

DISCUSSION PAPER

# Practical guide to climate change for general insurance practitioners

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Working Party, A Practical Guide to Climate Change for General Insurance Practitioners, Institute and Faculty of Actuaries, 18th November 2019, Staple Inn, High Holborn

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## Abstract

Climate change is one of the biggest challenges facing the world. Scientific research points out that it is predominately driven by human activity. There are three different types of risks that arise from this change. These have been broadly grouped into physical, transition and liability risks. These risks can impact general insurers to different degrees, depending on their business areas and investment strategies. These may pose different strategic, investment, market, operational and reputational risks. This paper provides General Insurance Practitioners with an overview of different aspects of insurance operations that may be affected by climate change. It highlights the impact of these risks on pricing and underwriting, reserving, reinsurance, catastrophe modelling, investment, risk management and capital management processes.

**Keywords:** Climate; Insurance; Actuaries; Pricing; Reserving

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## Executive Summary

Climate change will be a major source of risk and uncertainty for general insurers over the coming years. Actuaries and other General Insurance (GI) practitioners will need to assess the likely impact and appropriate responses to climate change, to help manage those risks and meet the demands of regulators and investors.

Global mean temperature reached 1°C above pre-industrial levels by 2017, which was one of the most active Atlantic hurricane seasons on record. The 18 warmest years in the instrument record (1880–2017) all occurred during the last 20 years, and the 2018 Californian wildfires were the most destructive in history (Governor's Strike Force, 2019).

There is a consensus amongst scientists that climate change is happening and that it is due to human activities, particularly greenhouse gas emissions. Modelling of future emissions scenarios, reflecting different global responses to climate change, point to a range of future global temperatures by the end of this century significantly higher than warming to date.

The impact of climate change on insurers arises through three different risk channels: physical, transition and liability. Under most emission scenarios, the frequency and severity of extreme weather events are likely to increase.

Physical risks include the direct effects of climate change, such as changes in the frequency or severity of catastrophe events. Efforts to mitigate the impact of climate change, through emissions reductions, and investment in sustainable infrastructure and energy give rise to transition risks. These include the stranding of fossil fuel reserves, a shift in investments towards new technologies and a reduction in the value of assets reliant on fossil fuels. Liability risks arise from the efforts of stakeholders to seek recompense for failures to mitigate, adapt or disclose climate change risks.

There is greater regulatory and investment interest in the financial risks arising from climate change for general insurers. Insurers will be expected to understand these risks to a sufficient degree to assess the implications for their risk profiles, integrate the management of these risks within their existing risk management systems and inform the development of their future strategy.

In pricing and underwriting, practitioners cannot assume that climate change risks can be avoided or fully priced-in. Practitioners may need to consider the extent to which past data reflect the effects of climate change to date and can be used as a basis for predicting the future. They may consider the range of climate change risks and the degree to which they are considered within the calibration of those models. Climate change can introduce material uncertainty in some assumptions. Practitioners may also need to develop leading indicators of potential future losses that can inform underwriting and pricing decision-making.

In reserving, practitioners may need to consider the potential for reserve deterioration and increased uncertainty in claims costs, from physical, transition and liability risks, recognising the exposure characteristics of different lines of business.

Catastrophe modelling can help quantify the possible impacts of climate change. These estimates will need to acknowledge the limitations of past data used to calibrate models. Sensitivity testing can be used to assess the impact of different input assumptions.

Reinsurance requirements may change, with changing risk profiles. Systemic effects are also expected on the demand for, cost and availability of reinsurance protection, particularly at a regional level. Insurers that invest in improved exposure management will be better placed to assess risks and buy protection.

Practitioners will increasingly integrate consideration of climate change risk into their investment strategy. Best practice is still emerging in this field but may include environmental, social and governance (ESG) impact assessments, carbon footprint analysis and the application of the Prudent Person Principle under Solvency II.

The risk management function can play a key role in developing an insurer's response to climate change. It can help build carbon literacy, a better understanding of the risks and appropriate lead indicators for monitoring trends. It can frame climate change risk and uncertainties within existing risk appetites. As well as the short-term impacts of climate change, the risk management function may help the business understand the potential impact on long-term business strategy.

The capital management function may need to reflect the impact of climate change in its economic, as well as statutory, capital requirements.

## 1. Introduction

The aim of this paper is to provide practical advice into how the risks arising from climate change may impact on the work of GI practitioners. It will help practitioners think about implications in

terms of both the short-term impacts to the business or clients and potential long-term impacts on business strategy, so that they can develop their judgements and provide appropriate advice.

The paper does not aim to provide specific quantitative advice as this will vary depending on each firm's own circumstances, objectives and business model. It should not be taken as formal guidance.

The scientific evidence is clear and unequivocal that the climate is changing and that the change is man-made (IPCC, 2014).

The last 4 years have been the four warmest years on record (National Oceanic and Atmospheric Administration (NAO), 2019), and the 2018 Californian wildfires were the most destructive in history (Governor's Strike Force, 2019).

Regulators and investors are taking an ever-increasing interest in the financial risks posed by climate change. GI practitioners will therefore want to consider carefully the various impacts that the physical, transition and liability risks have on their work.

The Institute and Faculty of Actuaries (IFoA) issued a non-mandatory Risk Alert on climate-related risks that states:

*“Actuaries should ensure that they understand, and are clear in communicating, the extent to which they have taken account of climate-related risks in any relevant decisions, calculations or advice”.* (IFoA, 2017)

The Risk Alert highlighted the Task Force on Climate-related Financial Disclosures (TCFD) established under the auspices of the Financial Stability Board with members from across the G20 that has developed recommendations for a consistent approach to disclosures of material climate-related risks for use by companies when providing information to lenders, insurers, investors and other stakeholders.

Following publication of the Risk Alert, the IFoA's Resource and Environment (R&E) Board is seeking to support members by producing a series of practical guides on the risks arising from climate change for different practice areas to raise awareness of the topic, encourage discussion, catalyse further research and help actuaries to think about how to develop their advice.

This guide has been produced to support actuaries operating in the worldwide GI market. It explains how climate risks may be relevant to GI organisations and is designed to support actuaries and others working in GI in exercising their judgement.

Although this guide is focused on climate change, other R&E issues are also relevant. The R&E Board and its Research and CPD sub-committee continue to co-ordinate the profession's research on climate change and in other R&E areas. This guide is intended to complement that research.

GI actuaries will want to consider what a proportionate approach to R&E issues would be. In practice, the weight given to R&E issues will depend on the insurer's circumstances, including the classes of business written, the nature and term of assets and liabilities and any stance taken on corporate social responsibility.

The guide contains the following sections:

- Section 1 – Climate change risk overview
- Section 2 – Regulatory context
- Section 3 – Relevance for general insurance
- Section 4 – Impacts on the key areas of focus for GI practitioners
- Section 5 – Highlights of some frequently asked questions.

Whilst the practical advice in section 4 is broken down into the key functions that a GI practitioner may be involved with, there will be some overlap between roles. For example, some elements of the “Reserving” section may be relevant to pricing practitioners, and vice versa.

## 2. Climate Change Risk Overview

In recent years, there have been several extreme weather events that have had a significant impact on the insurance industry. For example, 2017 was one of the most active Atlantic hurricane seasons on record, and the 2018 Californian wildfires were the most destructive in history. As a result, there has been increased discussion in the insurance community on the role of climate change in these events, and what the future might hold for the frequency and severity of weather-related natural catastrophes.

According to the Intergovernmental Panel on Climate Change (IPCC), there is scientific consensus that warming of the climate is “unequivocal” and that human activities, particularly greenhouse gas (GHG) emissions, are “extremely likely to have been the dominant cause of the observed warming since the mid-20th century” (IPCC, 2014). GHGs include carbon dioxide, methane and nitrous oxide and are emitted by burning fossil fuels (to generate heat, electricity and for transport), agriculture (e.g. livestock and rice production) and deforestation (“The Relevance of Resource and Environment Issues to Pension Actuaries” Working Party, 2017).

The paper “Young people’s burden: requirement of negative CO<sub>2</sub> emissions” outlined the risks associated with climate change, for example, stating that the:

*“Earth is now as warm as it was during the prior (Eemian) interglacial period, when sea level reached 6–9m higher than today”.* (Hansen *et al.*, 2017)

The British Antarctic Survey points out in the DWS Research Institute paper, “Experts on Climate Change” that:

*“The last time the Earth experienced broadly comparable levels of atmospheric carbon dioxide was during the mid-Pliocene, 3-5 million years ago. To find levels consistently above those of today you have to look much further back to the mid Miocene some 15 million years ago”.* (British Antarctic Survey, 2018)

There are a wide range of impacts from human-induced climate change, and there are mostly negative consequences, especially with higher rates of warming. In 2017, the global mean temperature reached 1°C above pre-industrial levels, and scientists are already observing effects of this increase across the world. There has been an observed increase in the frequency and severity of daily temperature and precipitation extremes (IPCC, 2014). Several studies have also identified links between climate change and catastrophe events. For example, the precipitation from Hurricane Harvey is estimated to have been made 15% more intense due to climate change (van Oldenborgh *et al.*, 2017). The anticipated impacts of climate change on extreme weather include increases in heatwaves, heavy precipitation, droughts, flooding and intense tropical cyclones.

