DESCARTES

TORNADO RISK

SCIENTIFIC PAPER

While recognized as a destructive force of nature, tornadoes have become an increasingly common occurrence. In 2024, over 1,882 confirmed tornadoes were reported in the United States, making it the year with the most confirmed events ever, according to NOAA.

Tornadoes are part of the severe convective storms (SCS) category, which made up the brunt of insured losses in North America in 2023 and 2024 and caused major issues to U.S. carriers due to high repair & replacement costs. Following up on our Edition 1 of *Global Weather Perils*, the ongoing prominence of SCS events and the development of new solutions, such as Descartes' satellite-based parametric covers for solar farms, present an opportunity to revisit the issue at hand.

THE PHYSICS BEHIND TORNADOES

Known for their iconic shape, tornadoes, also known as twisters, are rapidly spinning columns of air that stretch from the ground to the clouds. They often pull in debris, dust, or water mist to their base. While not always visible, a funnel cloud often forms, reaching down from the base of the cloud towards the ground.

Most tornadoes are relatively small, with a diameter of a few hundred yards or less. However, they generate powerful winds, with speeds exceeding 65 miles per hour, and reaching up to 200 mph in the most extreme scenarios. These whirling winds cause significant damage to key infrastructure such as T&D lines and data centers, agriculture, housing, and even corporate structures, such as warehouses and production facilities.

Tornadoes aren't necessarily isolated events, as it is possible for multiple tornadoes to spawn at the same time and even within the same storm. This phenomenon is commonly known as tornado outbreaks. One of the most recent outbreaks in the U.S. occurred in May 2024. Over multiple days, approximately 240 tornadoes were reported across several states, including Texas, Kansas, and Oklahoma.

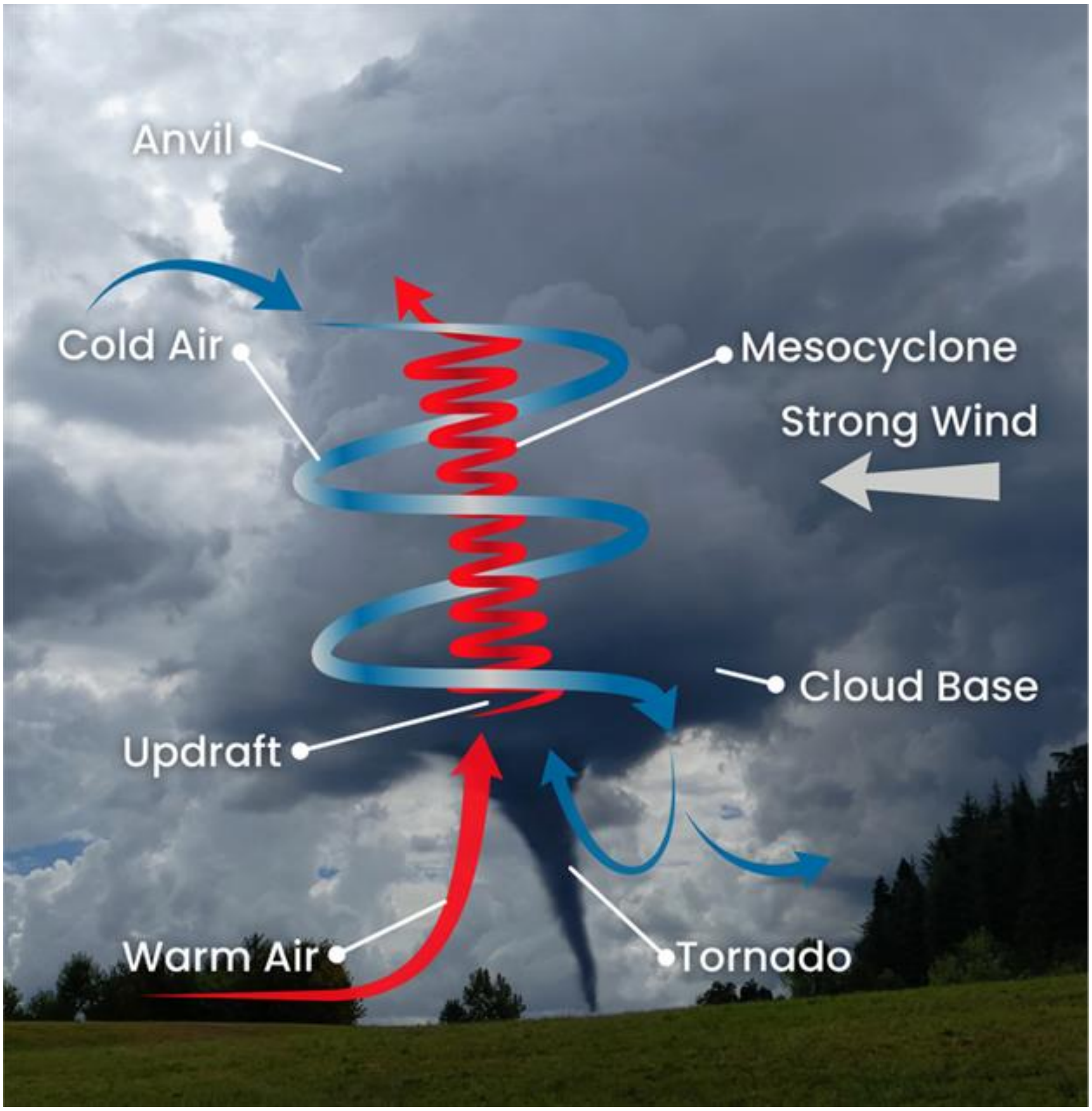
A Dollar Tree warehouse in Oklahoma after a violent EF4 tornado in April 28, 2024.

