GUY CARPENTER

September, 2020

CLIMATE CHANGE
Risks and Opportunities

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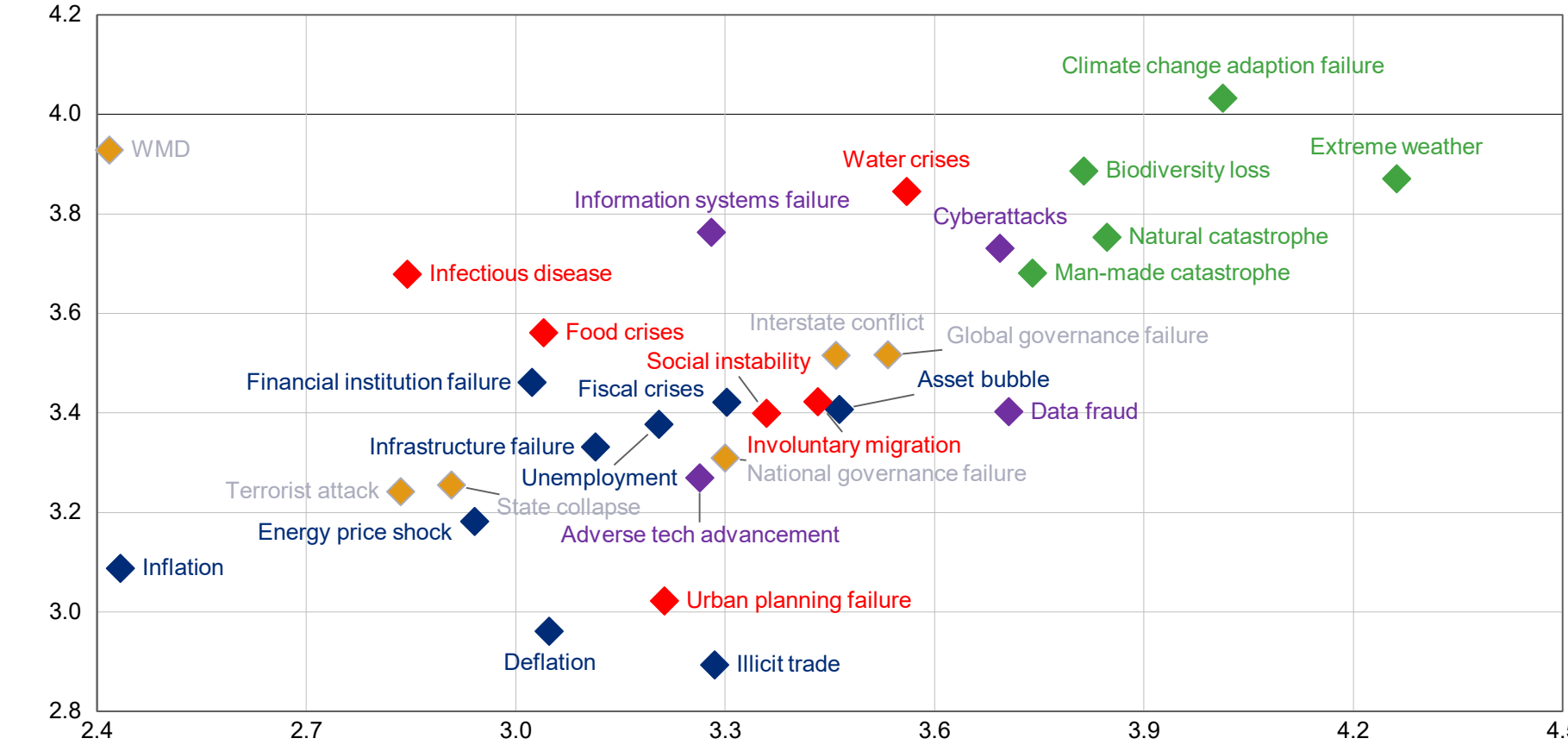
Outline

1. The global risk landscape
2. General impact of climate change on world economy and insurance sector
3. How insurance regulator are responding to climate change
4. How to incorporate latest scientific research into adjustment of CAT modeling results
5. Innovative insurance solutions related to climate change

The Global Risk Landscape

Global Risk Report 2020
Risk Perception Survey

Global Risks Landscape



Note: Global Risks Perceptions Survey (718 responses worldwide): Respondents were asked to rate each risk based on its likelihood and impact on a scale from 1 to 5
Source: World Economic Forum, *Global Risks Report 2020*

Paris Agreement

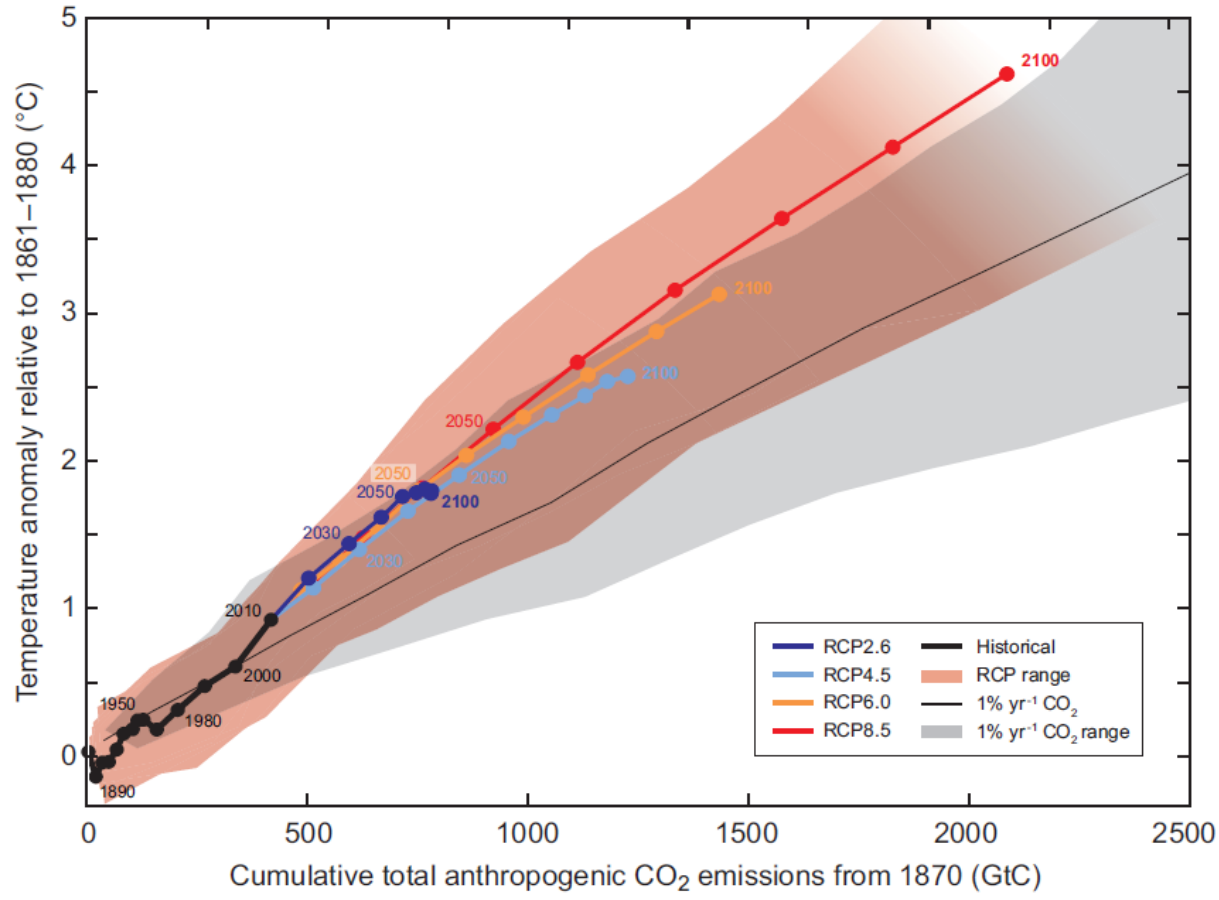
The Paris Agreement was a historic step in global efforts to combat climate change. Countries agreed to take action to hold global mean temperature increase well below 2° C and pursue efforts to limit warming to 1.5° C.

Such temperature targets can be translated to various other quantities: emissions budgets of cumulated future greenhouse gas (GHG) emissions and stabilization levels of atmospheric GHG concentrations.