The IPCC’s report on “Global Warming of 1.5°C” commented:

*“Trends in intensity and frequency of some climate and weather extremes have been detected over time spans during which about 0.5°C of global warming occurred (medium confidence). This assessment is based on several lines of evidence, including attribution studies for changes in extremes since 1950”.* (IPCC, 2018)

A key feature of climate change impacts on the (re)insurance industry will be regional variability. Changes in both the frequency and severity of extreme weather events will differ across the world. For instance, some areas such as Bangladesh are expected to see more rainfall, whilst others such as the Southwestern US are projected to experience more droughts. In addition, climate change may alter weather patterns, which could increase or decrease correlations between region perils.

Even sea-level changes may not be uniform. For example, Deutsche Asset Management’s report, “Physical Climate Risk in Equity Portfolios” (2015) highlights the concentration of high

value, long-lived capital assets in the Pearl River Delta, including cities such as Guangzhou and Shenzhen. They quote from a 2004 research report, “Coastal inundation due to sea level rise in the Pearl River Delta, China” and say:

“The Pearl River Delta is already experiencing a higher than average rate of sea level rise, with research suggesting that a 30 cm rise in relative sea level at the mouth of the estuary is possible by 2030 (against an average 8 cm globally)”. (Huang *et al.*, 2004)

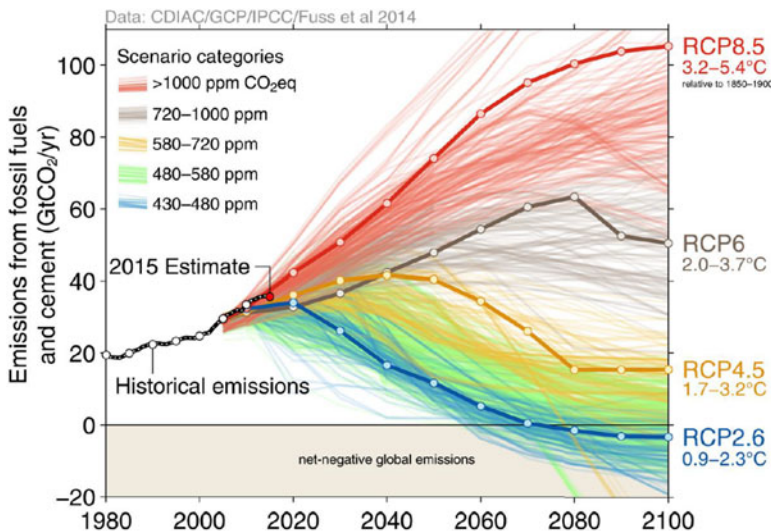
To investigate the potential impacts of climate change, scientists and policy makers have developed a set of future scenarios called the Representative Concentration Pathways (RCPs). The RCP scenarios describe alternative pathways for future GHG emissions, which consider economic growth and mitigation measures such as the switch to alternative energy sources (e.g. renewables) and the development of new technologies (e.g. that remove GHGs from the air).

“Four pathways have been selected for climate modelling and research, which describe different climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. The four RCPs, namely RCP2.6, RCP4.5, RCP6, and RCP8.5, are labelled after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/m<sup>2</sup>, respectively)” (Moss *et al.*, 2008)

The best-case scenario is RCP 2.6, which assumes that global emissions peak between 2010 and 2020, with emissions declining substantially thereafter due to the adoption of renewables and new technologies. The projected temperature increase for this scenario is 0.9–2.3°C by 2100.

In contrast, the worst-case is RCP 8.5, which represents a “business-as-usual” scenario prior to any commitments made as part of the Paris protocol and assumes emissions continue to rise throughout the 21<sup>st</sup> century, resulting in a temperature increase of 3.2–5.4°C by 2100. Thomas Buberl, Axa CEO said, “A +4°C world is not insurable” (Buberl, 2017).

The following graph provides a wide range of potential emission pathways.



The impact of climate change on extreme weather events will vary depending on the RCP scenario, with the most severe effects being observed under the RCP 8.5 pathway. There is also

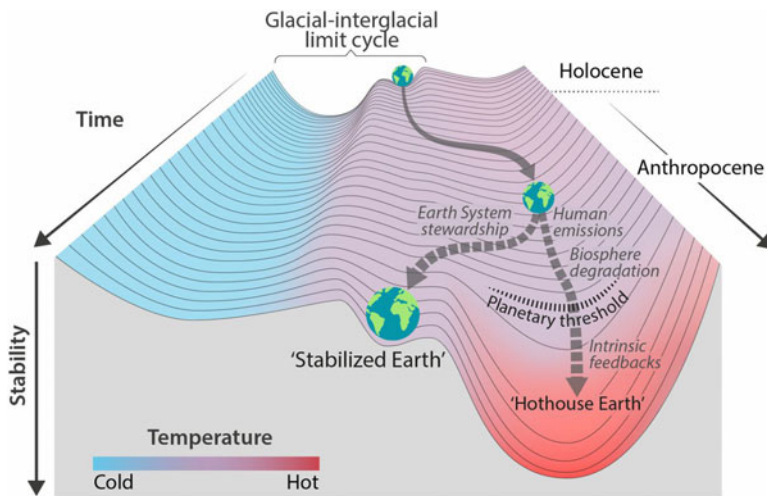
the possibility that climate change will result in irreversible “Tipping Points”. The National Research Council stated:

*“As the planet continues to warm, it may be approaching a critical climate threshold beyond which rapid (decadal-scale) and potentially catastrophic changes may occur that are not anticipated – because of complex feedback dynamics and existing computational limitations – by climate models that are tuned to modern conditions”.* (The National Research Council, 2011)

Will Steffen et al, in the paper, “Trajectories of the Earth System in the Anthropocene” propose a planetary threshold, beyond which the system follows an irreversible pathway driven by human-created feedbacks. They say:

*“Precisely where a potential planetary threshold might be is uncertain. We suggest 2°C because of the risk that a 2°C warming could activate important tipping elements, raising the temperature further to activate other tipping elements in a domino-like cascade that could take the Earth System to even higher temperatures (Tipping Cascades). Such cascades comprise, in essence, the dynamical process that leads to thresholds in complex systems”.* (Steffen et al., 2018)

Steffen *et al* highlight this point with the following illustration:



The RCP pathways do not assign probabilities to each of the pathways. However, for insurance companies considering how to incorporate climate appropriately into their strategy, it will be important to consider not only possible climate pathways but also what are probable climate pathways. Institutions such as Principles for Responsible Investment (PRI) are starting to carry out work on this, speculating that the combination of the economics of the energy transition and increased public awareness of the impacts of climate change may drive a more forceful policy response than has so far been seen.

Whichever path we take there is likely to be significant change, which will bring risks and opportunities for both the wider financial system and the work of actuaries.

Some practitioners may argue on waiting until climate change is more certain. In fact, scientists are as certain about the link between human behaviour and climate change as they are about the

link between smoking and lung cancer. For example, the American Association for the Advancement of Science said in its report, “What we Know”:

*“The science linking human activities to climate change is analogous to the science linking smoking to lung and cardiovascular diseases. Physicians, cardiovascular scientists, public health experts, and others all agree smoking causes cancer. And this consensus among the health community has convinced most Americans that the health risks from smoking are real. A similar consensus now exists among climate scientists, a consensus that maintains that climate change is happening, and that human activity is the cause”.* (Molina et al., 2014)

It is also important to recognise that whilst climate change is projected to become increasingly important for driving up future weather-related losses, changes in exposure and vulnerability will also have an impact. Exposure is expected to be a key driver of increases in loss in many parts of the world. For example, studies have shown that future coastal and river flood risk in Indonesia will be largely driven by increasing exposure (Muis et al., 2014). On the other hand, adequate investment in adaptation measures, such as flood defences or forest management, may help reduce losses. However, improvements are likely to be selective, with those countries and communities that can afford adaptation measures benefiting the most.

“Mitigation” refers to human efforts to reduce the drivers of climate change by reducing emissions or increasing natural carbon sinks whereas “adaptation” refers to adjustments to natural or human systems in response to actual or expected climatic change and effects.

### 3. Regulatory Context

In April 2019, the UK’s Prudential Regulation Authority (PRA) released its supervisory statement, SS3/19, “Enhancing banks’ and insurers’ approaches to managing the financial risks from climate change” (Prudential Regulation Authority, 2019). The paper sets out the PRA’s expectations concerning how firms:

- i. embed the consideration of the financial risks from climate change in their governance arrangements;
- ii. incorporate the financial risks from climate change into existing risk management practice;
- iii. use (long-term) scenario analysis to inform strategy setting and risk assessment and identification and
- iv. develop an approach to disclosure on the financial risks from climate change.

In October 2018, the UK’s Financial Conduct Authority released its own discussion paper on the impact of climate change and green finance on financial services (Financial Conduct Authority (FCA), 2018). Of relevance to GI practitioners are its thoughts on:

- i. ensuring that disclosures in capital markets appropriately give adequate information to investors of the financial impacts of climate change
- ii. the scope for the introduction of a new requirement for financial services firms to report publicly on how they manage climate risks.

In June 2019, the European Insurance and Occupational Pensions Authority (EIOPA, 2019) opened for consultation their draft opinion on sustainability within Solvency II Pillar 1.

