Mitigating, managing, and quantifying named windstorm risks

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Named windstorms, including tropical storms such as hurricanes, are one of the biggest causes of catastrophe losses worldwide, and the frequency of very intense tropical cyclones is expected to increase in a warmer world.

In our recent webinar on 20 June 2023, we looked at how these storms form and how they're measured, how we quantify the risks and how WTW helps clients to mitigate and manage their risks.

We also explored:

- How we quantify risks and probable losses
- Alternative risk transfer solutions for difficult to place windstorm risks
- Real world risk consultancy and claims examples
- Current research into windstorm-related risk topics

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What is a windstorm?

Windstorms are cyclonic storms that create powerful winds strong enough to cause damage to trees and buildings. They can also result in secondary perils such as heavy rain, river flooding, landslides and coastal flooding, causing significant damage and disruption.

There are two types of windstorms:

- **Tropical storms** including hurricanes.
- **Extratropical storms** which form at higher latitudes.

Tropical storms

Tropical storms form in areas where the atmospheric conditions are conducive to convective development, such as high sea-surface temperatures. They are fueled by the heat released from the evaporation and condensation of very warm water.

The term "windstorm" is used in insurance for all tropical cyclones, but they are known by different names depending on location — hurricanes in the Atlantic, cyclones in the Indian Ocean and southwest Pacific, and typhoons in the western Pacific.

How are tropical storms formed?

There are five factors that must be present for a tropical windstorm to form:

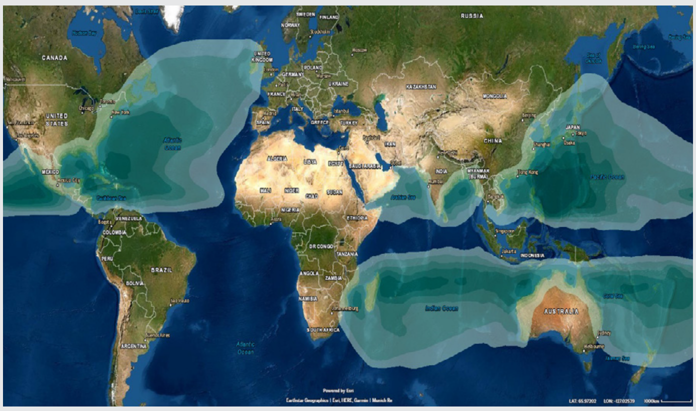
1. **Warm ocean temperatures**, exceeding 26°C, play a fundamental role by causing high and sustained evaporation rates. This process provides the necessary moisture and energy for the storm's development.
2. **An area of low atmospheric pressure** is crucial as it allows warm, moist air from the ocean surface to rise. This ascending air creates large cumulonimbus clouds, which are the building blocks of tropical storms.
3. **The atmosphere must be unstable**, meaning a cold upper atmosphere should be present to allow the warm air to rise even higher. This setup promotes the growth of tall cloud columns, which are essential for the formation of tropical storms.
4. **The Coriolis force**, a result of the Earth's rotation, plays a role in shaping the storm's distinctive structure. It causes the winds to circulate either clockwise or counterclockwise, creating the characteristic "eye" feature seen in satellite images of tropical cyclones.
5. **Wind shear must be low** to facilitate the organization and maintenance of the storm. Wind shear refers to varying wind speed and direction with height. If present, it would disrupt the formation and structure of the large cloud columns required for tropical storm development.

By having these five factors in place, the conditions become conducive for the birth and sustenance of a tropical windstorm.

