to be a major source of loss, the insurance sector is clearly moving away from the distinction between primary and secondary – if it hasn't already.

"I'm not very comfortable with these primary/secondary peril definitions," says a cat modelling leader at a major European insurer, who asked not to be identified.

"Hurricanes and earthquake cause massive damage, but the recent floods in Eastern Europe or the July 2021 floods were also major damage events. Even with hurricane, the driving peril for losses is often not wind: just look at Milton or Helene. In a warming climate, the flood peril could become the driving peril for hurricane losses."

They continue: "Our model development is not driven by this definition, but by perils and geographies where we are massively exposed."

In conclusion, the rise of secondary perils represents a significant shift in the natural catastrophe risk landscape. The insurance industry is adapting its approaches to risk modelling by integrating advanced technologies, coupled with a deeper understanding of the complex interplay between climate change and atmospheric perils. This should help to close protection gaps and create more effective and efficient insurance products.

A deep dive into flood risk modelling

As urbanisation and climate change propel flood into a primary peril for re/insurers, risk modellers are responding by capitalising on technology developments. Ronan McCaughey explains

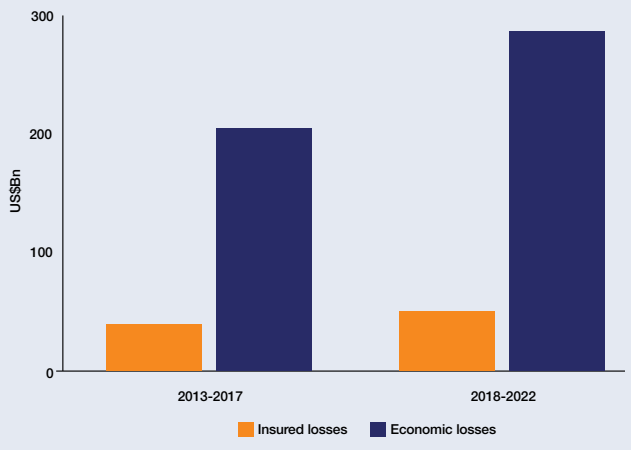
Floods affect nearly a third of the world's population, more than any other peril, and losses from flooding have been on an upward trend globally. In the decade through 2022, Swiss Re says cumulative insured losses from flood events globally of $88bn were more than 30% higher than losses during the previous decade.

Even within the last decade, there has been a notable increase in economic losses from flooding (see Figure 1) and the reinsurer states 2023's insured flood losses of $14bn were above the five and 10-year averages of $10bn and $9bn, respectively.

To put this in context, while flooding was traditionally considered a secondary peril and less attention was typically paid to modelling this risk, the situation has changed. Insurers recognise this threat now deserves the same importance as primary perils.

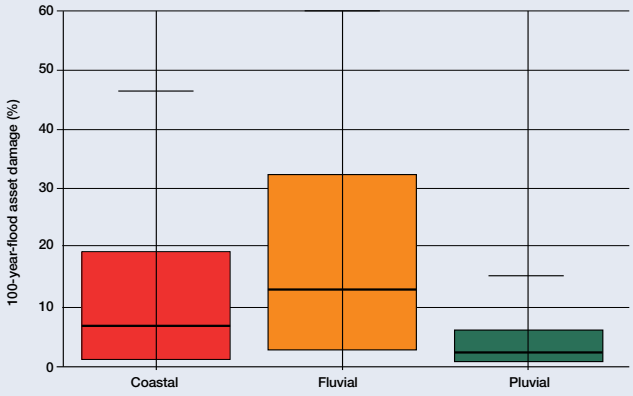
It is also important to understand the three different flood types and their associated financial impacts: pluvial flooding (from extreme rainfall), fluvial flooding (from rivers overflowing their banks) and coastal flooding (from high tidal water and storm surges). According to investment data provider MSCI, more than 40% of the global company locations it assessed are affected by at least one of the three flood types. Higher flood damage arises from fluvial, followed by coastal and then pluvial (see Figure 2).

Figure 1: Global flood losses 5-year periods, 2013-2022



Source: Swiss Re Institute. Adjusted to US$ value in 2023

Figure 2: Asset damage due to a 1-in-100 year event (1% annual exceedance probability) by flood type



Source: MSCI. Notes: Upper and lower quartiles in box; median value in bold horizontal line; whiskers at 150% interquartile range.

Evolving risk

Re/insurers face several challenges in understanding their exposures to flood. In the first place, it is a highly localised risk, so granularity of data and models is a necessity. Another is that the nature of the risk is changing, with floods becoming more frequent, severe, and occurring in places that have not seen significant inundation before.