In a joint paper, the International Association of Insurance Supervisors (IAIS) and the Sustainable Insurance Forum (SIF) described the role of insurance as follows:

*“In its role as risk manager, risk carrier and investor, the global insurance sector plays a cornerstone role in the management of climate-related risks and opportunities for individuals, households, firms, other financial institutions, and public authorities”.* (IAIS and SIF, 2018)

This guide outlines how R&E issues can represent material risks to general insurers, the implications for actuarial advice and practical suggestions to help actuaries meet professional requirements in this area. It may help GI practitioners avoid criticism for not treating climate change as a material risk, thus reducing potential reputational damage.

#### 4. Relevance for General Insurance

In his 2015 speech, “Breaking the tragedy of the horizon” (Carney, 2015), Mark Carney, Governor of the Bank of England, described three categories of risk arising from climate change: physical, transition and liability risks. These risks were further outlined in the IFoA Risk Alert. Each of these risk areas is relevant to GI and the roles of actuaries practising in the GI sector.

A good introduction to these risks can be found in the paper “Climate Change for Actuaries: an introduction” (Climate Change Working Party, 2019).

Whilst many of the risks are quite certain (e.g. warmer seas will mean that hurricanes may pick up more moisture), some remain relatively uncertain (e.g. whether some of the liability claims being brought to court will stand up).

##### 4.1. Physical Risks

The UK’s PRA defines physical risks as:

*“The first-order risks which arise from weather-related events, such as floods and storms. They comprise impacts directly resulting from such events, such as damage to property, and also those that may arise indirectly through subsequent events, such as disruption of global supply chains or resource scarcity”.* (Prudential Regulation Authority, 2015)

Physical risks can be further sub-divided between “chronic” risks or “acute”. For example, in the case of flood risk, a chronic risk might be the steady rise in sea levels over a long period of time, whilst an acute risk might be the risk of a serious flooding event that climate change may have contributed towards.

Insurers may be exposed to physical risks through insurable events or through their asset portfolios. As such, many of these might affect a general insurer’s balance sheet through both its assets and liabilities. These might include:

- i. *Droughts and wildfires.* Some parts of the world will see an increase in the duration and intensity of droughts. This will lead to increased crop damage, water scarcity (and social unrest) and wildfires. Although climate change may not be directly responsible for the ignition of wildfires, it may contribute to the propagation and therefore severity of wildfire events, and 2017 and 2018 have both seen particularly destructive wildfires around the world, most notably in California.



- ii. *Heatwaves*. An increase in the frequency and severity of heatwaves could lead to an increase in damage to infrastructure and the associated business interruption.
- iii. *Heavy rainfall and flooding*. In a warmer world, the atmosphere will hold more moisture, which will lead to an increase in the frequency of extreme precipitation events and associated flooding, causing damage to property and crops.
- iv. *Tropical cyclone surge and flooding*. As temperatures rise, the polar ice caps melt, which raises sea levels and increases the surge risk to coastal properties. For example, Lloyd's of London estimated that a 20 cm rise in sea levels at the southern tip of Manhattan Island contributed an additional 30% to the cost of storm surge losses in New York when the remnants of Hurricane Sandy struck the city in 2012 (Lloyd's, 2014).
- v. *Extra-tropical windstorms*. Changing patterns of atmospheric circulation could lead to higher or lower frequencies of windstorm events in certain regions and the potential for increased severity.
- vi. *Freeze*. Whilst freeze events may be expected to reduce in frequency and severity for many parts of the worlds, changing climate patterns may introduce more extreme freeze events in some localities.

The impacts from these changes are unlikely to be uniform across all geographies, with some regions seeing increases in risk and others experiencing decreases.

Furthermore, many of these risks may be interconnected. For example, a climate-related flood event can also lead to business continuity and supply chain risks. The World Economic Forum's Global Risks report (World Economic Forum, 2019) provides a good overview of the interconnected risks faced by society.

For further detail on the potential physical impacts of climate change, readers can consult the paper "Climate Change for Actuaries: An Introduction" or "Climate Change: Implications for Investors and Financial Institutions" (UNEP Finance Initiative and Cambridge University, 2014). However, the warning from the 2014 IPCC assessment report is stark:

*"Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks".* (IPCC, 2014)

#### 4.2. Transition Risks

The PRA defines transition risks as:

*"The financial risks which could arise for insurance firms from the transition to a lower-carbon economy. For insurance firms, this risk factor is mainly about the potential re-pricing of carbon-intensive financial assets, and the speed at which any such re-pricing might occur. To a lesser extent, insurers may also need to adapt to potential impacts on the liability side resulting from reductions in insurance premiums in carbon-intensive sectors".* (Prudential Regulation Authority, 2015)

These risks include a wide range of implications that arise out of actions that governments, regulators and society in general may take to limit the impacts of climate change, including the introduction of new policies and the adoption of new technologies.

These financial risks might affect a general insurer's balance sheet on its assets (A), liabilities (L) or both. Examples that might impact on general insurers might include:

- i. Loss of market value and/or investment income within investment portfolios, where investments are exposed to the risk of stranded assets. (A)

"Stranded Assets" can be defined as "Assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities. They can be caused by a range of environmental-related risks..." (Caldecott, *et al.*, 2014)

- ii. Changes in motor liability risks posed by a move away from fossil fuels. (L)
- iii. Changes in commercial risks from new or different manufacturing processes in a decarbonised world. (L)
- iv. Pressure from councils and regulatory authorities to disinvest from coal sector companies, increase their investments in the renewable energy sector and withdraw insurance support from projects and companies in the coal sector. (A)
- v. Financial impact of policy changes such as implementing carbon-pricing mechanisms to reduce GHG emissions, shifting, energy use toward lower emission sources, adopting energy-efficiency solutions, encouraging, greater water efficiency measures and promoting more sustainable land-use practices. (A)
- vi. Repricing of assets (e.g. fossil fuel reserves, land valuations and securities valuations) leading to an increased need for repricing of the corresponding insurance policies. (L)
- vii. Need for a thorough review of policy wordings to weed out hidden exposures leading to environmental liability. (L)
- viii. Disruptive changes across economic sectors and industries in the near term leading to political risks. (A+L)
- ix. Increased product liability due to technological changes supporting the transition to support lower-carbon economy, that is, overheating of energy storage batteries causing explosions. (L)
- x. Potential latent claims arising, that is, due to using energy saving LED devices that pose potential health concerns: ANSES, the French Agency for Food, Environmental and Occupational Health and Safety, has published a report entitled (in English), "Lighting systems using light-emitting diodes: health issues to be considered". The issues of most concern identified by the agency concern the eye due to the toxic effect of blue light and the risk of glare (ANSES, 2010). (L)
- xi. New emerging risks and increasing uncertainty as countries switch to alternatives such as wind, solar, wave, tidal, hydro, geothermal, nuclear and biofuels (A+L)

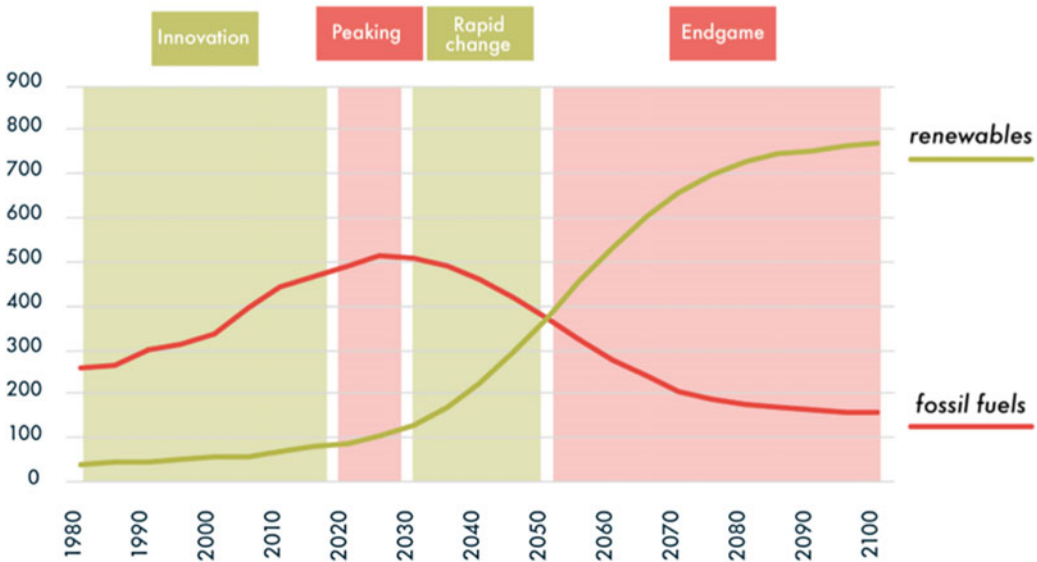
As pointed out in the TCFD recommendations, transitioning to a lower-carbon economy is likely to entail extensive policy, legal, technology and market changes.

The "Actuaries Institute Climate Change Working Group" in Australia (Dong *et al.*, 2018) has highlighted that transition risks and opportunities may arise from:

- i. policy and legal changes
- ii. technological advancement
- iii. change in demand or
- iv. reputational risk.

The following graph is an illustration of one potential pathway for the pace of change:

### Total primary energy (EJ)



Depending on the nature, speed and focus of these changes, transition risks may pose varying levels of financial and reputational risk to organisations. In fact, climate change has been identified as a potential source of reputational risk tied to changing customer or community perceptions of an organisation's contribution to or detraction from the transition to a lower-carbon economy. The risk associated with and financial impact of policy changes will depend on the nature and timing of the policy change. It is likely that longer term implications of this transition may be more far-reaching than its effect on financial disclosure norms.

