GUIDE 2021

Climate Change Solutions

A Guide to Measuring Acute Physical Risk

IN ASSOCIATION WITH:

AIR

Acknowledgements

This guide was written by Dr Peter Sousounis and Dr Alastair Clarke of AIR Worldwide.

About AIR Worldwide
AIR Worldwide (AIR) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, AIR Worldwide founded the catastrophe modeling industry and today models the risk from natural catastrophes, terrorism, pandemics, casualty catastrophes, and cyber incidents. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, longevity modeling, site-specific engineering analyses, and agricultural risk management. AIR Worldwide, a Verisk (Nasdaq:VRSK) business, is headquartered in Boston, with additional offices in North America, Europe, and Asia. For more information, please visit www.air-worldwide.com.

About Airmic
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CONTENTS

01 Introduction

Scientists at AIR Worldwide, a leading developer of catastrophe models, explain how acute physical risk from climate change is being measured in the insurance industry. They describe how catastrophe models are being built to account for climate change that has already occurred and are being adapted to quantify the future impact of climate change under a range of scenarios. A special discussion of supply chain risk is also provided for firms outside of insurance. This guide was written by Dr Peter Sousounis and Dr Alastair Clarke of AIR Worldwide.

At a very high level, climate change is a reference to how anthropogenic activity has and will continue to alter various aspects of the earth's climate. Changes in temperature and precipitation and in other characteristics – especially to the extent that weather extremes are influenced – is a primary concern of the insurance and other industries as well.

But physical risk is just one of three different financial risks that industries are concerned about (see Figure 1). Transition risk is a reference to how assets may change value as society continues to transition to greener sources of energy. A third type of risk, liability risk, is the risk that industries face from potential lawsuits regarding who is to blame (at fault) – and thus who should pay – for damages from weather extremes that climate change has caused as well as for resiliency measures to protect against future damage.

There are two kinds of physical risk: acute and chronic. Acute physical risk describes the changes in frequency and severity of catastrophes such as hurricanes and floods, while chronic physical risk describes the steady shift of weather patterns such as dry regions becoming drier and wet regions becoming wetter.

Acute physical risk may be at the top of the list of concerns for the insurance industry, as climate change is likely affecting insured risk already. A primary concern of the industry related to that risk is whether the catastrophe models that are available now account for climate change risk for the present (the next 0-10 years). But there is also increasing push from regulators and pull from investors for insurers to demonstrate that they can quantify short- to intermediate-term (10-30 years) and long-term (30+ years) views of risk.

Figure 1: Three kinds of financial risk stemming from climate change

02 Catastrophe models

Catastrophe (or cat) models are used by insurers to calculate the financial risk they face from extreme events happening today. A catalogue of simulated catastrophe events in the hazard module is intersected with an insurer's exposure data (Figure 2). The damage experienced by the affected exposure is computed in the engineering module through a set of damage functions. The damage is translated into financial loss through the financial module. Risk here is defined as the probability of exceeding certain insured losses.

Do catastrophe models incorporate climate change?
The concern regarding catastrophe models for today's climate is whether the models have adequately incorporated the climate change that has already occurred. The canonical catastrophe model is very data-centric. Multi-decade to century-long time series of data are typically used, and after perhaps correcting for changes in measurement technique, each year's worth of data is typically weighted equally when simulating a catalogue of events. However, if climate change is having an effect, the equal weighting of years can result in a model that reflects a much earlier climate when climate change was less significant.

Figure 3 shows that the annual cumulative precipitation over the contiguous United States has been generally increasing since 1950. The average precipitation in the current climate is higher than that in the 1950s and 1960s.

