



Catastrophe
and Climate

Research Program Newsletter

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Strategic Research Program Steering Committee

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Focus on Terminology: Attribution Analysis

By Max J. Rudolph and Steve Bowen

For those actuaries who desire to become more active in climate awareness activities, there are times when language becomes an issue. Terms used for decades in each specialty may mean something different to the other group or may be confusing to the layman.

Terms and definitions may mature over time. This column will alternate between inconsistent terms, evolving terms and terms that need a few extra words or examples to become understood by all. It is a recurring feature of this newsletter, so please let us know (max.rudolph@rudolph-financial.com) if you have a term that you think actuaries, climatologists or sustainability experts use in different ways from each other or from common use. Vocabulary awareness will lead to improved communications between these professionals.

Attribution analysis is a term used to mean something unique to specific actuarial practice areas and climate experts. Hopefully, the explanation that follows will provide some clarification about how other experts may use the term, so the groups don't talk past each other.

Attribution analysis - the issue

In the last couple of IPCC (Intergovernmental Panel on Climate Change <https://www.ipcc.ch/>) cycles scientists have developed techniques that extend models designed to project climate change. These models can now anticipate the changing likelihood of extreme weather in a specific location. They develop a distribution around weather phenomena like rainfall, temperature or drought that would have been likely had all fossil fuels remained in the ground. This is compared to a current estimate of the same distribution given recent events. At each point on both curves the likelihood of that event or worse is computed. An actual event, like Hurricane Harvey's heavy rainfall amount, is noted and the ratio of the current distribution of that event or worse is compared to the distribution assuming carbon levels from 1750. The resulting storm was determined to be three times more likely in a paper led by Dr. Frederikke Otto, who later published a book, *Angry Weather*, to describe the process and challenges.¹

The use of super computers originally limited the ability for this type of analysis to be performed with a news cycle, generally ending a week or two after the event, but efforts to pre-research specific events and locales and speedier computing has improved the turnaround time. This type of analysis is very relatable as it ties a recent event to the impacts of climate change.

For the private sector, attribution analysis is viewed in the context of trying to quantify the climate change influence on individual events. Weather and climate-related losses continue to accelerate as population and exposure growth amplifies in high-risk areas of the world, but the question remains: how much does climate change add to the cost of individual events as heavier rains fall, storms become stronger, etc.?

¹ Van Oldendorgh, et al. *Attribution of extreme rainfall from Hurricane Harvey, August 2017*. IOP Publishing. 2017. <https://iopscience.iop.org/article/10.1088/1748-9326/aa9ef2>

Actuarial take on attribution analysis

Most actuaries have been introduced to the term attribution analysis through investment practice and carried it over into other practice areas. Investment driven attribution analysis will deconstruct a portfolio's performance into components like asset allocation, individual picks, timing and investment style. A portfolio manager may be good at one component and utilize standardized benchmarks for the rest to highlight their talents.

A life actuary may utilize a similar process to show components of profit when pricing a product. These could be due to investments, mortality, or expenses. Actual to expected analysis is then used to attribute results relative to those expected.

Attribution analysis means something specific to a health practitioner. In the absence of a designated principal provider relationship responsible for the care of the patient, a provider is "attributed" based on the plurality of a patient's care being delivered by that provider.

There is a lot of potential overlap between actuaries and climate scientists, perhaps more than between actuarial practitioners. It is important to understand the differences and to get it right.

Summary

The Society of Actuaries sponsored a project that tied heat-related illness morbidity to anthropogenic climate change (summarized in the [April 2021 newsletter](#)),² and heat events were estimated to be about 15% more likely. This allows actuaries to take the next step to plan operationally and financially for a warmer planet, in this case with greater capacity in hospitals and higher expected costs for health care.

As actuaries interact with climate scientists, statisticians and the population at large, it becomes important for terms to be clarified so that public policy and finances reflect realistic future expectations. Anticipating this evolution of the environment will lead to more effective mitigation and adaptation techniques.

Max Rudolph is a principal at Rudolph Financial Consulting, LLC.

Steve Bowen is a Meteorologist and the Chief Science Officer at Gallagher Re.

² Puvvula, et al. *Estimating the Burden of Heat-related illness morbidity Attributable to Anthropogenic Climate Change in North Carolina*. GeoHealth. September 2022. <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2022GH000636>

Upcoming COP 27 in Egypt – An Actuarial Perspective

Contributors – Sam Gutterman, Bob Collie and Steve Bowen

What's the objective?

By Sam Gutterman

I recognize that the following raises more questions than it answers, but its intent is to get people thinking about some of the important issues that won't go away in an area where open questions abound.

It is well known that the future of climate change and its consequential damages and losses is quite uncertain. This uncertainty is a result of factors such as human behavior, government decision-making, and an incomplete or biased understanding of the climate risk process. At both a global and local level.

But they do not extend to whether there will be increasingly dramatic effects – the uncertainties only relate to the extent of the damages and losses that will be experienced by our and future generations.

In developing quantitative models, a range of scenarios or stochastically developed confidence intervals will be developed – our risk tolerance to these damages and losses will have to be considered. The potential for bias in the presentation of the uncertainties may be considerable.

And sometimes we don't pay enough attention to tail risks, although we have to recognize that they are tail risks – should one act as if the worst-case scenario or pathway will happen, in which cascading, or compound risks emerge after one or more tipping points are reached?

Each of us has to decide how recognizing the possible futures will affect our current and upcoming actions. What should our objectives be and how much damage and loss will we be willing to bear? Whether to prepare is no longer the most relevant question – I believe that we as a society, community, profession, and individuals need to be better prepared to undertake the most effective cost-benefit based actions consistent with our objectives. That is, what level of risk margin should policymakers and actuaries be shooting for?

But the main policy issue at COP 27 is who pays for the massive upcoming investments needed for both mitigation and adaptation purposes. This is especially important in light of social justice concerns and how to set the relative priorities of these efforts in light of competing global and local demands and needs. Both within countries and among countries.

A great deal of decision-making is outside the scope and expertise of actuarial practice. Nevertheless, we should attempt to play an effective role in providing useful and objectively developed information for applicable decision-makers, whether at a global, regional, national, or local level. Although we may not take 'sides', we can strive to help draw into the discussions of relevant stakeholders with objectively developed facts with appropriate disclosure of our assumptions. We also need to help ensure that the proper questions are being addressed.

How has the role of actuaries evolved in the past few years to support the Paris Agreement and any suggestions to improve engagement/impact?

By Bob Collie

Actuaries are hardly alone in being concerned about climate change. With atmospheric CO₂ reaching 421 parts per million (PPM) in 2022 the physical reality is unavoidable: greenhouse gases such as CO₂ trap heat like a blanket around the earth, and the more of it there is in the atmosphere, the warmer the planet gets, with cascading effects reaching every part of life.

As the climate change statement issued by the UK's Institute and Faculty of Actuaries (IFOA) in 2021 notes: "We are a profession specializing in risk management, and climate change is one of the greatest risks facing our world today."

The IFOA Statement rightly emphasizes that climate change gets to the heart of what the profession does – it represents a clear and present danger to the financial interests of the clients we serve. But even though climate change is financially material, its impact goes far beyond the financial. As a profession, we have an obligation to bring our skills and influence to bear, to be part of finding a way for society to meet the needs of the present without compromising the ability of future generations to meet theirs.