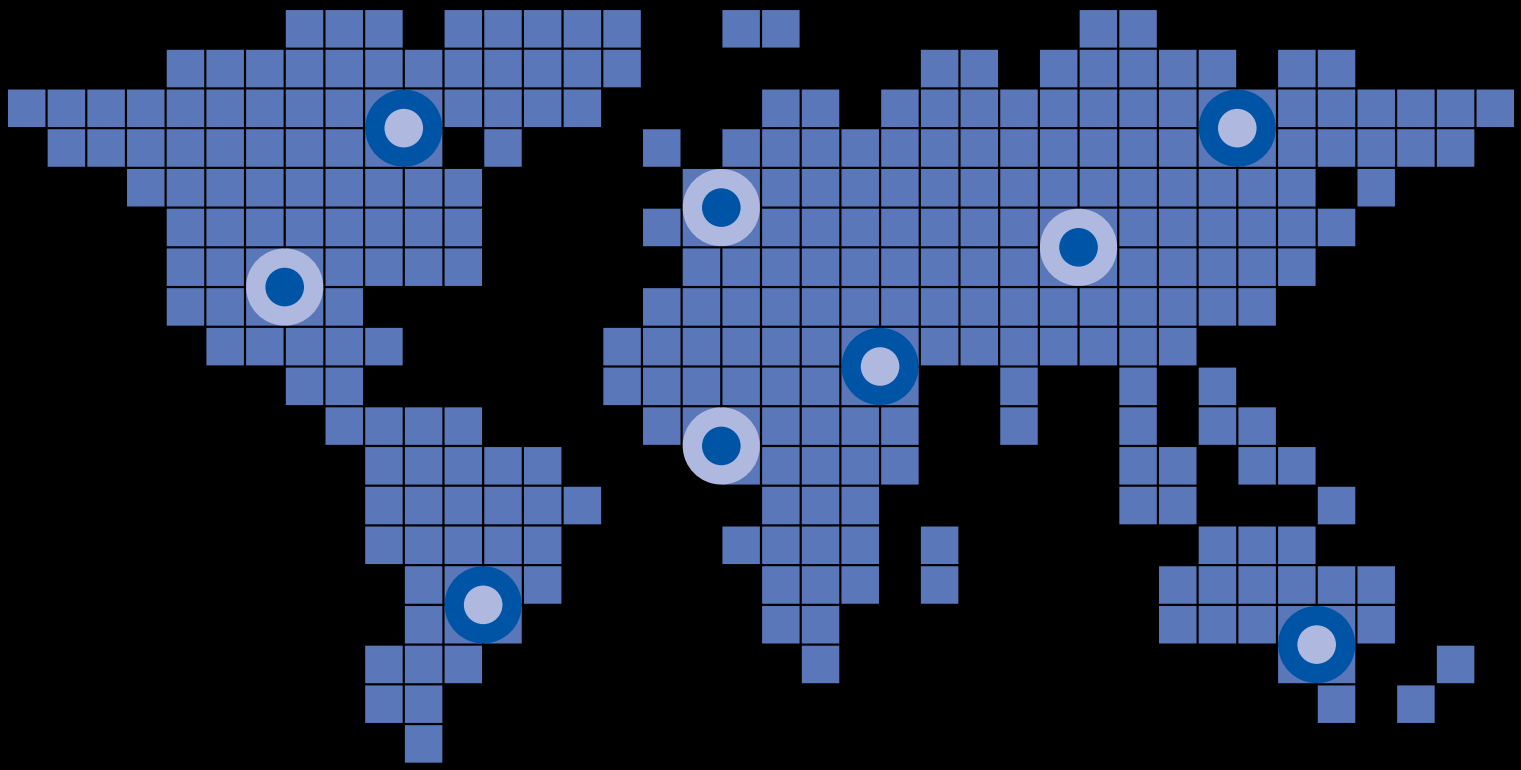
This change is driven by urbanisation and industrialisation, as well as climate change. There is a growing population that is increasingly being housed in urbanised areas, compounded by the trend for people to migrate to cities located near coasts and rivers. With impervious concrete or asphalt surfaces covering more of the land, it leaves less areas to absorb water.

Climate change is not a distant future possibility, but a current reality. The Central Bank of Ireland, in its Flood Protection Gap report published in October 2024, is just one organisation to warn of more frequent and severe floods as the impacts of climate change become clearer.

Matthew Jones, chief product officer at flood risk modelling firm Fathom, comments that flooding is a peril "where there is a reasonably high confidence it will be impacted by climate change as a warmer world is a wetter world, and sea levels are rising".

Fathom's Global Flood Cat — available now

The first truly global catastrophe model that considers both inland and coastal flood perils



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Understand
drivers of risk accumulations.

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Nalan Senol Cabi, head of catastrophe model research at Arch Insurance Group, says the increasing frequency and severity of flood events, caused in part by climate change, is adding further complexities to what is already a challenging peril to model.

Insurers' approaches

Alan Godfrey, exposure management director at Bermuda-headquartered property and casualty re/insurer Sompo, says flood risk is highly nuanced with potential losses coming from multiple mechanisms that need to be considered separately, and as a whole.

Fluvial flooding is perhaps the most obvious source of loss, explains Godfrey, while he says pluvial flooding – resulting from water falling in an area that cannot absorb it effectively – "requires just as much attention, but can be harder to model".

Godfrey says choosing a flood risk model can depend on a suite of factors unique to each company. "Depending on materiality, a desire to use the model to price risks up-front, or just perform accumulation assessments after the fact, the global scope, and the internal view of risk can all result in different decisions," he says.

Running a model

Running a flood model is a complex process. One of the most important factors in successful modelling is the resolution and quality of the data. This includes the exposure data from the re/insurers, as well as the input data on hazard and vulnerability provided by the risk modeller. External data, such as flood defence information, also needs to be integrated. All this data needs to be validated, corrected and/or adjusted where appropriate.

While vendors can provide the best possible model for flood, they do not often have the full visibility of individual re/insurers portfolios, claims data, or current internal risk management practices (e.g. underwriting and pricing guidelines) to be able to tailor that model for a specific portfolio.

Fathom's Jones explains part of the skill of the model builder is in how they handle and communicate uncertainties.

"There is uncertainty in every piece of building a catastrophe model. For example, in flood models, there is uncertainty in the terrain data, the dimensions of river channels, flood defences and the relationship between flood depth and flood damage," he says.

"You have to either mitigate uncertainty with clever techniques, or you represent it. For example, where we are uncertain about the distribution of river flows or sea levels (in data sparse areas), we use machine learning techniques to fill in data gaps. In areas where it is hard to reduce the uncertainty, for example in the distribution of losses for a specific level of flood depth, you need to represent it and include appropriate distributions in the model."

Model use best practice

Effective flood risk modelling depends on understanding the methodologies used in developing a flood model, and each one's strengths and weaknesses, according to risk experts interviewed by *InsuranceERM*.

Cameron Rye, head of modelling research and innovation at the WTW Research Network, says a key component is to understand how expert judgments influence model outcomes, from data selection (e.g. elevation models) to the scientific equations used.

Rye comments: "Since different model developers make different assumptions and choices, it's important for insurers to evaluate these decisions to avoid over-reliance on 'model land' and ensure their risk assessments are grounded in the real-world."

Jones says: "I would always ask how much I trust the model and what data underpins it. A model is only as good as the strength of its components. There are a number of things you can ask to ascertain that level of trust. For example, what science underpins the models and is that science open or not?

"Fathom's ethos is to openly publish everything in peer-reviewed journals so we know our work has passed scientific scrutiny."

Technological innovations

The advances in flood modelling are coming from improvements is multiple areas.

Data is a crucial one, and modellers say the availability of high-resolution earth observation data from the likes of the EU's Copernicus project, as well as more widespread remote sensing, for example of river depths, have had a significant impact on model enhancements.

Satellite technology continues to advance and modellers are looking to take advantage of the data produced. For example, Jones says Fathom is involved with US space agency NASA in a project called SWOT, "which is rapidly expanding our knowledge of river channels. The satellite mission surveys all of the Earth's water bodies in a 21-day cycle. Once complete, SWOT will help us to more accurately capture flood event water levels and improve flood map validation."

Flood modellers say satellite technology is also helping to improve the resolution and coverage of global rainfall data.

Alongside this is the easier access to powerful computers, thanks to cloud and GPU technologies, and advances in understanding the physics behind flooding. These are helping accelerate hydrological calculations and making it possible to complete hugely challenging tasks such as converting rainfall patterns into river flows.

These factors and many more have made it possible for the industry to evolve from flood mapping – which allows risk to be understood at individual locations – to developing flood catastrophe models that can gauge aggregated risk in portfolios.