#### 4.3. Liability Risks

The PRA defines liability risks as:

*“Risks that could arise for insurance firms from parties who have suffered loss and damage from climate change, and then seek to recover losses from others who they believe may have been responsible. Where such claims are successful, those parties against whom the claims are made may seek to pass on some or all of the cost to insurance firms under third-party liability contracts such as professional indemnity or directors’ and officers’ insurance.”* (Prudential Regulation Authority, 2015)

The definition focuses on the liability risks posed to insurers that might be exposed both through the insurance contracts they write and through the liability risks to their investments. Readers might also reflect on the possible implications for their own potential liability as professionals if they fail to communicate about, or take adequate account of, climate change risks as part of their advice.

Recent years have seen an increase in climate-related litigation claims being brought before the courts by property owners, municipalities, states, insurers, shareholders and public interest organisations.

The PRA identifies the following reasons for such litigation:

- i. Failure to mitigate: If insured parties are being held responsible for the physical impacts of climate change, such as through emissions of greenhouse gases.
- ii. Failure to adapt: If insured parties have not sufficiently accounted for climate change risk factors in their acts, omissions or decision-making.
- iii. Failure to disclose or comply: If insured parties (or insurers themselves) have not sufficiently disclosed information relevant to climate change, have done so in a manner that is misleading or have otherwise not complied with climate change-related legislation or regulation.

These three reasons may be familiar. For example, they could equally apply to businesses in the retail sector dealing with digitalisation, and its impacts on customer behaviour and high street sales. Practitioners may already be considering these points in relation to other trends and this is no different.

As the value of loss and damage arising from climate change grows, litigation risk is also likely to increase. For example, in New York City in January 2018, a lawsuit was announced against five major oil companies, seeking to collect billions of dollars in damages to pay for city efforts to cope with the effects of climate change (Savage, 2019).

## 5. Impacts on the Key Areas of Focus for GI Actuaries

At the time of writing this guide, a few tools are starting to emerge that GI actuaries and other practitioners could use to look at the physical impacts of climate change. An industry group facilitated by the PRA has produced a report titled “A framework for assessing financial impacts of physical climate change: A practitioner’s aide for the General Insurance Sector”. Further details are included in section 4.3 Catastrophe Modelling and a link to the report is included at the back of this guide under “Where can I find more information and data?”.

### 5.1. Pricing and Underwriting

This section discusses the impact of climate change on pricing and underwriting functions.

Pricing functions can vary widely between the experience rating found in the pricing of some larger commercial risks, and the exposure rating found in smaller commercial risks and in personal lines. However, both tend to rely on projecting from past data, with adjustment for future effects such as inflation, changes in terms and conditions, changes in underlying exposures and anticipated changes in the frequency and severity of events that give rise to insurance claims. Climate change will increase uncertainty about trends in the data and the degree of confidence that can be placed in those projections.

Many GI products are in the form of annually renewable contracts. Therefore, it may be tempting to assume that slow gradual changes in the climate will be experienced and only small differences in premiums will be needed to reflect these changes. However, acute physical risks include changes in the frequency of large cat events, where trends are difficult to identify. In pricing high-severity, low-frequency events such as large-scale catastrophe events, practitioners may wish to calibrate their models using a large number of past years; in those cases, an unrecognised (and non-linear) trend may introduce unwanted bias into any future trend. For example, using 30 years of past event data to calibrate a model may mean that it reflects a climate approximately 15 years out of date. Transition and liability risks may also include step-changes in the regulatory and legal environments. Therefore, pricing practitioners may need to consider the

ways in which climate change may have influenced their past data, the likely impact it has on trends and the outlook for the future.

In conjunction with the risk management function, pricing practitioners may wish to develop “leading indicators” for physical factors that reflect the impact of climate change, indicating where adjustments to pricing and underwriting practices may be required.

One example of a leading indicator developed in the USA and Canada is the Actuaries Climate Index (American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society and Society of Actuaries, 2016).

Examples of risks might include:

- i. For physical risks to property insurance, pricing practitioners may use catastrophe models to inform their assumptions about the incidence, expected value and potential variability of losses from catastrophe events. Practitioners may consider the range of climate change risks and the degree to which they are considered within the calibration of those models (see also section 4.3 on Catastrophe Modelling). Similarly, there may be new risks emerging outside the scope of the catastrophe models being used. For example, climate change may create new wildfire and subsidence risks in areas previously considered low risk, due to changed precipitation patterns including the occurrence of prolonged dry spells.
- ii. Physical risks also impact on weather index insurance, which is an alternative to crop insurance and is increasingly found in developing countries. The pricing methods and sensitivities to climate change were used to illustrate a report “Assessing pricing assumptions for weather index insurance in a changing climate”. The report highlighted that the pricing of weather index insurance is particularly sensitive to climate change assumptions and concluded that:

*“Without consideration of multiple sources of climate information, and an acknowledgement of the associated biases and errors, insurers are likely to miscalculate and misrepresent the underlying climate hazard risks”.* (Daron & Stainforth, 2014).

- iii. Transition risks from decarbonisation of the global economy may create new risks to insurers. These could, for example, include risks associated with high-capacity battery storage. For example, ClimateWire commented in a Scientific American article that:

*“Storing large amounts of energy, whether it’s in big batteries for electric cars or . . . , is still a young field. It presents challenges, especially with safety”.* (Irfan, 2011)

- iv. For liability risks on casualty products, there may be relatively little history of climate-related litigation. However, there is an increasing trend in litigation. For example, a policy brief from the London School of Economics highlighted several US municipality-lead lawsuits against fossil fuel companies alleging liability for public nuisance, failure to warn, design defect, private nuisance, negligence and trespass (Grantham Research Institute on Climate Change and the Environment, 2018).

Practitioners may also consider that pricing is only one lever to manage the climate risks coming onto an insurer’s books. Underwriting rules may need to be adapted for climate change. For example, as sea levels rise, some coastal areas may become uninsurable. Withdrawing cover from such areas will pose wider social and reputational challenges.

It might also be noted that new opportunities might arise from climate change. These might include new products that protect against risks arising from climate change or incentives for insureds to mitigate or adapt to climate change.

## 5.2. Reserving

This section discusses the impact of climate change on reserving processes and judgements, mainly from the perspective of a deterministic reserving process aimed at producing an “Actuarial Best Estimate”.

“Solvency II requires claims provisions to be (*Actuarial*) *Best Estimates*, defined as being the (discounted) mean of the distribution of possible outcomes.” (General Insurance Reserving Oversight Committee, IFoA, 2008)

Most reserving techniques for established lines of business place some reliance on past experience. However, as discussed in the previous section, climate change will increase uncertainty about the future, reducing the confidence that can be placed in such data.

Reserving practitioners may need to consider the extent to which those uncertainties would affect the expected value of future claims costs, as well as the risks and uncertainties that could affect those costs. Applying the principle of proportionality, focusing on where climate change could have the greatest impact on existing reserves, this analysis may consider the following questions:

- i. For physical risks, what existing chronic (high frequency) or acute (high impact) weather- and climate-related drivers of insurance claims might be affected by climate change? For example:
  - will freeze-related claims frequencies on household and motor policies reduce or lie within a wider range?
  - will the incidence and extent of flooding or windstorm events increase with changed weather patterns, or will there be an increased tendency for clustering of events?
  - are there any leading indicators, based on physical (weather and climate) rather than financial (claims) data that could provide more insights?
  - are these physical effects largely short term in their impact, and therefore less subject to uncertainty beyond the original period of exposure?
  - what changes, in response to climate change, such as changes in agriculture practices and investment in physical resilience, might impact future claims costs?
- ii. For transitional risks, what shifts in economic activity, supply chains, business practices and consumer behaviour might impact the underlying exposures?
  - will existing carbon-based industries receive lower investment and move to higher risk practices? For example, Paris City Council has urged European (re)insurance companies to stop supporting the coal industry (Insurance Business Magazine, 2018).
  - for new and emergent technologies, how can changes in the distribution of risk be anticipated in the reserving processes (e.g. will electric cars be slower and safer with more safety features, or silent and more dangerous with more risk of battery fires?)
  - what leading indicators, based on investment trends (e.g. volumes in different energy subsectors, the use of electric vehicles and investments in energy efficiency) could capture the rate of transition to a lower-carbon economy and its likely make-up?

- iii. For liability risks, for professional indemnity and other relevant classes, practitioners may need to consider the nature of the exposure:
  - are these policies on a claims-made or losses-occurring basis, the latter being more exposed to latent claims?
  - are there existing court cases, reflected in the current reserves or that are relevant to the existing reserves, that could indicate likely trends for the future?
  - applying the three broad liability headings of “failure to mitigate”, “failure to adapt” and “failure to disclose”, what claims might arise against these business classes?
  - in broad terms, what is the temporal nature of the exposure of the different classes of business and the reserves being held?
  - are the physical losses reported largely in real time and are the current and short-term impacts of climate change directly reflected in their incidence and extent?
  - for longer tail classes of business, to what extent might the emergence of climate change impacts, say on investors’ propensity to sue under directors and officers policies or for physical asset owners to sue under architect and engineer policies, be spread over time and subject to greater uncertainty?

In all these considerations, it is important to remember that prior to the emergence of climate change impacts future outcomes will continue to be uncertain. For this reason, practitioners are encouraged to present their impact analysis in the form of potential scenarios, from which deterministic “Actuarial Best Estimates” may be selected, taking on a broader range of considerations, including whether some risks and uncertainties are best reflected in capital modelling and the determination of capital requirements. Sensitivity tests can help highlight the range around that best estimate.

