RESEARCH INSIGHTS
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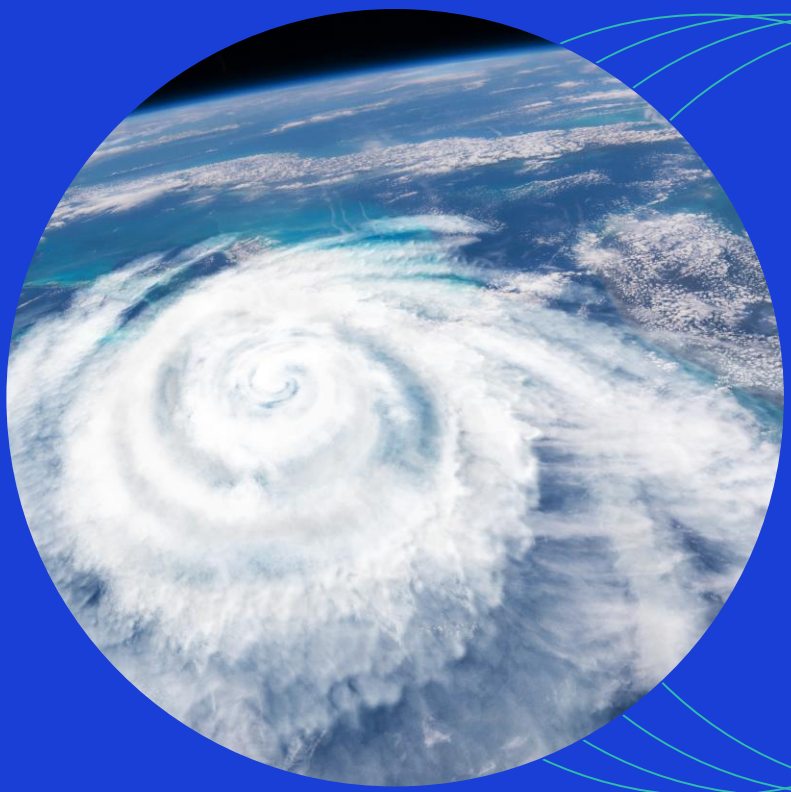
Is Physical Risk Financially Material?

A hurricane-event study



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Executive summary

Physical climate risks are intensifying in both frequency and severity. These risks have significant financial implications for investors because they can cause direct asset damage or business interruptions, leading to revenue losses, increased operational costs and reduced asset valuations.

Despite growing awareness, the integration of physical-climate-risk insights into investment processes remains underdeveloped.[1] Even the largest institutional investors may lack the data, tools or standardized approaches needed to operationalize insights into physical risk efficiently.[2]

This paper focuses on the risks associated with hurricanes — selected for their geographic specificity and global relevance, and the rich data on them — to assess the financial materiality of physical risk. The framework and empirical methods used here can be adapted to other hazard types, such as floods and wildfires, with adjustments to reflect each hazard's spatial and temporal characteristics.

Using MSCI GeoSpatial Asset Intelligence data, we analyzed hurricane activity from 2022 to 2024 to test whether localized exposure to physical climate hazards has a material impact on stock performance.[3] We found that:

- **Impacted stocks underperformed and the effect built over time:** Firms with assets located in hurricane paths experienced statistically significant underperformance, even after controlling for market, sector and style factors.[4] The impact was also widespread: During peak storm season, more than half of the constituents of the MSCI ACWI Index had assets exposed to hurricanes, representing roughly three-quarters of the index's total weight. This underperformance accumulated gradually and worsened through the end of our study window — 30 business days after hurricane impact.[5]
- **Tail risk rose after hurricane impact:** Hurricane-exposed firms showed more extreme negative outcomes. The fifth-percentile returns kept falling over the 36-day study window.
- **Exposure concentration deepened impact:** Firms with higher concentrations of assets or revenue exposure in hurricane-affected areas consistently underperformed more than those with diversified footprints.

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[1] "Guidance on Metrics, Targets, and Transition Plans," Task Force on Climate-related Financial Disclosures, October 2021. Linda-Eling Lee, Oliver Marchand and Russ Bowdrey, "Investors Envision a 2.8°C Future, with Escalating Risks of Severe Weather," MSCI Sustainability Institute, Oct. 31, 2024.

[2] "Investing in a Changing World: How Public Funds Are Addressing Climate-Related Physical Risks," CPP Investments Insights Institute, June 2025.

[3] MSCI GeoSpatial Asset Intelligence helps financial institutions explore location-specific exposures and quantify financial impact where it matters. It offers detailed insights into individual assets' locations, delivering essential data for risk management, due diligence, regulatory compliance and engagement.

[4] We used the MSCI Global Equity Factor Model - Trading. The underperformance was measured by excess returns, after controlling for country, industry and style factors.

[5] Past performance — whether actual, backtested or simulated — is no indication or guarantee of future performance.

- **Sector risk is uneven:** The utilities sector exhibited the most significant downside sensitivity, with their immobile, infrastructure-heavy asset base.[6] The information-technology (IT) and industrials sectors had broad exposure by issuer count, but the financial impact depended on how critical the exposed assets were to operations and whether those assets were concentrated in high-risk locations.
- **Adaptation may help:** The case-study findings suggest that firms with stronger management of physical risks or adaptation strategies (e.g., site redundancy and disaster-recovery planning) may experience more muted performance declines after an event.

This study provides an empirical foundation for integrating physical climate risks into investment decision-making. It also introduces a scalable analytical framework applicable across multiple climate hazards.

While prior climate-finance research[7] has largely relied on macro-finance models or indirect proxies such as carbon intensity or sea-level-rise exposure, our study provides direct, event-driven evidence of financial materiality. By linking real-time hurricane tracks to asset-level exposures and isolating idiosyncratic returns, we show that acute physical risks cause persistent underperformance, amplified by exposure concentration and sector sensitivity. This complements the broader literature with granular evidence on how localized climate hazards translate into firm valuation impacts.

[6] Sector definitions are based on the Global Industry Classification Standard (GICS®). GICS is the industry-classification standard jointly developed by MSCI and S&P Dow Jones Indices.

[7] Stefano Giglio, Bryan Kelly and Johannes Stroebel, "Climate Finance," Annual Review of Financial Economics, Vol. 13:15-36, November 2021.

Introduction

Recent hurricane seasons have highlighted the material financial risks posed by extreme weather.[8] Storms like Hurricane Ian and Typhoon Doksuri caused tens of billions of dollars in damage, disrupted business operations across global supply chains and moved capital markets. For investors, these events are not abstract climate scenarios — they are real, localized shocks with increasingly visible consequences for asset prices, insurance markets and earnings volatility.

Despite the mounting impact of climate-driven physical hazards, systematic integration of physical risk into investment workflows remains limited. While some investors may price in physical risks on a case-by-case basis, there is still no consistent, structured approach across the market.

This paper aims to help close that gap. Examining hurricanes that occurred between 2022 and 2024, we used asset-level data and event-driven methods to provide empirical evidence that localized physical climate exposure has statistically significant effects on firms' performance.[9] We focused on hurricanes because of their global relevance and geospatial precision, but the same framework can be applied to other acute hazards, such as floods or wildfires.

These findings underscore the urgency of embedding physical climate risk into investment processes with greater precision. Risk exposure cannot be reliably assessed using broad proxies such as a company's country of domicile or sector classification. What matters is the exact location of assets and how critical they are to operations.

In the following sections, we present evidence of measurable underperformance among hurricane-exposed firms, and we outline a practical framework, aligned with global standards, to help investors assess and manage physical climate risk more systematically.

Results and insights

Leveraging the MSCI GeoSpatial Asset Intelligence dataset, which links physical climate exposure to specific corporate asset locations, we examined whether firms impacted by hurricanes between 2022 and 2024 experienced statistically significant underperformance. This event study provides real-world evidence of why granular location data, vulnerability assessments and loss modeling are essential tools for forward-looking investment analysis. In the following section, we present the results and key insights from this analysis, with details of the framework provided afterward.

[8] Tropical cyclones, also known as hurricanes or typhoons (depending on the region where they occur), are among the most powerful and destructive natural phenomena on earth. They produce a wide range of impacts, from intense winds to heavy rainfall and storm surge. In this paper, we refer to the broader terminology of tropical cyclones: hurricanes.

[9] An event study is an empirical analysis that examines the impact of a significant catalyst occurrence or contingent event on the value of a security, such as company stock.

