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Harnessing climate data

Advancing data analytics to better integrate physical risks and opportunities

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About Nest

Nest (National Employment Savings Trust) is a UK-based workplace pension scheme with over 13 million members and GBP 50 billion assets under management (AUM) as at March 2025. Its investment portfolio spans various asset classes, including listed equities, bonds, property, infrastructure, and private credit and private equity all around the world. Nest has developed a strategy for managing both transition and physical climate risks and opportunities that focuses on four key levers that are available to Nest as an asset owner: Asset allocation and risk management; fund manager selection and monitoring; stewardship; and public policy and advocacy.

About UBS Asset Management

UBS Asset Management (UBS AM) is a large-scale and diversified global asset manager offering investment capabilities and styles across all major traditional and alternatives asset classes, from active to passive, as well as advisory support to institutions, wholesale intermediaries and Global Wealth Management clients.

Our goal is to bring our clients the ideas, understanding and clarity to help them deliver on their investment priorities. Our global capabilities include equity, fixed income, currency, real estate, infrastructure, private equity and hedge fund investment capabilities that can be combined into customized solutions and multi-asset strategies. We cover the main asset management markets globally and have a local presence in 25 locations across four regions: the Americas; Europe, the Middle East and Africa; Switzerland; and Asia Pacific. We have nine main hubs: Chicago; the Hong Kong SAR; London; New York; Sydney, Zurich; Tokyo; Singapore; and Shanghai.

About Oxford Sustainable Finance Group

Both financial institutions and the broader financial system must manage the risks and capture the opportunities of the transition to global environmental sustainability. The University of Oxford has world-leading researchers and research capabilities relevant to understanding these challenges and opportunities. Established in 2012, the Oxford Sustainable Finance Group is the focal point for these activities. The Group is multi-disciplinary and works globally across asset classes, finance professions, and with different parts of the financial system.

We also lead the UK Centre for Greening Finance and Investment; a national centre established to accelerate the adoption and use of climate and environmental data and analytics by financial institutions internationally. The Centre is a multi-university consortium, bringing together researchers with backgrounds in finance, environmental and climate science. We act as a platform to connect wider UK science and innovation with financial institutions, providing a route by which needs are understood and the latest climate and environmental science is made accessible and operationalised.

Executive summary

Climate change is no longer a distant, theoretical threat. The impacts are already being felt today with severe societal and financial consequences. Extreme weather events linked to climate change, such as unprecedented heatwaves, wildfires, floods, and droughts, have resulted in extensive loss of life and caused billions in economic damages globally, often without adequate insurance coverage.

Notable examples include Typhoon Hagibis in Japan (2019), which caused around 100 deaths and USD 10 billion in damages, which according to one estimate was made 67% more likely by climate change.[1] The 2021 floods in Western Europe, intensified by climate change, led to over 220 deaths and billions in infrastructure damage.[2] The 2023 wildfires in Canada, which burned over 13 million hectares, were worsened by climate change and resulted in widespread economic losses.[3] In 2024, over 1000 people were killed and millions displaced by unprecedented rains and flooding in Spain, and Western and Central Africa, weather patterns likely exacerbated by climate change.[4]

Researchers at Imperial College found that climate change increased wind speeds at landfall for hurricanes Helene and Milton in the US. The same researchers estimated that this potentially contributed to 45% of the damage caused by both hurricanes.[5] Most recently, the Los Angeles fires are estimated to cost USD 250 billion, making it one of the costliest natural disasters in US history.[6]

Despite efforts to reverse them, carbon emissions from fossil fuels and land-use change continue to increase, reaching record levels in 2024. Scientists estimate that, at current trends, there is a 50 per cent chance that global warming will exceed 1.5 degrees Celsius above pre-industrial levels within seven years. Indeed, in latest data shows that global temperatures in 2024 exceeded this level for the first time.[7] Every additional increment of global warming increases the intensity and frequency of extreme weather events, including heatwaves, heavy precipitation and droughts.[8]

The past decade has seen an improvement in climate-related financial disclosures, particularly regarding transition risks; however, despite the growing threat, corporate reporting on physical risks, both acute and chronic, remains limited, incomplete and inadequate.[9] Our own analysis of company disclosures reveals significant variability and a lack of standardization in reporting on the impacts and preparedness for physical risk events.

Third-party analytics can bridge this gap by using climate risk models to provide forward-looking risk assessments under different climate scenarios. This data can offer insights on the financial impacts of acute and chronic physical risks on assets, helping investors assess and identify the presence of physical risk in investment portfolios and inform decision-making. However, as we explore in this paper, current climate models and associated analytics face limitations such as limited insights on localized impacts, poor transparency on model assumptions, heavy reliance on proxies and estimations, and high uncertainty on corporate and financial decision making.

Nest, UBS AM and Oxford Sustainable Finance Group have co-authored this paper to advocate for enhanced physical risk disclosure and analytics for listed equity portfolios. We believe that the current state of data, methodologies, and company disclosures, along with the limitations of climate modelling and physical risk analytics, hinders investors from effectively integrating physical risk analysis into their portfolios. This is particularly evident in public market portfolios, where investors have less visibility and control over management decisions. With the increase in physical risk events and their significant impact on lives and economies, the time for better data and insights is now.

In this collaborative paper we set out to:

- Provide an overview of available datasets and models for investors and discuss their limitations
- Share insights from our joint effort to integrate forward-looking physical risk data into the Nest-UBS collaboration on climate investing
- Discuss our respective efforts to expand analysis of physical risk across our investment universe, and how stewardship and engagement can address some of the challenges posed by poor quality data.

1 Climate change added USD 4bn to damage of Japan's Typhoon Hagibis – World Weather Attribution
2 Heavy rainfall which led to severe flooding in Western Europe made more likely by climate change – World Weather Attribution
3 Climate change more than doubled the likelihood of extreme fire weather conditions in Eastern Canada – World Weather Attribution
4 www.axios.com/2024/09/17/deadly-floods-africa-rare-weather-pattern-climate
5 www.imperial.ac.uk/news/257054/climate-change-behind-almost-half-cost/
6 www.latimes.com/business/story/2025-01-24/estimated-cost-of-fire-damage-balloons-to-more-than-250-billion
7 www.earthobservatory.nasa.gov/images/152519/emissions-from-fossil-fuels-continue-to-rise
8 www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf
9 www.wri.org/research/physically-fit-financial-institutions-climate-recommendations-tcfd

Our asks of market participants:

1 **Data providers must enhance the clarity and consistency of analytical models and data on physical risk events**
Data providers play a crucial role in helping investors accurately assess physical climate risk. However, as this paper highlights, current climate risk models often have inherent limitations, such as their inability to provide localized insights onto extreme weather events. These challenges are compounded by a lack of methodological transparency in analytical models that translate climate risk into metrics estimating exposure or potential damage. As a result, inconsistent and opaque models lead to poor correlation across datasets and incoherent physical risk assessments, reducing investor confidence.