One way to circumvent this problem is to use a shorter series of data that better reflects the current climate. For example, one could build the model using the years 1990 to 2020, during which there was no significant trend. However, brevity of the data record can result in a less stable model – one that does not adequately capture the year-to-year

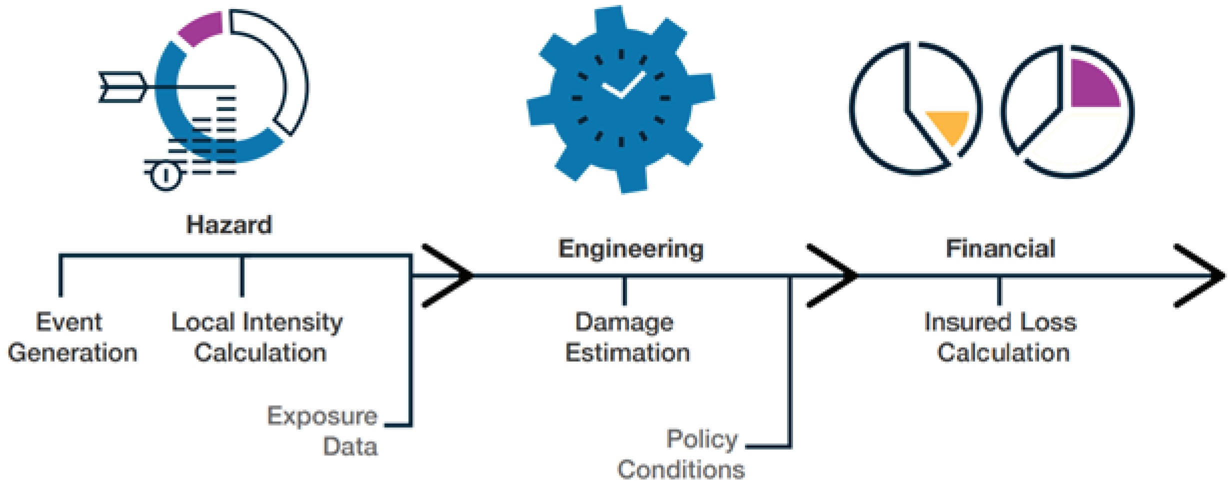

Figure 2: Catastrophe model framework consists of three modules: hazard, engineering and financial.

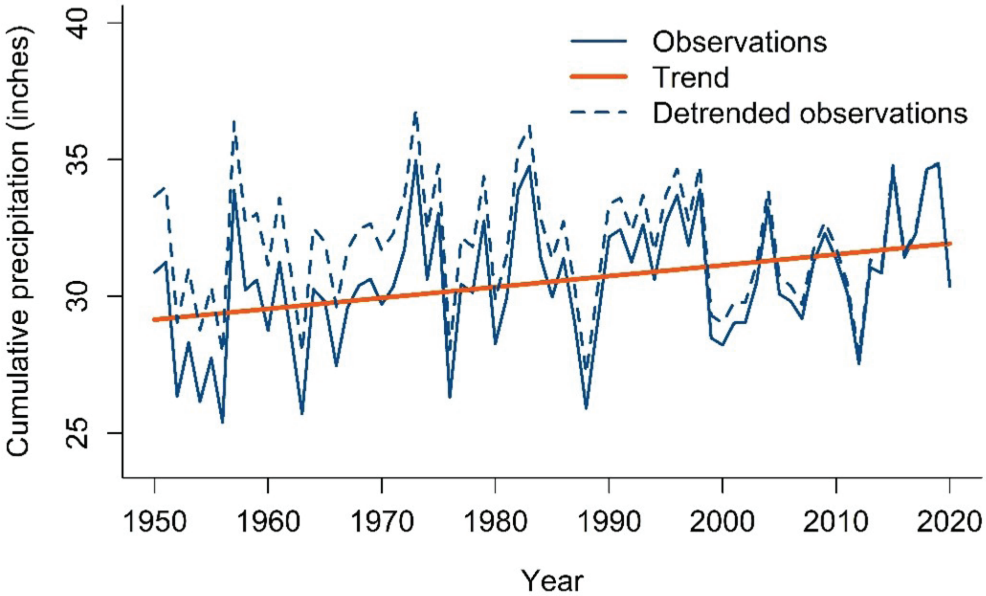

Figure 3: Annual cumulative precipitation in the contiguous United States from 1950 to 2020 (source: NOAA, 2021[1])

variability of financial losses, which can be very small one year and very large the next.

