

An aerial photograph of a river delta, showing a complex network of water channels and sediment deposits. The water is a deep blue, while the sediment is a light tan color. The channels form a series of loops and curves, creating a highly textured and intricate pattern. A white rectangular box is overlaid on the upper left portion of the image, containing text.

Willis Research Network
Willis Towers Watson 

Willis Research Network

Science For Resilience

2020

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Foreword

Welcome to our review of the fourteenth year of the Willis Research Network. As we enter a decade where climate themes and emerging people-based risks will dominate wider business, policy and society, we believe our combination of research partner continuity and innovation will deliver the depth and quality of inputs needed to meet these challenges.

In 2019 we have expanded into new fields in line with evolving needs and emerging risks. Through our Technology and People themes we have undertaken pioneering work to quantify political risks with Oxford Analytica and confronted cyber related threat and economic assessments with the Royal United Services Institute and the University of Oxford. At Loughborough University we have been working with Professor Chris Holland and others on the implications of artificial intelligence on insurance business models. Our work in these fields and other emerging risks will continue to strengthen as these threats develop.

Much of our early work evaluated the risks of extreme weather through advanced modeling and now these partnerships are being enhanced further to address future projections and scenarios. For example, at Newcastle University, Professor Chris Kilsby has been assisting in the development of future flood scenarios to

enable U.K. insurers to respond to the new climate risk stress tests by the Prudential Regulatory Authority.

At the U.S. National Center for Atmospheric Research (NCAR) we have supported Dr Greg Holland and Dr James Done in a partnership that has flourished for over a decade to enable a deep integration of detailed hurricane footprints in atmospheric models, a vital component to evaluate the risks of current extremes and future climates. At TMSI National University of Singapore we bid farewell and thank you to Professor Yui Liong who retires after 11 years contributing to the WRN and look forward to continued research on South East Asian flood risks with the team. While at the Karlsruhe Institute of Technology in Germany and Oklahoma University in Germany our collaborations on hail risk modeling gain greater urgency as losses to life and property grow across the world.

Our Earth risks research programme benefits from similar continuity and we describe work from our long-standing collaborations with Tohoku University, University College London and the Global Earthquake Model Foundation on hazard modeling alongside newer partnerships at San Diego State University and Temblor.

“ The WRN will be at the heart of our support to institutions reporting under the Task Force for Climate related Financial Disclosures (TCFD) and engagement in wider initiatives building climate resilience including the Coalition for Climate Resilient Investment and the Insurance Development Forum. ”

It is our pleasure to present some of this work in our annual brochure. I would like to acknowledge and thank all our research partners and the WRN management team that has brought integrated thinking to our research programme and its transmission into better modeling and decision support. Finally, and most importantly, thanks to our clients for their support and feedback that provides the essential foundation and motivation for our shared endeavor.

Rowan Douglas, CBE

WRN Chairman

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About Us

The Willis Research Network (WRN) is an award-winning collaboration between science and the insurance, finance and risk management sector. Its mission is simple: improve the understanding of risk through science, to increase the resilience of organizations and society as a whole.

While the risk and insurance industry continues to evolve and improve at an astonishing rate, key risk management issues are still not fully understood. And no single institution has the resources or breadth of knowledge to singlehandedly answer all of the questions around the quantification and management of risk. Understanding risk and resilience are still best met working in partnerships and embracing the skills of people across the globe.

Harnessing more than 50 organizations across the world in science, academia, think tanks and the private sector, the WRN forms innovative partnerships to confront the full spectrum of risk challenges. The WRN continues to build on the strength of its partnerships, delivering and incorporating solutions into models, methodologies and transactions that increase resilience and improve the market's understanding and coverage of risk.

The WRN is organized around six research hubs, which drive a number of research programs and research projects, producing academic and business-focused research outputs.

Outputs include data, models, applications, peer-reviewed journal articles, financial instruments and conferences. Along with longer term research programs, we continue to identify projects with tangible outputs for our clients within shorter time-frame, enabling us to deliver solutions on demand.

The WRN is proud to support early-career scientists, not only through funding, but also via internship and guidance in their studies. This reflects our wish to build long-lasting partnerships with academics at all stages of their careers.



How It Works

We are often asked how we select research projects. There are two main routes: business-driven requests and science-inspired topics. We aim for a good balance between risks on everyone's radar and emerging risks.



Key Research Hubs



Earth Risks

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Emerging Risks

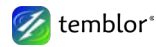
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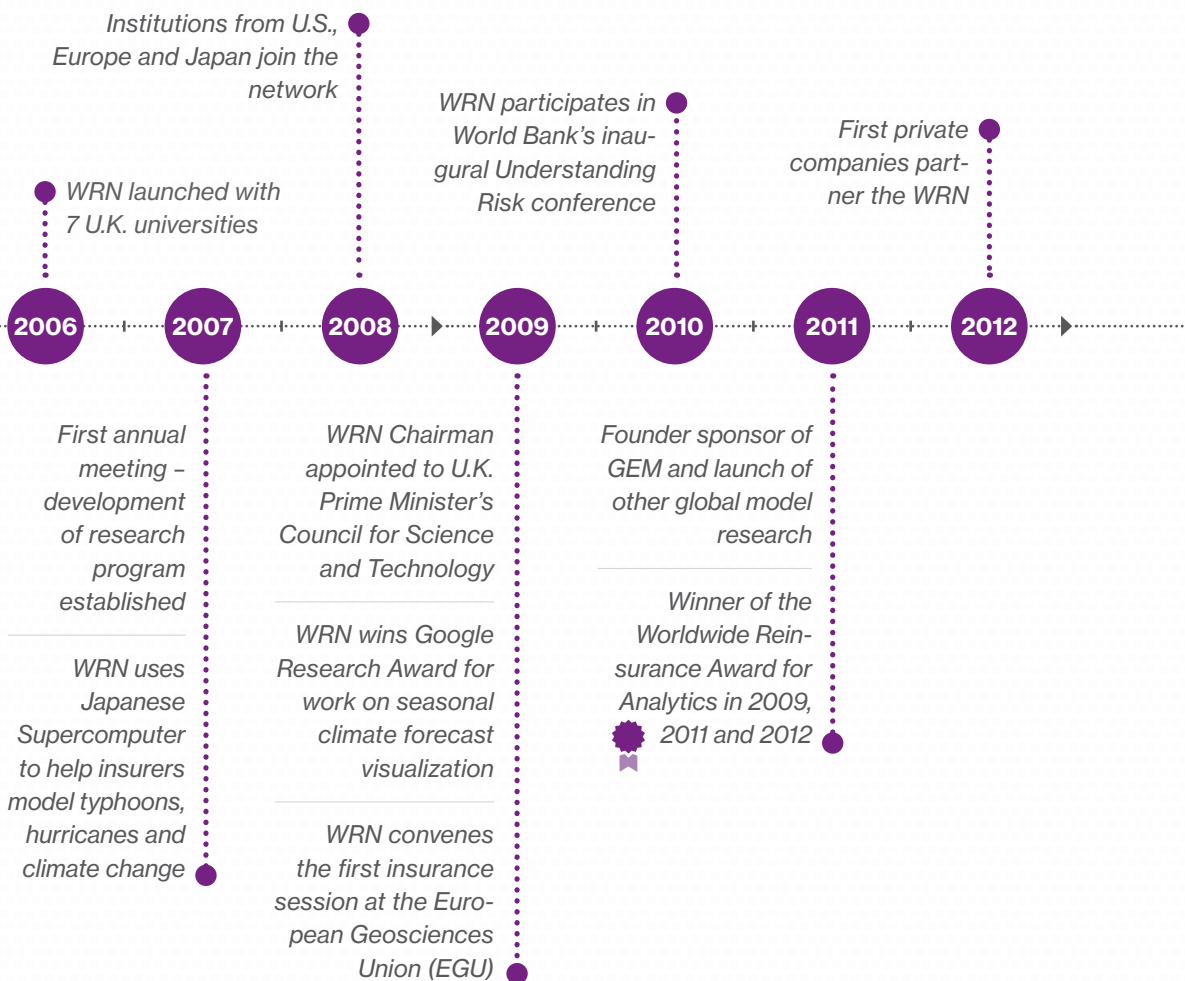
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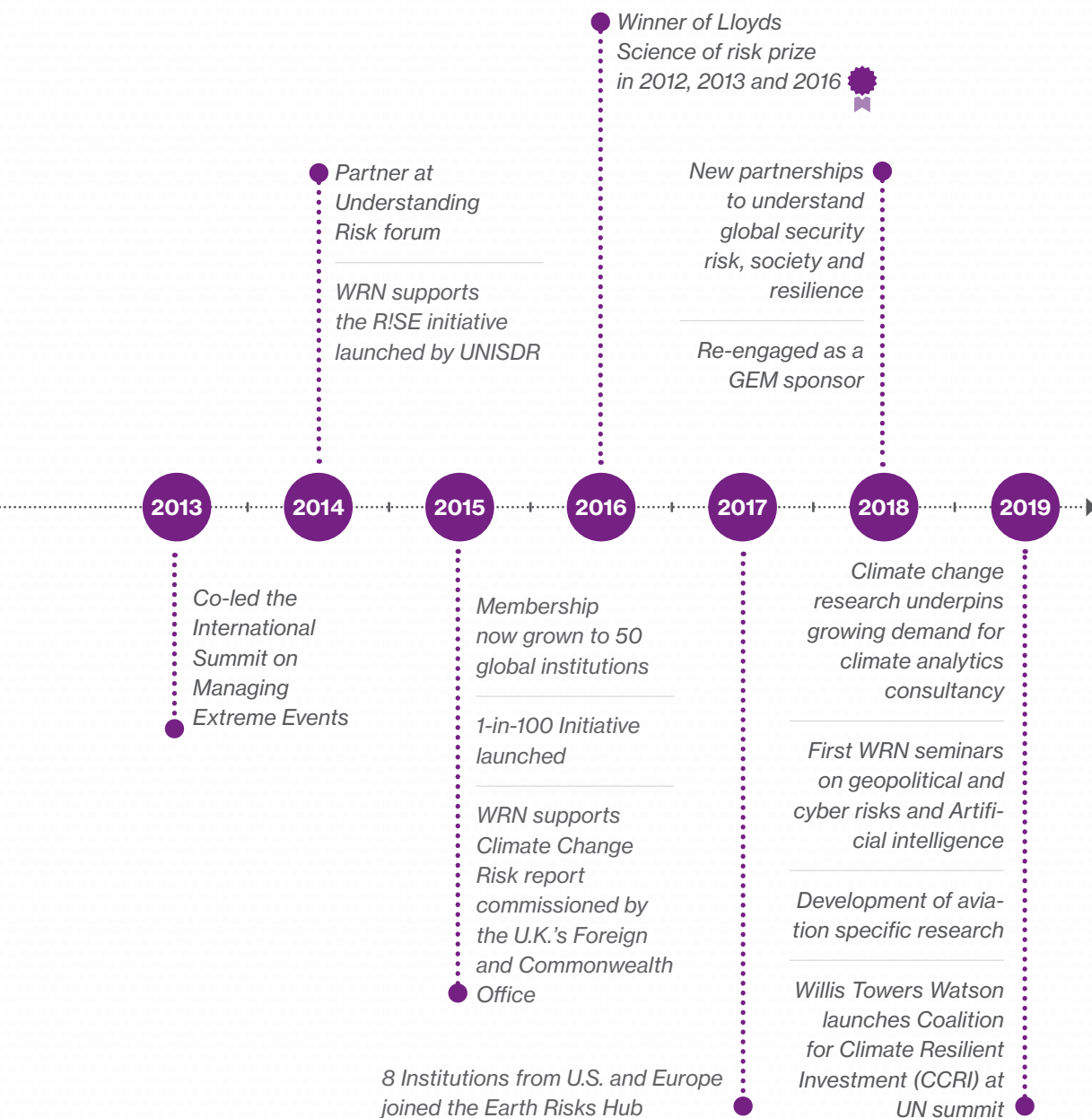
Willis Research Network Partners Over The Years





Our History









Weather and Climate



Weather and Climate

Building on over a decade of weather and climate research

The Weather and Climate research themes have long been pillars of our Willis Research Network portfolio. In 2019, weather and climate related risks threatened \$130.8bn of the gross domestic product (GDP) of the world's most prominent cities (an estimate by the Cambridge Centre for Risk Studies based on a sample of 279 cities representing 41% of the global GDP). As urban environments expand, exposures increase, and vulnerabilities become more complex, this figure is surely expected to increase.

Managing the risks associated with weather and climate risks is as relevant now as it has always been, but with new technologies and academic advances, the industry has a constant opportunity to innovate and companies can gain competitive advantage by adopting new analytical tools.

Our long-standing research partners in this space have created value for our business teams across Willis Towers Watson, while incrementally advancing the understanding of weather related natural catastrophe risk for the finance sector. Over the years innovative projects have influenced the industry and how risk is assessed. Whether our WRN partners help with internal catastrophe model development, augment our ability to interrogate and compare commercial risk models and analytics, or build our understanding of fundamental science which underpins our advice to clients

through ad hoc requests or more defined consultancy projects, our aim is to bridge the gap between the latest academic findings and expertise and our services to clients, while continuing to advance scientific understanding of the challenges facing the financial risk management community.

