GETTING WILDFIRE UNDER CONTROL
Reflecting on a record-breaking California wildfire season

MODELING A BREADBASKET
Probabilistic agricultural risk modeling for Brazil

CAPTURING THE RESILIENCE DIVIDEND
Incentivizing resilience initiatives in low-income countries

EXPOSURE

ISSUE 04

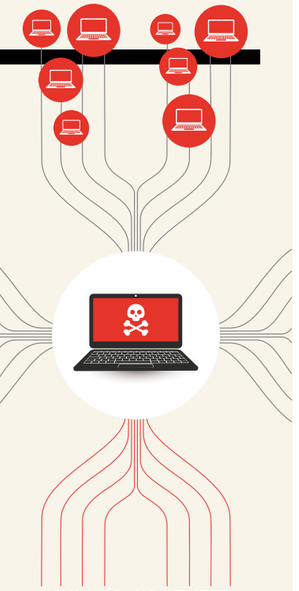
DATA FLOW IN A DIGITAL ECOSYSTEM

IN THIS ISSUE

DATA FLOW IN A DIGITAL ECOSYSTEM

The challenge to extract meaningful data for underwriting continues

PAGE 10



HOW CYBER BECAME A PEAK PERIL

How probabilistic modeling will facilitate the growth of the cyber (re)insurance market

PAGE 16

ASSIGNING A RETURN PERIOD TO 2017

Was the (re)insurance industry prepared for last year's terrible trio of hurricanes and what can we learn from HIM?

PAGE 6

MODELING THE WORLD'S FUTURE BREADBASKET

How a crop modeling collaboration with IRB Brasil Re could help build a more resilient agricultural base in Brazil

PAGE 27

GETTING WILDFIRE UNDER CONTROL

Why the 2017 California wildfire season was record-breaking on virtually every front

PAGE 19

OTHER STORIES

News analysis

Will location-specific data be classified as personal information under GDPR?

PAGE 4

The One Thing

What one thing would encourage further innovation in the (re)insurance industry?

PAGE 22

Capturing the resilience dividend

Why the 'resilience dividend' needs to be delivered upfront

PAGE 24

RMS Editorial and Design: Simon Bennett, Bob Owen. **EXPOSURE is published by Zebra Media Limited. www.zebracm.com. Editors:** Helen Yates, Nigel Allen. **Designer:** Maria Gonzalez. **Publisher:** Suzanne Hirst. Cover photo: JaCZhou/istockphoto.com

FOREWORD

CHANGING TIMES

Welcome to the fourth edition of EXPOSURE magazine and my first as chief executive officer at RMS. During my first six weeks in this role it has been a pleasure and privilege getting to know the team here and to start speaking with clients. It's clear from all these discussions that we are in a period of transformative change in the industry.

RMS is at an exciting point in our history, both as a risk modeling enterprise and as a facilitator of innovation more widely across the industry. We seek to deliver greater value to you through insights and analytics that enable more informed and data-driven decisions that can help you reduce your loss ratio, continue to reduce expenses, and capture new growth opportunities. Our products and services ultimately are focused on allowing you to better assess risks, to better manage exposures, to invest in resilient infrastructure and to innovate, all with an eye toward helping the industry close the protection gap in economies around the world.

There has never been so much data available to analysts and underwriters. The challenge we face together is finding the best ways to select, access, analyze and use that information in real time at the point of frontline underwriting to achieve the most optimum outcomes. Better and smarter data analytics will play an ever more meaningful role in our industry and we look forward to continuing in partnership with our clients to realize the powerful impact now possible.

I trust you will enjoy the content in this latest edition of EXPOSURE. As we turn our sights to a new hurricane season in 2018, it is clear from our Big Story, which considers the lessons from Hurricanes Harvey, Irma and Maria in 2017, that every event is unique and there is always room to learn and improve. We are all on a journey together.

KAREN WHITE
Chief Executive Officer, RMS

NEWS ANALYSIS

GDPR

PERSONAL PROPERTY

Will location-specific data be classified as personal information under GDPR?

May 25 will mark a seismic shift in how personal data is collected, stored, processed, accessed, used, transferred and erased. It sees the application of the European Union's General Data Protection Regulation (GDPR) across all 28 EU states, introducing some of the most stringent data management controls in place anywhere in the world.

The aim of the regulation is not to stifle the flow of data, but rather to ensure that at all stages it is handled in a compliant and secure way. However, the safeguards placed on the use of personal data will have a significant impact on an increasingly data-rich and data-dependent (re)insurance industry and could cap the potential capabilities of the new wave of high-resolution, real time analytics.

Location, location, location

Despite the fact that there are only weeks (at time of writing) to the implementation of this monumental piece of data legislation, there is still a distinct lack of clarity around a number of critical areas for the (re)insurance sector.

While uncertainty around the use of sensitive health-related information and criminal conviction data has sparked much industrywide debate, the possible capture of property-related location information under the "personal data" catchall has raised little comment. Yet the potential clearly exists and the repercussions of such a categorization could be significant if the market fails to address the issue effectively.

According to Corina Sutter, director of government and regulatory affairs at RMS: "The uncertainty lies in whether property-specific data, whether an address, postcode, geocoded information or other form of location identifier, can be used to identify an individual. While in most cases this information in isolation would not, [but] combined with other data it could contribute to their identification."

Given the current uncertainty as to how such data will be classified, RMS has made the decision to apply the same data management requirements for a processor of personal data under GDPR to location-specific information until such time as a definitive classification is reached.

No easy path

It is critical, however, that the (re)insurance industry clarifies this issue, as failure to do so could have far-reaching repercussions.

"If we cannot achieve a sense of clarity around the classification of property-specific data," says Farhana Alarakhiya, vice president of products at RMS, "our concern is that some (re)insurers may choose to aggregate property-specific data to achieve GDPR compliance. The analytical ramifications of such an approach would be huge."

Over the last decade, advances in data capture, data processing and data analysis have outpaced developments in virtually any other business-critical area. Vastly enhanced computational power coupled with an explosion in data-rich sources are exponentially boosting the analytical competence of the (re)insurance sector. Meanwhile, the Internet of Things (IoT) and big data afford huge untapped data potential.

"Any move to aggregate property-related data will severely impair the analytical power of the sector," believes Alarakhiya, "essentially diluting or dissolving the high-resolution data clarity we have achieved in recent years."

She highlights the example of flood cover. "The advances that we have seen in the development of flood-related cover are directly attributable to this increase in the availability of high-resolution property data. Two properties of equal value only meters apart can have markedly different risk profiles given factors such as variations in elevation. Without that ground-level data, such variables could not be factored into the underwriting decision-making process."

Building consensus

To head-off this analytical backslide, Alarakhiya believes the (re)insurance industry must engage in marketwide dialogue to first achieve consensus on how it should treat location-specific data. She thinks much can be learned from the approach adopted by the health care sector.

"Health care records constitute some of the most sensitive data stored by any industry," she points out. "Yet maintaining the granularity of that data is central to the effectiveness of any patient-level care. When faced with the issue of how to store and process such data, the sector took proactive action and worked to achieve data consensus through industrywide dialogue."

Such consensus laid the foundations for the introduction of a third-party certification system that facilitated the implementation and maintenance of consistent data management practices across the entire health care supply chain.

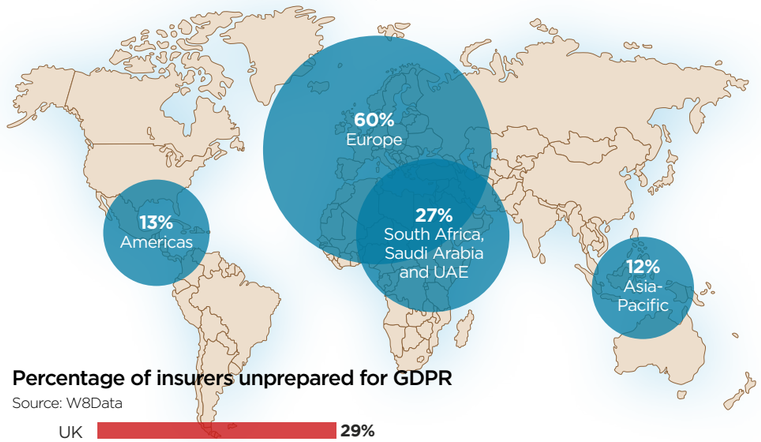
"This is the path that the (re)insurance sector must start moving down," Alarakhiya believes. "We simply cannot take the perceived easy route to compliance by aggregating property data."

Sutter concludes that industry consensus on this issue is essential. "Failure to achieve this," she states, "has the potential to degrade the quality and granularity of the property exposure data or location data the industry currently relies upon. We must strive to reach industrywide agreement on this if we are to preserve the analytical foundations we have all worked so hard to build."

Ready for GDPR?

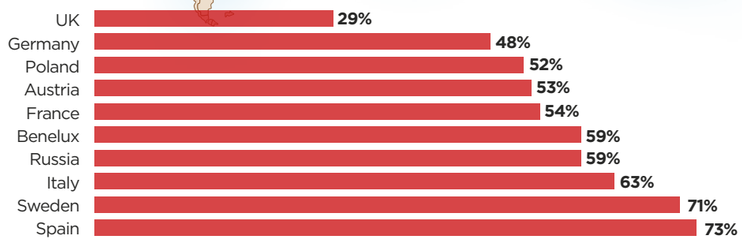
GDPR compliance readiness — by region

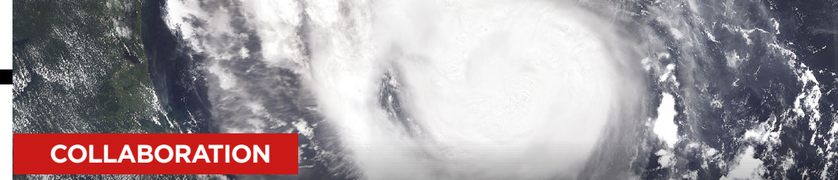
Source: EY - "Global Forensic Data Analytics Survey 2018"



Percentage of insurers unprepared for GDPR

Source: W8Data





COLLABORATION

BRINGING CLARITY TO SLAB CLAIMS

How will a new collaboration between a major Texas insurer, RMS, Accenture and Texas Tech University provide the ability to determine with accuracy the source of slab claim loss?

The litigation surrounding "slab claims" in the U.S. in the aftermath of a major hurricane has long been an issue within the insurance industry. When nothing is left of a coastal property but the concrete slab on which it was built, how do claims handlers determine whether the damage was predominantly caused by water or wind?

The decision that many insurers take can spark protracted litigation, as was the case following Hurricane Ike, a powerful storm that caused widespread damage across the state after it made landfall over Galveston in September 2008. The storm had a very large footprint for a Category 2 hurricane, with sustained wind speeds of 110 mph and a 22-foot storm surge. Five years on, litigation surrounding how slab claim damage had been wrought rumbled on in the courts.

Recognizing the extent of the issue, major coastal insurers knew they needed to improve their methodologies. It sparked a new collaboration between RMS, a major Texas insurer, Accenture and Texas Tech University (TTU). And from this year, the insurer will be able to utilize RMS data, hurricane modeling methodologies, and software analyses to track the likelihood of slab claims before a tropical cyclone makes landfall and document the post-landfall wind, storm surge and wave impacts over time.

The approach will help determine the source of the property damage with greater accuracy and clarity, reducing the need for litigation post-loss, thus improving the overall claims experience for both the policyholder and insurer. To provide super accurate wind field data, RMS has signed a contract with TTU to expand a network of mobile meteorological stations that are ultimately positioned in areas predicted to experience landfall during a real-time event.

"Our contract is focused on Texas, but they could also be deployed anywhere in the southern and eastern U.S.," says Michael Young, senior director of product management at RMS. "The rapidly deployable weather stations collect peak and mean wind speed characteristics and transmit via the cell network the wind speeds for inclusion into our tropical cyclone data set. This is in addition to a wide range of other data sources, which this year includes 5,000 new data stations from our partner Earth Networks."

The storm surge component of this project utilizes the same hydrodynamic storm surge model methodologies embedded within the RMS North Atlantic Hurricane Models to develop an accurate view of the timing, extent and severity of storm surge and wave-driven hazards post-landfall. Similar to the wind field modeling process, this approach will also be informed by ground-truth terrain and observational data, such as high-resolution bathymetry data, tide and stream gauge sensors and high-water marks.

"The whole purpose of our involvement in this project is to help the insurer get those insights into what's causing the damage," adds Jeff Waters, senior product manager at RMS. "The first eight hours of the time series at a particular location might involve mostly damaging surge, followed by eight hours of damaging wind and surge. So, we'll know, for instance, that a lot of that damage that occurred in the first eight hours was probably caused by surge. It's a very exciting and pretty unique project to be part of."

THE BIG STORY

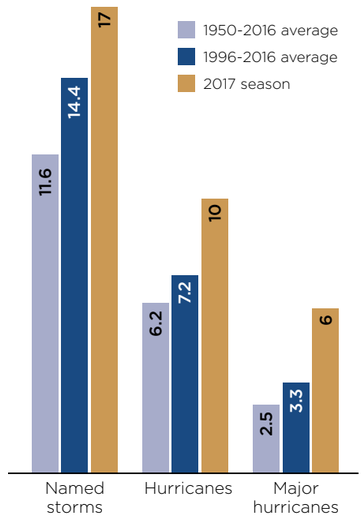
Hurricanes Harvey, Irma and Maria (HIM) tore through the Caribbean and U.S. in 2017, resulting in insured losses over US$80 billion. Twelve years after Hurricanes Katrina, Rita and Wilma (KRW), EXPOSURE asks if the (re)insurance industry was better prepared for its next 'terrible trio' and what lessons can be learned

ASSIGNING A RETURN PERIOD TO 2017

Hurricane season

Comparison of the 2017 North Atlantic hurricane season storms to the 1950-2016 and 1996-2016 averages

SOURCE: DATA FROM THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION HURRICANE RESEARCH DIVISION (2018) AND RMS



In one sense, 2017 was a typical loss year for the insurance industry in that the majority of losses stemmed from the "peak zone" of U.S. hurricanes. However, not since the 2004-05 season had the U.S. witnessed so many landfalling hurricanes. It was the second most costly hurricane season on record for the (re)insurance industry, when losses in 2005 are adjusted for inflation.