And it goes on to note that "the best value insurance premium that society can pay is to reduce our emissions today in order to avoid the irreversible consequences of unmitigated climate change tomorrow".

The profession's unique skills can, if applied with conviction and with the public interest in mind, make a significant contribution to a better understanding of the financial risks, to the design of sound and consistent global policy, including meaningful disclosure, and to finding ways to appropriately share risks, costs and benefits across all stakeholders.

And this all begins with better education. The better the current and emerging generations of professionals understand not only how finance works, but also how the natural world works and how the financial world interacts with it, the better placed we will be to play our part.

What should COP27 prioritize to enable countries to deliver on their commitments?

By Steve Bowen

There is no shortage of potential angles to where countries could direct their prioritizations. The most important topics, in my view, involve those with actionable solutions that can be easily measured. This of course centers on carbon and other greenhouse gas emissions, but more is needed beyond policy commitments to fundamentally alter what we're doing for tomorrow's climate. One big change would be enforcing accountability and enacting penalties for failing to meet climate goals. We've seen a lot of hugely positive momentum on the policy front and net-zero promises in recent years at the government and private sector level, but the ultimate question is whether these goals will be met. *(Also, part of the interview posted below)*

A Grand Hydrological Experiment

By Frank Grossman, FSA, FCIA, MAAA

In today's world of insurance, climate risk is often taken to mean concerns about property damage due to torrential storms and flooding, and their opposite, prolonged droughts and wildfires. At the same time, there is a growing awareness of the threats to human health and well-being posed by wet-bulb heat stress and air pollution. Yet climate risk is also challenging, long-standing assumptions about the reliability of technologies and built environments that depend on water.

Suez Blockage

Metal shipping containers are the workhorses of globalization, and the container ships that carry them have grown to gargantuan proportions in the pursuit of greater efficiency. Such is the 1,300-foot-long carrier *Ever Given*, designed to handle some 20,000 containers stacked 14-stories high above deck. It is "one of the largest container ships ever built, more sideways skyscraper than boat," according to *The New York Times*.

In March 2021, as the *Ever Given* began its northward transit of the Suez Canal, the desert wind suddenly gusted to more than 49 miles per hour and blowing sand reduced visibility. The ship's stacked cargo appears to have caught the wind like a sail, and less than half an hour after two canal authority pilots came aboard the vessel crashed into the bank—effectively blocking the canal.

Paradoxically, the Suez Canal is a 120-mile maritime shortcut and a logistical chokepoint, in one. Approximately 19,000 vessels carrying 12% of the world's trade, including 10% of the world's oil, passed through the canal in 2020. The six days that it took to refloat the *Ever Given* underscored the fragility of global supply chains and their importance to the world's economy. After all, the present run-up in inflation has been attributed, at least in part, to supply side shocks.

It could be argued that the sudden storm was not the proximate cause of the accident. Perhaps human error played a role. There was no local weather monitoring system to forewarn ships of storms, and the canal authority did not provide two tugboats to assist the *Ever Given's* journey, contrary to its own regulations. Apparently, there was also a dispute between the pilots and the captain on the bridge, according to the ship's voyage data recorder. Add to that the efficient design of ultra-large container ships and a confluence of inter-related factors seem to have been at work.

Old Man River

Some examples closer to home may be more illustrative. The mighty Mississippi River has recorded unusually low water levels this month from Missouri south to Louisiana, causing significant delays in regular barge traffic. The low water has been attributed to a lack of rainfall. The Rhine River—which is the primary avenue for the transportation of physical goods in western Europe—was similarly affected this summer.

The design of water-cooled nuclear power plants relies on ready access to water in bulk. Low river levels can make it necessary to throttle reactor output. And should riverine inflows be warmer than usual then their capacity to make an effective thermal transfer is reduced. This is aside from the effect of elevated outflow temperatures which can be lethal to aquatic life.

According to a February 2022 study by Jeffery Opperman et al, published in the journal *Water*, 61% of existing and future hydropower dams are located in river basins projected to have high or extreme risk for floods, droughts or both by 2050 under a pessimistic scenario. That dams in the western United States are subject to increasing drought

risk is evident. The massive Aswan High Dam on the Nile River—of vital importance to Egypt’s agriculture and energy production—is projected to be at medium to high risk for both flooding and water scarcity risks.

On the Road to COP 27

In this light, “water quality” describes not just potable water, or water of sufficient grade for manufacturing and food production. It could really, in an age of climate change, be considered much more broadly. What we are witnessing is a grand hydrological experiment of sorts.

“Hydrological” because our climate is like a global water engine with thermal energy as its fuel. It variously distributes water across the globe—delivering too little water here, or far too much there—seemingly without remorse. Climate change is also an “experiment” in that it challenges expectations, another name for our assumptions about how things ought to work.

Addressing global water quality is one issue among many to be addressed at the upcoming 27th annual Conference of Parties (COP) to the UN Framework Convention on Climate Change which will be held in Sharm El-Sheikh, Egypt. It’s important that some substantive progress be made this year. That’s because we’re actually dealing with an *uncontrolled* experiment given the absence of a second planet Earth to serve as a benchmark.

The New Normal – A Changing Supply of Fresh Water?

By Max J. Rudolph, FSA CFA CERA MAAA

Recently the Joint Risk Management Section asked for research proposals that discussed the “New” New Normal. It got me thinking about climate change as a threat multiplier, especially the many ways water interacts with climate change. A threat multiplier makes other risks more extreme and that is certainly true. Many of these interactions are influenced by human activities, providing opportunities for improvement. We should seek out interactions with positive results from interactions like disruptive technology or medical treatments, but I am challenged to come up with global examples related to water and climate change.

Water is necessary for human survival but has not received the attention that other components of climate change, like greenhouse gases, have. Water itself is a greenhouse gas so creates a feedback loop as temperatures rise and evaporation increases, leaving more moisture in the atmosphere and trapping more heat. There are even some signs that cloud cover at some locations is decreasing, which would have additional implications to these concerns.

While this list is not complete, here are some water concerns split between those that occur inland and those that are ocean based. Others can note what I have missed and go into more detail about specific risks and how they are a threat multiplier for water supply.

Land based

The water-based risks located on land tend to focus on freshwater access and temporary excess flows, but not entirely. Supply of potable water, food supplies and economic impacts are the major concerns. As temperatures warm, heat and humidity will cause stress to all creatures as the wet-bulb metric increases to levels too high to naturally cool down. This is especially concerning when a heat wave lasts at least three days or when conditions don't improve overnight.

Aquifers

Water held in sub-surface permeable rock is available for wells and use by individuals and farms. Water levels have been built up over long periods of time and allow humans to live in large numbers and farm in areas that are not sustainable otherwise. They are susceptible to contamination due to human activities. Aquifers are being depleted in the United States in key crop regions thanks to urban living and center pivot irrigation. They also interact with sea level rise, for example on the east coast of the United States, as aquifers are depleted and land sinks as sea levels rise.

Drought, water rights and soil degradation

Despite higher temperatures allowing more water in the atmosphere, weather patterns are shifting and extreme weather events, including drought, are becoming more common. This impacts water supply, vector borne diseases, agriculture, water transportation, power generation, wildfires, dust storms and pollution. Previously negotiated water rights will need to be renegotiated. Water reservoirs in the U.S. west are at their lowest levels since they were initially filled, and the Mississippi is so low that barges are being forced to stay in their berths. Soils become less healthy as they dry out. Health outcomes for humans and other creatures are worse and include indirect causes as competition increases for limited resources.