To address these challenges, we encourage data providers to increase transparency by clearly articulating methodologies, underlying assumptions and inherent limitations. They should also promote standardization by working pre-competitively to improve the consistency and comparability of model outcomes. Finally, integrating resilience metrics into datasets is crucial to enable a comprehensive and holistic understanding of risk exposure, factoring in adaptation interventions.

2 **Companies should quantify and disclose risks in a granular, location-specific manner**
Generic future scenarios can misrepresent risks that lead to poor business (and investment) outcomes. Building resilience to a changing climate requires planning and investment. To accurately price risk and resilience, the market needs disclosures that are granular and robust.

Companies must provide detailed, location-specific information on physical assets and infrastructure, including the availability and affordability of insurance, allowing investors to accurately assess the potential impact of climate risks on their portfolios. This includes disclosing asset geolocations and quantifying the effects of previous material physical risk events, as well as potential future risks. To enable comprehensive risk assessment, companies should adopt a value chain approach, extending beyond operational boundaries.

3 **Capital markets and regulators must adopt a standardized approach to integrating physical climate risk**
Currently, the methods for assessing and integrating physical risk are fragmented and unstructured, resulting in poor insights and heightened risk for investment portfolios. The second- and third-order effects of growing physical risks, including, for example, the impact of insurance premiums on home ownership and consumer spending, remain unclear. The market should unify its approach to risk assessment and integration, providing clear signals to companies and policymakers.

While central banks have set supervisory expectations on climate transition and physical risks, there is an opportunity to expand supervision into physical risk methodologies and data analytics. This would ensure a consistent and standardized approach to measuring and managing physical risk.

4 **Expanding investor engagement on physical risk**
As an industry, we need to address the limitations of existing climate datasets by leveraging engagement and stewardship programs to improve disclosure and management of physical risk, while incentivizing adaptation and resilience.

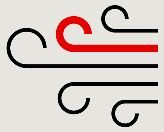
Physical risk from climate change presents an unprecedented and non-linear challenge that can affect portfolios across asset classes both idiosyncratically and systemically. Enhancing transparency and standardization can empower investors to confidently integrate these risks and collaborate with their portfolio companies to manage them effectively, thereby minimizing potential impacts on portfolio value.

How physical climate risks translate into financial impacts

Changes to the climate, and related extreme weather events pose tangible risks to issuers and investment portfolios. Following the approach of the Taskforce on Climate-related Financial Disclosure (TCFD) climate risks are split between 1) risks related to *physical* impacts of climate change, and 2) risks related to the *transition* to a lower carbon economy.[10]

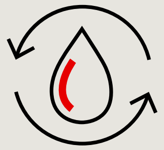
> The International Sustainable Standards Board (ISSB) defines physical risks:
>
> "Risks resulting from climate change that can be event-driven (acute) or from longer-term shifts (chronic) in climate patterns. These risks may carry financial implications for entities, such as direct damage to assets, and indirect effects of supply-chain disruption."

Company financial performance may be impacted by changes in water availability, sourcing, and quality; food security; and extreme temperature changes affecting organizations' premises, operations, supply chain, transport needs, and employee safety. Physical risks resulting from climate change can be broken down into:



Acute risk

Entailing climate events such as wildfires, cyclones, hurricanes, droughts and flooding.



Chronic risk

Longer-term shifts such as rising average temperatures, change in precipitation patterns, water stress, agricultural productivity, sea level risk and ocean acidification.

10 Recommendations of the Task Force on Climate-related Financial Disclosures

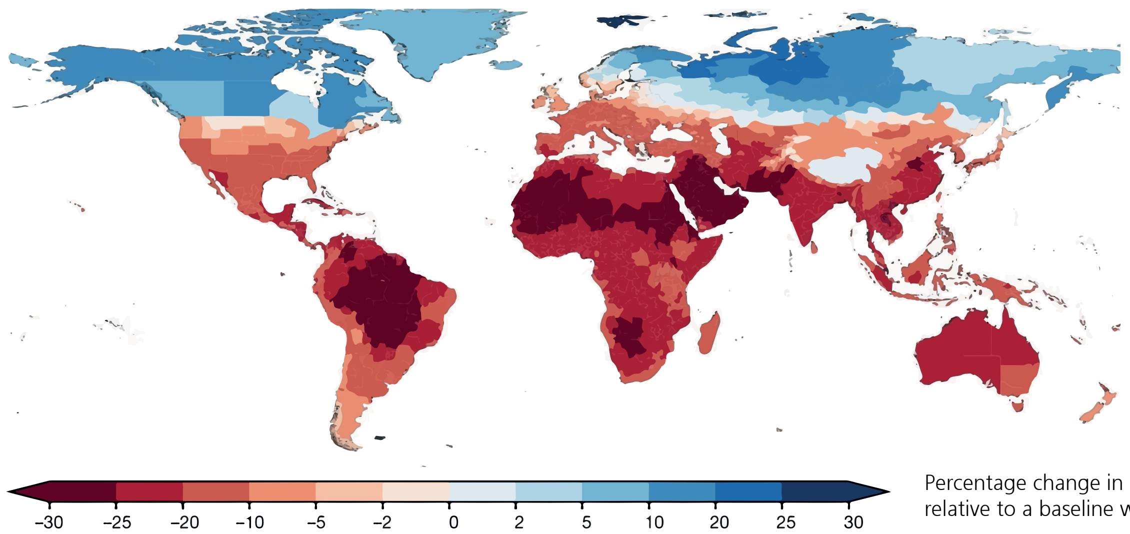
Integrating physical risks into investment portfolios

Physical risks from climate change will persist and are likely to worsen over time

Despite efforts to reduce carbon emissions, the physical impacts of climate change are expected to worsen in the coming decades due to inertia in the climate system. This refers to the delayed response of the climate to changes in greenhouse gas concentrations, meaning that even if emissions were to stop immediately (which is far from likely), the climate would continue to warm and change for some time due to the energy already absorbed by the Earth's system. This occurs because processes like ocean heat uptake and ice melt have long timescales, which cause a lag between the cause (increased greenhouse gases) and the effect (temperature rise and other climate changes).