As the climate warms and the character of extreme weather impacts change, our partnerships with the academic community via the WRN will be essential for navigating the new landscape of risk ahead.

“ Our mutual interactions under the Willis Research Network have been remarkably productive, from the generation of ideas through to research that is both academically stimulating and societally useful. ”

Greg Holland,
National Center for
Atmospheric Research

Geoffrey Saville
Weather and Climate Research Manager

A Changing Climate Of Risk And Opportunity

There is no avoiding the reality of climate change. For many regions, the evidence of our changing climate and impacts on the natural world and patterns of weather is clear. Climate science is advancing to provide greater sophistication in how the Earth system is modeled, and refining links between human-induced warming and individual weather events through progress in attribution science. Alongside the physical sciences and economic modeling, social science is providing new insights and access to scenarios to represent the possible future warmer world. The scientific community has provided the fundamental understanding and methodological approach to make projections about the future. However, it is up to civil society, business and government to quantify how these possible futures will affect them, and make a choice based on their risk appetite, capability and aspirations to achieve a better world.

However, the actions based on these choices are not simple. Maintaining financial stability and responding to disasters to protect lives, livelihoods and businesses, will involve risks, but with risks come opportunities. The insurance and risk management industry is in prime position to meet this challenge head-on. The WRN has been supporting Willis Towers Watson's increasing efforts in this space for some time, by

forging links between latest scientific understanding and representation of natural catastrophes and financial impacts across the full risk spectrum.

The attention being given to the impacts of climate change has never been higher. We have never seen such a confluence of drivers pushing societal responses to changing climate risks forward. This range of drivers includes C-suite corporate interest, industry regulatory pressure, analytical capability, public awareness and climate activism. It seems that the time is, now, for acting on climate issues as competitive advantage is becoming tangible and the risks are material across many industries.

Starting the conversation

A new language of climate risk is developing. Willis Towers Watson has been active in this space for many years: from driving the 1-in-100 Initiative back in 2014 and chairing the Insurance Development Forum which was announced at Paris Climate Summit (COP21), through to influencing the creation of the Task Force on Climate-related Financial Disclosures (TCFD) which has gained significant traction in the corporate risk management arena. Affecting the insurance industry directly, 2019 saw the inclusion of future climate scenarios as part of the General Insurance Stress Tests issued by the Prudential Regulation

Authority (PRA). These, and other industry or policy drivers, are providing a foundation for climate risk assessment which supports ongoing reporting of climate risk. A range of different frameworks have been released by entities seeking to help companies meet these requirements, and while frameworks like TCFD are currently voluntary, the momentum is expected to continue with more binding requirements on climate risk management on the horizon. These, and other industry or policy drivers, are providing a foundation for the quantification and stress-testing of climate risk such as the recently delivered project to U.K. insurers, where our research supported regulatory climate reporting requirements.

Taking the initiative

In a concerted effort to transform how infrastructure investments decisions are made, Willis Towers Watson CEO, John Haley, announced the launch of the Coalition for Climate Resilient Investment (CCRI) at the U.N. Climate Summit in September 2019. Over 15 major companies have already signed up with more than \$5 Trillion in assets under management, with more on the way. The goal is to utilize analytics to

price climate risk to support and incentivize the development of climate resilient infrastructure. This three-year initiative will build on previous collaborations and frameworks across multiple industries. The WRN is a key contributor from Willis Towers Watson, both in terms of our credibility for the top-down initiatives described, the 'stratosphere', but also in the bottom-up view, the 'troposphere'; the foundations for developing new analytical capabilities, services and innovations for climate risk assessment for our clients, industry and society at large.

Climate risk research in action

The WRN Weather and Climate hub has seen increasing demand from our industry leaders on extending our work on climate science to explore impacts of future climate scenarios on weather extremes. Climate risk assessment frameworks need completing, new platforms require content, and complex models and data benefit from expert advice. The long relationships we have developed through the WRN can support the acceleration of our efforts to provide climate risk advice and meaningful access to the possible future scenarios and their financial impacts. By continuing on this

“ It is critical that climate-vulnerable countries and communities continue to attract investment and that infrastructure is built to withstand future climatic hazards. ”

John Haley
Willis Towers Watson CEO


journey together, Willis Towers Watson and its academic partners can provide the guidance and new tools needed to build greater financial resilience for our clients, while also supporting important new science published in the peer-reviewed literature.

We have supported a number of research projects focussed on climate change in the past. Through the WRN, we have driven tropical cyclone research with scientists at Princeton University to understand the impact of doubling the levels of carbon dioxide on storm activity, and supported the National Center for Atmospheric Research (NCAR), who identified an increase of the proportion of intense tropical cyclones related to climate change, as well as collaborated on developing a method to provide a global view of risk associated with tropical

cyclone winds around the world. We also have looked at flood research through recent work with Newcastle University to help our clients respond to the PRA requests for climate change stress testing on increases in flood risk. And we have recently set up new projects with existing partners at Columbia University, Karlsruhe Institute of Technology, NCAR, and the National University of Singapore, which focus on the impacts of climate change on extremes relating to the key loss driving perils such as severe convective storms (Hail and Tornado events), tropical cyclones and flooding. As the reach of the WRN extends to support new industries, we are investigating projects and partnerships that will explore climate related risks, from wildfires to heat stress and health. This will allow

Managing climate risk and opportunities with our holistic framework





Willis Towers Watson services to unlock new avenues of financial success for our clients.

Supporting business decisions

Climate change is a theme which influences many spheres of scientific research. Through building on research into climate risk, the WRN can support our advice and services to our clients across all industries. Willis Towers Watson has developed a framework to guide managing business change, mitigating risk, and unlocking hidden potential from climate change. This utilizes a holistic framework addressing physical and transition risk in ensuring a clear understanding of the risk profile.

With the confluence of regulatory pressure, public opinion and increasing analytical capability, the next few years will be an exciting time for the application of the latest research in climate science. And there is no time to waste. The effects of 1°C of warming are already being seen around the world. Projecting into the future how society will react to the challenge of climate change is the biggest uncertainty in climate

science, but scenarios can be used in predicting the state of the climate and environment whichever path we take. Whether we stay on a 'business as usual' pathway which increases the rate of global warming to reach 4°C or more above pre-industrial levels by 2100, or we manage to make a transition to a low or zero carbon economy in the next few decades to reduce the rate of warming to under 2°C to mitigate the worst effects of climate change, private and public interests will need to collaborate to adapt. The financial and professional services sector will play a key role in maintaining stability and resilience as more changes occur. At Willis Towers Watson we have been setting the foundations to help our clients assess, monitor and manage their climate risks for many years through our industry experts, analytical capability and external collaborations, like the WRN. We need to build on those strong foundations to support a more climate resilient future and help our clients seize the opportunities created by the changing landscape of risks.

A Long Partnership On Hail Risk



Our partnership with KIT started 10 years ago and focuses on hail risk, specifically developing extreme hail event sets for use in Willis Re catastrophe models. After initially working on European Hail Risk, our research partners at KIT (Professor Michael Kunz and Dr Heinz Jürgen Punge) changed regional focus to apply their methodology to Australia. The new hazard model will improve upon the existing risk relativities from the original hazard model, which was the first model of

its type to utilize nationally consistent satellite imagery and weather radar data. The development of a national proxy for hail size, defined for multiple return periods at any given location, will allow our clients to insert the modeled results directly into their pricing algorithms without the need for a top down Average Annual Loss distribution, adjusted by relativity. The event set would also form the basis of a national probabilistic severe thunderstorm model.

Building a hail event set

The event set was derived from weather radar observations of severe convective storms over Australia. Areas of likely hail impact are determined using peer-reviewed and established methods from the scientific literature, and were used in creating daily footprints. In Australia, the weather radar network does not cover the entire continent, and so strong regional biases are present and need calibration. To correct for the biases, we combined the radar outputs with the existing methodology from the European model based on overshooting cloud top temperatures delivered by collaborators at NASA. Severe convective storms were identified from the satellite imagery as cold cloud tops created by strong updrafts, which are also where we see the largest hail stones. This technique was successfully deployed as a basis for the Willis Re European Hail model's event set.

This combination of data sources with techniques developed by KIT allowed for the generation of thousands of years' worth of events for the Willis Re Australia hail catastrophe model event set, and represents a good approximation of the spatial correlation between severe convective events.

Characteristics of the hail events and overall distribution and correlations were validated against the Australian Bureau of Meteorology's Severe Storms Archive. The result was many millions of simulated hail events to represent a full range of possible impacts from this significant loss driving peril.

Willis Re is then able to leverage the insight provided by this collaboration to inform clients about the probabilistic loss potential from the peril. This supports the development of a view of risk to satisfy regulatory and portfolio optimization requirements.

References

Bedka, K.M., J.T. Allen, H.J. Punge, M. Kunz, and D. Simanovic, 2018: A Long-Term Overshooting Convective Cloud-Top Detection Database over Australia Derived from MTSAT Japanese Advanced Meteorological Imager Observations. J. Appl. Meteor. Climatol., 57, 937-951,
<https://doi.org/10.1175/JAMC-D-17-0056.1>



Karlsruhe Institute of Technology

Working with experts at this leading European hail risk research institution, Willis Research Fellow Dr. Heinz Jürgen Punge has been liaising with Willis Towers Watson teams in London and regional offices on identifying key applied aspects of hail hazard quantification.

Extreme Hail Storms In The U.S.

Although the official boundaries of Tornado Alley are not clearly defined, Oklahoma is definitely in the middle of it. Therefore it was not surprising that WRN identified Oklahoma University as a leading institution to provide a research data and academics with a focus on extreme hail storms. This partnership enhances our ability to give clients meaningful and timely advice on the occurrence and impact of severe thunderstorm events in the United States.

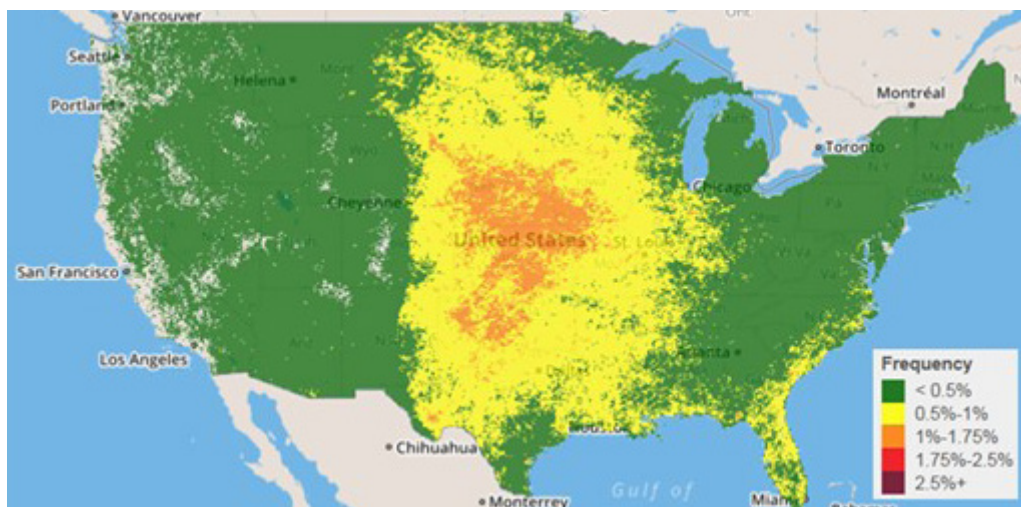
High resolution hail events in near real-time

When severe thunderstorms occur in the U.S., radar-detected hail data provided by Oklahoma University, is used in near real-