RCP	Forcing	Temperature	Emission Trend
1.9	1.9 W/m2	~1.5 °C	Very Strongly Declining Emissions
2.6	2.6 W/m2	~2.0 °C	Strongly Declining Emissions
4.5	4.5 W/m2	~2.4 °C	Slowly Declining Emissions
6.0	6.0 W/m2	~2.8 °C	Stabilising Emissions
8.5	8.5 W/m2	~4.3 °C	Rising Emissions

Climate Change Projections
Carbon budget

There is a linear relationship between cumulative emissions and warming.



IPCC, 2014

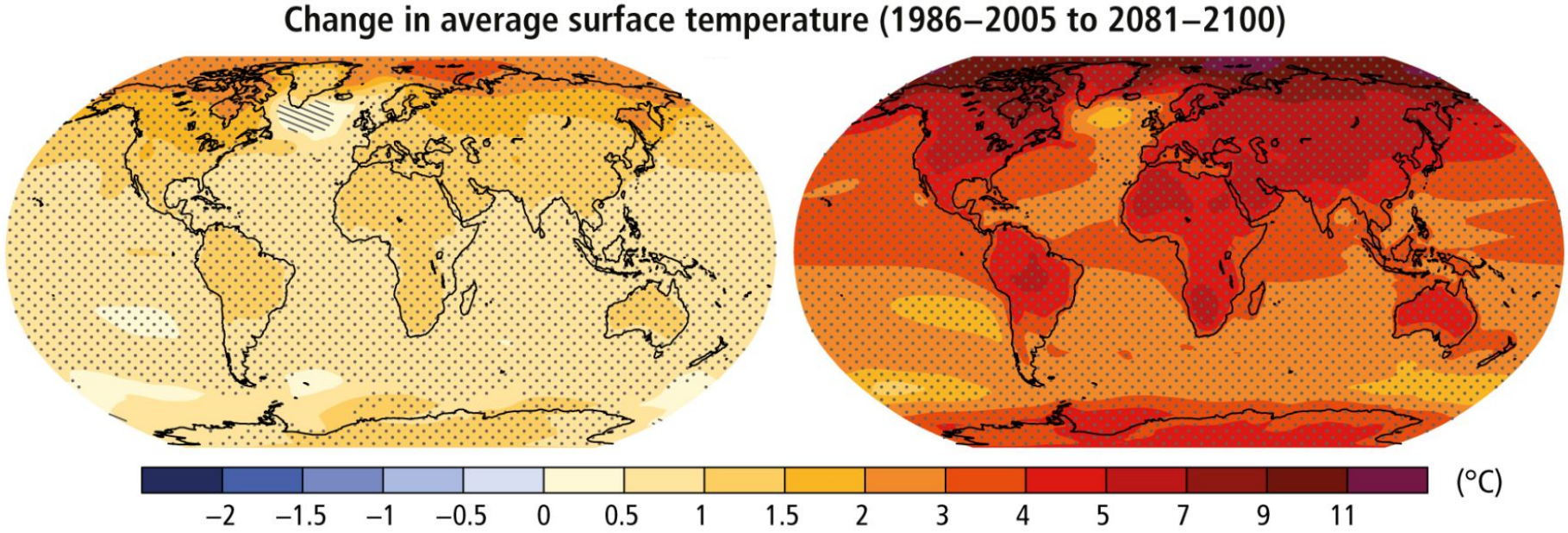
Climate Change Projections
Temperature

Stringent mitigation scenario

RCP2.6

High emissions scenario

RCP8.5

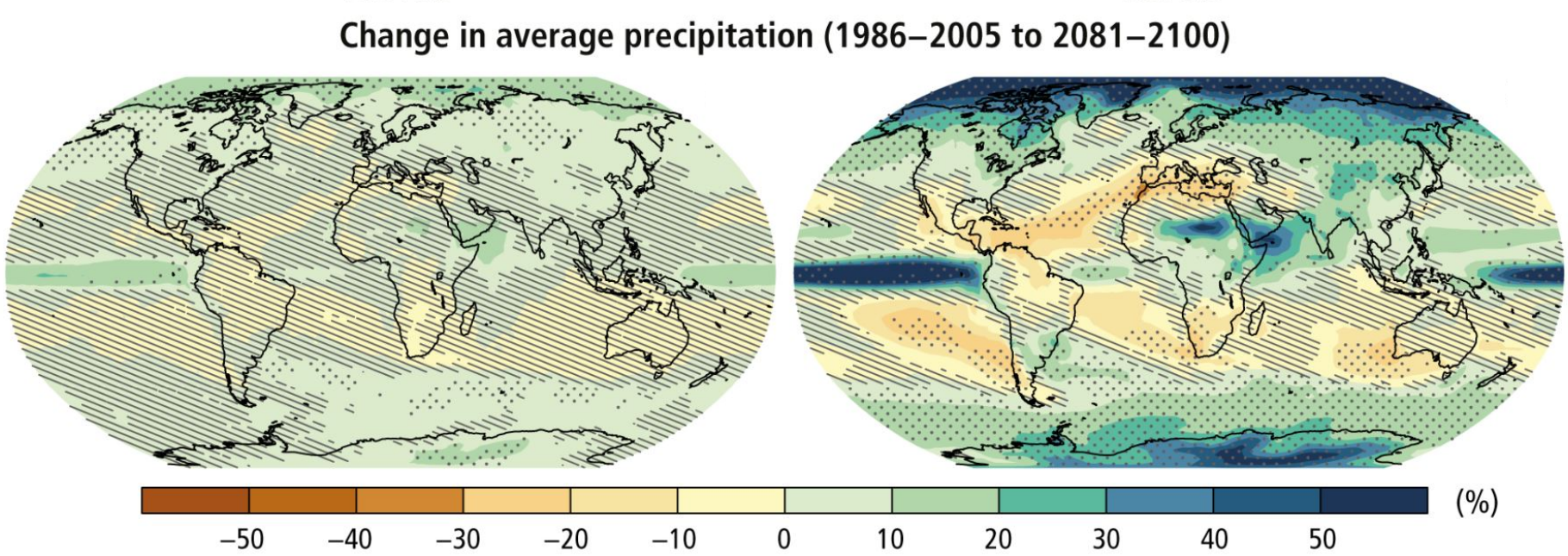


IPCC, 2014

Climate Change Projections
Precipitation

Stringent mitigation scenario

High emissions scenario



IPCC, 2014

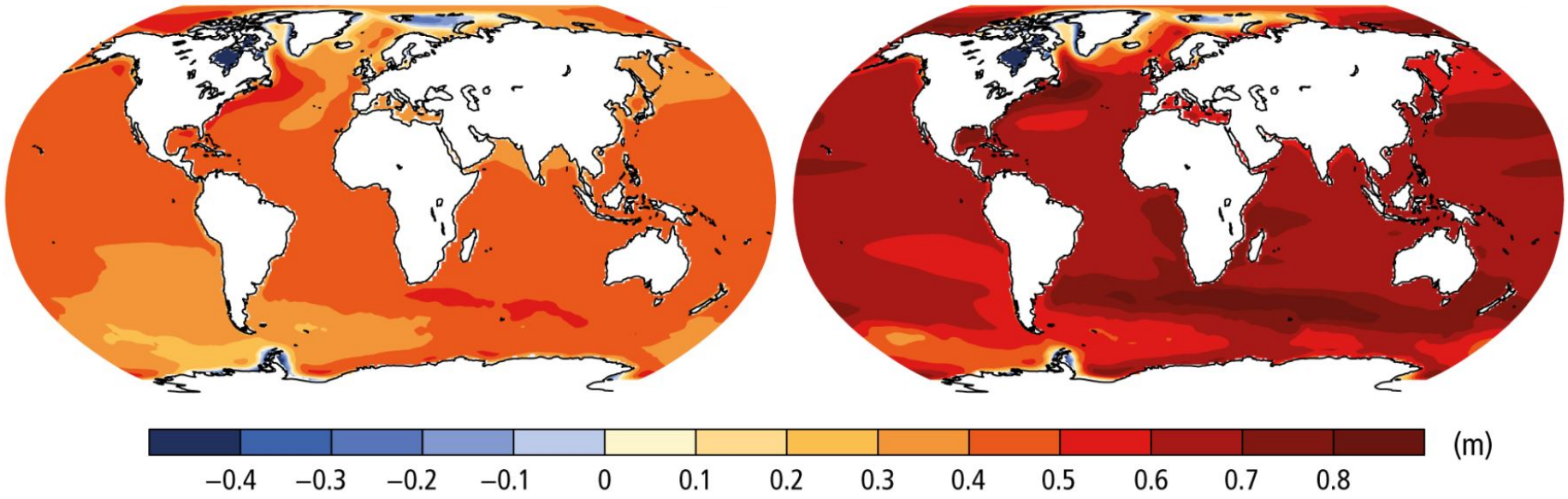
Climate Change Projections
Sea level rise