Research from the Potsdam Institute for Climate Impact Research suggests global national income levels could be 19% lower by 2050 due to historical emissions and committed global warming[11], compared to a baseline without climate impacts. Significant economic consequences are predicted across both developed and emerging markets.[12] The National Bureau of Economic Research estimates that a 1-degree Celsius rise in global temperature reduces world GDP by 12% – a figure six times larger than previously estimated.[13]

Figure 1



Percentage change in income per capita relative to a baseline without climate impacts

Projected income changes in 2049 compared to an economy without climate change. Income changes are committed in the sense that they are caused by historical emissions. (Image: Kotz et al., Nature)

11 www.pik-potsdam.de/en/news/latest-news/38-trillion-dollars-in-damages-each-year-world-economy-already-committed-to-income-reduction-of-19-due-to-climate-change
12 Ibid.
13 www.nber.org/papers/w32450

Physical climate risks are increasingly critical to investment strategies

Acute and chronic physical risks are already disrupting operations, damaging infrastructure, impacting people and economies and reducing asset values. Extreme events affect companies differently depending on the geographical footprint of their operations, supply chains, and level of preparedness. Additionally, companies that invest in climate adaptation measures may gain a competitive advantage and avoid losses, with the World Resources Institute estimating a return of USD 2 to USD 10 for every dollar invested in climate adaptation.[14]

However, climate risks are long-term, non-linear, and systemic, making them difficult to hedge or diversify for investors with globally diversified portfolios. To ensure that risks and opportunities are assessed, priced, and managed accurately, investment strategies require data and analytics that are spatially explicit, granular, and scientifically robust. These tools must should incorporate climate adaptation measures to identify opportunities and incentivize investments in climate resilience.

Climate models are critical to help investors gauge physical risk impacts, but challenges remain

A warmer world is inevitable, but the specifics of that future remain uncertain. Forward-looking modelling is essential for investors to grasp the financial risks and opportunities presented by a changing climate, both for individual investments and across portfolios. Climate science provides valuable data and tools to analyze past, present, and future climate conditions. Central to this effort are climate models, which simulate and predict how the Earth's climate system responds to factors like greenhouse gas emissions, aerosols, and land-use changes. These models enable scientists to project future climate scenarios, helping us anticipate the unfolding impacts of climate change.

How climate models get translated into financial impacts for investment portfolios

General Circulation Models (GCMs) are complex mathematical models that simulate the Earth’s climate by capturing physical processes in the atmosphere, oceans, land, and ice. These models, which integrate variables such as temperature, pressure, and wind, project how the global climate may change in response to increasing greenhouse gas concentrations.

GCMs provide essential data for statistical models used to assess physical risk in investment portfolios. By simulating climate change scenarios, GCMs help researchers estimate how the intensity of extreme weather events, like floods or tropical cyclones, might evolve. For example, as greenhouse gas levels rise, GCMs project an increase in the maximum wind speeds of cyclones.

Investment risk models then use this data to estimate potential financial losses through key factors such as:

Asset exposure	Vulnerability	Market pricing
Locating and valuing assets, such as power plants, to determine their vulnerability to extreme events	Using historical data to estimate potential asset losses based on event intensity	Modelling how physical damages translate into financial losses for portfolios

By combining these factors, statistical models can estimate the relative exposure and loss due to extreme events under different climate change scenarios.

Most analytical models originate from the insurance industry. First-generation models typically link geospatial data (e.g., company facilities) with weather hazard climate models, and aggregate climate hazard exposure at the company level. Second-generation models analyse facility usage and assess the financial impact of climate hazards based on this usage. Key metrics include Climate Value at Risk (CVaR) and discounted financial losses expressed as a percentage of revenue or asset value. Today, numerous physical climate risk models and analytics are available from a wide range of academic, public, and commercial sources, each with their own methodologies and assumptions. The next section covers the current landscape of datasets and models and their limitations in more detail.

14 Adaptation Finance and Investment I World Resources Institute

Assessing physical risk models and datasets

Having laid the groundwork for understanding the evolving implications of physical risk for assets and the financial markets, the next logical question is how to integrate this risk into investment decisions.

One challenge is that climate models, developed for scientific purposes, cannot be readily applied to assess physical climate-related financial risks. Several key limitations[15,16,17] exist:

- **Climate patterns tend to have a non-linear and chaotic nature:** So climate modelling is challenged by a high degree of uncertainty.
- **Insufficient understanding of extreme events and tipping points:** Climate models are not designed to predict weather and struggle to accurately forecast the frequency and intensity of extreme events that pose the most significant financial risks. They also fail to account for tipping points in the climate system, which can trigger rapid and irreversible changes.
- **Limited insights on near-term and localized impacts:** Global climate models typically operate at broad spatial and temporal scales, often lacking meaningful information for specific regions, especially over the next two-to-three decades. In general, uncertainty increases as models narrow geographic focus, extend predictions further into the future or address more complex phenomena. This makes physical risk modelling for hazards and timeframes relevant to investment decisions an evolving science that retains fundamental uncertainties.
- **High uncertainty for corporate and financial decision-making:** Each model carries inherent uncertainties, shaped by natural climate variability, feedback mechanisms, model structure, and emission scenarios. This overall uncertainty, particularly when forecasting at fine spatial scales or over shorter time frames, currently limits the usefulness of climate models for financial decision-making.

Many of these uncertainties cannot be entirely modelled away, creating challenges for precise risk assessments. These uncertainties also translate into misaligned datasets and unreliable physical risk assessments.

Due to demand, the data ecosystem for physical risk continues to expand.[18] The UN Environment Programme Finance Initiative has identified approximately 65 climate risk tools for financial institutions covering physical (or integrated) risk.[19] The data provided across the spectrum covers acute and chronic physical risks, is available at asset, company or country level, and includes hazard maps, frameworks, forecasts, ratings, composite scores and more. Although the database of providers is by no means exhaustive, it highlights the broad branches of the data ecosystem, and potential for varying methodologies and conflicting results on physical risk data.