According to Aon Benfield, HIM caused total losses over US$220 billion and insured losses over US$80 billion — huge sums in the context of global catastrophe losses for the year of US$344 billion and insured losses of US$134 billion. Overall, weather-related catastrophe losses exceeded 0.4 percent of global GDP in 2017 (based on data from Aon Benfield, Munich Re and the World Bank), the second highest figure since 1990. In that period, only 2005 saw a higher relative catastrophe loss at around 0.5 percent of GDP.

But, it seems, (re)insurers were much better prepared to absorb major losses this time around. Much has changed in the 12 years since Hurricane Katrina breached the levees in New Orleans. Catastrophe modeling as a profession has evolved into exposure management, models and underlying data have improved and there is a much greater appreciation of model uncertainty and assumptions, explains Alan Godfrey, head of exposure management at Asta.

"Even post-2005 people would still see an event occurring, go to the models and pull out a single event ID … then tell all and sundry this is what we're going to lose. And that's an enormous misinterpretation of how the models are supposed to be used. In 2017, people demonstrated a much greater maturity and used the models to advise their own loss estimates, and not the other way around."

It also helped that the industry was extremely well-capitalized moving into 2017. After a decade of operating through a low interest rate and increasingly competitive environment, (re)insurers had taken a highly disciplined approach to capital management. Gone are the days where a major event sparked a series of run-offs. While some (re)insurers have reported higher losses than others, all have emerged intact.

HARVEY BROKE ALL U.S. RECORDS FOR TROPICAL CYCLONE-DRIVEN RAINFALL WITH OBSERVED CUMULATIVE RAINFALL OF 51 INCHES

"In 2017 the industry has performed incredibly well from an operational point of view," says Godfrey. "There have obviously been challenges from large losses and recovering capital, but those are almost outside of exposure management."

According to Aon Benfield, global reinsurance capacity grew by 80 percent between 1990 and 2017 (to US$605 billion), against global GDP growth of around 24 percent. The influx of capacity from the capital markets into U.S. property catastrophe reinsurance has also brought about change and innovation, offering new instruments such as catastrophe bonds for transferring extreme risks.

Much of this growth in non-traditional capacity has been facilitated by better data and more sophisticated analytics, along with a healthy appetite for insurance risk from pension funds and other institutional investors.

For insurance-linked securities (ILS), the 2017 North Atlantic hurricane season, Mexico's earthquakes and California's wildfires were their first big test. "Some thought that once we had a significant year that capital would leave the market," says John Huff, president and chief executive of the Association of Bermuda Insurers and Reinsurance (ABIR). "And we didn't see that.

"In January 2018 we saw that capital being reloaded," he continues. "There is abundant capital in all parts of the reinsurance market. Deploying that capital with a reasonable rate of return is, of course, the objective."

Huff thinks the industry performed extremely well in 2017 in spite of the severity of the losses and a few surprises. "I've even heard of reinsurers that were ready with claim payments on lower layers before the storm even hit. The modeling and ability to track the weather is getting more sophisticated. We saw some shifting of the storms — Irma was the best example — but reinsurers were tracking that in real time in order to be able to respond."

How Harvey inundated Houston

One lesson the industry has learned over three decades of modeling is that models are approximations of reality. Each event has its own unique characteristics, some of which fall outside of what is anticipated by the models.

The widespread inland flooding that occurred after Hurricane Harvey made landfall on the Texas coastline is an important illustration of this, explains Huff. Even so, he adds, it continued a theme, with

The Buffalo Bayou River floods a park in Houston after the arrival of Hurricane Harvey

flood losses being a major driver of U.S. catastrophe claims for several years now. "What we're seeing is flood events becoming the No. 1 natural disaster in the U.S. for people who never thought they were at risk of flood."

Harvey broke all U.S. records for tropical cyclone-driven rainfall with observed cumulative rainfall of 51 inches (129 centimeters). The extreme rainfall generated by Harvey and the unprecedented inland flooding across southeastern Texas and parts of southern Louisiana was unusual.

However, nobody was overly surprised by the fact that losses from Harvey were largely driven by water versus wind. Prior events with significant storm surge-induced flooding, including Hurricane Katrina and 2012's Superstorm Sandy, had helped to prepare (re)insurers, exposure managers and modelers for this eventuality. "The events themselves were very large but they were well within uncertainty ranges and not disproportionate to expectations," says Godfrey.

"Harvey is a new data point — and we don't have that many — so the scientists will look at it and know that any new data point will lead to tweaks," he continues. "If anything, it will make people spend a bit more time on their calibration for the non-modeled elements of hurricane losses, and some may conclude that big changes are needed to their own adjustments."

DOES THIS MEAN THAT A US$100 BILLION-PLUS LOSS YEAR LIKE 2017 IS NOW A 1-IN-6-YEAR EVENT?

But, he adds: "Nobody is surprised by the fact that flooding post-hurricane causes loss. We know that now. It's more a case of tweaking and calibrating, which we will be doing for the rest of our lives."

Flood modeling

Hurricane Harvey also underscored the importance of the investment in sophisticated, probabilistic flood models. RMS ran its U.S. Inland Flood HD Model in real time to estimate expected flood losses. "When Hurricane Harvey happened, we had already simulated losses of that magnitude in our flood model, even before the event occurred," says Dr. Pete Dailey, vice president of product management and responsible for U.S. flood modeling at RMS.

"The value of the model is to be able to anticipate extreme tail events well before they occur, so that insurance companies can be prepared in advance for the kind of risk they're taking on and what potential claims volume they may have after a major event," he adds.

Harvey has already offered a wealth of new data that will be fed into the flood model. The emergency shutdown of the Houston metropolitan area prevented RMS meteorologists and engineers from accessing the scene in the immediate aftermath, explains Dailey. However, once on the ground they gathered as much information as they could, observing and recording what had actually happened to affected properties.

"We go to individual properties to assess the damage visually, record the latitude and longitude of the property, the street address, the construction, occupancy and the number of stories," he says. "We will also make an estimate of the age of the property. Those basic parameters allow us to go back and take a look at what the model would have predicted in terms of damage and loss, as compared to what we observed."

The fact that insured losses emanating from the flooding were only a fraction of the total economic losses is an inevitable discussion point. The majority of claims paid were for commercial properties, with residential properties falling under the remit of the National Flood Insurance Program (NFIP). Many residential homes were uninsured, however, explains ABIR's Huff.

"The NFIP covers just the smallest amount of people — there are only five million policies — and yet you see a substantial event like Harvey which is largely uninsured because (re)insurance companies only cover commercial flood in the U.S.," he says. "After Harvey you'll see a realization that the private market is very well-equipped to get back into the private flood business, and there's a national dialogue going on now."

Is 2017 the new normal?

One question being asked in the aftermath of the 2017 hurricane season is: What is the return period for a loss year like 2017? RMS estimates that, in terms of U.S. and Caribbean industry insured wind, storm surge and flood losses, the 2017 hurricane season corresponds to a return period between 15 and 30 years.

However, losses on the scale of 2017 occur more frequently when considering global perils. Adjusted for inflation, it is seven years since the industry paid out a similar level of catastrophe claims — US$110 billion on the Tohoku earthquake and tsunami, Thai floods and New Zealand earthquake in 2011. Six years prior to that, KRW cost the industry in excess of US$75 billion (well over US$100 billion in today's money).

So, does this mean that a US$100 billion-plus (or equivalent in inflation-adjusted terms) loss year like 2017 is now a one-in-six-year event? As wealth and insurance penetration grows in developing parts of the world, will we begin to see more loss years like 2011, where catastrophe claims are not necessarily driven by the U.S. or Japan peak zones?

"Increased insurance penetration does mean that on the whole losses will increase, but hopefully this is proportional to the premiums and capital that we are getting in," says Asta's Godfray. "The important thing is understanding correlations and how diversification actually works and making sure that is applied within business models.

"In the past, people were able to get away with focusing on the world in a relatively binary fashion," he continues. "The more people move toward diversified books of business, which is excellent for efficient use of capital, the more important it becomes to understand the correlations between different regions."

"You could imagine in the future, a (re)insurer making a mistake with a very sophisticated set of catastrophe and actuarial models," he adds. "They may perfectly take into account all of the non-modeled elements but get the correlations between them all wrong, ending up with another year like 2011 where the losses across the globe are evenly split, affecting them far more than their models had predicted."

As macro trends including population growth, increasing wealth, climate change and urbanization influence likely losses from natural catastrophes, could this mean a shorter return period for years like last year, where industry losses exceeded US$134 billion?

"When we look at the average value of properties along the U.S. coastline — the Gulf Coast and East Coast — there's a noticeable trend of increasing value at risk," says Dailey. "That is because people are building in places that are at risk of wind damage from hurricanes and coastal flooding. And these properties are of a higher value because they are more complex, have a larger square footage and have more stories. Which all leads to a higher total insured value.

"The second trend that we see would be from climate change whereby the storms that produce damage along the coastline may be increasing in frequency and intensity," he continues. "That's a more difficult question to get a handle on but there's a building consensus that while the frequency of hurricane landfalls may not necessarily be increasing, those that do make landfall are increasing in intensity."

Lloyd's chief executive Inga Beale has stated her concerns about the impact of climate change, following the market's £4.5 billion catastrophe claims bill for 2017. "That's a significant number, more than double 2016; we're seeing the impact of climate change to a certain extent, particularly on these weather losses, with the rising sea level that impacts and increases the amount of loss," she said in an interview with Bloomberg.

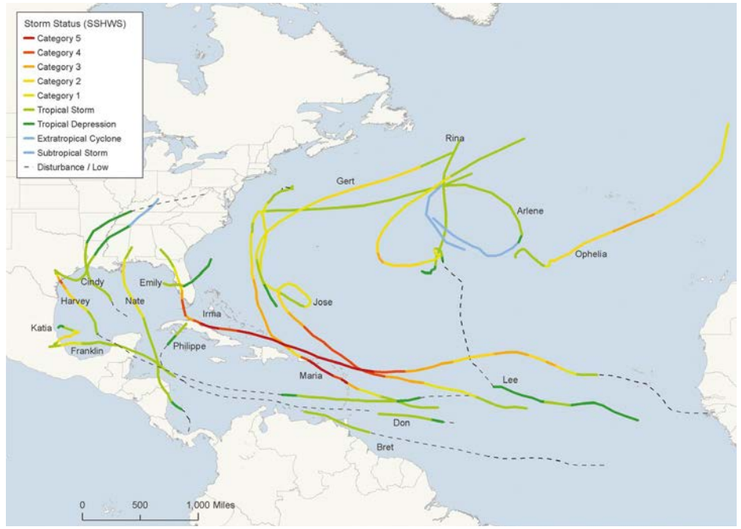
While a warming climate is expected to have significant implications for the level of losses arising from storms and other severe weather events, it is not yet clear exactly how this will manifest, according to Tom Sabbatelli, senior product manager at RMS. "We know the waters have risen several centimeters in the last couple of decades and we can use catastrophe models to quantify what sort of impact that has on coastal flooding, but it's also unclear what that necessarily means for tropical cyclone strength.

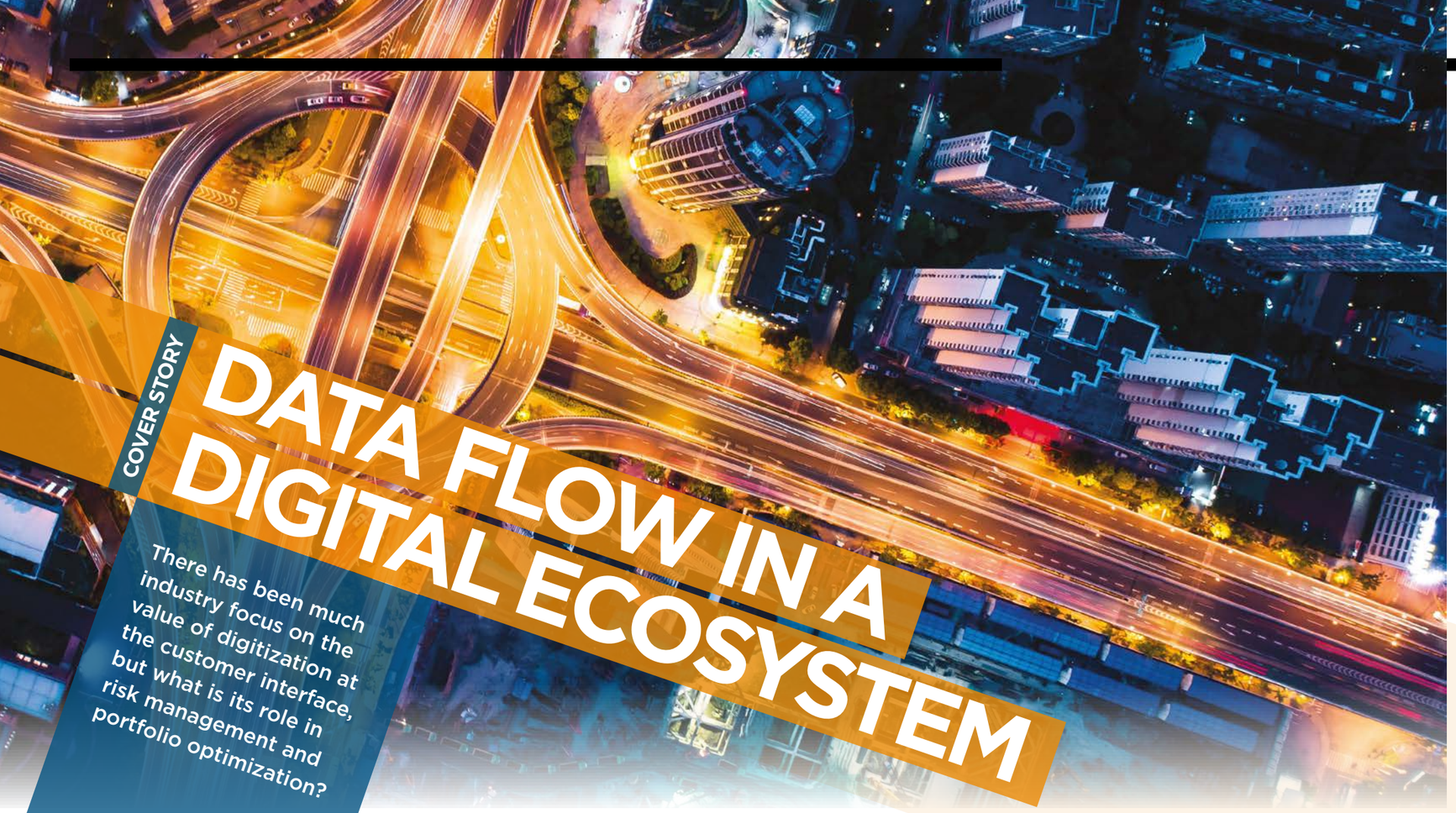
"The oceans may be warming, but there's still an ongoing debate about how that translates into cyclone intensity, and that's been going on for a long time," he continues. "The reason for that is we just don't know until we have the benefit of hindsight. We haven't had a number of major hurricanes in the last few years, so does that mean that the current climate is quiet in the Atlantic? Is 2017 an anomaly or are we going back to more regular severe activity? It's not until you're ten or 20 years down the line and you look back that you know for sure."

