Insights
Environmental, Social & Governance (ESG)

December 2022

Historical Reprint

Physical Climate Risk Data: A Primer and Evaluation

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A wide range of environmental, social, and governance (ESG) data vendors are now providing physical climate risk data in addition to traditional carbon data. In this piece, we discuss how this development of data — which has just landed in the ESG space within the last few years — can be acquired and used by investors. We also provide insights into the current shortfalls of physical climate risk data; like many types of ESG data, conclusions must be drawn with a critical eye and standardization is lacking across vendors. We believe that this information can indeed be used, in conjunction with other climate inputs, to drive investable strategies, but users need to be aware of the substantial differences that can arise from leveraging one vendor over another, or from focusing on a particular scenario or set of criteria.

What is Physical Climate Risk Data?

Certain backward-looking climate data, such as carbon emissions, have been available for decades, for a subset of public entities. However, climate data has recently seen a significant uptick in interest, thanks to new and upcoming environmental regulations, and the development and release of numerous groundbreaking forward-looking datasets and tools, such as physical risk, transition risk, and temperature scores (see Examining the Properties of Forward-Looking Climate Metrics).

Physical climate risk data is powerful forward-looking data that measures physical risk, which broadly encompasses the quantification of a company or country's exposure to natural catastrophes that could be reliably tied to climate change and a warming environment. Climate change in turn can impact real assets, buildings, infrastructure, workforce productivity, and other similar real-life elements. For companies issuing debt or equity, physical risk levels may vary depending on the issuer's financial profile and its exposure to geographical risks, including where the company operates, the total value of its assets, and the countries in which it generates revenue. Climate- and weather-related hazards can have a financial impact on a company at both the operational and the market level, and can lead to negative financial stability or abrupt loss in value and productivity during operations and normal business activities.

Many types of climate-related negative events and natural catastrophes are captured by most of the leading climate data vendors in the market. These events include:

- Droughts
- Tropical cyclones and hurricanes
- Heat stress
- Wildfires
- Coastal or river floods
- Cold waves
- Water stress

Some of these events can be categorized as acute, or short-term and sudden, while others are chronic, taking a long time to worsen. Acute risks occur from rare natural catastrophes such as cyclones and wildfires, and can be considered individual, distinct occasions. Chronic risks like extreme hot or cold manifest primarily via reduction in labor productivity or production processes efficiency.

Acquiring and Understanding Vendor Data

Physical Climate Risk Metrics

ESG data vendors have launched a bevy of tools and datasets to try to capture companies' exposure to climate risk. Some have also tried summarizing those risks and their impacts on companies' bottom lines by distilling the information into numerical scores and ratings

Unlike other types of climate data, physical risk is normally calculated from the bottom up, focusing on exposures at the asset level (buildings, infrastructure, and other real assets). This is due to the importance of a company's physical assets and their geographical location. Intuitively, companies with the majority of their real assets located in areas plagued by significant climate hazards are more likely to be severely and negatively impacted by climate-related financial losses when compared to firms with assets situated in low-risk geographies.

Most vendors adopt the bottom-up, real-asset-level approach when estimating physical risk for a particular company or portfolio; however, not all of them currently provide expansive, granular, asset-level input data. Instead, some vendors prefer to disclose only high-level results. All of the vendors, however, deliver physical risk scores that reflect the expected sensitivity of each company to several key climate hazards.

Physical Climate Risk Vendor Methodologies

Three of the leading climate data providers in the market are S&P Trucost, MSCI, and ISS. Below, we outline the main features of their physical climate risk tools and analyze the key differences in their approaches and results. All three vendors tackle similar types of physical risks and climate hazards, and all employ similar IPCC RCP pathways.[1] But they measure physical risks in different ways. While S&P Trucost and ISS use 0–100 scores to identify risks associated with various types of weather and climate hazards, MSCI prefers to rely on "Climate Value-at-Risk" metrics, which are expressed as percentages of the value of the companies themselves that would be lost due to specific climate hazards.