Among the developments in the last five years, in October 2024 Fathom released its global flood catastrophe model, described as the first of its kind to calculate the financial risk for all major flood perils including fluvial, pluvial and coastal.

As flood cat models become better established, one further step is to build on the dynamic link between flood and tropical cyclones. While most fear the deadly high winds from hurricanes and typhoons, the rainfall and storm surge associated with them often contributes to – and can be the majority source of – financial and human losses. Fathom itself is pursuing a collaboration with tropical cyclone modelling firm Reask to make the idea of a combined hurricane-and-flood model a reality.

Driven by urgent demand from the re/insurance sector to understand flood risk, modellers' relentless pursuit of improvements is key to helping the sector provide essential cover for businesses and homes, in an ever-changing world.

A new wave of flood risk analysis

Dr Matthew Jones, chief product officer at Fathom, explains how the flood risk modeller's approach stands out compared with other vendors, why insurers are paying more attention to flood risk, and the benefits of its solutions

Can you explain how Fathom's approach differs from other vendors in the market?

Fathom's approach to modelling has always been different, thanks to our deep roots in academic research and commitment to transparency. Our goal is simple: to bridge the gap between scientific advancements and real-world applications.

This involves publishing our work in open-access, peer-reviewed journals. This opens our models up in a market traditionally dominated by black-box models and ensures Fathom's products are built on robust and evolving research.

What does the term niche model provider mean in the context of flood?

When flood models first became commercially available they were often part of a larger suite of peril models offered by large firms. Having access to any flood model was groundbreaking. However, this limited approach to modelling left gaps in the industry's knowledge of flooding.

Fathom's approach to modelling stands out for its comprehensive coverage, advanced techniques, and commitment to transparency. Now a team of almost 60 flood specialists, Fathom engages in research and develops technologies that wouldn't be possible if we had broader scope. This includes products like our Global Flood Map, our new Global Flood Cat and datasets like FABDEM+.

Are insurers paying more attention to modelling flood risk? Why?

Flooding is already one of the most costly natural disasters globally, causing significant damage and loss of life. In 2023 large-scale flooding events resulted in $14bn in insured losses alone. As exposure increases and climate change intensifies weather patterns, insurers are acutely aware they cannot afford to ignore the growing financial threat of flooding.

Several recent flood events have put a spotlight on flood risk. Flash floods in St Louis and the German floods in 2021 showcased a real lack of preparedness. Hurricanes Helene and Milton in the south-eastern US this year further underscore this point; both experienced rapid intensification due to warmer sea surface temperatures, and demonstrated the real and compounding impact that catastrophic events can have on a region.

Traditionally, insurers relied on historical claims data to assess flood risk. However, given changes in climate and increasing flood exposure, relying solely on past data is insufficient. Flood is also a high-resolution and uncertain risk that cannot be fully captured by claims data alone. Insurers are embracing tools that help anticipate and mitigate potential losses and this is driving the adoption of more sophisticated models such as Fathom's Global Flood Cat.

What new technology/products is Fathom working on for insurance?

We recently launched our Global Flood Cat model, the first truly global catastrophe model that considers both inland and coastal flood perils.

This significant milestone represents over a decade of work and completes the final piece in the founding Fathom jigsaw puzzle. For insurers, it means they can now not only assess individual asset level risk using our hazard data, but also quantify risk across portfolios anywhere globally.

Our aim is to expand the accessibility and usability of our products by improving integration with other risk management tools and to explore partnerships.

How do you expect flood risk modelling to evolve over the next two or three years?

We anticipate significant evolution in flood risk modelling, driven by technological advancements and greater integration of sophisticated datasets, including improved terrain data.

We're involved in a NASA-led mission called SWOT, which is rapidly expanding our knowledge of river channels. The satellite mission surveys all of the Earth's water bodies in a 21-day cycle.

How does Fathom work with platforms to help insurers get access to multiple best-in-class views?

Fathom uses the Oasis Loss Modelling Framework to build its models, ensuring compatibility with catastrophe modelling platforms. Fathom has partnered with Nasdaq since our first catastrophe model launch and our model underpinned the Moody's Open Modeling Engine pilot last year.

We believe it is incredibly attractive for customers to access multiple views of risk through one platform. Ease of access, streamlined data conversion and standardised exposure and results data mean greater flexibility and efficiency for risk professionals. ■

www.fathom.global

Top challenges for cat modellers

InsuranceERM spoke to catastrophe modellers and exposure managers at re/insurers and brokers to understand the main frustrations with their work - and how to improve this

Tina Thomson, Gallagher Re

Jessica Turner, MS Amlin

Ming Li, Acrisure Re

Data

This entire article could have been given over to dissatisfaction about data, a reflection of how important it is to the natural catastrophe (natcat) modelling process. Experts say the three main issues boil down to scarcity of data, obtaining sufficiently detailed data, and having it in a useful format.

Tina Thomson, global head of research and international catastrophe analytics at broker Gallagher Re, sums up the situation. "The key to understanding natcat exposures starts with having granular and information-rich data about your exposure locations and assets," she says.

"What you get out of a natcat model is only as good as the data you put in. For localised perils liked flood, it's even more important to have detailed location information, as for example, compared to a windstorm model where a postcode of a property can be still sufficient to assess its likelihood to be hit by an event."

Jessica Turner, head of exposure management at speciality re/insurer MS Amlin, says the major challenge for flood modelling is getting information on the built environment, such as details of flood defences and local drainage. "This is an issue the vendors cannot solve on their own. It needs local and federal government involvement to help insurers with better flood defence information, which ultimately means better data collection and dissemination."

Assessing vulnerability

Thomson also notes challenges around modelling vulnerability. The vulnerability functions of models are "either developed using engineering approaches or based on observed loss data. A natcat model is then calibrated overall with claims and industry loss data. Given the different methodologies to build a natcat model, you can have a wide range of results."

One cat modelling leader at a major European insurer, who asked to remain anonymous, says the industry is not using all the available data to define vulnerability models for different regions. "That is why a model can perform relatively well at portfolio level, but one can legitimately question it at a more detailed level, such as at the level of a site. If we had more confidence in site-level modelling, we could use it for pricing. There is a major step to go from portfolio-level to site-level," the modelling expert says.

Claims data

Ming Li, global head of CAT at reinsurance broker Acrisure Re, says one of the problems he faces is reconciling post-event loss estimates with the real claims experience that emerges in time.

"The model can be quite different from the experience. So how do you address that discrepancy? How do you validate the models, maybe even make adjustments to the models to have them customised to the portfolio? That is going to take effort and not just from us, but through collaboration with model vendors and clients."