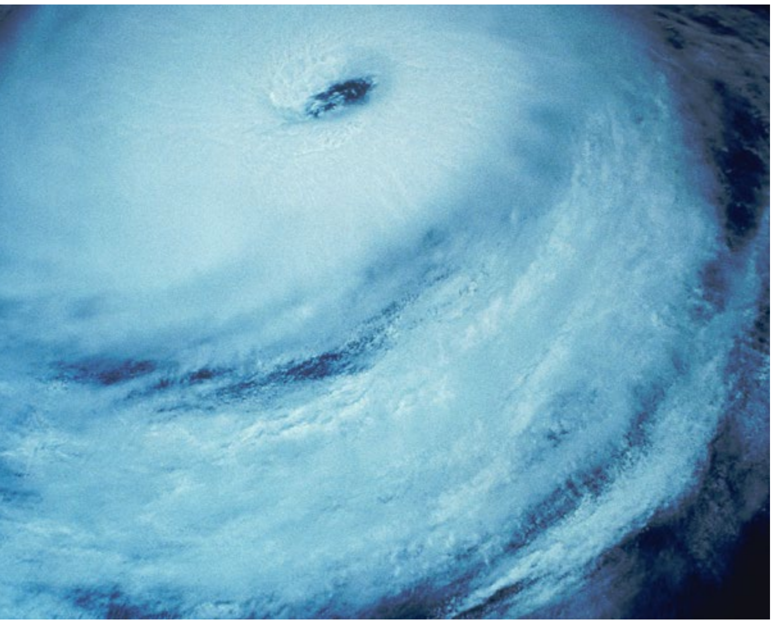
At windspeeds of 74mph and above, the storm is named and categorized by the local meteorological office. In the North Atlantic, the Saffir-Simpson scale, from Category 1 (74-95 mph) to Category 5 (above 155 mph) is used. Due to the conditions required, tropical storms tend to peak in the late summer/early autumn.

Tropical cyclones typically fade when they make landfall, losing access to warm ocean waters that fuel their energy. Additionally, as they move into the mid-latitudes, they encounter wind shear and cooler ocean temperatures, disrupting their structure and leading to their eventual decay.

Figure 1: **Tropical Cyclone Risk Zones**



Source: Munich Re (NATHAN)



Extra-tropical storms

Extra-tropical storms are cyclonic storms that occur in the mid to high latitudes. They can form over ocean or land and can cover an area up to 1,000km^2, sometimes much larger than tropical storms.

Extra-tropical storms are fueled by strong jet streams found in the mid-latitudes and the convergence of warm and cold air masses. They generally last only a couple of days, usually in autumn and winter. As extra-tropical storms can form over land, they are not diminished by making landfall, in fact they can intensify.

How are extra-tropical storms formed?

They originate when cold air from the polar regions collides with warm air from the tropics. At the boundary between these two air masses, known as a weather front, significant temperature and pressure differences occur. The contrast in air properties causes a drop in surface air pressure, leading to the formation of a low-pressure system.

As the pressure decreases, the surrounding air begins to flow towards the low-pressure center. Due to the Earth's rotation and the Coriolis effect, the winds spiral cyclonically around the low-pressure center in the northern hemisphere (counterclockwise) and anticyclonically in the southern hemisphere (clockwise).

As the cold and warm air masses mix, they create an environment where water vapor condenses into clouds. These clouds often extend into large bands, which can lead to heavy rainfall over a broad area.

Are windstorms increasing with climate change?

It's hard to say for certain as the processes that create storms involve complex interactions between weather and ocean dynamics.

These are some of the possible impacts if global temperatures continue to rise:

- **Higher sea surface temperatures** will lead to tropical storms at higher latitudes.
- **Increased heat content in the oceans** could cause storms to move slower, produce more rainfall and be more prolonged.
- **A warmer atmosphere** can hold more water, increasing the intensity of rainfall from storms.
- **Sea level rise** will increase the risk of coastal flooding from storm surge.
- **Arctic amplification** means the poles are heating faster than the rest of the world, this could lead to a smaller temperature gradient between the poles and the tropics, affecting extra-tropical storm formation.

Assessing storm and climate risks

WTW's **Global Perils Diagnostic** tool can help to assess the storm risk level at a particular site or across a portfolio. By entering complete and accurate address information, you can produce a hazard map and a hazard score, which can help in conversations with the client and the markets.

WTW's **Climate Diagnostics** tool can help to plot likely climate impacts on client operations, assessing for rainfall, drought, heat stress and sea level rise.

How can we quantify a client's risk?

We can measure and quantify a client's risk using powerful catastrophe modeling tools.

Based on detailed location characteristic information from the client's schedule of values, and the type and structure of the property, the tools calculate the probable financial losses in a range of possible storm scenarios.

An example of a catastrophe model output is shown below. It includes:

- **Ground up loss** — the likely financial loss the portfolio could experience.
- **Gross loss** to the insurer once insurance conditions, including deductibles and limits, are applied.
- **Average annual loss** — a guide to the premium that needs to be charged.
- **Return period** — the likely frequency of a loss occurring.
- **Probable maximum loss (PML)** — the likely loss if worst case storms happen.
- **Coefficient of variation.** The higher the coefficient, the greater the uncertainty about the model results. A good coefficient number is between 4-8. If the number is higher, it could be because of incomplete information. It's worth checking that you have included the type of construction, occupancy and survey report data.