Stringent mitigation scenario

RCP2.6

High emissions scenario

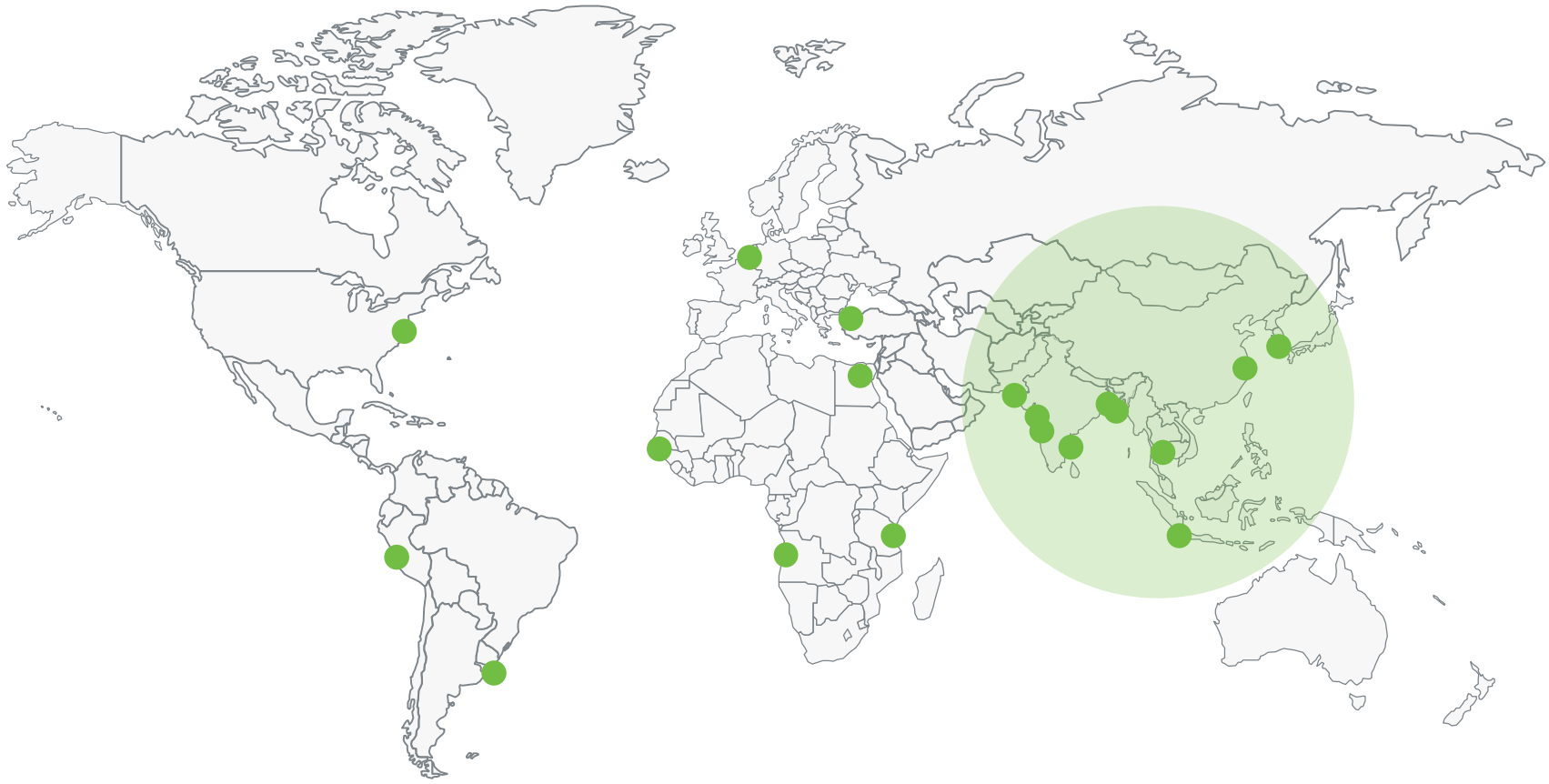
RCP8.5



IPCC, 2014

Asia is especially vulnerable to rising sea levels

Cities with >10 million people at risk of 0.5m sea-level risk by 2100

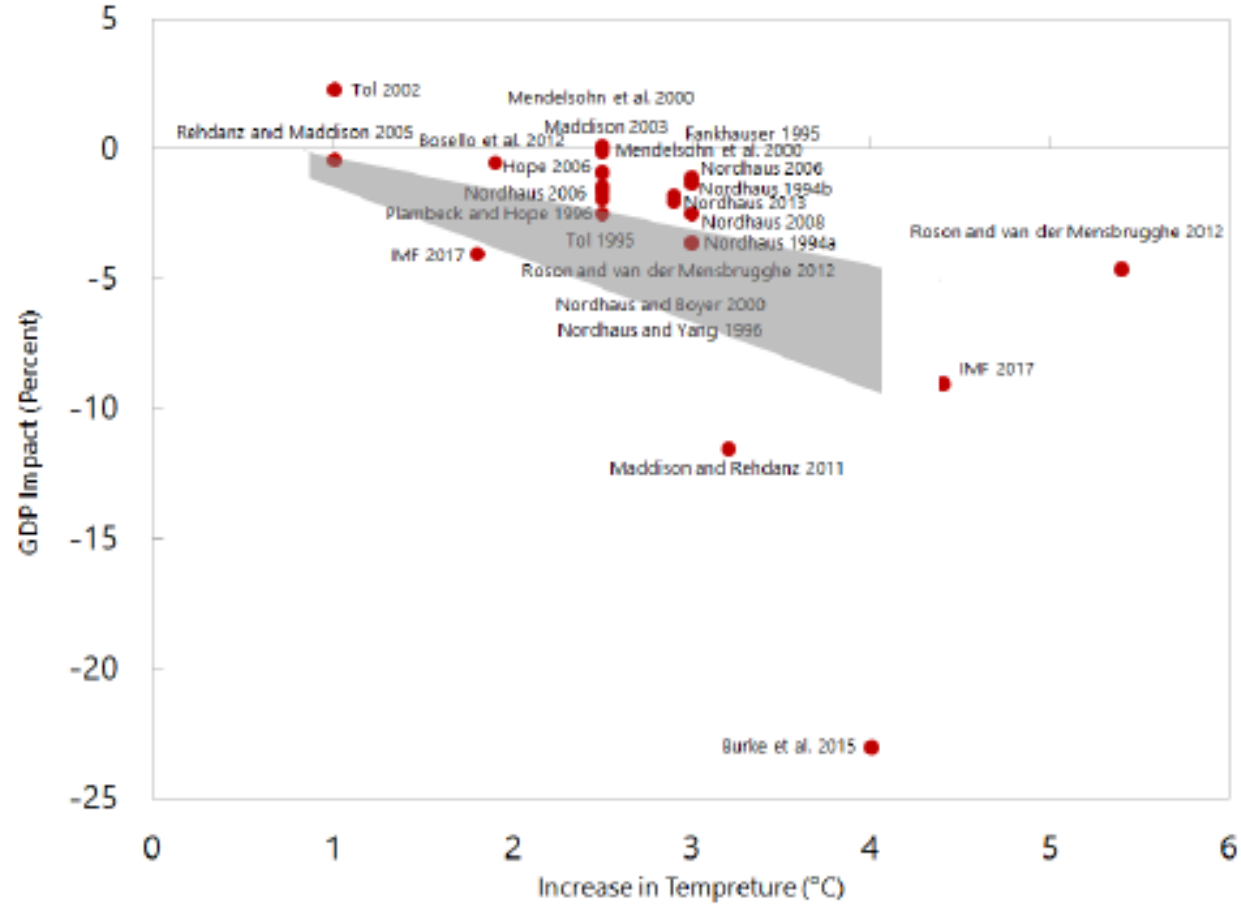


Climate change is becoming a top risk for doing business in both advance economies and developing markets