Stocks did not weather the storm

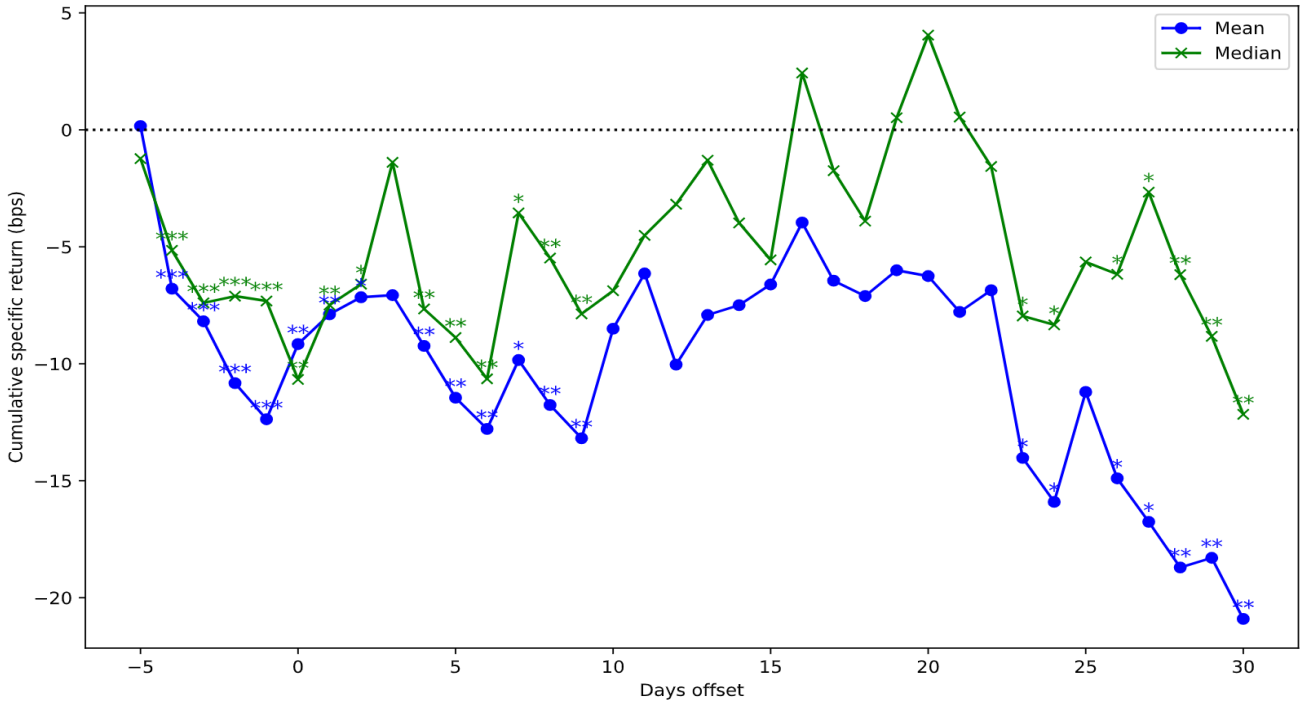
To test whether hurricanes have had a measurable impact on equity performance, we conducted an event study using excess return of companies with hurricane-impacted assets. Leveraging MSCI's equity-factor model, we isolated idiosyncratic (stock-specific) returns (i.e., excess return, returns that remain after controlling for country, industry and style factors). This allowed us to observe the unique effect of hurricane exposure independent of broad market drivers.

We examined cumulative excess return five business days before to 30 business days after each hurricane's impact. Across this window, on average, impacted issuers systematically underperformed.

Underperformance built gradually, not all at once

Our analysis, as highlighted below, shows that on average the negative excess return for hurricane-impacted issuers accumulated over time, with statistically significant underperformance emerging during the first two weeks following hurricane impact. While this initial effect began to fade between days 15 and 27, the average cumulative return continued to decline, reaching its lowest point around trading day 30. Notably, our event window ended at day 30, and the downward trend in returns had not yet reversed.

Mean and medium cumulative excess return for impacted companies

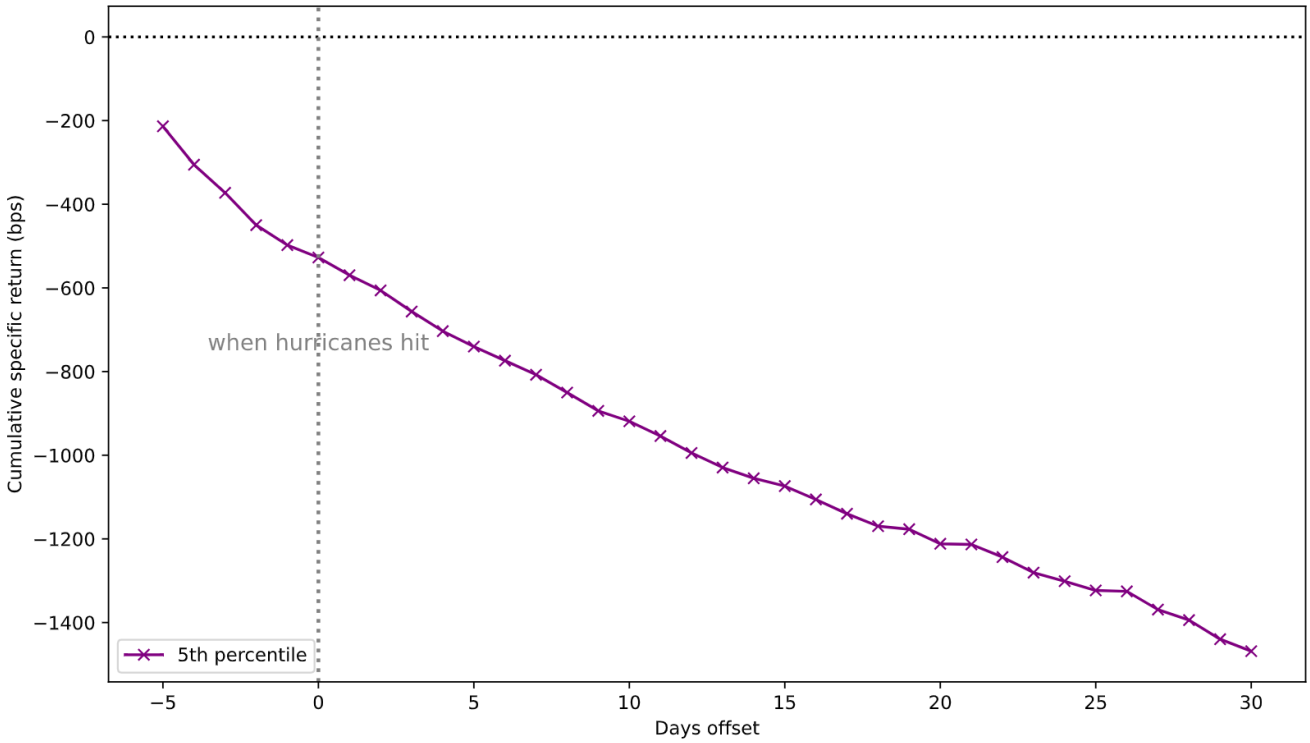


Data as of August 2025. The two lines show the mean and median of cumulative excess returns for issuers affected by hurricanes, measured over the observation window of five business days before impact and 30 business days after. The chart indicates that these firms continued to underperform throughout the 30 business days following the event, with the number of impacted issuers varying month to month. During peak hurricane season, such as September 2022, more than half of the MSCI ACWI Index constituents — over 1,600 issuers — were affected. (*** statistically significant at the 99% confidence level that the mean of all impacted issuers' excess returns is below 0; ** at the 95% level; * at the 90% level.) Source: MSCI ESG Research

Elevated downside risk

The distribution of excess returns showed evidence of elevated downside risk, particularly in the first two weeks and again after day 28. As shown below, the fifth-percentile returns for impacted issuers fell sharply and continued to deteriorate throughout the 30-day window, exceeding -1,400 basis points at the lowest point. While the skewness metrics did not indicate an extreme asymmetry, the combination of deep downside outliers and widening return dispersion suggested that physical risk from hurricanes introduces elevated downside risk.