Dean Saunders, head of exposure management at property and specialty reinsurer Ariel Re, agrees there is a challenge with handling claims data so that it can be fed back and used. "It can be challenging as a reinsurer to match cedant claims data to our exposure unless there is good granular underlying claims information available to match to underlying exposures."

Risk scoring

Acrisure Re's Li notes how models are often supplemented with other data products. "With the recent advances in technology and data science, there are plenty of data products, for example, companies offering a wildfire risk score or a flood risk score.

"But there are just too many data vendors. It is great to have a choice, but you have to work with clients to evaluate which one is the most credible and most relevant to their portfolio. You need evidence to support that decision, and sometimes the crowd is just too big to pick the credible one from."

Coding and inconsistency

Cat models are only abstractions of the real world, but modellers are always trying to better reflect the factors that materially affect losses. One of the difficulties with this is coding more detailed data on specific risks in a way that is compatible with the model.

Li explains one common question in cat modelling is how to model the actual cash value because of depreciation, versus the replacement cost value of property. "That is a topic that is never well addressed in the vendor models. You also want to capture all the important nuances in often very complicated insurance and reinsurance structures, such as coinsurance and hour clauses, as accurately as possible. How to code the data to make sure it's compatible with the model format is a challenge."

Ariel Re's Saunders highlights consistency of data as a problem in the cat modelling process. "There is potentially a wide set of data sources that our clients can use to enrich their data on top of the basic information provided by the underlying insured. These sources can have varied views and mean that the same property could be interpreted in different ways by different insurers depending on how the data is enriched and what primary or secondary modifiers they believe are important to record for their files. This can create complexity for a reinsurer in assessing risk quality and makes modelling and comparisons challenging."

Unmodelled perils

"I would like greater model coverage," says MS Amlin's Turner, summing up a frequent frustration expressed by cat modellers.

"There are still a lot of peril-regions where insurers are writing business where there aren't models or the models are old. I'd like models to be updated more frequently, especially in light of the changing climate," she says.

Nick Hassam, head of catastrophe model products at risk modelling firm Reask, who previously worked as a cat modeller at brokers and insurers, says beyond availability and modernity, users also demand transparency – so they can understand the strengths and weaknesses of models – and adaptability.

Managing uncertainities

The anonymous European cat modelling leader highlights "understanding the cascade of uncertainties in natcat models and how to deal with that in the model output, and in communicating the model output" as an obstacle for the industry.

"As an example, flood models are based on a digital elevation model that has uncertainty by definition, and we must understand how this uncertainty is changed all along the modelling chain," the expert says.

Matthew Jones, chief product officer at flood modelling firm Fathom, says: "You've got to ensure you either mitigate the uncertainty with clever techniques, or you represent it. For terrain data, for example, there was a good satellite data set captured in 2014 and released by Copernicus which was good, but it didn't enable us to see beneath trees and buildings, which is what we need for flood modelling. We came up with a machine learning technique to do that and published that dataset as something useful for flood modelling.

"Conversely, there are areas where you just can't reduce the uncertainty. For example, we know the damage uncertainty for a given depth of flooding is huge, but we don't know how to reduce it partly because there's a lack of nicely curated open claims datasets that we can do that with, so we have to ensure this uncertainty is well represented in the model," Jones says.

Automation

MS Amlin's Turner expresses a view shared by other cat modellers about the processes they go through in their daily routines: "I would like to have greater automation. Part of this is on me and my team, but I think in general cat modelling and exposure management is still a very manual process."

Reask's Hassam says cat modelling is an involved process "simply because there are subjective decisions that are required to be made".

"There is always the potential in these instances for technology to automate those processes. But until such time as you can encapsulate the complexities of risk appetite within code, it's difficult to actually really facilitate that automation in a scalable way," he says.

Hassam says the industry has tended to use automation to extract more information, i.e. generate more data, rather than accelerate processes. "They've used automation to better understand the limitations of risk models or generate other views of risk that perhaps a machine wouldn't be able to pick up on."

Acrisure Re's Li highlights another common issue that could benefit from automation: the translation of data between different formats. The model vendors use varying data formats and despite efforts to bridge these differences, challenges persist due to inconsistent handling of data elements and ongoing changes in model data formats. Translating between them remains "a very tedious process", particularly when dealing with complex policy structures and specialty risks.

He adds: "If we could streamline this process, it would be tremendously helpful for us."

Talent

At a basic level, cat modelling cannot be done without people who have experience in areas such as meteorology, climatology, data analytics and software development. Attracting such people to the sector is vital and is a key topic for MS Amlin's Turner and others.

"My top challenge right now is bringing talent into the industry and nurturing that talent. Insurance is not necessarily the first career that graduates think of, but I think cat modelling and exposure management is a great place to spend your career," she says.

Fresh hurricane models sweep in

As one of the main causes of catastrophic loss, insurers have always paid attention to hurricane risk. Efforts to improve modelling of this peril are focusing on the associated flooding, accounting for climate change and seasonal forecasts. Christopher Cundy reports

Tropical cyclones – commonly referred to as hurricanes and typhoons – are a principal cause of catastrophic loss for insurers and are partly responsible for the emergence of catastrophe modelling as a discipline.

The first cat models were developed in the late 1980s. But it was after Hurricane Andrew in 1992 – when more than a dozen insurers went bust after failing to understand their aggregate exposure to the category 5 storm – that adoption of cat models really progressed.

The initial approach to modelling hurricanes involved using historical records and then statistical approaches to extrapolate outside those records, to generate thousands of scenarios (the "event set"). By repeatedly running these scenarios through a catastrophe model, a probability distribution showing expected losses can be created.

This approach has served the industry well, successfully helping to manage risk from devastating events such as Atlantic hurricanes Helene and Milton, which struck Florida in September and October 2024.

Flood components

But there are always areas to improve, and one that cat model users are particularly keen on is understanding the potential for flooding associated with hurricanes, which can be a significant source of loss.

"We have been modelling hurricanes for over 25 years. The science has come a long way but we're at the stage where there's decreasing gains in terms of modelling them better," says Jessica Turner, head of exposure management at re/insurer MS Amlin.

"But bigger event catalogues would be good: with Milton, there weren't many analogue storms in the catalogues.

Alex Kronenberg, senior vice president at SiriusPoint, says the two most established modelling firms – Moody's RMS and Verisk – have made incremental improvements to hurricane models in recent years, particularly in the area of integrating flood.

"Notably, Verisk has made significant adjustments in the implicit inclusion or exclusion of precipitation flood. Additionally, the transition from modelling storm surge as merely a loading factor to developing it into a standalone model has enhanced our team's capability to understand risks comprehensively. Despite these advancements, the risk of litigation following various events remains a pertinent issue," he says.