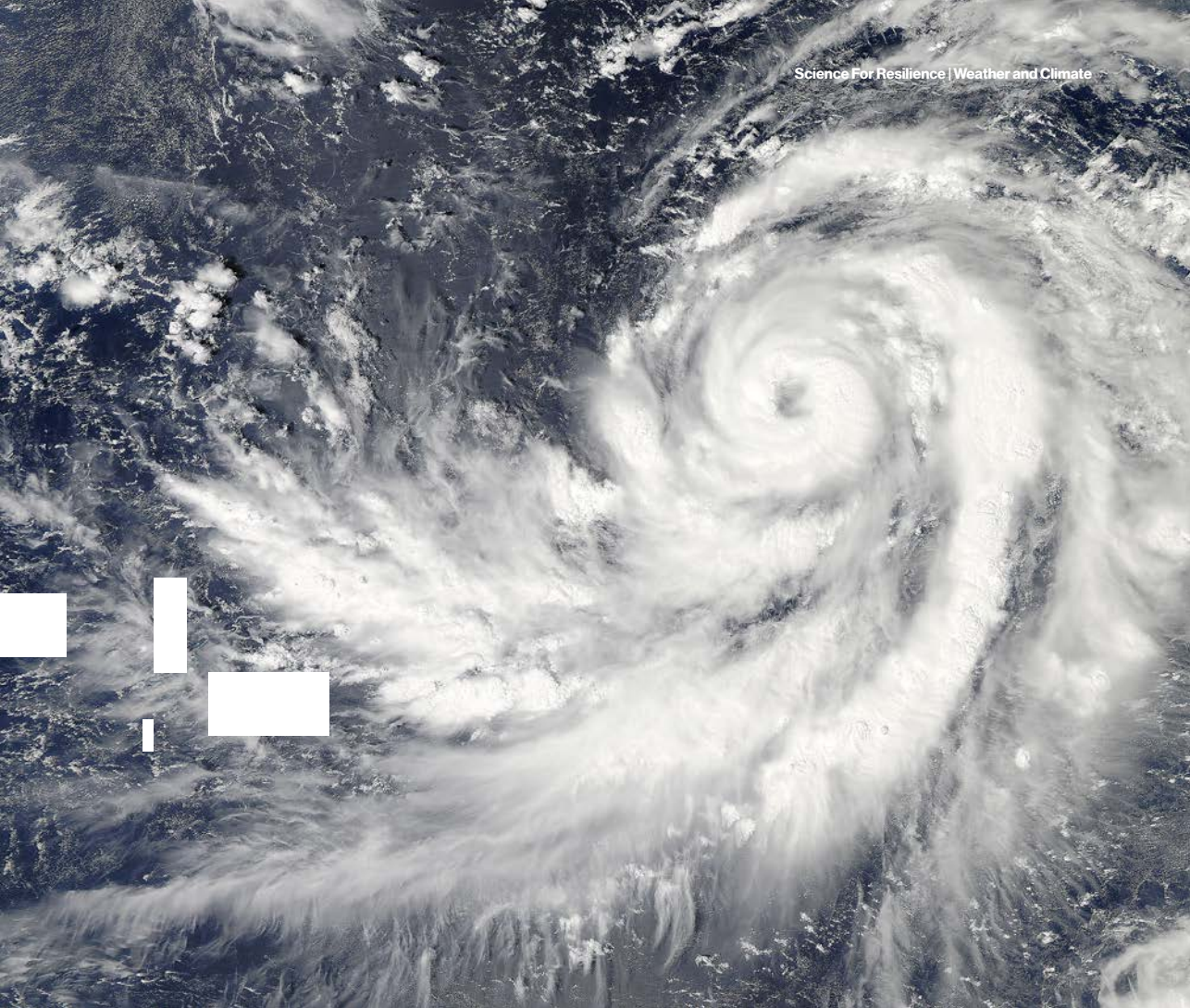
time, to give clients detailed perspectives on the extent and intensity of those storms, relative to their exposures. The portfolio insights from this capability can help to inform their event response decisions.

Longer term climatology of extreme hail events

The data also spans many years and when aggregated, gives climatological views more detailed than those available from most vendor models. These can help inform clients underwriting decisions. When combining the historical data with historical losses, this gives clients informed views on their claims and expected losses.



Frequency of hail exceeding 0.25 inches, based on data spanning the years 2000 through 2018.



Oklahoma University

Willis Research Fellow Dr. Travis Smith is a research meteorologist for the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) at the University of Oklahoma. He also manages the Severe Weather Warning Applications and Technology Transfer Group (SWAT) at the NOAA National Severe Storms Laboratory, which aims to improve the lead time and accuracy of severe weather warnings and forecasts in order to save lives and reduce property damage.

A Step Forward In Modeling Tropical Storm Footprints

The National Center for Atmospheric Research (NCAR) is a long-standing partner in the field of tropical cyclone impact research. An ongoing project within this partnership is the generation of wind footprints for tropical cyclones around the world. These footprints are a representation of the maximum gust observed during the passage of a storm through a region. The combination of such hazard data with vulnerability information characteristics for the area provides a deterministic stress-testing capability to assess the sensitivity of losses to historical or scenario events, with the potential to climate condition the view of risk. Over the course of last year NCAR has provided to Willis Towers Watson a global catalogue of historical tropical cyclone wind footprints, developed in close collaboration with Willis Re International's Catastrophe Analytics team and feeds directly in to Willis Re's

service offering. Such outputs are used for the evaluation, validation and adjustment of catastrophe models, and help develop or further refine the Willis Re View of Risk. In addition, the footprinting model augments existing analytical capabilities with respect to realistic disaster scenarios and event response. The methodology behind this work will be published in academic literature, and outputs are being used throughout Willis Towers Watson's various business activities where an independent assessment of tropical cyclone risk is required.

Advancing understanding of tropical cyclone risk

Through this global footprinting project, tropical cyclone wind fields are generated using a hybrid approach, by combining peer-reviewed hurricane wind profiling techniques with a state-of-the-art numerical boundary layer

“ We advanced a hurricane wind model that reacts physically to hills, valleys and changing land use. Through this new modeling capacity, we are advancing our view of global tropical cyclone wind risk and also our fundamental understanding of hurricane winds at landfall. I'm excited to explore all the applications of this work. ”

James Done
Project Lead, NCAR



model. The latter component is a truly innovative approach and significantly improves the representation of surface-level winds, and models the winds that create damage to buildings and infrastructure on the ground.

Wider research on climate variability and climate change to come

This project is part of a wider NCAR research partnership which also includes

in-depth analysis of how the frequency and severity of hurricanes are modified by different climate conditions, either on a year-to-year timescale, or on a much longer time horizon due to climate change.

Look out for more on this research as it develops, in WRN insights and blogs, events and future brochures.



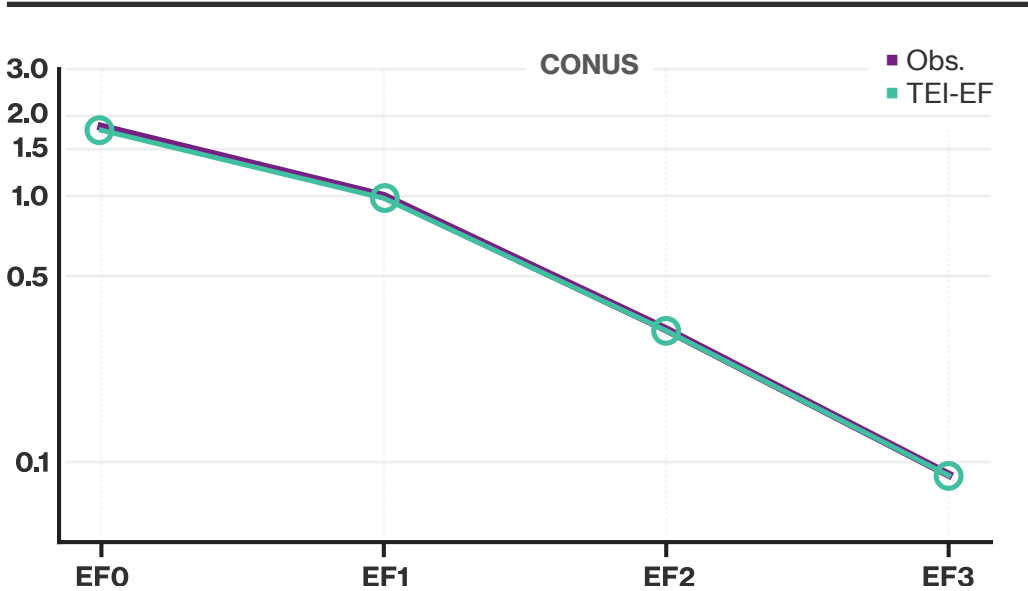
National Center for Atmospheric Research (NCAR)

Senior Academic Dr. Greg Holland and current Willis Research Fellow Dr. James Done have been working with the WRN for many years, helping us improve our understanding of tropical cyclone impacts through their multi- sectoral research and variety of partnerships.

Tornado Intensity Distribution

Our partners at Columbia University previously developed the Tornado Environment Index (TEI) which predicts the expected number of tornadoes based on atmospheric conditions and is currently used to make monthly forecasts. They have now developed an intensity-dependent TEI which

predicts the number of tornadoes by Enhanced Fujita scale (EF-Scale) rating. The TEI-EF explains the observed power-law scaling between tornado frequency and intensity, and how that scaling varies by location and time of year.



Relationship between EF intensity (x-axis) and log-number of observed and TEI-EF tornadoes (y-axis) for the whole contiguous United States (CONUS) (similar results are found for the majority of CONUS). The relationship is linear among EF1-EF3, but deviates for EF0.

Tornado outbreaks

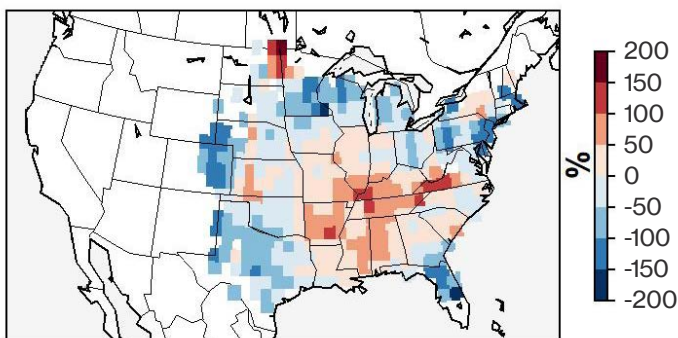
Understanding the properties of U.S. tornado outbreaks (clusters of tornadoes), such as their distribution in space and time, is particularly important, since these events are likely to drive major loss events. Columbia University has identified changes in the location, timing, intensity, and spatial extent of U.S. tornado outbreaks over recent decades. These changes can be explained to some extent by changes in the atmospheric properties that have been recorded at the time of the outbreaks.

Future climate

Columbia University is beginning to apply the same approach for climate change, looking at the atmospheric conditions related to severe convective storms (SCS), that they have used to diagnose the historical record and make forecasts. They are analysing atmospheric conditions in the latest generation of climate change projections (CMIP6) that are associated with SCS activity. This work will quantify the expected future changes in SCS activity and help to explain whether SCS activity changes that have been observed are due to climate change or natural variability.

Outbreaks occurrences

Differences in percentage (between 1999–2016 and 1979–1998 time periods) of yearly averages of outbreaks occurrences.



Columbia University

Columbia University in the City of New York is a leading global research university, with engineering and science facilities designed and equipped for next-generation research. The Columbia Initiative on Extreme Weather and Climate focuses on understanding the risks to human life and property from extreme weather events and on developing solutions to mitigate those risks. Dr. Micheal Tippett, Professor Adam Sobel, and Dr. Chiara Lepore have been working with the WRN to help us understand and better manage risks from climate extremes, with a focus on severe thunderstorm impacts.





Flood



Flood

Rising Levels of Flood Risk

Flood poses significant risk to society. Recent natural catastrophic events have put the flood peril back under the spot light for the re/insurance industry. There is an increased concern for the potential impacts of extreme flood events, both on property and infrastructure, but also on communities and ecosystem resilience necessary to support protection for people, businesses, and the natural environment. Recent regulatory requirements around quantifying the impact of climate change on flood risk will continue to push the industry towards taking action to measure these risks.

Climate change is known to affect the hydrologic cycle and processes in different regions of the world, and inherently, all the physical parameters that define flood risk are varying in time and space. To quantify flood risk, all the physical parameters, such as precipitation, terrain, soil moisture content, river flows etc. need to be considered. To quantify the climate change impact on flood risk, the impact on each parameter needs to be considered and the impact through the physical processes need to be calculated; incorporating the frequency/intensity changes in precipitation, urbanization impact on land use and land cover data and changes in peak river flows etc.

To address this complex phenomenon and to create innovative solutions will require a close collaboration between business and academia, and this is one of the challenges that the WRN is aiming to address.

Nalan Cabi
Senior Lead Flood Specialist

Quantifying The Climate Change Impact On Flood Risk

Pragmatism and speed of delivery are not traditionally associated with academic output. Yet this is exactly what our longstanding partnership with Professor Chris Kilsby and Dr. Francesco Serinaldi at Newcastle University has delivered. This year, we have benefitted from a close collaboration with our Willis Re International team on the Bank of England, Prudential Regulation Authority (PRA), General Insurance Stress Test 2019, climate change scenarios, U.K. Inland Flood stress tests. This work is key to advising our clients on the projected portfolio losses due to PRA's climate change scenarios.