2017 storm tracks

North Atlantic storm tracks and intensities

SOURCE: RMS





COVER STORY

DATA FLOW IN A DIGITAL ECOSYSTEM

There has been much industry focus on the value of digitization at the customer interface, but what is its role in risk management and portfolio optimization?

In recent years, the perceived value of digitization to the insurance industry has been increasingly refined on many fronts. It now serves a clear function in areas such as policy administration, customer interaction, policy distribution and claims processing, delivering tangible, measurable benefits.

However, the potential role of digitization in supporting the underwriting functions, enhancing the risk management process and facilitating portfolio optimization is sometimes less clear. That this is the case is perhaps a reflection of the fact that risk assessment is by its very nature a more nebulous task, isolated to only a few employees, and clarifying the direct benefits of digitization is therefore challenging.

To grasp the potential of digitalization, we must first acknowledge the limitations of existing platforms and processes, and in particular the lack of joined-up data in a consistent format. But connecting data sets and being able to process analytics is just the start. There needs to be clarity in terms of the analytics an underwriter requires, including building or extending core business workflow to deliver insights at the point of impact.

Data limitation

For Louise Day, director of operations at the International Underwriting Association (IUA), a major issue is that much of the data generated across the industry is held remotely from the underwriter.

"You have data being keyed in at numerous points and from multiple parties in the underwriting process. However, rather than being stored in a format accessible to the underwriter, it is simply transferred to a repository where it becomes part of a huge data lake with limited ability to stream that data back out."

That data is entering the "lake" via multiple different systems and in different formats. These amorphous pools severely limit the potential to extract information in a defined, risk-specific manner, conduct impactful analytics and do so in a timeframe relevant to the underwriting decision-making process.

"The underwriter is often disconnected from critical risk data," believes Shaheen Razzaq, senior product director at RMS. "This creates significant challenges when trying to accurately represent coverage, generate or access meaningful analysis of metrics and grasp the marginal impacts of any underwriting decisions on overall portfolio performance.

"Success lies not just in attempting to connect the different data sources together, but to do it in such a way that can generate the right insight within the right context and get this to the underwriter to make smarter decisions."

Without the digital capabilities to connect the various data sets and deliver information in a digestible format to the underwriter, their view of risk can be severely restricted — particularly given that server storage limits often mean their data access only extends as far as current information. Many businesses find themselves suffering from DRIP, being data rich but information poor, without the ability to transform their data into valuable insight.

"You need to be able to understand risk in its fullest context," Razzaq says. "What is the precise location of the risk? What policy history information do we have? How has the risk performed? How have the modeled numbers changed? What other data sources can I tap? What are the wider portfolio implications of binding it? How will it impact my concentration risk? How can I test different contract structures to ensure the client has adequate cover but is still profitable business for me? These are all questions they need answers to in real time at the decision-making point, but often that's simply not possible."

According to Farhana Alarakhiya, vice president of products at RMS, when extrapolating this lack of data granularity up to the portfolio level and beyond, the potential implications of poor risk management at the point of underwriting can be extreme.

"Not all analytics are created equal. There can be a huge difference between good, better and best data analysis. Take a high-resolution peril like U.S. flood, where two properties meters apart can have very different risk profiles. Without granular data at the point of impact your ability to make accurate risk decisions is restricted. If you roll that degree of inaccuracy up to the line of business and to the portfolio level, the ramifications are significant.

"NOT ALL ANALYTICS ARE CREATED EQUAL. THERE CAN BE A HUGE DIFFERENCE BETWEEN GOOD, BETTER AND BEST DATA ANALYSIS"

— FARHANA ALARAKHIYA, RMS

"Having the best data analysis is not the end of the story. Think about the level of risk involved in underwriting at different stages of the decision-making process. The underwriter needs the best analysis in context with the decision they are taking, analytics at an appropriate level and depth, flexing to accommodate their needs," she argues.

Looking beyond the organization and out to the wider flow of data through the underwriting ecosystem, the lack of format consistency is creating a major data blockage, according to Jamie Garratt, head of digital underwriting strategy at Talbot.

"You are talking about trying to transfer data which is often not in any consistent format along a value chain that contains a huge number of different systems and counterparties," he explains. "And the inability to quickly and inexpensively convert that data into a format that enables that flow, is prohibitive to progress.

"You are looking at the formatting of policies, schedules and risk information, which is being passed through a number of counterparties all operating different systems. It then needs to integrate into pricing models, policy administration systems, exposure management systems, payment systems, et cetera. And when you consider this process replicated across a subscription market the inefficiencies are extensive."

A functioning ecosystem

There are numerous examples of sectors that have transitioned successfully to a digitized data ecosystem that the insurance industry can learn from. For Alarakhiya, one such industry is health care, which over the last decade has successfully adopted digital processes across the value chain and overcome the data formatting challenge.

"Health care has a value chain similar to that in the insurance industry. Data is shared between various stakeholders — including competitors — to create the analytical backbone it needs to function effectively. Data is retained and shared at the individual level and combines multiple health perspectives to gain a holistic view of the patient.

"The sector has also overcome the data-consistency hurdle by collectively agreeing on a data standard, enabling the effective flow of information across all parties in the chain, from the health care facilities through to the services companies that support them."

Garratt draws attention to the way the broader financial markets function. "There are numerous parallels that can be drawn between the financial and the insurance markets, and much that we can learn from

how that industry has evolved over the last 10 to 20 years."

"As the capital markets become an increasingly prevalent part of the insurance sector," he continues, "this will inevitably have a bearing on how we approach data and the need for greater digitization. If you look, for example, at the advances that have been made in how risk is transferred on the insurance-linked securities (ILS) front, what we now have is a fairly homogenous financial product where the potential for data exchange is more straightforward and transaction costs and speed have been greatly reduced.

"It is true that pure reinsurance transactions are more complex given the nature of the market, but there are lessons that can be learned to improve transaction execution and the binding of risks."

For Razzaq, it's also about rebalancing the data extrapolation versus data analysis equation. "By removing data silos and creating straight-through access to detailed, relevant, real-time data, you shift this equation on its axis. At present, some 70 to 80 percent of analysts' time is spent sourcing data and converting it into a consistent format, with only 20 to 30 percent spent on the critical data analysis. An effective digital infrastructure can switch that equation around, greatly reducing the steps involved, and re-establishing analytics as the core function of the analytics team."

The analytical backbone

So how does this concept of a functioning digital ecosystem map to the (re)insurance environment? The challenge, of course, is not only to create joined-up, real-time data processes at the organizational level, but also look at how that unified infrastructure can extend out to support improved data interaction at the industry level.

"The ideal digital scenario from a risk management perspective," explains Alarakhiya, "is that all parties are operating on a single analytical framework or backbone built on the same rules, with the same data and using the same financial calculation engines, ensuring that on all risk fronts you are carrying out an 'apples-to-apples' comparison. That consistent approach extends from the individual risk decision, to the portfolio, to the line of business, right up to the enterprise-wide level."

At the underwriting trenches, it is about enhancing and improving the decision-making process and understanding the portfolio-level implications of those decisions.

"A modern pricing and portfolio risk evaluation framework can reduce assessment times, providing direct access to relevant internal and external data in almost real time," states Ben Canagaretna, group chief actuary at Barbican Insurance Group. "Creating a data flow, designed specifically to support agile decision-making, allows underwriters to price complex business in a much shorter time period."

"The feedback loop around decisions surrounding overall reinsurance costs and investor capital exposure is paramount in order to maximize returns on capital for shareholders that are commensurate to risk appetite. At the heart of this is the portfolio marginal impact analysis – the ability to assess the impact of each risk on the overall portfolio in terms of exceedance probability curves, realistic disaster scenarios and regional exposures. Integrated historical loss information is a must in order to quickly assess the profitability of relevant brokers, trade groups and specific policies."

"IT'S ABOUT CREATING A DATA FLOW DESIGNED SPECIFICALLY TO SUPPORT DECISION-MAKING"

— BEN CANAGARETNA, BARBICAN INSURANCE GROUP

There is, of course, the risk of data overload in such an environment, with multiple information streams threatening to swamp the process if not channeled effectively.

"It's about giving the underwriter much better visibility of the risk," says Garratt, "but to do that the information must be filtered precisely to ensure that the most relevant data is prioritized, so it can then inform underwriters about a specific risk or feed directly into pricing models."

Making the transition

There are no organizations in today's (re)insurance market that cannot perceive at least a marginal benefit from integrating digital capabilities into their current underwriting processes. And for those that have started on the route, tangible benefits are already emerging. Yet making the transition, particularly given the clear scale of the challenge, is daunting.

"You can't simply unplug all of your legacy systems and reconnect a new digital infrastructure," says IUA's Day. "You have to find a way of integrating current processes into a data ecosystem in a manageable and controlled manner. From a data-gathering perspective, that process could start with adopting a standard electronic template to collect quote data and storing that data in a way that can be easily accessed and transferred."

"There are tangible short-term benefits of making the transition," adds Razzaq. "Starting small and focusing on certain entities within the group. Only transferring certain use cases and not all at once. Taking a steady step approach rather than simply acknowledging the benefits but being overwhelmed by the potential scale of the challenge."

There is no doubting, however, that the task is significant, particularly integrating multiple data types into a single format. "We recognize that companies have source-data repositories and legacy systems, and the initial aim is not to 'rip and replace' those, but rather to create a path to a system that allows all of these data sets to move. In the RMS(one)® platform for example, we have the ability to connect these various data hubs via open APIs to create that information superhighway, with an analytics layer that can turn this data into actionable insights."

Talbot has already ventured further down this path than many other organizations, and its pioneering spirit is already bearing fruit.

"We have looked at those areas," explains Garratt, "where we believe it is more likely we can secure short-term benefits that demonstrate the value of our longer-term strategy. For example, we recently conducted a proof of concept using quite powerful natural-language processing supported by machine-learning capabilities to extract and then analyze historic data in the marine space, and already we are generating some really valuable insights.

"I don't think the transition is reliant on having a clear idea of what the end state is going to look like, but rather taking those initial steps that start moving you in a particular direction. There also has to be an acceptance of the need to fail early and learn fast, which is hard to grasp in a risk-averse industry. Some initiatives will fail — you have to recognize that and be ready to pivot and move in a different direction if they do."

View of the devastation caused by the tsunami that hit Japan in 2011

TSUNAMI

WHERE TSUNAMI WARNINGS ARE ETCHED IN ANCIENT STONE

As RMS releases its new Japan Earthquake and Tsunami Model, EXPOSURE looks back at the 2011 Tohoku event and other significant events that have shaped scientific knowledge and understanding of earthquake risk

Hundreds of ancient markers dot the coastline of Japan, some over 600 years old, as a reminder of the danger of tsunami. Today, a new project to construct a 12.5-meter-high seawall stretching nearly 400 kilometers along Japan's northeast coast is another reminder. Japan is a highly seismically active country and was well prepared for earthquakes and tsunami ahead of the Tohoku Earthquake in 2011. It had strict building codes, protective tsunami barriers, early-warning systems and disaster-response plans.

But it was the sheer magnitude, scale and devastation caused by the Tohoku Earthquake and Tsunami that made it stand out from the many thousands of earthquakes that had come before it in modern times. What had not been foreseen in government planning was that an earthquake of this magnitude could occur, nor that it could produce such a sizable tsunami.

The Tohoku Earthquake was a magnitude 9.0 event — off the charts as far as the Japanese historical record for earthquakes was concerned. A violent change in the ocean bottom triggered an immense tsunami with waves of up to 40 meters that tore across the northeast coast of the main island of Honshu, traveling up to 10 kilometers inland in the Sendai area.

The tsunami breached sea walls and claimed almost everything in its path, taking 16,000 lives (a further 2,000 remain missing, presumed dead) and causing economic losses of US$235 billion. However, while the historical record proved inadequate preparation for the Tohoku event, the geological record shows that events of that magnitude had occurred before records began, explains Mohsen Rahnama, chief risk modeling officer at RMS.

"If you go back in the geological record to 869 in the Tohoku region, there is evidence for a potentially similarly scaled tsunami," he explains. "Since the Tohoku event, there's been a shift in the government assessments moving away from a focus on what happened historically to a more full consideration of the geological record."

The geological record, which includes tsunami deposits in coastal lakes and across the Sendai and Ishinomaki plains, shows there were large earthquakes and associated tsunami in A.D. 869, 1611 and 1896. The findings of this research point to the

importance of having a fully probabilistic tsunami model at a very high resolution.

Rahnama continues: "The Tohoku event really was the 'perfect' tsunami hitting the largest exposure concentration at risk to tsunami in Japan. The new RMS tsunami model for Japan includes tsunami events similar to and in a few cases larger than were observed in 2011. Because the exposure in the region is still being rebuilt, the model cannot produce tsunami events with this scale of loss in Tohoku at this time."

Incorporating secondary perils

In its new Japan earthquake and tsunami model release, RMS has incorporated the lessons from the Tohoku Earthquake and other major earthquakes that have occurred since the last model was released. Crucially, it includes a fully probabilistic tsunami model that is integrated with the earthquake stochastic event set.