The fifth-percentile cumulative excess return for impacted companies

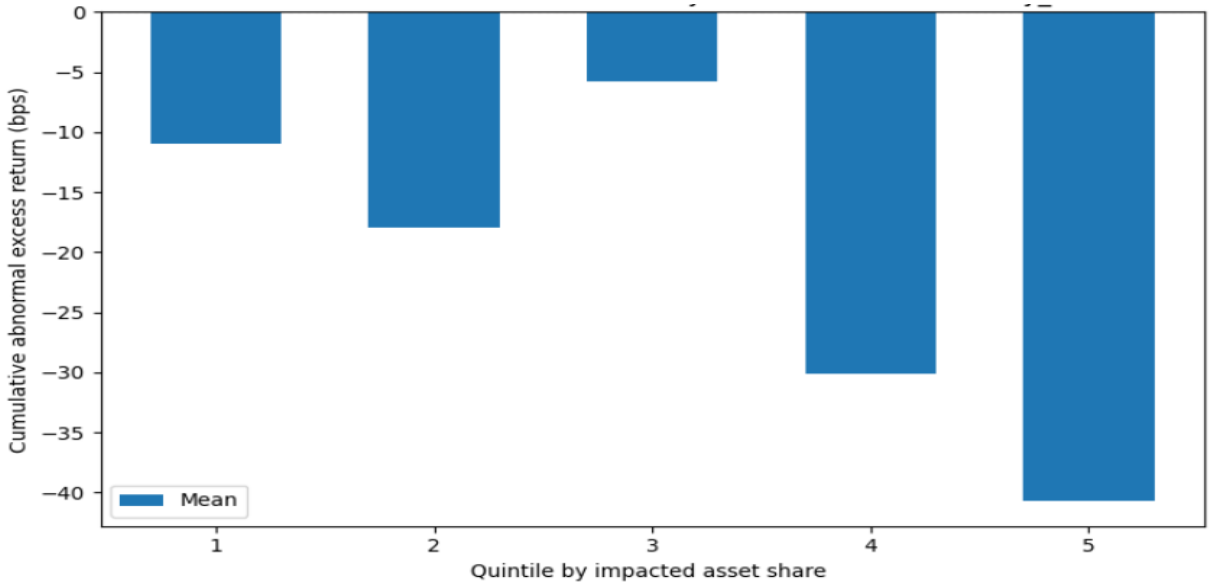


Data as of August 2025. The line shows the daily fifth percentile of cumulative excess returns for issuers affected by hurricanes, measured over the observation window of five business days before impact and 30 business days after. The chart highlights the pronounced downside faced by the most severely impacted firms. Source: MSCI ESG Research

Exposure concentration amplified return impact

Our analysis shows that the magnitude of market underperformance increased with the concentration of asset or revenue exposure to hurricane-affected areas. Using the MSCI GeoSpatial Asset Intelligence dataset, we grouped impacted issuers into quintiles based on their share of assets or output located in hurricane zones. Firms in the top quintiles, those with the greatest physical or financial dependency on impacted sites, consistently showed deeper underperformance relative to the less exposed impacted issuers, as illustrated below.

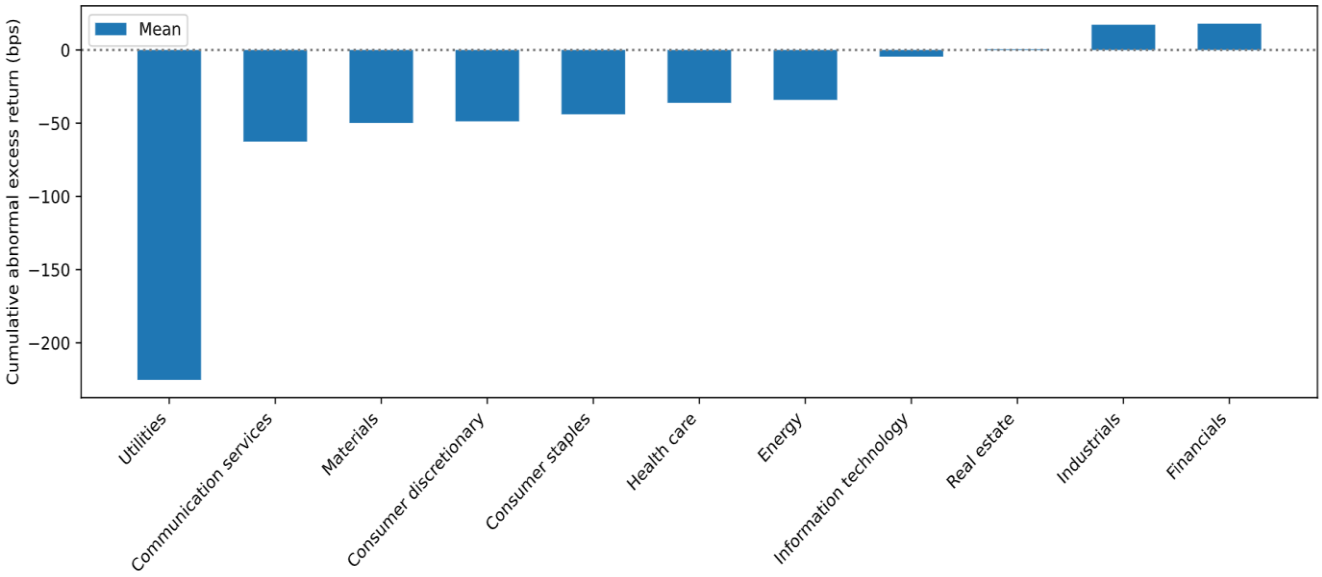
Cumulative excess return by impacted asset share (30th business day after)



Data as of August 2025. We grouped the affected issuers into quintiles according to the share of their assets exposed to hurricanes. Firms in the top quintiles — those with the highest proportion of impacted assets — consistently exhibited greater underperformance, as measured by cumulative excess returns from five business days before to 30 business days after impact, compared with less-exposed issuers. Source: MSCI ESG Research

Sectors with immobile and infrastructure-heavy assets, such as utilities, experienced greater underperformance, as our next chart shows.

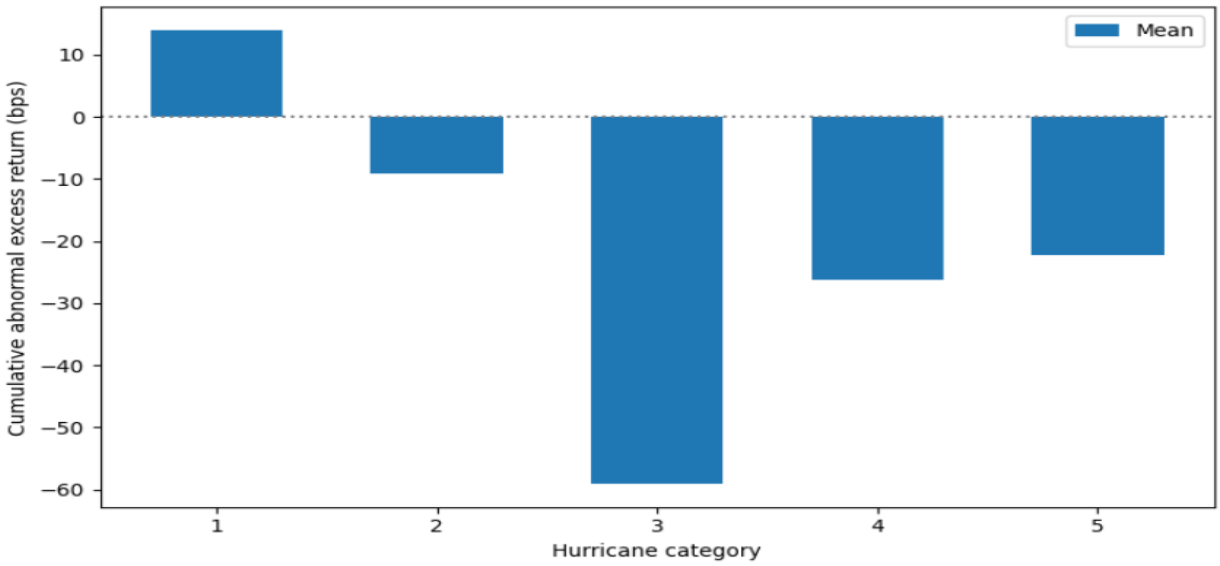
Mean cumulative excess return by sector



Data as of August 2025. The chart shows each sector's average cumulative excess return over the observation window, spanning five business days before to 30 business days after impact. Among sectors, utilities recorded the lowest return, which was statistically significant. Source: MSCI ESG Research

Interestingly, no strong pattern emerged regarding hurricane strength, indicating that firm-level context (such as asset location and revenue concentration) may matter more than storm category alone.

Mean cumulative excess return by hurricane category



Data as of August 2025. For each hurricane category (1 through 5), the chart plots the average cumulative excess return over the window from five business days before impact to 30 business days after. Category 3 hurricanes are associated with the lowest returns. Source: MSCI ESG Research

These patterns show that the financial impact of physical climate risk varied with the concentration of exposed operations or revenue. Concentrated exposure amplified firm-level underperformance.