Figure 2: **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.

Windstorm			
		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.

Strategic risk consultancy for windstorms

To help clients make decisions on how to mitigate and manage their windstorm and other climate related risks, WTW offers a comprehensive risk consultancy service, including in-depth risk analysis, catastrophe modeling and catastrophe engineering vulnerability assessments.

Armed with the right information, clients can see their mitigation, risk management and risk transfer and optimization options much more clearly.

Example:

Tropical cyclone analysis for hotels in Australia

An Australian hotel group wanted to understand its risks and potential losses from tropical cyclones and associated storm surges across its portfolio to understand key loss drivers and their impact on insurance limits.

Hazard review: we used WTW's Global Peril Diagnostic to assess the overall exposure to coastal flood and windstorms to identify the top 20 sites most at risk.

Catastrophe modeling: we then modeled the portfolio losses, based on factors such as the age, construction and roof type of buildings, using data gathered from engineering reports and Google maps. The models also helped to identify high risk locations for further evaluation.

Deep dive to understand local hazards: at the six highest risk sites, we reviewed historic tropical cyclone and flood data from local sources. We were able to source and review local government hazard maps for storm surges and flooding and reviewed the Australian Design Codes to measure construction standards against the hazard reviewed.

Single site catastrophe risk engineering assessment: a WTW risk engineer visited sites to evaluate the building and site vulnerabilities. Using virtual in-depth workshops with site operations at the more remote sites, we gained a deeper understanding of how tropical cyclone events would impact the site, in particular, the lead time for replacement of equipment.

Climate change assessment: for the client's coastal hotels, we carried out a preliminary climate change assessment to help them understand the likely impact of potential increase in storm surges, by using local government and wider research on the regional trend in tropical cyclones wind speeds and coastal storm surge depth.

Remodeling the portfolio: using the information gathered from the single site engineering assessment, we remodeled the portfolio and calculated that the average annual losses for flood and windstorm would increase by around 60%.

Mitigation advice: each individual site was given a set of recommendations and a cost-benefit analysis of their implementation, ranking the actions in order of value for money. Advice was also provided on business continuity planning and preparedness.

Benefits to the client: armed with the analysis we provided, our client understood the risk for the overall portfolio and specific sites. This allowed them to put mitigation strategies in place for the most vulnerable sites and to select the appropriate insurance limits for the wider portfolio.

Example:

Tropical cyclone impacts on vulnerable Pacific island populations

An insurer asked for a review of the tropical cyclone parametric insurance offered to Pacific Island nations across Polynesia and Micronesia to understand why take-up of the insurance was falling and how to overcome its limitations.

Historic review: From 2015 to 2023 the number of countries buying the cover fell from five to three. Some countries were reluctant to pay the premium, as they were aware of other countries who had experienced large, destructive events that were not captured by the insurance leading to an underpayment. Other countries found it hard to understand the benefit of the insurance and did not prioritize putting money aside to pay for it.

The approach: the client offered tropical cyclone insurance for emergency response based on a 'modeled loss parametric approach':

- When a tropical cyclone occurs, characteristics such as the wind speeds and path of the cyclone are run through a catastrophe model, which includes data on the exposure of buildings, infrastructure and crops, and the vulnerability of the location.
- If the model shows a monetary loss, then 23% of this is assumed to be needed for emergency response.
- A payout is made within two weeks if the loss amount exceeds the client's excess.

After thorough analysis of the policy terms, modeled assumptions and in-depth research into the context of the region, it was clear that this wasn't appropriate. Emergency response activities in these regions are focused on providing shelter, water, sanitation, and medicines rather than rebuilding damaged buildings. A new approach was needed that modeled the impact of tropical cyclones on people rather than buildings.