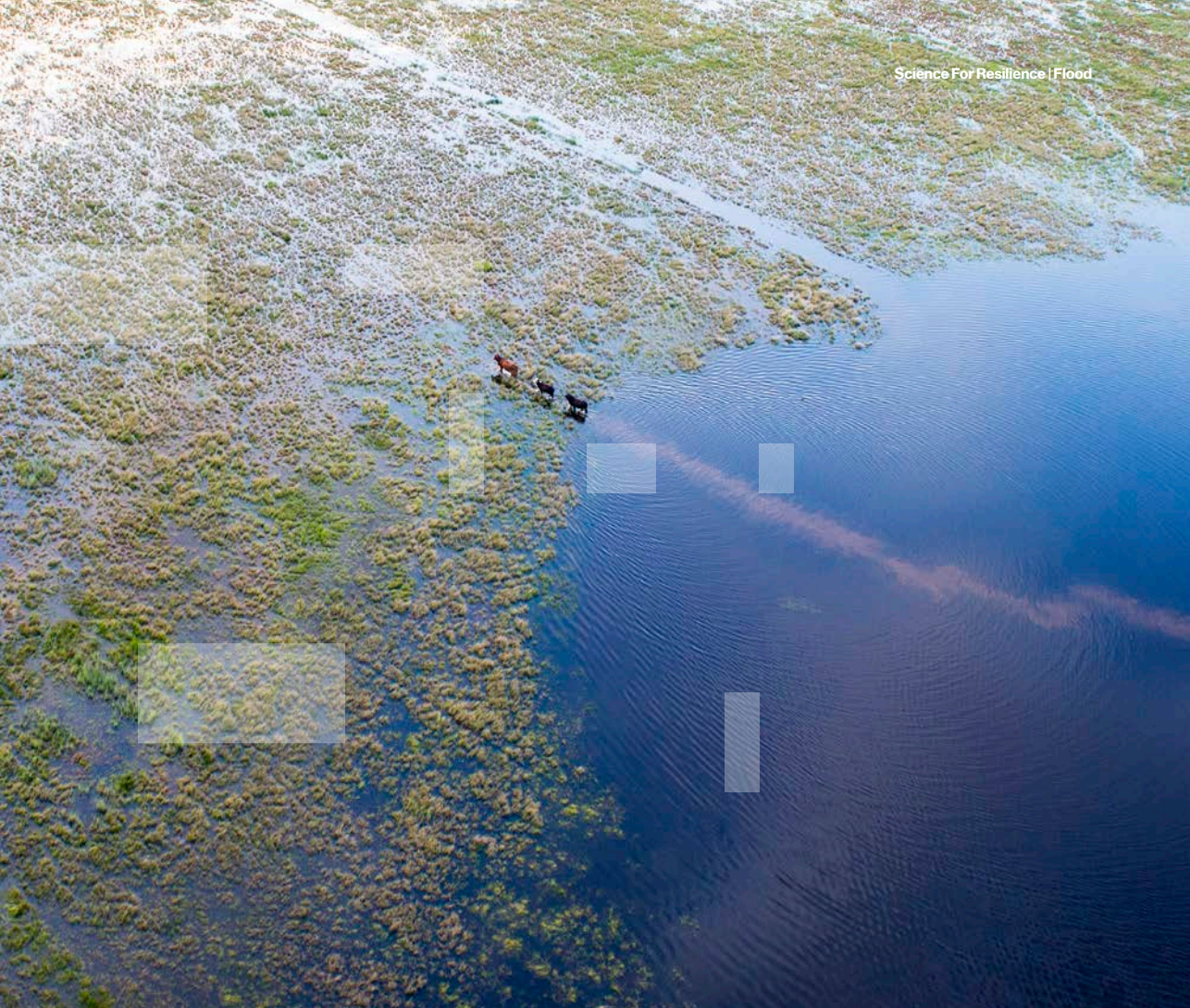
Developing a framework to quantify climate change impact on flood risk

Building on the initial request from the PRA, our current collaboration is focused on building a more comprehensive framework to quantify the climate change impact on flood risk in the U.K. using the U.K. Climate Projections and the projected variation of river peak flows across the country. This is based on peer-reviewed literature which relates to systematic shifts in return period of annual maximum river flows due to climate change impact. The world leading statistical expertise available through our WRN partnership with Newcastle University remains a key part of our research portfolio and continues to feed directly into our client advisory services.

Metrics and statistics

Inherently, all the physical parameters that define flood risk are spatially varying. The most explicit climate change signal can be seen at in peak river flows. Our approach involves using statistical analysis to quantify the estimated spatial variation in flood risk. The approach then leverages the science to provide model adjustments and stress-tests to quantify flood loss impact using a method that is repeatable for other regions.





Newcastle University

Professor Chris Kilsby and current Willis Research Fellow Dr. Francesco Serinaldi at Newcastle University have significant expertise in the physical mechanisms and statistical analysis of extreme rainfall and river flooding.

In addition, Dr. Serinaldi's research is world leading in terms of the development of methods to understand the spatial dependence and clustering of extreme processes in hydrology.

Providing A View Of Risk In Emerging Markets

Filling the gaps in model coverage in Asia

In the wake of the extreme flooding in Thailand in 2011, a significant proportion of the industry was relocated from Thailand to the Hanoi region in Vietnam. As a consequence, Willis Towers Watson clients needed detailed assessment of the flood risk from the Red River to the industrial estates with increased exposures. Alongside that, flooding in Indonesia continues to present significant problems for insurers with risks outside Jakarta.

NUS Tropical Marine Science Institute (TMSI) has significant experience in developing hydrological and hydraulic models for evaluating flood risk in South East Asia. Flood simulations rely heavily on high quality digital elevation models (DEM) and TMSI has well-established

links to the data providers in the region.

Utilising satellite data (SRTM and Sentinel-2 multispectral imagery) to derive a high resolution DEM using artificial neural networks this NUS research improved the SRTM DEM significantly to allow better flood risk modeling in the research areas. TMSI outputs for Jakarta have been integrated into Willis Towers Watson models for the region and are deriving real benefits in helping clients understand and manage their risks.

The Willis Research Network continues to support TMSI research that is enhancing the Willis Re Indonesia Flood Model.

Alongside this, we are exploring the influences of climate change on extreme flood and rainfall distributions that could form the basis of scenarios and event sets.





National University of Singapore

Tropical Marine Science Institute (TMSI) in Singapore is a center of excellence for research, development and consultancy in tropical marine science as well as environmental science. Currently our collaboration is looking at climate change impacts on rainfall distributions in South East Asia. This includes historical trends, attribution of climate change to current extreme rainfall events, development of realistic scenarios for portfolio sensitivity analysis and hazard event set adjustments in catastrophe models.



An aerial photograph capturing a powerful volcanic eruption. Dark, jagged lava flows dominate the left side of the frame, with bright orange and red molten lava visible at several points. Large, billowing plumes of white smoke or ash rise from the lava fields. To the right, the dark, turbulent ocean meets the shore, with white foam from crashing waves visible. The overall scene is one of intense geological activity.

Earth



Managing geological risks in modern society

Societies have always had to learn how to integrate into their daily lives the unavoidable threat of seismic events and their apparent random nature. The increase in exposure through urban expansion and the interconnectivity of economies has seen in the last decade some of the most devastating impact of earth related perils on societies, with more than 630,000 lives lost since 2000 due to earthquakes and corresponding cascading hazards like tsunamis and landslides – and economic losses of over US\$ 500 billion. Since any land use must contend with geological risks, whether naturally initiated or human-induced, the Earth Risks branch of the Willis Research Network was born to focus on geological risks. These, by definition, include all kind of natural hazards caused by geological conditions such as volcanic eruptions, earthquakes, tsunamis, mass movements (e.g. landslides), floods and sinkholes. For over a decade, earth scientists have been working in close collaboration with private and public partnerships around the world to produce technologically advanced models to improve preparedness and resilience of communities and infrastructures in catastrophe-prone regions. However, according to scientists, the 2011 M 9.0 Tohoku earthquake greatly exceeded previous scientific estimates of magnitude potential, killing 20,000 in its tsunamogenic aftermath. These and previous devastating events have

prompted rethinking of whether we fully understand the geological risk potential for damage, and whether there are larger and more devastating disasters yet to be observed. The Earth Risks hub focusses on bringing to the industry the latest relevant science on geological hazards to address these questions and inform our view of risk. This section illustrates some of the relevant initiatives and collaborations we have been working on for the past few months.

Rosa Sobradelo
Earth Risks Research Manager

Leading Edge Volcanic Ash Forecasting

Solutions for Aviation

With more than 1,500 potentially active volcanoes in the world, and on average about 10 to 20 volcanoes erupting (on land) at any given time (Smithsonian Institution), it is expected that the presence of volcanic ash in the atmosphere is a serious threat to global aviation. Once in the atmosphere, volcanic ash particles interact with meteorological conditions to be transported over large distances by wind before settling on the ground. The unpredictable behaviour of volcanic eruptions, with some lasting for several months, requires to further understand the potential impact to society of this non-modeled peril.

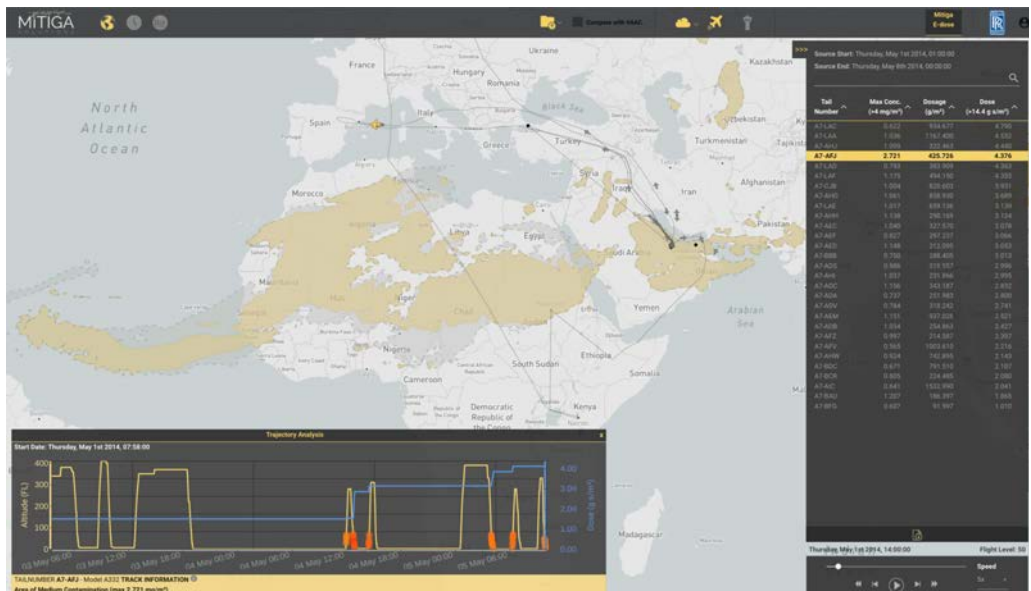
In addition to volcanic ash, sandstorms and mineral dust are also key hazards for airlines, which affect flight safety, aircraft routes, infrastructure and engine lifetime. The BSC is a world-renowned institution in the development of computer applications for science and engineering, and leaders in modeling volcanic ash dispersal in the atmosphere. The Willis Research Network (WRN) has been collaborating with Mitiga Solutions, an offshoot of the Barcelona Supercomputing Center (BSC), to assess the extent and height of the impact of those hazards in near real-time. This can be done at each stage of an aircraft's operation and in ongoing emergencies, prior to an event for early warning and for efficient management during an emergency. These modeling capa-

bilities can also be used to test and enhance preparedness. Such advances in modeling are expected to help airlines and associated organizations mitigate their exposure, re-route planes, minimise delays and cancellations, and related economic losses.

Unlike traditional reports provided by the Volcanic Ash Advisory Centers (VAACs) offering the aerospace community static, 2-D information at six-hour intervals, MITIGA's modeling offers a 3-D view of the present disruption at specific altitudes and is updated as information becomes available. This collaboration gives Willis Towers Watson the opportunity to bring airlines, airports and associated organizations in both the public and private sectors closer to the state of the art tools, which predict and mitigate the impact of natural hazards to air traffic management and aviation operations.

Merging hazard and air traffic data

Mitiga Solutions has been focusing on the development of solutions to help aviation stakeholders reduce the impact of volcanic ash, mineral dust, sea salt and other atmospheric hazards. MITIGA combines global high-resolution weather data, flight plan configuration and routes, and engine dose to aerosol contaminant intake, with impact calculator engine tools, for safer and more efficient air traffic and asset management.



Bridging the gap between science and Industry

Our partnership with Mitiga Solutions is another example of our continuous effort to use research and innovation to inform business decisions, and understand the risks associated with such a threat. This initiative will also support our clients as they continuously strive to increase operational efficiencies without sacrificing safety.

Being able to provide valuable data insight to our aviation and aerospace clients puts the WRN at the forefront of applied research for volcanic risk and reflects Willis Towers Watson's commitment to delivering bespoke risk management solutions.

References

Smithsonian Institution, https://volcano.si.edu/gvp_currenteruptions.cfm

MITIGA

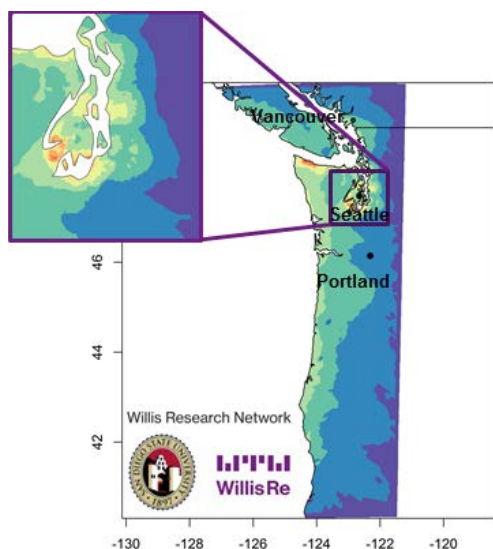
Solutions
for natural
hazards

Mitiga Solutions

Mitiga Solutions is an offshoot of the Barcelona Supercomputing Center which specialises in high-performance computing. It is certified by Eurocontrol, and Mitiga Fall3d is the dispersion model currently in use by the Darwin and Buenos Aires Volcanic Ash Advisory Centers. The Barcelona Supercomputing Center is also the official provider for the sand and dust storm warnings of the World Meteorological Organization. Learn more at: mitigasolutions.com

3D Earthquake Tail Risk Estimation

In recent decades there have been significant steps in understanding the impacts of earthquakes on the built environment, with contributions from seismology, geology, engineering and social science. In comparison to these disciplines, catastrophe modeling could be considered to still be in its early stages of development, with a number of key scientific advances that still need to be incorporated. The WRN continues to work on making this happen.