THE FORMATION OF TORNADOES

To understand how tornadoes are formed, we need to first understand the concept of severe convective storms, which are a type of weather event characterized by significant updrafts of warm and moist air. With powerful rising currents of air, SCS storms manifest in different shapes, often including more than one storm, such as thunderstorms, hail storms, tornadoes, and straight-line winds.

When wind speed and direction change with height, it can cause the updraft to start rotating. This rotating updraft can intensify and eventually become a funnel cloud that touches the ground as a tornado. The process by which a tornado forms is also referred to as tornadogenesis.

It is important to mention that not all convective storms will produce tornadoes; however, they create the adequate environment for tornadogenesis because of their associated heavy winds and intense updraft. The most destructive tornadoes are usually formed within a so-called supercell due to a rotating updraft within them.

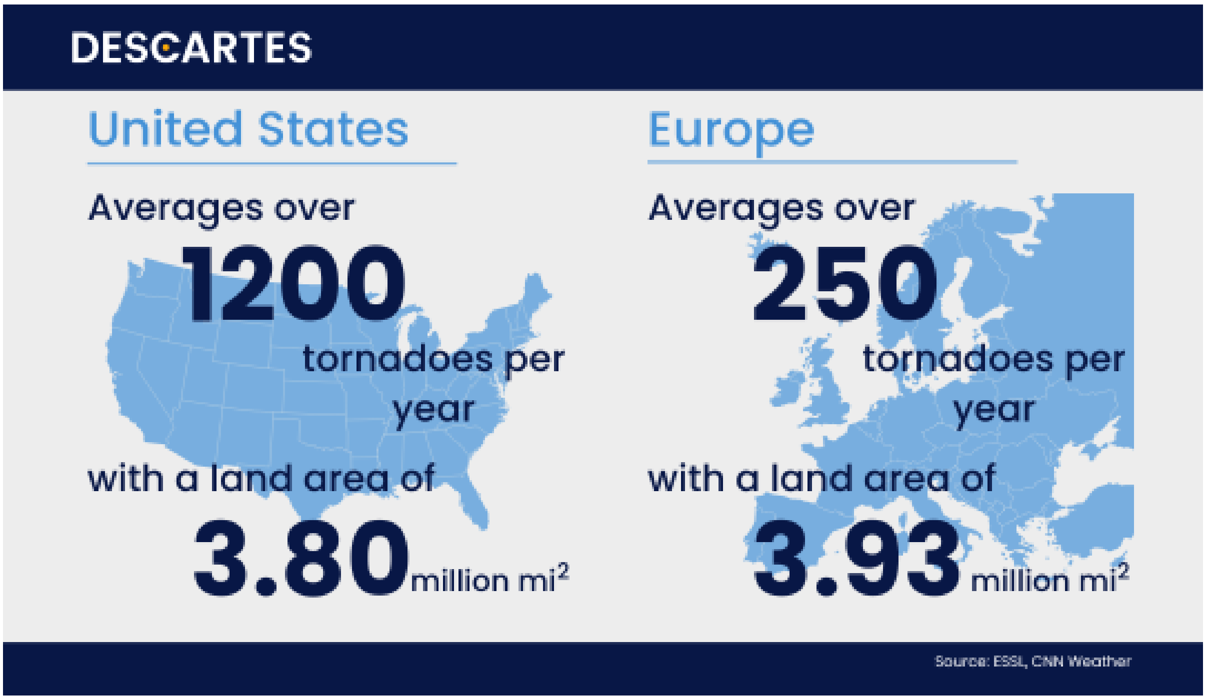


Source: LifeSecure

Even if the current understanding of the environmental factors responsible for tornadogenesis is strong, scientists are still trying to fully understand the complex and exact interactions leading up to a tornado. New technology helps scientists study tornadogenesis more closely, thus improving our understanding of these powerful storms.

Tornado occurrence throughout the year

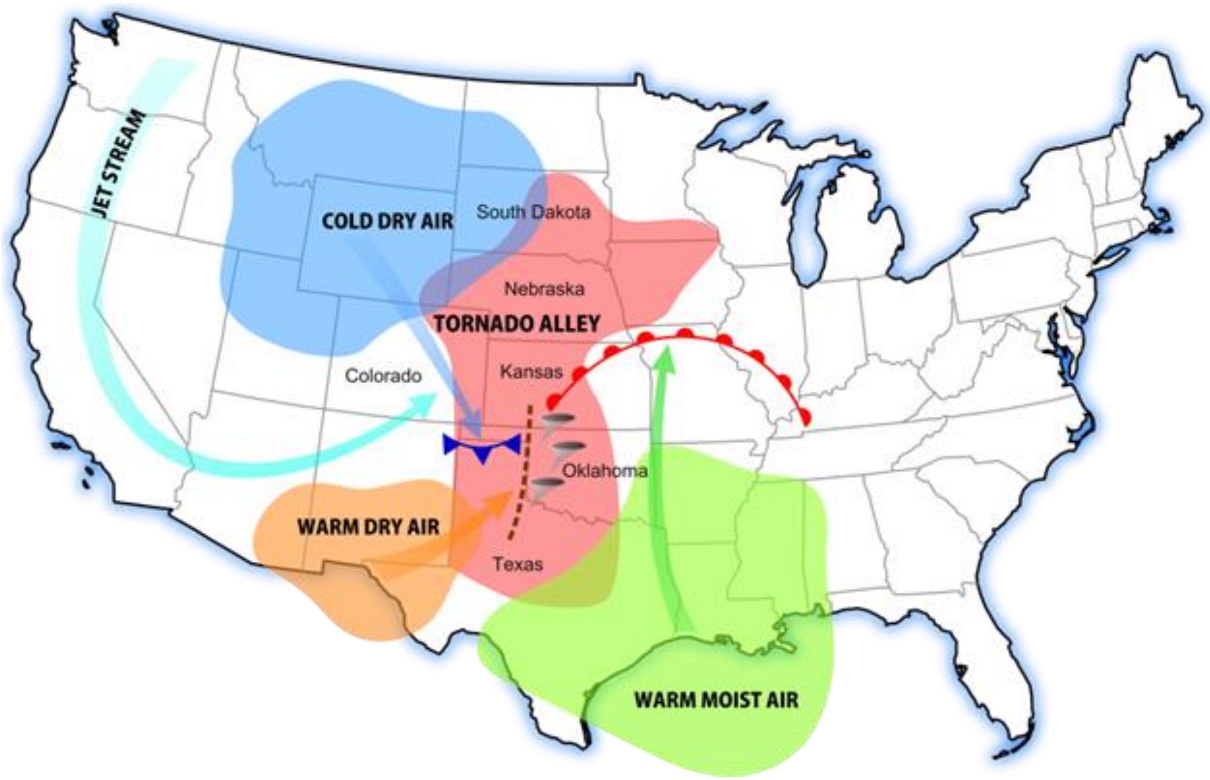
Although typically associated with the U.S., tornadoes occur globally. Almost every country in Europe has been affected by at least one tornado since 1950 and even countries like Japan, Australia and Canada have experienced tornado events.