Timing matters: Peak storm months concentrate climate risk

Hurricane exposure is not uniformly distributed across time. It follows a highly seasonal pattern, with outsize implications for portfolio risk during peak months. Our month-by-month analysis of impacted issuers from 2022 to 2024 shows that hurricane risk was intensely concentrated between August and October, during peak activity in the North Atlantic and western North Pacific Ocean basins.

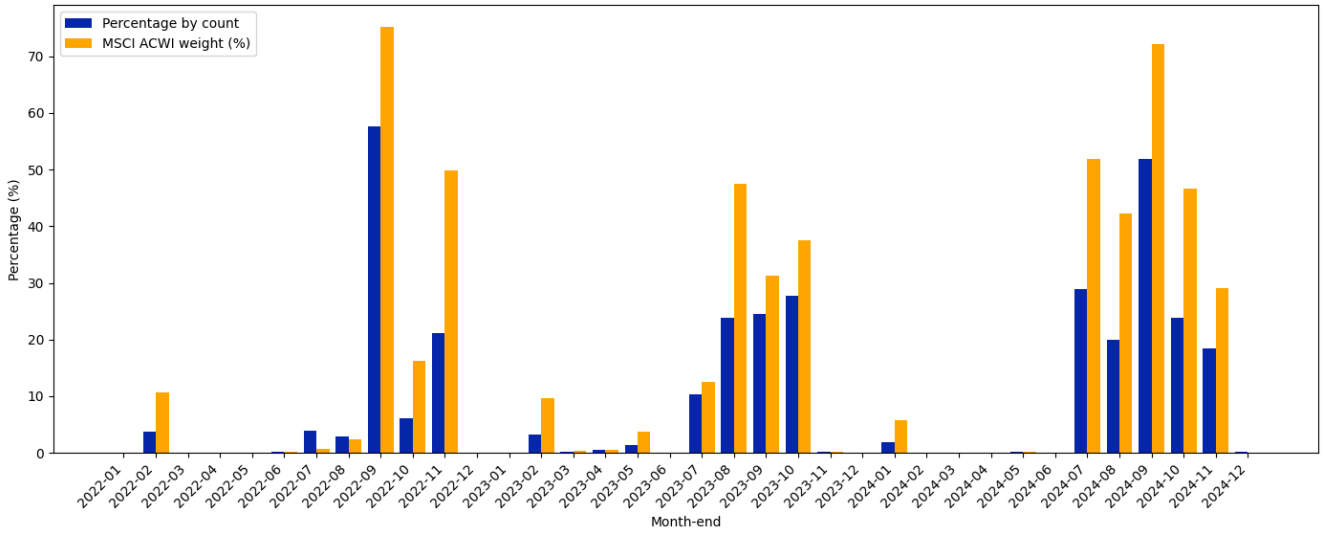
Risk peaks with the storm season

As shown in our next chart, during these peak periods, the number of companies impacted by hurricanes surged dramatically:

- From August to October 2022, close to 58% of MSCI ACWI Index constituents by count had at least one physical asset located within a hurricane-impact zone.
- Those same firms represented more than 75% of the index's total market weight, highlighting a systemic and large-cap concentrated risk profile.

Investors faced a seasonal clustering of risk and a concentration of vulnerability. Such risk needs dynamic, event-driven portfolio monitoring for climate-risk exposure.

Impacted issuers (percentage by count vs. percentage by weight in MSCI ACWI Index)



Data as of August 2025. This chart highlights seasonal spikes in hurricane exposure across the MSCI ACWI Index. The blue bars show the percentage of index constituents with at least one asset impacted in a given month, while the orange bars show the combined index weight of those issuers. Peaks are concentrated between August and October, the peak of the Atlantic and Pacific hurricane seasons. In many months, the orange bars rise above the blue, indicating that a relatively small number of large-cap firms account for a disproportionately high share of exposure — amplifying systemic risk even when only a limited set of companies is affected. Source: MSCI ESG Research

Importantly, the spikes in index weight (orange bars in this chart) often exceed those in issuer count (blue bars). This indicates that a relatively small number of large-cap companies account for the bulk of portfolio exposure — creating systemic risk even if the overall number of impacted issuers is modest.

Implications for investors

- **Hurricane risk surges seasonally:** Investors should incorporate seasonal risk sensitivity into monitoring tools, particularly during peak storm months.
- **Storm season often overlaps with earnings windows:** Peak storm periods often coincide with earnings announcements and rebalancing windows, amplifying portfolio volatility.
- **Tail-risk management should be seasonally calibrated:** Allocators and risk managers may benefit from layering tail-risk hedges or adjusting exposure during high-risk months.

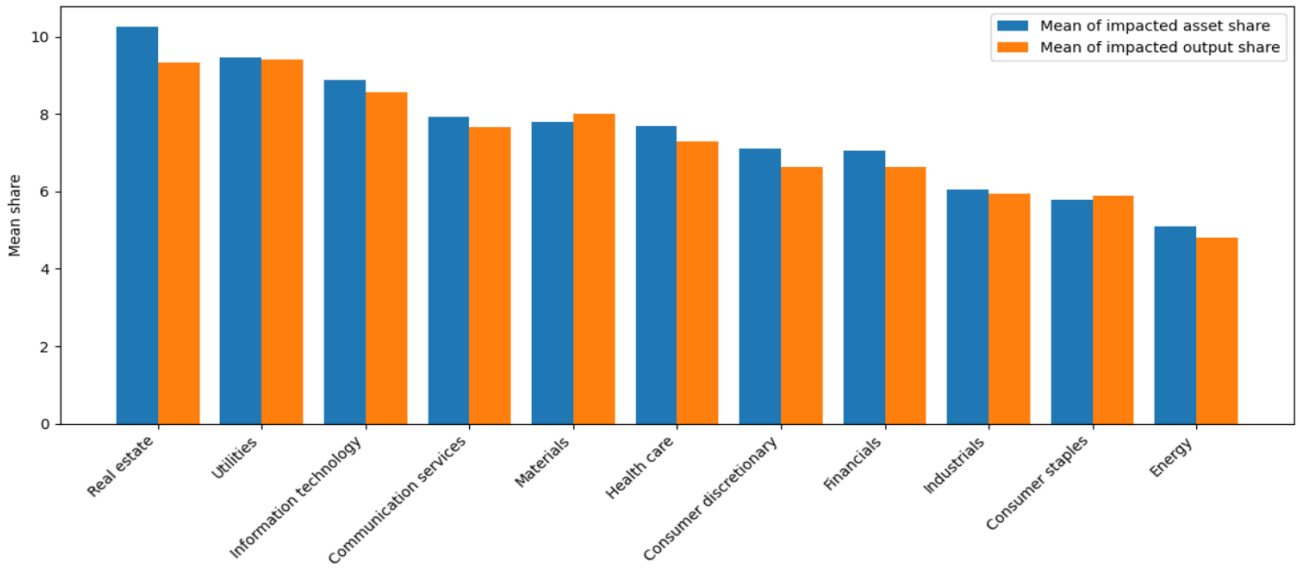
Sectors at risk: Who gets hit and who moves markets

While hurricanes are physical phenomena, their financial consequences are not equally distributed across sectors. Some sectors are impacted more broadly, with many companies exposed. Others may have fewer impacted firms, but those firms represent a larger share of global portfolios. Understanding both dimensions is essential for sector-aware climate-risk management.

Real estate and utilities: High asset and output concentration

Analysis of asset and output exposure revealed important distinctions among sectors. The real-estate sector had the highest concentration of hurricane-affected assets, indicating that physical infrastructure in this sector is highly vulnerable. In contrast, the utilities sector exhibited the highest output concentration, signaling that a small number of impacted facilities can have a significant effect on overall sector revenue or service delivery, as the chart below shows.

