Managing severe convective storm risks

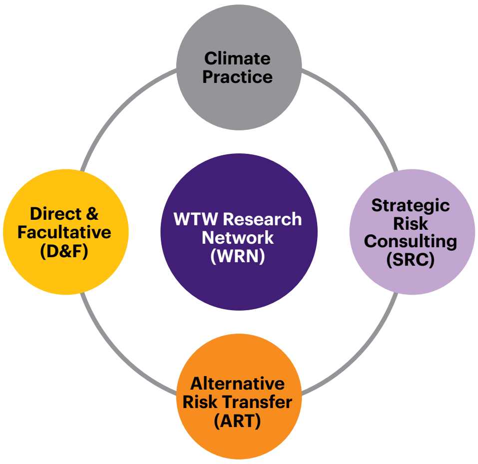
January 2024

Severe convective storms, including tornadoes and large hailstones, can cause similar annual losses to large windstorms, such as cyclones.

Our webinar on 19 September 2023 gathered experts from across WTW to help clients navigate these perils. Together, colleagues from our Direct and Facultative broking, Strategic Risk Consulting, Alternative Risk Transfer and the WTW Research Network explored:

- How and where severe convective storms happen
- How we quantify risks and probable losses
- Real-world risk consultancy and property claims examples
- Parametric insurance solutions for hail and tornado risks
- Latest research and how it can inform better risk decision making

Figure 1: **WTW Natural Catastrophe Analytics**



WTW Speakers

Katie Latham
Natural Catastrophe Analytics Manager
Direct & Facultative

David Smith
Catastrophe and Climate Risk — Senior Associate
Climate Risk Practice

David Williams
Data and Research Consultant
Alternative Risk Transfer

Daniel Bannister
Weather and Climate Risk Research Lead
WTW Research Network

Lucy Smith
Property Broker
Direct & Facultative

What are severe convective storms?

Severe convective storms are intense atmospheric disturbances that can cause powerful winds, large hail, heavy rainfall and occasionally tornadoes.

They arise from specific atmospheric conditions, including:

- **Atmospheric instability:** when surface air is warm and the air higher up is significantly colder, it results in rising warm air
- **Latent heat release:** as this warm, moist air rises and condenses, it releases heat, driving storm intensity
- **Pressure differences:** differences in air pressure, or pressure gradients, can amplify wind strength
- **Low air pressure:** allows sufficient warm air to rise into the atmosphere
- **Wind shear:** variations in wind speed and direction with altitude can increase a storm's longevity and potentially lead to the formation of tornadoes

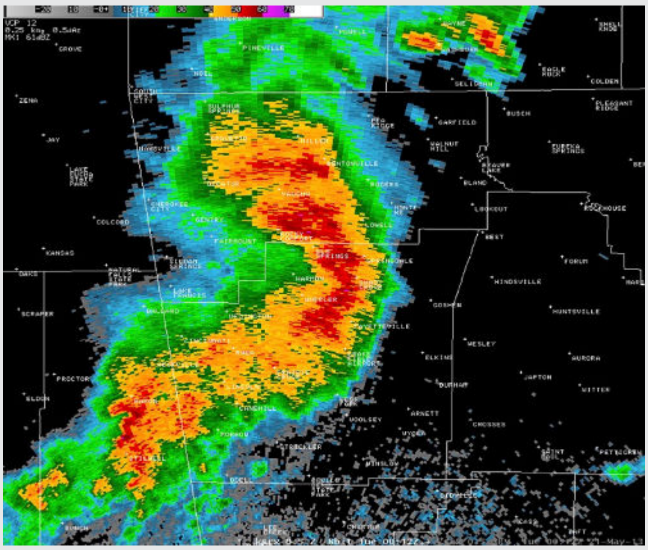
Detecting storms and measuring their intensity

Today, we have sophisticated radar and satellite technology to help us detect and track developing storms. In the past, this was done by observation and reports from members of the public. Events that happened in sparsely populated areas often went unrecorded, so we don't have a complete record of severe convective storm history in many areas.