Figure 3: **Why the Pacific Islands need tropical cyclone insurance**

Natural hazard risk	**Limited financial capacity**	**Geographical spread of islands**	**Climate change vulnerability**
The Pacific Island Countries' and Territories' proximity to the South Pacific Convergence Zone (SPCZ) mean they are exposed to meteorological risks such as **tropical cyclones, flooding and droughts**. For example, between 1980-2020, Fiji has experienced 31 storms per year on average.	Governments do not have the financial capacity to cope with multiple losses from natural hazards every year. For example, the Disaster Relief Budget in the Solomon Islands as of 2015 was only **SI $2.2 million (~USD 305,250)** which could have been quickly exhausted in a catastrophic event, with risk modeling analysis estimating a 77% chance of disaster losses (earthquake and tropical cyclone) exceeding this amount in any given year.	Logistical operations are made difficult due to geographical spread of islands, as well as a disproportionate amount of population in rural areas. For example, the Cook Islands have 15 islands, which are spread across nearly 2 million km^2. In the 2016 Solomon Island earthquake and tsunami, logistical costs were nearly as much as the emergency relief supplies themselves (25% vs 31% of total International Foundation for Red Cross's Disaster Relief Emergency Grant Budget).	The Intergovernmental Panel on Climate Change states there is medium confidence in the frequency of extreme La Niña and El Niño events increasing under climate change, as well as high confidence in an increase in local sea level extremes under all emission scenarios — with small islands expected to experience historical centennial events annually by 2050.

The Population Cyclone Index (PCI): WTW designed an innovative index to underpin the parametric insurance program, looking at the impact of wind on people, rather than buildings. When a tropical cyclone occurs, the impact is calculated with a formula based on windspeed squared, multiplied by the population for each 100m^2 grid map cell. This formula is applied to every grid cell of the country and aggregated to give a total PCI number. The higher the number, the more people are impacted by the storm and the greater the payout. The wind speed must be above 34 knots and impact at least 1 person in order to generate a PCI above 0.

Testing the model: we tested the feasibility of the index against the client's existing model with available emergency response cost data for 12 tropical cyclones in the Pacific islands.

- The existing model showed a 68% correlation with actual emergency costs.
- The PCI model showed an 86% correlation with the same emergency response costs.
- After increasing the PCI dataset to 17 historic tropical cyclones, the PCI correlation increased to 93%.

Alternative Risk Transfer

Alternative risk transfer provides alternative ways to transfer or finance risks that may be difficult or cost prohibitive to place through traditional insurance markets.

It includes:

- Parametric solutions for specific risks that might not be insurable through regular policies.
- Multi-year or multi-line structures.
- Captive solutions enabling companies to retain risk internally.
- Access to capital markets, which can provide additional sources of capacity to the insurance market.

Parametric solutions

Parametric solutions provide cover for specific perils, usually weather or natural catastrophe risks. They pay out when a particular 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.

For example, a policy could pay 25% of the policy limit if wind is recorded at 105mph at a location or 100% of the limit if windspeed is recorded at 125mph.

Because claims are based on an agreed measurement, rather than an estimation of losses, they can be paid quickly, which can help with cash flow in the aftermath of a storm.

Parametric solutions can be an alternative to traditional insurance, and are well suited to alleviate the losses due to non-damage business interruption. Parametric solutions can also complement traditional insurance structures. For example, parametric solutions can act as an infill for a large deductible on property programs.

If you suffer a loss but the pre-agreed trigger is not reached in the insurance policy, then the policy will not pay out. This can be managed through effective risk modeling and appropriate structuring to ensure the coverage is calibrated to fit the client's risk as closely as possible.

Parametric case study

We developed a world-first parametric solution for a Central American government. The policy will pay out if a storm if the storm reached an agreed level of severity and rainfall within a set indemnification zone.

The solution enabled the client to refinance its sovereign debt and finance loan repayments after hurricane events. The tailored solution offered protection across the client's geography and a transparent payout structure, with no manual loss adjustment required.