### **5.3. Catastrophe modelling**

Catastrophe models cover a wide spectrum of risks including casualty, and man-made and natural catastrophe risk. As such, they have the potential to help GI practitioners quantify risk across each of physical, transitional and liability climate change risks. Natural catastrophe models are the most established in the market, and hence this section of the report focuses primarily on physical risks.

The PRA has published a report proposing a framework for the assessment of financial impacts of physical climate change. The report is the product of a working group with representatives from across the GI market. It includes detailed case studies to help (re)insurers assess financial impacts on liabilities from climate change risk, using tools that are already available within the GI sector and illustrating how the proposed framework can operate in practice. A link is included in the resources at the back of this guide under “Where can I find more information and data?”.

GI practitioners may wish to consider the implications of climate change and catastrophe modelling in two dimensions:

- i. Extent to which catastrophe models capture present-day climate risk:

Natural catastrophe models are the most appropriate tools the insurance industry has for quantifying risk from atmospheric perils, such as tropical cyclones, floods and wildfires. These models have been calibrated using historical events and therefore implicitly account for climate change trends. However, most commercially available models are not designed to quantify climate change risk, and hence careful interpretation of the results is necessary. For example, the 1:50-year flood or windstorm event in the historical record does not necessarily represent the present-day 1:50-year event if climate change has altered the probability of occurrence. This means that models calibrated on long historical records (e.g. US hurricane) may not adequately represent the present-day risk, which may have been modified by climate change. That said, several vendors

provide alternative “near-term” views of risk for US hurricane, which are calibrated on more recent observations and could therefore be used to test the sensitivity of a portfolio to climate variability.

ii. Quantification of future climate risks through catastrophe models:

GI practitioners need to account for the fact that all the elements of future climate change impacts may not be captured in the catastrophe model outputs they are using. One solution to this problem is sensitivity testing, which can provide a useful tool for investigating the potential impact of future climate change on insurance portfolios. For example, in the future we may observe more intense hurricanes or more severe floods. To quantify the climate sensitivity, practitioners could work with catastrophe modellers to modify the frequency and/or severity of simulated events based on scientific studies (e.g. increasing the frequency of extreme floods). This will provide practitioners with a stress test for their portfolio, which may help clarify how different books of business and/or regions could be impacted by climate change.

Catastrophe models are often used across a wide range of insurance functions including pricing, underwriting, portfolio management, capital management, reinsurance structuring and pricing, and business strategy. These functions have different time horizons, and therefore different approaches could be adopted for quantifying climate risk. For example:

- *Short term*: since many (re)insurance products are priced and underwritten on an annual basis, GI practitioners could assume that the implicit climate risk built into catastrophe models provides adequate repricing at an individual risk level. However, the practitioner may also need to consider other factors, such as how well the catastrophe model captures climate risk (e.g. how old is the model?), and whether recent claims reflect the view of risk provided by the model.
- *Medium term*: on timescales of 5–10 years, sensitivity testing can be used to influence portfolio steering. Practitioners may need to work with catastrophe modellers to develop sensitivity tests (i.e. scenarios) to understand what the risk to the portfolio might look like in the medium term.
- *Long term*: impacts of climate change to the capital position of a book of business (e.g. the cost of inaction) can be quantified using catastrophe modelling tools as part of forward-looking assessments, recognising the uncertainties involved (e.g. sensitivity testing). Furthermore, with a changing climate risk profile, GI practitioners may decide to withdraw business in certain areas and grow business in others (e.g. geographies/lines of business). Catastrophe models could provide information to help in designing such evolving business strategies.

“Sensitivity testing” refers to the assessment of modelling outputs where key inputs (parameters) are varied within a plausible range. Examples of these inputs include the frequency and severity of hazard events, and the assumed relationship between hazards and damage (i.e. “vulnerability”).

Accepting that past climate change impacts are partly reflected in catastrophe models, GI practitioners may need to consider, in collaboration with catastrophe modelling experts and as a way of exploring potential impacts with the firm’s management, a range of different scenarios (or sensitivity tests). These scenarios might include use of best estimate calibrations provided by the catastrophe models, as a base case; a middle case assuming a slight increase in the estimated trend and, a “worse” case, where a sharp non-linear increase or step-change in impacts was assumed to occur.



When calibrating external catastrophe models for a company's own past experience, practitioners may want to consider the difficulties in discerning past trends (see also section 4.1 Pricing and Underwriting) and the potential for non-linearity in past and future trends.

#### 5.4. Reinsurance

Climate change is expected to have far-reaching and substantial impacts, leading to system-level shifts in conditions in the natural environment. The higher frequency and severity of extreme weather events, as well as increased chronic physical risks, will increase the cost and importance of reinsurance protection for insurers. John Dacey, CFO, Swiss Re said in 2018:

*“Climate change is in fact warming not just the Earth but also the oceans and one of the reasons why the expectation of future hurricanes is so high is that last years’ three hurricanes together – the \$135 billion of losses – are a one-in-10-year event not a one in a 100-year event. We see the possibility for a repetition of these kinds of losses in the foreseeable future”.* (Dacey, 2018)

With more extreme weather events, concentration risk will increase, not only putting pressure on reinsurance but also raising the need for insurers to more actively manage the physical distribution of their exposures. If there are more catastrophes in concentrated areas, there will also be more instances of “demand surge” pushing up the cost of individual loss events, which will need to be modelled and protected against.

“Demand surge” is the “increase in the cost of repair or replacement of damaged property that may occur following a large-scale disaster when many individuals and organisations vie for a limited supply of labour and materials needed for repair”. (International Risk Management Institute, n.d.)

Reinsurers that have global portfolios also need to be concerned with the impact of climate change on teleconnections and how this could result in outsized losses.

“Teleconnection in atmospheric science refers to climate anomalies being related to each other at large distances (typically thousands of kilometres). The most emblematic teleconnection is that linking sea-level pressure at Tahiti and Darwin, Australia, which defines the Southern Oscillation”. (Anon., 2018)

Climate change could impact reinsurance structures if more events are hitting reinsurance layers. This does not automatically mean that reinsurers will withdraw cover, but the terms and conditions, premiums, etc. could change.

More generally, insurers may be better placed to monitor, manage and buy reinsurance for their portfolios if they have accurate exposure management systems in place. However, climate change impacts may come with large quantitative uncertainties particularly at the regional level, and practitioners may not wish to be overly reliant on modelled outputs from those systems.

If climate change increases the potential for losses from a particular peril or region, then reinsurers may place a cap on these exposures, reducing the availability and increasing the cost of reinsurance cover. A firm that has detailed quality data on its exposures will be better placed to seek cover from its existing reinsurers, to engage with other reinsurers and to develop capital market solutions, such as the placing of catastrophe bonds.

Insurers will also need to manage sideways exposures, where the potential for a greater number of large or extreme events in a single year may exhaust reinstatements on catastrophe reinsurance programmes.

If an insurer has needed reinsurance to be able to offer cover for larger single or significant accumulation risks than its own capacity could accommodate, then the continued availability of this reinsurance and the ongoing viability of its existing business plan may also need to be reassessed in the light of climate change.

Some reinsurers have, for many years, recognised the potential risks and uncertainties posed by climate change. They have been active in carrying out and publishing research to assist in their own management of risk and to develop and offer solutions to clients. Potentially, technical support provided by reinsurers to cedants may help insurers in assessing the potential impact of climate change, as well as monitoring emerging trends over time.

In dealing with a changing risk environment, it is important that insurers have a clearly defined risk appetite that can inform decisions at the aggregate portfolio, line of business and individual risk level. The pay-off between reinsurance costs, the protection provided and the expected impact on the insurer's risk profile and financial performance can then be assessed within a common framework.

Commenting on a recent report by Moody's, Reinsurance News said that the effects of climate changes may present many opportunities for insurers and reinsurers to expand their operations by introducing new products, expanding existing ones and by closing the protection gap (Sheehan, 2018).

*"Protection gap"* is illustrated by the Insurance Development Forum (IDF): "70% of economic losses from natural hazards remain uninsured and in middle/low-income countries the uninsured proportion of economic losses often exceeds 90%". (Insurance Development Forum, 2018)

Moody's predicts that insurance is likely to become a more widespread part of comprehensive risk adaptation strategies as the financial and economic risks associated with climate change become more pronounced, and as governments, businesses and individuals become more aware of these risks.

Depending on the severity and concentration of both chronic (e.g. significantly increased levels of precipitation or localised wildfires where rainfall has reduced markedly) and acute (e.g. severe rainfall leading to flooding and landslide events) some risk concentrations may become too great for regional reinsurers to diversify. Although they may choose to mitigate some of the risk through retrocession into the global reinsurance market, ultimately costs may increase.

For similar reasons, national catastrophe schemes may also become challenged, testing the level of support for and viability of those arrangements. These schemes may be scaled-back or cease, reducing the levels of protection and financial resilience of the affected areas, as well as creating knock-on effects for conventional insurance providers in the region.

### 5.5. Investment

GI actuaries may wish to consider the implications of climate change for investment portfolios.

Again, it is perhaps helpful to consider the implications of climate change on investment in terms of physical, transition and liability risks.