For tornadoes, meteorologists use the Enhanced Fujita (EF) scale to gauge intensity. The scale links wind gusts with levels of damage, ranging from EF0 at 65-85mph causing light damage to EF5 at more than 200mph, which is strong enough for houses to be lifted off their foundations.

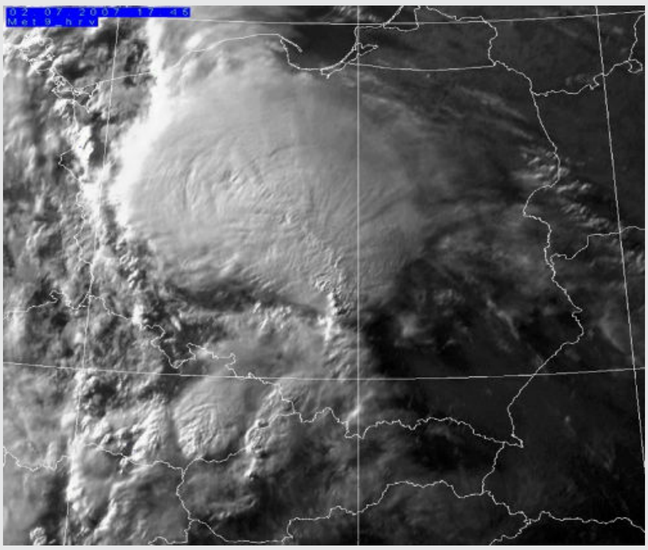
Figure 2: **Radar and satellite imagery of severe convective storms**

Radar image of severe convective storm in the U.S.



Source: NSC
For illustrative purposes only

Satellite image of severe convective storm in Poland



Source: NASA
For illustrative purposes only

How is severe convective storm risk identified?

Which areas are most at risk?

Severe convective storms happen all over world. The most damaging storms, including tornadoes, tend to occur in the U.S., but they can also occur in Asia, Europe, Africa and Australia.

Convective storms can be very sudden and fast-moving, making it hard to model or predict exactly where they will strike. The area at risk of a storm can be very large, but the impact area is usually small.

Assessing whether locations are at risk

Hazard maps, such as WTW's Global Perils Diagnostic tool, can help assess exposure to severe convective storms at key locations. By entering complete and accurate address information, you can produce a hazard map and a hazard score, which can help you make more informed risk management decisions.

Are severe convective storms increasing with climate change?

Over the last few decades, detection of severe convective storms has increased, partly due to advances in technology and increased public awareness and reporting. Additionally, urbanization has brought more infrastructure and people into harm's way, increasing our exposure and vulnerability to such storms.

In general, research suggests that a warmer atmosphere can hold more moisture, which provides more fuel for severe convective storms. This doesn't mean that severe convective storms or tornadoes will increase everywhere or all the time, but the potential for intense storms in some regions may rise.

Some research suggests that while certain elements that give rise to severe storms, such as instability, may increase with warming, others like wind shear might decrease in some regions. This interplay is complex and a topic of ongoing research. But it's likely that as global temperatures rise and local climates shift, regions that historically may not have been prone to severe convective storms may become at risk, and vice versa.

WTW Natural Catastrophe Review: why are the impacts increasing?

Our Natural Catastrophe Review for January to June 2023[1] includes a study from WTW Research Network and Columbia University looking at a record year for severe convective storms in the U.S.

The article explores why losses have been increasing in recent years, examining factors such as increased urbanization, climate, landscape and environmental changes.

[1]www.wtwco.com/en-gb/insights/2023/07/natural-catastrophe-review-january-june-2023

How can we quantify severe convective storm risk?

We can measure and quantify risk using powerful catastrophe modeling tools, such as Moody's RMS and Verisk.