Alex Kronenberg, SiriusPoint

Improving the flood element of hurricane modelling is also a priority for Erik Lindgren, wind perils lead at Swiss Re. "We will update our Northwest Pacific tropical cyclone model in the coming years, and one emphasis will be on improving the tropical cyclone-induced rainfall modelling. The learnings will be incorporated across our tropical cyclone model landscape."

Forward-looking views

Another preoccupation for hurricane modellers has been trying to understand how the hazard is evolving, in light of the warming planet.

"It is vital that models are calibrated to represent current and near-future risk, rather than long-term history," explains Lindgren. "Hurricane activity in the North Atlantic has been elevated compared

to long-term history since the mid-1990s, and any risk view that is calibrated to long-term North Atlantic hurricane activity will underestimate current risk."

SiriusPoint's Kronenberg says he is also looking forward to models incorporating a more forward-looking view: "The next big innovations we would anticipate would be increased weather changes and rapid intensification and we therefore look forward to seeing how the models will develop."

Like many cat modellers, he has been watching this year's hurricane season with interest.

"Will recent cat activity cause an increase in cat load factors that people consider for the Golden Coast/West coast of Florida, as well as other regions and perils? Of particular interest was how Hurricane Milton quickly developed, intensified into a category 5 storm before making landfall as a category 3. The rapid intensification is something that we saw with both Helene and Milton – so the whole industry is looking closely at whether that intensification pattern is something that is the new norm or more seasonal variations."

Thomas Loridan, Reask

MS Amlin's Turner says: "We think climate change is going to increase the severity of hurricanes. Milton and Beryl [in the 2024 season] are great examples of that, where the warm sea surface temperatures are fuelling rapid intensification. But the jury is still out on whether it will affect frequency. Some of the new high resolution climate models are showing an increase in frequency as well. The vendors do update their hurricane models relatively frequently and we are comfortable that the Moody's RMS medium term rates catalogue is representing today's average climate."

Physical modelling

But rather than attempt to recalibrate assumptions in models to account for climate change, some firms are taking a different approach. Thomas Loridan, chief science officer at risk modelling firm Reask, explains his company has developed a method of creating event sets and wind fields, based on the actual physics that drives hurricane formation, strength and movement.

"If I want to understand the risk on the east coast of Florida, I can base it on what's happened in the past and extrapolate it. But that's not enough, because I need to account for the fact the ocean temperatures are warming pretty fast, and that has implications for intensification, steering patterns and the like. You can't just rely on history: you need to make sure your models have some understanding of the physics that drive the risk," Loridan says.

Reask's approach means climate drivers of hurricane risk can be easily integrated and thus enable users to understand how their exposures might fare in the future.

Another important implication of the approach is that users can have a worldwide view of risk and better understand the global aggregation in their portfolios. "Because our models are global and based on climate physics, you can start to question the correlation of risk between Japan typhoon and US hurricanes, and how that is changing during the phases of El Niño versus La Niña," Loridan says.

The firm's next step is to launch a fully-fledged hurricane cat model, and work on integrating hurricane-related rainfall and storm surge, which it is doing in partnership with flood modelling company Fathom.

Seasonal forecasts

The vast majority of North Atlantic hurricanes occur in a season that lasts from 1 June to 30 November and for decades scientists have tried to forecast how many storms and hurricanes might emerge over the season. For example, it is well understood that factors such as the phase of the El Niño-Southern Oscillation (ENSO) affects the risk of hurricane formation; with the science steadily improving, it could be useful for insurers to understand how active a season will be, and their likelihood of loss in the coming year.

According to a cat modelling leader at a major European insurer, who asked to remain anonymous: "I have a lot of hope in seasonal forecasts improving how insurers manage natcat risk and mitigate it efficiently. Such datasets are not new but the number of members in a simulation ensemble set has significantly increased in recent years, allowing for more robust probability calculations on the severity of a hurricane season and potential landfall areas."

Swiss Re's Lindgren cautions that pre-season forecasts still have limited accuracy, mainly because it is difficult to forecast the ENSO phase prior to the start of the season.

"Seasonal hurricane forecasts released in summer have higher accuracy, but by then the hurricane season has already started and the forecasts may be too late to significantly influence business decisions," he adds.

Lindgren also points out that annual hurricane losses are driven by individual events, not overall activity, and the current forecasts typically predict activity across the entire Atlantic Basin rather than a particular location.

Nick Hassam, Reask's head of catastrophe modelling, says there are structural elements in the traditional re/insurance market that are incompatible with the present ability of seasonal forecasters: namely that reinsurance contracts tend to be renewed at fixed dates – usually 1 January – which gives a short window in which to reduce or increase exposure before the season starts.

But seasonal forecasting is proving more useful to the insurance-linked securities (ILS) market, where secondary trading of ILS means fund managers can consider their portfolio position and trade in and out, as seasonal forecasts develop.

"People have said for years that 'we don't need a seasonal forecast because we can't change anything'. But now we see our clients saying 'actually this is quite useful information' and they're starting to find new ways to use it," Hassam says.

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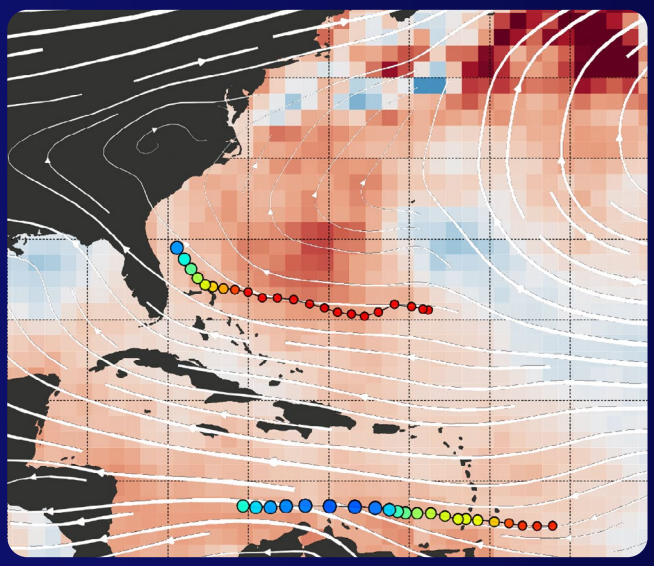