From 2023 to 2024, Nest partnered with researchers at the Oxford Sustainable Finance Group and UK Centre for Greening Finance and Investment to analyze, test and incorporate different physical climate risk datasets and tools across their portfolios. As part of this work, we assessed the suitability of 10 vendors/products for analyzing physical climate risks in a global equities portfolio. Based on the methodology documentation we had available, we looked at four product features:

- Is the analysis performed at the asset-level based on location and spatially explicit datasets?
- What type of climate or hazard models are being used?
- Is the uncertainty in the model quantified?
- How clear and transparent is the communication around the methodologies?

15 Climate Services: The Business of Physical Risk by Madison Condon l SSRN
16 Business risk and the emergence of climate analytics l Nature Climate Change
17 Acute climate risks in the financial system: examining the utility of climate model projections l IOPscience
18 www.ft.com/content/f6c4a0a9-1cd3-4be5-abd7-40fb64c902c9?accessToken=zwAGJGz9rE9gkdP2xKCpHNNL5dOr10D7ZMkCyQ.MEUCIQDqTgx7xep6mPmkLWW8ZncEQ4vhNvKD-wWr8vFopKtfFQIgXcVV20fdBY-BAiSOFGHq72zxiGZILEQKJ3Kptrfwl9g&sharetype=gift&token=e11f84ed-2ce9-4a0c-8c24-c63994d19c16
19 www.cgfi.ac.uk/wp-content/uploads/2022/12/CFRF-Climate-Risk-Product-Providers-database-December-2022.xlsx

Our assessment showed that most, but not all, vendors performed their analyses at the physical asset level. We did find significant variation in the type of climate/hazard models used, and the (risk) modelling approaches overall across vendors. Additionally, only very few vendors seem to acknowledge and quantify the uncertainties within their outputs. The methodology information available from most vendors is insufficiently detailed or transparent to allow for meaningful interpretation of the product outputs. Most data providers also do not offer physical risk estimates with confidence intervals. This transparency is necessary for users to understand the degree of uncertainty around the estimation methods.

Table 1: Review of physical climate risk vendors and products

Vendor	Asset-level analysis	Climate/hazard models	Uncertainty	Transparency
Vendor 1	No	Coupled Model Intercomparison Project (CMIP) models[20]	Unknown	Low
Vendor 2	Yes	Combination of global models and bespoke peril models	Quantified	High
Vendor 3	Yes	Climate conditioned catastrophe models	Unknown	Unknown
Vendor 4	Yes	CMIP models	Not quantified	Medium
Vendor 5	Yes	Combination of observed past hazards and future global models	Unknown	Weak
Vendor 6	Yes	Bottom-up modelling approach	Not quantified	Medium
Vendor 7	No	Top-down modelling approach	Not quantified	Low
Vendor 8	Yes	Combination of CMIP models and other open hazard/risk models	Distribution	High
Vendor 9	Yes	CMIP models + other open hazard/risk models	Not quantified	Medium
Vendor 10	Yes	Downscaled global models	Unknown	Medium

20 www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained

Case study: Physical risk analytics in practice

Going beyond this cross-sectional comparison, UBS AM examined the consistency of results between two physical risk data providers[21], hypothetically referred to as Data Provider A and Data Provider B. Data Provider A produces the Climate Value at Risk (CVaR), while Data Provider B produces the Physical Risk Exposure score and the Financial Impact score.[22] We assessed the correlation of the CVaR against the Physical Risk Exposure and Financial Impact score data on a FTSE Developed universe. Our hypothesis was that companies with higher exposure to physical risk should exhibit high corresponding CVaR, and high financial impact scores.

Our analysis revealed a positive, albeit moderate, correlation of 7.17% between the CVaR and Exposure scores. However, when we analyzed the relationship of the CVaR with the Financial Impact score the correlation shifted to a negative 14.79%.[23]

The findings are instructive, signalling that despite improvements in physical risk projections over the years, there are still gaps in convergence and data quality. This divergence is also highlighted in a study[24] comparing six physical risk scores from different providers. The results underscore the challenge of reconciling different risk projections that are influenced by varying assumptions and models.

Moreover, the sampled data providers also exhibit inconsistent terminologies and metrics, further complicating comparisons and the selection of the best fit for a robust risk management strategy. A study from the World Resource Institute (WRI)[25] corroborates this perspective, noting how the lack of standardized metrics and comprehensive methodologies leads to varying results among data providers.

While concerns about physical risk data often focus on data vendors, individual firms are also culpable, given that patchy asset disclosures and inconsistent reporting standards contribute significantly to these shortcomings. For instance, information of physical assets' location and operational characteristics are often not reported. This could lead to data vendors not having the right inputs for physical risk assessments. As an example, one public South Korean industrial firm believed to operate assets across 200+ locations has no assets disclosed in our data vendor's database.

For physical risk assessments at the country level (e.g., a sovereign debt portfolio), there is an alternative based on open-source data (e.g., NASA Earth Observation (NEO) or Copernicus Climate Data Store (CDS)). However, it is more challenging if the aim is to link global weather hazards with company level data (i.e., model the impact of weather hazards on the financial positioning of a company).

Another key limitation observed is that physical risk data primarily focuses on the total amount of risk a company faces (based on the location of its assets), but does not consider how companies are adapting or building resilience, resulting in an incomplete view of actual risk. Consider a data center investing in infrastructure hardening and resilience, while also collaborating with their insurance partners to identify and implement the right adaptation interventions for assets in high-risk locations. This asset is less sensitive to physical risk events vs. another asset in the same location that is not investing in these measures. However, current datasets currently fail to incorporate this resilience into their exposure and impact metrics for the company.

Finally, physical risk datasets cannot account for the second- and third-order effects of climate impacts. For example, in the US, 32% of the average single family mortgage payment in 2024 went to property taxes and home insurance, the highest rate ever.[26] The broader macroeconomic and inflationary implications of constrained insurance coverage and rising premiums are poorly understood.