Europe as a whole is comparable to the size of the U.S., but there is a large difference in the number of tornadoes.

Each state in the U.S. has experienced tornadoes since 1950. Texas and Oklahoma are most affected, with more than 2,000 EF1+ events recorded since 1950. Although tornadoes can occur all year long, a peak in activity is observed during the spring and summer periods, between April and July, depending on the state. Peak activity for tornadoes in Texas is in May, while Florida is most affected in June.

Due to the high frequency of tornadoes, the central plains of North America were nicknamed "Tornado Alley" by the media. Maps of Tornado Alley are not exactly defined, but it is usually located east of the Rocky Mountains and west of the Appalachian Mountains.



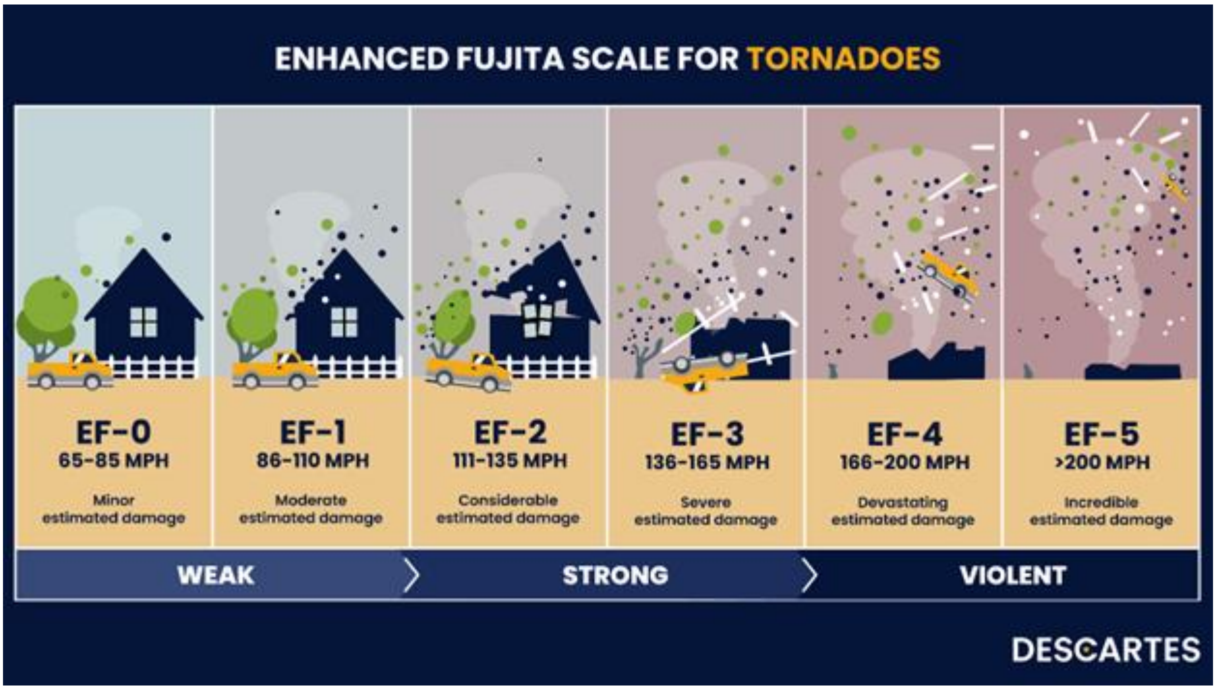
Source: *By Dan Craggs - Own work, CC BY-SA 3.0*

A MEASURED AND CLOSELY MONITORED PHENOMENON

Measuring tornado events poses a unique challenge. Their intense power, suddenness and localized nature makes real-time measurement with satellites, radar and sensors very difficult. Nevertheless, close monitoring is crucial to ensure community safety and resilience.