Inland flooding

Rain and snow patterns are becoming more sporadic and extreme, with less relative snow that would release moisture slowly as it melts. Snowmelt and rainfall events cause inland flooding of river systems and harms

agriculture, transportation, property values and power generation as infrastructure is destroyed and annual crop harvests reduced or eliminated. Surface runoff flushes everything, good like soil nutrients and bad like pollutants, into the local watershed and beyond. Convective storms create localized flooding.

Convective storms

With more moisture in the air, convective storms become more powerful. This leads to heavy rainfall, lightning, flooding, hail and tornados. These are costly events that damage infrastructure and make it harder to successfully harvest a crop.

Glaciers

A warmer earth melts glaciers and other forms of ice. This fresh water is often a source of drinking water (think of any mountain range and how the local region relies on snow melt to make the area habitable). The replacement of ice by dirt and rock creates albedo feedback, where ice that had reflected sunlight is replaced on the landscape by dark ground that absorbs the energy and increases warming.

Pollution

Many greenhouse gases are either considered pollutants or are created at the same time, lessening the quality of life. Pollutants are found in the air, water, ground and all living things. Very few are positive, and many are feedback loops for global warming and water degradation.

Permafrost

Freshwater is tied up in permafrost, primarily located in the far north, and has started to melt. The organic matter that had been frozen decays, releasing methane in a positive feedback loop.

Ocean based

Water in the ocean is salty so non-potable. When it evaporates it leaves the salts behind. As oceans grow (warmer oceans expand and sea levels rise) how will rainfall patterns change? Will the total fresh water supply be reduced? Will acidity hit a tipping point and devastate ocean-based food chains?

Acidification

More carbon is absorbed by the oceans as the surface area exposed to the atmosphere expands, increasing acidity. This is somewhat offset by fresh-water dilution when ice on Greenland, Antarctica and sea ice melts (from the air above and water below), all releasing fresh water into the oceans.

Sea level rise

Higher temperatures increase the volume of all water sources (liquid expands with higher temperature) and, as ice melts from land ice, sea levels will rise. This will interact with rising or falling land masses. This can be for reasons like aquifer depletion or a rebound from the Ice Age (weight of the ice forced the land down and it is still rebounding). For example, Norfolk Virginia is experiencing rising ocean levels as land falls and oceans rise (a problem for its port infrastructure and regularly flooded air base).

An example showing the magnitude of these changes is when Greenland sheds ice (this may impact the Gulf Stream that warms England as well). If all the ice on Greenland melted, oceans would rise by about 10 inches. It recently has contributed .04 inches per year of sea level rise. Sea levels around Florida are currently rising by 1 inch every 3 years, making storms more destructive and threatening fresh water supplies in southern Florida.

Tropical storms

More moisture in the atmosphere and warmer oceans have led to more powerful tropical storms around the world. There is still much to be learned from this evolving risk about the number of storms that form annually. Property damage, injuries and deaths are due to storm surge, wind and heavy rainfall.

Conclusion

Temperatures are increasing, sea levels are rising, and rain/snow events are becoming more extreme. No models are needed to determine any of these facts. Where models are important is to develop plans for mitigation and adaptation that improve future scenarios. This will save lives and property.

Sustainable economic development means taking climate change into account as strategic, long time horizon decisions are made. This is a problem where enterprise risk management tools can be utilized to aggregate and measure interactions between variables. By utilizing these tools, we can make changes that slow, if not reverse, the temperature increases and water supply issues we are already dealing with. This will improve water outcomes and make the earth a better place to live for all creatures.

Superstorm Sandy Would Cost \$148B, Double the Economic Losses if it Were to Hit Again: Moody's Analytics

By Firas Saleh, Ph.D.

On the heels of Hurricane Ian with an estimated US \$67 billion in insured losses, the impact of natural catastrophes and the associated risk is top of mind. For over 30 years, risk models from Risk Management Solutions, Inc. (RMS) – a Moody's Analytics company, have calculated economic and insured losses from major perils such as hurricanes. Using RMS modeling, it is therefore possible to look at previous catastrophic events and gauge their impact now and in the future under future climate change scenarios where frequency or intensity of events changes, together with exposure projections.

For instance, Hurricane (or Superstorm) Sandy now comes into focus as October 29 marks the tenth anniversary of Sandy's landfall in the New York metro area. A storm that severely impacted 24 states, Sandy was the deadliest, most destructive, and strongest hurricane of the 2012 Atlantic hurricane season, inflicting nearly US \$82 billion (CPI-Adjusted) in economic losses according to NOAA³ in the U.S. and killing 233 people across eight countries from the Caribbean to Canada. Sandy also caused the New York Stock Exchange to close for two consecutive business days, which last happened in 1888 due to a major winter storm.

What Made Superstorm Sandy so Devastating?

Hurricane Sandy produced record-breaking waves, devastating storm surge and floods in New York and New Jersey. The floods were extensive, as storm tides poured into harbors and inlets, across low-lying beaches, and overpowered seawalls.

Sandy – Reassessing New York City Flood Risk

With Sandy, in total, a staggering 51 square miles of New York City flooded—17 percent of the city's total land mass, way beyond the extent of existing flood maps. As a result, when Sandy struck, most New York City property owners affected by the storm did not have adequate flood insurance — or any flood insurance at all.

Many property owners did not realize their building was at risk of flood as they were outside of Federal Emergency Management Agency (FEMA) Special Flood Hazard Areas (SFHAs) and were not even mandated to buy a National Flood Insurance Program (NFIP) policy – required for homeowners looking to secure a mortgage from a federally-backed lender.

In 2015 FEMA released “post-Sandy” preliminary Flood Insurance Rate Maps (PFIRMs) to increase floodplain areas by 42 percent, but after New York City officials appealed against these in 2016, arguing erroneous assumptions and prohibitive cost of flood insurance for homeowners moved into the 100-year flood zones, FEMA agreed to revise the city's maps.

Presently, the current risk decisions and mandate to buy a flood insurance policy when a mortgage is backed by a federally regulated lender are still based on flood maps from 2007. These maps don't include the current representation of risk and any representation of pluvial flooding which is placing exposure known to be vulnerable to flooding at risk.

³ NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters

According to FEMA, when Sandy made landfall in 2012, 169,000 policies were in place in New York and 236,000 NFIP policies were in place in New Jersey. Claims filed from Sandy were 57,000 in New York and 74,000 in New Jersey. With an average claim payment of US \$61,000, the NFIP paid claims totaling more than US \$8 billion in these two states.

Fast forward 10 years and as of August 2022, the NFIP policies in force in New York are 169,280 and 198,422 in New Jersey. While the number of NFIP policies now in force since Sandy remained flat in New York, there was a 15 percent decline in the number of New Jersey policies. In New Jersey, reports show 12,000 policyholders dropped their flood insurance after the implementation of the Risk Rating 2.0 – a new pricing methodology first introduced in October 2021. From September 2021 to June 2022 NFIP policies declined by six percent which is generally attributed to rising Risk Rating 2.0 rates and affordability.

At the same time, waterfront developments are steadily increasing. A 2022 study by the New York City Comptroller reports market rate values of real estate in the “100-year” flood zone have increased to over \$176 billion which represents a 44% increase since Superstorm Sandy.