Physical risks to investment portfolios could include threats to infrastructure or real estate arising from rising sea levels or extreme weather events. Alternatively, a catastrophic climate change event such as a tsunami might cause such damage to an enterprise or an economy as to lead to default on debt by the issuer. Droughts or famines caused by climate change might lead to mass

migration of populations, associated political change or even wars, with consequential economic impacts and falls in the values of assets.

From an investment perspective, transition risks include the possibility of a fall in the value of the shares or debt securities of carbon-intensive companies due to “stranded assets” or legislation to deal with climate change. For example, Citigroup has estimated that if the rise in global temperatures is to be constrained to two degrees above pre-industrial levels, the total value of stranded assets could be over \$US100 trillion based on 2015 market prices (Citi GPS, 2015).

Similarly, some companies face risks to their business model arising from competition from producers of “greener” alternatives, for instance, those producing energy from carbon sources, or motor vehicle manufacturers.

A further consideration is that, as “ESG” investment strategies become more widespread, investors in these types of strategies may disinvest from securities issued by carbon-intensive companies, leading to a fall in their price, even if their assets do not actually become “stranded”.

*“Environmental, social and governance (ESG) refers to the three central factors in measuring the sustainability and ethical impact of an investment in a company or business. These criteria help to better determine the future financial performance of companies (return and risk)”.* (Anon., 2018)

In particular, PRI defines the environmental “E” of ESG as including:

*“Issues relating to the quality and functioning of the natural environment and natural systems. These include: biodiversity loss; greenhouse gas (GHG) emissions, climate change, renewable energy, energy efficiency, air, water or resource depletion or pollution, waste management, stratospheric ozone depletion, changes in land use, ocean acidification and changes to the nitrogen and phosphorus cycles”.* (PRI, 2017)

Alongside the “downside” transition risks outlined above, there may also be investment opportunities arising, for example, for investment in new technologies such as “green energy”, new infrastructure or electric cars.

There may also be investment opportunities arising from the catastrophe events linked to the physical risks of climate change. There can be an increase in economic activity as repairs to buildings and infrastructure are carried out.

*“Green energy” is “energy that can be produced in a way that protects the natural environment, for example by using wind, water, or the sun”.* (Cambridge University, 2018)

In a 2008 article for the New York Times, Drake Bennett wrote:

*“Rebuilding efforts provide a short-term boost by attracting resources to the region, economists say. By destroying old factories and roads, airports and bridges, the disasters allow new and more efficient infrastructure to be built, forcing the transition to a sleeker, more productive economy in the long term”.* (Bennett, 2008)

Various studies have suggested that stock markets may also receive a boost following catastrophic events, but it is not clear that such a boost is significant or any more than short term in nature.

Indeed, a 2007 PIMCO report, “Do natural disasters affect the stock market?” looked at the correlation between catastrophe bonds and stock markets. It commented:

*“Markets tended to rally after a catastrophic event – though not to a statistically significant degree”.* (Brynjolfsson & Dorsten, 2007)

However, a study by the Cambridge Centre for Risk Studies looked at extreme catastrophe events and found that they would have a detrimental impact:

*“The nature of high quality investment portfolios is that they are robust to short term market fluctuations, but these investment portfolios are not immune to the levels of market depreciations that occur from events of this magnitude”.* (Cambridge Centre for Risk Studies, 2018)

Whilst there remains considerable uncertainty over the effects of climate change and the extent of the rise in global temperatures, a prudent approach in the presence of uncertainty argues for acting sooner rather than later, given the potential severity of the consequences of inaction.

Under Solvency II, Article 162 describes the Prudent Person Principle, and in the UK, the PRA rulebook states:

*“The firm must only invest in assets and instruments the risks of which it can properly identify, measure, monitor, manage, control and report and appropriately take into account in the assessment of its overall solvency needs in accordance with Conditions Governing Business 3.8(2)(a)”.* (Prudential Regulation Authority, 2018)

It is only natural to be concerned that a change in investment strategy could lead to a lower rate of return. However, a considerable number of academic studies (Deutsche Asset and Wealth Management (UK), 2015) have shown the reverse to be true, with the adoption of ESG (which includes action on climate change) investment strategies being associated with subsequent higher investment returns.

As an example, in January 2018, the New York City Pension Fund stated its intention to disinvest \$5bn from investments linked to fossil fuels, citing both poor historical and poor expected returns (The Guardian, 2018).

There are some practical steps practitioners can take in relation to investment strategy to account for the impact of climate change. Some of these are outlined below:

- i. setting out formally your approach to climate change-related risks within your investment policy;
- ii. arranging for carbon footprint analysis of your investment portfolio to determine its potential exposure to climate change risks; this might include forward-looking analysis;
- iii. asking your investment managers to detail the steps they are taking to deal with climate change and including formal expectations in the investment mandates.

It is anticipated that a further practical guide aimed at investment practitioners will be available in the coming months. Further information can also be found through PRI’s website: [www.unpri.org](http://www.unpri.org).

## **5.6. Risk Management**

The risk management function within a firm may actively consider whether the other functions within the business, including the strategic planning function, as well as the executive and the

board, have a sufficient understanding and awareness of climate change to accurately assess its potential impact on the risk profile, day-to-day functioning and future viability of the firm.

*“Firms would be expected to identify, measure, monitor, manage, and report on their exposure to these risks. Firms should be able to evidence this in the written risk management policy, management information and board risk reports”.* (Prudential Regulation Authority, 2019).

Where that understanding, and awareness is lacking, the risk management function may need to consider “capacity building” within the business. This may include providing training, guidance, case studies and supporting research, with the aim of building “carbon literacy” and integrating climate change risks within the firm’s existing systems of governance and control. Pending this integration, the risk management function can identify and assess material risks and support the development of appropriate responses within the firm, working in partnership with other functions in the business.

*Carbon Literacy:* “An awareness of the carbon dioxide costs and impacts of everyday activities, and the ability and motivation to reduce emissions, on an individual, community and organisational basis”. (The Carbon Literacy Project, 2019)

A further role for risk management may be to ensure that stress and scenario tests are adequately calibrated and wide-ranging in their scope. The function can share its knowledge of past failures and “near misses” utilising Counterfactual Disaster Risk Analysis (Woo, 2018) methods to help develop challenging but credible assumptions. For example, in their joint 2017 paper, “Reimagining History”, Lloyd’s and RMS give the following counterfactual example:

*“During the blizzard of February 2013, a four-foot storm surge hit Boston at low tide, not high tide. With the high tide already a foot higher than average because of the new moon, coincidence of the storm surge with this high tide would have given rise to the 100-year flood (Conti, 2015). In this example, the chance of such coincidence with the high tide was approximately 1/6. As with a dice throw, the odds favoured insurers”.* (Lloyd’s and RMS, 2017)

The TCFD recommendations include the disclosure of climate change scenarios. Their 2017 report included a useful technical supplement on the use of scenario analysis (Task Force on Climate-related Financial Disclosures, 2017).

Actuaries within a risk management function may respond to the risk from climate change by:

- i. assessing the potential climate change impacts for short-, medium- and long-term time horizons, their impact on the firm’s viability, future strategy and capital requirements.
- ii. incorporating climate risk within the risk register, including capturing its classification, quantification, potential mitigants and recommended actions.
- iii. carrying out forward looking stress and scenario tests. The tests could aim to check the insurer’s resilience to physical risks (e.g. increased storms), transition risks (e.g. investment asset value impacts from a disorderly transition to a low-carbon economy) and liability (e.g. increased lawsuits).
- iv. Making appropriate disclosures of current and future risks such as those based on TCFD recommendations. Business may also use TCFD to inform underwriting and investment decision-making.

The risk management function could also define and assess key performance indicators to monitor exposures, and emerging trends. A deep understanding of exposures will go a long way in

responding to a changing landscape. An inappropriate strategy to deal with climate-related changes, say that ignores trends in the occurrence of extreme weather events or disruption and uncertainty, may inhibit the insurer from achieving its strategic objectives.

Climate changes may also affect the appetite of stakeholders, for example, shareholders may be unable to provide further capital, regulators may become more stringent and require that capital allocation choices are aligned with the future needs of the low-carbon economy and policyholders may desire broader scope in the cover provided, increasing potential exposure and uncertainty for the firm. The risk management (or actuarial) function could inform the insurer regarding the future impacts of policy wordings and limits, where these could lead to uncompensated risks, exceed the risk-bearing capacity of the firm or move beyond its stated risk appetite.

### **5.7. Capital Management**

Capital is needed for insurance companies to provide financial stability and protection to policyholders. In most countries, insurance companies are required to hold a minimum level of capital by the regulator, but they also need to decide on the appropriate “economic” level of capital commensurate with their risk appetite and strategic objectives. Capital is also one of the principal measures of the value of a firm, so its proper management, maintenance and potential growth are of prime concern to the management and owners of a GI firm.

The capital management function responsibilities may vary, but typically include:

- determining the level of capital required (capital modelling)
- forecasting and maintenance of the capital position
- publication and disclosure of capital on a regulatory or voluntary basis.

Typically, a capital model is used to project risks within the company and estimate the level of capital required to achieve a target level of security over a selected timeframe, consistent with a stated risk appetite.

By incorporating climate change impacts into its modelling, a firm can identify potential vulnerabilities and explore the feasibility of its existing and alternative business strategies. Given the uncertainties involved, this work may need to explore an appropriate range of permutations in the varying nature, extent and timing of impacts that could arise. The translation of these impacts into financial risks on the balance sheet may also be informed by the work of other functions within the firm, for instance, underwriting and pricing, reserving and catastrophe modelling.