As a result, a network of agencies and individuals are dedicated to addressing this issue. In the U.S., the Storm Prediction Center, a branch of the National Weather Service (NWS), provides critical support. They issue severe weather outlooks nationwide and send on-site experts to conduct post-storm surveys and release event reports. These reports are complemented by storm chasers' data (e.g., video surveillance).

Other organizations, like the European Severe Storms Laboratory (ESSL) or Australia's Bureau of Meteorology (BoM), also play a vital role in tracking and understanding these powerful tornadoes around the world.



The Enhanced-Fujita scale: a proven tornado measurement tool

In 2007, the U.S. National Weather Service (NWS) released the Enhanced-Fujita scale (EF-scale) and a methodology that allows the categorization of tornado events to be based on the intensity and estimated wind speed. It's the NWS that officially publishes the EF category within a few days after an event.

This scale is built upon the work of Dr. T. Theodore Fujita, who initiated a standardized framework for the estimation of tornado intensity back in 1971, and is now widely used in the U.S. Its primary goal is to improve the accuracy in the matching of tornado wind speed with the severity of the observed damage by leveraging an extended list of 28 assets (also called Damage Indicators) with different building types, materials and construction quality.

The EF-scale derives the wind speed of a tornado using detailed damage reports from storm chasers and inputs from different sources and technologies such as weather stations, social media and drone or satellite images, thus providing an accurate vision of tornado risk in densely populated areas where most of the exposure lies.

Beyond the EF-scale

While the EF-scale is widely used, other scales also exist. The International Fujita Scale (IF-Scale) aims to be a globally applicable standard for damage assessment, though there are several local adaptations of the EF-scale (e.g., Japanese EF-scale by the Japan Meteorological Agency in 2015) or of the Damage Indicators used (e.g., Canadian Damage Indicators). In the UK, the TORRO scale (T-scale) differs from other scales by focusing on wind speed estimation rather than damage assessment.

A PERIL WITH STRONG ECONOMIC IMPACT

As one of the most destructive natural disasters, tornadoes cause substantial economic and insured losses each year. Just in 2024, outbreaks between April to May alone resulted in $14 billion in economic losses. Furthermore, in late May 2023, a devastating tornado outbreak touched several states and led to $4.3 billion in insured losses.

Whilst tornadoes affect towns and homeowners, it can also affect businesses, corporates, and infrastructure. Examples of utility-scale solar farms being hit by tornadoes have become more common, particularly as solar power investments grow in size, alongside potential interruptions in the transmission & distribution networks. Warehouses and logistic services are also particularly affected, due to their wide build, often causing larger supply chain issues. More recently, the introduction of data centers in Texas and other states has also meant that large tornado insurance capacity requirements have difficulty being fully met, especially once the wide non-damage business interruption factors come into play.

Emerging trends

The cost-per-capita has increased over the past several years in the United States, driven in part by factors such as an increase in exposure as well as economic and population growth. In general, more property development in high-risk zones have exposed more valuable assets to natural hazards.

While tornado activity is prominent in the Midwest, southern states might face an increasing risk of outbreaks in 2025. According to studies by NOAA, warmer temperatures during the La Niña seasons could produce a sharper frontal zone between warmer air and the cold Arctic air to the north, potentially leading to an increase in tornadoes.

Limitations of traditional insurance coverage Just as the origination and measurement of tornadoes present challenges, so is the proper risk modeling of these extreme weather events, as it is difficult for conventional insurers to integrate. For SCS events, the five-year average for insured losses has become almost five times higher than in the 2000s, presenting a massive risk increase to most national U.S. carriers. Tornado risk has now become a thorn in most portfolios.