Preferential weighting of a long time series can be a better approach. For example, when creating a catalogue of simulated severe convective storms with hail, tornadoes and damaging winds, years and events such as those observed in more recent years can be preferentially simulated and occur more frequently in the resulting catalogue. The weighting may be linear but subject to the constraint that the summed probability equals one.

Detrending is another technique that can work well – where the detrending is based on recent data. The effect of this technique is that data from the past are effectively mapped to current conditions. The technique is illustrated in Figure 3 where the trend is used to map all the observations to the year 2020. This leads to notably higher precipitation values between 1950 and 1980. This technique allows for longer time series of data to be used, for a better reflection of current conditions and for improved stability. More sophisticated detrending techniques may be developed and used to account for adjusting the variance (interannual variability) for the earlier years (not shown).

What if climate change is having a significant effect?

If climate change is having a significant impact, then even detrending may not be enough to build a cat model fit for use in five to ten years from now. Any model is only as good as the data that goes into it. If unprecedented events can occur in the next ten years, then model utility is compromised because there are no events like them in the catalogue. While any catastrophe model worth its salt will include events that have not happened before, the question is how much variation should be built into the model.

Without actual observations, statistical techniques (e.g. extreme value theory) may be used to better understand potential tail events. But this approach requires fitting a statistical model to a long time series of data. Physical (physics-based) models that simulate unforeseen but theoretically plausible events are much preferred if they are properly benchmarked and not too time-consuming to run. The output of a physical model that's been run for a short stint into the future (0-10 years) can be used to build a cat model fit for the next ten years. While physical models may capture how the mean and some of the variability may evolve, other methods that better capture extremes still need to complement the process.

Key takeaways for users of catastrophe models

It is imperative that users of cat models understand exactly how the models are built in terms of what data was used by the model vendor and from what historical period. It is also important to know what steps were taken by the model vendor to determine whether climate change has been playing a role and, if so, what procedure was used so that the model reflects the current risk. It is equally important that the model vendor demonstrates that the model reflects the current risk, not just by comparing the modelled hazard against the entire historical period of data that may have been used, but against a period of recent observations.

03 Climate change scenario analyses

Many industries and firms are focused on the risk that will evolve in the coming few years. Some may desire a longer view of up to ten years, but very few consider risks on longer time horizons. This systemic aversion to examining long-term risk could mean that many industries suffer the worst consequences of climate change. Mark Carney, the former Governor of the Bank of England, called this the "tragedy of the horizon"[2]. Here we describe techniques and tools that can help firms overcome this 'tragedy' and be better prepared for climate change.

Horizon scanning

Horizon scanning is a way of anticipating threats to your business that could emerge in the long term. It helps firms to be comfortable with change and take advantage of new opportunities, and it has been credited with helping Shell to foresee the 1973 oil crisis[3].

Horizon scanning starts by choosing the furthest time horizons that could conceivably affect the decisions you make today (e.g. 2050), then contemplating the threats and opportunities that could emerge in regular increments (e.g. every five years) out to the furthest horizon. Perhaps transition risk will be your main threat in the next five to ten years, but physical risk will become more important in ten to 30 years from now. The aim is not to forecast the most likely outcome, but instead to consider a range of plausible scenarios.

Scenario development

Scenarios are essentially narratives of how the future could play out. Once the narratives are established, numbers can be assigned to them and the scenarios can be modelled to give metrics that help inform decision-making. The Intergovernmental Panel on Climate Change (IPCC) creates scenarios to help us understand how climate change might pan out. The latest set are the five Shared Socioeconomic Pathways (SSPs), and these are currently applied to climate models in the Sixth Phase of the Coupled Model Intercomparison Project (CMIP6). The previous phase (CMIP5) used a different set of scenarios called Representative Concentration Pathways (RCPs), which are four projections of greenhouse gas concentrations out to 2100. RCPs can be paired with SSPs, thus maintaining consistency between each modelling phase.