Flood risk analysis and insurance coverage needs to increase. Using hurricane and flood models, plus climate change models that support the latest scientific consensus, together with databases that represent changes in exposure – to accommodate projected growth in construction and building values, RMS recently analyzed a range of factors, from the impacts of sea-level risk and increased exposure growth to establish the impact of Sandy if it were to hit the U.S. East Coast again in 2050. And our estimate shows that if Sandy were to hit in 2050 the total economic losses would nearly double to \$148 billion.

Commercial Real Estate Impact

After Sandy, NYC office net operating incomes dropped 7.73% in 2014 Q3 – almost two years after the disaster. The storm not only directly damaged those properties, driving up vacancy and expenses, but it also heightened flood risk fears among office tenants and property owners. With a growing acceptance of climate change and global warming, New York City’s experience with Superstorm Sandy offers a cautionary tale when viewed through the broader lens of future climate risks to our cities, infrastructure, and commercial real estate.

For more information on the commercial real estate impact:

<https://cre.moodyanalytics.com/insights/research/ten-years-later-the-effect-of-superstorm-sandy-on-nyc-neighborhoods-and-commercial-real-estate/>

Firas Saleh is Director of Model Product Management at RMS, a Moody’s Analytics company, holds a Ph.D. in hydrology.

RMS risk models underpin risk decisions for the nearly US \$2 trillion Property & Casualty insurance industry. For over 30 years, RMS has led the catastrophe risk modeling and analytics industry, helping to shape the world’s view of risk for insurers, reinsurers, financial services organizations, and the public sector.

SOA Featured Research Projects

By Priya Rohatgi, ASA

Following are the three most recent papers published by SOA Research Institute.

A Practical Guide for Working with Weather Datasets - Topic1: The Main Types of Weather Datasets, Oct 2022

By Patrick Wiese, ASA

This is the first in the series that SOA Research Institute released this month. This paper provides an overview of the main types of weather datasets. The goal of this series is to serve as a practical guide for actuaries and researchers who wish to analyze weather datasets. Also, provide computer programs – developed by SOA staff and by volunteers – to help reduce the upfront time and effort required to begin working with these datasets/sources.

The second paper will discuss some of the computer programming strategies needed for processing large weather datasets using a standard personal computer.

Each subsequent paper will focus on a particular weather dataset, accompanied by a free, open-source computer program for the analysis. Because each program is open source, researchers can modify and expand the code to suit their own purposes.

A wide range of datasets will be covered in this series of papers, including (1) data collected by weather stations; (2) data estimated using Doppler radar and/or sensors on satellites; (3) “reanalysis” datasets generated by weather models that assimilate historical data from many sources (land-based stations, ships, planes, weather balloons, buoys, satellites, and radar) and produce, as an output, spatially and temporally complete historical records; (4) short and medium term forecasts, (5) sub-seasonal and seasonal forecasts and (6) long-range climate projections.

You can find it at: [main-types-weather-dataset-report.pdf \(soa.org\)](https://soa.org/main-types-weather-dataset-report.pdf)

A Hydro-EVT Approach to Flood Insurance Pricing, Oct 2022

By Chaopeng Shen, PhD and Zhongyi Yuan, ASA, PhD

With an increase in the number of extreme weather events per year, which are more severe than the last, this feels very timely. *This research provides a modeling framework for assessing the inundation risk of properties and their expected flood damages, thereby laying a foundation for flood insurance pricing. The authors here use a combination of extreme value statistics and hydrology models to assess properties’ inundation probabilities and a mixed (generalized) beta model to model insurance claim losses.*

For assessing the inundation probabilities, the researchers use a regional analysis of flood risk to introduce a hierarchical model consisting of an extreme value model that produces a heavy-tailed distribution for the annual peak streamflow at a nearby gage. A hydrologic model then produces inundation levels and associated probabilities for various streamflow rates and across various locations.

Furthermore, to investigate insurance losses to flood risk, the paper studies over 50 years of claims data from the National Flood Insurance Program with 2.5 million records. Identifies the property characteristics that predict flood damages for inundated properties and derive a mixed beta model that links the conditional property damage, conditional on the property’s inundation, with relevant property characteristics.

Available at: [A Hydro-EVT Approach to Flood Insurance Pricing \(soa.org\)](https://soa.org/A-Hydro-EVT-Approach-to-Flood-Insurance-Pricing)

Climate, Weather and Environmental Sources, 2022 Update

By Climate, Environmental and Sustainability Research Committee

SOA research Institute recently published the latest version of the 2017 report, authored by Dr. Rob Erhardt, *that compiled a collection of sources that deal with what scientists know and what actuaries could do. In this update report, sources have been chosen with practicing actuaries and the public in mind. In the original report, nearly all governmental sources come from the United States. In the current version an attempt was made to include sources from actuarial bodies and regulators worldwide.*

This is an ongoing effort, please feel free to share if you happen to know of a source that didn't get included.

Available at <https://www.soa.org/resources/research-reports/2022/climate-weather-environment/>

Actuarial Weather Extreme series

Last but not the least, couple of reports were published recently under the Actuarial Weather Extreme Series showing the tremendous scale of Hurricane Ian as it hit Florida and the geographic range of the perils associated with the hurricane.

<https://www.soa.org/globalassets/research-report/weather-extremes-sept-2022.pdf>

<https://www.soa.org/globalassets/research-report/weather-extremes-oct-2022.pdf>

In the News

By Priya Rohatgi, ASA

Here are some recent events that are at the intersection of Climate change, the evolving environmental risks and policy initiatives and regulatory framework to mitigate its impact. As you click through the articles below, we invite you to consider how these events may impact actuarial applications, and to note any associations to economic and insured losses.

1. First-of-its-kind initiative by the Treasury Department

<https://www.axios.com/2022/10/18/treasury-climate-risks-property-insurance-data>

Treasury's Federal Insurance Office (FIO) is seeking comments on a proposed data collection from property and casualty insurers in all 50 states to help assess climate-related financial risks across the U.S.

[Treasury Department looks for climate risks lurking in property insurance](#), Oct 18, 2022

The FIO's data request, which will have a 60-day comment period, is part of work underway at Treasury, the Federal Reserve and the SEC, among other institutions, to determine the risks climate change poses to the financial system more broadly.

The data collection proposal is aimed at identifying the potential for disruptions to private insurance coverage in parts of the country that are especially at risk of climate impacts.

It would generally apply to large property and casualty insurers in most states. It would not apply to small insurers with policies below \$100 million, with the exception of those in 10 particularly at-risk states.

The information would be aggregated by ZIP code and would not include information on individual homeowners' policies. It would also go back five years to try to capture market shifts.

www.axios.com

2. Water stresses pose significant risk to energy infrastructure

<https://www.ft.com/content/3dd9ad29-40cf-4270-b0d9-74c03c85a3aa>

In its latest [report](#), the WMO said existing energy infrastructure was already “under stress” and climate change was likely to directly affect fuel supply, energy production and the physical resilience of existing and future energy projects.

[World weather agency sounds alarm on dams, power and nuclear plants](#), Oct 15, 2022

Flood and drought risk was particularly highlighted. In 2020, 87 per cent of the global electricity generated from thermal, nuclear and hydroelectric systems directly depended on water availability, the WMO said, but some of the facilities are located in areas that were experiencing water stress.

www.ft.com

3. **Disaster Risk Reduction needs enhanced early warning system globally**

<https://public.wmo.int/en/un-warns-half-world-not-prepared-disasters>

[A new report from the United Nations Office for Disaster Risk Reduction \(UNDRR\) and the World Meteorological Organization \(WMO\)](#) warns that half of the countries globally are not protected by multi-hazard early warning systems.