All three vendors utilize bottom-up models to locate hundreds of thousands of real assets, buildings, machinery, and infrastructure, as well as assess their corporate ownership. These efforts allow the data providers to aggregate asset-level results and consolidate them at the company level. However, the models employed to detect and categorize those assets are complex and include proprietary information, calculations, and methodological choices. Only a small subset of the predominant vendors in the market are currently releasing raw, asset-level results. The majority are instead only allowing downstream users of the information to access the aggregated company-level metrics.

Figure 1

Differences and Similarities in Vendors' Methodological Approaches to Physical Risk Modeling

Vendor	ISS	S&P Trucost	MSCI
Hazards/Extreme Weather Data Collected	Tropical Cyclones	Tropical Cyclones	Tropical Cyclones
	Coastal Floods	Coastal Floods	Coastal Floods
	River Floods	River Floods	River Floods
	Wildfire	Wildfire	Wildfire
	Heat Waves	Extreme Heat	Temperature (Heat)
	Drought	Drought	
		Water Stress	River Low Flow
		Extreme Cold	Temperature (Cold)
			Snow
			Wind
			Precipitation
Model Foundation*	IPCC5	IPCC6	IPCC5
Max Model Year	2050	2100	2100
Scenarios**	RCP 4.5/8.5	Four Climate SSPs	10 Scenarios (IPCC and NGFS)
Asset-level Data	Yes	Yes	Yes
Physical Risk Model Method***	Aggregate Financial Costs	Aggregate Costs	Aggregate Financial Costs
Coverage (# of Companies)	15,000	20,000	25,000+
Coverage (# of Assets)	250,000+	2,200,000+ (870,000 available to downstream users)	Almost 500,000
Proprietary Rationale	Two buckets: operational and market risks, and focus on both likely and worst-case scenarios	8 hazards, 8 time horizons, and 4 scenarios	10 climate scenarios, focus on both an average and an aggressive scenario, and two types of exposure: asset value exposure to direct loss, and business interruptions
Numerical Outputs	0–100 physical risk score and management score, as well as value-at-risk results and financial risk measures	Company-level percent of assets at risk, and exposure scores	Value-at-risk results

Source: State Street Global Advisors, as of September 30, 2022.
* This refers to Intergovernmental Panel on Climate Change assessment cycles, with vendors leveraging either the fifth or sixth IPCC assessment reports.
** This refers to greenhouse gas (GHG) concentration trajectories and pathways that explore a range of future, plausible climate outcomes.
*** This refers to the way the vendors' financial modeling processes aggregate losses and market changes into a representation of how the financial impacts affect the value of the company.

Comparative Analysis and Empirical Results

A key difference that is quickly noticeable in Figure 1 is that company coverage varies between 15,000 and almost 25,000 global issuers. Coverage tends to be strong for developed markets and large-cap universes, and it trails off slightly for smaller companies and emerging markets.

Other key differences among providers' approaches to physical risk modelling are tied to their choices of scenarios, climate pathways, and time horizons; their use of different databases and estimation models to collect information and generate details on asset-level results; and the fact that vendors tend to focus on slightly different kinds of climate hazards.

However, our data showed an even more striking outcome: When viewing the correlation coefficients between the physical risk scores of the three vendors, we found no correlation between the scores across the vendors. Differences in bottom-up collection of information, as well as in the inputs and rationale employed to power the three models, lead to extraordinary discrepancies in scores and company-level results among the different vendors. That means that the decision to use one data provider's results versus another's could have significant repercussions on the measured risk characteristics of a particular universe or portfolio.

Another key highlight is the fact that that only a minority of companies seem to be subject to significant climate risks, whereas the majority of holdings tend to display no or minor exposure to climate hazards. It is also interesting to note that, as is often true of other ESG ratings, scores seem to be "biased" in favor of large-cap universes and developed markets, with smaller companies and firms in developing markets tending to be rated lowwer and deemed to present heightened risks and increased climate hazards.

Below, we examine the global regions that seem to be the most and least affected by climate risks, starting with countries most adversely impacted. We aggregated companies from the MSCI ACWI universe by country and calculated average results at the country level (Figure 2).