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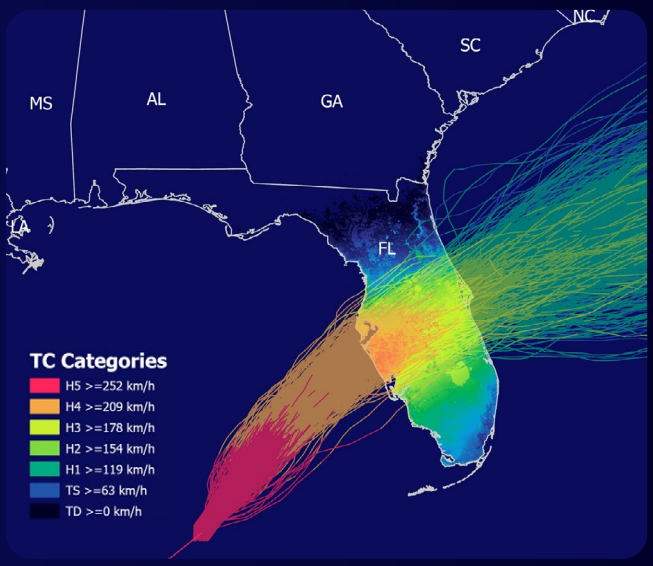

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Reask: revolutionising natcat modelling

Thomas Loridan, co-founder and chief science officer at Reask, a natural catastrophe risk modeller and climate risk analytics firm, discusses the company's dynamic approach, the value of physics-based and machine-learning models, and its planned innovations

What sets Reask apart from traditional natcat modelling processes?

Traditional models are mostly static and region-specific, lacking the ability to account for the dynamic nature of climate. They typically analyse risk on a backward–looking, peril-by-peril basis without considering global risk correlations.

At Reask, we integrate physics into our models and use machine learning to extract important signals from vast amounts of global climate data. This allows us to simulate the physical processes driving extreme weather events and capture the interconnectedness of the world's climate system.

You cannot just rely on history or an extrapolation of history to model tomorrow's risk. There needs to be some understanding of how climate physics drives the risk, and how that climate is changing. This is what we have done differently.

How does Reask incorporate physics and machine learning into its models?

Our use of physics-based machine learning (ML) is best illustrated from two modelling use cases.

First, we build algorithms that can generate synthetic events that are not based solely on historical statistics, but also on physics. To do so we take historical event data and overlay what we know about the main climate drivers, so ML models can learn to link certain conditions, such as warmer oceans, and event behaviours, like rapid intensification.

This process allows our models to capture how changes in climate variables affect the frequency and severity of events, like tropical cyclones. By basing our models on the underlying physics of the climate system, we can create dynamic models that adjust as climate conditions change.

The second important use case for ML is about capturing local risk with high granularity. For our tropical cyclone wind and rain models, we have created a unique proprietary database of global 1-km resolution events using numerical weather prediction tools.

By allowing machine learning models to train on this database, we can then simulate physically realistic wind and rain patterns over complex terrain in a fraction of the time it takes to run numerical weather prediction models. This is how Reask can simulate millions of high-resolution events globally on the fly.

What advice would you give to insurers dealing with the complexities of climate risk and natcat modelling?

First and foremost, it's essential to understand that not all models are created equal. Organisations should carefully assess whether a model's methodology aligns with their specific needs and regulatory requirements.

Embracing advanced modelling techniques that incorporate physics and machine learning can provide a significant advantage. Such models offer a more connected and dynamic view of risk, which is increasingly necessary in the face of climate change.

Working with modelling providers who are open about their methodologies and willing to tailor solutions to your needs can also make a substantial difference. At Reask, we publish our work openly and are committed to helping our clients navigate these challenges effectively.

Why is it important to have a global, climate-connected view of risk?

Extreme weather events are interconnected on a global scale. Climate phenomena like El Niño or La Niña can affect weather patterns around the world. By having a physics-based model that understands these global connections, we provide more accurate assessments of risk across different regions and perils.

What innovations is Reask working on?

Over the past six years, we have been focused on building global tropical cyclone models. However, recently, we have been working in collaboration with UK flood risk modeller, Fathom, to provide a full loss calculation model.

This involves tropical storm-induced rain, storm surge and wave perils, and importantly feeding that through the Fathom framework so we can monitor flood risk and have a complete view of tropical cyclone risk.

The initiative is planned to start with the release of a model for the US, late next year, in collaboration with Fathom.

We have also been working on drought modelling with an industry partner and we have started to do some work on wildfire risk. ■

To view Reask's research papers visit www.reask.earth

A new bridge to the open modelling world

The launch of a system to connect the Moody's RMS universe with catastrophe models based on Oasis standards is a landmark moment for the insurance industry's open modelling initiative. Christopher Cundy reports

The idea of a more open catastrophe modelling environment is to break the historic association between the platform on which a model must be run, and the model itself with its hazard, vulnerability and exposure modules.

For years, the cat modelling landscape was two dominated by two platform providers and their respective suite of models, prompting user concerns about being locked into a spiralling cost of modelling and a potential lack of competition and innovation.

The insurance industry's response was the Oasis Loss Modelling Framework, an open-source framework – and latterly a platform – for cat modelling that is free for anyone to use.

Launched in January 2014, momentum has been growing steadily, to the point there are now 19 model vendors basing their models on Oasis standard. But in 2024 one of the most important milestones in the open modelling initiative was achieved: a bridge between one of the dominant cat modelling platforms – Moody's Insurance Solutions (previously known as RMS) – and the open modelling world inspired by Oasis.

In July 2024, users of Moody's Insurance Risk Platform (IRP) for the first time were able to seamlessly access independent models from the likes of JBA Risk Management, ARA and Fathom alongside their usual RMS models. Key to making the relationship possible was Nasdaq Risk Modelling, a SaaS platform built on Oasis, which sits between Moody's and the independent modellers.

Cihan Biyikoglu, managing director at Moody's responsible for product management of the Moody's RMS models and risk management tools, explains how clients can simply select whichever model they wish to run from a dropdown menu. Aside from the licensing costs for the Nasdaq system and the models, there is no additional model licensing charges when using Moody's Insurance Solutions (Moody's RMS) tools.

"The beauty of it is, it gives customers a couple of things. One of them is they don't have to deal with the nightmare of converting very complicated data types. The other is that IRP can become their single platform to aggregate all their modelled risk," he says.

> "Customers don't have to deal with the nightmare of converting very complicated data types"
> Cihan Biyikoglu, Moody's

Integration challenges

Behind the scenes, the integration has faced several challenges. First, independent modellers did not want to put their models directly onto other platforms, in order to protect their intellectual property. Second, was making the seamless conversion of exposure data a reality.

Nasdaq helped with both aspects. Their platform, originally called ModEx before its developer Simplitium was acquired by Nasdaq in 2019, has become the leading enterprise-level solution for users to access independent cat models.