Between limited historical data and deficiencies in the risk modeling of severe convective storms, insurers may also face treaty restrictions, making it increasingly difficult for them to retain the opaque tornado risk in their portfolio. By decreasing limits and increasing deductibles, they hope to better manage the volatility caused by severe convective storms, including tornadoes, leading to an overall deterioration of traditional insurance coverage.

With relatively inexpensive land and the wide availability to build on it, as well as favorable tax regimes in states like Texas, the construction of renewable energy facilities and critical infrastructure, such as data centers and logistic warehouses, has greatly increased in risk-prone areas. As a result, tornadoes pose an increasing risk to economic and sustainable development in these areas by deterring lenders from further investing in key infrastructure.

Damage to a Pfizer pharmaceutical factory in Rocky Mount, N.C., from a tornado that struck on July 19 2023. (NPR, Sean Rayford/Getty Images)

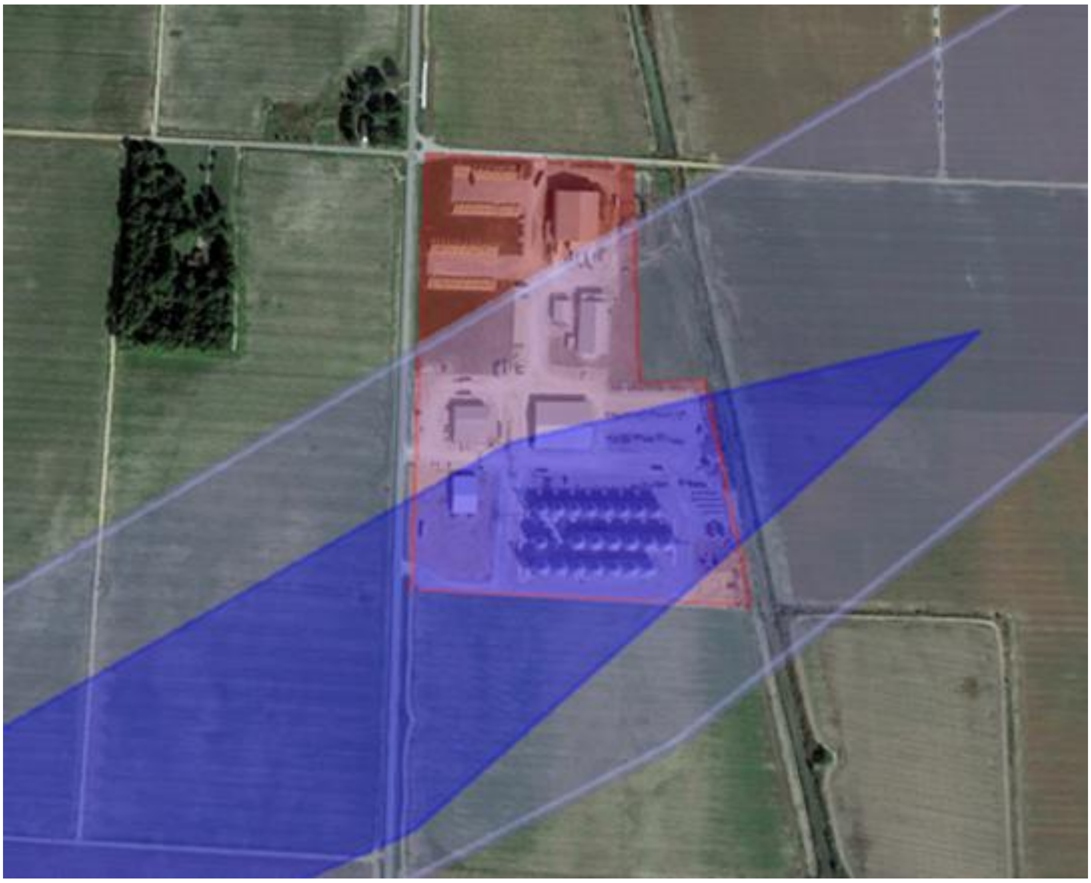
PARAMETRIC INSURANCE AS A WELL-SUITED COVERAGE SOLUTION

Due to the escalating insurance losses of severe convective storms, it may become increasingly difficult for exposed and vulnerable corporations to find the right insurance capacities needed to protect themselves against destructive tornado forces. As the rise of secondary perils (which are natural catastrophes that happen relatively frequently and typically cause low-to-medium sized losses) presents the latest catastrophe challenge to insurance, the market is likely to react firmly, as in the case with wildfire risks in California.