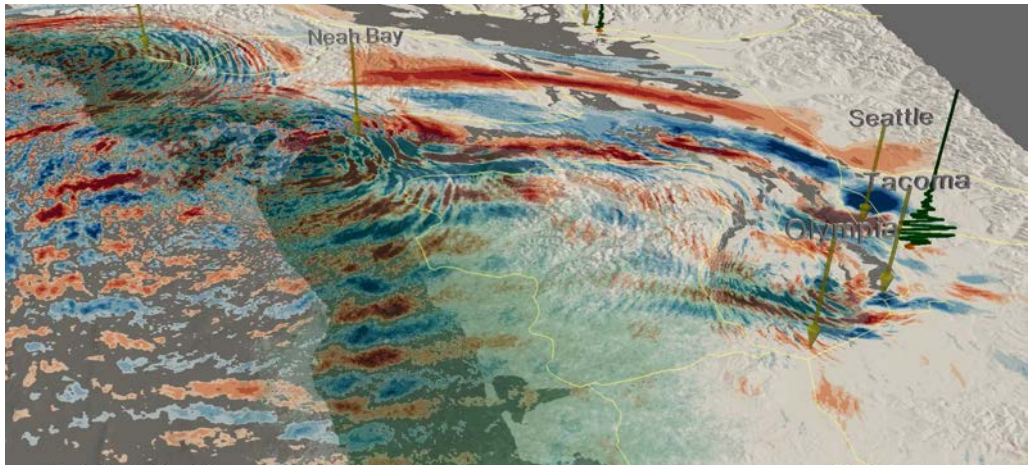


Spectral acceleration at 3sec (in m/s²) from a M9 scenario predicted by 3D ground motion simulation (left) compared to an equivalent scenario from a catastrophe model (right). The differences in ground motion from the two approaches are highlighted for Seattle region.

Since 2017, the WRN has been working with researchers from San Diego State University (SDSU) investigating how physics-based 3D ground motion simulation techniques can support decision-making in the re/insurance industry. SDSU scientists Prof. Kim Olsen and Dr. Daniel Roten have been pioneering this methodology to capture phenomena that current catastrophe models tend to oversimplify.

Use of 3D simulation to reduce the uncertainty in loss estimates

One key area to estimating insured losses from earthquake risk is ground motion footprints and any potential uncertainty. However, seismic waves and the resulting ground motions are strongly sensitive to details of the rupture propagation as well as 3D structural boundaries in the crust. However, the techniques typically used in models today rely on a highly simplified rupture geometry, with no information on rupture front propagation, and empirical ground motion prediction equations that are poorly calibrated to mega-thrust earthquake events. This results in highly uncertain loss estimates that are then sometimes meaningless. The WRN has been using this collaboration to refine loss estimates for earthquake mega-thrust scenarios that can drive tail risk. We demonstrate how 3D simulation of such scenarios reduces the uncertainty in the loss estimates and yet how more detailed spatial characteristics are captured.



Snapshot from the 3D ground motion simulation of an extreme event on the Cascadia Subduction Zone.
(Source: San Diego State University)

Improving Loss Estimations for better informed decision-making

Using this approach, we find that certain locations around Seattle and Vancouver observe a significantly amplification in our modeling, other locations the opposite, in a way that is not typically captured by the ground motion prediction equations employed in conventional loss estimation. Moreover, the losses resulting from 3D

ground motion simulations are characterized by a much lower volatility than in catastrophe models, thus allowing a more accurate and less uncertain loss estimation, as an input to decision making. The study provides Willis Towers Watson's clients with a higher confidence in tail risk assessment and portfolio optimization and helps them in making more informed reinsurance purchase and internal modeling.



SAN DIEGO STATE
UNIVERSITY

San Diego State University

San Diego State University (SDSU) has been a member of WRN since 2017. Prof. Kim Olsen and Dr. Daniel Roten at SDSU are among the primary developers of the Anelastic Wave Propagation (AWP) code used to generate physics-based ground motion predictions for future Cascadia megathrust earthquakes in the Pacific Northwest. The simulations are taking into account the three-dimensional structure of the sedimentary basins, the ocean water layer, realistic variation in the rupture pattern, and the amplification and nonlinear effects of the near-surface low-velocity layers.

The Odd Couple: Aftershocks And Clustering

In the scientific community and re/insurance industry it is well established that earthquakes tend to interact with each other. Following a significant event, important changes in underlying seismicity take place, either due to the occurrence of aftershocks in the days, months or even years to come, or due to the permanent transfer of stress that can bring neighboring faults closer or further away from failure. Events like Christchurch (2010-2011), Central Italy (2012, 2016-2017), Mexico (2017-2018) have highlighted the significant impact sizeable aftershocks and triggered events can have. Coulomb stress transfer calculations have allowed us to better understand and quantify the expected changes in seismicity, both spatially and temporally. WTW enables clients to quantify the impact on risk transfer decisions from risk that is either not modeled or not well captured.

Building a forward-looking view of earthquake frequency following an event

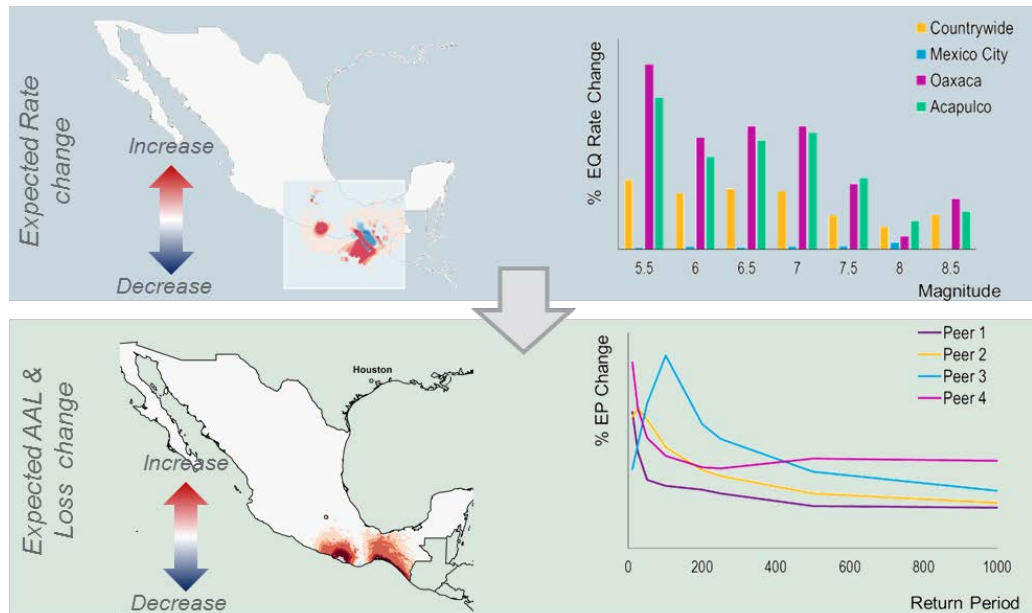
The Willis Research Network (WRN) collaboration with Dr. Ross Stein, CEO and co-founder of Temblor Inc., and Prof. Shinji Toda from Tohoku University, leaders in estimating the impact of past earthquakes on the probability of occurrence of future events, is the first step towards the incorporation of stress transfer and aftershock risk in catastrophe

modeling and the re/insurance industry. Every earthquake imparts stress to its immediate surroundings, however these effects tend to diminish rapidly over time. Depending on the orientation and level of slip on surrounding faults loss estimates can increase or decrease significantly – we provide the science to quantify these effects. The most common example of this is the generation of aftershocks as stresses increase in surrounding areas after an earthquake. Successive mainshocks also occur in regions of stress increase, and so this process is not limited to aftershocks. In contrast, the rate of earthquakes drops in the ‘Coulomb stress shadows,’ where stresses can be balanced, preventing failure. The Temblor and Tohoku team forecast earthquake rate changes caused by stress transfer in recent great earthquakes: the 2019 Marmara Sea earthquake, the 2017-2018 Mexico sequence, the 2016 Kaikoura, New Zealand event and the 2011 Tohoku and 2016 Kumamoto events in Japan. They generally find substantial changes in hazard in large populated urban regions during the first several years after these events.

The collaboration with Willis Towers Watson has subsequently allowed the development of a methodology and framework for the incorporation of these seismicity forecasts in the world of catastrophe modeling.

This is achieved by the rapid creation of conditioned event sets that provide a forward-looking view of risk and facilitate critical decision-making around reinsurance

capacity adequacy, both vertical and sideways, and portfolio optimization following a significant earthquake.



Implementation of the seismicity change due to the 2017-2018 M=8.2 Mexico sequence in terms of earthquake rate (top), and corresponding impact on Average Annual Loss (AAL) and Exceedance Probability (EP) curve for typical portfolios (bottom).



temblor®

Temblor, Inc.

Temblor is a Silicon Valley tech company providing personal, immediate, and credible sources of seismic risk understanding and solutions. Their free mobile and web app and daily blog have gained 900,000 users worldwide in under 16 months, and their enterprise projects for insurance and financial clients has given them an understanding of key unmet needs. Temblor's CEO Ross Stein, CTO Volkan Sevilgen, and collaborator Shinji Toda from IRIDeS of Tohoku University, are the world pioneers in Coulomb stress transfer, and will lead this effort.

Sequential Earthquake And Tsunami Fragility Of Buildings

Tsunamis have contributed to over 250,000 deaths between 1994 and 2013. Statistically, they are the deadliest natural hazard, with an average of 79 deaths for every 1,000 people affected, compared to four deaths per 1,000 for other natural hazards. Past tsunamis have caused widespread damage and economic losses, with a direct loss of over \$200 billion being estimated for the 2011 Tohoku event alone. To mitigate ground shaking and tsunami risks for coastal communities, reliable tools are needed to assess the effects of these hazards on coastal structures.

Case-study buildings in Japan, Chile & USA

The Willis Research Network (WRN) has been investing in research to understand buildings' tsunami vulnerability for several years, and is collaborating with UCL EPICentre, who are leading the research in the field of tsunami physical modeling and vulnerability. This project aims to fill the gap in the fragility assessment of buildings in coastal areas, subjected to onshore flow from tsunami preceded by earthquake ground shaking. From this research, we have developed advanced structural analysis procedures, which have been used to simulate the response of various case-study buildings located in tsunami-prone countries, e.g. Japan and Peru. This required accounting for the preceding ground shaking damage, leading to the derivation of combined earthquake and tsunami fragility curves. It is found that the preceding ground

motion only slightly influences the final earthquake and tsunami fragility functions. The small impact of the ground motion on tsunami fragility is caused by the fundamentally different response of the structure to the two perils. This indicates that the fragility of seismically designed structures can be approximated by assessing the earthquake and tsunami response separately.

Developing simplified methods for tsunami assessment of structures

Guidance on how to perform tsunami fragility assessment is being included within the revised version of ASCE7 Standard (Associated Criteria for Buildings and Other Structures), which will be published in 2022. This work has been conducted in collaboration with the University of Hawaii. The project aims to further develop simplified methods for fragility and vulnerability evaluation of buildings subjected to earthquakes and tsunami, by defining a procedure for tsunami vulnerability assessment of buildings. To facilitate the use of the proposed analytical methods, their implementation in an award-winning commercial engineering package is currently in progress. This project will be instrumental for Willis Towers Watson in validating recently developed models that contain a tsunami component. Moreover, this will be paramount in the evaluation of tsunami impact as a secondary peril.



UCL EPICentre

EPICentre at UCL is a multidisciplinary research group that investigates risk to society and infrastructure from earthquakes and other natural hazards. Our collaboration with UCL is currently looking at developing a novel, robust, unified framework for assessing the vulnerability of critical urban infrastructure to the combined effects of earthquake ground shaking, tsunamis and induced soil liquefaction. The research is not only looking at these cascading hazards but is also taking into account the effect of infrastructure interdependence across various systems and how this affects the infrastructure's ability to provide its services.

Reducing Gaps In Model Coverage And Informing Model Validation

With the vision to create societies that are resilient to earthquakes, the Global Earthquake Model (GEM) initiative was founded more than 10 years ago and has become one of the world's most complete sources of risk resources and a globally accepted standard for earthquake risk assessment. Willis Re is a proud founding member and has actively collaborated with GEM to bring our clients the latest earthquake science to inform risk decisions.