General Impact of Climate Change
World Economy & Insurance Sector

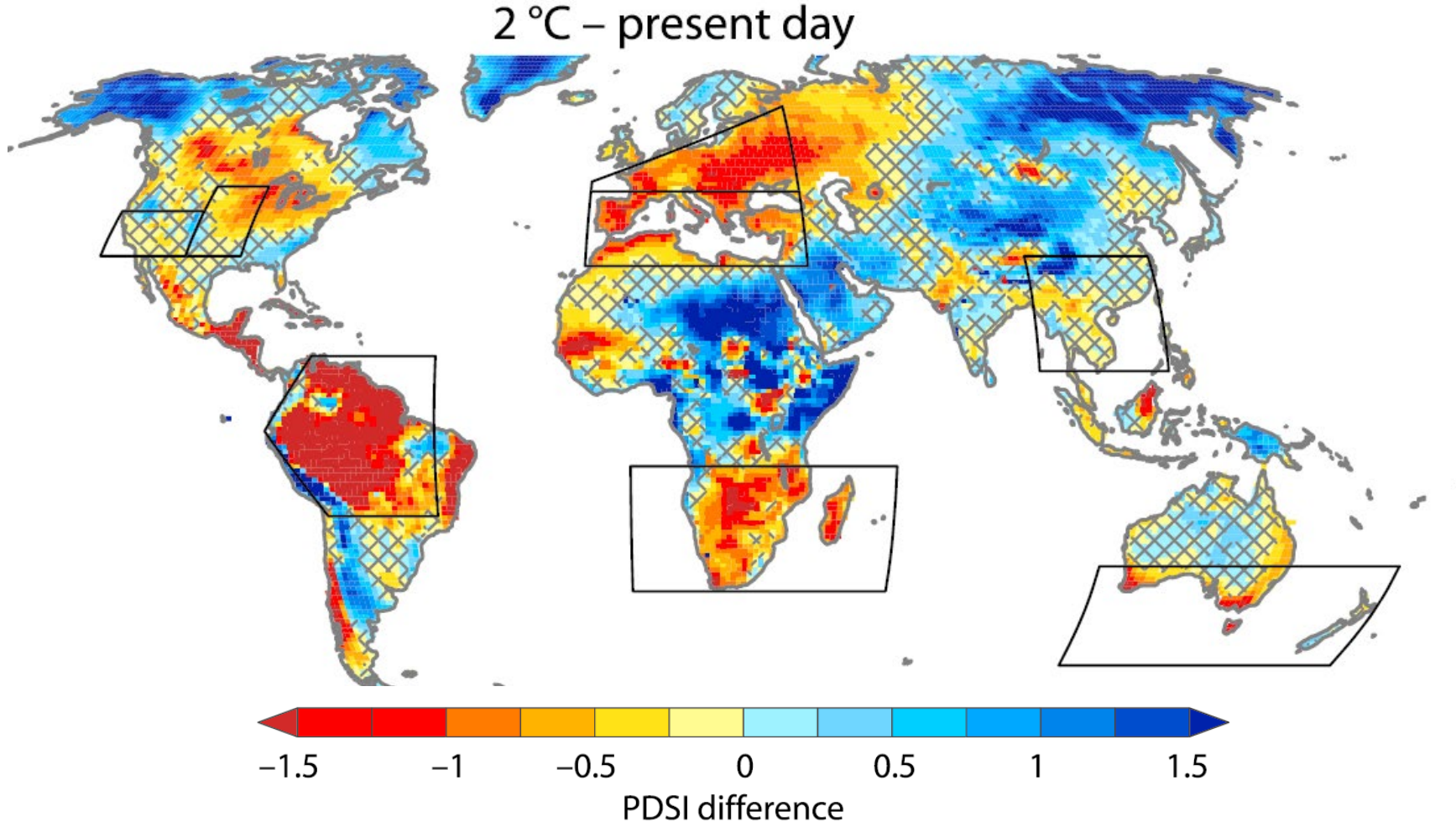
World Economy

- A paper published by the National Bureau of Economic Research in 2019 estimated a reduction in world real GDP per capita by 7.22 percent by 2100, in the absence of mitigation policies.
- With the Paris Agreement in place, assuming it is fully abided by, the reduction in world real GDP per capita would be alleviated, to around 1 percent.



Source: LONG-TERM MACROECONOMIC EFFECTS OF CLIMATE CHANGE: A CROSS-COUNTRY ANALYSIS

Insurance Sector - Physical Risks
Droughts



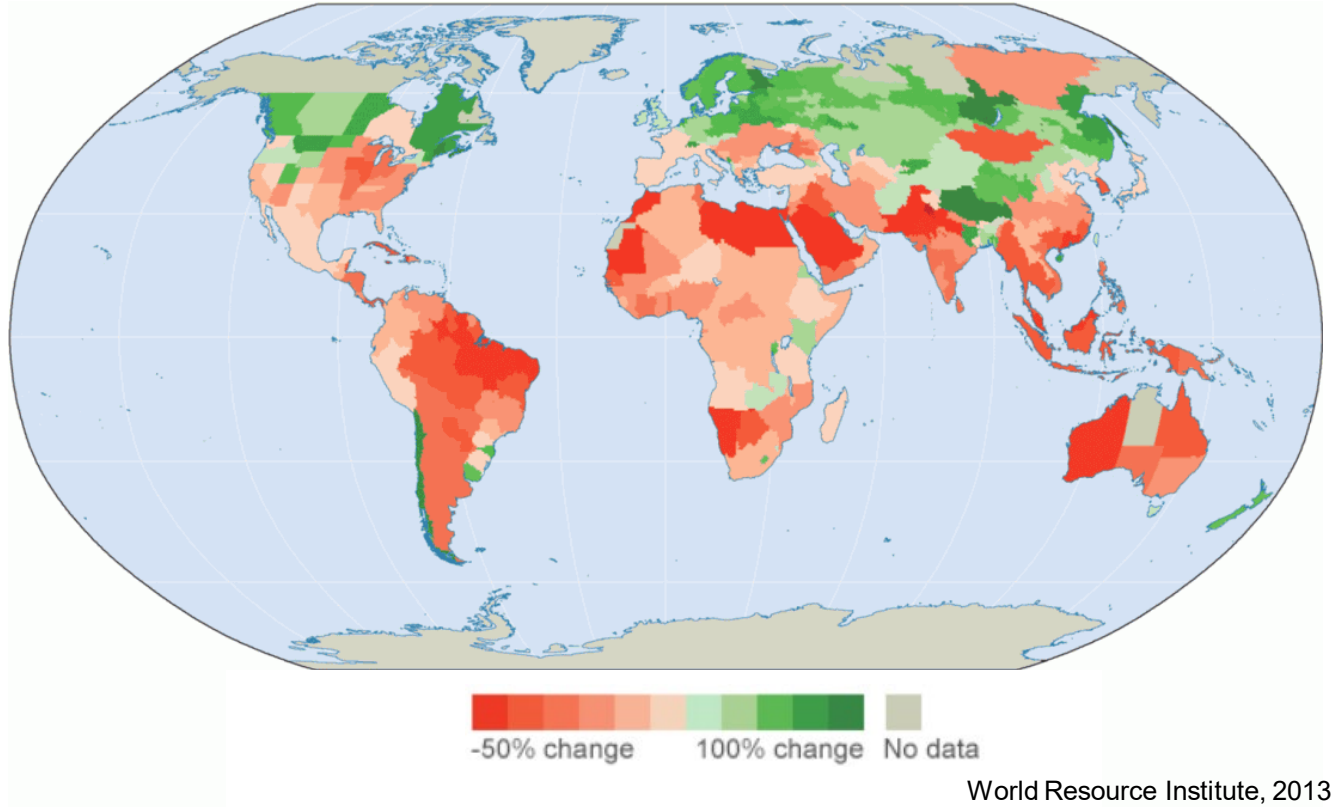
Changes in mean Precipitation Drought Severity Index (PDSI) from present day to 2 °C

Lehrner et al., 2017

Insurance Sector - Physical Risks
Droughts

Higher temperatures and changing rainfall patterns resulting in shorter growing seasons will impact crop yields.