Also, non-modelled and emerging climate risk may need to be considered within the capital model. For example,

- Some of the chronic physical effects of climate, including sea level risk, changed precipitation patterns and the incidence of localised wildfires may not be captured in existing catastrophe models but could instead be reflected in “attritional” loss assumptions or in loss ratios at a line of business or portfolio level.
- Under some transition risk scenarios, existing sectors of the economy that are a source of insurance business may be severely impacted by technological or regulatory disruption, leading to strategic challenges and a period of heightened uncertainty whilst new markets are developed.
- Climate risk may introduce dependencies or “ripple effects” across different risk types and regions or lines of business. For example, capital modelling actuaries may need to consider how climate change as a risk driver influences:
  - Excess mortality resulting from heatwaves
  - Agriculture yields
  - The pattern of property cat and marine cargo losses.

These risks may be driven by similar underlying root causes but lead to very different consequences. For instance, an increase in sea level may lead to more losses in a region (physical risk), causing mass migration to the mainland, hence changing economic activity levels on the mainland with consequences for the availability and performance of investment assets (transition risk). At the same time, governments may take measures to curb carbon emission, impacting financial markets and asset returns.

A stable capital position may be desirable to ensure a consistent level of protection for policyholders over time, as well as a predictable return on capital for shareholders. However, given the potential disruptions involved, insurers will need to be prepared to explore a challenging range of stress tests and loss scenarios, to determine the potential impact on their capital and identify the different risk mitigation (and avoidance) actions that they might take. These could include more extensive reinsurance cover, better monitoring of portfolios, stricter limits on policies or withdrawal from individual lines of business.

Rating agencies may introduce new climate risk measures when evaluating companies' financial ratings and this may affect the ratings of insurance companies. For example, S&P highlighted, in a research paper, that many companies' ratings could incorporate environmental and climate factors. This notably impacted the oil, gas and energy sector more than others. GI practitioners may wish to consider their firms' environmental and climate risk profiles to anticipate and, potentially, avoid sudden movements in their credit ratings.

As climate change-related risks become more prominent in the public's consciousness, regulators may require more disclosure from companies to ensure the appropriateness of their level of capital. Prior to this, by voluntarily adopting the TCFD disclosure recommendations, companies would be able to conduct a "climate audit". This will provide shareholders, management, regulators and other stakeholders with valuable information to better understand the company's climate risk profile. This would also foster greater knowledge sharing amongst practitioners within the insurance industry. Through early adoption of the new disclosure requirements, the company would avoid the greater strain in resources should regulators choose to make climate risk disclosure compulsory.

## 6. Frequently Asked Questions

*"Why should I worry about climate change when our contracts are annually renewable and can adapt quickly to change?"*

Acute physical risks include changes in the frequency of large cat events, where trends are difficult to identify. High-severity, low-frequency events such as large-scale catastrophe events may require practitioners to calibrate their models using a large number of past years; in those cases, an unrecognised (and non-linear) trend may introduce unwanted bias into any future trend. For example, using 30 years of past event data to calibrate a model may mean that it reflects a climate approximately 15 years out of date.

Transition and liability risks may also include step-changes in the regulatory and legal environments. Therefore, practitioners will need to consider the ways in which climate change may have influenced their past data, the likely impact it has on trends and the outlook for the future.

Investment portfolios may include longer term exposure to companies exposed to physical, transitional and liability risks, and company strategy over the planning horizon and beyond may need to consider the impacts of climate change.

*"Why don't we wait until the science is more certain?"*

According to the IPCC, there is scientific consensus that warming of the climate is "unequivocal" and that human activities, particularly GHG emissions, are "extremely likely to have been the dominant cause of the observed warming since the mid-20th century" (IPCC, 2014).

Scientists are as certain about the link between human behaviour and climate change as they are about the link between smoking and lung cancer (Molina *et al.*, 2014).

*“Why should I comment on climate change when I’m not a climate change expert?”:*  
The IFoA’s non-mandatory Risk Alert on climate-related risks stated that:

*“Actuaries should ensure that they understand, and are clear in communicating, the extent to which they have taken account of climate-related risks in any relevant decisions, calculations or advice”. (IFoA, 2017)*

This asks actuaries to think carefully about the extent to which they have taken account of climate-related risks and in particular, highlighting where climate change introduces material financial risk or uncertainty.

*“How soon can I expect climate change to affect my work?”:*

Climate change is no longer an “emerging risk”, it is likely to have had a material financial impact already on most GI operations.

There is a growing interest from regulators, investors and customers around the world. Furthermore, actuaries have a professional duty to highlight material financial uncertainties. This means that climate change is affecting the work of GI practitioners now.

*“How can I influence my colleagues to ensure they take climate change seriously?”:*

The paper “Climate change for Actuaries: an introduction” includes a very useful section on communicating about climate change risks. It discusses five inner defences that stop people from engaging with climate change and then highlights five solutions (Climate Change Working Party, 2019).

The “Uncertainty Handbook” published by the University of Bristol and Climate Outreach is also a very useful resource. It sets out 12 practical principles for communication around climate change uncertainty. A copy of the uncertainty handbook can be downloaded from:

<https://climateoutreach.org/resources/uncertainty-handbook/>

*“Where can I find more information and data?”:*

The range of information available is growing rapidly. Therefore, the list below may quickly expand, and some of the links may become out of date. However, at the time of writing, we found the following sources very helpful:

- The PRA’s paper on “The impact of climate change on the UK insurance sector” (September 2015): <https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/publication/impact-of-climate-change-on-the-uk-insurance-sector.pdf>.
- The PRA’s supervisory statement SS3/19 (April 2019): <https://www.bankofengland.co.uk/prudential-regulation/publication/2019/enhancing-banks-and-insurers-approaches-to-managing-the-financial-risks-from-climate-change-ss>.
- The PRA’s report “A framework for assessing financial impacts of physical climate change: A practitioner’s aide for the General Insurance Sector”: <https://www.bankofengland.co.uk/prudential-regulation/publication/2019/a-framework-for-assessing-financial-impacts-of-physical-climate-change>.
- The IFoA’s Climate Change Working Party Report, “Climate Change for Actuaries”: An Introduction”: <https://www.actuaries.org.uk/documents/climate-change-actuaries-introduction>.
- Actuaries Institute of Australia Climate Change Working Group’s paper on Transition Risk for General Insurers (November 2018): <https://www.actuaries.org.uk/news-and-insights/news/climate-transition-risk-general-insurers>.
- Deutsche Asset Management’s paper, “Measuring Physical Climate Risk in Equity Portfolios”: [http://427mt.com/wp-content/uploads/2017/11/Measuring-Physical-Climate-Risk-White-Paper\\_Four-Twenty-Seven-2017.pdf](http://427mt.com/wp-content/uploads/2017/11/Measuring-Physical-Climate-Risk-White-Paper_Four-Twenty-Seven-2017.pdf).
- TCFD’s final recommendations (June 2017): <https://www.fsb-tcfd.org/publications/final-recommendations-report/>.



- The CRO Forum’s position paper on “Insurability and Resilience in a Changing Climate” (January 2019): <https://www.thecroforum.org/2019/01/24/crof-eri-2019-the-heat-is-on-insurability-and-resilience-in-a-changing-climate/>.
- The UN Environment Programme’s draft paper on “Underwriting environmental, social and governance risks in non-life insurance business” (February 2019): <https://www.unepfi.org/psi/underwriting-esg-risks/>.
- The World Economic Forum’s Global Outlook (January 2019): <https://www.weforum.org/reports/the-global-risks-report-2019>.
- BP’s Global Energy Outlook 2019: <https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html>.
- The Global Calculator’s range of scenario data: <http://tool.globalcalculator.org/globcalc>.
- Deep decarbonisation pathways project’s range of scenarios and data: <http://deepdecarbonization.org/countries/visualization-of-country-scenarios/>.
- Data on CO<sub>2</sub> and other GHG emissions: <https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions>.

“How can I engage more with the IFoA’s work on Climate Change?”:

There are several ways to stay in touch with the Profession’s work on climate change and other R&E issues. These include:

- registering your interest in R&E newsletters by logging into the Profession’s website ([www.actuaries.org.uk](http://www.actuaries.org.uk)) and amending your preferences.
- attending one of the many R&E events organised by the profession
- volunteering to support the work of the R&E board, its “Research and CPD” sub-committee or one of its working parties: <https://www.actuaries.org.uk/get-involved/volunteering-ifo>.

**Acknowledgements.** With thanks to all the various colleagues and fellow professionals who have helped with the content of this report including:

- Dr Cameron Rye and Junaid Seria for their contributions towards the catastrophe modelling section and other elements within the report,
- Dr Juan Duan and Giorgis Hadzilacos for their contributions towards the catastrophe modelling section and
- All those who have contributed to both formal and informal peer reviews of this paper.