[UN warns that half the world is not prepared for disasters](#), Oct 13, 2022

“Worryingly, this report highlights significant gaps in protection as only half of the countries globally have Multi-Hazard Early Warning Systems. This is a situation that needs to urgently change to save lives, livelihoods, and assets,” said Ms. Mami Mizutori, Special Representative of the UN Secretary-General for Disaster Risk Reduction and Head of UNDRR.

“The number of recorded disasters has increased by a factor of five, driven in part by human-induced climate change and more extreme weather. This trend is expected to continue. Early warning systems are a proven and effective climate adaptation measure, that save lives and money,” said Prof. Petteri Taalas, WMO Secretary-General.

“But we can and must do better. We need to ensure that early warnings reach the most vulnerable and that they are translated into early action,” adding, “This is why WMO is spearheading a UN initiative on Early Warnings for All in the next five years.”

www.public.wmo.int

4. **Yet another year of costly disasters**

<https://abcnews.go.com/US/damage-weather-climate-disasters-exceed-100b-2022-noaa>

Damage from weather and climate disasters in 2022 could approach \$100 billion in the U.S. by the end of the year, according to estimations from the National Oceanic and Atmospheric Administration.

[Damage from weather, climate disasters could exceed \\$100B in 2022, NOAA says](#), Oct 11, 2022

So far this year, 15 events -- including the recent Hurricanes Fiona and Ian -- have incurred damages of more than \$1 billion, NOAA announced on Tuesday. It is the 8th consecutive year in which the U.S. has endured 10 or more billion-dollar disaster events.

The current tally for 2022 is \$29.3 billion in destruction, — but this does not yet include the costs for Hurricane Ian, the Western Wildfires and Hurricane Fiona, which may push the 2022 total closer to \$100 billion, a total reached in four of the last five years.

www.abcnews.go.com ; [NOAA](#)

5. How Climate Change fuels tropical storms?

<https://theconversation.com/hurricane-ian-capped-2-weeks-of-extreme-storms-around-the-globe>

When Hurricane Ian hit Florida, it was one of the United States' most powerful hurricanes on record, and it followed a two-week string of massive, devastating storms around the world

[Spiked Wind Speed and Even Higher Storm Surges: What a warmer world means for Hurricanes](#)

Climate change increases the upper limit on hurricane strength and rain rate and that it also raises the average sea level and therefore storm surge. The influence on the total number of hurricanes is currently uncertain, as are other aspects. But, as hurricanes occur, we expect more of them to be major storms. Hurricane Ian and other recent storms, including the 2020 Atlantic season, provide a picture of what that can look like.

Our research has focused on hurricanes, climate change and the water cycle for years. Here's what scientists know so far...

www.theconversation.com

6. Hurricane Map – Path and probability of hurricane force winds

<https://www.ft.com/content/ce4f722b-9c90-4509-8bb4-c22bbb37845b>

The 'cone of uncertainty' and why it is misunderstood.

[How to read a hurricane map?](#)

Hurricanes Fiona and Ian have claimed the lives of an unconfirmed number of people, caused hundreds of millions of dollars' worth of damage and left millions without power. For all these reasons, weather agencies spend vast amounts of time and resources predicting the possible paths that hurricanes might take — yet how they convey those predictions to the public can still create confusion.

The most common way of displaying the predicted path of a hurricane is deployed by the National Hurricane Center (NHC). It is referred to as the "cone of uncertainty".

www.ft.com

7. Flooding is not just a coastal problem

<https://www.politico.com/hurricane-ian-will-financially-ruin-homeowners>

The storm inundated the homes of thousands of Floridians who don't have flood insurance, exposing weaknesses in the nation's effort to address the rising costs of extreme weather.

[Ian will 'financially ruin' homeowners and insurers](#), Oct 01, 2022

The personal financial losses are a reflection of Ian's intensity and the fact that millions of Americans nationwide haven't bought flood insurance. The federal government's National Flood Insurance Program — the dominant source of flood coverage in the U.S. — protects only a tiny fraction of homeowners, almost all of them in coastal areas.

Ian's web of damage was unusually widespread as the hurricane drove storm surge onto coastal areas and triggered river overflows and flash flooding across inland Florida, where almost nobody has flood insurance.

www.politico.com

8. Flesh-eating bacteria infections spike in the aftermath of Hurricane Ian

<https://www.bbc.com/news/world-us-canada-63309246>

"The Florida Department of Health in Lee County is observing an abnormal increase in cases of *Vibrio vulnificus* infections as a result of exposure to the flood-waters and standing waters following Hurricane Ian," a spokesperson at the county health department said on Monday.

[Florida flesh-eating illness cases spike after Hurricane Ian](#), Oct 19, 2022

Officials say Lee County, where the category four storm made landfall on 28 September, has recorded 29 illnesses and four deaths owing to the bacteria. All but two cases were diagnosed after the hurricane.

Vibrio vulnificus infections can be caused after bacteria enters the body through open cuts. The bacteria live in warm brackish water, like standing floodwaters.

www.bbc.com

9. Mandatory Flood insurance in FL?

<https://www.insurancejournal.com/news/southeast/2022/10/19/690739.htm>

A bold but not-so-new idea is to require all Citizens' policyholders to purchase flood insurance, no matter where they live in Florida. It may sound heavy-handed but has met with approval from at least one industry heavyweight.

['Requiring Citizens' Policyholders to Also Buy Flood Insurance Could Address Problems](#), Oct 19, 2022

Less than 20% of Floridians in vulnerable areas carry flood insurance. Uninsured flood losses from Hurricane Ian are projected to be as high as \$16 billion – almost half as much as insured wind damages, according to CoreLogic, the data analytics firm.

Many policyholders with Citizens Property Insurance Corp. who did not carry flood insurance will likely end up in hard-fought claims disputes with the insurer over whether the Ian damage was from wind or water, adding to Citizens' \$3 billion in annual litigation expenses.

www.insurancejournal.com

10. A whisper that has echoed across millennia

<https://www.theatlantic.com/science/archive/2022/10/indigenous-aboriginal-ice-age-stories-true/671681/>

Indigenous stories from the end of the last Ice Age could be more than myth.

[Scientists Can No Longer Ignore Ancient Flooding Tales](#), Oct 10, 2022

"These stories are anecdotes, but enough anecdotes makes for data," Brendryen explains. "By systematically collecting these kinds of memories or stories, I think you can learn something."

Beyond capturing historical events, geomyths offer a glimpse into the inner lives of those who were there, says Tim Burbery, an expert on geomyths at Marshall University in West Virginia, who was not involved in the research: "These are stories based in trauma, based in catastrophe."

www.theatlantic.com

11. Insurers likely to be next casualty of hurricane Ian

<https://www.artemis.bm/news/florida-insurer-challenges-securing-reinsurance-2023-moodys>

"Securing reinsurance coverage for 2023 will be even more difficult for these companies following Hurricane Ian, Moody's explained.

[Florida carriers face challenge securing reinsurance in 2023: Moody's](#), Oct 18, 2022

There's a chance more Florida carriers fail, or face rating pressures, after hurricane Ian too, which could further complicate the issues the state's insurance market faces.

"The combination of significant Ian losses, poor historical operating results, deteriorating capitalization and higher reinsurance costs may contribute to additional insolvencies among Florida-only insurers over the coming year," Moody's warns.