Projected Impacts on Crop Yields in a 3° C Warmer World

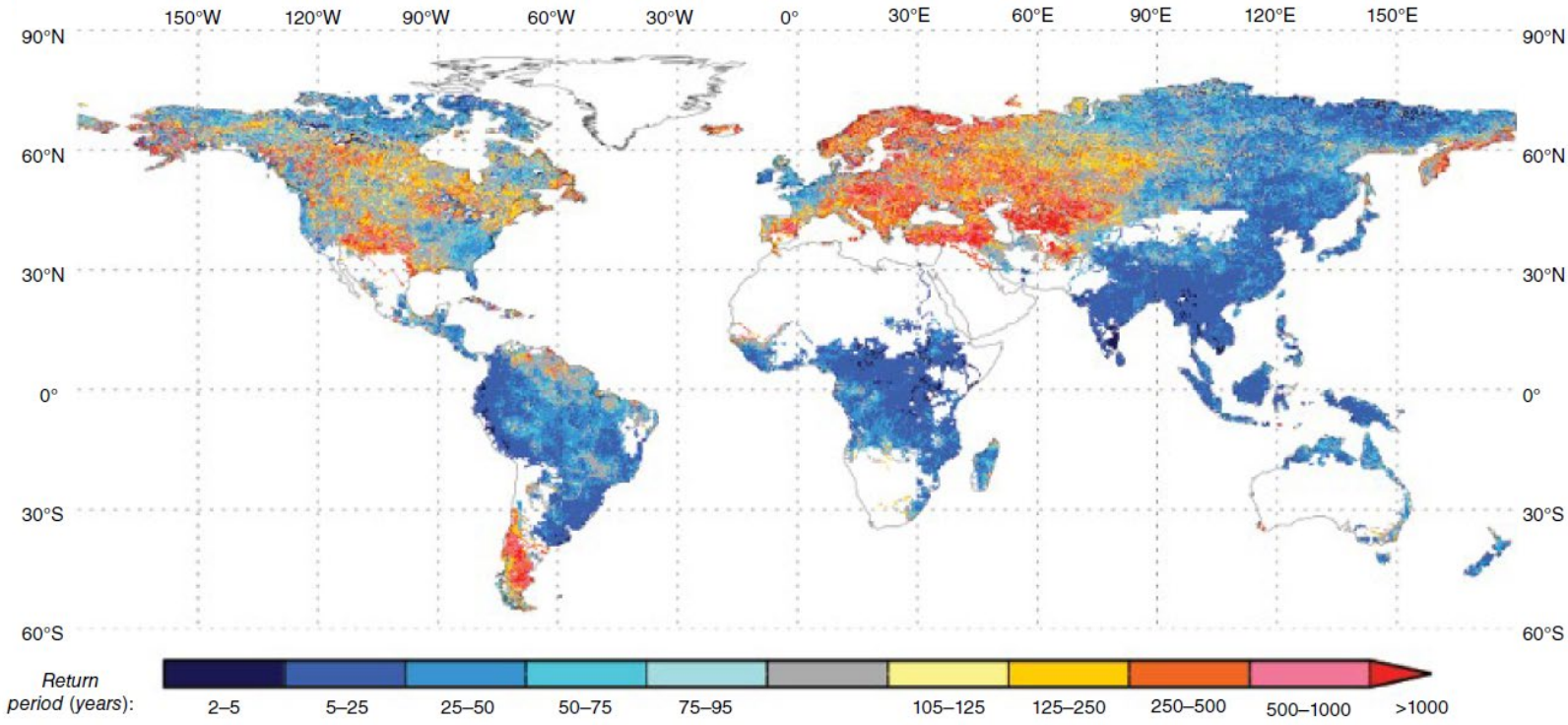


World Resource Institute, 2013

Insurance Sector - Physical Risks
Projected changes in flood return periods

A warmer climate will increase the risk of floods in many regions.

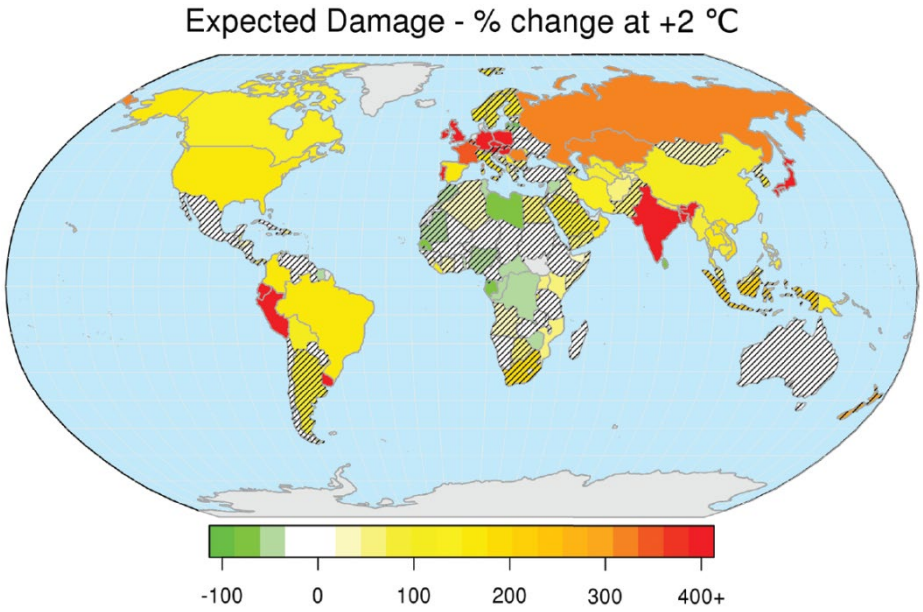
2100 return period of a 100-year flood event in the 20th century in a high emissions scenario

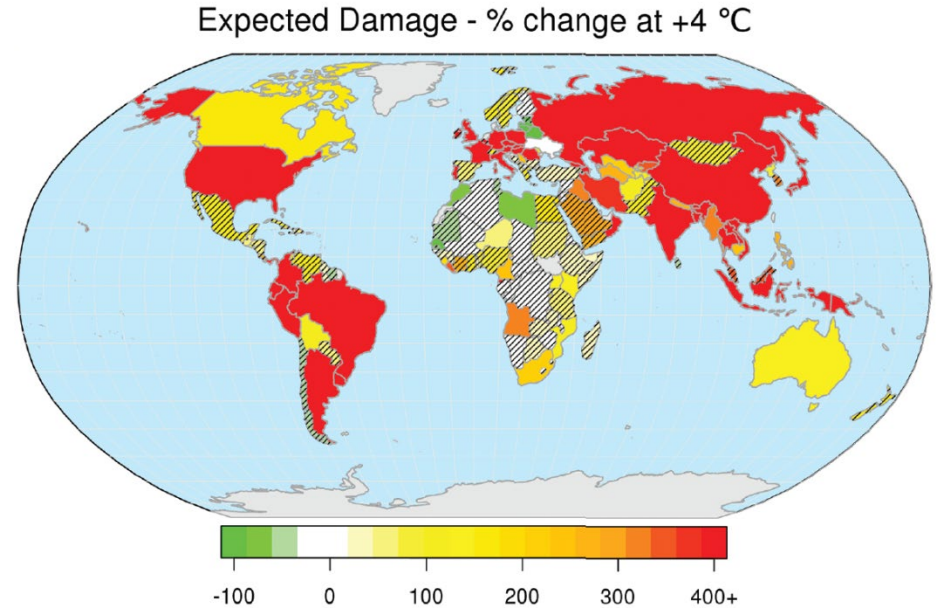


Yamazaki et al., 2018

Insurance Sector - Physical Risks
Projected changes in river flood risk

- At 4 °C warming 70% of the world population and GDP will face an increase in flood impact over 500%.
- Asia is among the regions with the largest increase in flood risk.





Alfieri et al., 2017

Insurance Sector - Physical Risks
Europe - Windstorm and Other Atmospheric Perils

The impact of warmer temperatures and climate change on extreme weather events is **complex** and **uncertain**, and it is **dependent** on **geographical** area.

Peril	Theoretical Impact	Historical Observations	Future Projections
Wildfire	Warm, wet springs (encouraging vegetation growth) followed by hot, dry summers increase the risk.	Heat waves have been increasing in frequency, intensity and duration. Wet periods are wetter, dry periods drier.	Projections conflict for northern Europe. Increased risk in the Mediterranean.
Freeze	Fewer cold spells decreases the risk of freeze-related perils.	Cold spells have decreased in frequency, intensity and duration.	Decreased risk across Europe although early growth due to warm winters can damage crops.
Windstorm	Moisture transport and temperature gradients are impacted in conflicting ways; outcomes are inconclusive.	The majority of studies show no observed trend in European storminess.	Most studies support an increase in storm activity along the central North Atlantic storm track, but agreement on the magnitude and local impacts does not exist.
Hail, wind and lightning	Risk is increased from elevated temperature and moisture. Upper-air changes may decrease the risk.	Incomplete record of direct observations. Studies on environmental proxies are conflicting.	There is general agreement that hailstorm frequency will increase in the future; severity is less certain.