WTW Research Network

Science for resilience

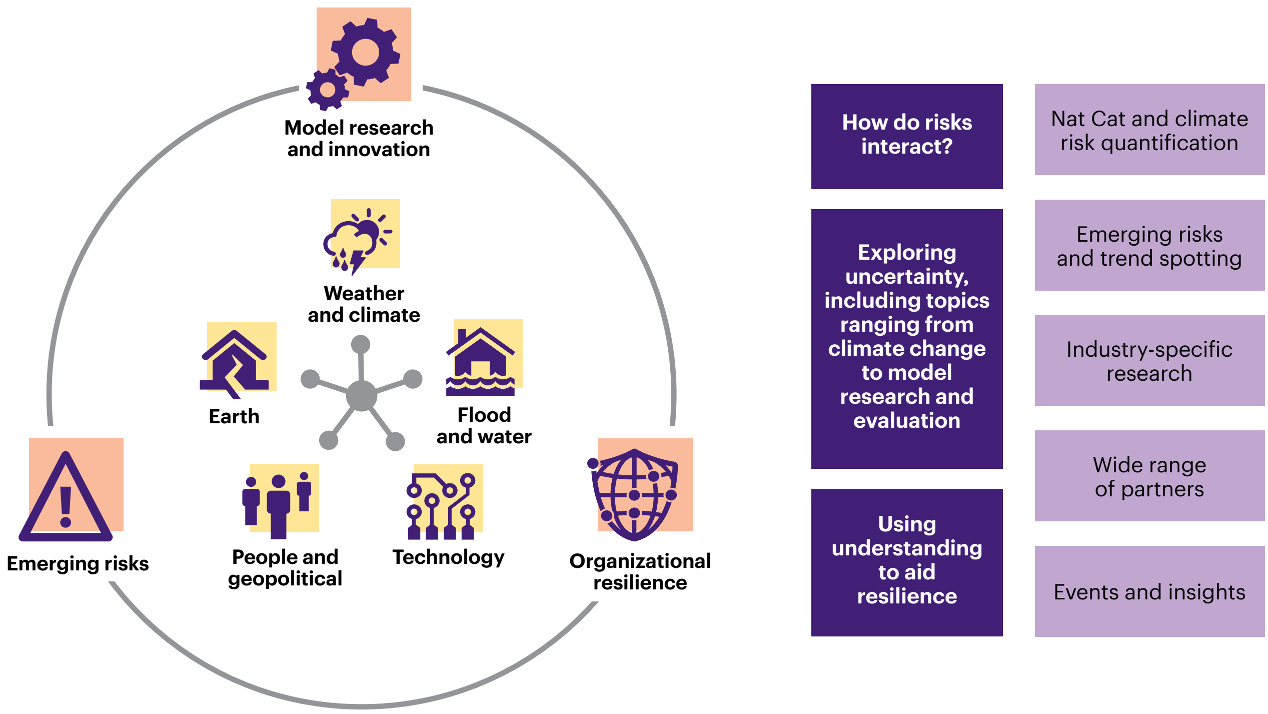
The WTW Research Network (WRN) represents a 17-year investment in research and ongoing horizon scanning to help organizations protect their assets. We bring forward leading scientific thinking to reduce uncertainty, providing new perspectives that will help with natural catastrophe risk management and resilience.

Our 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.

The network is grouped into hubs looking at different global risk areas. **The Weather & Climate Risk Research Hub** covers all aspects of climate risk from natural hazards like windstorms 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[1] and Insights on the results of their research on important topics and recent hazard events, such as the Natural Catastrophe Review that explored US convective storms[2], an Annual Review[3] showcasing research projects across all hubs, and events hosted by WTW to showcase research by sponsored students and academics.

Figure 4: **Supporting solutions to real world challenges with science-based research**



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

Example:

Understanding hurricane wind and rain footprints†

Working with the National Center for Atmospheric Research (NCAR) in Colorado, USA, we explored the effects of wind and rain impacts from hurricanes by using innovative physical modeling. The results generated a combined wind and rain footprint which feeds into solutions for clients.

It is important to consider the compound impacts of wind and rain. For example, a low windspeed storm can also have a large rain footprint and vice versa. We also explored how these factors change over time when a hurricane makes landfall. Data on the severity of an event is useful in parametric solutions where the loss structure is calibrated against the footprint and severity of the storm.

Example:

The Role of the North Atlantic Oscillation in estimating return periods across Europe[4]

WTW Research Network researchers, at the University of Exeter, have developed a method to estimate the strength of extreme European winter windstorms based on observed windstorm footprints and simulated 200-year return period wind gusts over Europe. Traditional models used to assess this risk have limitations due to limited historical data, but the new approach improves estimation accuracy.

The project looked at the effect of North Atlantic Oscillation (NAO) on the strength of European windstorms and what impact future changes could have on gust speeds. The findings show that future changes in the NAO could lead to even more severe wind gusts in certain regions, emphasizing the need to consider future natural variability in risks assessments.

Research such as this can benefit European industries and government agencies that do not typically use catastrophe models to understand and manage their windstorm risk.

[4]WTW Research Network Annual Review 2023 https://www.wtwco.com/en-gb/insights/2023/02/wtw-research-network-annual-review-2023-science-for-resilience

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