Using GEM to inform business decisions

The use of GEM insight into earthquake risk has been beneficial in several ways for our clients. There have been four key areas where our partnership with GEM has been deployed:

- **Using the latest hazard data to support underwriting**

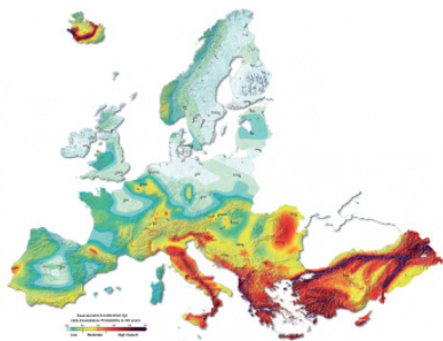
The homogenized global hazard map developed by GEM (on rock soil) merged with the in-house vulnerability expertise has allowed Willis Re to produce annualized loss estimates and influence business decisions by refining original risk underwriting.

- **Refining exposure data to provide an enhanced view of loss estimates**

GEM's extensive industrial, commercial and residential exposure databases at different levels of granularity are often employed to augment the quality of exposure data. These can be leveraged to refine or inform the likely construction typology, building height or year built, and subsequently allow a better risk quantification.

- **Evaluating and calibrating existing vendor models for use in decisions around reinsurance**

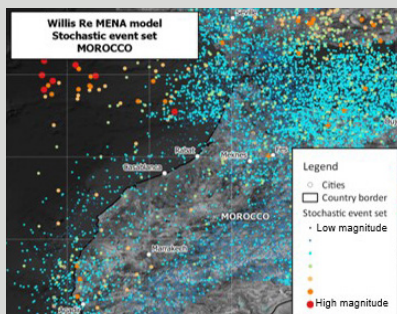
As a platform to merge scientific views in a neutral, un-biased way to provide the most up to date view of earthquake hazard, GEM's models are often used as a reference for benchmarking against the different industry models. Up to date regional catalogues from GEM facilitate the calibration of older catastrophe vendor models and they proved to be



Hazard & annualized loss estimates

particularly helpful in regions where there is large uncertainty. This is important when maximum loss estimate curves are very different amongst vendors, and earthquake drives top layer purchase. Models are validated, and if necessary calibrated, for specific lines of business where evidence from recent events supports it.

- **Creating a View of Risk where vendors do not have a well accepted model**
Areas with low earthquake insurance penetration, where generic catastrophe models do not have a well-informed view of risk, often require bespoke solutions and proprietary model development. GEM is often used to guide the creation of our View of Risk, e.g. Middle East & North Africa EQ (See our 2019 brochure for further details on this).



~ 450 stochastic events, 72k historical

Latest GMPEs and 3D fault rupture

Comprehensive view across 16 countries

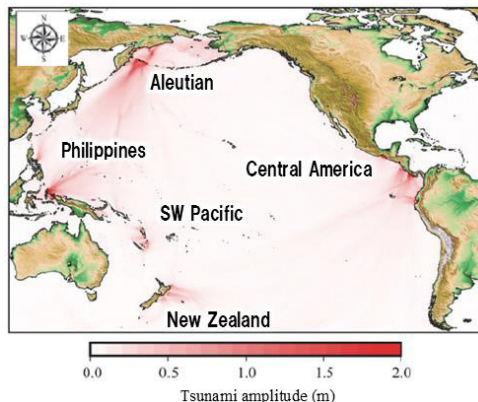


Global Earthquake Model (GEM) Foundation

Initiated by the OECD's Global Science Forum, GEM was formed in 2009 as a non-profit foundation in Pavia, Italy, funded through a public-private sponsorship with the vision to create a world that is resilient to earthquakes. GEM's mission is to become one of the world's most complete sources of risk resources and a globally accepted standard for earthquake risk assessment. Learn more at <http://www.globalquakemodel.org>.

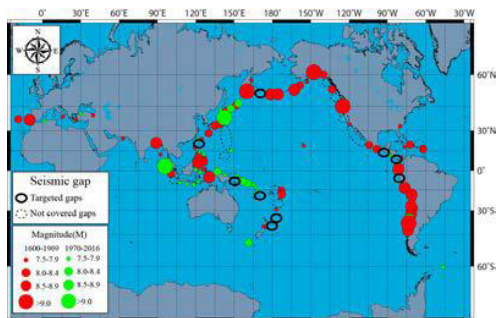
Seismic Gaps As The Source For Future Tsunamis

Tsunami means 'Harbour Wave' in Japanese. A tsunami occurs when gigantic waves are created due to volcanic eruptions, earthquakes or landslides under the sea. Since 2009, the WRN and Willis Re have worked in partnership with Tohoku University and then the International Research Institute of Disaster Science (IRIDeS) in Japan to improve the understanding and quantification of tsunami risk in south-east Asia. Mostly recently, this has included research focused on the assessment of multi-layered tsunami countermeasures; and insights into "black" tsunamis. IRIDeS have also been studying and identifying tsunami-prone areas, which has been particularly relevant for areas where new



Source: IRIDeS. IRIDeS findings have raised awareness in the international community, leading to collaborations with groups operating in the highlighted areas, such as New Zealand

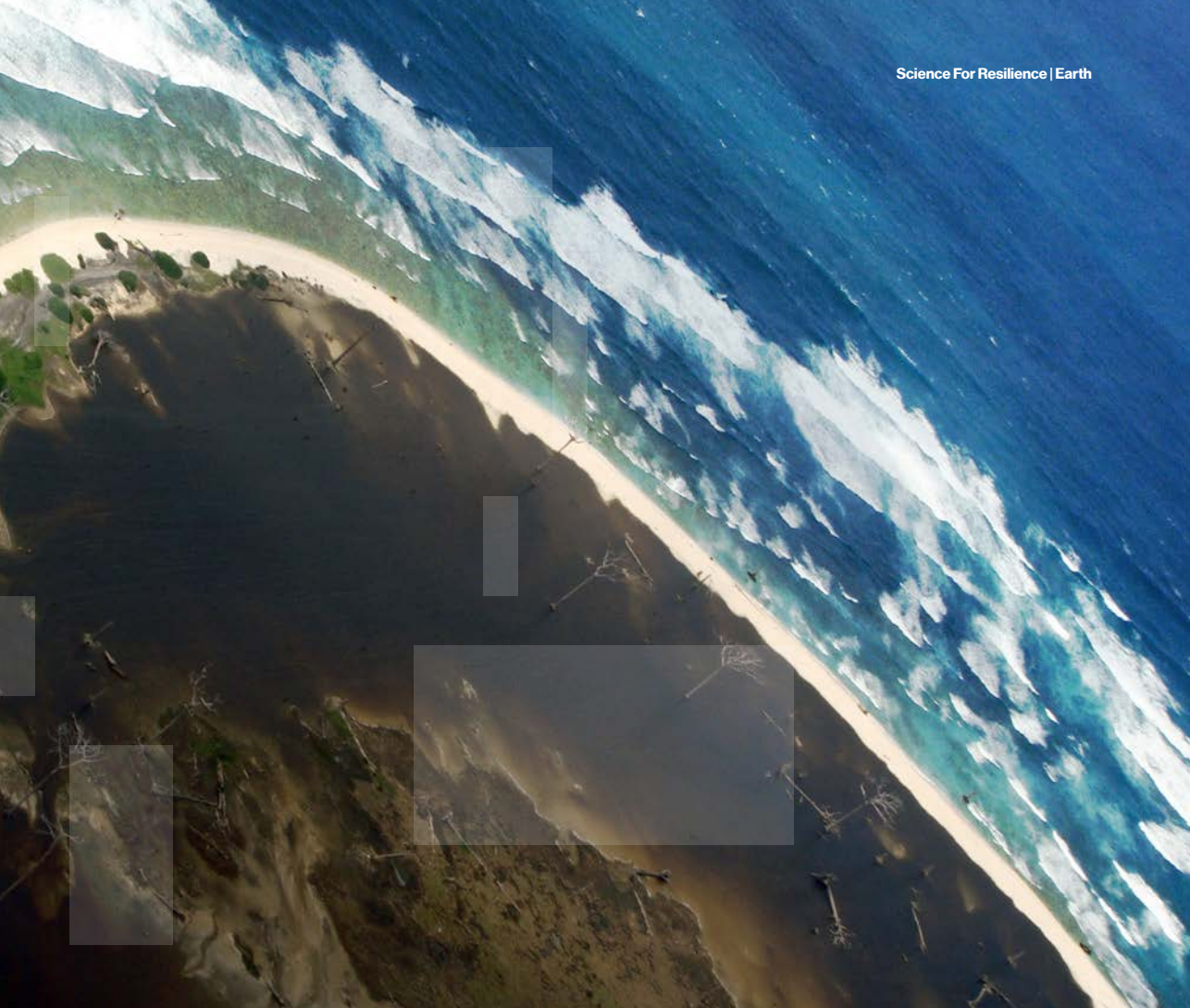
Above figure shows the simulation results of the maximum tsunami amplitude



Source: IRIDeS

Above figure shows the seismic gaps in the Pacific Ocean, selected according to what has been specified in some prior studies. The size of the potential earthquakes in the seismic gaps was estimated taking into account the length of the seismic gap and the largest size of past earthquakes. Numerical tsunami simulations were performed for the selected seismic gap scenarios

evidence indicates a higher risk than previously believed and can be used to inform a portfolio stress-test. The IRIDeS study highlights how potential gaps in historical catalogues might not account for local, smaller scale, earthquake-triggered tsunamis. These events, which a century ago might have gone unnoticed, could cause large economic disruption today in highly populated coastal areas. IRIDeS performed further assessment of tsunami potential, based on seismic gap areas, and compared these with previously published results from the historical tsunami assessment.



Tohoku University

Tohoku University joined the WRN in 2008. It founded the International Research Institute of Disaster Science (IRIDEs) after having experienced the catastrophic disaster in 2011. The IRIDEs conducts world-leading research on natural disaster science and disaster mitigation, and aims to become a world centre for the study of the disasters and disaster mitigation.



An aerial, high-angle photograph of a large, open public space, likely a plaza or square, paved with light-colored, square tiles. The space is filled with numerous people of various ages and ethnicities, seen from above as they move in different directions. Some are walking in small groups, others alone, and some are standing. The overall scene conveys a sense of a busy, public gathering place. A dark rectangular box is overlaid on the left side of the image, containing the word "People" in white text.

People



People Risk Management in the Modern World

Insurtech and AI may be getting more mainstream in insurance and risk management, but this is still very much a people business. Our sector still thrives on personal relationships and human interaction, and within that there is a balance of “people risk” to consider. A good risk manager will look at both sides of the coin.

*People risk can mean risk **to** people, from natural disasters, identity theft, terrorism, and technology; but it can also mean risk **from** people, such as insider threats, malicious acts and negligence, to the organization itself. Our research themes in our People hub link closely with the work underway across the wider Willis Research Network portfolio, but they all focus on one thing – the risks to and from people.*

A good example is cyber risk, which is often perceived as a typically technology-driven risk. But organizations ignoring the human drivers of this risk do so at their own peril... In fact, according to a 2017 Willis Towers Watson Cyber Risk Culture Survey, 66% of cyber breaches are caused by a weakness in your people line of defence, through a range of employee negligence (including lost laptops, the accidental disclosure of information, weak passwords) and malicious acts by disgruntled employees. Organiza-

tions succeed when cyber risk awareness is embedded within their culture and employees form the first line of defence against cyber risk.

Our partnership with the Royal United Services Institute explores all facets of resilience to hybrid aggression (including cyber) with a particular emphasis on individuals (employees or civilians). We are learning from particularly resilient societies where there has been a regular and determined programme across public and private sectors, such as in the Baltic and Scandinavia. Where else than Sweden would you find a reality TV show called Blackout, where ten participants are expected to survive for 12 days without electricity? Are all our liberal societies well prepared for an unexpected national major crisis?

We also continue to invest in research on political violence and terrorism, which have an undeniable impact on people and the economy. These human-induced hazards can be difficult to predict or model, and our long-term partnership with Oxford Analytica in this space has allowed us to move from a qualitative approach to a more transparent quantitative approach to political risk, without denying the uncertainty that such modeling entails.

“ Risk professionals tend to think about people risk as “duty of care” or risk to employees. Whereas HR managers think about people risk as risk to the organisation from human factors. A more joined up approach is needed, with organisations viewing people risk as two sides of the same coin. People no longer want to be seen as your greatest asset -they are investors of their human capital in your firm. Companies have to attract that investment and increasingly employees want to work for climate considerate companies.”

Crispin Marriott

Client Relationship Director

Other areas of research continue to be explored. Mortality and longevity trends will have a massive influence on the way business and society is shaped in the future. The supply chain networks across the globe remain driven by the people who manage them. Transportation and the Aviation industry in particular, have specific challenges that are driven from modern political trends and wider societal sentiment.

Understanding the complex relationship between geopolitical drivers of risk has also been a key focus of research, supporting our advisory services to clients. The impact of rising climate change regulation, activism or litigation is one example amongst others of the impact of people decisions on business. Our links with the Thinking Ahead Institute will multiply the insights and the impact of our work in this space to enhance the resilience of our clients.

