Catastrophe and Climate

SOA Research INSTITUTE

Research Program Newsletter

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Focus on Terminology: Permafrost

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 that have been used for decades in each specialty are used in ways that mean something different to the other group or are 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 commonplace in the actuarial space and 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 people working in sustainability areas use in different ways from each other or from common use. The hope is that having vocabulary awareness will improve communications between professionals.

By focusing primarily on permafrost in this essay, we consider a topic most people have some familiarity with. Hopefully, the explanation that follows will clarify the importance of thinking about linear versus higher order interactions and the impact of tipping points and feedback loops.

Permafrost - the issue

As the planet warms, we see climate documentaries where a scientist visits an ice-covered lake, pokes a hole in the ice and lights the methane released on fire (amateurs should not try this on their own!). This is due to previously frozen permafrost releasing methane as organic material resumes the process of decay as it melts. Long frozen microbes will also be freed, with some causing human disease, but here we will focus on greenhouse gas emissions.

It is estimated that there are more greenhouse gases in permafrost than are currently present in the atmosphere, so modelers should consider this as they estimate future changes1. Much of the earth's permafrost occurs in the Arctic and in Greenland, which are warming at twice the rate of other places on the planet2, and where glaciers and sea ice are also melting. The Arctic is currently a carbon sink, taking up more carbon than it releases. As the area warms many processes will interact and could transform the region into a carbon source, similar to the role of draining peatland. Decaying matter will release carbon in an offset with new plants that absorb carbon to determine how much of a climate change multiplier melting permafrost will become.

Historically, a warming earth has seen quick reversals as ice melts, sea level rises and temperatures spike. It is not always an orderly, or linear, change from one temperature regime to another. In fact, some modelers hypothesize that we may hit a tipping point if temperatures increase about 3 degrees Celsius, jumping quickly another 3 degrees as a tipping point is reached. Permafrost could be a key component in triggering this tipping point as large amounts of greenhouse gases are released over a short period of time, warming the planet further.

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[1] Schaefer, Kevin. *Methane and Frozen Ground.* National Snow & Ice Data Center. https://nsidc.org/cryosphere/frozenground/methane.html

[2] UN News. *If you're not thinking about the climate impacts of thawing permafrost, (here's why) you should be.* January 30, 2022. https://news.un.org/en/story/2022/01/1110722

The human population can't wait for the initial rise in temperatures to take action. That would be too late as events would already be rolling downhill. Our recent historical data sets include none of these instances, so modelers need to consider deterministic narrative scenarios (like the shared socioeconomic pathways) to understand implications on health, finance, agriculture, geopolitics and other metrics. This would be the most challenging scenario humans have ever encountered and the solutions will require individual and group limits.

Summary

A warming planet may unlock higher order interactions that cause a tipping point, adding complexity to any model. As actuaries interact with climate scientists, statisticians and the population at large, it becomes important for terms to be clarified so that public policy around infrastructure and safety measures reflect realistic future expectations. Anticipating scientific and financial results through narrative scenarios will lead to more effective mitigation and adaptation techniques.

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Steve Bowen is a Meteorologist and the Head of Catastrophe Insight at Aon.

Inflation – a Catastrophe?

By Sam Gutterman

In discussing catastrophes, inflation does not immediately come to mind. **Can inflation, the periodic change in the cost of living, become a catastrophe?** Although the term 'catastrophe' has a wide range of meanings – from a narrow one that only considers a destructive natural disaster, say, an earthquake, to any event or condition with disastrous consequences, its emergence can also depend on whose perspective is applied.

My answer to the question is that inflation can be a catastrophe, in at least two types of situations: (1) inflation can push an individual, household, business, and even a country over the edge, whether to food and housing insecurity or bankruptcy, if unable to offset its effects with corresponding increases in income or if unable to pass along their increased costs, and (2) if it becomes embedded in expectations, as in North America in the 1970s or in hyper-inflationary economies such as Brazil, Zimbabwe, or Venezuela have at times experienced.

A household with one or more wage-earners or jobs may be able to financially sustain themselves through a bout of high inflation by increasing their income, gaining more generous wage envelopes, reducing living expenses, downsizing, or using accumulated savings. However, any of these options can also be accompanied with unwanted mental, financial, or physical costs.