Issuer asset share and output share by sector



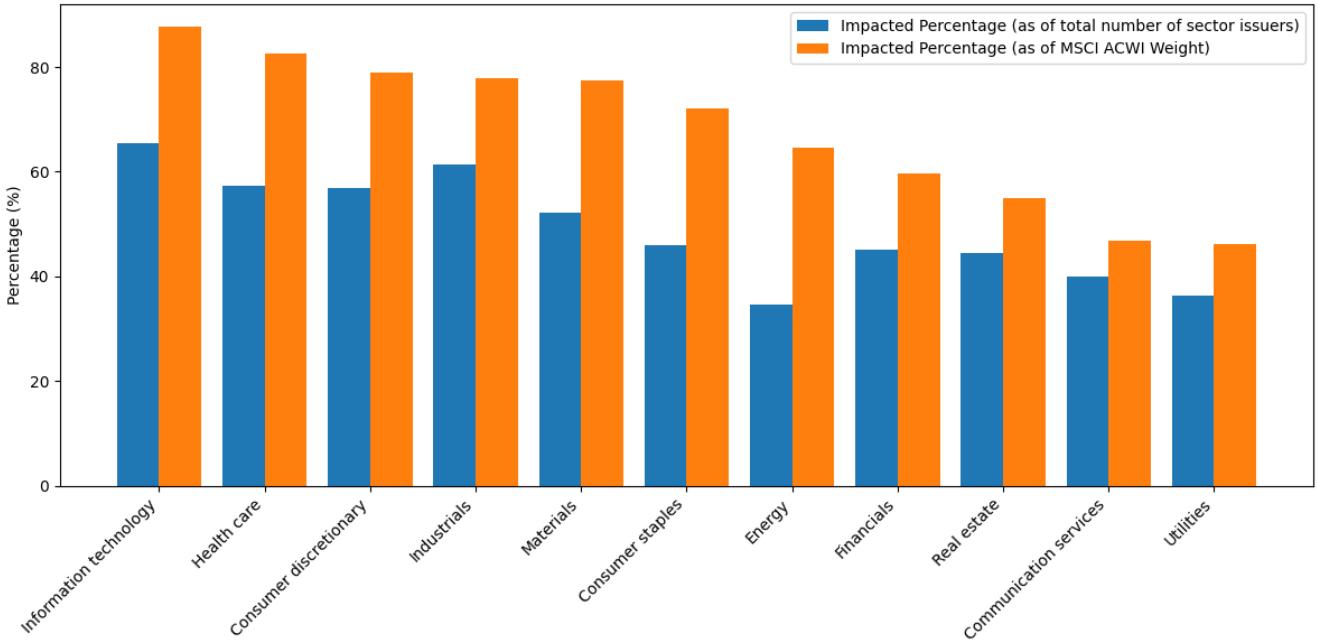
Data as of August 2025. This chart compares the average share of hurricane-exposed assets (blue bars) and hurricane-exposed output (orange bars) across sectors. Real estate shows the highest concentration of affected assets, while utilities stands out for having the highest share of exposed output, suggesting that when assets are hit, a larger portion of sector operations is disrupted. Source: MSCI ESG Research

IT and industrials: Broad exposure across firms and weight in sector

By contrast, the IT and industrials sectors led in number of issuers impacted, either by the number impacted or by corresponding weight in sector in the MSCI ACWI Index:

- Nearly 65% of IT issuers within the MSCI ACWI Index had at least one asset located in a hurricane impact zone, collectively accounting for 88% of the sector's index weight.
- The industrials sector had the largest number of impacted issuers, nearly 20% of all affected companies, though the overall impacted issuers' weight in sector in the MSCI ACWI Index was lower than the IT sector.
- In contrast, the IT sector comprised only 15% of impacted issuers but 30% of the total index weight of all impacted firms.

Percentage of impacted issuers by count vs. percentage by MSCI ACWI Index weight



Data as of August 2025. The chart compares the share of issuers in each sector impacted by hurricanes (blue bars) with their weight in the MSCI ACWI Index (orange bars). In IT, more than 65% of issuers were affected, representing nearly 90% of the sector's index weight, illustrating how concentrated exposure can amplify portfolio-level risk. Source: MSCI ESG Research

Implications for investors

- **IT and industrials are widely exposed:** The IT and industrials sectors have many impacted companies with large index weights that may contribute to outsized hurricane exposure in portfolios.
- **Real estate and utilities are fragile:** The real-estate and utilities sectors are the most sensitive to hurricanes and face elevated downside risk due to the concentration of their fixed physical assets and outputs.
- **Investors need sector-specific strategies:** Broad sector labels are not enough; asset-level data helps identify which companies within each sector drive the most risk.

While the overall event study showed a consistent pattern of underperformance among hurricane-exposed firms, the results also highlight that risk is uneven across sectors and highly dependent on asset location and exposure concentration. To help investors systematically assess and manage these risks, the next section outlines a physical-risk framework for financial institutions, drawing on common components from leading standards and guidelines.

Physical-risk framework for financial institutions

Our results confirmed that hurricanes have materially affected stock performance. To assess and manage such risks systematically, investors can apply a structured framework widely recognized across major standards.

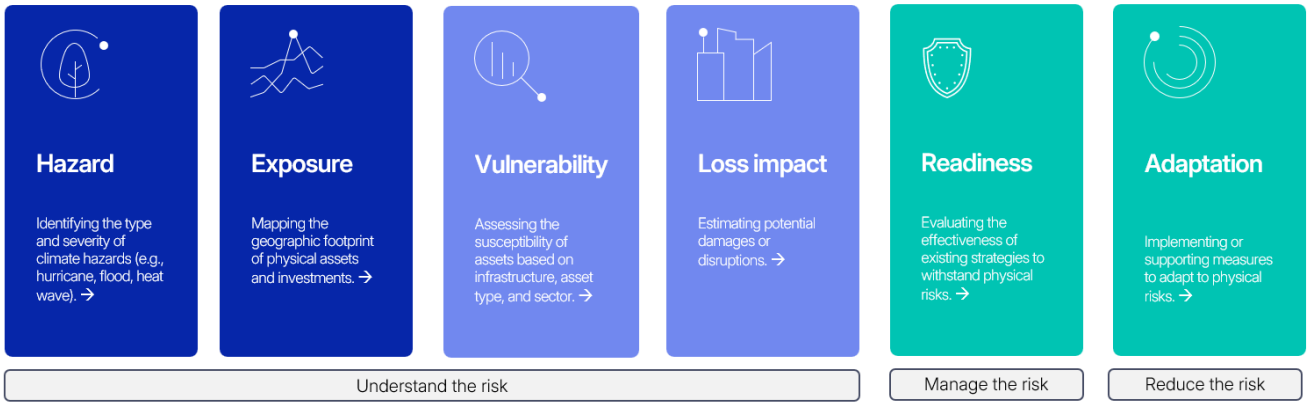
Integrating physical climate risks into investment decision-making requires a structured approach. While climate hazards are inherently local, their financial impacts are increasingly global, systemic and sector specific. A clear framework can help investors translate hazard exposure into financial implications.

Across leading standards — such as the EU Taxonomy, Corporate Sustainability Reporting Directive, International Sustainability Standards Board, Basel Committee on Banking Supervision, CDP (formerly the Carbon Disclosure Project) and Network for Greening the Financial System (NGFS) — there is growing convergence around six core components of physical risk. This paper adopts that shared taxonomy:

- **Hazard:** Identify the type, frequency and intensity of climate-related hazards, such as hurricanes, floods and heat waves. These are modeled using location-specific data.
- **Exposure:** Map the geographic footprint of assets. Asset-level location data is critical, as headline classifications like country or sector do not reflect where physical risk actually resides.
- **Vulnerability:** Assess how sensitive an asset is to damage, based on structural features, design and dependence on surrounding infrastructure.
- **Impact:** Estimate the potential financial consequences of a hazard, including direct asset damage and indirect disruption to operations or revenues.
- **Readiness:** Evaluate how prepared a company is to withstand climate-related risks through physical protection, planning and response capabilities.
- **Adaptation:** Assess implementation or support to reduce risk and improve resilience. For example, retrofitting facilities or diversifying supply chains.

This framework, illustrated below, serves as the foundation for our event study, in which we test whether asset-level exposure to hurricanes translates into statistically significant differences in market outcomes.

Physical-risk framework



Source: MSCI ESG Research

Call to action: Investor readiness

The empirical evidence from our hurricane-event study confirmed that physical climate risk is financially material, persistent and measurable at the asset level. Investors may benefit from enhancing portfolio resilience and improve risk-adjusted outcomes by incorporating these insights. For example:

- **Map asset exposure:** Identify corporate assets located in hurricane-prone areas and quantify their share of revenue, output or capital, and potential financial impact.
- **Monitor seasonal risk:** Recognize that hurricane risk is concentrated between August and October and incorporate this temporal sensitivity into portfolio monitoring.
- **Integrate adaptation metrics:** Evaluate firm-level resilience — including disaster-recovery plans, site redundancy and insurance coverage — and use this information in valuation and risk assessment.
- **Adjust hedging and allocation strategies:** Calibrate tail-risk hedges, adjust exposure and implement portfolio tilts based on exposure concentration and sector sensitivity.
- **Engage at-risk issuers:** Engage more strategically with exposed issuers.