Moody's also believes that Florida's litigation environment and also social inflation will boost losses from hurricane Ian, further adding pressure to the marketplace

www.artemis.bm

12. When it rains, it pours

<https://www.tudelft.nl/citg/rarest-extreme-rainstorms-will-become-even-more-intense>

Rare extreme rainfall events, which occur roughly once every hundred years, will show the greatest increase in magnitude under future climate change.

[Rarest extreme rainstorms will become even more intense](#), Oct 18, 2022

In the most favorable scenario, in which we greatly reduce greenhouse gas emissions, rare rainfall events over land will increase by approximately 14%. In the most unfavorable scenario, where emissions will rise even more sharply, precipitation extremes will increase by approximately 38%. Gründemann: "Which scenario we could expect is unknown, as it depends on many factors including the international effort to combat climate change.

The findings were calculated on the basis of 25 international climate models on which the IPCC reports are also based. Therefore, this study builds on other state-of-the-art research. The researchers noticed that all models predict the same outcomes for precipitation on land: the rarer the extremes, the more their relative increases.

Rainfall will not increase equally across the world. "Africa, for example, will be hit much harder compared to the Netherlands," Gründemann says. <https://www.nature.com/articles>

www.tudelft.nl

13. Waterworld – is it inevitable?

<https://www.universetoday.com/27-to-78-cm-of-sea-level-rise-from-melting-greenland-ice-caps>

Recent climate research, published in the [Nature Climate Change](#) journal has confirmed that melting icecaps in Greenland will contribute a minimum of 27cm rise in ocean levels even if we collectively stop burning fossil fuels immediately.

[27 to 78 cm of sea Level Rise Could be Locked in From Melting Greenland ice Caps](#), Oct 04, 2022

We have reached a “point of no return”. And what makes it worse is that this is the most conservative estimate, as it only factors the contribution made by the ice shelf in Greenland.

As support grows within the scientific community, activists are helping to spread the word, because the real change will come from hard-line political and legislative action. In the words of Professor Gail Whiteman at the University of Exeter, “The results of this new study are hard to ignore for all business leaders and politicians concerned about the future of humanity. It is bad news for the nearly 600 million people that live in coastal zones [less than 10m above sea level] worldwide. As sea levels rise, they will be increasingly vulnerable, and it threatens approximately \$1tn of global wealth.”

www.universetoday.com

14. Extreme summer droughts – rare events no more

<https://www.theguardian.com/climate-crisis-made-summer-drought-20-times-more-likely>

Record northern hemisphere drought in 2022 hit crops and power stations, worsening food and energy crises.

[Climate crisis made summer drought 20 times more likely, scientists find](#), Oct 05, 2022

The climate crisis made the record drought across the northern hemisphere this summer at least 20 times more likely, scientists have calculated. Without human-caused global heating, the event would have been expected only once every four centuries.

The dry conditions, assessed using data on soil moisture, largely resulted from the heatwaves that struck across North America, Europe and Asia, with lower rainfall relatively less important. The scientists said a summer as hot as that of 2022 would have been “virtually impossible” without global heating and in Europe alone there were 24,000 heat-related fatalities.

The analysis examined conditions across the northern hemisphere, excluding the tropics, and in western and central Europe, where the drought was particularly severe and significantly reduced crop yields. The European summer was the driest in records that stretch back to 1950, while the northern hemisphere drought was the second driest on record, after 2012.

www.theguardian.com

15. Drying up rivers have significant adverse impact on economies

<https://www.cnn.com/world/rivers-lakes-drying-up-drought-climate-cmd-intl>

A painful lack of rain and relentless heat waves are drying up rivers in the US, Europe, Asia and the Middle East

[The world's rivers are drying up from extreme weather](#), Aug 20, 2022

The consequences of the Colorado River crisis are enormous: Around 40 million people in seven states and Mexico rely on the river's water for drinking, agriculture and electricity.

The Yangtze River, China - The impact of the drying Yangtze has been enormous. In Sichuan, a province of 84 million people, hydropower makes up about 80% of electricity capacity. Much of that comes from the Yangtze River, and as its flow slows down, power generation has dwindled, leaving authorities there to order all its factories shut for six days

The Rhine starts in the Swiss Alps, flows through Germany and the Netherlands and then flows all the way out to the North Sea. It's a crucial channel for European shipping, but right now, it's a nightmare to navigate

The River Po, Italy - A big problem is that millions of people rely on the Po for their livelihood, mostly through agriculture. Around 30% of Italy's food is produced along the Po, and some of the country's most famous exports, like Parmesan cheese, is made here.

The Loire River, France - The Loire in France sustains a valley of vineyards that produce some of the world's most famous wines. The river stretches over around 600 miles and is considered France's last wild river, supporting biodiverse ecosystems throughout the valley, much of which is protected by The United Nations Educational, Scientific and Cultural Organization. Authorities are releasing water from dams into the river, mostly to ensure there is enough to cool four nuclear power plants that sit along it.

The Danube is Western Europe's longest river and a crucial shipping channel that passes through 10 countries. In Romania, Serbia and Bulgaria, workers are dredging the river just to ensure vessels can still navigate it.

www.cnn.com

Studies/Research Published Outside the SOA

By Priya Rohatgi, ASA

In this section we try to direct our readers to some of the work done by fellow actuarial societies and other professional associations/institutions in the US and around the world. The risks related to climate instability and loss of biodiversity are not only global in scale but are long term, uncertain and highly complex. Therefore, we feel the need to collaborate, share knowledge and tap into the research and developments that are happening around the world and across disciplines.

Climate-Related Disclosures and Risk Management: Standards and Leading Practices

Jérôme Crugnola-Humbert (lead) Actuary SAA (Switzerland), Certified Actuary (France) Santiago Fiallos, Certified Actuary (France) Darren Fleming, FNZSA, FIA (New Zealand) Amanda Latham (UK) Xi Cynthia Yuan FIA (China)

This paper is the fifth in the series of paper published by the International Actuarial Association (IAA) Climate Risk Task Force. *The aim of this paper is to assist actuaries (and others) to understand the principles and leading practices for preparing climate-related disclosures, and how they can be used to inform risk management processes in relation to the impacts of climate change. Using their specific skills and their professional judgment, actuaries are well placed to help companies, investors, policymakers, and society to better understand the risks and opportunities involved and meet the disclosure standards and reporting requirements.*

While climate-related disclosures should reflect a company's own business and regulatory environment, the expectation is that in due course the various frameworks will become sufficiently standardized to facilitate comparisons across firms, industries, and countries.

Just as importantly, companies will be able to leverage these disclosures to structure their climate strategy and governance, demonstrate their resilience to climate-related risk and communicate in a transparent way how they contribute to building a more sustainable world.

https://www.actuaries.org/IAA/Documents/Publications/Papers/CRTF_Paper5_Final_October2022.pdf

The Climate Risk Task Force is hosting a webinar to present this paper on Thursday, 3 November 2022 at 8:00 AM (EDT). If interested follow the [link](#) to register.