Yet these mitigation strategies may not be sufficient for those with limited resources. And many in retirement may find inflation problematic with no offsetting income increase, even when the COLAs in their Social Security checks are seemingly large.

Other alternative means of dealing with inflation might include earning higher interest rates on any savings, reaping benefits from a booming stock market (if only!), or seeing an increase in their real estate/property value. But these only work if the household has been able to accumulate a retirement nest-egg that can take advantage of these sources. Those with fixed or limited income or wealth may experience problems, and businesses may be unable to maintain their income because of high fixed costs or excessive debt. And not everyone has a job whose earnings trajectory can keep up with their costs – due to, say, disability, underemployment, or unemployment.

In looking at aggregate or macro data, it is easy to forget that the national cost of living does not really relate to any individual's circumstances, a general problem with any such measure or index, especially one dealing with economic or demographic outcomes. Inflation measures a composite average national cost of an average basket of goods and services used by an average person. Who is average anyway and who consumes the same type and amount of goods and services each period? It is clearly an abstract construct to facilitate macro-level decisions, which does not necessarily relate to one's visit to the grocery store or gas station!

If the rate of change in expenditures of an individual, household, business, or country deviates a lot from the average, such as needed repairs to a house, a dental emergency, a family vacation, or an unusually large amount of debt, …, then the aggregate rate of inflation does not relate at all. If a household needs to pay for a lot of expensive gasoline or the cost of lumber needed in a house repair, that household may, if not properly prepared, suffer its own financial catastrophe or meltdown as it juggles its daily or monthly budget.

But most inflationary periods are temporary, that is, at worst they usually take the form of a spike that the monetary authority can control. But of course, what goes up must come down – really? Well, in most cases anyhow.

If a significant part of inflation gets embedded in actual or general expectations, a wage-price spiral may ensue that can be difficult to overcome and at best can lead to long-term cost creep during which a business or country can lose its competitiveness. If not accompanied by dramatic action or sustainable action, it can be accompanied by its own set of intended or unintended headaches. Such a catastrophe can wreak havoc with resource allocation among people, institutions, and over time.

Not all economies are well-managed; and even if they are, they may simply suffer from bad luck or unfortunate external developments. In normal times, monetary authorities in economically developed countries, whose role it is to protect the economy from excessive inflationary pressures (usually purposely vague as to what 'excessive' is), can control inflation from 'getting out of control'.

However, in less economically-well off or weakly managed economies, the economy can become volatile and in extreme cases inflation can skyrocket to uncomfortably elevated levels, even to the point of stagflation or hyper-inflation – something to avoid at all cost. I will always remember sitting next to the CEO of a Zimbabwean insurance company in a flight over Africa who was forced to pay weekly wages to her staff in the form of chickens every week. An increase in the cost of bread or rice has been known to lead to an overthrow of a government.

If debt burdens become excessive, especially if denominated in a foreign currency, the only option for a country may become impoverishment, bankruptcy, or, if lucky, a bail-out by a multinational institution such as the IMF. A rough analogy to a household is the social safety net, if available. Such a catastrophe can touch all those living in such a country. If a household or business, it could lead to malnutrition or financial ruin.

In sum, small gradual inflationary trends can usually be managed and can be anticipated, with most people being able to adapt. But there are circumstances where inflation becomes out of control or unmanageable, with catastrophic outcomes. Those affected can include: (1) vulnerable households and businesses who are 'on the edge' with fragile financial resources, (2) those who aren't prepared for increases in their expenses, although inflation may only be one of the drivers involved, (3) those unlucky enough to be hit with expenses that have been especially affected by significant cost increases, such as where fuel or rent is an inordinate percent of their total expenditures, and (4) those unlucky enough to live in a location hit with stagflation or hyper-inflation.

In some cases, and for some people, inflationary circumstances can lead to disastrous results. Where practical, effective advanced planning can help to avoid the most disastrous consequences, but where not practical, beware of its consequences!

Salad Days

By Frank Grossman, FSA, FCIA, MAAA

One of life's little pleasures is a *salade Lyonnaise*, one of the rudiments of French cooking. It is made of salad greens dressed with crispy lardons and a proper vinaigrette (salad oil, red wine vinegar, Dijon mustard, salt and pepper, with perhaps a splash of water and pinch of sugar) all topped by a poached egg. Such a salad, accompanied by a good baguette and salted butter, makes a fine meal anytime but especially during the humid dog days of August.