Using detailed location characteristic information from your schedule of values, and the type and structure of the property, the tools can calculate likely damage and probable losses in a range of possible storm scenarios.

Catastrophe model results provide the probability of exceeding a loss amount as a percentage or return period. This will vary depending on the data input into the model, any assumptions made and the model settings.

The tools also calculate the financial impact, including:

- **Ground up loss** — the total likely financial loss caused by the event being modeled.
- **Likely average annual loss**.
- **Probable maximum loss (PML)** — the likely loss if worst-case storms happen.

Catastrophe models also give a co-efficient of variation. The higher the co-efficient, the greater the uncertainty within the model results.

Generally, a good co-efficient number is between 4-8. If the number is higher, it could be because of incomplete information. In this case it's worth checking whether you have included enough detail. For example, on the type of construction, occupancy and survey report data.

Figure 3: **A typical modeled-loss calculation**

Modeled Exposure
The Total Insured Values (Buildings, Contents and Business Interruption combined) modeled for the peril and region of interest.

Ground Up Loss
Estimated losses **BEFORE** insurance conditions have been applied.
Also known as 'True Loss'.

Gross Loss
Estimated losses **AFTER** insurance conditions have been applied.
Also known as 'Market Loss'.

Return Period
An estimate of the frequency (in years) that the portfolio will sustain a loss of a given size or greater.

Exceedance Probability
The percentage probability of the portfolio experiencing the estimated loss values or greater.

Severe convective storm			
		Ground up	**Gross Loss**
Modeled Exposure		**9,861,729,184**	**9,861,729,184**
0.01%	10,000	679,493,455	501,489,172
0.40%	**250**	**57,790,448**	**52,866,064**
1.00%	100	30,899,825	24,945,023
2.00%	50	17,215,724	11,515,630
20.00%	5	257,272	0
Average Annual Loss		1,690,996	1,113,387
Standard Deviation		17,733,244	10,874,524
Coefficient of Variation		10.49	9.77

Probable Maximum Loss (PML)
The worst case expected after taking into account relevant mitigating factors that may prevent a Maximum Possible Loss (MPL), such as shutters on windows or sprinkler systems.

Average Annual Loss (AAL)
Also known as the Pure or Technical Premium, it provides an estimate of premium required to protect against all catastrophic losses. The higher the value, the higher the exposure of the portfolio.

Standard Deviation
Gives a view of the volatility in the average annual losses (AAL). Provides a measure of how close the actual loss for a given year is likely to be to the AAL. The higher the difference between this value and the AAL, the higher uncertainty.

Coefficient of Variation
The standard deviation divided by the average annual loss (AAL). It can be used to compare with other perils or portfolios.

Property claims

U.S. businesses suffer the biggest losses because of the frequency of convective storms. Insured losses can be up to $17 billion a year: almost as much as cyclones. In Europe, there have been severe tornadoes at EF level 3 and above in the UK, Belgium, France and Italy.

Severe convective storm losses can accumulate during an insurance period since they can happen at any time of year — unlike cyclones which only happen in one season. This can mean big differences between the best and worst years.

Case study:

Large hail claim, auto dealer

A large car dealership, with 80 branches across the U.S., suffered extensive losses during a severe convective storm in Plano, Texas that produced baseball-sized hail stones. Around 80% of vehicles at two dealership locations were written off (including 250 new cars), with extensive damage to buildings and signage.

The total gross claim was $23 million. London insurers agreed to pay $10 million of this within a month so the client could replenish their inventory quickly and get back up and running, reducing their business interruption loss. After the incident, the client installed hail tents and canopies to protect against future storms.

This demonstrates how London markets can respond swiftly to large scale losses, enabling clients to recover quickly and avoid prolonged business interruption.

Strategic risk consultancy for severe convective storms

As described above, severe convective storms can be very local and unpredictable, destroying buildings on one side of a street while leaving the other side untouched. This can make it difficult to take business decisions, such as whether or how much to invest in storm protection, or what type of insurance to buy.