Insurers and other cat model users can – and do – build their own solutions off Oasis and there are firms offering bespoke risk modelling services. "But if you want to run models regularly and

Cihan Biyikoglu, Moody's

James Lay, Nasdaq Risk Modelling

Dickie Whitaker, Oasis LMF

you have exposures in regions that you want to monitor regularly, then it probably makes more sense to have a system like ours," explains James Lay, commercial director at Nasdaq Risk Modelling.

Nasdaq manages the distribution of some 300 country-peril models and 13 model vendors, and handles the updates to the models and Oasis itself: "That's not a small undertaking when you're talking about open-source projects," Lay adds.

To solve the first problem, Moody's IRP connects with Nasdaq, where the independent models are run, effectively keeping the vendors' IP at arm's length from Moody's.

> "The integration is about as seamless as you can expect, both technically and financially"
> Dickie Whitaker, Oasis LMF

Converting data

The root of the second challenge lies in the proprietary data formats that each modelling system uses to store exposure data. For example, Moody's RMS models use its Exposure Data Module (EDM) standard, while Oasis models use the Open Exposure Data (OED) standard.

"As a user of cat models, you're faced with this task of translating one data format into another in order to run the model in question," says Lay.

In practice, the Moody's system converts exposures from EDM to OED and delivers to Nasdaq; the models are executed on Nasdaq; then the data from Nasdaq, which is in the Open Reporting Data format, is transformed so it can be used in IRP.

This data conversion has been at the core of the quest to make an efficient, consolidated workflow for users that wish to use both RMS and independent models.

The challenges go deep. As Biyikoglu explains, the standards are not rigidly implemented. "Every model vendor uses the data types in a unique way. So, for example, the way in which Fathom uses the OED is slightly different from JBA or ARA. They each have different modifiers that help them understand the exposures. We found work needed to be done to allow the best version of the model to show up in the results. That's the harder part of the work we needed to do."

Moreover, as models are updated and improved, they can interpret OED or EDM slightly differently, and the standards themselves are regularly updated. "Our system has to deal with all that complexity," says Biyikoglu.

The challenge partly explains the phased approach to integrating the Nasdaq modelling universe into IRP. At production launch, the ARA US hurricane model, Fathom's US flood model and JBA's global flood models were available. Fathom's Global Flood Cat model is also now available and further models are being integrated in response to client demand: currently, that includes models from Impact Forecasting and CATRisk Solutions.

The engine can also convert exposure data in the CEDE format proprietary to Verisk, previously AIR Worldwide, but there are no plans to integrate models from Moody's biggest rival.

Multiple views

For Dickie Whitaker, chief executive of Oasis LMF, the initiative with Nasdaq and Moody's "is really cool because it's a representation that Oasis as a platform is the way to consume alternative models".

He says the integration "is about as seamless as you can expect, both technically and financially" and facilitates multiple views of risk – one of his tenets behind the development of Oasis, as multiple views are one of the simplest ways of understanding the uncertainty of cat models.

Biyikoglu adds solving the data conversion headache helps model vendors overcome a key distribution challenge.

"It really becomes much easier for model vendors to reach the market and it motivates innovation in this space. We need more models. Even though we develop a lot of models and I believe we have the best science in the models, it's unrealistic to think that Moody's Insurance Solutions can build every model that the insurance industry will need.

"I'm hoping this opens the door to a lower barrier for entry for anybody who wants to build models for the industry."

Modellers blaze a trail on wildfire risk

Three of the biggest wildfire-related disasters have come in the past five years. Faced with this growing risk, the insurance industry is making radical advances in its modelling capabilities. Sarfraz Thind reports

Wildfire has become one of the costliest and yet complicated catastrophe risks for insurers to manage. Historically classed as a secondary peril, insurers in exposed regions are increasingly looking at this as a primary risk for their businesses. That is no surprise given the growing losses from wildfires, triggered by climate change and property development.

According to industry association the Insurance Information Institute, the top three costliest wildfires in the US, which all happened in California, caused an estimated $23bn in insurance losses. 2018's Camp Fire was the most expensive, causing $10.75bn in losses and 85 deaths.

While fires have caused loss worldwide, notably in southern Europe and Australia, it is North America where the impact has been hardest. The three US states most prone to wildfires are Texas, California and North Carolina, though it is the second of these that has seen most hurt. In Canada, which suffered its worst wildfire season in 2023 in terms of area burned, the western provinces of Alberta, British Columbia and Northwestern Territories have borne the brunt.

Given the evident risk, it is understandable that insurers wish to focus on developing better wildfire risk models. But fulfilling this ambition is not likely to be an easy task.

"It's almost unimaginable how complicated it is to simulate what happens in a real fire," says Nancy Watkins, principal and consulting actuary at consultancy Milliman.

Wildfire losses

In dollar terms, wildfires are nowhere near as costly for insurers as hurricanes. According to Jolee Crosby, CEO Canada and English Caribbean at reinsurer Swiss Re, wildfire accounts for $5bn to $10bn of global insured losses every year, which is approximately 5-10% of overall insured losses globally.

Few companies would expect one wildfire to significantly impact their surplus, whereas a hurricane can be spread over a much wider geography and do much more damage. And yet, for insurers, the complications of modelling wildfires means the peril offers just as significant loss potential as the more well-researched hurricane or earthquake risks.

"The predictability and management of hurricane risk is much more evolved and stable compared to wildfire risk, and so it's more difficult for companies to get their arms around whether or not to offer coverage in a certain area and how to price for the latter," Milliman's Watkins says.

The relative newness of major wildfire losses means it may have been ignored from a modelling perspective. That is changing now, thanks to the advances in technologies and techniques that have been necessary to understand the unique risk characteristics of this peril.

Unique risks

Wildfire has several aspects that mean modelling it is potentially more difficult than for other perils. For one, the risk can vary radically between one location and another just a few kilometres apart. This requires very granular models, which are computationally expensive, says Swiss Re's Crosby.

While wildfire ignition depends on a combination of atmospheric, soil and vegetation conditions, the triggers can be natural (e.g. lightning strikes) or man-made (e.g failure of utility infrastructure, a carelessly disposed cigarette, or even arson). California's Camp Fire, for example, was caused when a single metal hook carrying a power line broke. But modelling human influence is never the easiest task.

"One of the main problems in wildfire modelling is predicting when and where fires will start, especially since nearly 80% of wildfires are caused by humans," says Daniel Bannister, weather and climate risks research lead at broking and advisory firm WTW. "It's harder to predict human behaviour than it is to model natural events like windstorms."

