Climate Science – A Summary for Actuaries

What the IPCC Climate Change Report 2021 Means for the Actuarial Profession

Part IV: Actuarial Applications

Rade Musulin, Australia

Lead Author
Chair, Resource and Environment Virtual Forum
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Climate risk requires new ways of thinking for actuaries

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Traditional</th>
<th>Climate</th>
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<tbody>
<tr>
<td>Basic education</td>
<td>Covers most key skills needed</td>
<td>Has very little content on climate risk</td>
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<tr>
<td>Post-qualification education</td>
<td>Covers advanced topics relevant to work</td>
<td>Is not yet well developed</td>
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<tr>
<td>Key skills</td>
<td>Mathematics, data, computer science</td>
<td>Natural perils, climate modeling, macroeconomics, social science, etc.</td>
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<tr>
<td>Expertise</td>
<td>Actuaries are the “experts in the room”</td>
<td>Actuaries are but one of many experts</td>
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<tr>
<td>Data</td>
<td>Financial and insurer specific</td>
<td>External to the institution, far more demographic, requires long term projection</td>
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<tr>
<td>Pace of change</td>
<td>Moderate, building on significant base</td>
<td>Warp speed</td>
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<tr>
<td>Uncertainty</td>
<td>Believed to be well understood and quantifiable with existing tools</td>
<td>High, with varying levels of confidence on various dimensions of the problem</td>
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Learning the lexicon is important (including the acronyms)

ANNEX II Glossary

All definitions listed below, unless stated otherwise, come from the Working Group I Sixth Assessment Report Annex VII Glossary.

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.

Aerosol: A suspension of airborne solid or liquid particles, with typical particle size in the range of a few nanometers to several tens of micrometres and atmospheric lifetimes of up to several days in the troposphere and up to years in the stratosphere. The term aerosol, which includes both the particles and the suspending gas, is often used in this report in its plural form to mean ‘aerosol particles’. Aerosols may be of either natural or anthropogenic origin in the troposphere; stratospheric aerosols mostly stem from volcanic eruptions. Aerosols can cause an effective radiative forcing directly through scattering and absorbing radiation (aerosol–radiation interaction), and indirectly by acting as cloud condensation nuclei or ice nucleating particles that affect the properties of clouds (aerosol–cloud interaction), and upon deposition on snow- or ice-covered surfaces. Atmospheric aerosols may be either emitted as primary particulate matter or formed within the atmosphere from gaseous precursors (secondary production). Aerosols may be composed of sea salt, organic carbon, black carbon (BC), mineral species (mainly desert dust), sulphate, nitrate and ammonium or their mixtures.

Alts (Sixth Assessment Report): An IPCC assessment report is published once every 9-10 years. Since its establishment in 1988, the IPCC has completed five Assessment Reports and is now on its sixth (AR6). The Sixth Assessment Report consists of contributions from each of the three IPCC Working Groups, three Special Reports, and a Synthesis Report (SYR), which integrates the Working Group contributions and the Special Reports produced in the cycle.

Breadbasket: Breadbasket are the part of a country or region that produces large amounts of food, especially grain, for the rest of the country or region. (Definition from the Oxford Advanced American Dictionary)

Climate extreme (extreme weather or climate event): The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. By definition, the characteristics of what is called extreme weather event may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., high temperature, drought, or heavy rainfall over a season). For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes'.

Glossary for IAA Climate-Related Risk Publications

Glossary of Defined Terms Used in IAA Climate-Related Risk Publications

This glossary is the single repository of all defined terms used in IAA climate-related risk publications.

ACIP: French Prudential Supervisory Authority

Adaptation: the process of adjustment to actual or expected climate and its effects.

Anthropogenic global warming: global warming caused by human greenhouse gas emissions.

AR: Assessment Report of the Intergovernmental Panel on Climate Change. The first assessment report is commonly called FAIR.