To help clients make these decisions, WTW offers a complete risk consultancy service, including in-depth risk analysis, hazard modeling and vulnerability assessments. Armed with the right information and cost-benefit analysis, clients can see mitigation, risk management and risk transfer options much more clearly.

Example:

Hail risk analysis for vehicle yard in Saudi Arabia

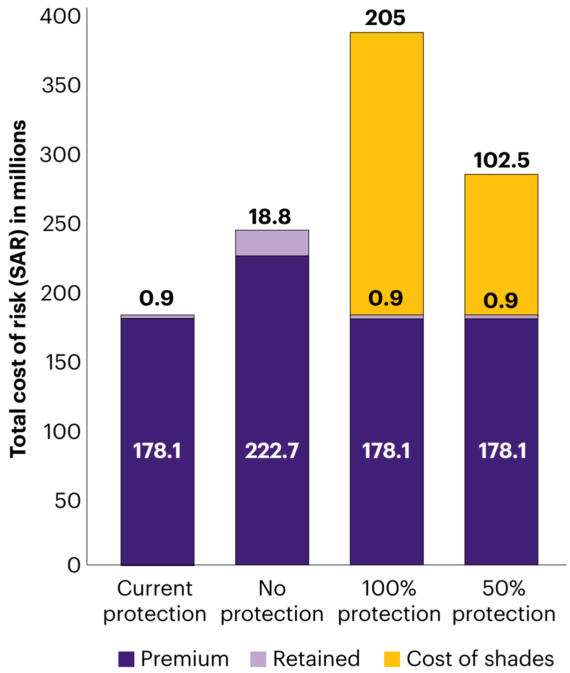
Our client had suffered a recent loss at one of their vehicle yards. They wanted to understand the probable maximum loss expectancy of a low-probability severe hailstorm hitting their other vehicle yards. In particular they needed to:

- Evaluate the current risk transfer arrangements.
- Stress test whether insurance was good value for money.
- Assess the impact of risk mitigation and whether it could reduce the total cost of risk.

We carried out a detailed hazard review, a vulnerability and loss assessment, a desktop probable maximum loss (PML) calculation, and a cost-benefit analysis.

Hazard review: the client had clusters of vehicle yards across three different cities and it was very unlikely that multiple city clusters would be impacted by the same weather event. However, the close proximity of vehicle yards in the same city cluster increase the local risk of two sites being struck at once. There was a lack of historic storm records, so existing information was of limited use. We worked with WTW Research Network experts to analyze hail hazards in the region, looking at the most recent research and data available from other insurance databases.

Figure 4: **Total cost of risk to the client**



Vulnerability and loss assessment: the client had protective sunshades at one of their sites. We analyzed the protection they provided and how the fabric would withstand severe storm winds and hail. We found they would protect against hail falling vertically, but if the hail fell at a 45 degree angle, some cars would be damaged.

PML calculation: based on all the data and analysis, we provided a PML calculation from damage to vehicles in three scenarios:

- **Worst case:** 45 degree hail; gaps in sunshades
- **Medium case**: 45 degree hail; no gaps in sunshades
- **Best case:** vertical hail; no gaps in sunshades

Cost benefit analysis: finally, we carried out a cost-benefit analysis of the cost of investing in better sunshades and extending them to all sites compared against the cost of insurance without sunshades. We analyzed this at 50% sunshade coverage and 100% coverage and found that the cost of the sunshades outweighed any risk reduction benefit. These findings meant we could advise the client that improving their insurance cover would be a more effective investment than further risk mitigation.

Alternative Risk Transfer

Alternative risk transfer (ART) provides alternative ways to transfer or finance risks where capacity is unavailable, or where the pricing makes insurance too expensive. It can be used as part of a blended approach to risk financing along with traditional insurance.