Anchoring Climate Change Risk Assessment in Core Business Decisions in Insurance

Maryam Golnaraghi, Director Climate Change & Environment, and the Geneva Association task force on climate change risk assessment

This is the third and final report in the series published by the *Geneva Association task force on climate change risk assessment*, launched in 2020. The aim here was advancing and accelerating the development of holistic methodologies and tools for conducting forward-looking climate change risk assessment. *Build on the first two reports⁴, this report is aimed at the board of directors and executive management of P&C and life re/insurers as well as regulatory and supervisory bodies, offering insight into how to anchor climate change risk assessment in core business decision-making processes using an exploratory, iterative and adaptive process, while leveraging resources,*

⁴ The Geneva Association. 2021a. Climate Change Risk Assessment for the Insurance Industry – A holistic Framing of Decisions and Other Key Considerations for Both Sides of the Balance Sheet. Authors: Maryam Golnaraghi and The GA Task Force on Climate Change Risk Assessment. (February). https://www.genevaassociation.org/sites/default/files/research-topics-document-type/pdf_public/climate_risk_web_final_250221.pdf The Geneva Association. 2021b Insurance Industry Perspectives on Regulatory Approaches to Climate Change Risk Assessment. Authors: Maryam Golnaraghi and The GA Task Force on Climate Change Risk Assessment - (June). https://www.genevaassociation.org/sites/default/files/research-topics-document-type/pdf_public/climate_regulation_web2.pdf

experiences, data and tools across the company. It provides guidance on how to design and utilize business use cases to frame and drive the assessment towards a holistic approach, taking into consideration both sides of the balance sheet. In addition, the report provides an overview of the evolving regulatory and supervisory approaches since 2021 in alignment with GA task force recommendations. Based on the findings of their recent survey, they also share new insights from regulatory bodies on their priorities and related questions for re/insurers across jurisdictions to guide their climate change risk assessment efforts.

[Anchoring Climate Change Risk Assessment in Core Business Decisions in Insurance | The Geneva Association](#)

Meteorologist to the Actuaries – Q & A with Steve Bowen

By Priya Rohatgi

For this edition, I reached out to a meteorologist, **Steve Bowen**, whose professional life straddles the two disciplines. He is currently the Chief Science Officer at Gallagher Re. His day-to-day work entails providing input to strategies



focused on combating the growing hazards - physical, non-physical, societal and financial - posed by climate change. He often leads post-event damage surveys to help identify ways to better mitigate risk and devotes considerable time towards integrating new findings in the field of climate science with analytical techniques in the re/insurance sector.

He frequently collaborates with the governmental agencies, academia, and industry groups and has co-authored several published peer-reviewed journals. Last but not the least, he has been a frequent contributor to the terminology section of this (Catastrophe & Climate Committee) Newsletter.

We are currently in the midst of 2022 Atlantic Hurricane Season, which has been an unusual one from start. It started slowly, with no hurricanes up until August and then came Hurricane Fiona and Ian making calamitous landfall in Puerto Rico, Canada and the United States. Researching the news pieces and some of the weather data with my member colleagues for the [Actuarial Weather Extreme Series](#), I was intrigued by not only the impact of the Hurricane Ian but also its cycle of development. It felt different. Ian officially made landfall as hurricane four times (Cuba, Florida (x2), and South Carolina). Before hitting Florida, it rapidly intensified to Category 4 with peak estimated sustained winds of 155mph (almost a category 5). It slightly weakened to a 150mph storm as it came ashore and brought record-breaking storm surge and winds topping 100mph to many coastal areas around Lee, Charlotte, and Collier counties in Florida. This prompted the idea of the following Q&A with Steve Bowen.

We hope you will enjoy Steve’s discussion and gain valuable perspective on this important topic.

Also, if you have any questions that you would like us to include or if you would like to participate and share your own journey, please reach out to us at research@soa.org or on SOA Hub Climate Risk Group.

Can we disaggregate any Climate Change impacts on path, severity, duration, impact in the instance of Hurricane Ian and Fiona?

There were pretty distinct characteristics of climate change found in both Ian and Fiona. Ian followed perhaps the most concerning behavioral trend that we've seen in a changing climate: rapid intensification to the point of landfall. As the oceans get warmer, and warmer at deeper levels of the ocean, this provides more "fuel" for storms to strengthen and often at a faster pace given more heat / energy available. There has been a notable uptick in storms strengthening all the way to the coast during the past 10-20 years when comparing to longer-record activity back to the start of the Satellite Era (~1966) when data is considered highest quality in the Atlantic Basin. Fiona was also another example of climate influence as it dropped torrential rainfall in Puerto Rico and elsewhere in the Caribbean while tracking at a slow rate of forward speed. Both of those components re-emphasize that hurricane risk extends far beyond just the categorical wind speed. Water is the most deadly and often most destructive part of a storm.

Media reports suggest that Ian unexpectedly intensified over a 24h period to almost a Category 5. Is this a new phenomenon and do we understand the confluence of factors driving this?

This is not a new phenomenon, but such rapid rates of intensification are increasing. A recent study (<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021GL095774>) highlights how tropical cyclones are in fact showing more occurrences of 24-hour rapid intensification at the global level and not just the Atlantic Ocean. Rapid intensification (RI) is defined as a storm that strengthens by 35 mph in a 24-hour period; while explosive rapid intensification is marked by storms gaining at least 60 mph in a 24-hour period. Perhaps, most concerning is the explosive RI metric that has shown a statistically significant increase in the past 30+ years. Warmer oceans, warmer and wetter atmospheres, and more favorable other atmospheric thermodynamic conditions have allowed this to occur.

Hurricane Trajectory and Cone: has the path variability been impacted by the warming climate? Is it impacted by bouts of rapid intensification?

This is a great question and one in which a lot of uncertainty still exists. There is actually no obvious trend in global hurricane landfalls. The greater inter-annual influence from storms is often the phase of the El Niño-Southern Oscillation (ENSO): El Niño, La Niña, ENSO-neutral. Those phases typically influence weather pattern and jet stream set-ups that drive the steering mechanisms, and the "frequency wave" undulation shape of the jet stream can bring storms closer to shore in some areas and recurving out into the open ocean in others. One definite risk from climate change is that as the oceans warm, this will allow tropical cyclones to track further north into higher latitude locations while maintaining tropical characteristics because ocean waters are warm enough to support sustained intensity. Will it lead to more landfalling storms? TBD.

Sustained wind speed (mph) reported in the media is significantly higher than the number recorded by the GHCN station e.g., Fort Myers. Why?

This is a really important point that often does not get reported in the media. Sustained wind speeds listed by the National Hurricane Center in their forecast updates represent the "over the water" estimate. As soon as a storm begins interacting with land, the frictional effects typically reduce wind speeds by 10-20% almost instantaneously. This is why you rarely see inland or coastal observations matching the estimated "over water" wind speeds. However, if you live near the top of a mid- or high-rise building, you often see winds significantly higher since the minimizing effects of land friction are reduced.

Severity vs frequency: it seems severity is going up faster than frequency for hurricanes. Is this true and if yes, do you have a view on how this evolves?

True. We have yet to see any trend emerge showing an overall increase in the number of tropical cyclones globally. However, we are absolutely seeing a higher percentage of storms that reach hurricane strength becoming higher intensity events. This means we are seeing more Category 3, 4, and 5 rated storms on the Saffir-Simpson Hurricane Wind Scale. As climate change continues to influence the global behavior of individual storms, it is safe to assume that we'll continue to see more high-intensity and high-impact events even if the overall number of storms stays the same.

1-in-100/500 years events seem to occur a lot more frequently now. Is it time to recalibrate to account for the shift in climate?