21 The choice of these two data providers was mainly determined by the data coverage against a global equity benchmark in addition to UBS existing access to the datasets.
22 CVAR measures climate related valuation impacts from climate hazards. The physical risk exposure scores measure point-in-time risk exposure at the asset and enterprise level from climate hazards, while the financial impact measures the costs linked to damages from those hazards.
23 The 2030 Medium Impact scenario was used for both Exposure and Financial Impact scores.
24 Hain, L.I., Kölbel, J.F., Leippold, M., 2021. Let's Get Physical: Comparing Metrics of Physical Climate Risk. www.papers.ssrn.com/sol3/papers.cfm?abstract_id=3829831
25 World Resource Institute – Assessing Physical Risk from Climate Change.
26 www.wsj.com/economy/housing/home-insurance-property-tax-vs-mortgage-cost-43ab76ed

These limitations make applying current physical climate risk models and analytics for investment decision-making vulnerable to unintended consequences such as[27]:

- **Mistaking numerical precision for accuracy:** The granularity of numerical outputs could obscure the broader, systemic risks posed by climate change. Detailed outputs from models can create a false sense of certainty, leading users to trust the models more than they should.
- **Presenting a skewed view of risk:** Since future climate outcomes cannot be tested against current model predictions, the precision of these models can mislead users into assuming greater accuracy.
- **Risk of misallocating capital:** Investors might incorrectly believe they understand and are mitigating risks. Based on incomplete or inaccurate assessments, investors could prematurely withdraw or invest capital in the "risky" areas, foregoing returns and exacerbating the vulnerabilities of companies or regions.

This does not mean that investors should not heed the latest climate science when looking to understand physical climate risk in their portfolios. Integrating the latest scientific insights available is the only way forward, but we need to acknowledge that this is an evolving field with inherent uncertainties, and requires continuously refining models and solutions.

Figure 2: Why integrating physical risk in a portfolio is important

Proactive risk identification
Despite its flaws, physical risk data serve as a crucial tool for identifying climate related threats, enabling investors to take preemptive actions before the risks materialize thus preserving portfolio value.

Enhanced portfolio resilience
Incorporating physical risk metrics albeit imperfect, allows investors to fortify their portfolios against future disruption. Hence, achieving a more robust balance by mitigating vulnerabilities across sectors and geographies.

Adaptive investment strategies
As physical risk data continues to evolve, forward-looking strategies that already capture signals from this data would also be well positioned to benefit from the incremental advancements in precision of the data.

Alignment with evolving regulation
As regulations become increasingly demanding, a portfolio integrated with physical risk metrics potentially keeps it compliant with emerging disclosure standards.

Source: UBS Asset Management

27 www.wsj.com/economy/housing/home-insurance-property-tax-vs-mortgage-cost-43ab76ed?st=WEbTrL&reflink=article_copyURL_share

It is necessary to understand the methodologies and limitations of climate analytics solutions and gaps in data.

All solutions make methodological choices, and with climate change projections, uncertainty is unavoidable. How we address and interpret this depends largely on the specific use case. Data providers are essential in enabling investors to accurately assess physical climate risk. Given the inherent uncertainties, it is crucial for providers to enhance the clarity and consistency of their analytical models and data related to physical risk events by:

- **Increasing transparency:** Clearly articulating methodologies, underlying assumptions and inherent limitations. As our analysis demonstrates, numerous physical risk datasets have opaque models and assumptions, hindering usability and interpretation for data consumers.
- **Promoting standardization:** Collaborate pre-competitively to improve the consistency and comparability of model outputs. Variations in risk sensitivity estimates may be justified at the asset level due to the availability of data. However, investors should be able to expect to see broadly consistent outcomes at sector and regional levels. Any deviations should be accompanied by clear methodological explanations. Vendors must standardize and align core assumptions to ensure coherence in outcomes.
- **Integrating resilience metrics:** Incorporate resilience metrics into datasets to provide a comprehensive and holistic understanding of risk exposure which factors adaptation interventions. Currently, adaptation interventions, even when reported, lack standardization, impeding measurement. However, the insurance industry offers valuable guidance. For example, Swiss Re has developed resilience indexes that assess resilience to shocks and catastrophes by analyzing the uninsured or unprotected resources required for full risk mitigation. They have also created a benefit-to-cost ratio metric to enhance transparency and comparability of adaptation projects.[28] Vendors can explore whether these methodologies can be transferred to analytical models on climate risk for public market portfolios.

Case study: AI's impact on extreme weather predictive analytics and the implications for data providers

AI is revolutionizing extreme weather forecasting by enhancing accuracy and speed. Machine learning models analyze vast historical datasets to identify complex patterns. Google DeepMind's GenCast outperformed the European Centre for Medium-Range Weather Forecasts (ECMWF) in 97.2% of cases, reaching 99.8% accuracy beyond 36 hours.[29] Huawei's PanguWeather model, trained on 40 years of data, also matched and exceeded traditional methods. AI-driven "nowcasting" (rather than forecasting) further improves short-term weather predictions.[30,31]

Companies are already using AI-driven insights for real-time decisions and long-term strategic planning, including investment and site selection.[32] For investors, this necessitates more precise climate risk assessments. For climate risk data providers, there will be growing demand to incorporate real-time, AI-powered analytics and/or more granular, localized weather-related risk assessments into their offerings. Another implication may be the need to offer tailored solutions to specific industries or asset classes to reflect the nuances of AI-driven forecasts.

28 www.swissre.com/risk-knowledge/risk-perspectives-blog/climate-resilience-adaptation-measurement
29 www.deepmind.google/discover/blog/gencast-predicts-weather-and-the-risks-of-extreme-conditions-with-sota-accuracy
30 www.cfr.org/article/world-faces-sharp-rise-extreme-weather-can-ai-help
31 www.thenationalnews.com/news/uae/2025/01/29/nowcasting-how-ai-is-reshaping-weather-forecasts
32 www.icef.go.jp/wp-content/uploads/2024/11/ICEF-AI-Climate-Roadmap-Second-Edition-2024.pdf

Integrating physical risk data into global rules-based equity portfolios

The UBS Climate Aware methodology enables the development of systematic rules-based strategies that, for instance, provide exposure to global equities while managing risks and opportunities associated with the transition to a low-carbon economy. This methodology sits at the intersection of sustainable investment and climate action, built on three pillars: mitigation, adaptation, and transition. It integrates both quantitative and qualitative metrics for a multidimensional, forward-looking approach.

Our current methodology primarily focuses on mitigating climate transition risks while enhancing exposure to current and emerging climate technologies. We initially did not consider physical risks for two reasons: a) our emphasis was on transition risks, and b) we believed it was prudent to wait for improvements in methodologies addressing physical risks.