ART solutions includes:

- Parametric solutions covering specific perils, usually weather or natural catastrophe risks
- Multi-year or multi-line structures
- Captive solutions enabling companies to retain risk internally

Parametric solutions

Parametric solutions are often used to cover gaps left by property policies. For example, where higher deductibles or lower limits have been applied to certain risk types, or to provide cover for losses not covered by property insurance, such as non-damage business interruption or long-term loss of attraction.

Unlike property policies, cover is not tied to damage. Instead, parametric solutions pay out when the weather event reaches a certain magnitude in a particular location according to a measurement or formula that is pre-agreed between the insurer and the client.

Benefits

Transparency: cover is based on independent data and pre-agreed payouts. For example, a policy could pay 25% of the policy limit if wind is recorded at 105mph, 50% at 115mph, and 100% at 12mph. Similarly, the cover could be based on the size of hail or the amount of rainfall.

Speed: because claims are based on an agreed measurement, rather than an estimate of losses, there is no loss adjusting process. Claims can be paid quickly which can help with cash flow in the aftermath of a storm.

Broad coverage: there's no limitation on what the money can be used for, which means it can help cover costs, such as business interruption, supply chain disruption and loss of attraction — not possible under property insurance.

Challenges

Basis risk: the main drawback of parametric solutions is that if an event doesn't reach the agreed trigger measurement, the policy will not pay out — this is referred to as basis risk. However, basis risk can be managed through effective risk modeling and appropriate structuring to ensure the cover is calibrated to fit your risk as closely as possible.

Parametric solutions case studies:

Automotive hail risk

Our client operates a network of car dealerships in Kansas on open lots with significant exposure to hailstorms. Following earlier hail-related losses, the company's insurer increased the deductible, which could mean our client having to retain more of this risk on their balance sheet.

WTW arranged a parametric solution based on hailstone size, customized to the client's risk profile and locations. It pays out a proportion of the limit every time hail exceeds a set measurement as shown in the table below.

As part of the solution, the company installed weather monitoring sensors to provide live hail storm tracking and independent measurements of the hail size. The accuracy of these measurements meant the insurer was prepared to offer a relatively high level of cover, reducing the basis risk.

Hail Size	Payout (%)	Payout ($)
1.25"	25%	$125,000
1.50"	50%	$250,000
2.0"	100%	$500,000

Solar array hail risk

A company operating solar arrays in locations exposed to hailstorms had accepted higher property deductibles related to average hailstorm scenarios. They wanted to cap retained losses for the most severe hailstorms.

WTW arranged a parametric hail program with payments based on hailstone sizes. In this case, the client only receives payment when the hail reaches 2.5 inches or more. But the payments are larger to account for the scale of devastation that such a storm might cause, as shown in the table. As in the previous case study, the company installed weather monitoring sensors to provide independent measurements of the hail size.

Hail Size	Payout (%)	Payout ($)
1.75"	0%	-
2.50"	50%	$1.25M
3.0"	75%	$1.875M
4.0"	100%	$2.50M

Golf course tornado and hail risk

Following a series of hailstorms and tornadoes, a golf course had experienced a decline in business, including green fees and restaurant sales. These loss of attraction costs were not covered by the company's property program.

WTW designed a parametric program that would pay when the location experienced severe hail or tornado events. We created separate measures and thresholds for each peril.

- **Hail:** paid when the hail stones exceeded specific sizes.
- **Tornado:** paid when the storm reached a magnitude of more than 1 on the EF scale.

Independent measurements were provided using radar and artificial intelligence customized to the site.