<https://www.willistowerswatson.com/assets/23440/cyber-risk-culture-survey.pdf>

Hélène Galy

Managing Director

Understanding Security Threat, Building Resilience

Can hacking be an act of war? Although insurers don't usually cover acts of war, modern technology and the advent of "hybrid warfare" are blurring the lines between peace and war. The NotPetya impact on shipping, supermarkets and law firms shows how the private sector can easily become collateral damage in this new world context. When does Industry recognise an act of sabotage, subversion, espionage and measures that will undermine their integrity and performance, and the actions that should be taken? Who are we employing and what are we part of? All are examples of the reality of today and questions that require our constant attention. To increase awareness of this emerging risk, the Willis

Research Network (WRN) joined the 4-year RUSI Modern Deterrence programme, which investigates how societies can prepare, withstand and respond to the modern threats of "hybrid warfare".

The programme provides a platform and research hub for governments, the private sector and civic organizations to explore risks and vulnerabilities of resilient societies.

This partnership directly supports Willis Towers Watson's Geopolitical Risk initiative and Cyber proposition, putting Willis Towers Watson in a leading position for client advisory work.

“ The new security threats targeting societies are not exclusively military; on the contrary, they often involve no military equipment and target civil society. So targeted countries need to not just monitor the aggression but also understand how to better defend themselves against it. RUSI's Modern Deterrence project brings together key practitioners from government, politics and industry, allowing them to jointly discuss best practices and new ideas. Willis Towers Watson's expertise in identifying and analysing emerging risks makes it an ideal partner for us. We're proud to just have completed our first year of productive collaboration with the WRN. ”

Elisabeth Braw

Senior Research Fellow, Modern Deterrence Director, RUSI

Understanding Hybrid Warfare

Non-military aggression comes in various forms:

- Cyber attacks on utilities telecommunication providers, national institutions, logistics companies...
- Disinformation campaigns ("fake news")
- Hostile investments

Supporting resilient societies and organizations

The programme aims to influence thinking in governments and the private sector on the crucial issue of how to improve defence against comprehensive threats and, in some cases, aggression. During the first year, focus has been on deterrence by societal resilience, the key component which is often missing.

The following tangible outcomes from this research programme are integrated into our client advisory services:

- Sharing best practices from leading countries including the Baltic countries, Norway, Switzerland and Singapore
- Bringing together strategists and practitioners from government, armed forces and civil society (private sector and the public) to discuss and promote practical measures:

- National security courses for emerging leaders
- Incentivising companies to play a stronger role in national security
- Total defence exercises
- Resilience training and exercises in local communities
- Training government officials to counter disinformation
- Crisis response
- Resilience against supply chain disruptions
- Improving resilience of sectors critical to national security, including telecom and financial services
- Thought-leadership publications and conferences to influence policy and private sector

In 2020, the focus will shift to the need to redefine Command & Control in this new context of hybrid aggression.

Find out more about this programme in its first Annual Report:

<https://rusi.org/rusi-reports/modern-deterrence-first-year>

<https://www.willistowerswatson.com/en-GB/Insights/trending-topics/geopolitical-risk>

<https://www.willistowerswatson.com/en-US/Solutions/cyber-risk-management>



Royal United Services Institute for Defence and Security Studies

The Royal United Services Institute for Defence and Security Studies (RUSI) is the world's oldest independent think tank engaged in cutting edge research on international defence and security issues. Founded in 1831 by the Duke of Wellington, RUSI embodies nearly two centuries of forward thinking, free discussion and careful reflection on a range of topics, from air power & technology to sanctions. <https://rusi.org/>

Understanding And Quantifying Political Risk

The threat posed to businesses by political upheavals or government action, such as expropriation, trade embargo or political violence, are difficult risks to manage as the past is often a poor guide to the future.

Political risks can emerge rapidly in societies that have enjoyed stable business conditions for years simple trend assessments or data analysis are inadequate in gauging the financial impact of political risk.

Political risk has increased significantly, now becoming a reoccurring and material cost of doing business. If risk levels remain elevated, companies will fall under increasing pressure from shareholders for greater levels of transparency around the losses actually incurred and the companies' ability to monitor, quantify and manage these risks as well as their strategy to mitigate them.

Our partnership with Oxford Analytica complements our internal expertise to provide superior advisory services to our clients.

Political risk expertise Global Risk Index

Oxford Analytica has a 1,400-strong contributor network, which comprises senior faculty in first-class universities, scholars in leading research institutes, and world-class industry and sector specialists.

That breadth of expertise allows it to find the right qualitative and quantitative experts to derive political risk assessments for over 165 countries. This network also supports client conversations, bespoke analysis and macro monitoring via The Oxford Analytica Daily Brief.

Political Risk Survey Report

Since 2017, Willis Towers Watson and Oxford Analytica have collaborated to publish an annual Political Risk Survey Report. It is based on a survey of senior executives at leading global firms (followed by in-depth interviews) across different industry sectors to determine their response to ongoing global political volatility.

Global Horizons

Oxford Analytica organises a yearly conference "Global Horizons" which gathers CEOs, policy-makers and government leaders, allowing them to engage with leading geopolitical experts to analyse the key global issues facing decision-makers in both the private and public sectors.



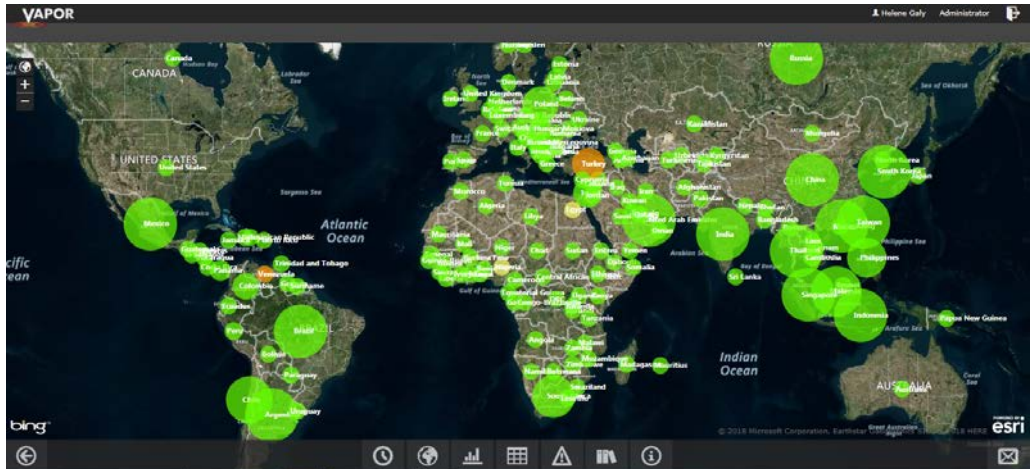
Report available at <https://www.willistowerswatson.com/en/insights/2018/09/political-risk-survey-report>.

Value At Political Risk - VAPOR

VAPOR is a jointly created analytics platform that allows global companies to assess and compare the financial implications of exposure to a suite of political risks – in individual countries, regionally, or globally.

Harnessing the combined strength of Oxford Analytica's geopolitical analysis and the extensive analytics experience of the Willis Towers Watson team, VAPOR allows companies to assess alternative investment scenarios in an uncertain world. This is a

useful tool that can support investment (including new country assessments) and risk management decisions, allowing political risk estimates to be incorporated into financial planning and enterprise risk management. Risk assessments are industry-specific, for six political risk perils in 165 countries. Risk ratings provided by Oxford Analytica are based on a 40-year track record of advising clients on political risk scenarios, and a rigorous research and risk modeling methodology.



Oxford
Analytica

Oxford Analytica

Oxford Analytica is a global analysis and advisory company drawing on an extensive global network of experts to advise clients on strategy and performance in complex markets. We have been working with Oxford Analytica since 2006. For more information please visit their website <http://www.oxan.com/>





Technology



Technology

Technology v4.0

The future of our relationship with Technology is increasingly challenging and complex. As we enter the fourth industrial revolution - a digital revolution characterized by the fusion of technologies blurring the lines between the physical, digital, and biological spheres, the risk landscape is changing with it. While evidence of technology induced losses, when compared with natural catastrophe events for instance, have been relatively small until now, there is little surprise in reports predicting not if, but when, cyber-attacks, technologically induced disruption and destruction of critical infrastructure become the largest driver of loss across the insurance industry. And partitioned from the loss, the opportunities of the Industrial revolution are of course compelling. It is through our research and development of models and knowledge that we can help our clients optimize speed to capability and in an environment when competitive advantage can be quickly diminished turn a digitalized revolution and its associated threats into opportunity.

As reported in our recent work with the World Economic Forum, cyber resilience means more than security and it requires a

focus on protecting critical functions, not just assets. In the view of the World Economic Forum, cybersecurity and privacy challenges remain underestimated, and it is essential for public and private sector leaders to embrace a collaborative and risk informed approach globally, by sharing practices, insights and threat intelligence, to ensure a secure and resilient ecosystem (WEF 2019 Report on 'IIoT Safety and Security Protocol').

WRN technology risk themes combine broad areas of understanding with niche areas of research that reflect the specialist knowledge driving this area. Using work with partners at institutions including the University of Oxford, University of Cambridge and Loughborough University we aim to go beyond the hype associated with technology and provide tangible insights to develop our view of risk and support our client proposition aimed at assessment, quantification and protection against cyber risks. Themes range from specific scenarios generating \$100 billion losses to the applicability of current tools and methodologies to assess industry

“As observed by Charles Darwin, ‘it is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change’. Organizations that understand and act on the technology, curiosity, innovations and warnings inherent in the Industrial Revolution can adapt much like Darwin’s finches and turn an increasingly ambiguous and fast-moving world to their advantage.”

Andrew Hall

Client Relationship Director,
Strategy and Risk

wide, systemic global risk and the economics of cyber risk to help internal model development, specific consultancy and improve the advice we can offer clients.

Understanding the full extent of the technological revolution sits at the heart of our conceptual, physical and moral developments and our constant scrutiny and research will remain the source of innovation across the market. This area of work is therefore the bedrock or ‘centre of gravity’ for all areas of study and development, across technology, capital and people.

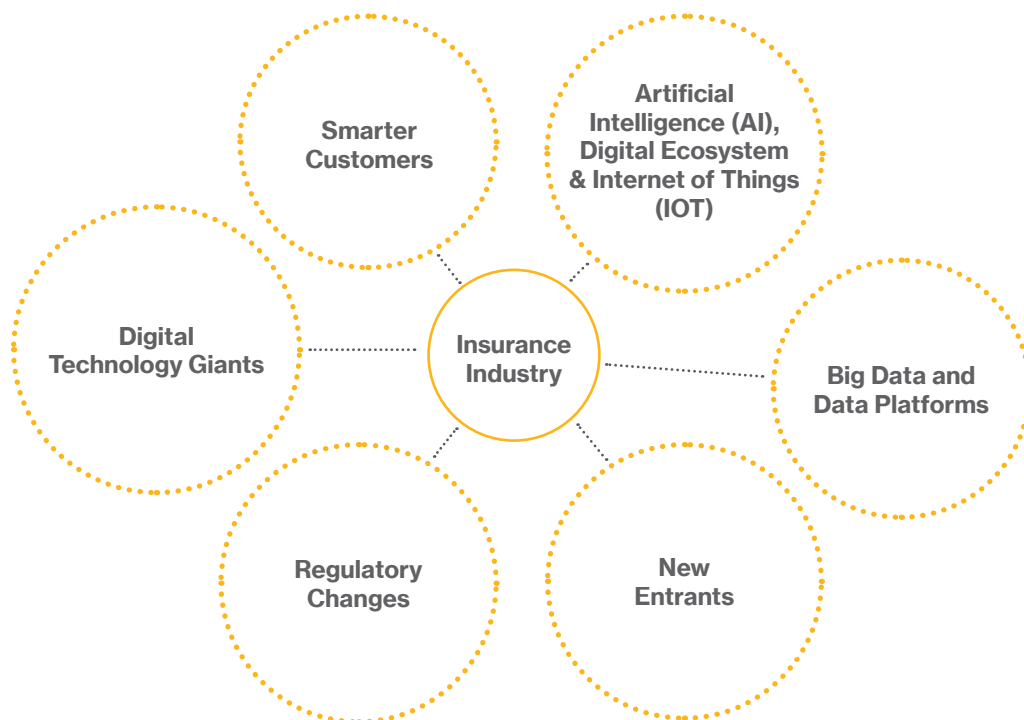
Stuart Calam

Program Director

Artificial Intelligence And Emerging Business Models In Insurance

Artificial Intelligence (AI) poses fundamental questions for the insurance industry. How will AI and other forces shape the insurance industry? Can AI be used defensively by incumbent firms or is it purely a disruptive force exploited by new entrants?

Loughborough University and the Willis Research Network are collaborating on research into the effects of AI on business models, and some answers to these questions are starting to emerge. Our work highlights some key initial ideas and results – on the competitive forces shaping insurance markets and on their consequences for insurance business models.



Technological, social, competitive and regulatory forces reshaping the insurance industry.

Competitive Forces Reshaping Insurance Markets

We have identified six key forces that are reshaping insurance markets today.

1. Artificial Intelligence (AI), Digital Ecosystem and Internet of Things (IOT):

AI is a set of algorithms that adapt and learn, using very cheap and fast computing power, which creates systems with human-like performance in areas such as risk assessment, customer service, image recognition, dynamic pricing and automation of narrowly defined administrative tasks. AI is implemented within a digital ecosystem of existing transactional systems, industry technical standards, search intermediaries, mobile systems and the new and emerging IOT. IOT embeds Internet connectivity into 'things' such as cars, buildings and individuals that creates rich and granular data at scale.