BAM: Business as Usual, a scenario where no actions to lower greenhouse gas emissions are being taken. It is equivalent to a pathway with radiative forcing of 9.5 W/m² by 2100 (Representative Concentration Pathway RCP 8.5).

Biophere: the sum of all ecosystems of the Earth, or the zone of life.

BP: British Petroleum

Carbon footprint: the amount of greenhouse gases – primarily carbon dioxide – released into the atmosphere by a particular human activity.

Carbon footprint per capita: A measure of the carbon dioxide emission per person. Values range from 50 tons in Qatar to approximately 16 tons in Canada and the US, 8.6 tons in the European Union and close to zero in sub-Saharan Africa. (Data from Emissions Database for Global Atmospheric Research EDGAR for 2015).

Carbon footprint per GDP: A measure of carbon dioxide emission per GDP. It is defined as log GDP at Purchasing Power Parity and range from 0.5 for China to 0.3 for the US and Canada and 0.1 for Switzerland. (Data from the World Bank for 2014)

CEBES: Climate Biennial Explanatory Scenario (Bank of England)

CCB: Carbon Capture and Storage are technologies for capturing carbon dioxide and storing it so that it will not enter the atmosphere.

CFIR: Climate Financial Risk Forum, a forum set up in 2019 and co-chaired by the UK prudential and contact regulators-PRA and FCA

Climate: the long-term average and variability of weather, typically averaged over a period of 30 years.

Climate Action 100+: Investor initiative launched in 2017 to ensure the world's largest corporate greenhouse gas emitters take necessary action on climate change.

Climate change: the statistically defined change in the average and/or variability of the climate system, which includes the atmosphere, the water cycle, the land surface, the cryosphere, the biosphere and their interactions.

Climate refugee: people fleeing the effects of climate change. The United Nations Human Rights Committee ruled that “refugees fleeing the effects of the climate crisis cannot be forced to return home by their adoptive countries”.

Climate-related risk: the potential negative impacts of climate change on an entity.
Key concepts: confidence and likelihood

- **Confidence**: a qualitative measure of the validity of a finding, based on the type, amount, quality and consistency of evidence (e.g., data, mechanistic understanding, theory, models, expert judgment) and the degree of agreement.

- **Likelihood**: a quantitative measure of uncertainty in a finding, expressed probabilistically (e.g., based on statistical analysis of observations or model results, or both, and on expert judgment by the IPCC author team or from a formal quantitative survey of expert views, or both).

- **Disclosure and reliance on other experts**: it is important to disclose uncertainties and the degree to which we have relied on other experts, especially when incorporating science which is not a core component of our training.

<table>
<thead>
<tr>
<th>Term</th>
<th>Likelihood of outcome</th>
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<tbody>
<tr>
<td>Virtually certain</td>
<td>99-100% probability</td>
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<tr>
<td>Extremely likely</td>
<td>95-100% probability</td>
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<tr>
<td>Very likely</td>
<td>90-100% probability</td>
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<tr>
<td>Likely</td>
<td>66-100% probability</td>
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<tr>
<td>More likely than not</td>
<td>&gt;50-100% probability</td>
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<tr>
<td>About as likely as not</td>
<td>33 to 66% probability</td>
</tr>
<tr>
<td>Unlikely</td>
<td>0-33% probability</td>
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<tr>
<td>Very unlikely</td>
<td>0-10% probability</td>
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<tr>
<td>Extremely unlikely</td>
<td>0-5% probability</td>
</tr>
<tr>
<td>Exceptionally unlikely</td>
<td>0-1% probability</td>
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</table>
“Human Influence is Already Making Many Extreme Climate Events, Including Heatwaves, Heavy Rainfall, and Droughts, More Frequent and Severe.”
Compound extreme events – an example

- In December 2021, a tornado outbreak in Kentucky (USA) killed 74 people and caused large property losses. One of the most severe December events in history, it reflected abnormally high temperatures and unusual jet stream patterns. It was one of several extreme events affecting the U.S. in 2021, such as the Texas cold spell (Winter Storm Uri) in February and unprecedented heat in the Northwest in June.