WTW Research Network

Science for resilience

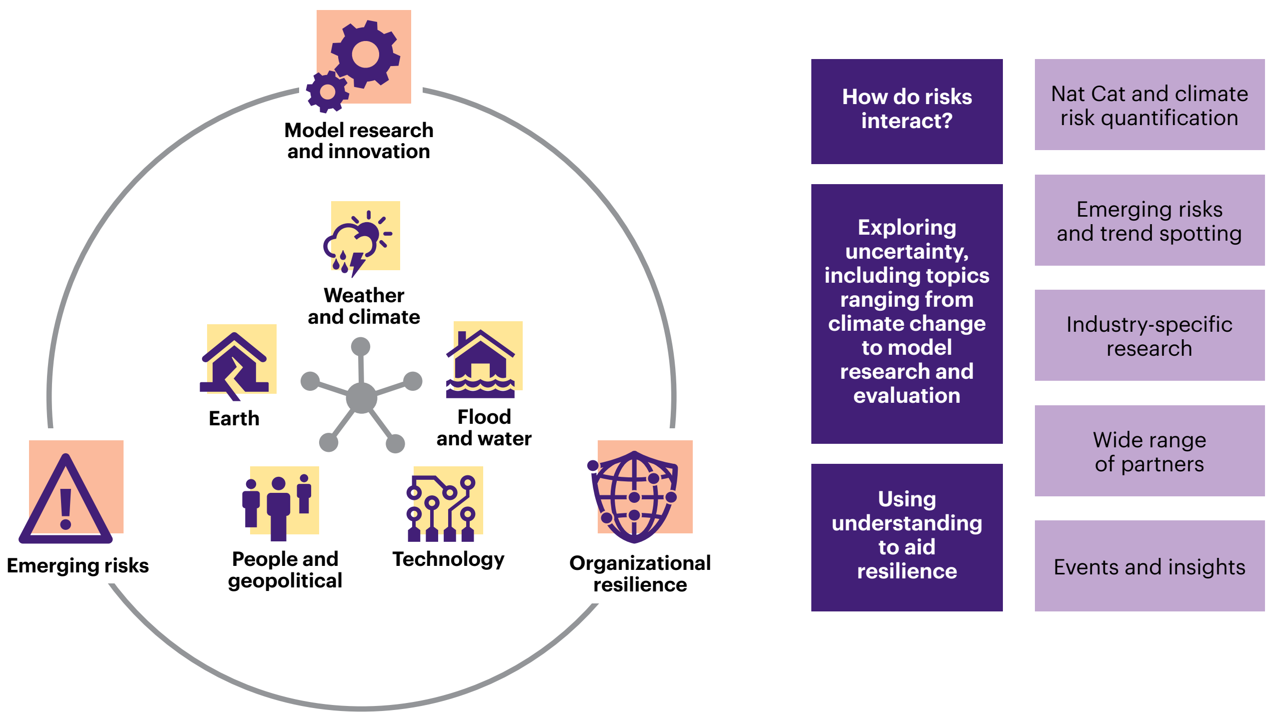
The WTW Research Network (WRN) represents a 17-year investment in research and ongoing horizon scanning to help organizations protect their assets. The network includes dedicated research hubs and more than 60 partners in science, academia, think tanks and the private sector.

Together, we bring best practice research and evidence into risk models, advice, thought leadership, focused roundtables, and knowledge sharing events, to reduce uncertainty and help with natural catastrophe risk management and resilience.

The Weather and Climate Risk research hub covers all aspects of climate risk from natural hazards such as severe convective storms to transition risk research for a low carbon economy and liability risk associated with loss and damage arising from climate change.

The WRN team regularly publish white papers[2] and insights on the results of their research on important topics and recent hazard events, such as the Natural Catastrophe Review[3], and an annual review[4] showcasing research projects across all hubs.

Figure 5: **Supporting solutions to real world challenges with science-based research**



[2]www.wtwco.com/en-gb/insights/research-programs-and-collaborations/wtw-research-network#wnss-white-papers
[3]https://www.wtwco.com/en-gb/insights/2023/07/natural-catastrophe-review-january-june-2023
[4]https://www.wtwco.com/en-gb/insights/2023/05/weather-and-climate-risks

Examples of research on severe convective storm risk:

A long partnership on hail risk

The WTW Research Network, working with Karlsruhe Institute of Technology (KIT) and NASA, has been addressing hail hazard and risk assessment challenges for over 10 years now.