In practice, carriers of traditional insurance may look to restrict the underwriting guidelines currently put into place, initiate non-renewals and capacity reductions, and increase premiums.

Thankfully, alternative risk transfers present themselves as a viable solution to fill the coverage gaps found in the market, alongside the E&S market in the U.S.

For example, Descartes' EF Scale Tornado Product provides transparent coverage and swift payouts to companies across the United States. Damages are assessed by NOAA experts, reports are based on recognized national institutions, and payouts are triggered by the publicly reported EF scale. A payout is triggered when a tornado footprint passes within the polygon outlay of the insured location with a damage intensity that meets the predefined thresholds in the payout structure, as agreed upon in the policy. The payout is then computed based upon the tornado intensity at the location.



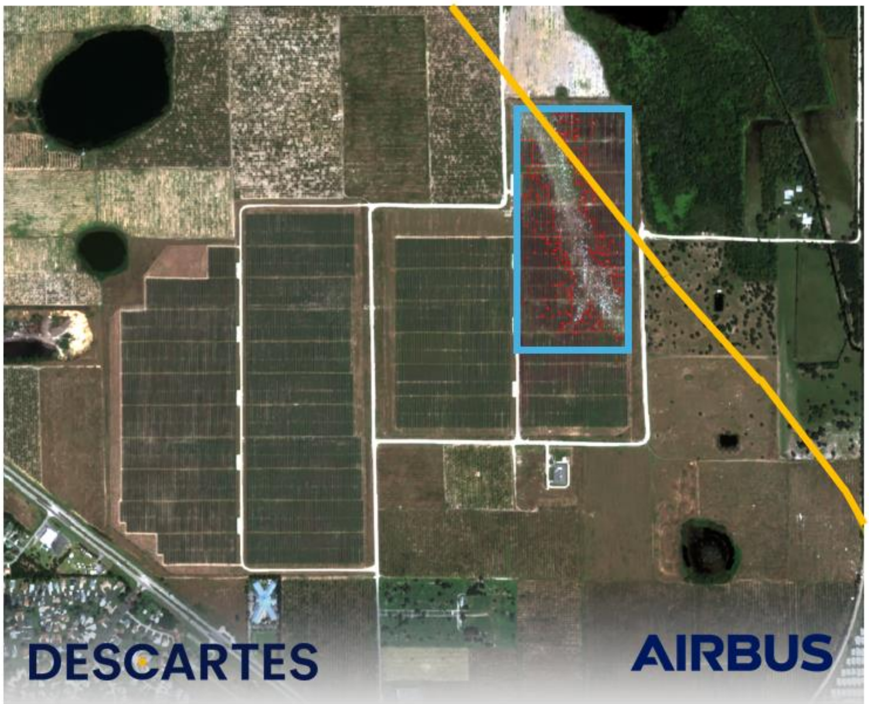
Tornado footprint affecting a location - Source: Descartes

To understand the inner workings and effects of such a cover, the EF-scale parametric product provides information on historical payouts, even if the assets were not present at the time of the event or directly impacted at the time of the event.

Especially in times of higher interest rates and inflation, the rapid multi-million dollar payouts provided by parametric insurance favor the reconstruction and swift return to operationality of clients hit by tornadoes. The payouts can be multi-purpose, and as the damage does not need to be physical, they can be used to cover both immediate damage and ensure balance sheet protection.