The salad's key ingredient is its tasty, lacey frisée endive greens. Though it's all too easy to underestimate each compact frisée, an average head can easily yield ten good salads. An important characteristic of frisée, shared by other members of the endive family (curly endive, escarole), is its ability to tolerate heat stress without bolting and going to seed as other greens are apt to do. Frisée is an ideal summertime vegetable whose culinary tradition dates back to antiquity.

The Wisdom of Markets

Imagine my surprise just the other day when I spotted frisée endive at my local Toronto grocer: wrapped in clear plastic, each head weighing just under a pound for $5.45 (C$6.99) all the way from sunny Spain! That's right, salad greens delivered across the Atlantic Ocean by refrigerated air transport. In principle, an effective carbon pricing regime could internalize their true shipment cost (viz. the environmental impact of the jet fuel's GHG emission residue) into an even higher shelf price. Yet Canada's carbon tax policy is singularly unambitious despite the criticism it routinely receives.

It bears noting that Spain is currently suffering a severe drought, and July 2022 was the hottest month on record since the collection of weather data began in 1961. Doubtless European Union agricultural subsidies and aid for air carriers provides support for the cultivation of perishable produce and its international export under these conditions. Yet is the doctrine of comparative advantage sufficient to explain the presence of Spanish frisée—some 3,700 miles (6,000 km) from the field in which it was grown—and the dearth of locally grown frisée at the grocery store?

On the demand side, it's difficult to believe that many shoppers get a status lift from the conspicuous consumption of a particular variety of lettuce. After all, we're not referring to the blingy purchase of an upmarket SUV or a second house in the country. While on the supply side, is it not possible to grow frisée endive in southern Ontario for less than five dollars a head? Barriers to entry are often cited as a factor inhibiting competition, but surely, they are significantly lower for agriculture than for the tech sector (where intellectual property is vital) or the insurance industry (due to regulation), for example.

Better Data and Decisions

It's been suggested that one way of solving the climate crisis is to improve the quality and quantity of information disclosures and associated price signals. Implicit in this approach is having metrics that make sense, as well as some manner of "metric arithmetic" that makes sense too. An example where this is not always the case is gross domestic product, inasmuch as its growth rate is widely taken to be a proxy for national well-being. Following the destruction of a homestead by a wildfire or flood, the subsequent economic cost of relief, recovery, and reconstruction buoys GDP—seemingly a small comfort to the homeowner.

The follow-on expectation is that better information will inevitably translate into better decision making. However, a blinkered faith in market-based solutions risks being misplaced. This is at least in part because the doctrine of consumer choice too often leads to optimal or expedient decisions, and not prudent ones. Our system of global food

supply is illustrative. The fragility of its attenuated logistics was laid bare by a pandemic crisis. In its own small way, the frisée endive anecdote reflects the illogic of our food system. A large agribusiness firm, located half a continent and an ocean away, delivers produce that any child could grow given a plot of arable land, a handful of seeds, a trowel and a watering can. In an age of accelerating climate change, how much longer will our salad days last?

SOA Featured Research Projects

By Priya Rohatgi, ASA

This summer SOA Research Institute published a couple of papers which are directly related to Life and Health practices but have far reaching application to different insurance practices in various jurisdictions.

Climate Impact on Tick-borne Illnesses, *July 2022*

By Yubo Wang, PhD; Sara Goldberg, FSA; Sarah Hogekamp, DAV; Yaryna Kolomiytseva, MA; R. Dale Hall, FSA

Is the world entering an era of pandemics and infectious disease? This recent report by SOA Research institute is an effort to better understand the complex relationship between climate variables and the increasing incidence of vector-borne illnesses worldwide via conducting an in-depth analysis of spread of Lyme Disease (LD) in US.

This report explores the shifting geography of LD in the U.S. and beyond (Europe and Asia) and some of the potential determinants of its spread - the host (ticks) and intermediate host activity, range, and survival ultimately determine potential for exposure to LD. Another factor is human activity in high-exposure areas. Also, they found empirical evidence suggesting some extreme weather events to have both a positive and negative effect on tick survival and activity. The authors further examined the healthcare costs and complications related to LD.