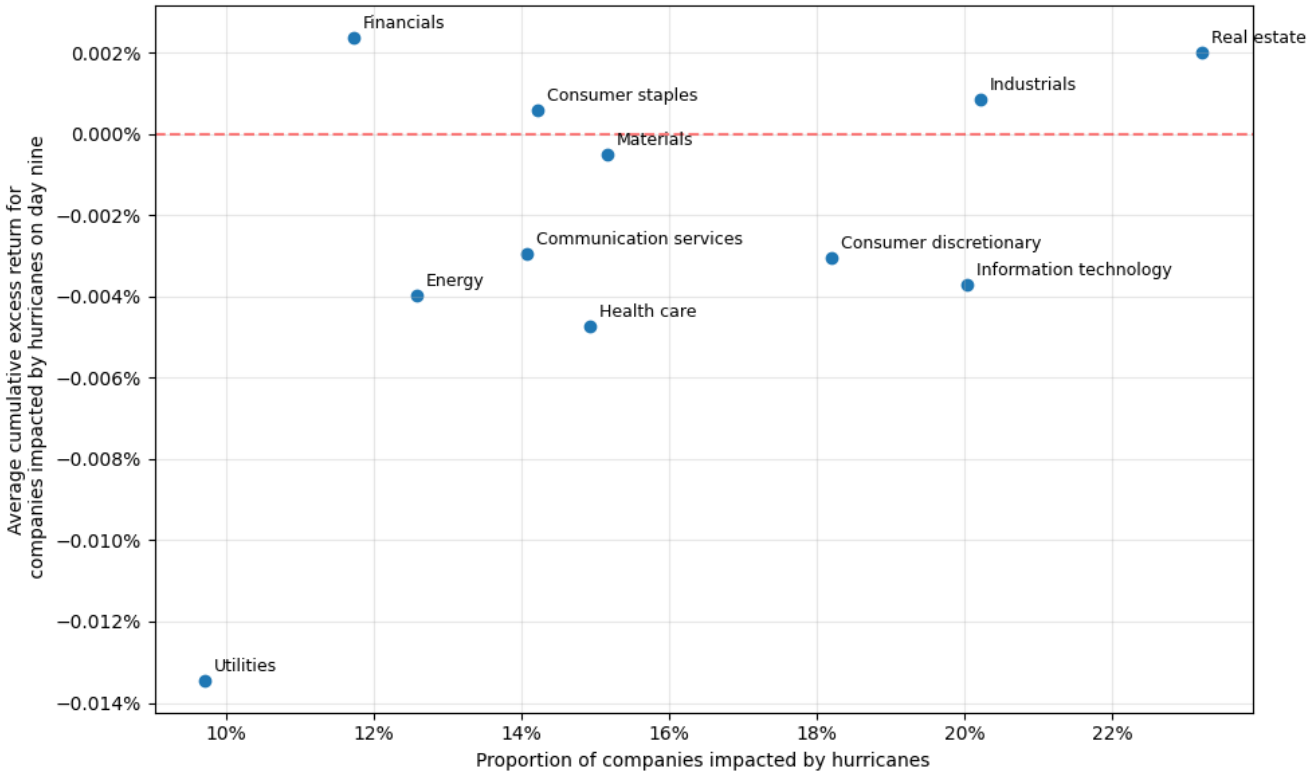
By looking closely at where company assets are located, keeping an eye on seasonal hurricane risk and checking how well firms are prepared to adapt, investors can move from reacting after disasters to planning ahead. This shift can help protect portfolios from sudden shocks and make sure climate risks are better reflected in valuations and investment decisions. Next, we turn to a case study for a closer look.

Climate adaptation may lower downside risk: Utilities and IT case study

Our analysis of MSCI ACWI Index constituents' hurricane risk between 2022 and 2024 revealed that companies with assets impacted by hurricanes experienced underperformance as measured by average cumulative excess returns, especially by around day nine after the hurricanes hit.

Among sectors, we observed a wide divergence in market performance and the proportion of companies impacted by hurricanes. The utilities sector had the biggest underperformance. The IT and real-estate sectors had the highest share of companies impacted by hurricanes during the study period, based on the MSCI ACWI Index weight and count of impacted issuers, respectively.

Proportion of companies impacted by hurricanes vs. average cumulative excess return performance on day nine



Data as of August 2025. This chart is based on MSCI ACWI Index constituent data from 2022 to 2024. The proportion of companies impacted by hurricanes is calculated as the ratio of affected firms within each sector to the total number of firms in that sector. Excess return reflects the performance that remains after controlling for country, industry and style factors, using MSCI's equity-factor model. Analysis excludes vector-based assets, such as gas pipelines and power lines. Source: MSCI ESG Research

Within IT and real estate, we chose 10 companies with the highest and lowest cumulative excess returns on day nine for hurricane-impacted periods, considering average as well as maximum and minimum returns. Among the bottom 10 IT firms, we observed a notably higher exposure to hurricanes compared to their top-performing sector peers.

Importantly, the top 10 performers in these sectors were more likely to show evidence of proactive efforts to identify and assess physical climate risks, as well as to integrate climate-related risks into their business-risk process.[10] Such firms included Dell Technologies Inc., Anker Innovations Technology Co. Ltd., Korea Electric Power Corp. and Sembcorp Industries Ltd. In contrast, the bottom 10 companies — such as Suzhou TFC Optical Communication Co. Ltd. and WiseTech Global Ltd**.** — were less likely to report such efforts. The practices of both sets of firms suggest that companies, including those with higher hurricane exposure, may mitigate that risk through adaptation planning and investments.

Having adaptation plans does not fully eliminate financial costs for companies with higher hurricane exposure, however. Unregulated utilities can incur substantial storm-related costs with no guaranteed regulatory cost recovery, relying instead on market mechanisms and legislative interventions to mitigate losses. In 2021, NRG Energy Inc. booked a pre-tax loss of USD 967 million related to Winter Storm Uri.[11] Even regulated utilities (such as Entergy Corp., CenterPoint Energy Inc. and National Grid Plc.) either faced lengthy delays in recouping storm-related costs through tariff increases or were unable to fully recover such costs amid regulatory pushback. Examples of such regulation include the Texas Senate Bill 1789, which became effective on Sept. 1, 2025.

Often, losses related to business interruption exceed asset-damage costs (as per the example of NRG Energy). Even when real-estate firms (such as Independence Realty Trust Inc., Camden Property Trust and Kimco Realty Corp.) report minimal direct costs from property damage or rental-income losses, they often face broader financial impacts. These include higher insurance deductibles and premiums, as well as increased costs for materials and labor in hurricane-affected regions.[12]

Although our analysis focused on stock performance during hurricane events, the market response may not be immediate. For example, shares in railroad operator CSX Corp. fell 4% after its 2024 Q3 earnings report showed higher-than-expected rebuilding costs and lost revenue related to the Hurricanes Helene and Milton.[13]

[10] This data can be accessed via MSCI ESG Manager using CLIM_PHY_RSK_TS and CLIM_RISK_INT_BUS_RSK_TS factor codes (client access only).

[11] "NRG Energy, Inc. Reports First Quarter 2021 Results," NRG Energy Inc., May 6, 2021.

[12] Emily Flitter, "As Hurricanes Strike, Insurance Costs Soar for Commercial Real Estate," *New York Times*, Oct. 8, 2024.

[13] Josh Funk, "CSX Profit Rose 8% in the Third Quarter but Hurricane Damage Will Impact Current Period," *Associated Press*, Oct. 16, 2024.

Conclusion

This study provides clear empirical evidence that physical climate risk is financially material. Using asset-level exposure data, we have shown that firms with assets located in hurricane-prone areas experienced statistically significant underperformance and elevated volatility, even after controlling for sector, country and style-factor influence on risk and return. These effects persisted over the study period, highlighting the long-lasting market impact of acute climate hazards.

Importantly, our results demonstrate that location matters: Investors cannot rely solely on a company's headquarters or sector classification. Asset-level information, combined with firm-specific resilience measures, is critical to accurately assess and price risk.

By mapping asset exposure, monitoring seasonal hurricane risk, integrating adaptation assessments and calibrating hedging or allocation strategies (as summarized in the supporting table in the appendix), investors can move from reactive to proactive management of physical climate risk. This approach can not only help protect portfolios from acute shocks but ensure that climate risk is more consistently and systematically incorporated into valuation, stewardship and portfolio decision-making.