However, growing evidence suggests that meeting the 1.5-degree decarbonization targets is unlikely, making it increasingly important to prepare for a probable rise in weather hazards and the associated financial losses from physical risks.

In this context, this section outlines our key thoughts and challenges as we research how to systematically incorporate physical risks into our rules-based strategy.

- First generation physical risks models (e.g., **exposure related**) tend to have a bias towards large companies with operations spread in multiple locations (e.g., high-emitting industries such as oil and gas, mining and utilities). Thus, a strategy that seeks to reduce the carbon footprint of the portfolio (typically high intensity companies in these same sectors) tends to indirectly mitigate exposure to physical risks. We investigated the correlation between the Scope 1 carbon intensity and physical risk exposure scores and found a positive relationship of 0.64 between the two variables, illustrating the strong parallel between the activities of high-emitting sectors and their vulnerability to physical climate change events. Table 2 highlights this as the three highest emitting sectors also face high physical risk.
- In second-generation models that focus on **financial exposure**, the correlation between industries and physical risk events appears to break down. Multiple sectors, beyond high-emission industries, are showing significant financial impacts from these events. As a result, a climate strategy can alter relative exposures to industries typically not considered carbon intensive, such as the insurance sector. This necessitates careful consideration of risk allocation (e.g., ex-ante tracking error) between transition and physical risks, as trade-offs may arise. A hierarchical approach is essential for allocating risk across different climate risks. Additionally, attributing returns or risks in a climate strategy over various investment horizons may face challenges in disentangling the contributions of transition and physical risks.
- **Unintended biases or risks** related to country, region (developed vs. emerging markets) or industry (e.g., cruise lines), among others, need to be considered when incorporating physical risks into an investment strategy.
- Physical risks can be seen as **risk mitigation** or protection ('insurance') against tail risks associated with extreme weather hazards. Thus, physical risks can be implemented via negative tilts or exclusion of companies screened out for high exposure to physical risks. Transition risks consider both **opportunities** (e.g., climate technologies) and **risks** such as carbon taxes from the investment thesis point of view. Thus, positive and negative tilts tend to be available for a climate strategy design. While adaptation and building resilience to physical risk presents opportunities, the industry is still assessing metrics for this.

Despite the positive progress in physical risk methodologies (e.g., 1st and 2nd generation), integrating physical risk data in a systematic data-driven investment process remains challenging from two perspectives:

A. Models simply compute exposure or financial risks related to climate hazards on a company's physical assets. However, they do not incorporate the **resilience or adaptation measures** and policies that companies can take (or have taken) to mitigate physical risks. Currently, this data is qualitative in nature and not available for many companies (e.g., global equities context).

B. The data does not incorporate physical risks transmitted through the **supply chains**. The COVID-19 pandemic has shown the significance of supply chain disruption and the hidden risks in a highly interconnected world.

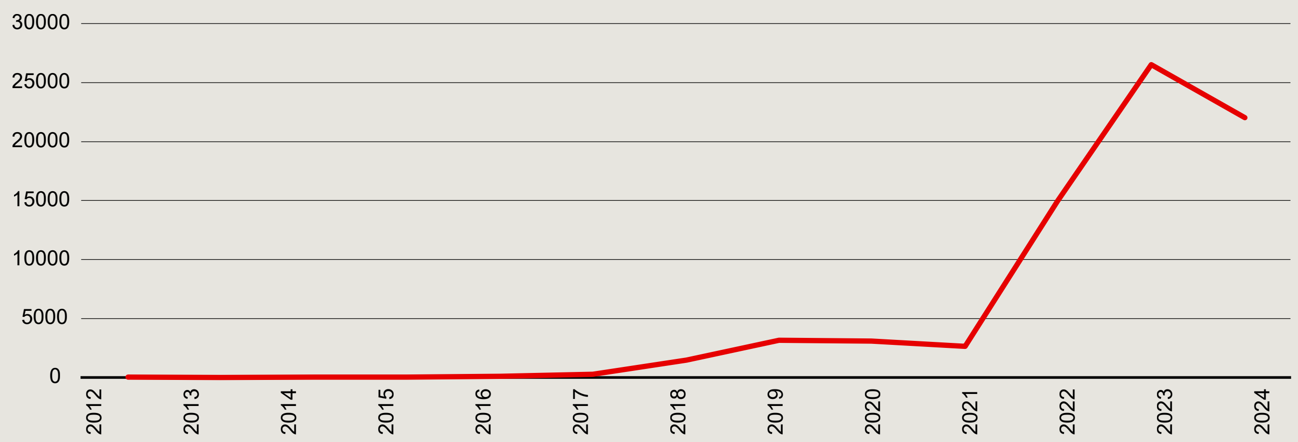
Artificial Intelligence and/or machine learning tools can help to overcome these limitations (see case study using AlphaSense). This is a path for future research.

We believe it is important to incorporate the management of physical risks into our engagement program for climate strategy. The qualitative and targeted nature of our engagement allows for a more effective integration of these risks. We will discuss this topic further in the next section.

Case study: AlphaSense

AlphaSense uses machine learning techniques to retrieve and process data from natural language and unstructured information embedded in key company documents e.g., earnings transcript, ESG reports. The chart illustrates the historical mentions and references to these keywords ('physical climate risk'. 'climate adaptation', and 'climate resilience').

Figure 2: Trend chart of keyword mentions



Source: AlphaSense, as of 31 October 2024

Table 2: Carbon intensity vs. physical risk exposure

Sectors	Carbon intensity scope 1 (average scores)	Physical risk scores (average scores)
Utilities	13.01	38.95
Energy	5.01	35.86
Basic Materials	4.49	40.92
Industrials	1.24	29.70
Consumer Discretionary	0.58	29.89
Consumer Staples	0.44	31.31
Technology	0.19	23.79
Real Estate	0.18	32.83
Health Care	0.14	26.40
Telecommunications	0.05	22.96
Financials	0.04	13.15

Source: Trucost, as of 30 September 2024

The integration of physical risk into strategic asset allocation

Impact on growth:

Extreme weather events generally have a negative effect on economic growth, by damaging infrastructure, displacing labor and reducing productivity. For example, projections suggest that climate change could displace 62 million working-age people over the 21st century.

Impact on inflation:

While extreme weather events like hurricanes have a small average inflation effect, it can be significant for severe events. Weather-driven food price shocks have been shown to significantly influence inflation in the eurozone. Overall, inflation may become more volatile, especially in regions prone to frequent extreme weather events.