## References

- American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society and Society of Actuaries** (2016). *Actuaries Climate Index*, available at <http://actuariesclimateindex.org/about/>.
- Anon.** (2018). *Wikipedia*, available at <https://en.wikipedia.org> (accessed 2018).
- ANSES.** (2010). *Lighting systems using light-emitting diodes: health issues to be considered*.
- Bennett, D.** (2008). Do natural disasters stimulate economic growth? *The New York Times*, 8 July.
- British Antarctic Survey** (2018). *Experts on Climate Change*, Frankfurt, DWS.
- Brynjolfsson, J. & Dorsten, M.** (2007). *Do Natural Disasters Affect the Stock Market?* Newport Beach, PIMCO.
- Buberl, T.** (2017). *AXA accelerates its commitment to fight climate change*, available at <https://group.axa.com/en/newsroom/press-releases/axa-accelerates-its-commitment-to-fight-climate-change> (accessed 2019).
- Caldecott, B., Tilbury, J. & Carey, C.** (2014). *Stranded Assets and Scenarios*, Oxford, Smith School.
- Cambridge Centre for Risk Studies** (2018). *Impacts of Severe Natural Catastrophes on Financial Markets*, Cambridge, Cambridge Centre for Risk Studies.
- Cambridge University** (2018). *Cambridge Dictionary*, available at <https://dictionary.cambridge.org/dictionary/english/green-energy> (accessed 2018).
- Carbon Tracker** (2018). *2020 Vision: Why You Should See Peak Fossil Fuels Coming*, London, Carbon Tracker.
- Carney, M.** (2015). *Breaking the Tragedy of the Horizon - Climate Change and Financial Stability*. London: Bank of England.
- Citi GPS** (2015). *Energy Darwinism II - Why a low carbon future doesn’t have to cost the Earth* *Global Perspectives & Solutions*, August.

- Climate Change Working Party** (2019). *Climate Change for Actuaries: An Introduction*, London, IFOA.
- Dacey, J.** (2018). *Interview with CNBC's Joumana Bercetche* [Interview], 3 August 2018.
- Daron, J.D. & Stainforth, D.A.** (2014). Assessing pricing assumptions for weather index insurance in a changing climate. *Climate Risk Management*, (1), 76–91.
- Deutsche Asset and Wealth Management (UK)** (2015). *ESG and Corporate Financial Performance: Mapping the Global Landscape*, London, DWS.
- Dong, M., Paddam, S. & Wong, S.** (2018). *Climate Transition Risk for General Insurers*, Sydney, Actuaries Institute of Australia.
- EIOPA** (2019). *Consultation Paper on an Opinion on Sustainability Within Solvency II*, Frankfurt, EIOPA.
- Financial Conduct Authority (FCA)** (2018). *DP18/8: Climate Change and Green Finance*, London, Financial Conduct Authority (FCA).
- Financial Reporting Council** (2017). *TAS 100: Principles for Technical Actuarial Work and TAS 200: Insurance*, available at <https://www.frc.org.uk/actuaries/actuarial-policy/technical-actuarial-standards/technical-actuarial-standards-2017>.
- Fuss, S., Canadell, J.G., Peters, G.P., Tavoni, M., Andrew, R.M., Ciais, P., Jackson, R.B., Jones, C.D., Kraxner, F., Nakicenovic, N., Le Quéré, C., Raupach, M.R., Sharifi, A., Smith, P. & Yamagata, Y.** (2014). Betting on negative emissions. *Nature Climate Change*, (4), 850–853.
- General Insurance Reserving Oversight Committee. IFOA.** (2008). *Actuarial Best Estimates and Proxy Methods*.
- Governor's Strike Force** (2019). *Wildfires and Climate Change: California's Energy Future*, Sacramento, State of California.
- Grantham Research Institute on Climate Change and the Environment** (2018). *Policy Brief: Global Trends in Climate Change Legislation and Litigation: 2018 Snapshot*, London, London School of Economics.
- Hansen, J., Sato, M., Kharecha, P., Von Schuckmann, K., Beerling, D.J., Cao, J., Marcott, S., Masson-Delmotte, V., Prather, M.J., Rohling, E.J., Shakun, J., Smith, P., Lacs, A., Russell, G. & Ruedy, R.** (2017). Young people's burden: requirement of negative CO<sub>2</sub> emissions. *Earth System Dynamic*, 18 July.
- Huang, Z., Zong, Y. & Zhang, W.** (2004). Coastal Inundation due to Sea Level Rise in the Pearl River Delta, China. *Natural Hazards*, October.
- IAIS and SIF** (2018). *Climate Change Risks to the Insurance Sector*, Basel, IAIS.
- IFoA** (2017). *Climate Risk Alert*, available at <https://www.actuaries.org.uk/news-and-insights/media-centre/media-releases-and-statements/ifo-warns-climate-change-financial-risks> (accessed 2018).
- Insurance Business Magazine** (2018). Paris City Council calls on insurers to ditch coal.
- Insurance Development Forum** (2018). Available at <http://theidf.org/> (accessed 2018).
- International Risk Management Institute** (n.d.) *Demand surge*, available at <https://www.irmi.com/term/insurance-definitions/demand-surge> (accessed 2018).
- IPCC** (2014). *Climate Change 2014 Synthesis Report*, Geneva, IPCC.
- IPCC** (2018). *Global Warming of 1.5 C*, Geneva, IPCC.
- Irfan, U.** (2011). Available at <https://www.scientificamerican.com/article/battery-fires-risks-storing-larg-amounts-energy/>.
- Lloyd's and RMS** (2017). *Reimagining History: Counterfactual Risk Analysis*, London, Lloyd's.
- Lloyd's** (2014). *Catastrophe Modelling and Climate Change*, London, Lloyd's.
- Moss, R., Babiker, M., Brinkman, S., Calvo, E., Carter, T., Edmonds, J., Elgizouli, I., Emori, S., Erda, L., Hibbard, K., Jones, R., Kainuma, M., Kelleher, J., Lamarque, J., Manning, M., Matthews, B., Meehl, J., Meyer, L., Mitchell, J. & Zurek, M.** (2008). *Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts, and Response Strategies*. Technical Summary. IPCC Expert Meeting Rep. Available at [https://en.wikipedia.org/wiki/Representative\\_Concentration\\_Pathway](https://en.wikipedia.org/wiki/Representative_Concentration_Pathway) (accessed 2018).
- Molina, M., McCarthy, J., Wall, D., Alley, R., Cobb, K., Cole, J., Das, S., Diffenbaugh, N., Emanuel, K., Frumkin, H., Hayhoe, K., Parmesan, C. & Shepherd, M.** (2014). *What we Know: The Reality, Risks and Response to Climate Change*. American Association for the Advancement of Science, Washington DC.
- Muis, S., Güneralp, B., Jongman, B., Aerts, J. C. & Ward, P. J.** (2016). *A global reanalysis of storm surges and extreme sea levels*.
- National Oceanic and Atmospheric Administration (NOAA)** (2019). Available at <https://www.noaa.gov/news/2018-was-4th-hottest-year-on-record-for-globe>.
- PRI** (2017). *PRI Reporting Framework: Main definitions 2018*, London, PRI.
- Prudential Regulation Authority** (2015). *The Impact of Climate Change on the UK Insurance Sector*, London, PRA.
- Prudential Regulation Authority** (2018). *PRA Rulebook Online*, available at <http://www.prarulebook.co.uk/>.
- Prudential Regulation Authority** (2019). *Supervisory Statement SS3/19. Enhancing Banks' and Insurers' Approaches to Managing the Financial Risk from Climate Change*, London, PRA.
- Savage, K.** (2019). *Climate Liability News*, available at <https://www.climate-liability-news.org/2019/03/27/new-york-climate-suit-emissions/>.
- Sheehan, M.** (2018). Climate change offers growth opportunities for re/insurers: Moody's. *Reinsurance News*, 27 March.
- Steffen, W., Rockström, J., Richardson, K., Lenton, T.M., Folke, C., Liverman, D., Summerhayes, C.P., Barnosky, A.D., Cornell, S.E., Crucifix, M., Donges, J.F., Fetzer, I., Lade, S.J., Scheffer, M., Winkelmann, R. & Schellnhuber, H.J.**

- (2018). Trajectories of the Earth system in the Anthropocene. *PNAS*, **115** (33), 8252–8259. (see: <https://www.pnas.org/content/115/33/8252>)
- Task Force on Climate-related Financial Disclosures** (2017). *The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities*, Basel, Financial Stability Board.
- The Carbon Literacy Project** (2019). *The Carbon Literacy Project*. available at <http://carbonliteracy.com/> (accessed 2019).
- The Guardian** (2018). Available at <https://www.theguardian.com/us-news/2018/jan/10/new-york-city-plans-to-divest-5bn-from-fossil-fuels-and-sue-oil-companies>.
- The National Research Council** (2011). *Understanding Earth's Deep Past: Lessons for Our Climate Future*. Washington DC, The National Academies Press.
- “The Relevance of Resource and Environment Issues to Pension Actuaries” Working Party** (2017). *Supplementary Information on Resource and Environment Issues and their Implications for Sponsor Covenant Assessments*, London, IFoA.
- UNEP Finance Initiative and Cambridge University** (2014). *Climate Change: Implications for Investors and Financial Institutions*, London, IIGCC.
- van Oldenborgh, G.J., van der Wiel, K., Sebastian, A., Singh, R., Arrighi, J., Otto, F., Haustein, K., Li, S., Vecchi, G. & Cullen, H.** (2017). *Attribution of extreme rainfall from Hurricane Harvey, August 2017*, available at <http://iopscience.iop.org/article/10.1088/1748-9326/aa9ef2/meta>.
- Woo, G.** (2018). *Counterfactual Disaster Risk Analysis*, available at <https://www.variancejournal.org/issues/articlesinpress/Counterfactual-Woo.pdf>.
- World Economic Forum** (2019). *The Global Risks Report*, Davos, World Economic Forum.