Satellite-based tornado product for solar farms

Solar farms, many of which are constructed in areas highly exposed to tornadoes and hail, represent a particular case. While the EF Scale Tornado Product is fully applicable to large structural buildings in urban areas, relying solely on the EF Scale to determine the damage to solar panels in remote places introduces some basis risk and potential inaccuracies. To safeguard utility-scale solar farms in rural areas against tornado damage, Descartes developed a parametric solution that utilizes very high-resolution satellite data and market-leading analytics to insure transition-sector investments against physical damage, business interruption, and other intangible impacts of tornadoes. Payouts are based on the area of the solar farm destroyed by the tornado as observed by the post-event satellite imagery, removing claims ambiguity and reducing the potential mismatch between payouts and actual losses.



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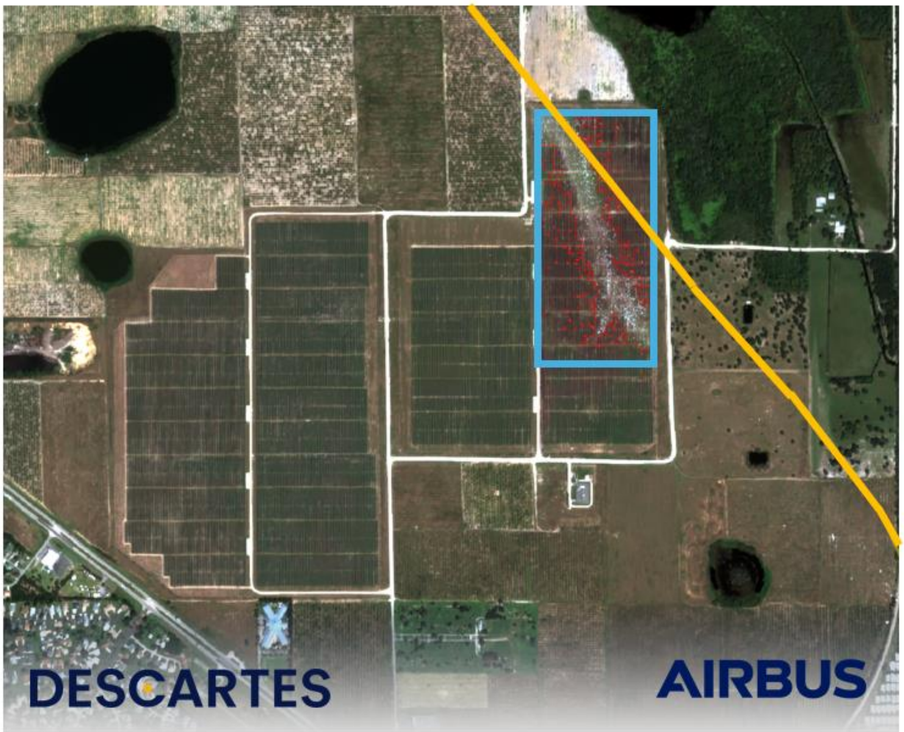
Tornado track reported by NOAA.
Damaged area detected with Descartes product

Case study: managing risks for solar farms

After being affected by a weak EF-1 tornado, and thus unable to obtain traditional insurance coverage any longer, a U.S.-based solar farm owner reached out to

Descartes with a request for parametric coverage. Acknowledging that the typical EF-scale parametric tornado product is better suited for large structural buildings in urban areas, Descartes introduced the satellite-based parametric product to this client.

As a result of very high resolution satellite images used for the risk analytics and claim assessment, Descartes and its partners can detect significant damage to solar panels, identifying snatched panels and capturing damage even outside of the tornado's footprint. Thanks to historical satellite images of the solar plant site, the client was shown how the product would have performed and how they would have been adequately paid in the same scenario. The product methodology offered an improved correlation between damage on the ground and the modeled payouts following a tornado event for solar farms, reducing basis risk and offering coverage even for low-intensity events.



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The power of parametric insurance

Thanks to parametric insurance, clients have an agile solution to cover against tornado risks. By leveraging cutting-edge technology and data-driven insights, Descartes’ transparent and bespoke parametric solutions help clients stay resilient in the face of emerging risks. With rapid claims payouts based on predefined parameters, clients gain the stability they need to quickly recover and minimize disruption.

Let's work together!

Contact us here