2. Big data and data platforms: big data from customers and IOT, combined with AI, enable incremental change to existing

business models and new types of AI/big data-enabled business models. An important new phenomenon is the concept of data platforms, which assemble big data from a range of sources. The ownership, access and control of these data platforms pose important strategic questions for insurance companies – for example, collaborative data marketplaces, proprietary data platforms and open data systems all have very different competitive implications.

3. New entrants taking advantage of rapid developments in digital technology and experimenting with new business models, often ignoring historical approaches such as demographic data, in favour of direct measurements of risk based on behavioural insights.

4. Industry regulators encouraging innovation while balancing the risk of relatively unknown and unproven approaches adopted by new entrants.

5. Digital technology giants enjoy three areas of competitive superiority over



School of Business and Economics, Loughborough University

Loughborough University is proud of its long history as an institution of further and higher education. Thanks to the vision of its founding father, Dr. Herbert Schofield, it has been able to grow and develop into one of the country's top universities. Today it is one of the country's leading universities, with a reputation for excellence in teaching and research, strong links with business and industry and unrivalled sporting achievement. Research is at the very heart of the school, which is committed to leading the way in advancing knowledge across the full range of business disciplines. The research centres and interest groups provide clusters of expertise recognized internationally for the quality of their research. We have worked closely with Prof. Alistair Milne and Prof. Chris Holland looking at the use of Artificial Intelligence in the insurance industry.

insurance firms: deep relationships with customers in other markets; experience and broad capabilities in AI technology; expertise in handling big data. However, can the tech giants translate these advantages and apply them to insurance markets and how should incumbents block their market entry?

6. Customers have greater expectations because of digital experience gained from other markets and have better access to market data through search intermediaries. In addition, the insurance market is mature, so customers have significant market knowledge and confi-

dence to switch suppliers and test novel approaches.

Business Model Landscape

To understand the emerging business model landscape, we have developed a new strategy framework, highlighting the interdependence of data innovation and business models.

Fig 2 is our business model change – data innovation matrix. The horizontal axis is the magnitude of business model change. The vertical axis is the level of data innovation. AI systems can be applied in all quadrants but

Fig. 2

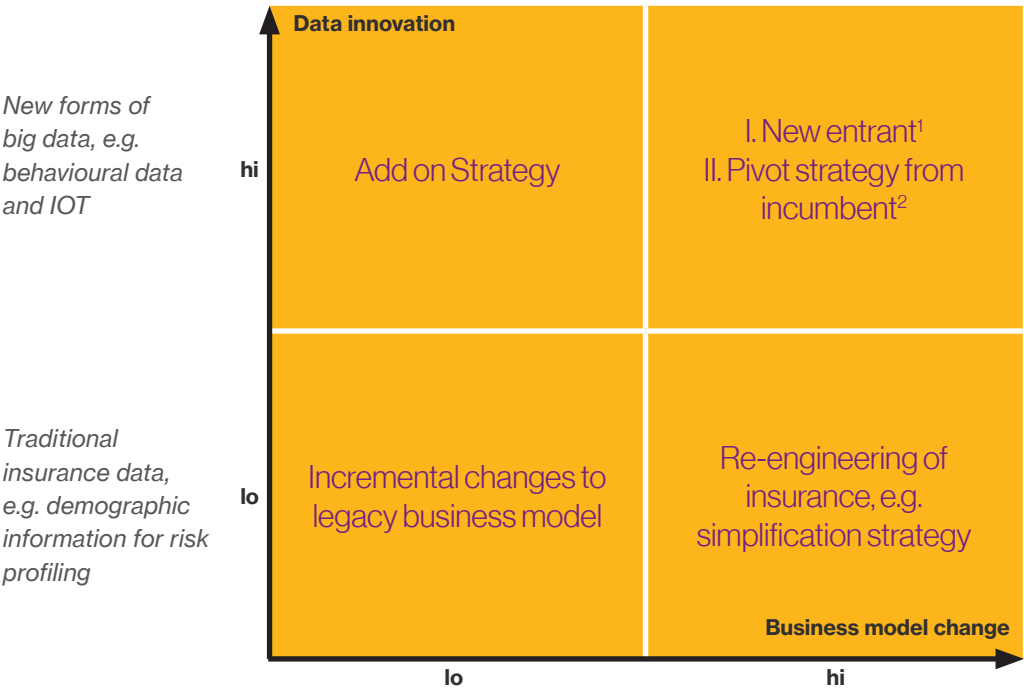


Figure 2. Business Model Change – Data Innovation Matrix

with very different objectives and outcomes. This matrix reveals four distinct AI-based business models:

- **LO – LO Incremental changes to legacy business model.** AI can be used to improve existing business processes and data, without radically changing the logic of the business model, e.g. Robotic Process Automation (RPA). This is an important strategy for leading incumbent firms because it defends their market positions by increasing their efficiency and improving the value of the insurance offer and service levels to reduce customer churn.
- **HI – HI New Entrant and Pivot Strategy by Incumbent.** An AI-enabled new entrant uses IOT data sets to offer behavioural insurance combined with a new customer interaction model, facilitated by regulatory changes⁽¹⁾. An incumbent firm radically changes its business model and abandons its historical approach⁽²⁾. This is termed a strategic pivot and AI is used to develop new insights and algorithms to model new types of big data, e.g. health and exercise data. Three important strategic question for incumbents regarding a pivot strategy are:
 - Will a pivot strategy be profitable, or would it be better to defend the current market position?
 - The timing is a difficult choice – be a first mover or a fast follower?
 - The implementation of a pivot strategy is difficult because of strategic inertia from legacy business models and the scale and complexity of legacy systems – would a brand-new spinout company be a better option?
- **HI – LO Re-Engineering.** Incumbents and new entrants can both deploy a re-en-

gineering approach that depends much more on business simplification than digital technology, e.g. a simple, flat price approach to accidental damage to mobile phones could be offered at the point of sale. This strategy relies on market scale and uses insurance to enhance the value of a consumer product.

- **LO – HI Add on Strategy.** This approach embraces new forms of data but retains the existing business model. For example, by using behavioural data to refine an existing demographic price model. This strategy risks adding complexity to the business model without commensurate improvements in performance.

Future Direction

Our proposed typology classifies insurance business models into meaningful groups and allows managers to understand their strategic position within a broader competitive landscape. Our future research will explore the following questions:

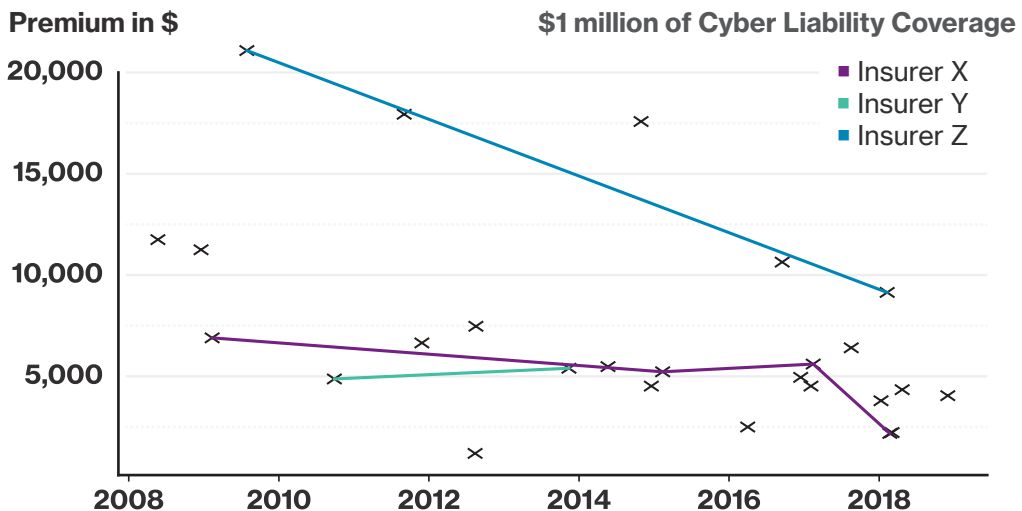
- What is the strategic logic and performance of each type of business model?
 - How can the implementation of AI systems be facilitated and encouraged by sharing of best practice and Government policy?
 - What are the key strategic differences between incumbents and new entrants, vis-à-vis AI strategy and business models?
 - What is the emerging digital ecosystem in the insurance value chain?
 - How rapidly are these developments proceeding in different market segments?
- The immediate impact is most obvious in consumer markets, but similar developments are affecting commercial and specialist lines.

The Economics Of Cyber Risk

Markets selling formal promises about cyber risk are booming. The cyber insurance market collects \$4 billion in premiums and cyber security vendors have started to attach warranties to their products. Daniel Woods, from the University of Oxford's EPSRC Centre for Doctoral Training in Cyber Security, wrote his PhD titled "The Economics of Cyber Risk Transfer" on these emerging issues, supporting our wider aims on providing a more thorough, refined quantification of cyber risk. Exploring how underwriters in the Lloyd's of London market assess cyber risk allowed mapping of cybersecurity controls in

insurance proposal forms to a popular cybersecurity framework and discovered the industry tends to overlook more technical controls. Interviews with underwriters further revealed that face-to-face communication provide insights into the applicant's security culture; an important driver of cybersecurity losses.

A quirk of insurance regulation provided access to 26 different cyber pricing schemes from insurers in California, revealing how premiums vary by coverage type, amount and firm characteristics over time and suggests cyber insurance prices have been

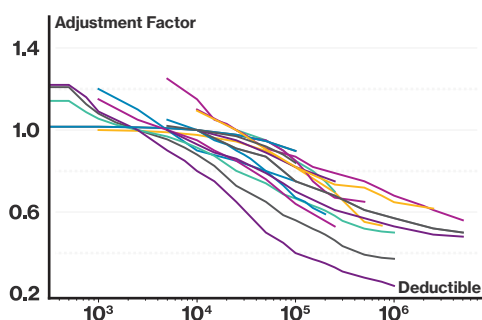


Cyber liability insurance premiums over time for selected insurers

consistently falling over the last decade. Cyber insurance prices also provide a unique window into risk quantification – notoriously difficult through organizational reluctance to report attacks. Motivated by an insurance market existing before cyber loss data, a method to infer cyber loss distributions from insurance prices provides a novel approach to probability estimates for cybersecurity losses based on market expectations. These estimates can be tailored to firm size, industry or incident type by varying the prices

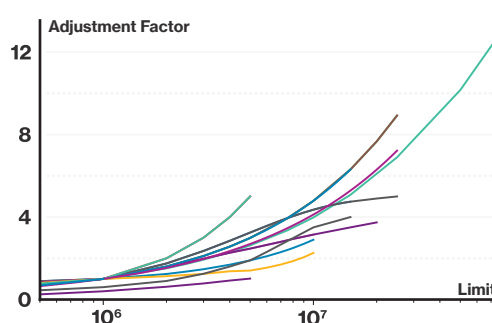
fed into the algorithm and allow us to tailor insight to our clients specific profiles. Further contributions explored how insurers might use claims data to improve their understanding of cyber risk, and introduced an abstract economic model using Monte Carlo simulations to explore different information-sharing strategies. The results suggest the market tilts towards monopoly when uncertainty about risk controls is high, which could explain why a few firms sell the majority of cyber insurance at present.

Adjustments for Deductible Amount



Uncertainty around cyber insurance pricing

Adjustments for Limit Amount



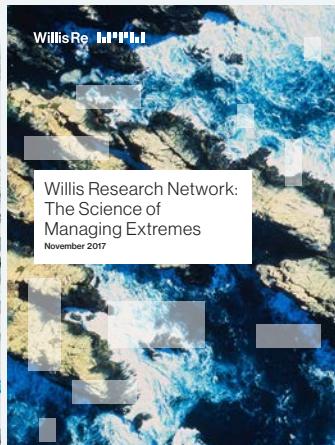
University Of Oxford

The University of Oxford's EPSRC Centre for Doctoral Training in Cyber Security educates a new generation of research leaders as well as the highest tier of security professionals, who appreciate the real-world challenges which arise from security needs in existing and emerging contexts, equipped with both the expertise and adaptability to address those needs. We equip our students with the skills and knowledge to become as agile in their thinking as the attackers are – and as resourceful in defence as their counterparts are in attack.

Learn More About The Willis Research Network

To view previous brochures and for upcoming WRN events and communications please visit our website at

willisresearchnetwork.com



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About Willis Towers Watson

Willis Towers Watson (NASDAQ: WLTW) is a leading global advisory, broking and solutions company that helps clients around the world turn risk into a path for growth. With roots dating to 1828, Willis Towers Watson has 45,000 employees serving more than 140 countries and markets. We design and deliver solutions that manage risk, optimise benefits, cultivate talent, and expand the power of capital to protect and strengthen institutions and individuals. Our unique perspective allows us to see the critical intersections between talent, assets and ideas – the dynamic formula that drives business performance. Together, we unlock potential. Learn more at willistowerswatson.com.



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