One of the hallmarks of climate change is the "sliding scale" of what we consider to be "normal". A 1-in-100 year event in 1980, for example, may now be more accurately viewed as a 1-in-75 or 1-in-50 year event today. We

“A 1-in-100year event in 1980, for example, may now be more accurately viewed as a 1-in-75 or 1-in-50year event today”.

definitely need to be changing how we frame these return period events, however. A 1-in-100 year event should more appropriately be described as a 1% chance of an event occurring in any year at any given location. It does not mean that the clock gets reset and we shouldn't expect such an event again for another 100 years.

La Niña: Are you concerned about the 'Triple Dip' extension into the third winter this year?

It is very rare to observe three consecutive La Niña events. Perhaps the most concerning part is in the Western U.S., particularly California and the Desert Southwest. La Niña winters usually lead to minimal or reduced "peak water season" precipitation from October to March that is critical to replenish agricultural and drinking water reserves for the rest of the year. Many states have been dealing with critically low water supply and another year with limited winter / spring precipitation will only further amplify the humanitarian risk underway. It will also enhance more wildfire risk.

Reinsurers and insurers - are they adequately augmenting historical datasets with scenario analysis and sensitivity testing in keeping with the pace of climate change?

The biggest challenge for the re/insurance industry and other financial markets is how to quantify the potential risk and scale of climate change. Historical data is only so useful. Future hazard conditions and changing population / exposure / wealth values are all incredibly important parameters that will drive what future loss potential may look like just from a property sector view alone. If future conditions will not look much like the past, then there are limitations in what historical data can provide. There is a real need to balance sensitivity testing with various lower and higher-end probability scenarios to better account for the large uncertainties that exist in model projections.

New Building codes for climate resilience seem to have worked: given escalating risks, what is the inflection point for retrofitting existing infrastructure?

“Hurricane Ian provided just the latest statistical data points that show if you build the right way, you can considerably reduce the potential for damage”.

Building codes work. Plain and simple. Hurricane Ian provided just the latest statistical data points that show if you build the right way, you can considerably reduce the potential for damage. While we'll never be able to reduce damage risk to zero, it is a really positive step forward. The broader concern is how to handle older building stock and especially in communities with a higher portion of residents unable to afford the construction costs required to properly retrofit their properties. Many of these communities are usually among the most vulnerable to disaster risk. This will undoubtedly require some public and private sector collaboration to allow access to subsidies and guarantee equal right opportunities.

Hard market for Insurance in Florida. How do you see this evolving?

Very difficult to say. The Florida insurance market was in a tough spot prior to Hurricane Ian, and now there will be significantly more pressure on many local, regional, and national insurance carriers. There is an expectation that more carriers will struggle to stay in business, which will force even more policyholders to Citizens Property Insurance Corp. -- which is a Florida state-run carrier and viewed as the "insurer of last resort". Issues around claims litigation, third-party assessors, and increased storm-related claims filings since 2017 have really amplified loss costs and put the market in a precarious position. There will need to be a fundamental change in how the industry is managed and regulated, otherwise premiums will continue to rapidly rise and there will be less private market options available to the public.

National Adaptation Plan - do you think it is time for a unified plan and call to action?

This is a great concept, but one which would likely be very difficult to implement on a national scale. Each region of the country has its own unique set of disaster-related risk. There is not a "one-size-fits-all" solution, but certainly there are some basic takeaways around how to build, where to build, how to plan for the anticipated localized changes in disaster risk to a specific region, and how to better communicate / educate the public on non-partisan ideas that can benefit everyone. As disaster costs continue to reach new highs, the public sentiment seems to acknowledge that "normal" is changing and unless we begin to adapt to the climate of tomorrow, we'll always be playing catch-up and trying to address the climate of yesterday. Being proactive is essential.

Is the industry adapting tools for damage assessment? (E.g., Skai, which uses machine learning to analyze satellite imagery from before and after a disaster and estimate the severity of damage to buildings, enabling initiatives like the Google charity "Giving Direct").

There has definitely been a terrific step forward in how we are able to do rapid assessments to analyze where some of the hardest-hit areas may be located. It is helping accelerate how insurers assess and process claims, for example. There are still limitations to how much technology is able to provide. This is mostly around flood-related impacts. One big challenge of satellite-based technology is cloud cover. If an area has been flooded, but satellite imagery shows an unaffected physical structure a day later with water receded, you've likely missed significant water inundation which can result in a complete loss of indoor contents. We've made a lot of strides, but there are still areas that need a lot of additional work to fully survey and capture hazard impacts.

"One big challenge of satellite-based technology is cloud cover".

What should COP27 prioritize to enable countries to deliver on their commitments?

There is no shortage of potential angles to where countries could direct their prioritizations. The most important topics, in my view, involve those with actionable solutions that can be easily measured. This of course centers on carbon and other greenhouse gas emissions, but more is needed beyond policy commitments to fundamentally alter what we're doing for tomorrow's climate. One big change would be enforcing accountability and enacting penalties for failing to meet climate goals. We've seen a lot of hugely positive momentum on the policy front and net-zero promises in recent years at the government and private sector level, but the ultimate question is whether these goals will be met.

Book Recommendations

Here is a recent title recommended by our committee member.

“Purpose and Profit” by *George Serafeim*

A very welcome addition to the ESG conversation; readable; positive; content-rich (he's been publishing substantive research for many years now). He's especially good on the need for better data and how that might be done (he is one of the co-founders of the Impact-Weighted Accounts Project). And I smiled when I got to his conclusion, in which he tells of a CEO who interrupted a moan-fest with the observation "The problem isn't that we don't have the tools or the resources. The problem isn't that we don't have data. The problem is much more straightforward than that. The problem is that all of you who are complaining just don't care enough about these issues. Exactly: all the regulation and disclosure in the world will make no difference unless there are people who care enough to engage with it.

Recommended by Bob Collie, member of the Catastrophe & Climate Research Steering Committee

About the Society of Actuaries Research Institute

Serving as the research arm of the Society of Actuaries (SOA), the SOA Research Institute provides objective, data-driven research bringing together tried and true practices and future-focused approaches to address societal challenges and your business needs. The Institute provides trusted knowledge, extensive experience and new technologies to help effectively identify, predict and manage risks.

Representing the thousands of actuaries who help conduct critical research, the SOA Research Institute provides clarity and solutions on risks and societal challenges. The Institute actuaries, academics, employers, the insurance industry, regulators, research partners, foundations and research institutions, sponsors and non-governmental organizations, building an effective network which provides support, knowledge and expertise regarding the management of risk to benefit the industry and the public.

Managed by experienced actuaries and research experts from a broad range of industries, the SOA Research Institute creates, funds, develops and distributes research to elevate actuaries as leaders in measuring and managing risk. These efforts include studies, essay collections, webcasts, research papers, survey reports, and original research on topics impacting society.

Harnessing its peer-reviewed research, leading-edge technologies, new data tools and innovative practices, the Institute seeks to understand the underlying causes of risk and the possible outcomes. The Institute develops objective research spanning a variety of topics with its [strategic research programs](#): aging and retirement; actuarial innovation and technology; mortality and longevity; diversity, equity and inclusion; health care cost trends; and catastrophe and climate risk. The Institute has a large volume of [topical research available](#), including an expanding collection of international and market-specific research, experience studies, models and timely research.

Society of Actuaries Research Institute
475 N. Martingale Road, Suite 600
Schaumburg, Illinois 60173
www.SOA.org