- At the same time, lumber, a key component of home construction and rebuilding, hit $1,700/thousand board feet, far above its historical range of $300-$400. A recent article in *The Atlantic* magazine points to climate-related drivers for this increase, including beetle infestations, extreme fires, and floods in timber-producing regions in Canada.
Actuarial questions with this compound event

- Is the likelihood of extreme tornados changing from historical norms?
- Is the cost of rebuilding being affected by high lumber prices?
- Are these random unusual events or part of a long-term trend?
- Are catastrophe models used to manage extreme event risk still accurate?
- Is my reinsurance program sufficient?
- Do I need to adjust rates to reflect these trends?

“Examples are concurrent heatwaves and droughts in multiple locations, compound flooding (e.g., a storm surge in combination with extreme rainfall and/or river flow), compound fire weather conditions (i.e., a combination of hot, dry, and windy conditions), or concurrent extremes at different locations such as in multiple breadbaskets. The chances of experiencing compound extreme events has likely increased since the 1950s.”
Using IPCC output to understand regional effects

- Global warming will not affect the world uniformly
- Most insurance and banking applications will consider risks at a regional or national level
- Understanding risks will support building future views of physical risk such as:
  - Hot extremes leading to heat stress (affects workers, mortality, morbidity)
  - Heavy precipitation leading to flood (affects property insurance or loan portfolios)
  - Agricultural and ecological drought leading to crop failure (affects agriculture insurance and political stability)
- Extreme climate may also affect wider economic conditions such as the price of building materials such as lumber in the last example
Actuaries’ time horizons tend to be shorter, but vary by the assignment:

- Property and motor risks have insured risk (e.g., pricing and claim) duration of 3-5 years
- Strategic considerations, such as pricing and product design, can extend this to 20 years
- Banks and other lenders may issue loans for 30 years
- Social security systems (including pension) may need to consider long term economic trends and intergenerational issues

When considering near-term and regional changes, actuaries need to also consider natural climate variability, which is caused by drivers other than humans:

- **Internal natural variability** includes well established climate cycles such as El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), or Atlantic Multidecadal Variability
- **External natural variability** includes drivers outside the climate system, such as volcanic eruptions

“Extremes scale with global warming but natural variability will modify changes over shorter timeframes, particularly evident at regional scales”
Other key points

- Temperature scenario information is helpful because many climate characteristics (e.g., rainfall, heatwaves, or droughts) scale almost linearly with the level of global warming.
- Mitigation (reducing emissions) will not occur immediately; warming will continue in the near term and almost all scenarios yield similar warming through 2050.
- Some effects, such as rising sea levels, will occur gradually but past emissions have already locked the climate system into changes which will emerge over decades or centuries.
• **Representative Concentration Pathways (RCPs)**, which are related to various warming scenarios

• **Time horizons** (points where conditions will be evaluated)

• **Localized impacts**, taking output from Global Circulation Models (GCMs) and translating them into local weather

• **Shared Socioeconomic Pathways (SSPs)**, which can include:
  – Economic and technical changes
  – A view of the prospective political situation
  – The nature of economic changes (e.g., gradual or abrupt)
  – The level of societal resilience

• **The time horizons may differ** for physical and transition risk; physical risk is generally slower and gradual, transition risk (including Legal & Reputational) can be abrupt and subject to reversals

• **Geographic scope**: physical risk reflects global efforts, transition may be local
Regulatory expectations – Australian example

Regulatory considerations must be considered but building capability in climate risk should be done to strengthen a firm’s ability to support stakeholders’ interests, not as a compliance effort.
Estimating future climate risk in asset portfolios

01 Research
Conduct research on relevant perils in collaboration with experts in natural perils. Perform literature reviews and examine commentary from latest insurance industry research.