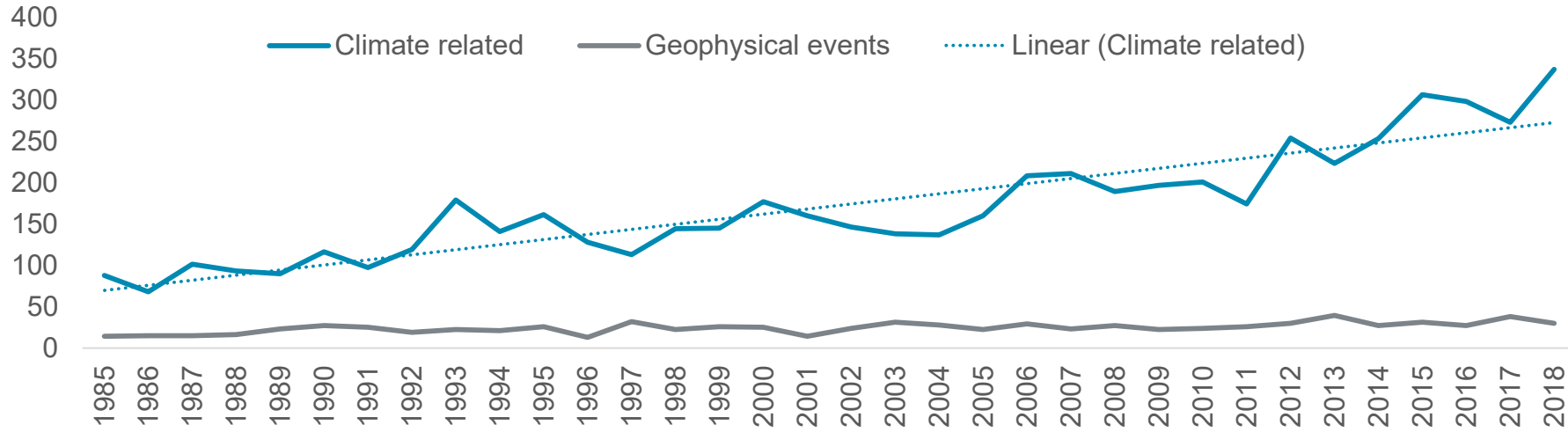
Insurance Sector - Physical Risks
Europe - Flooding

However, it is clear that they are likely to increase the frequency and magnitude of some natural disasters in certain geographical areas.

Peril	Theoretical Impact	Historical Observations	Future Projections
Precipitation	Daily precipitation rates will increase by 7% per degree C. Subdaily rate increases may be greater.	Observations of daily and subdaily precipitation rates are consistent with theory. The severity of the most extreme precipitation events is increasing.	Extreme precipitation events are expected to increase in frequency and intensity.
Surface Water Flooding	Heavier precipitation rates will increase the risk of surface water flooding, especially in urban environments.	Rarely studied separately from precipitation.	Risk will increase across Europe, as the most extreme precipitation events are increasing in severity.
River Flooding	Precipitation does not directly translate to riverine flood risk due to antecedent conditions, catchment properties, land use, water management and the built environment.	No consistent, unambiguous trend in streamflow has been found except alpine catchments where a decrease in spring is linked to diminished snowpack.	Mixed changes are projected, with some areas of increase, such as Western Europe, and others with decrease, such as in Alpine and Nordic regions.
Coastal Flooding	Mean sea level rise will increase the risk of coastal flooding.	Mean sea level rises of 3 mm per year on average and accelerating have been observed.	Coastal flooding is projected to increase in severity and frequency due to mean sea level rise.

Insurance Sector - Physical Risks
Asia

Numbers of natural disaster events for Asia



Source: Munich Re

Insurance Sector - Transition Risks

Transition risk arises from disruptions and shifts associated with the transition to a low-carbon economy, which may affect the value of assets or the costs of doing business for firms.

Transition risks may be motivated by policy changes, market dynamics, technological innovation, or reputational factors.

Transition and physical risks interplay with each other

SOURCE: Oliver Wyman analysis

Insurance Sector - Transition Risks
Investment

Severely disrupted ← → **Emergence**

TRADITIONAL ENERGY PRODUCERS

Global AUM fossil fuel **divestment** increased by

120x

since 2014 to reach

US$6.24 trillion

MINING AND QUARRYING

27-32%

of regions containing global copper resources face significant climate change

TRANSPORT

Electric vehicles in circulation to increase **100x** from 3.1 million to

>300 million

from 2017 to 2040

UTILTIES

Smart grid to drive power and usage efficiency amidst higher energy consumption

Global market to reach

US$70 billion

by 2024

AGRICULTURE

Precision farming as a way to reduce wastage per unit

US$9.53 billion

in 2023, from US$5.09 billion (2018)

GREEN FINANCIAL SERVICES

Global **green bond** issuances grew at a CAGR of

85.82%

between 2013 and 2017

RENEWABLE ENERGY

Investment in **solar** and **wind energy** to reach

US$8.4 trillion

between now and 2050 which still lags IEA Sustainability Development Scenario's benchmark

Source: Climate Change Post, CISION PR Newswire, BP Energy Outlook, IEA Global EV Outlook, ReportsnReports, Global Market Insights, BNEF, International Finance Corporation

Insurance Sector - Transition Risks
Underwriting

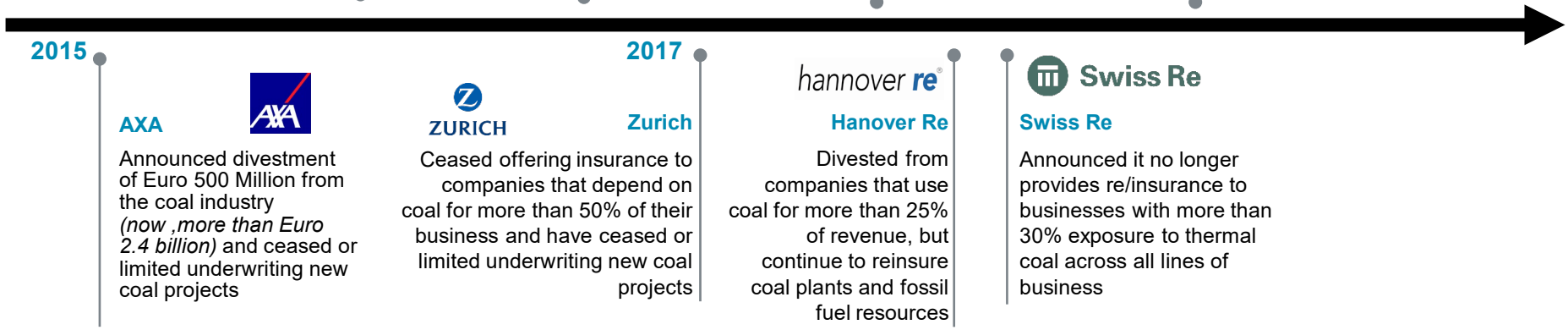
… due to the significant CO2 emissions

- These insurers have decided to stop insuring clients in thermal coal-dependent industries
- Recognize that these assets do not meet certain ESG criteria

… and wanting to move towards a lower-carbon economy

- Perceive as beneficial as it reduces exposure to potential environmental liability risks associated with thermal coal industries
- Minimize exposure to carbon transition risks

Snapshot of recent divestitures (2015–present)



1. Moody's 2018 survey on European insurers' approach to ESG factors

Insurance Sector - Liability Risks

- Liability risk includes the risk of climate-related claims under liability policies, as well as direct claims against insurers for failing to manage climate risks.
- Research by UN Environment has found that climate-related litigation has increased significantly around the world.
- Liability risks could arise from management and boards of insurers not fully considering or responding to the impacts of climate change, or appropriate disclosure of current and future risks.
- As of 2019, climate change cases have been brought in at least 28 countries around the world with three-quarters of those cases filed in the US.

Reponses from Insurance Regulators

UK
Bank of England

In December 2019, the Bank of England published a discussion paper, which sets out its proposed framework for the 2021 Biennial Exploratory Scenario (BES) exercise.