Impact on interest rates:

The increased probability of natural disasters and the resulting volatility in output may raise the risk premium, leading to higher financing costs for firms and lower demand for capital, which in turn lowers equilibrium interest rates. Additionally, physical impacts of climate change can lower productivity by diverting investment towards abatement rather than productivity-enhancing technologies, further reducing firms' demand for capital and pushing down interest rates.

Nest has started using a well-known portfolio management application that incorporates physical risk metrics to help us better identify potential risk hotspots across portfolios. This climate risk assessment is now included in the asset class dashboard reviewed by Nest's asset allocation committee on a monthly basis.

The physical risk assessment uses the Intergovernmental Panel on Climate Change (IPCC) scenarios, which show different pathways and different levels of temperature rises to 2100 and what this means for physical climate risk. The model covers a number of key hazards including temperature, tropical cyclones, sea level rise and inland flooding and wildfire and assesses impacts on both macro variables (such as GDP, employment and mortality) as well as micro variables (such as energy expenditures or crop yields). Both revenue and operation risk is evaluated for corporate operations. For sovereigns, climate risk is assessed at geographic area level and aggregated to country level.

The data suggests that equities are most exposed to physical risks, with emerging market equities more exposed to physical risks in particular than developed market equities. The main impacts from physical risks are revenue impacts from increasing temperatures. The biggest sectoral physical risk exposures across Nest's portfolio are in consumer discretionary, industrials and information technology. Due to their high allocation to equities, the Nest Higher Risk and Sharia fund choices have a higher exposure to physical climate risks than the default fund.

As highlighted above, there are several challenges with using this type of data due to the complexity of the models and the assumptions used. But while it's important to treat the numeric outputs with some caution, these scenarios can still be helpful for investors to understand relative risk across asset classes. Frameworks, such as the climate resilience framework being developed by the Institutional Investor Group on Climate Change (IIGCC), seek to build out additional guidance for asset owners embedding physical risk assessments into any asset allocation process.

Integration of climate risk into research and stewardship

In 2023, UBS AM integrated physical risk metrics from third-party vendors including S&P Trucost into our investment management processes for active investments. This metric combines various climate hazards such as coastal flood, drought, extreme cold, extreme heat, fluvial flood, tropical cyclone, water stress, and wildfire, weighted by the asset's sensitivity to each hazard. The score varies according to four future climate change scenarios and time horizons. We use metrics reflecting a "moderate" climate change scenario for the year 2030, which aligns with typical investment horizons and the ongoing energy transition.

These metrics are incorporated into our proprietary ESG Risk Dashboard, which generates a risk signal across several ESG risk dimensions, including physical risk. We conduct a bottom-up assessment of highest risk issuers to understand their exposure to and management of physical risk events. Fundamental analysts integrate this research into their holistic ESG assessment of the issuer, providing a forward-looking view that informs portfolio manager investment decisions. Where relevant, we may also apply these insights across additional asset classes.

If physical risks warrant engagement, we initiate dialogue with the investee companies, and these cover companies in our active and rules-based portfolios. To enable our research and engagement, we have developed a systematic process to assess physical risk exposure and climate adaptation and resilience. This process helps us understand how companies assess and manage risks and opportunities linked to climate and weather extremes associated with current and projected temperature increases.

Figure 3: UBS AM research process on issuers that demonstrate high risk exposure on physical risk metrics

Risk assessment

01 Geographic asset footprint of the company mapped to location-based physical risk exposure (real-time future)

02 Sector-specific considerations and vulnerability to specific physical risks (real-time and future)

Company awareness, management

03 Awareness and qualification of risk

04 Mitigation/opportunities identified can offset increased costs

Final assessment

05 Reflection/summary

UBS AM research process on issuers that demonstrate high risk exposure on physical risk metrics

When conducting research on issuers, we consider the following parameters:

Risk assessment:

– **Concentration of risk:** Is the company vulnerable to any level of concentration risk by geography, sector or climate hazards?

Risk awareness:
– **Identification:** Does the company identify physical climate risk impacts?
– **Time horizon:** Over what time horizon does the company assess its risk impacts?
– **Material assets:** Does the company disclose the geolocation and business segment of its most material assets?
– **Recent weather impacts:** Does the company disclose information on the impacts of recent extreme weather events?

Risk management:
– **Board oversight:** Does the company clearly disclose how physical risk is discussed and overseen at the board level including a climate resilience strategy?
– **Resilience:** Does the company disclose actions and spending towards improving climate resilience?
– **Stakeholder engagement:** Does the company's risk management strategy include engagement with its upstream (suppliers), downstream (customers, key distributors) and local stakeholders (communities, local and national governments)?

Opportunity:
– **Adaptation:** Does the company disclose any products or services on adaptation opportunities?

In our research of issuers flagged as demonstrating very high physical risks, we observed that, while most companies disclose some climate risk information, the current level of disclosure is inadequate for investors to understand and manage these risks. Many companies omit critical asset-level data, and the discussion remains high level and qualitative. This poor disclosure compounds the limitations of climate models and analytics making it difficult for investors to assess companies' exposure to physical risk events and their ability to manage them effectively.

An example of leading practice:

Veolia, the French-headquartered utility and environmental services company, exemplifies best practices in reporting physical risk.

The company, which responds annually to the CDP questionnaire, quantifies the long-term financial impacts of extreme weather events on its business, as well as the costs associated with mitigating these risks, including insurance coverage, prevention, and adaptation measures. Veolia provides details on its site-level resilience and adaptation activities. Furthermore, the company demonstrates its ability to capitalize on the growing demand for adaptation and resilience capabilities across markets, owing to its expertise in water treatment, infrastructure maintenance, and technologies such as desalination.

The role of stewardship is crucial
Datasets alone do not provide a holistic view of risk. Generic future scenarios can lead to misrepresentation of risk and poor business outcomes. Information on adaptation measures is particularly needed for translating exposure to hazards into actual risk and identifying investment opportunities. Without granular, location-specific details on physical assets and infrastructure, investors struggle to accurately evaluate the potential impact of climate risks on companies and how they're working to mitigate them.

Engagement with companies can help to bridge these information gaps and drive clear expectations on disclosure. UBS AM has a long-standing climate engagement program, which we expanded in 2024 to include physical risk. We are also members of an industry working group on adaptation and resilience that is aiming to develop a standardized approach to measuring and managing climate resilience for investment portfolios.