Unlike much of the climate-finance literature that relies on macro models or proxies, this study provides direct, event-driven evidence that acute physical hazards measurably affect firm valuation.

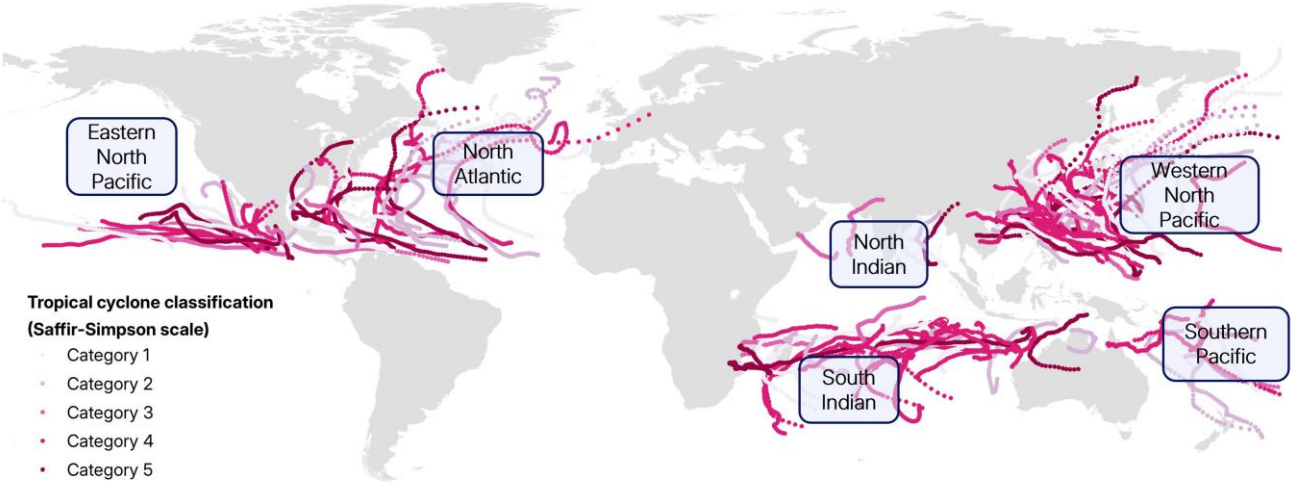
Appendix

Hurricanes are getting stronger

Tropical cyclones — also known as hurricanes or typhoons, depending on the region where they occur — are among the most powerful and destructive natural phenomena on earth. They produce a wide range of impacts, from intense winds to heavy rainfall and storm surge.

Globally, hurricane activity is most concentrated in the North Atlantic and western North Pacific Ocean basins, affecting businesses and infrastructure across eastern North America, as well as parts of Southeast and East Asia. As shown in the map below, the tracks of all hurricanes from 2022 to 2024 illustrate the concentrated geographic corridors where such storms most frequently intensify and land. The exhibit is color-coded by storm strength (darker colors indicate a more intense storm) and reveals that major hurricanes — Category 3 and above — can occur across all analyzed ocean basins, underscoring that a company's climate-risk exposure is tied to the physical location of its assets.

Global hurricane tracks, 2022-2024



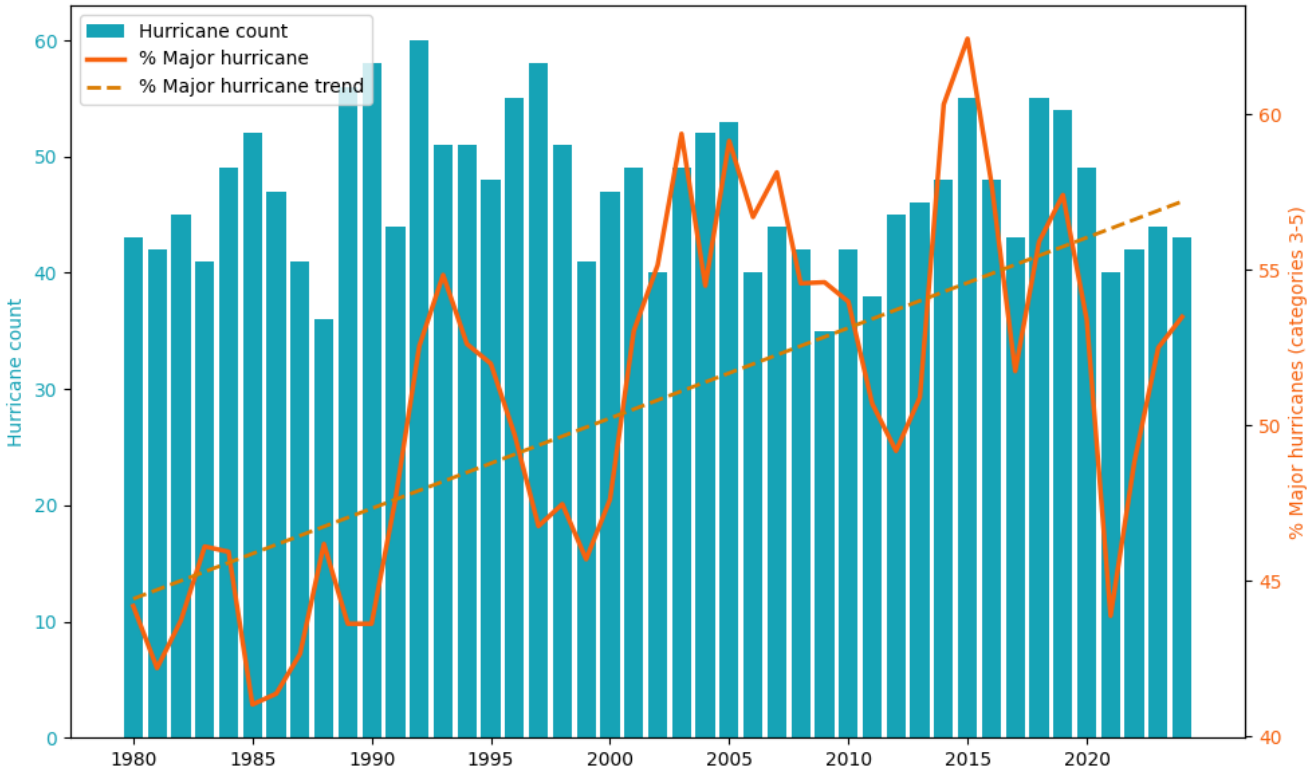
This exhibit maps the tracks of all hurricanes worldwide from 2022 to 2024, with color coding by intensity over each storm's lifecycle. Darker colors indicate more intense storms.

While hurricane activity can vary significantly from year to year, growing populations and rapid urban development in coastal regions have heightened both exposure and vulnerability to these storms.[14] For investors, understanding the impact of hurricanes is increasingly important, as the rising frequency and intensity of such storms can lead to infrastructure damage and supply-chain and operational disruptions — factors that may materially affect company performance.

[14] Wanyun Shao, "Coastal Cities' Growing Hurricane Vulnerability Is Fed by Both Climate Change and Unbridled Population Growth," *The Conversation*, Sept. 11, 2024.

Further, long-term trends point to a worrying escalation in the strength of hurricanes. While the number of hurricanes over the years has remained fairly constant, as shown below, the proportion of major hurricanes (Categories 3 to 5) relative to all global hurricanes has steadily risen over the past four decades. While year-to-year variability is expected, the upward trend in the three-year rolling average and regression line confirm a shift toward more intense and damaging storms, should they make landfall. This trend is consistent with climate-model projections that link warming sea-surface temperatures to greater storm intensification.[15]

Hurricanes have become more intense, if not more frequent, over the past 50 years



Data as of August 2025, based on the International Best Track Archive for Climate Stewardship project. The light-blue bars show the total number of hurricanes each year (left y-axis), while the orange line shows the share of major hurricanes as a three-year rolling average (right y-axis), smoothing out interannual volatility. The trend highlights the increasing prevalence of more intense hurricanes over time. Source: MSCI ESG Research

[15] Cecile L. Defforge and Timothy M. Merlis, "Observed Warming Trend in Sea Surface Temperature at Tropical Cyclone Genesis." *Geophysical Research Letters* 44 (2): 1034-1040.

Glossary: Common components of physical-risk frameworks

Physical climate risk is increasingly recognized by regulators, investors and industry organizations. Major frameworks and guidelines (including the EU Taxonomy, Corporate Sustainability Reporting Directive, International Sustainability Standards Board, Basel Committee on Banking Supervision, CDP, NGFS and ISO 14091) converge on a shared set of core components that provide a structured approach to assessing, managing and disclosing physical risk. These common elements ensure comparability and consistency across firms and portfolios, while allowing investors to evaluate climate-related exposures and vulnerabilities systematically.