RCPs and SSPs are scenarios devised by researchers that have important but limited applications in industry. To overcome these limitations, financial bodies are devising their own set of scenarios which are more relevant to their members. The Network for Greening the Financial Sector (NGFS) has created eight scenarios to explore the coupled developments of physical and transition risk[4]. Three of these scenarios are commonly used and are labelled as Orderly, Disorderly and Current policies. In the Orderly and Disorderly scenarios, the world avoids excessive global warming levels, but Disorderly means that society acts late – with high transition risk. The Current policies scenario, also known as

'Hot house world', assumes that no climate policies are introduced, leading to low transition risk but high physical risk.

Earlier this year, the Bank of England asked some of its regulated banks and insurers to participate in the Climate Biennial Exploratory Scenario (CBES) exercise. The scenarios used in CBES were similar to the three NGFS scenarios, but were called Early Policy Action, Late Policy Action and No Additional Policy Action. In terms of physical risk, there is no difference between the Early and Late Policy Action scenarios and therefore they can be combined. Figure 4 shows how the global mean temperature rise, relative to the pre-industrial era, is projected to change during the NGFS Orderly and Current policies scenarios. Also shown are RCPs 2.6, 6.0 and 8.5. For CBES, firms were asked to report their financial risk for the four scenario horizons marked by the triangles and crosses in Figure 4.

Building a toolkit

At the moment, maybe the cat model is the only tool at your disposal for measuring the financial risk of catastrophes. To quantify the change in financial risk due to climate change (acute physical risk), new tools are needed. A new cat model can be built or the original cat model can be conditioned to reflect a future climate.

Global Mean Temperature Rise (°C)

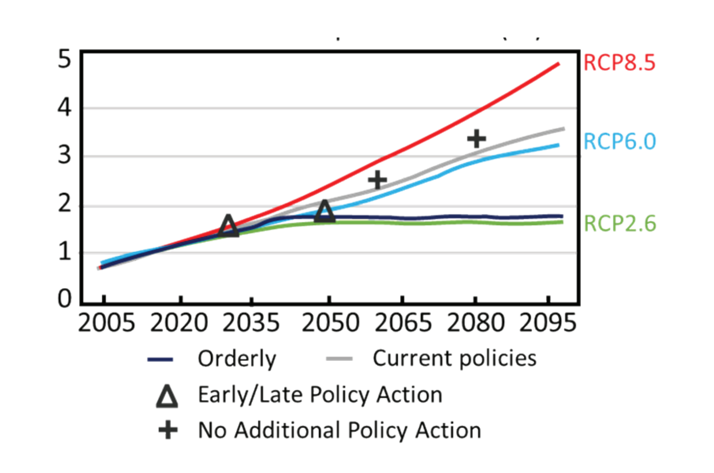

Figure 4: Global mean temperature rise projections out to 2100 from different scenarios from NGFS, IPCC and CBES 2021.

Cat models can be adjusted to reflect future climate states on longer time horizons such as ten years or more by using physical climate models. The climate model can be run under different projections of greenhouse gas concentrations and its output can be used to build a new cat model or to condition the cat model. This strategy is highly effective provided one accounts for the inherent biases known to exist in most climate models and the fact that climate models cannot yet capture certain extremes observed in reality. High-resolution simulations of climate models can better capture peak amplitudes, but at a severe computational cost, as it takes almost 10 times the amount of computer time to run a simulation with twice the horizontal resolution. Coarser simulations can be used and the output downscaled, where the downscaling is performed either with a more simplified physical model or using statistical methods.

Climate change conditioned catalogue

A new cat model can take several years to develop, but forward-looking views of risk under a range of climate scenarios are needed now. Therefore, model vendors prefer to condition their existing models using guidance from climate model outputs.