"Since the Japan model was last updated we've had several large earthquakes around the world, and they all inform how we think about the largest events, particularly how we model the ground motions they produce," says Ryan Leddy, senior product manager at RMS, "because good instrumentation has only been available over the last several decades. So, the more events where we sample really detailed information about the ground shaking, the better we can quantify it.

"Particularly on understanding strong ground shaking, we utilized information across events," he continues. "Petrochemical facilities around the world are built with relatively consistent construction practices. This means that examination of the damage experienced by these types of facilities in Chile and Japan can inform our understanding of the performance of these facilities in other parts of the world with similar seismic hazard."

The Maule Earthquake in Chile in 2010, the Canterbury sequence of earthquakes in New Zealand in 2010 and 2011, and the more recent Kumamoto Earthquakes in Japan in 2016, have added considerably to the data sets. Most notably they have informed scientific understanding of the nature of secondary earthquake perils, including tsunami, fire following earthquake, landslides and liquefaction.

The 2016 Kumamoto Earthquake sequence triggered extensive landsliding. The sequence included five events in the range of magnitude 5.5 to 7.0 and caused severe damage in Kumamoto and Oita Prefectures from ground shaking, landsliding, liquefaction and fire following earthquake.

"Liquefaction is in the model as a secondary peril. RMS has redesigned and recalibrated the liquefaction model for Japan. The new model directly calculates damage due to vertical deformation due to liquefaction processes," says Chesley Williams, senior director, RMS Model Product Management. "While the 1964 Niigata Earthquake with its tipped apartment buildings showed that liquefaction damages can be severe in Japan, on a countrywide basis the earthquake risk is driven by the shaking, tsunami and fire following, followed by liquefaction and landslide. For individual exposures, the key driver of the earthquake risk is very site specific, highlighting the importance of high-resolution modeling in Japan."

The new RMS model accounts for the clustering of large events on the Nankai Trough. This is an important advancement as an examination of the historical record shows that events on the Nankai Trough have either occurred as full rupturing events (e.g., 1707 Hoei Earthquake) or as pairs of events (e.g., 1944 and 1946 and two events in 1854).

This is different from aftershocks, explains Williams. "Clustered events are events on different sources that would have happened in the long-term earthquake record, and the occurrence of one event impacts the timing of the other events. This is a subtle but important distinction. We can model event clustering on the Nankai Trough due to the comprehensive event record informed by both historical events and the geologic record."

The Tohoku event resulted in insurance losses of US$30 billion to US$40 billion, the costliest earthquake event for the insurance industry in history. While the news media focused on the extreme tsunami, the largest proportion of the insurance claims emanated from damage wrought by the strong ground shaking. Interestingly, likely due to cultural constraints, only a relatively low amount of post-event loss amplification was observed.

"In general for very large catastrophes, claims costs can exceed the normal cost of settlement due to a unique set of economic, social and operational factors," says Williams. "Materials and labor become more expensive and claims leakage can be more of an issue, so there are a number of factors that kick in that are now captured by the RMS post-event loss amplification modeling. The new Japan model now explicitly models post-event loss amplification but limits the impacts to be consistent with the observations in recent events in Japan."

Supply chain disruption and contingent business interruption were significant sources of loss following the Tohoku event. This was exacerbated by the level seven meltdown at the Fukushima nuclear power plant that resulted in evacuations, exclusion zones and rolling blackouts.

"We sent reconnaissance teams to Japan after the event to understand the characteristics of damage and to undertake case studies for business interruption," says Williams. "We visited large industrial facilities and talked to them about their downtime, their material requirement and their access to energy sources to better understand what had impacted their ability to get back up and running."

Recent events have re-emphasized that there are significant differences in business interruption by occupancy. "For example, a semiconductor facility is likely going to have a longer downtime than a cement factory," says Williams. "The recent events have highlighted the impacts on business interruption for certain occupancies by damage to supply sources. These contingent business interruptions are complex, so examination of the case studies investigated in Japan were instrumental for informing the model."

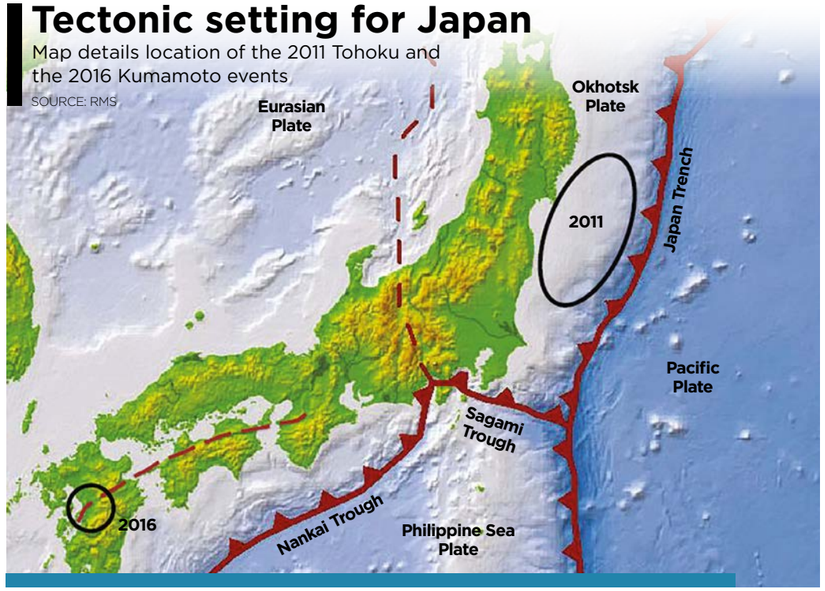
Rebuilding in the seven years since the Tohoku Tsunami struck has been an exercise in resilient infrastructure. With nearly half a million people left homeless, there has been intense rebuilding to restore services, industry and residential property. US$12 billion has been spent on seawalls alone, replacing the 4-meter breakwaters with 12.5-meter-high tsunami barriers.

An endless convoy of trucks has been moving topsoil from the hills to the coastline in order to raise the land by over 10 meters in places. Most cities have decided to elevate by several meters, with a focus on rebuilding commercial premises in exposed areas. Some towns have forbidden the construction of homes in flat areas nearest the coasts and relocated residents to higher ground.

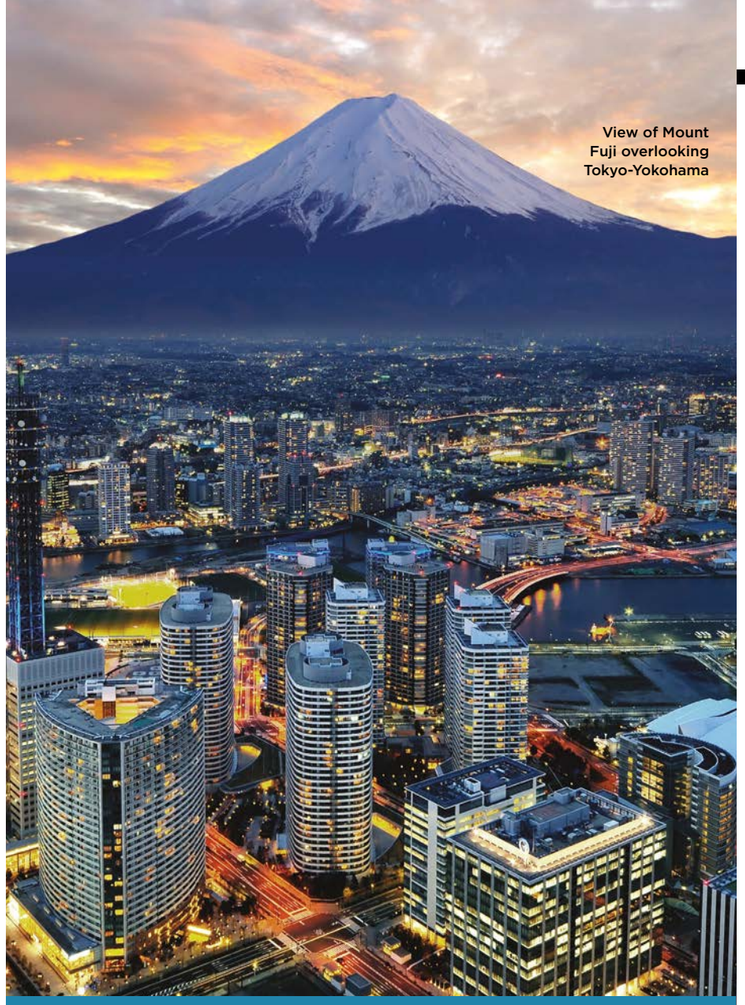
Tectonic setting for Japan

Map details location of the 2011 Tohoku and the 2016 Kumamoto events

SOURCE: RMS



"SINCE THE TOHOKU EVENT, THERE'S BEEN A SHIFT ... TO MOVING FURTHER BACK IN TIME USING A MORE FULL CONSIDERATION OF THE GEOLOGICAL RECORD" — MOHSEN RAHNAMA, RMS



View of Mount Fuji overlooking Tokyo-Yokohama

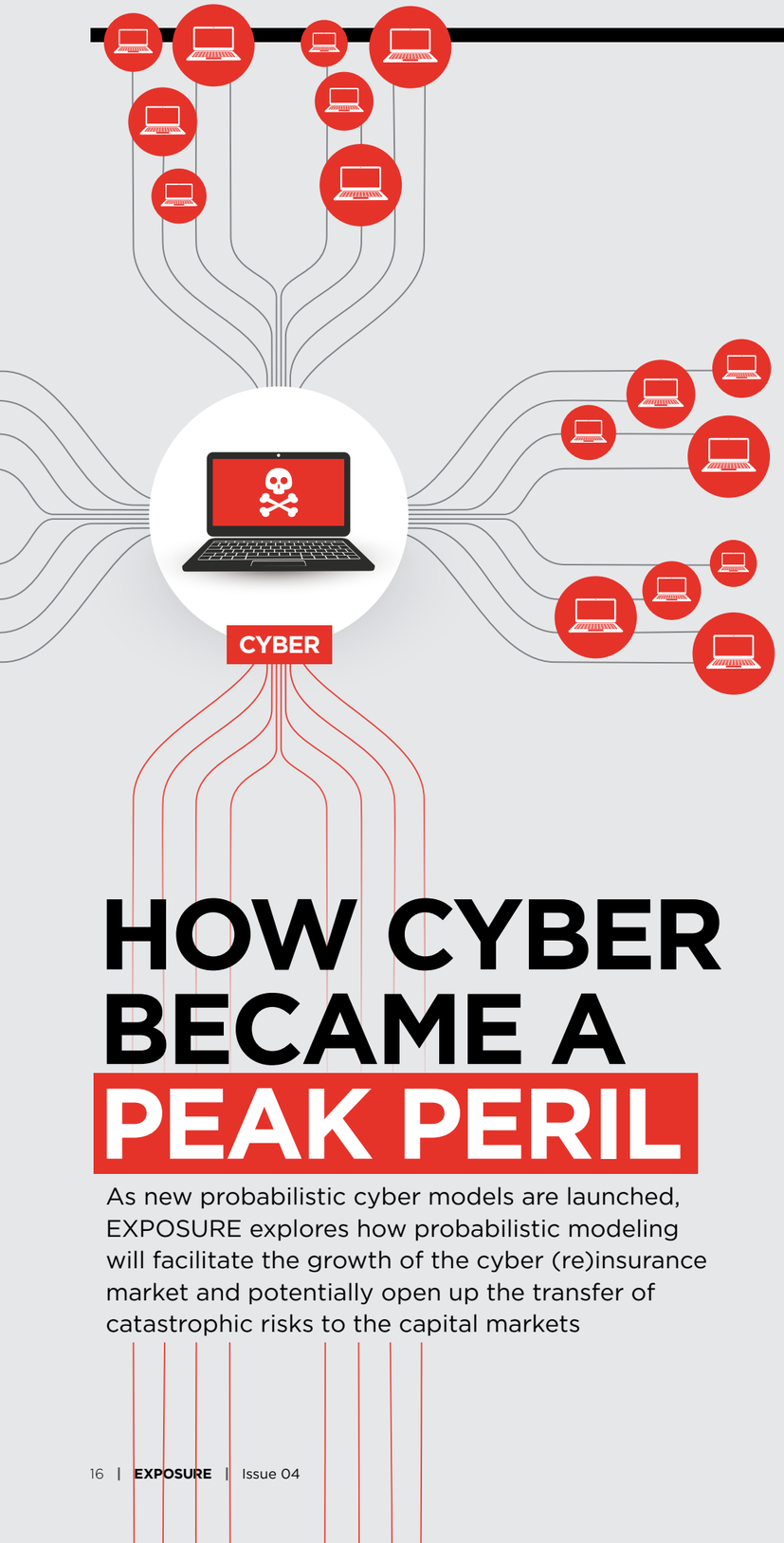
TOKYO-YOKOHAMA: THE WORLD'S MOST EXPOSED METROPOLIS

The Japanese metropolis of Tokyo-Yokohama has the world's greatest GDP at risk from natural catastrophes. Home to 38 million residents, it has potential for significant economic losses from multiple perils, but particularly earthquakes. According to Swiss Re it is the riskiest metropolitan area in the world.

A combination of strict building codes, land use plans and disaster preparedness have significantly reduced the city's vulnerability in recent decades. Despite the devastation caused by the tsunami, very few casualties (around 100) related to partial or complete building collapse resulting from ground shaking during the magnitude 9.0 Tohoku Earthquake.

The big numbers

38 million	US$1.5 trillion	US$153 billion
number of residents	Tokyo's annual GDP	Tokyo's total GDP at risk



HOW CYBER BECAME A PEAK PERIL

As new probabilistic cyber models are launched, EXPOSURE explores how probabilistic modeling will facilitate the growth of the cyber (re)insurance market and potentially open up the transfer of catastrophic risks to the capital markets

The potential for cyber-attacks to cause global, systemic disruption continues to ratchet up, and to confuse matters further, it is state actors that are increasingly involved in sponsoring these major attacks. Last year's major global ransomware attacks — WannaCry and NotPetya — were a wake-up call for many businesses, in terms of highlighting the potential scale and source of cyber incidents. The widespread disruption caused by these incidents — widely suspected of being state-sponsored attacks — confirmed that cyber risk is now in the realm of catastrophe exposures.