1. **Hazard:** *What types of physical risks are relevant?*
   Identify the nature, frequency and intensity of climate-related hazards — such as hurricanes, floods, wildfires and heat waves — that could impact assets or operations. MSCI models both acute and chronic hazards across multiple time frames (e.g., current, 2030, 2050 and 2100) and climate scenarios (those aligned with the NGFS and Intergovernmental Panel on Climate Change). Hazards are modeled using location-specific intensity data (e.g., flood depth and wind speed) and are a primary input into risk estimation.

2. **Exposure:** *Where are the assets and investments located?*
   Map the geographic footprint of physical assets and infrastructure. Asset-level location data, down to latitude and longitude, is essential because climate risk is geographically determined. MSCI's dataset includes more than two million corporate assets classified by operational role, asset type and geospatial footprint, enabling linkage of hazards to financial exposure.

3. **Vulnerability:** *How susceptible are the assets to damage?*
   Assess the condition, construction, elevation and design of assets, as well as their dependence on local infrastructure. Two assets exposed to the same hazard may have vastly different risk profiles based on their vulnerability. MSCI models vulnerability through region- and sector-specific damage functions, calibrated using global historical data such as LitPop, EM-DAT and engineering case studies. For example, flood vulnerability is adjusted by local protection standards (e.g., levees) and regional urbanization levels (e.g., Global Human Settlement Layer).

4. **Impact (loss potential):** *What could the financial consequences be?*
   Estimate the financial consequences of hazard exposure — both direct (e.g., asset damage) and indirect (e.g., business interruption) — from hazard events. This informs value-at-risk calculations and enables stress testing at the firm or portfolio level.

5. **Adaptation and readiness:** *Is the issuer prepared to manage or reduce risk?*
   Evaluate the ability of assets and companies to withstand or adapt to physical risk. Readiness includes protective infrastructure, insurance and business-continuity planning. While external disclosures (e.g., CDP responses) can inform this, MSCI integrates structural resilience (e.g., building codes) and regional adaptation factors into its financial-impact model to estimate how prepared an asset is to avoid or reduce losses. This calculation can inform the company's capacity to mitigate losses and recover quickly.

Data

- **Hurricane data**: Hurricane data is obtained from the International Best Track Archive for Climate Stewardship (IBTrACS) project, which represents the most comprehensive global collection of tropical-cyclone information available.[16] IBTrACS consolidates storm data from multiple regional meteorological centers to ensure accuracy and consistency worldwide. For this analysis, we focused on all tropical cyclones from 2022 to 2024 with a minimum classification of hurricane Category 1 or higher (i.e., USA_SSHS ≥ 1), encompassing hurricanes of all strengths. From this dataset, we used the following key attributes:
  - **Storm ID and name:** Identifier for tracking and reference
  - **Ocean basin:** Geographical area where the storm originated and evolved (e.g., North Atlantic)
  - **Coordinates:** Latitude and longitude of center of storm
  - **Time:** Observations recorded at an interval of at least six hours
  - **Intensity:** Measured using the Saffir-Simpson Hurricane Wind Scale, which is based on the wind speed at the center of the storm at the time of observation
- **MSCI GeoSpatial Asset Intelligence dataset:** This dataset includes the locations of more than two million corporate assets, which can be linked to their issuer.
- **MSCI Company Physical Risk Insights – Issuer-Level dataset:** Assets considered impacted by a hurricane are linked to their respective companies to assess the impact of the storm on the company. The MSCI Physical Risk Metrics – Issuer-Level dataset links assets to the company level for information on hazard exposure and financial impact.
- **Constituents of the MSCI ACWI Index:** Information on these constituents was used for our analysis on the financial materiality of hurricane risk to a global-equity portfolio.
- **MSCI factor model:** We used an MSCI factor model for our analysis on the financial materiality of hurricane risk to a global-equity portfolio.

Methodology

The broader climate-finance literature has shown that both transition and physical risks can be priced across asset classes, but most studies rely on macro-finance models or indirect proxies for exposure. Giglio, Kelly and Stroebel (2021), for example, emphasize how integrated assessment models and climate-disaster frameworks capture long-term risk premia, while empirical work often uses measures such as carbon intensity, sea-level rise or climate-news indices to infer pricing effects.

Our study takes a different approach. We apply an event-study design with geospatial precision, linking real-time hurricane tracks from 2022–2024 to asset-level corporate exposures and isolating idiosyncratic stock returns after controlling for market, sector and style factors. This allows us to provide direct, causal evidence that acute physical risks are financially material, showing underperformance that

[16] "International Best Track Archive for Climate Stewardship data," National Oceanic and Atmospheric Administration, accessed July 8, 2025.

accumulates over time, amplifies with exposure concentration and varies across sectors. In addition, by documenting the seasonal clustering of hurricane risk and the moderating effect of corporate adaptation strategies, our findings complement the structural and long-horizon perspectives in the existing literature with a granular, event-driven view of how physical hazards affect firm valuation.

We analyzed the financial materiality of hurricane risk by linking asset-level exposure data to company performance, using a global-equity sample drawn from MSCI ACWI Index constituents between 2022 and 2024. Our approach incorporated three distinct components:

Identifying impacted assets and issuers

We used hurricane data from the IBTrACS project, focusing on hurricanes classified as Category 1 or above on the Saffir-Simpson scale. At each six-hour observation point, a 200-kilometer radius is applied around the center of each storm to assess the potential impact on surrounding assets.[17]

The radius was overlaid onto corporate assets' locations from the MSCI GeoSpatial Asset Intelligence dataset, with assets located within this radius classified as impacted by the hurricane. Issuers were then tagged as impacted based on whether any of their assets fell within the determined impacted radius of a hurricane.

Isolating impact on excess returns

We assessed whether these impacted issuers experienced performance in equity markets. Using MSCI's equity-factor model, we isolated excess (idiosyncratic) returns by removing systematic exposures to country, industry and style factors. This enabled a clean test of whether hurricane exposure had a unique effect on stock performance.

We analyzed:

- Cumulative excess returns over an event window spanning five days before to 30 days after each hurricane
- Statistical significance through t-tests on daily return differences across the event window

Measuring risk and return dispersion

In addition to average return effects, we evaluated:

- The volatility of excess returns across the event window
- The skewness and tail risk of return distributions
- The sector and regional variation in impact patterns

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[17] Xiaoqi Zhang, Gregor C. Leckebusch and Kelvin S. Ng, "Objective Identification of Tropical Cyclone Systems with Potential for Storm Surge Impact in the Western North Pacific." *Atmospheric Science Letters* 26 (5), e1303, May 13, 2025.

While the size of a hurricane can vary considerably from storm to storm, the typical hurricane is approximately 480 kilometers wide. "Hurricane Facts," National Weather Service, accessed Aug. 13, 2025.

This approach allowed us to quantify both systematic and idiosyncratic effects of hurricane exposure, with our analysis grounded in asset-level data and performance attribution.

Supporting table: Key findings → investor action

Key finding	Suggested investor action
High hurricane season risk (August to October)	Adjust hedging strategies; monitor portfolios seasonally
High concentration of exposed assets	Focus on top-quintile firms for risk analysis and allocation adjustments
Sector-specific sensitivity (utilities, real estate)	Consider sector tilts, scenario testing and engagement on resilience
Observed tail risk and underperformance	Apply portfolio-level stress tests and hedges for downside risk
Adaptation to mitigate loss	Integrate adaptation measures into valuation and stewardship

References

"Getting Physical: Scenario Analysis for Assessing Climate Risks," BlackRock Investment Institute, 2019.

Stefano Giglio, Bryan Kelly and Johannes Stroebel, "Climate Finance," *Annual Review of Financial Economics*, Vol. 13:15-36, November 2021.

Emirhan Ilhan et al., "Climate Risk and Corporate Bonds," 2021.

Mathias S. Kruttli, Brigitte Roth Tran and Sumudu W. Watugala, "Pricing Poseidon: Extreme Weather Uncertainty and Firm Return Dynamics," *The Journal of Finance*, Vol. LXXX, No 2, April 2025.

"International Best Track Archive for Climate Stewardship data," National Oceanic and Atmospheric Administration, accessed July 8, 2025.

"Recommendations of the Task Force on Climate-related Financial Disclosures," Task on Climate-related Financial Disclosures, 2017.

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