Figure 2
Vendors Designate Different Countries as Most and Least Impacted by Physical Climate Risks

MSCI	S&P TRUCOST	ISS
Most Impacted		
INDONESIA	QATAR	MALAYSIA
HONG KONG	EGYPT	EGYPT
PHILIPPINES	UNITED ARAB EMIRATES	PHILIPPINES
THAILAND	ISRAEL	INDONESIA
MALAYSIA	NORWAY	THAILAND
TAIWAN	NETHERLANDS	CHINA
Least Impacted		
SWEDEN	MEXICO	HUNGARY
AUSTRIA	SOUTH AFRICA	AUSTRIA
LUXEMBOURG	NEW ZEALAND	POLAND
SWITZERLAND	AUSTRIA	GREECE
NEW ZEALAND	CANADA	NEW ZEALAND
DENMARK	AUSTRALIA	CANADA

Source: State Street Global Advisors, as of September 30, 2022. Based on average physical risk scores from MSCI, S&P Trucost and ISS.

Vendors provide different results when evaluating physical climate risks from a country-specific lens. MSCI and ISS indicate that APAC-region countries are the most adversely impacted by climate risks, whereas S&P Trucost implies that MENA-region countries are at high risk. MSCI and ISS indicate that the least risky countries are located predominately in Europe, whereas the countries that S&P Trucost identifies as low risk are scattered across the globe.

Use of Physical Risk Data in an Investment Context: Opportunities and Challenges

As previously mentioned, physical risk data can be employed to inform various types of climate-related reports and can be included in environmental risk management systems. Different vendors also offer several possibilities to utilize their physical risk data for portfolio construction and investment management purposes.

- **Tilted Strategies** The first possibility is to leverage overall physical risk scores to potentially create tilted or optimized strategies that would overweight companies with high ratings (i.e., companies with assets in low-risk environments, or companies managing climate hazards successfully), and discount firms with low ratings (i.e., those operating in risky geographical locations and with assets that would be particularly at risk).

- **Estimated Risks** An alternative approach would be to leverage the vendors' value-at-risk functions and toolkits to estimate the change in share price of holdings of a selected universe or portfolio as a result of negative impacts from climate hazards and physical risks. The portfolio manager could then leverage that information in order to align the portfolio with long-term objectives, or limit exposure to risky assets.

Both of the aforementioned tactics would suffer from similar issues: (1) the necessity for asset managers and clients to trust subjective scores or forecasted results based on specific, varying scenarios and certain assumptions, and (2) the need to employ models attempting to reliably estimate extremely variable, inconsistent and uneven long-term results. By contrast, in current ESG investing practices, asset managers employ backward-looking, established results and scores based on company-reported practices or market-observed performances, risks, and opportunities. Thus, companies are scored based on their observed past and current initiatives.

In addition, investors using physical risk data must consider whether scores and performance-related metrics would need to be sector- and industry-neutral, or would need to take into account business operations, supply chains, and other industry-specific characteristics and features of companies in a particular universe. Asset managers would also potentially need to add sensitivity modifiers, such the ones employed by S&P Trucost to represent the relative sensitivity of a company to each physical risk indicator.

Picking the "right" or more trustworthy scenario,[2] period, horizon, and RCP pathway are also important steps. These decisions will also be highly dependent on the list of extreme weather scenarios available and the IPCC, International Energy Agency, or other agency-determined emissions pathways originally selected by the different vendors. To make things even more complicated, several vendors provide the ability to select alternative risk scenarios. For example, MSCI offers both "average" and "aggressive" physical risk scenarios. Additionally, asset managers would need to consider the interactions and potential additive characteristics of assets that are exposed to multiple physical risks.