If the time horizon and climate scenario of concern are not too extreme, output from physical models can be used to create statistical representations of how a peril might behave in the future. These statistical representations can act as targets to resample the original catalogue of simulated events in the cat model. The resulting resampled catalogue is called a climate change conditioned catalogue.

The benefits of such an approach include providing a relatively quick way to get probabilistic information about how risk may change. Challenges include creating targets for the cat model parameters and achieving the target in the resampled catalogue.

A climate change conditioned catalogue reflects a particular climate scenario at a specific horizon. It can be used to answer questions such as 'how might the average annual loss or 100-year loss change in the future?' New events are not actually part of the solution unless the parent catalogue is very large (e.g. 100,000-year catalogue of events) and the climate change conditioned catalogues are smaller (e.g. 10,000 years). Fundamentally new events cannot be part of the solution. Taking an extreme example, if the current climate does not support hurricane activity in France but the science supports that possible future outcome, sampling from a current climate catalogue is not going to yield an acceptable result.

Nevertheless, climate change conditioned catalogues are becoming an important tool in insurance. The case study, titled 'Responding to CBES 2021', describes how this tool was used to help firms respond to this year's CBES.

Climate change event set

Let's say you are concerned about a category 5 hurricane hitting Miami today, you might wonder what that same event would be like under a future climate. A climate change event set answers this question. It is a set of perturbed versions of the same event where the perturbations reflect various ways in which climate change could influence the reoccurrence of an event from the past. Hence, for a hurricane, the perturbations reflect how climate change may influence the intensity, forward speed and precipitation rate of that hurricane, and its storm surge under sea level rise. Each perturbation could represent a range of different possible outcomes for a particular climate scenario and future time horizon.

Unlike a climate change conditioned catalogue, the events in a climate change event set are not typically assigned a probability of occurrence. However, a unique benefit of climate change event sets is that they allow users to pinpoint the climate change trend to which their future financial risk is most sensitive.

Key takeaways and recommendations for scenario analyses

Businesses should not focus solely on immediate threats but should devote time to considering future threats in the short and long term. This will make them more comfortable with change and more resilient to shocks. Horizon scanning can help firms to identify future threats and opportunities. Once the time horizons of concern are defined, firms should develop a set of plausible scenarios that could develop out to the furthest time horizon of interest. For climate change, there are multiple sets of scenarios, and firms may want to start with the NGFS scenarios.

Firms should try to quantify how their risk (and revenue) could change in each scenario. Consider the tools that are available today. Do they answer the questions firms have? Do they consider the full range of scenarios and time horizons that interest them? Are they easy to use and affordable? Importantly, do they appropriately utilise the state of scientific knowledge, including the uncertainties of climate change, without overselling false precision?

Perhaps the tools for quantifying climate change risk are not exactly answering the questions that firms have. In that case, firms may choose to work with model vendors to design and develop new tools. Quantifying climate change risk is in its embryonic stage, so firms that move early to work with vendors can influence the development of tools that suit their needs.

04 Case study: Responding to CBES 2021

A primary insurer with exposure in Great Britain uses a cat model to quantify its current financial risk to inland flooding. It uses the model to calculate its average annual loss (AAL) and 1-in-100 year aggregate loss. It has been asked to participate in CBES 2021 and to report how climate change could change its AAL and 100-year loss under four scenario horizons: Early/Late Policy Action (E/LPA) in 2030 and 2050, and No Additional Policy Action (NAPA) in 2060 and 2080. For consistency with the time horizons in E/LPA, the Bank of England calls the NAPA 2060 and 2080 horizons "2030" and "2050" respectively[5]. To help the insurer respond to CBES 2021, it uses climate change conditioned catalogues provided by its cat model vendor.

The model vendor uses the future rainfall targets provided by the Bank of England for CBES 2021. There are four targets for each scenario horizon. The rainfall targets for NAPA 2030 are shown in Table 1.