02 Scenario Assumptions
Using research from both climate science (IPCC) and financial regulators (NGFS), consider the behavior of physical risks under climate scenarios associated with different emissions pathways at different time horizons (e.g., current, 2030, 2050, 2070).

03 Modelling Process
Feed assumptions into peril models, altering future physical risk. Run portfolios assuming a static portfolio, following the recommended approach by Australian OMRI.

04 Impact Assessment
Summarize by geographic region (such as postcode) or portfolio; results may not be credible at a property level.

05 Address Level Risk
Quantify the expected average annual losses (AAL) for each extreme weather hazard under each scenario and time horizon. Translate AAL changes into relevant metrics such as insurance premiums or the impact on the value of property.
Changes in Climate Impact Drivers (Table 3) can be helpful

<table>
<thead>
<tr>
<th>Climatic impact-driver</th>
<th>Heat and Cold</th>
<th>Wet and Dry</th>
<th>Wind</th>
<th>Snow and Ice</th>
<th>Coastal and Oceanic</th>
<th>Other</th>
<th>Radiation at surface</th>
<th>Atmospheric CO₂ at surface</th>
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<tbody>
<tr>
<td></td>
<td>Main air temperature</td>
<td>Extreme heat</td>
<td>Cold spell</td>
<td>Frost</td>
<td>Mean precipitation</td>
<td>Mean temperature</td>
<td>Fire weather</td>
<td>Mean wind speed</td>
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<td>Southern Australia</td>
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<td>New Zealand</td>
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Note: There are several region-specific qualifiers/exceptions attached to some of the directions of change/confidence levels indicated above. (12.4)

Key for observational trend evidence
- Past upward trend (medium or higher confidence)
- Past downward trend (medium or higher confidence)

Key for attribution evidence
- ** High confidence (or more)
- * Medium confidence

Key for level of confidence in future changes
- High confidence of increase (or more)
- Medium confidence of increase (or more)
- Low confidence in direction of change
- Medium confidence of decrease
- High confidence of decrease
- Not broadly relevant
What do actuaries’ clients need in the climate space?

- **Education and guidance** with an emphasis on understanding how climate risk may affect their organizations, what opportunities exist, and what skills they will need to acquire.

- **Assistance with synthesizing the vast amount of information** on climate risk into actionable intelligence, with periodic updates as knowledge advances.

- **Physical risk assessment** for relevant perils reflecting current and future risk, with appropriate understanding of confidence levels and uncertainty.

- **Transition risk assessment** (including legal and reputational risk) for their markets, investment portfolios, and operations.

- Process to embed climate risk into the overall **risk management framework**.

- Assistance with **reporting to various stakeholders**.

- **Measurement of emissions** for their business, including their suppliers, and ways (if desired) to certify their carbon neutrality or progress towards net zero.

- **Strategies** for product design, pricing, underwriting, reinsurance, technologies, etc.
Summary

• Actuaries have much to offer helping manage climate risk:
  – Adapting risk measurement tools to incorporate the science
  – Bringing stochastic thinking to the issue
  – Understanding tail risk
  – Adjusting pricing or underwriting strategies to reflect climate risk
  – Developing new metrics for economic activity or biodiversity loss
  – And much more…

• We must develop new skills and techniques; continuing education is critical

• Actuarial organizations around the world are gearing up to support members in climate

• We hope to continue our collaboration with the scientific community through efforts like this one with the IPCC

• There are massive challenges, but also huge opportunities ahead
For more information

- IAA website: [www.actuaries.org/iaa](http://www.actuaries.org/iaa) (see Publications, Papers, Climate Issues)
- Upcoming webinar on “Application of Climate-Related Risk Scenarios to Asset Portfolios” on 26 April 2022 at 08:00 US EDT
- Speaker contact: Rade Musulin, rmusulin@sprynet.com
Thank You - Questions and Discussion