It is key to understand that, because physical risk data tools are fairly new and experimental solutions, they are subject to several challenges and deficiencies, including:

- Asset location, spatial resolution, and company-level aggregation uncertainty and low-confidence estimates

- Use of assumptions, subjective scenarios, and sensitivity frameworks to weigh and assess the expected impact of climate hazards on various companies

- Lagging outcomes from climate risks, as climate is a long-term behavior of meteorological components such as temperature, precipitation, and wind. According to the World Meteorological Organization,[3] at least a 30-year horizon is required to infer trustworthy conclusions and average values that are not subjected to natural variability

- Vagueness and difficulties in determining which climate-related risks are already being captured by companies' valuations; In other words, the purpose of climate models is to identify the *additional* costs posed by climate change that is not priced in

- Limitations in the factors that physical climate risk models can account for. For instance, supply chain risks, business opportunities, and insurance coverage could prevent asset owners from incurring severe monetary losses in the event of particularly hazardous weather events. Or companies' resilience and adaptation initiatives may not be consistently and accurately captured (or even in scope) for some models

- Relative lack of historical data

Contributors/ Contact Us

Forward-looking and scenario data are a new, challenging and exciting resource for investors. Physical risk data in particular, with their focus on asset-level risks caused by climate hazards, provide users the ability to identify problematic "hot spots" and to create contingency plans to manage future risk.

Most of the leading ESG vendors currently offer comprehensive climate suites that include, alongside traditional carbon data, temperature rise, scenario analysis, and transition and physical risk metrics.

Key conclusions include:

- The vendors we evaluated reach significantly different conclusions on physical risks for the same companies and universes. Indeed, there seems to be extremely low or no correlation among their findings due to differences in methodologies, asset-level data, scenarios, and bottom-up estimation and aggregation models

- That in turn results in different countries being designated as low or high risk for various climate hazards

- All three data providers seem to agree that emerging markets, as a whole, tend to be subject to higher risks compared to developed countries. However, the actual distribution and severity of climate hazards highly differs from vendor to vendor.

Users of physical climate risk data need to be conscious of discrepancies between vendors and aware of the implications of choosing specific data and scenarios. Nevertheless, physical risk information, when used in conjunction with traditional carbon data as well as additional future-looking climate scenario tools, can help provide users with a comprehensive big picture of climate risks and opportunities for particular strategies and portfolios.

Notably, physical risk data can be seamlessly incorporated into portfolio and company-level reports, including Task Force on Climate-Related Financial Disclosures (TCFD)-aligned collateral. They can also be employed as one of the components behind comprehensive environmental risk management systems. More analysis is needed to assess the usefulness of these data for portfolio management and strategy development purposes.