The model vendor uses the targets to resample its 10,000-year catalogue of flood simulations and create a climate change conditioned catalogue that matches the target rainfall rates for NAPA 2030. The insurer uses the catalogue to recompute its portfolio AAL and 100-year loss, and both increase by about 20% under this scenario horizon. The catalogue enables the insurer to compute changes to postal sector AAL across Great Britain.

	Temperature rise (°C)	Summer rainfall rate	Winter rainfall rate	Annual rainfall rate	Annual London rainfall rate
NAPA 2030	2.5	3%	19%	10%	17%

Table 1: Projected changes in UK rainfall rates for NAPA 2030 relative to 2020, based on CBES 2021

05 Solutions beyond insurance

This guide has primarily focused on measuring acute physical risk from the perspective of the insurer, but we also recognise that many firms outside of insurance need to measure this risk too. While cat models are primarily intended for insurers to estimate their potential financial loss, the cat model framework, illustrated in Figure 2, can be leveraged and adapted to quantify other kinds of costs and loss of revenue exacerbated by climate change.

If climate change makes storms, floods and wildfires more frequent and more severe, firms should first ask whether their business has been affected by these kinds of catastrophes in the past. The answer may not be immediately obvious. Perhaps your factory has been flooded before leading to costly repairs and revenue loss; this was likely covered by your insurer and will likely be so again unless climate change is so severe as to make your factory uninsurable! However, have you considered the times that your factory avoided a flood, but it still lost revenue because an important supplier was impacted? This is known as contingent business interruption and may not be covered by your insurance policy. Another name for it is supply chain risk. Supply chain networks are vulnerable to climatic extremes, as notoriously demonstrated by the 2011 flooding in Thailand, which affected global computer and automobile supplies[6]. Your firm might benefit from quantifying the supply chain risk caused by the current climate and the acute physical risk brought on by climate change under different climate scenarios[7].

Summary

There are three kinds of financial risk caused by climate change: physical, transition and liability risk. Physical risk has two forms: chronic and acute, where chronic refers to steady changes in climate patterns and acute refers to the increased frequency and severity of extreme climatic events such as hurricanes and floods.

Insurers use cat models to estimate the potential losses due to natural disasters. It is essential that such models account for the climate change that has already occurred. Model vendors can use various techniques to do this. Historical data can be preferentially weighted to more recent years, the data can be de-trended or a more recent period of historical data can be used.

Firms need to consider the possible effects of climate change in the long term too. Horizon scanning and scenario analyses are essential here. New tools are now available to help firms quantify acute physical risk. Insurers now have access to climate change conditioned catalogues and climate change event sets that answer 'what if' questions. Beyond insurance, firms can access supply chain models and work with model vendors to measure their acute physical risk from global supply chains.

Once a number is put on risk, firms can decide a course of action. While climate change may be new, dealing with risk is not. The choices facing firms are still the same: to avoid, mitigate, transfer or accept the risk. The goal is to stay resilient and continue to grow revenue in the face of climate change. And remember that the task of measuring acute physical risk will not be a one-off but will occur again and again as the science of climate change evolves and the future plays out.

References

[1] NOAA National Centers for Environmental information, Climate at a Glance: National Time Series, published September 2021, retrieved on 22 September 2021 from https://www.ncdc.noaa.gov/cag/

[2] https://www.bankofengland.co.uk/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability

[3] https://hbr.org/2013/05/living-in-the-futures

[4] https://www.ngfs.net/sites/default/files/medias/documents/820184_ngfs_scenarios_final_version_v6.pdf

[5] https://www.bankofengland.co.uk/-/media/boe/files/stress-testing/2021/the-2021-biennial-exploratory-scenario-on-the-financial-risks-from-climate-change.pdf

[6] https://www.air-worldwide.com/publications/air-currents/2012/The-2011-Thai-Floods--Changing-the-Perception-of-Risk-in-Thailand/

[7] http://w3.air-worldwide.com/SupplyChainIssueBriefRegistration

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