Humans also have a lot of influence on how wildfires spread or are contained – for example, in preventing fire spread through firefighting or building fireproof structures. The one overarching truth remains, however, that wildfire risk is increasing due to climate change.

"No doubt, the fire seasons are longer," says Watkins. "The weather tends to be hotter and drier and there are more dead trees than ever."

Changing data inputs, including that caused by climate change on vegetation, in turn requires significant amounts of software and geospatial data expertise to manage. Then there is also the problem

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Nancy Watkins, Milliman

Sarah Russell, Bellwether

for wildfire modellers of analysing fire correlation.

"Few folks have been able to understand deeply how fire risk is correlated across a portfolio," says Sarah Russell, managing director at mapping and spatial analysis firm Bellwether that sits within X, the innovation arm of tech giant Alphabet. "We look at the correlation between any two buildings as being about more than just distance but also about the landscape, vegetation, and weather patterns that exist between those two buildings."

Insured losses have also risen because of urbanisation trends. Decades of development have meant more properties built in the higher risk wildland-urban interface.

"In the US, we don't actually have much concern about fires that burn many, many trees," says Watkins. "That might be a different kind of problem, but it's not an insurance problem. The insurance crisis that we've been experiencing associated with wildfire has to do with urban conflagration or suburban conflagration, where you have houses that are densely clustered, and they start becoming the fuel, which is another thing that is difficult to model."

Modelling advances

But there have been important advances in modelling the risk of wildfire in the last few years. These days, insurers are using all kinds of inputs, and many are placing greater emphasis on understanding the interaction of community and how the risk of one house is dependent on its surroundings.

"Forest fire modelling is well established, and there is the data to support it," says Watkins. "But modelling structure-to-structure spread and how fires are introduced from the wildland into how they cross over into a built environment, those advances require much more granular knowledge of the conditions that are contributing factors."

Watkins says modellers are considering structure, separation, distance, how far apart houses are from each other and unique characteristics of individual parcels, like whether the zone around the house has been cleared of vegetation and whether there are vents under eaves to keep embers from going up into the house.

This level of detail – which is a necessity to move the wildfire modelling world on – was expensive and difficult to capture in the past but has become more readily available and less cost intensive. Insurers are using advanced photography and artificial intelligence (AI) to capture additional information coming from satellite or drone imagery, to gather together patchworks of information more efficiently and more continuously than ever before.

Russell is a particular fan of the opportunities presented by AI.

"AI has changed everything for the field of wildfire risk. It has made it possible to do things that we didn't think possible, like infer and forecast ember spotting. AI makes it possible to learn the dynamics of fire risk in a given geography and then apply that learning in a brand new, 'foreign' land."

AI also makes it possible to work with disparate and imperfect data about weather, vegetation and buildings and draw accurate conclusions anyway. Russell says her company has built a system that solves the data engineering problem of geospatial data – where the data comes in many varied formats, can be too big and is not always time-stamped – and "I would argue we are now working 10 times faster."

But this is only the start. In future, modellers will be capturing details like fire engines or fire personnel information, and factoring in how long it takes for a fire engine to get to a specific venue and what kind of efficiency they have in combating fire.

Watkins says her group is already working on this with the California Fire Chiefs Association, the aim being to capture data on individual fire battalions across western parts of California, their training, staffing levels, equipment, mutual aid agreements from neighbouring battalions, and the drive time from each one of those battalions.

There might not be any obvious way to avoid the incidence of fires in vulnerable US states. But what can be controlled is when that fire approaches a community, how to protect homes and lives and prevent the size of economic losses that have been seen to date.

In this way, the improvements in wildfire modelling can be a win-win: both to help insurers to get a better handle on losses, and to better inform society of risk mitigation measures.

Harness advanced technology to reduce wildfire risk

Sarah Russell, managing director at Bellwether, a mapping and spatial analysis project at X, Alphabet's moonshot factory, explains how Bellwether can support insurers with wildfire risk management

What is Bellwether offering insurers for wildfire risk management?

We have launched a product that is being sold in the form of an API, and we deliver two scores to clients. One score is a forward-looking score that deals with the probability of wildfire at an address one year into the future. The other score concerns the probability of a wildfire at that same address five years into the future.

The product updates itself four times a year. This means every three months we re-run the model to account for growth in vegetation and changes in weather patterns. Our wildfire forecast score is available for anywhere in the US, as well as Canada and Australia.

We are also working on a global wildfire forecast score and we have a catastrophe model that is in production.

How does Bellwether's approach to wildfire risk differ from traditional vendors?

We came to this area with a beginner's mind. I'm an entrepreneur and a medical doctor and my background is in healthcare. We believed the insurance industry was going to be the tip of the spear in pricing climate risk and we thought we could empower insurers to do a better job in pricing that risk. Fundamentally, policymakers need insurance to work. California does not want the insurance market to walk away. They need a functioning private insurance market. This is the product's whole motivation.

We were not interested in beating Moody's RMS or Verisk. Instead, we said let's see how we can help the insurance industry.

We are blessed with broad access to Google Maps and all the layers that go into Google Maps. As it happens, much of this data is freely available and open to the public through Earth Engine, which is a cloud-based geospatial analysis platform that enables users to visualise and analyse satellite images of our planet. We spent about a year building the software to make it faster and easier to organise all of that data in Google Cloud and now we can work with hundreds of data layers, going back 20 years.

All of this data on the characteristics of almost every square inch of the world is perfect for a machine learning approach.

The result of our wildfire prediction tool is a probability score between zero and one. That is probably the most unique aspect of our product. By contrast, other vendors produce low, medium, high and extreme forecasts for wildfire risk, which are relative scores.

Can Bellwether help to stop insurers reducing wildfire coverage in the US?

Yes! This is the thing we are asked most about internally. People are, understandably, deeply concerned about the fact that so many people are losing wildfire coverage in the US.

The loss of coverage means the loss of wealth and it is a big deal.

The only way to stop this process is to actually shed light on true risk and get as much insight on that risk as possible.

When you are very granular and clear about risk, there are two things that happen. First, you learn that not everything you think is high risk is in fact high risk; and people are painting with too broad a brush.

The second thing is you can see where the risk is coming from and because it is wildfire, you can mitigate that risk. With fire, for example, you can manage the land in ways that are informed by our cat model approach. What's more, you can use a more sophisticated model like ours to actually quantify the risk reduction associated with a land management strategy.

Is it inevitable that climate change will increase wildfire risk?

In addition to climate change increasing the frequency of wildfires, it makes them much more intense. The two main factors are too much rain and too much drought.

With too much drought everything dries out and is more likely to burn; and with too much rain, things grow back too fast and there is more fuel. Climate change is a massive driver of wildfire risk. ■

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