Climate risk variables		Macrofinancial variables	
Physical variables	Transition variables	Macroeconomic variables	Financial market variables
• Global and regional temperature pathways. • Frequency and severity of specific climate-related perils in regions with material exposure (including UK flood, subsidence and freeze). • Longevity. • Agricultural productivity.	• Carbon price pathways. • Emissions pathways (aggregate, and decomposed into world regions and sectors). • Commodity and energy prices (including renewables), by fuel type. • Energy mix.	• Real GDP (aggregate and decomposed by sector). • Unemployment. • Inflation. • Central bank rates. • Corporate profits (aggregate and decomposed by sector). • Household income • Residential and commercial property prices.	• Government bond yields for major economies. • Corporate bond yields for major economies (investment grade and high yield). • Equity indices. • Exchange rates. • Bank Rate.

UK
Bank of England – Prudential Regulation Authority (PRA)

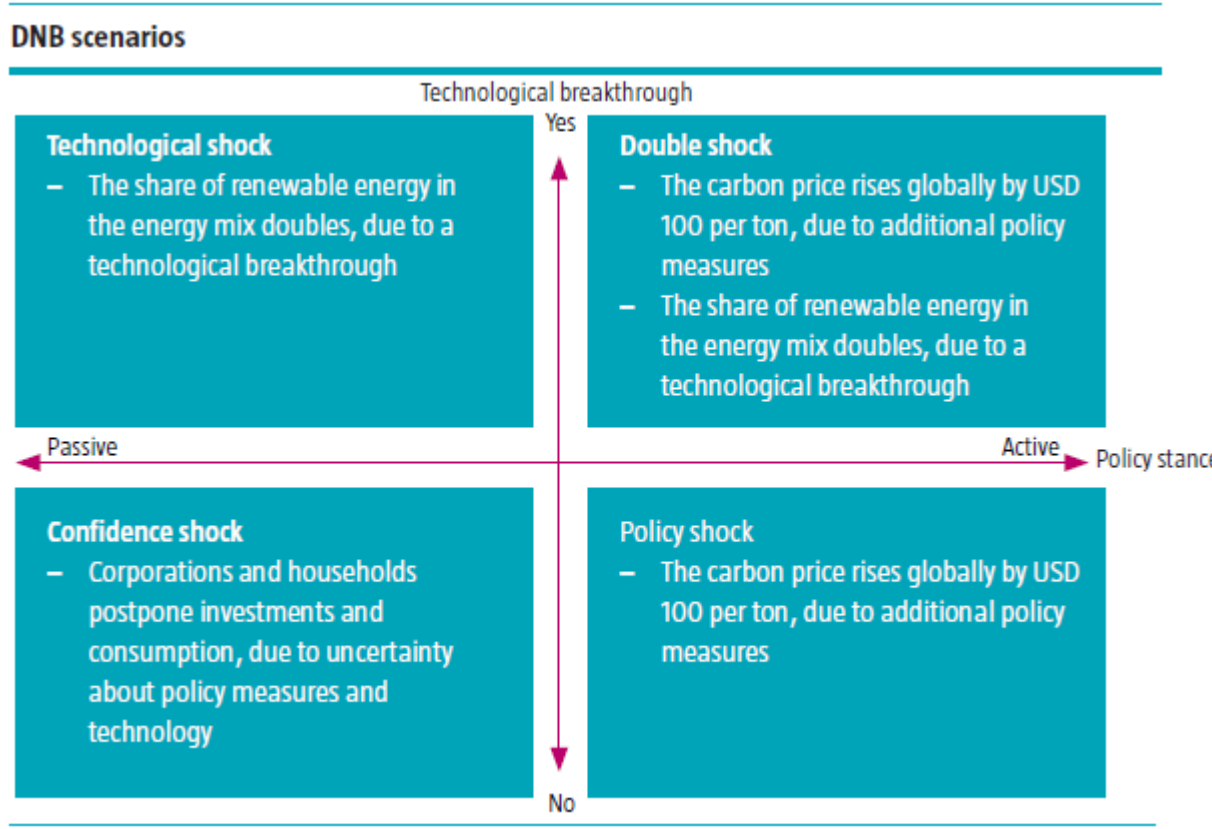
General Insurance Stress Test 2019
- Climate Change Scenarios

		Transition Risks			Physical Risks		
Sector	Assumptions	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
US Hurricane exposed LoBs - Hurricanes[1]	% increase in frequency of major hurricanes				5%	20%	60%
	Uniform increase in wind speed of major hurricanes				3%	7%	15%
	% increase in surface run-off resulting from increased tropical cyclone-induced precipitation (cumecs)				5%	10%	40%
	Increase in cm in average storm tide sea-levels for US mainland coastline between Texas and North Carolina. Figures exclude wave set-up and run-up.				10cm	40cm	80cm

			Transition Risks			Physical Risks		
Sector	% of investment portfolio in following sectors	Assumptions	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
Fuel extraction[1]	Gas/Coal/Oil (inc. crude)	Change in equity value for sections of the investment portfolio comprising material exposure to the energy sector as per below:						
		Coal	- 45%	-40%				
		Oil	- 42%	-38%				
		Gas	-25%	-15%			-5%	-20%
Power generation[1]	Power transmission and delivery of natural gas and, renewables (production and transmission)	Coal	-65%	-55%				
		Oil	-35%	-30%				
		Gas	-20%	-15%				
		Renewables (inc. nuclear)	+10%	+20%			-5%	-20%

Netherlands
De Nederlandsche Bank (DNB)

At the end of 2018, the DNB published a paper to gain insight on the financial and economic impact of four climate transition risk scenarios.



Singapore
Monetary Authority of Singapore

Severe Flood Scenario

In this scenario, an island-wide storm (extreme rainfall) has resulted in severe flooding in various parts of Singapore, with an average flood depth of 600mm. It is assumed that the application of this stress scenario is at the start of 2019.

- The Public Utilities Board (PUB) publishes a list of flood-prone areas/hotspots and the insurers are expected to assess their accumulations in those areas, then pick the top 10
- Determination of the PML is up to the insurer but they need to provide a description of the methodology used – MAS may further question them if the methodology / rationale is deemed inadequate
- The impact of the top 10 losses will then need to flow through the financial statements all the way to the Capital Adequacy Ratio

US
NAIC

The NAIC Climate Risk Disclosure Survey was created in 2009–10, to determine whether insurers were incorporating climate change into their risk management and investment strategies.

The NAIC Climate Risk Disclosure Survey continues on an annual basis with the participating states. Additionally, the NAIC has a Climate Change and Global Warming Working Group that is tasked with the following:

- Review the enterprise risk management efforts by carriers and how they may be affected by climate change and global warming;
- Investigate and receive information regarding the use of modelling by carriers and their reinsurers concerning climate change and global warming;
- Review the impact of climate change and global warming on insurers through presentations by interested parties;
- Investigate sustainability issues and solutions related to the insurance industry;
- Review innovative insurer solutions to climate change, including new insurance products through presentations by interested parties.

US
California Department of Insurance

In January 2016, recognizing the potential financial risks to insurer investments in thermal coal, oil, gas and utilities that rely on coal, oil and gas, California Insurance Commissioner launched the Climate Risk Carbon Initiative (CRCI). The CRCI has two main components:

- A request that California-licensed insurers voluntarily divest from thermal coal enterprises, applicable to all California-licensed insurers (CDI Thermal Coal Divestment Request)