The introduction of probabilistic catastrophe modeling for cyber therefore comes at an opportune time. In terms of modeling, although a cyberattack is human-made and very different from a Florida hurricane or Japanese earthquake, for instance, there are some parallels with natural catastrophe perils. Most notable is the potential for sizable, systemic loss.

"Catastrophe modeling exists because of the potential correlation of losses across multiple locations and policies all from the same event," explains Robert Muir-Wood, chief research officer at RMS. "This concentration is what insurers most fear. The whole function of insurance is to diversify risk.

"Anything that concentrates risk is moving in the opposite direction to diversification," he continues. "So, insurers need to find every way possible to limit the concentration of losses. And cyber clearly has the potential, as demonstrated by the NotPetya and WannaCry attacks last year, to impact many separate businesses in a single attack."

Cyberattacks can easily make a loss go global. Whereas a Florida hurricane can damage multiple properties across a small geographical area, a ransomware attack can interrupt the day-to-day running of thousands of businesses on an unprecedented geographical scale. "When I think of systemic risk I think of an attack that can target many thousands of organizations, causing disruption of digital assets using technology as a vector for disruption," says Tom Harvey, senior product manager at RMS cyber solutions.

"What's the equivalent of a cyber hurricane? None of the insurers are quite sure about that. When you write a cyber insurance policy you're inherently taking a bet on the probability of that policy paying out. Most people recognize there are systemic risks out there, which increases the probability of their policy paying out, but until models have been developed there's no way to really quantify that," he adds. "Which is why we do what we do."

RMS estimates a substantial outage at a leading cloud service provider could generate an insurable economic loss of US$63 billion — and that is just for the U.S. In economic loss terms, this is roughly equivalent to a catastrophic natural disaster such as Superstorm Sandy in 2012.

To estimate these losses, the RMS model takes into account the inherent resiliency of cloud service providers, which capitalizes on extensive research into how corporations use the cloud for their revenue generating processes, and how cloud providers have adopted resilient IT architectures to mitigate the impact of an outage on their customers.

The majority of the loss would come from contingent business income (CBI), a coverage that typically has an 8-12 hour waiting period and is heavily sublimited. Coupled with the still relatively low cyber insurance penetration, a significant proportion of this loss will fall on the corporates themselves rather than the insurance industry.

The evolution of cyber modeling

In the early days of cyber insurance, when businesses and insurers were grappling with an esoteric and rapidly evolving threat landscape, cyber was initially underwritten using various scenarios to determine probable maximum losses for a portfolio of risks.

RMS launched its Cyber Accumulation Management System (CAMS) in 2015, initially focused on five key cyber exposures: data exfiltration, ransomware, denial of service, cloud failure and extortion. "Within each of those classes of cyberattack we asked, 'What is the most systemic type of incident that we would expect to see?'" explains Harvey. "Then you can understand the constraints that determine the potential scale of these events.

"We have always conducted a great deal of historical event analysis to understand the technical constraints that are in place, and then we put all that together. So, for example, with data exfiltration there are only so many threat actors that have the capability to carry out this type of activity," he continues. "And it's quite a resource intensive activity. So even if you made it very easy for hackers to steal data there's only so many actors in the world (even state actors) that would want to.

A malicious hack that takes down a cloud service provider has the potential to trigger **US$63 billion** in economic losses, roughly equivalent to a catastrophic natural disaster like 2012's Superstorm Sandy

"WHAT'S THE EQUIVALENT OF A CYBER HURRICANE? NONE OF THE INSURERS ARE QUITE SURE ABOUT THAT"

— TOM HARVEY, RMS

"From an insurance point of view, if you are insuring 5,000 companies and providing cyber coverage for them, you could run the model and say if one of these catastrophes impacts our book we can be confident our losses are not going to exceed, say US$100 million. That's starting to provide some comfort to those insurers about what their PML [probable maximum loss] scenarios would be."

The affirmative cyber insurance market is now four times the size it was when RMS developed its first-generation cyber risk model, and as the market diversifies and grows, clients need new tools to manage profitable growth.

Harvey adds: "The biggest request from our clients was to assess the return periods of cyber loss and to link probabilities with accumulation scenarios, and help them allocate capital to cyber as a line of insurance. In the release of RMS Cyber Solutions Version 3, which includes the first probabilistic model for cyber loss, we estimate the scalability of the various loss processes that make up the drivers of cyber claims.

"Stochastic modeling helps explore the systemic potential for catastrophe loss estimates resulting from each cyber loss process: incorporating the statistical volatility of claims patterns from these in recent years, the technical constraints on scaling factors and attack modes of each process, and the parallels with loss exceedance distributions from other perils that RMS has modeled extensively.

"From this, we now provide loss exceedance probability (EP) distributions for each cyber loss process, with reference accumulation scenarios benchmarked to key return periods from the EP curve. These are combined into a total loss EP curve from all causes. RMS has been expanding on these scenarios in recent years, coming up with new situations that could occur in the future and incorporating a rapidly growing wealth of data on cyberattacks that have occurred. Knowing how these real-life incidents have played out helps our cyber modeling team to assign probabilities to those scenarios so insurers can more confidently assign their capital and price the business."

With the ability to model cyber on a probabilistic basis to enable insurers to more accurately assign capital to their portfolio of risks, it is hoped this will facilitate the growth of both the cyber insurance and reinsurance market.

Taking out the peaks

As the cyber (re)insurance market develops, the need for mechanisms to transfer extreme risks will grow. This is where the capital markets could potentially play a role. There are plenty of challenges in structuring an instrument such as a catastrophe bond to cover cyber risk, however, the existence of probabilistic cyber models takes that one step closer to becoming a reality.

In 2016, Credit Suisse was able to transfer its operational risk exposures to the capital markets via the Operational Re

GETTING PHYSICAL

There are only a handful of examples of instances where a cyber intrusion has caused substantial physical damage. These are well-known and include a German steel mill attack and the Stuxnet virus, which attacked a nuclear plant. However, in spite of this, many experts believe the potential for physical damage resulting from a cyberattack is growing.

"There are three instances globally where cyber has been used to cause physical damage," says Julian Enoizi, CEO of Pool Re. "The damage caused was quite significant, but there was no attribution toward those being terrorist events. But that doesn't mean that if the physical ISIL caliphate gets squeezed they wouldn't resort to cyber as a weapon in the future."

In our previous article in EXPOSURE last year about the vulnerabilities inherent in the Internet of Things, following the Mirai DDoS Attack in 2016, we explored how similar viruses could be used to compromise smart thermostats causing them to overheat and start a fire. Because there is so little data and significant potential for systemic risk, (re)insurers have been reluctant to offer meaningful coverage for cyber physical exposures.

They are also concerned that the traditional "air-gapping" defense used to protect supervisory control and data acquisition systems (SCADA) by energy and utilities firms could more easily be overcome in a world where everything has an Internet connection.

Until now. In March this year, the U.K.'s terrorism insurance backstop Pool Re announced it had secured £2.1 billion of retrocession cover, which included — for the first time — cyber terrorism. "We identified the gap in our cover about two-and-a-half years ago that led us to start working with academia and government departments to find out whether there was an exposure to a cyber terrorism event that could cause physical damage," says Enoizi.

"While it was clear there was no imminent threat, we wanted to be able to future-proof the product and make sure there were no gaps in it," he continues. "So, we did the studies and have been working hard on getting the insurance and reinsurance market comfortable with that."

Even after two years of research and discussions with reinsurers and brokers, it was a challenge to secure capacity from all the usual sources, reveals Enoizi. "Pool Re buys the largest reinsurance program for terrorism in the world. And there are certain reinsurance markets who would not participate in this placement because of the addition of a cyber trigger. Some markets withdrew their participation."

This does suggest the capital markets could be the natural home for such an exposure in the future. "It is clear that state-based actors are increasingly mounting some of the largest cyberattacks," says RMS's Muir-Wood. "It would be interesting to test the capital markets just to see what their appetite is for taking on this kind of risk. They have definitely got a bit bolder than they were five years ago, but this remains a frontier area of the risk landscape."

catastrophe bond, which was fronted by insurer Zurich. Among the perils covered was a cyberattack and rogue trading scenarios. Certainly, investors in insurance-linked securities (ILS) have the appetite to diversify away from peak zone natural catastrophe perils.

"On a high level, absolutely you could transfer cyber risk to the capital markets," thinks Ben Brookes, managing director of capital and resilience solutions at RMS. "All the dynamics you would expect are there. It's a potentially large systemic risk and potentially challenging to hold that risk in concentration as an insurance company. There is the opportunity to cede that risk into a much broader pool of investment risk where you could argue there is much more diversification.

"One question is how much diversification there is across mainstream asset classes?" he continues. "What would the impact be on the mainstream financial markets if a major cloud provider went down for a period of time, for instance? For cyber ILS to be successful, some work would need to be put into that to understand the diversification benefit, and you'd need to be able to demonstrate that to ILS funds in order to get them comfortable.

"It could be an insured, for example, a business highly dependent on the cloud, rather than an insurance or reinsurance company, looking to cede the risk. Particularly a large organization, with a sizable exposure that cannot secure the capacity it needs in the traditional market as it is at present," says Brookes.

ILS INVESTORS HAVE THE APPETITE TO DIVERSIFY AWAY FROM PEAK ZONE NATURAL CATASTROPHE PERILS

"The isolation and packaging of that cause of loss could enable you to design something that seems a little bit like a parametric cyber bond, and to do that relatively soon," he believes.

"We're at a point where we've got a good handle on the risk of cloud provider failure or data exfiltration at various different levels. You could envisage building an index around that, for instance the aggregate number of records leaked across the Fortune 500 in the U.S. And then we can model that — and that's something that can be done in relatively short order."

WILDFIRE

GETTING WILDFIRE UNDER CONTROL

The extreme conditions of 2017 demonstrated the need for much greater data resolution on wildfire in North America

The 2017 California wildfire season was record-breaking on virtually every front. Some 1.25 million acres were torched by over 9,000 wildfire events during the period, with October to December seeing some of the most devastating fires ever recorded in the region*.

From an insurance perspective, according to the California Department of Insurance, as of January 31, 2018, insurers had received almost 45,000 claims relating to losses in the region of US$11.8 billion. These losses included damage or total loss to over 30,000 homes and 4,300 businesses.

* CALFIRE and U.S. Forest Service

On a countrywide level, the total was over 66,000 wildfires that burned some 9.8 million acres across North America, according to the National Interagency Fire Center. This compares to 2016 when there were 65,575 wildfires and 5.4 million acres burned.

Caught off guard

"2017 took us by surprise," says Tania Schoennagel, research scientist at the University of Colorado, Boulder. "Unlike conditions now [March 2018], 2017 winter and early spring were moist with decent snowpack and no significant drought recorded."

Yet despite seemingly benign conditions, it rapidly became the third-largest wildfire year since 1960, she explains. "This was primarily due to rapid warming and drying in the late spring and summer of 2017, with parts of the West witnessing some of the driest and warmest periods on record during the summer and remarkably into the late fall.

"Additionally, moist conditions in early spring promoted build-up of fine fuels which burn more easily when hot and dry," continues Schoennagel. "This combination rapidly set up conditions conducive to burning that continued longer than usual, making for a big fire year."

While Southern California has experienced major wildfire activity in recent years, until 2017 Northern California had only

experienced "minor-to-moderate" events, according to Mark Bove, research meteorologist, risk accumulation, Munich Reinsurance America, Inc.

"In fact, the region had not seen a major, damaging fire outbreak since the Oakland Hills firestorm in 1991, a US$1.7 billion loss at the time," he explains. "Since then, large damaging fires have repeatedly scorched parts of Southern California, and as a result much of the industry has focused on wildfire risk in that region due to the higher frequency and due to the severity of recent events.

"Although the frequency of large, damaging fires may be lower in Northern California than in the southern half of the state," he adds, "the Wine Country fires vividly illustrated not only that extreme loss events are possible in both locales, but that loss magnitudes can be larger in Northern California. A US$11 billion wildfire loss in Napa and Sonoma counties may not have been on the radar screen for the insurance industry prior to 2017, but such losses are now."

Smoke on the horizon

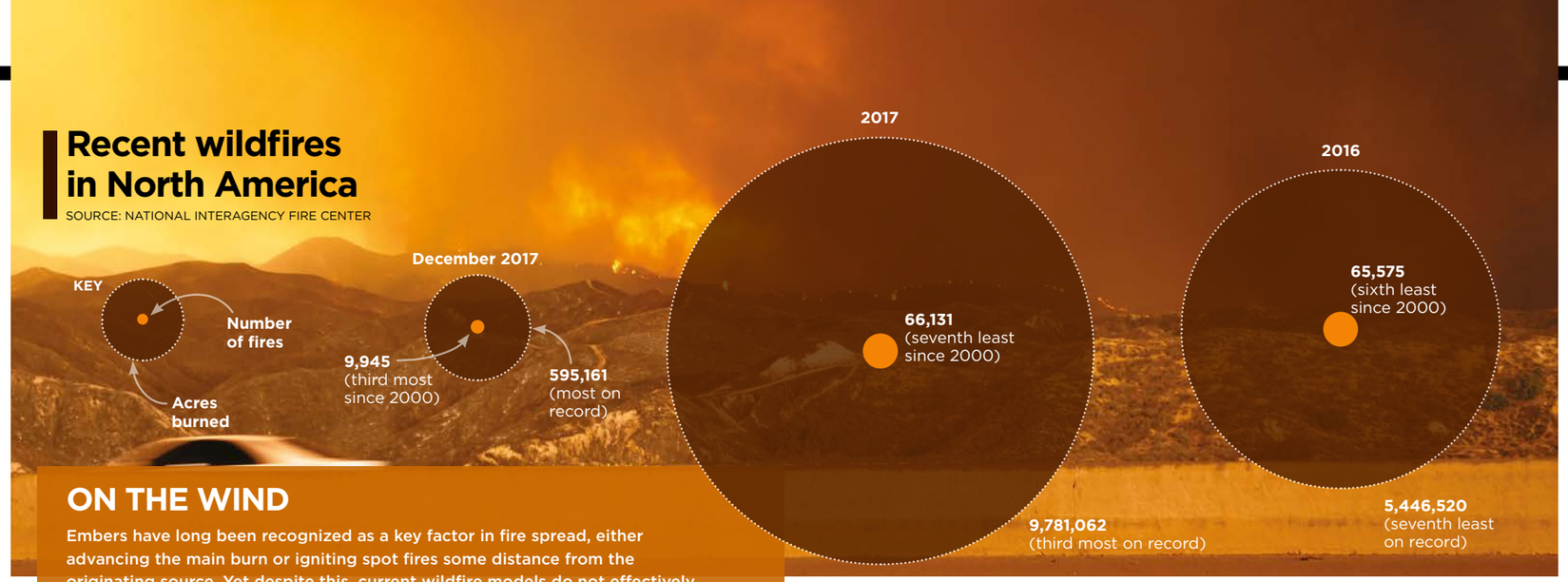
Looking ahead, it seems increasingly likely that such events will grow in severity and frequency as climate-related conditions create drier, more fire-conducive environments in North America.