Appendix

Vendor	Brief Summary and Methodological Highlights
S&P Trucost	The S&P Trucost Physical Risk dataset focuses on eight climate hazards and covers over 2 million assets, linked up to over 20,000 companies. When asset-level information is unavailable for a company, Trucost estimates the physical risk from the geographical location of the firm's headquarters and its revenue exposures in different countries. Trucost employs four future climate change scenarios based on the most recent IPCC RCPs and Shared Socioeconomic Pathways (SSPs), and informed by the TCFD technical guidelines. Trucost evaluates physical risks using a historical baseline and draws data every 10 years from 2020 to 2090. The vendor employs climate variables to calculate climate physical risk indicators. Those are outputs of the CMIP6 climate change models (The Coupled Model Intercomparison Project Phase 6 was established by the World Climate Research Program). Trucost is able to assign physical risk scores to over 20,000 companies in its universe by: 1. Assembling models and datasets representing projected (or historical baseline) risks for eight climate change hazards across four climate change scenarios and eight periods. This leads to the production of a global climate change physical hazard map; 2. Geolocating physical assets and mapping them to their respective company; 3. Assigning physical risk scores to individual assets and then calculating company-level ratings via normalization. The Trucost physical risk assessment model assigns risk scores from 1 (lowest risk) to 100 (highest risk); 4. Estimating revenue exposure-based physical risk, in the absence of asset-level data; 5. Calculating a composite score for each company in scope. That composite score is intended to provide a combined measure of company exposure to all eight climate change physical risk indicators. In addition to a composite score that equally weights all indicators for a given scenario, Trucost also offers a sensitivity-adjusted rating, which takes into account how sensitive the company is to each physical risk indicator. For example, companies with high water dependency are assumed to be more severely impacted by the physical consequences of water stress.
ISS	The ISS climate physical risk dataset covers both the current and future risk exposure of six climate hazards and natural catastrophes for around 15,000 global issuers. Those risks are assessed for both a "likely" and a "worst-case" scenario. Those two scenarios simulate how climate responds to different GHG concentration pathways in the atmosphere over time. As is the case for S&P Trucost, ISS employs granular corporate data to assess an issuer's geographical footprint. This climate physical risk solution assesses a company's exposure to physical risk by simulating the impact of different types of climate hazards on that firm's operations and sales. That assessment then enables ISS to estimate the current and future value at risk due to exposure to the identified hazards. ISS divides physical risks into two main buckets: operational and market risks. Operational risks are quantified by considering the costs of repairing or replacing assets damaged by climate hazards (such as tropical cyclones, coastal and river floods, and wildfires) and the potential loss of income that is incurred by business interruption. Additionally, ISS identifies market risks as the hazards that can put revenue at risk due to the nationwide effects of physical risk on a country's gross domestic product (such as sea-level rise, the negative effects of droughts, heat stress on crops and agricultural productivity, loss in labor productivity due to extreme temperatures, and negative health effects on humans). ISS's value at risk of a particular company uses a valuation model to estimate the potential change in share price of that company's stock after considering the combined financial impacts of physical risk. Additionally, ISS provides a more "traditional" numerical physical score, which is aimed at measuring the change in a company's financial risk relative to its GICS sector. This is computed by calculating the total change in financial risk divided by the revenue of the issuer relative to its sector. ISS also created a "management score" that shows whether a company considers physical climate risk as a component of its broader risk management strategy.
MSCI	MSCI uses physical climate scenarios and projections to outline future acute and chronic physical climate risks for over 25,000 publicly traded companies. MSCI's climate risk assessment is hybrid in nature, as both top-down and bottom-up elements are used to inform its calculations. The bottom-up nature of the model relies mainly on MSCI's Asset Location Database, which, in conjunction with the use of fundamental data, is able to pinpoint almost 500,000 individual assets, their locations, and their corporate ownership. The MSCI Physical Risk Calculation model employs three layers: • Exposure at the company facility level, which focuses on identifying the presence of people, resources, and other assets in places or settings that could be adversely impacted by climate risks. MSCI considers two types of exposure: a. Direct loss of asset value, meaning the asset might be damaged or destroyed by climate hazards and replacing it would require additional costs b. Indirect loss, meaning business interruptions which would lead to loss of value generation • Vulnerability, or the propensity and sensitivity of those assets to be affected. In order to classify vulnerability for different businesses, MSCI has developed a set of sector-specific vulnerabilities tailored to the Statistical Classification of Economic Activities in the European Union (NACE) sector classification system. • Hazard, or the probability of occurrence and intensity of extreme weather events MSCI employs IPCC RCP scenario analyses on extreme weather events to model and describe how the physical aspects of the climate system would change in response to increasing GHG emissions. Those aspects include temperature, sea-level rise, and changes in frequency and severity of events. MSCI models climate impacts through 2100 using a combination of statistical extrapolation of historical data and future projections. MSCI also displays two types of potential outcomes for each model, showcasing both an "average" as well as an aggressive or "worst-case" scenario. Similar to other vendors, MSCI employs exposure growth modelling to calculate future changes in the value of assets and portfolios using its climate value-at-risk models.

Endnotes

1 The ICPP RCP refers to the Intergovernmental Panel on Climate Change Representative Concentration Pathways. These pathways for emissions, greenhouse gases, aerosols among other concentrations are based on scenarios adopted by the IPCC. See https://ipcc.ch/2022/11/25/ipcc-circulates-final-draft-ar6-synthesis-report/.

2 A climate change scenario is a projection of greenhouse gas emissions in the future, usually looking at a variety of horizons. It can take into account numerous variables, including physical risks, regulatory requirements, speed of compliance with those regulations, economic activities, increase in populations, technological advancements, etc.

3 https://library.wmo.int/doc_num.php?explnum_id=4166

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ID1915773-5347211.2.1.GBL.RTL 1223
Exp. Date: 12/31/2024