In our discussions, we emphasise best practices for meaningful disclosure:

– **Quantify and disclose the impact of prior material physical risk events:** Companies are already experiencing the impacts of climate change, but few provide any level of systematic disclosure. For example, from January to June 2024, natural disasters in China's most critical centers of industrial activity cost nearly USD 13 billion in damages and impacted over 32 million people.[32] For individual businesses, these disasters have resulted in service disruption and infrastructure damage. Disclosing the financial impact of prior extreme weather events can help investors assess the magnitude of impact, the effectiveness of the response and whether increased costs can be managed by the firm.
– **Quantify future risks and opportunities:** Quantification of risks and opportunities can help companies allocate capital towards building resilience early on. For example, one company conducted a scenario analysis that estimated that weather-related disruptions in the medium term could be equivalent to 16 times its current earnings before interest and taxes. However, the cost to respond to these risks (including insurance, prevention and adaptation measures) was estimated as six times its current earnings. In another example, a textile manufacturer noted that a warming climate has led to stronger demand for moisture-absorbing and quick-drying fabrics, signalling an area of specialization and growth for the company.
– **Taking a value chain approach:** Physical risk metrics often only consider operational impacts. However, companies should disclose all relevant risks across the value chain. For example, drought can have a significant impact on feed and commodity prices, impacting already squeezed margins for the consumer staples sector.[34] Research has found that heat negatively impacts the financial performance of suppliers, and this effect ripples through supply chain connections to customers.[35] Additionally, firms tend to sever relationships when adverse weather conditions at their suppliers' locations become more frequent. This clearly underscores the importance of this issue for supply chain resilience. Climate risk analytics do not account for these vulnerabilities as they typically focus on hazard exposure within company operations, such as buildings and factories. Companies must disclose systemic and supply chain vulnerabilities to provide a comprehensive view of their risk exposure. Assessing the impact on employees and communities: High temperatures significantly reduce productivity and overall economic output.[36] Extreme heat impairs cognition, learning, and task performance. Hurricanes and coastal storms can cause injuries and spread hazardous chemicals and pathogens due to facility damage, storm surge, and flooding. Companies must understand the impact of physical risk events on their key stakeholders, including employees and the communities in which they operate.
– **Implications on insurance coverage:** Extreme weather events have strained insurance coverage, leading to increased premiums, coverage cuts and regional exclusions.[37] For example, in APAC, only nine percent of the economic damages from climate risk events such as flooding and drought were covered by insurance.[38] Companies should discuss their current insurance coverage and future expectations to help investors understand their level of protection.
– **Reporting to platforms such as CDP:** Standardized reporting platforms, such as CDP, can help companies improve the content and quality of their physical risk disclosures.

33 www.reuters.com/world/china/natural-disasters-china-caused-13-bln-economic-loss-january-june-2024-07-12
34 www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=108718
35 www.academic.oup.com/rfs/article/37/6/1729/7467073
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37 www.washingtonpost.com/business/2023/09/03/natural-disaster-climate-insurance/
38 www.insurancebusinessmag.com/asia/news/catastrophe/aon-unveils-economic-impacts-of-natural-disasters-on-apac-region-483548.aspx

Case study: How engagement helped us better understand the impact of increasing hurricane risk on cruise lines

Cruise lines are increasingly vulnerable to physical risks, particularly from hurricanes and coastal flooding. Research on the sector highlights growing concerns regarding the frequency and intensity of hurricanes, especially in the Caribbean, which is the world's largest cruise market. "Hurricane Alley," an area including Southern Florida and popular US ports such as Miami and Fort Lauderdale, sees frequent storms due to rising sea temperatures. Events like Hurricane Harvey (2017) and Irma (2017) have demonstrated how hurricane activity can disrupt cruise operations, leading to port closures and significant rerouting costs.

Data suggests that hurricanes increase the operational costs of cruises by up to 25%, primarily due to additional fuel consumption. Moreover, these events can negatively impact critical services such as food supply and overall port operations, threatening profitability. Despite this, the cruise industry's current disclosures remain vague, often offering high-level commentary on mitigation strategies without concrete, specific measures.

To gain deeper insight, we engaged with key industry players, who emphasized their sophisticated storm monitoring systems and weather-tracking capabilities. While they acknowledged increased extreme weather events, they highlighted improvements in storm preparedness, which have mitigated financial impact. However, the industry's overall transparency on weather-related risks and their management needs enhancement.

While cruise companies have made strides in managing hurricane risks, more detailed reporting on risk exposure and mitigation strategies is needed. Our engagement allowed us to communicate these expectations and gain further clarity on how companies address these challenges.

Where next?
Data is undoubtedly our friend as we continue the journey towards a low-carbon economy. Climate data allows investors to get a better handle on the financial risks and opportunities of our everchanging climate and gain insights on the financial impacts of acute and chronic physical risks on assets, ultimately helping investors to inform decision-making. Yet even the best of friends come with limitations. Data as we currently have it is limited, not transparent enough, and heavily reliant on estimations. Still, as the famous statistician, George Box, once remarked "All models are wrong, but some are useful". We cannot be complacent while waiting for the wave of more robust and reliable data. The biosphere is evolving in ways that are simultaneously predictable and unpredictable. We must commit to using the best available data and models, as well as upholding their integrity and influence on key decision-making.

The future is bright on the climate-data front with advancements in AI and machine learning tools (such as AlphaSense and Google DeepMind's GenCast for AI-driven forecasts) and more developed frameworks (such as the IIGCC's climate resilience framework). More reliable data may help us navigate through the various challenges our rapidly changing climate will throw up, both in terms of physical and transition risks. In the meantime, we reiterate the importance of market participants to focus on the following:

- Data providers must continue to enhance the clarity and consistency of analytical models and data on physical risk events
- Companies should quantify and disclose risks in a granular and robust manner, including:
  - Supply chain resilience assessments
  - Climate hazard exposure analyses with resilience or adaptation measures incorporated to mitigate physical risks
- Capital markets and regulators must adopt a standardized approach to integrating physical climate risk
- Investor engagement on physical risk must expand

This paper attempts to add useful insight on the challenges facing investors in comprehensively undertaking physical climate risks assessment across their portfolios. We highlight the developments needed in data to best support the needs of investors in managing these important risks and to inform investment decision making which we hope readers find helpful.

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