"Since 1985, more than 50 percent of the increase in the area burned by wildfire in the forests of the Western U.S. has been attributed to anthropogenic climate change," states Schoennagel. "Further warming is expected, in the range of 2 to 4 degrees Fahrenheit in the next few decades, which will spark ever more wildfires, perhaps beyond the ability of many Western communities to cope."

"Climate change is causing California and the American Southwest to be warmer and drier, leading to an expansion of the fire season in the region," says Bove. "In addition, warmer temperatures increase the rate of evapotranspiration in plants and evaporation of soil moisture. This means that drought conditions return to California faster today than in the past, increasing the fire risk."

While he believes there is still a degree of uncertainty as to whether the frequency and severity of wildfires in North America has actually changed over the past few decades, there is no doubt that exposure levels are increasing and will continue to do so.

"The risk of a wildfire impacting a densely



ON THE WIND

Embers have long been recognized as a key factor in fire spread, either advancing the main burn or igniting spot fires some distance from the originating source. Yet despite this, current wildfire models do not effectively factor in ember travel, according to Max Moritz, from the University of California.

"Post-fire studies show that the vast majority of buildings in the U.S. burn from the inside out due to embers entering the property through exposed vents and other entry points," he says. "However, most of the fire spread models available today struggle to precisely recreate the fire parameters and are ineffective at modeling ember travel."

During the Tubbs Fire, the most destructive wildfire event in California's history, embers sparked ignitions up to two kilometers from the flame front. The rapid transport of embers not only created a more fast-moving fire, with Tubbs covering some 30 to 40 kilometers within hours of initial ignition, but also sparked devastating ignitions in areas believed to be at zero risk of fire, such as Coffey Park, Santa Rosa. This highly built-up area experienced an urban conflagration due to ember-fueled ignitions.

"Embers can fly long distances and ignite fires far away from its source," explains Markus Steuer, consultant, corporate underwriting at Munich Re. "In the case of the Tubbs Fire they jumped over a freeway and ignited the fire in Coffey Park, where more than 1,000 homes were destroyed. This spot fire was not connected to the main fire. In risk models or hazard maps this has to be considered. Firebrands can fly over natural or man-made fire breaks and damage can occur at some distance away from the densely vegetated areas."

"The Tubbs Fire created an ember storm of a magnitude we had not seen before," says RMS's Kevin Van Leer. "It was the perfect combination of vegetation height and extreme 'Diablo' winds, which meant the embers were easily caught by the wind and therefore traveled long distances."

The latest RMS North America Wildfire HD Models will enable for the first time the explicit simulation of ember transport and accumulation, allowing users to detail the impact of embers beyond the fire perimeters.

"The simulation capabilities extend beyond the traditional fuel-based fire simulations," he explains, "enabling users to capture the extent to which large accumulations of firebrands and embers can be lofted beyond the perimeters of the fire itself and spark ignitions in dense residential and commercial areas."

He adds: "As we saw with Tubbs, areas not previously considered at threat of wildfire were exposed by the ember transport. By introducing this ember simulation capability, the industry can now quantify the complete wildfire risk appropriately across their North America wildfire portfolios."

"EVEN THOUGH THERE IS DATA ON THOUSANDS OF HISTORICAL FIRES ... IT IS OF INSUFFICIENT QUANTITY AND RESOLUTION TO RELIABLY DETERMINE THE FREQUENCY OF FIRES"

— MARK BOVE, MUNICH REINSURANCE AMERICA

populated area has increased dramatically," states Bove. "Most of the increase in wildfire risk comes from socioeconomic factors, like the continued development of residential communities along the wildland-urban interface and the increasing value and quantity of both real estate and personal property."

Breaches in the data

Yet while the threat of wildfire is increasing, the ability to accurately quantify that increased exposure potential is limited by a lack of granular historical data, both on a countrywide basis and even in highly exposed fire regions such as California, to accurately determine the probability of an event occurring.

"Even though there is data on thousands of historical fires over the past half-century," says Bove, "it is of insufficient quantity and resolution to reliably determine the frequency of fires at all locations across the U.S.

"This is particularly true in states and regions where wildfires are less common, but still holds true in high-risk states like California," he continues. "This lack of data, as well as the fact that the wildfire risk can be dramatically different on the opposite ends of a city, postcode or even a single street, makes it difficult to determine risk-adequate rates."

According to Max Moritz, Cooperative Extension specialist in fire at the University of California, current approaches to fire mapping and modeling are also based too much on fire-specific data.

"A lot of the risk data we have comes from a bottom-up view of the fire risk itself. Methodologies are usually based on the Rothermel Fire Spread equation, which looks at spread rates, flame length, heat release, et cetera. But often we're ignoring critical data such as wind patterns, ignition loads, vulnerability characteristics, spatial relationships, as well as longer-term climate patterns, the length of the fire season and the emergence of fire-weather corridors."

Ground-level data is also lacking, he believes. "Without very localized data you're not factoring in things like the unique landscape characteristics of particular areas that can make them less prone to fire risk even in high-risk areas."

Further, data on mitigation measures at the individual community and property level is in short supply. "Currently, (re)insurers commonly receive data around the construction, occupancy and age of a given risk," explains Bove, "information that is critical for the assessment of a wind or earthquake risk."

However, the information needed to properly assess wildfire risk is typically not captured. For example, whether roof covering or siding is combustible. Bove says it is important to know if soffits and vents are open-air or protected by a metal covering, for instance. "Information about a home's upkeep and surrounding environment is critical as well," he adds.

At ground level

While wildfire may not be as data intensive as a peril such as flood, Kevin Van Leer, senior product manager at RMS, believes it is almost as demanding. "You are simulating stochastic or scenario events all the way from ignition through to spread, creating realistic footprints that can capture what the risk is and the physical mechanisms that contribute to its spread into populated environments. We've just reached the point computationally where we're able to do that."

The RMS North America Wildfire HD Models, due for release early fall 2018, capitalizes on this expanded computational capacity and improved data sets to bring probabilistic capabilities to bear on the peril for the first time across the entirety of the contiguous U.S. and Canada.

"Our high-resolution simulation grid enables us to have a clear understanding of factors such as the vegetation levels, the density of buildings, the vulnerability of individual structures and the extent of defensible space," Van Leer explains.

"We also utilize weather data based on re-analysis of historical weather observations that allows us to create a distribution of conditions from which to simulate stochastic years. That means that for a given location you can generate a weather time series that includes wind speed and direction, temperature, moisture levels, et cetera. All factors that influence wildfire activity."

He concludes: "Wildfire risk is set to increase in frequency and severity due to a number of factors ranging from climate change to expansions of the wildland-urban interface caused by urban development in fire-prone areas. As an industry we have to be able to live with that and understand how it alters the risk landscape."

THE ONE THING

WHAT ONE THING WOULD... ENCOURAGE CONTINUED INNOVATION IN THE INSURANCE INDUSTRY?

In each edition of EXPOSURE we ask three experts for their opinion on how they would tackle a major risk and insurance challenge. This issue, we consider how (re)insurers can embrace new technologies, provide new products or collaborate more closely in order to solve the world's risk problems more effectively. With insight from Tom Hutton, Stephan Ruoff and Eugene Gurenko

TOM HUTTON

Managing Partner, XL Innovate

Continued innovation will result from the visible impact and success of a few high-profile ventures. And it will be maintained by a willing and supportive regulatory environment and a stable source of venture investment and liquidity.

Nearly 30 years ago, when RMS was started, there were no examples of successful insurtech venture stories to emulate. Most venture investors doubted that a tech company could achieve penetration and growth serving the insurance industry, known as a tech laggard. Meanwhile, carriers had little experience with risk collaborations, apart from their work with brokers. All of this presented quite a challenge.

The current stream of insurtech ventures has grown out of success stories in financial technology (Lending Club, SoFi, etc.), examples of novel data and analytics for insurance customers, liquidity events in the space, investor support from traditional VCs and corporate venture arms, and media coverage. The insurtech conferences alone are mind-bending, with thousands of attendees and hundreds of exhibitors.

The next step in the innovation cycle will require a few breakout success stories from this new wave of ventures. Success stories can be measured in carrier impact (data and analytics), market impact (new distribution, new product), high visibility and, most of all, financial success. There are already a number of likely breakouts in this current wave, including the likes of Lemonade or Trov, and more. A similar analogy can be seen in fintech, where startups like Credit Karma, Square, Venmo and Kabbage showed the rest of the industry what could be possible early on.

So watch for these breakout companies and any acquisitions in the space. The rest will follow.

Innovation in insurance will result from the visible impact and success of a few high-profile ventures

STEPHAN RUOFF

CEO, Tokio Millennium Re AG

The advancement of network and platform thinking would facilitate greater industry innovation. Technology has changed how (re)insurance business is transacted. We are seeing blockchain initiatives through consortia such as B3i and R3 and the Lloyd's electronic placement platform "PPL".

Through cloud technology and distributed ledgers, we have solutions that enable shared data platforms. However, we must learn from trading environments such as stock exchanges. Here, trading parties operate on a single platform where data flows easily, and which supports interaction between the various parties.

Our industry should develop a similar risk-exchange environment — a transactional environment that supports a consistent data approach and enables all parties to interact with data in a communal environment rather than each storing their own data on their specific platforms.

We must develop and adopt shared data standards so that risk information can be consumed in a single recognized format. This would prevent data duplication and reduce internal processing requirements and transaction costs. This could also reduce regulatory burdens, as developing an industrywide data language could spawn a more harmonious global market regulation on how data can be used.

Another key aspect is data mining through artifical intelligence (AI) to boost risk quantification and predictive analytics. With better data standards plus more widely shared platforms, more risk can be insured, thus further reducing the protection gap.

Our thinking must go beyond (re)insurance itself. At TMR, we have helped pioneer greater data consistency and network thinking to drive more interaction between insurance and capital markets to help match risk and capital pools. We believe such efforts create huge innovation potential.

We must develop and adopt shared data standards so that risk can be consumed in a single data format

EUGENE GURENKO

Lead Insurance Specialist, World Bank Finance

In most countries, government still continues to play the role of the reinsurer of last resort. Such an open-ended commitment creates strong disincentives on the part of homeowners to acquire insurance coverage for natural disasters.

As government involvement in post-disaster compensation is not going away, the reinsurance industry has an important and innovative role to play to encourage the development and growth of the primary catastrophe insurance market.

Primary insurers are always highly reluctant to offer catastrophe risk insurance products to consumers without unlimited reinsurance coverage. However, this is hard to find because of the initial small scale of such catastrophe insurance pilots, potentially high concentration of risk in the early stage of portfolio building and uncertain premium growth prospects. So how can these challenges be resolved?

One solution is for reinsurance capacity to be pooled to support the development of local insurance markets. The U.S. private flood insurance market, for instance, could be a great testing ground for such a concept whereby large reinsurers would provide earmarked guaranteed reinsurance capacity to any primary insurer that agrees to sell a preapproved (by a panel of reinsurers) flood insurance product at a minimum technical price. Such an approach will go a long way toward considerably raising the level of catastrophe insurance coverage provided by the reinsurance market without waiting for notoriously difficult shifts in government disaster compensation policy.

Reinsurance capacity can be pooled to support the development of local catastrophe insurance markets

RESILIENCE

CAPTURING THE RESILIENCE DIVIDEND

Incentivizing resilience efforts in vulnerable, low-income countries will require the 'resilience dividend' to be monetized and delivered upfront

The role of the insurance industry and the wider risk management community is rapidly expanding beyond the scope of indemnifying risk. A growing recognition of shared responsibility is fostering a greater focus on helping reduce loss potential and support risk reduction, while simultaneously providing the post-event recovery funding that is part of the sector's original remit.

"There is now a concerted industrywide effort to better realize the resilience dividend," believes Ben Brookes, managing director of capital and resilience solutions at RMS, "particularly in disaster-prone, low-income countries — creating that virtuous circle where resilience efforts are recognized in reduced premiums, with the resulting savings helping to fund further resilience efforts."

Acknowledging the challenge

In 2017, RMS conducted a study mapping the role of insurance in managing disaster losses in low- and low-middle-income countries on behalf of the U.K. Department for International Development (DFID).

It found that the average annual economic loss across 77 countries directly attributable to natural disasters was US$29 billion. Further, simulations revealed a 10 percent probability that these countries could experience losses on the magnitude of US$47 billion in 2018, affecting 180 million people.

Breaking these colossal figures down, RMS showed that of the potential US$47 billion hit, only 12 percent would likely be met by humanitarian aid with a further 5 percent covered by insurance. This leaves a bill of some US$39 billion to be picked up by some of the poorest countries in the world.

The U.K. government has long recognized this challenge and to further the need in facilitating effective international collaboration across both public and private sectors to address a shortfall of this magnitude.

In July 2017, U.K. Prime Minister Theresa May launched the Centre for Global Disaster Protection. The London-based institution brings together partners including DFID, the World Bank, civil society and the private sector to achieve a shared goal of strengthening the resilience capabilities of developing countries to natural disasters and the impacts of climate change.

The Centre aims to provide neutral advice and develop innovative financial tools, incorporating insurance-specific instruments, that will enable better pre-disaster planning and increase the financial resilience of vulnerable regions to natural disasters.

Addressing the International Insurance Society shortly after the launch, Lord Bates, the U.K. Government Minister of State for International Development, said that the aim of the Centre was to combine data, research and science to "analyze risk and design systems that work well for the poorest people" and involve those vulnerable people in the dialogue that helps create them.