What sets this partnership apart is really the pioneering approach. Our models were the first to leverage nationally consistent satellite imagery and weather radar data, revolutionizing the industry's understanding of hail risk. This in turn, has allowed us to develop national proxies for hail size, enhancing the precision of risk assessment.

In 2013, KIT and NASA developed the first fully probabilistic European hail model, which covers 34 countries. In 2021, they went further with the South African hail model based on their advance hail detection algorithms. This has advanced the accuracy of hail assessments, which can now predict the time of year and time of day that hail is likely to occur — helping organizations to plan daily and seasonal mitigations.

These advances have many practical applications, for example:

- enabling more accurate risk assessment,
- helping to define parametric thresholds,
- and guiding targeted preventive measures and resilience strategies for asset protection.

Using latest climate models to assess severe convective storm risks

The WTW Research Network also has a longstanding partnership with Columbia University into tornado risks in past, present and future climates. The research looks at activity in the current climate and in a warmer world, and assesses whether changes in global activity are due to climate change or natural variability.

Most recently, the research partnership has uncovered the connection between El Niño–Southern Oscillation (ENSO) and tornado weather:

- When La Niña conditions prevail in the Pacific Ocean, tornadoes can be expected to increase, but the exact magnitude and number of storms remains uncertain.
- When El Niño Southern Oscillation (ENSO) and the Antarctic Oscillation (AO) align, severe thunderstorm activity can increase or decrease.
- When ENSO and AO oppose each other, they cancel each other out and near-normal activity is expected.

Such information is particularly important as we head into an El Niño year. Understanding the interplay between ENSO and other climate factors is crucial for anticipating weather patterns and their potential impacts and for developing innovative solutions mitigate tornado risks.

Summary of main points

Severe convective storms are large and damaging thunderstorms that can cause tornadoes, large hailstorms, heavy rainfall and damaging straight-line winds.

These storms can travel across a very wide area, and it can be very difficult to predict where or when they will strike.

Powerful analytics and modeling tools can predict location-specific risk levels and probable losses, informing better risk management and mitigation strategies.

Alternative risk transfer, such as parametric insurance, can provide a solution for severe convective storm risks where capacity is unavailable or where the pricing makes insurance too expensive.

The WTW Research Network furthers understanding of severe convective storm risks through science-based evidence. This, in turn, helps our climate risk practice and risk transfer experts to optimize solutions to fit the needs of individual organizations and locations.

Contacts

For further information please contact:

Asia

Paul Ward
Head of Property and Casualty
+65 6958 2800
paul.ward@wtwco.com

Australia and New Zealand

Trent Williams
Head of Broking, Australasia
+61 423 598 493
trent.williams@wtwco.com

Europe

Victor De Jager
Head of Property for Europe
+31 (0)6 2111 6250
victor.de.jager@wtwco.com

GB

Katie Latham
Natural Catastrophe Analytics Manager
Direct & Facultative
katherine.latham@wtwco.com

Lucy Smith
Property Broker
Direct & Facultative
lucy.smith@wtwco.com

David Smith
Catastrophe and Climate Risk — Senior Associate
Climate Risk Practice
david.smith2@wtwco.com

David Williams
Data and Research Consultant
Alternative Risk Transfer
williamsdax@wtwco.com

Daniel Bannister
Weather & Climate Risks Research Lead
WTW Research Network
daniel.bannister@wtwco.com

North America

Scott St. George
Head of Weather & Climate Risks Research
WTW Research Network
scott.stgeorge@wtwco.com

Christian Ryan
North American Industry Leader
christian.ryan@wtwco.com

South America

Roman Mesuraca
Regional Head of P&C & Broking — LatAm
+54 11 4324 1195
roman.mesuraca@wtwco.com

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