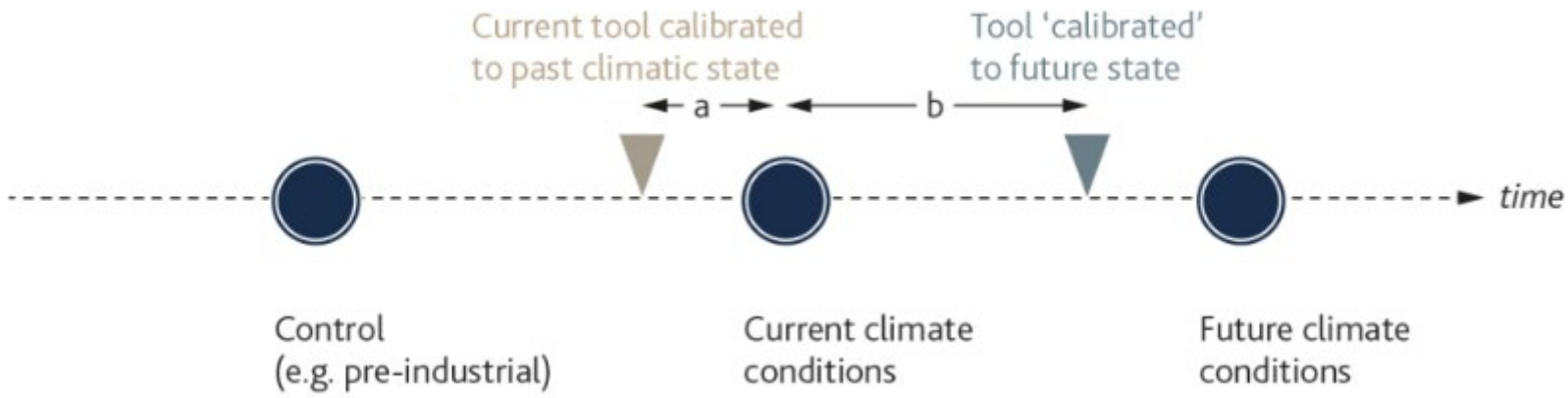
- Required financial disclosures by insurers of their investments in fossil fuel (thermal coal, oil, gas, and utilities) enterprises through a survey or "data call", which is applicable to California-licensed insurers with 2015 direct written premiums equal to or greater than US$100m nationwide ("CDI Fossil Fuel Data Call")

Adjusting CAT Models

Are catastrophe models reflecting the current risk?

Models are calibrated to the longest available observational time series in order to capture extremes.

This assumption of non-stationarity may not reflect the current risk.



UK
PRA

PRA suggested two ways to adjust the model to reflect a future climate:

1. Rebuilding the model

A catastrophe model can be completely or partially rebuilt to reflect an adjusted climate, using different input variables and parameters.

2. Adjusting model outputs

Catastrophe model outputs such as the event loss table (which includes event losses and rates) for events and years in a model can be adjusted without having to rebuild the model.

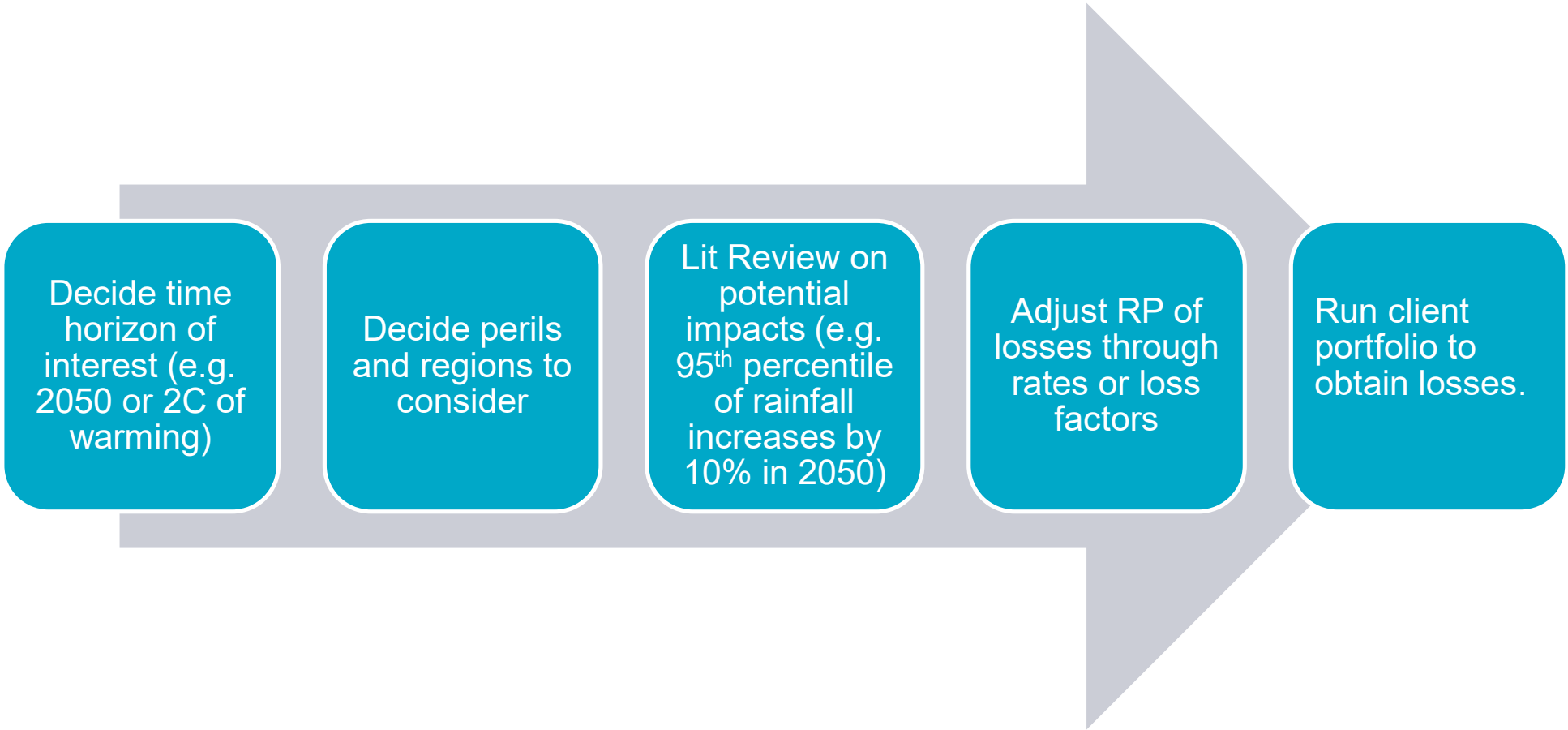
A framework for assessing financial impacts of physical climate change

A practitioner's aide for the general insurance sector

May 2019

This report was written by a cross-industry working group

Model adjustment workflow for users rather than vendors



Innovative Insurance Solutions

Parametric Insurance

Parametric covers are alternative risk solutions provided by insurance and reinsurance companies that enable organizations to finance or to transfer risk in a non-traditional way.

The solutions revolve around a measurable index and are based on predefined triggers or pay out mechanisms – without necessarily needing physical damage to occur.

The Pfalzgrafenstein castle from the 14th century sits on a sandbank in the Rhine in Kaub, Germany, during historically low water levels. (Michael Probst / Associated Press)

Natural Catastrophe Pool

In 2018, according to Munich Re, the total insured losses in Europe totaled EUR **5 billion**.

However the economic losses totaled EUR 13.5 billion, resulting in uninsured losses of EUR **8.5 billion**.

This equates to **63 percent** of underinsurance. Governments typically pick up these unbudgeted costs either through welfare payments, emergency disaster relief expenditure or by rebuilding infrastructure and repairing damages.

A **natural catastrophe pool** helps to transfer risk from public to private balance sheets.

財團法人住宅地震保險基金
Taiwan Residential Earthquake Insurance Fund

FEMA

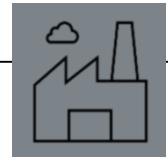
CEA CALIFORNIA EARTHQUAKE AUTHORITY™

MARSH & McLENNAN COMPANIES

Spectrum of options for re/insurance risk pooling

A spectrum of risk-pooling models exists for difficult risk types, ranging from private to public-private partnerships to state-financed funds for non-insurable risks

PRIVATE ⟷ **PUBLIC**

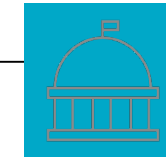


(Semi-) private pooling reinsurance schemes

- A joint entity would be set-up by e.g. insurers where risk can be pooled and knowledge shared
- Could be voluntary or legally mandated/ compulsory (e.g. including any pricing restrictions)
- Financing primarily provided by the private sector and limited (if any) government financing initially and typically no committed reserve[1]

Public-private partnership (PPP) reinsurance schemes

- A joint reinsurance entity is set up which is funded by premiums paid by insurers for reinsuring the risk (running costs and partly also building up the reserve)
- Government explicitly provides backing to the reserve (limited or unlimited) and could also finance the initial build
- Participation could be voluntary or legally mandated/compulsory



Public funds for non-insurable risks

- A pure government set-up, without any direct private involvement (apart from aligning coverage)
- A fund would be set up with a reserve, built up over time, that can be used to pay out claims in the case of a pandemic event
- Claims towards the fund should be aimed at covering risk events that cannot be covered by existing insurance offerings

Relevant option space for managing pandemic risk

Given their global nature, pandemics are unlikely to offer (re)insurers any diversification. Public support will be required to enable the (re)insurance industry.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