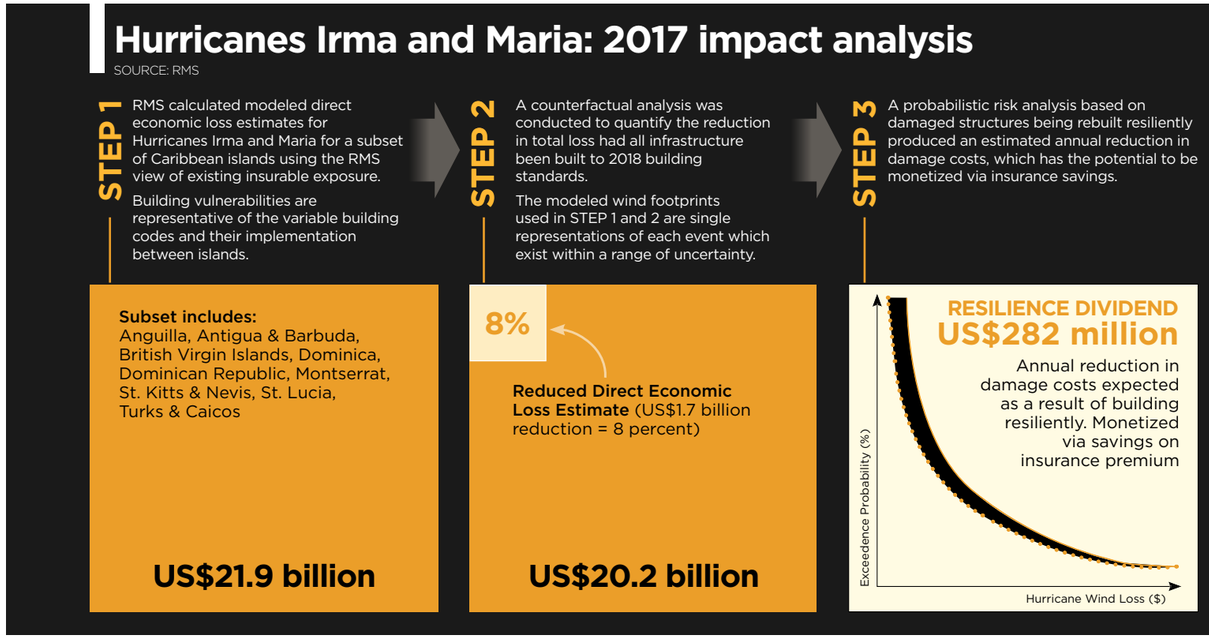
"It is about innovation," he added, "looking at new ways of working and building new collaborations across the finance and humanitarian communities, to design financial instruments that work for developing countries."

A lack of incentive

There are, however, multiple barriers to creating an environment in which a resilient infrastructure can be developed.

"Resilience comes at a cost," says Irena Sekulska, engagement manager at Vivid Economics, "and delivers long-term benefits that are difficult to quantify. This makes the development of any form of resilient infrastructure extremely challenging, particularly in developing countries where natural disasters hit disproportionally harder as a percentage of GDP."

The potential scale of the undertaking is considerable, especially when one considers that the direct economic impact of a natural catastrophe in a vulnerable, low-income country can be multiples of its GDP. This was strikingly demonstrated by the economic losses dealt out by Hurricanes Irma and Harvey across the Caribbean and the 2010 Haiti Earthquake, a one-in-ten-year loss that wiped out 120 percent of the country's GDP.



Another problem is that the success of any resilience strategy is largely unobservable. A storm surge hits, but the communities in its path are not flooded. The winds tear through a built-up area, but the buildings stand firm.

"The challenge is that by attempting to capture resilience success you are effectively trying to predict, monitor and monetize an avoided loss," explains Shalini Vajjhala, founder and CEO of re:focus, "and that is a very challenging thing to do."

A tangible benefit

"The question," states Acton, "is whether we can find a way to monetize some of the future benefit from building a more resilient infrastructure and realize it upfront, so that it can actually be used in part to finance the resilience project itself.

"In theory, if you are insuring a school against hurricane-related damage, then your premiums should be lower if you have built in a more resilient manner. Catastrophe models are able to quantify these savings in expected future losses, and this can be used to inform pricing. But is there a way we can bring that premium saving forward, so it can support the funding of the resilient infrastructure that will create it?" It is also about making the resilience dividend tangible, converting it into a return that potential investors or funding bodies can grasp.

"The resilience dividend looks a lot like energy efficiency," explains Vajjhala, "where you make a change that creates a saving rather than requires a payment. The key is to find a way to define and capture that saving in a way where the value is clear and trusted. Then the resilience dividend becomes a meaningful financial concept — otherwise it's too abstract."

The dividend must also be viewed in its broadest context, demonstrating its value not only at a financial level in the context of physical assets, but in a much wider societal context, believes Sekulska.

"Viewing the resilience dividend through a narrow, physical-damage-focused lens misses the full picture. There are multiple benefits beyond this that must be recognized and monetized. The ability to stimulate innovation and drive growth; the economic boost through job creation to build the resilient infrastructure; the social and environmental benefits of more resilient communities. It is about the broader service the resilient infrastructure provides rather than simply the physical assets themselves."

Work is being done to link traditional modeled physical asset damage to broader macroeconomic effects, which will go some way to starting to tackle this issue. Future innovation may allow the resilience

MONETIZING THE RESILIENCE DIVIDEND: PROPOSED SOLUTIONS

"Each proposed solution, to a greater or lesser extent, meets the requirements of the resilience brief," says Acton. "They each encourage the development of resilient infrastructure, serve to monetize a portion of the resilience dividend, deliver the resilience dividend upfront and involve some form of risk transfer."

Yet, they each have limitations that must be addressed collectively. For example, initial model analysis by RMS suggests that the potential payback period for a RESCO-based solution could be 10 years or longer. Is this beyond an acceptable period for investors? Could the development impact bond be scaled-up sufficiently to tackle the financial scope of the challenge? Given the donor support requirement of the insurance-linked loan package, is this a viable long-term solution? Would the complex incentive structure and multiple stakeholders required by a resilience bond scuttle its development? Will insurance pricing fully recognize the investments in resilience that have been made, an assumption underlying each of these ideas?

RMS, Vivid Economics and re:focus are working together with Lloyd's and the Centre to further develop these ideas, adding more analytics to assess the cost-benefit of those considered to be the most viable in the near term, ahead of publication of a final report in June.

"The purpose of the Lab," explains Vajjhala, "is not to agree upon a single solution, but rather to put forward workable solutions to those individuals and institutions that took part in the dialogue and who will ultimately be responsible for its implementation should they choose to move the idea forward."

And as Sekulska makes clear, evolving these embryonic ideas into full-fledged, effective financial instruments will take significant effort and collective will on multiple fronts.

"There will need to be concerted effort across the board to convert these innovative ideas into working solutions. This will require pricing it fully, having someone pioneer it and take it forward, putting together a consortium of stakeholders to implement it."

RESILIENCE ESCO (RESCO)

Agents who are willing to pay for resilience measures upfront and earn returns over time from insurance premium savings (resulting from the resilience measure) being transferred to them. This resolves capital constraints and short-time horizon issues.

DEVELOPMENT IMPACT BOND FOR RESILIENCE

A pay-for-performance contract where investors supply capital upfront and returns are based on both the successful provision of services (school enrollment rates for example) and criteria related to implementation of resilience or insurance.

INSURANCE-LINKED LOAN PACKAGE

A loan is provided with favorable terms if it is used for resilience measures or depending on what resilience investments are made, and with criteria for insurance purchase. This concession can be in the form of a rebate rather than reduced interest payments to help bring the resilience dividend upfront.

DEVELOPMENT APPLICATION OF A RESILIENCE BOND

A resilience bond is combined with a (concessional) funding instrument. Investors (including possible public finance providers) supply the upfront capital for resilience investments and are repaid in part by the resilience rebates from the resilience bond.

dividend to be harnessed in other creative ways, including the potential increase in land values arising from reduced risk exposure.

The Innovation Lab

It is in this context that the Centre for Global Disaster Protection, in partnership with Lloyd's of London, launched the Innovation Lab. The first lab of its kind run by the Centre, held on January 31, 2018, provided an open forum to stimulate cross-specialty dialogue and catalyze innovative ideas on how financial instruments could incentivize the development of resilient infrastructure and encourage building back better after disasters.

Co-sponsored by Lloyd's and facilitated by re:focus, RMS and Vivid Economics, the Lab provided an environment in which experts from across the humanitarian, financial and insurance spectrum could come together to promote new thinking and stimulate innovation around this long-standing issue.

"The ideas that emerged from the Lab combined multiple different instruments," explains Sekulska, "because we realized that no single financial mechanism could effectively monetize the resilience dividend and bring it far enough upfront to sufficiently stimulate resilience efforts. Each potential solution also combined a funding component and a risk transfer component."

"The solutions generated by the participants ranged from the incremental to the radical," adds Vajjhala. "They included interventions that could be undertaken relatively quickly to capture the resilience dividend and those that would require major structural changes and significant government intervention to set up the required entities or institutions to manage the proposed projects."

Trevor Maynard, head of innovation at Lloyd's, concluded that the use of models was invaluable in exploring the value of resilience compared to the cost of disasters, adding "Lloyd's is committed to reducing the insurance gap and we hope that risk transfer will become embedded in the development process going forward so that communities and their hard work on development can be protected against disasters."

Mass soybean harvesting at a farm in Campo Verde, Mato Grosso, Brazil

AGRICULTURE

BRAZIL: MODELING THE WORLD'S FUTURE BREADBASKET

How a crop modeling collaboration with IRB Brasil Re could help bridge the protection gap and build a more resilient agricultural base for the future in Brazil

Brazil is currently the world's second largest corn exporter, and is set to overtake the U.S. as the globe's biggest soybean exporter, with the U.S. Department of Agriculture (USDA) predicting a record Brazilian soybean crop of 115 million metric tons in its outlook for 2018.

Yet this agricultural powerhouse — responsible for around a quarter of Brazil's GDP — remains largely underinsured, according to Victor Roldán, vice president and head of Caribbean and Latin America at RMS. A situation that must be addressed given the importance of the sector for the country's economy and growing weather extremes farmers must contend with under climate change conditions.

"Natural perils are identified as the industry's main risk," he says. "Major droughts or excess of rain have been big drivers of losses for the sector, and their frequency and severity shall increase under future climate change conditions. During 2014 to 2017, El Niño affected Brazil with some of the largest droughts in some areas of the country and excess of rain in others.

"There is a need to structure more effective and attractive insurance products to protect the farmers," he continues. "For this we need better analytics, a better understanding of the perils, exposure and vulnerability."

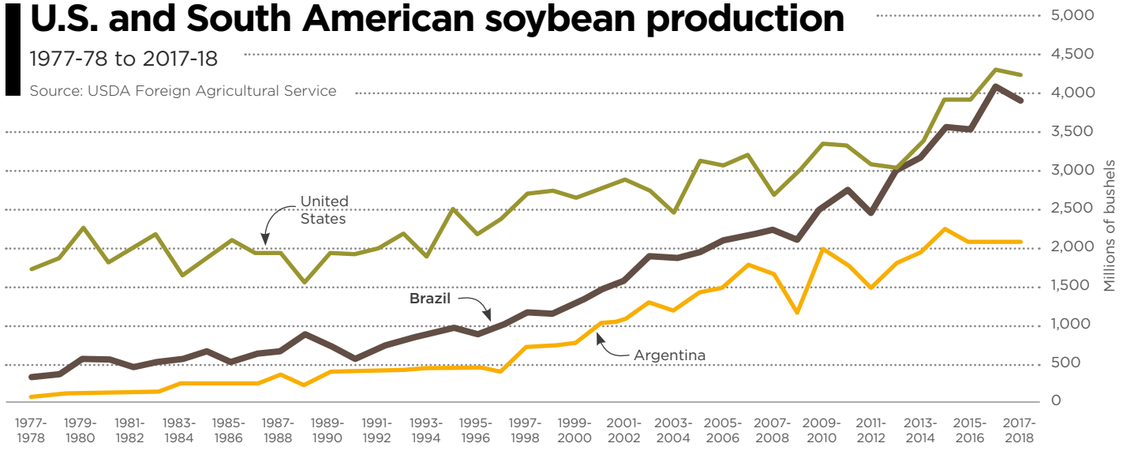
Worst drought in 80 years

The worst drought in 80 years reached its height in 2015, with farmers in Sao Paulo losing up to a third of their crops due to the dry weather. Production of soy shrank by 17 percent between 2013 and 2014 while around a fifth of the state's citrus crops died. Meanwhile, heavy rain and flash floods in the south of the country also detrimentally impacted agricultural output.

The effects of climate change over the next 25 years could lead to further heavy crop losses, according to a study carried out by Brazil's Secretariat of Strategic Issues (SAE). It found that some of the country's main crops could suffer a serious decline in the areas already under cultivation, anticipating a decline of up to 39 percent in the soybean crop. This could translate into significant financial losses, since the soybean crop currently brings in around US$20 billion in export earnings annually.

IRB Brasil Re has been the leader in the agricultural reinsurance sector of the country for decades and has more than 70 years of agricultural claims data. Today agricultural risks represent its second-largest business line after property. However, insurance

THE EFFECTS OF CLIMATE CHANGE OVER THE NEXT 25 YEARS COULD LEAD TO FURTHER HEAVY CROP LOSSES



"MAJOR DROUGHTS OR EXCESS OF RAIN HAVE BEEN BIG DRIVERS OF LOSSES FOR THE SECTOR, BUT ALSO CLIMATE CHANGE IS A WORRYING TREND" — VICTOR ROLDÁN, RMS

penetration remains low in the agricultural sector, and IRB has been seeking ways in which to encourage take-up among farmers.

The 2015 drought was a turning point, explains Roldán. "As the largest reinsurance player in Brazil, IRB needed to address in a more systematic way the recorded 16.3 percent increase in claims. The increase was due to the drought in the Midwestern region, which adversely affected corn, soybean and coffee crops and, separately an increase in the historical average rainfall level in the Southern region, which caused damage to the crops."

Building a probabilistic crop model

A better crop-weather modeling approach and risk analytics of crop perils will help the market to better understand their risks and drive growth in crop insurance penetration. IRB is partnering with RMS to develop the first fully probabilistic hybrid crop model for the agricultural insurance sector in Brazil, which it is planning to roll out to its cedants. The model will assess crop risks linked with weather drivers, such as drought, excess rainfall, temperature variation, hail events, strong wind and other natural hazards that impact crop yield variability. The model will be suited for different crop insurance products such as named perils (hail, frost, etc.), Multiple-Peril Crop Insurance (MPCI) and revenue covers, and will also include livestock and forestry.

"Weather-driven impacts on crop production are complex perils to model given the natural variability in space and time, the localized nature of the hazards and the complex vulnerability response depending on the intensity, but also on the timing of occurrence," explains Olivier Bode, manager, global agricultural risk at RMS.

"For instance, plant vulnerability not only depends on the intensity of the stress but also on the timing of the occurrence, and the crop phenology or growth stage, which in turn depends on the planting date and the selected variety along with the local weather and soil conditions," he continues. "Thus, exposure information is critical as you need to know which variety the farmer is selecting and its corresponding planting date to make sure you're representing correctly the impacts that might occur during a growing season. The hybrid crop model developed by RMS for IRB has explicit modules that account for variety specific responses and dynamic representation of crop growth stages."

The model will rely on more than historical data. "That's the major advantage of using a probabilistic crop-weather modeling approach," says Bode. "Typically, insurers are looking at historical yield data to compute actuarial losses and they don't go beyond that. A probabilistic framework allows insurers to go beyond the short historical yield record, adding value by coupling longer weather time series with crop models. They also allow you to capture future possible events that are not recorded in past weather data, for example, drought events that might span over several years, flood occurrences extending over larger or new areas as well as climate change related impacts. This allows you to calculate exceedance probability losses at different return periods for each crop and for specific scenarios."

There is also significant potential to roll out the model to other geographies in the future, with Colombia currently looking like the obvious next step and opportunity. "The El Niño weather phenomenon affects all of Latin America; it decreases rains by more than 60 percent during the rainy seasons in many countries," explains Roldán. "Like Brazil, Colombia is a very biologically diverse country and features a variety of ecosystems. Currently, most of the country has underutilized agricultural land."

Colombia is already a key player worldwide in two products: coffee and cut flowers. But the country signed a number of free trade agreements that will give its producers more access to foreign markets. "So, the expansion of agribusiness insurance is urgently needed in Colombia," says Roldán.

TECH TALK

IN THE EYE OF THE STORM

Advances in data capture are helping to give (re)insurers an unparalleled insight into weather-related activity

Weather-related data is now available on a much more localized level than ever before. Rapidly expanding weather station networks are capturing terabytes of data across multiple weather-related variables on an almost real-time basis, creating a "ground-truth" clarity multiple times sharper than that available only a few years ago.

In fact, so hyperlocalized has this data become that it is now possible to capture weather information "down to a city street corner in some cases," according to Earth Networks' chief meteorologist Mark Hoekzema.

This ground-level data is vital to the insurance industry given the potential for significant variations in sustained damage levels from one side of the street to the other during weather-related events, he adds.

"Baseball-sized hail can fall on one side of the street while just a block over there might be only pea-sized hail and no damage. Tornados and lightning can decimate a neighborhood and leave a house untouched on the same street. The greater the resolution of the data, the more accurate the damage verification."

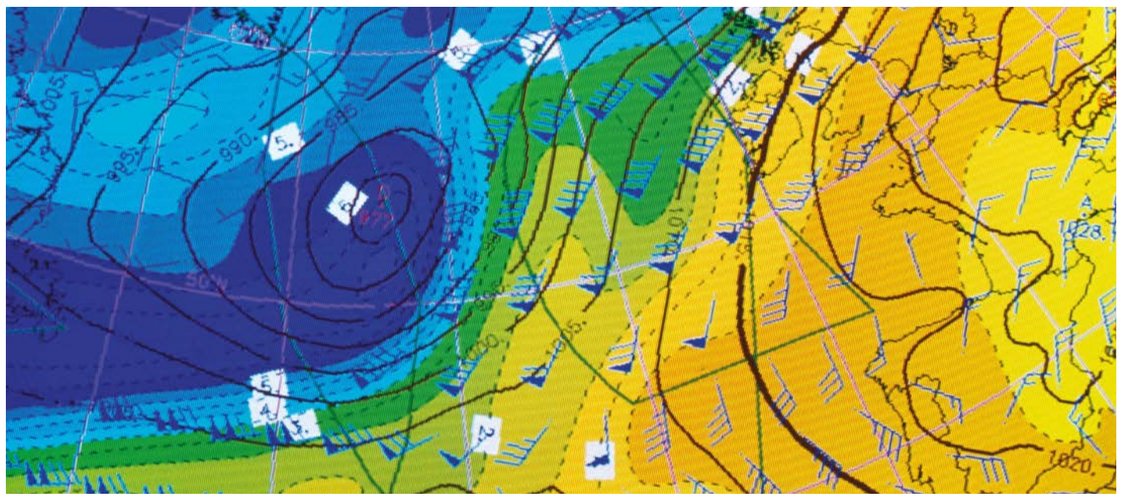
High-resolution perils

This granularity of data is needed to fuel the high-resolution modeling capabilities that have become available over the last five to ten years. "With the continued increase in computational power," Hoekzema explains, "the ability to run models at very high resolutions has become commonplace. Very high-resolution inputs are needed for these models to get the most out of the computations."

In July 2017, RMS teamed up with Earth Networks, capitalizing on its vast network of stations across North America and the Caribbean and reams of both current and historical data to feed into RMS HWind tropical cyclone wind field data products.

"Through our linkup with Earth Networks, RMS has access to data from over 6,000 proprietary weather stations across the Americas and Caribbean, particularly across the U.S.," explains Jeff Waters, senior product

"THE GREATER THE RESOLUTION OF THE DATA, THE MORE ACCURATE THE DAMAGE VERIFICATION" — MARK HOEKZEMA, EARTH NETWORKS



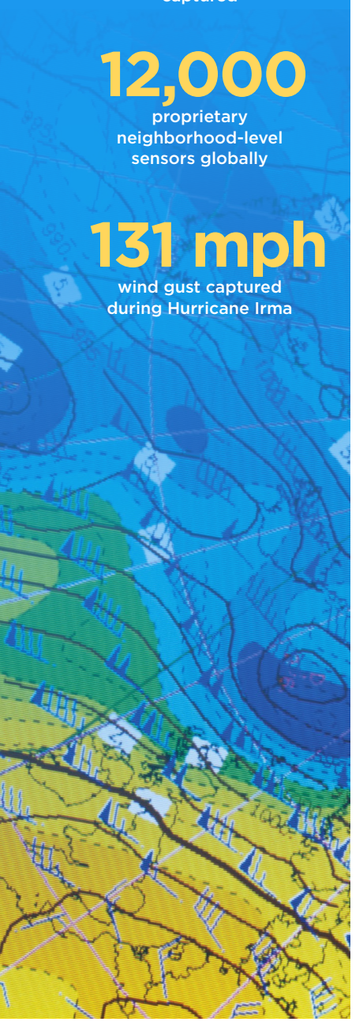
Earth Networks in numbers

25
terabytes of data collected daily

>25
weather variables captured

12,000
proprietary neighborhood-level sensors globally

131 mph
wind gust captured during Hurricane Irma



manager of model product management at RMS. "That means we can ingest data on multiple meteorological variables in almost real time: wind speed, wind direction and sea level pressure.

"By integrating this ground-level data from Earth Networks into the HWind framework, we can generate a much more comprehensive, objective and accurate view of a tropical cyclone's wind field as it progresses and evolves throughout the Atlantic Basin."

Another key advantage of the specific data the firm provides is that many of the stations are situated in highly built-up areas. "This helps us get a much more accurate depiction of wind speeds and hazards in areas where there are significant amounts of exposure," Waters points out.

"THROUGH OUR LINKUP WITH EARTH NETWORKS ... WE CAN INGEST DATA ON MULTIPLE METEOROLOGICAL VARIABLES IN ALMOST REAL TIME" — JEFF WATERS, RMS

According to Hoekzema, this data helps RMS gain a much more defined picture of how tropical cyclone events are evolving. "Earth Networks has thousands of unique observation points that are available to RMS for their proprietary analysis. The network provides unique locations along the U.S. coasts and across the Caribbean. These locations are live observation points, so data can be ingested at high temporal resolutions."

Across the network

Earth Networks operates the world's largest weather network, with more than 12,000 neighborhood-level sensors installed at locations such as schools, businesses and government buildings. "Our stations are positioned on sturdy structures and able to withstand the worst weather a hurricane can deliver," explains Hoekzema.

Being positioned at such sites also means that the stations benefit from more reliable power sources and can capitalize on high-speed Internet connectivity to ensure the flow of data is maintained during extreme events.

In September 2017, an Earth Networks weather station located at the Naples Airport in Florida was the source for one of the highest-recorded wind gusts from Hurricane Irma, registering 131 miles per hour. "The station operated through the entire storm," he adds.

This network of stations collates a colossal amount of data, with Earth Networks processing some 25 terabytes of data relating to over 25 weather variables on a daily basis, with information refreshed every few minutes.

"The weather stations record many data elements," he says, "including temperature, wind speed, wind gust, wind direction, humidity, dew point and many others. Because the stations are sending data in real time, Earth Networks stations also send very reliable rate information — or how the values are changing in real time. Real-time rate information provides valuable data on how a storm is developing and moving and what extreme changes could be happening on the ground."

Looking further ahead

For RMS, such pinpoint data is not only helping ensure a continuous data feed during major tropical cyclone events but will also contribute to efforts to enhance the quality of insights delivered prior to landfall.

"We're currently working on the forecasting component of our HWind product suite," says Waters. "Harnessing this hyperlocal data alongside weather forecast models will help us gain a more accurate picture of possible track and intensity scenarios leading up to landfall, and allow users to quantify the potential impacts to their book of business should some of these scenarios pan out."

RMS is also looking at the possibility of capitalizing on Earth Networks' data for other perils, including flooding and wildfire, with the company set to release its North America Wildfire HD Models in the fall.

For Earth Networks, the firm is capitalizing on new technologies to expand its data reach. "Weather data is being captured by autonomous vehicles such as self-driving cars and drones," explains Hoekzema.

"More and more sensors are going to be sampling areas of the globe and levels of the atmosphere that have never been measured," he concludes. "As a broader variety of data is made available, AI-based models will be used to drive a broader array of decisions within weather-influenced industries."

IN CASE YOU MISSED IT

RMS sits at the intersection of technology, science and domain experience, giving us a unique perspective on what's going on in the world of tech, modeling and computing. "In Case You Missed It" is our round-up of the latest developments from Silicon Valley to Bangalore that EXPOSURE doesn't want its readers to miss. In this edition, Paul Burgess, client director for Asia-Pacific at RMS, picks his top three headlines from across the region.

01. REGULATING REGULATION

The Philippines recently introduced regulations to increase solvency and resilience to shocks for its insurance market. Insurers must maintain a minimum risk-based capital ratio of 100 percent and statutory net worth requirements. But news reports state that up to 10 non-life insurers left the market as a result of net worth requirements. It is always difficult for national insurance regulators to get the balance between ensuring stability, promoting market growth and encouraging competition with local and foreign companies.

Myanmar is a typical example. Aon reported a total gross written premium of US$46 million in 2015 for a country with a population of around 53 million — very low, even by developing market standards. In a news report in Frontier Myanmar, Aon forecast that with an "increasingly open, competitive market," the market for non-life insurance could rise to US$1.4 billion by 2030. Toward the end of 2017 a total of 24 foreign insurance companies await licenses from the regulators. But hopefully, the stage is set for a strong, growing market to boost innovation and insurance penetration levels.

02. REACHING 50 PERCENT

India's Prime Minister Modi has been instrumental in increasing the level of agricultural insurance coverage in his country. Now in its third year, the Pradhan Mantri Fasal Bima Yojana (PMFBY) scheme has its sights on increasing insurance coverage to 50 percent of the gross cropped area in 2018-19. In its first year, insurance coverage increased to 30 percent of the gross cropped area in 2016-17, compared to 23 percent in the previous period.

Getting to 50 percent is not without its challenges. Increasing the efficiency of claims payouts and encouraging all 36 states and territories to embrace the scheme will help. Model adoption is also increasing, as insurers recognize the benefits, such as simulating losses over periods of 10,000 years rather than yield records dating back just 15 years. Despite these bumps along the road, Prime Minister Modi shows what can happen when a government sets bold targets. With a clear goal, government, farmers, insurers and innovators from science and technology have come together and set their sights on 50 percent coverage. This is vital in a country where 55 percent of the population rely on farming for their livelihood.

BIG NUMBERS

28%
percentage of the Philippines population with micro-insurance policies

2nd
India's world ranking in farm output

NZ$21B (US$15.4B)
insured cost of 2010-11 Canterbury earthquakes

03. SHOULD HIGH RISK MEAN HIGH COST?

New Zealand property owners are starting to see the impact of more granular earthquake risk modeling in terms of adjustments to their premiums. After the major earthquakes in 2010-11, RMS invested heavily in developing risk models that considered new insights from the Canterbury Earthquake Sequence, including extreme liquefaction and the important contribution of seismic hazard from previously unknown faults.

According to recent media reports, major New Zealand insurers will start using modeling to price premiums based on how at-risk each property is to earthquakes. As an example, a news story in New Zealand news site Stuff stated the annual cost to cover a NZ$1 million (US$740,000) home in Auckland for earthquake-related damages was about NZ$40 but the equivalent property in Wellington cost NZ$5,400 to insure.

New Zealand Insurance Council chief executive Tim Grafton was quoted saying, "Increasingly we want to see communities around New Zealand are not undertaking developments that are just going to end up in social and economic disaster for people." Insurers increasingly signal to government, property owners and planners about the need to manage the risk posed by buildings in high-risk areas, and transparent, granular risk pricing kick-starts the debate.

RMS solutions help insurers, financial markets, corporations, and public agencies evaluate and manage risks throughout the world, promoting resilient societies and a sustainable global economy.

Risk Management Solutions, Inc.
7575 Gateway Blvd.
Newark, CA 94560 USA
www.rms.com