The other key feature of this study is the use of non-spatial and spatial panel data models to estimate the effects of weather, land cover, and socio-economic variables on the Lyme disease incidence in the U.S. This modelling technique currently appears to be underutilized in actuarial profession particularly among the life & health practice in the insurance industry. The study applies a modelling approach which accounts for geographic dependence through novel use of spatial autoregressive model with autoregressive disturbances (SARAR) and provides a regression model as a framework for other infectious diseases and their link to climate.

You can find this paper at https://www.soa.org/research-report/2022/climate-impact-tick-borne-illness-report.pdf

Climate Risk Analysis for Life and Health Insurance Companies, *June 2022*

Authored by Didier Serre

This paper is a well-written summary of the panel discussion that was jointly sponsored by the SOA Research Institute Catastrophe & Climate Program and the Swiss Re Institute. The primary focus here was the potential impact of climate change on the life & health insurance companies in US - the current challenges with climate risk analysis and considerations for both qualitative and quantitative approaches to climate risk modeling. The panelists discussed ways to reflect and adjust assumptions, trends, offsets, and climate data to assess the direct and indirect impacts, as well as compound effects across multiple scenarios. They also covered, effective communication and disclosures of climate-related information to various stakeholders.

The panelists were selected to represent a diverse array of opinions and were encouraged to contribute from their individual perspectives working in areas such as insurance, reinsurance, state regulation, consultancy, meteorology, and climate finance.

If you have not seen it already, do add this paper to your reading list climate-risk-analysis-life-health-report.pdf (soa.org)

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. Farewell to James Lovelock: A Scientific Pioneer
   https://theconversation.com/james-lovelock-the scientist-inventor-who-transformed-our-view-of-life-on-earth
   James Lovelock, the maverick scientist, and inventor died surrounded by his family on July 27, 2022 – his 103rd birthday.

> James Lovelock: the scientist-inventor who transformed our view of life on Earth
>
> He is best known for his Gaia hypothesis, developed with the brilliant US biologist Lynn Margulis in the 1970s, which transformed the way we think of life on Earth.
>
> Gaia challenged the orthodox view that life simply evolved and adapted to the ever-changing environment. Instead, Lovelock and Margulis argued that species not only competed but also cooperated to create the most favorable conditions for life.
>
> Earth is a self-regulating system maintained by communities of living organisms, they claimed. These communities adjust oxygen and carbon dioxide levels in the atmosphere, salinity in the ocean and even the planet's temperature to keep them within the acceptable bounds for life to thrive.
> www.theconversation.com

2. Inflation Reduction Act of 2022
   https://nymag.com/intelligencer/2022/08/whats-in-the-inflation-reduction-act
   Senate Democrats passed the Inflation Reduction Act on August 07, delivering a long-sought legislative win for both President Joe Biden and the party ahead of the fall midterms. The massive climate, health care, and corporate tax bill will now head to the House, where it is also expected to pass, before Biden signs the legislation into law sometime over the next week.

> Senate Democrats Finally Get Their Massive Climate, Health Care, and Tax Bill Done
>
> The budget-reconciliation bill, which is a more limited iteration of what Democrats tried and failed to do with the "Build Back Better" package over the winter, contains the largest-ever federal investment targeting climate change — about $370 billion worth — after decades of failed efforts to mount a substantive federal response to global warming.
>
> www.nymag.com

3. Wildfire Response and Drought Resiliency Act

https://grist.org/extreme-weather/house-passes-major-drought-and-wildfire-resilience-package

The legislation would prevent fires, bump pay for firefighters, and protect water resources.

> As the West burns, House passes major drought and wildfire resilience package
> One of the bill's headline provisions would increase the minimum wage for wildland firefighters employed by the U.S. Forest Service to $20 per hour and allow them paid mental health leave.
>
> In addition to bolstering the government's capacity to fight fires when they happen, the package contains a slew of measures that would address prevention and recovery.
>
> Protecting and shoring up water resources are major themes across the board in the package. It would boost funding for water recycling and reuse programs. There's funding for desalination research and project development, which would help cities and states that are looking to suck up seawater, strip it of salty minerals, and use it to replenish groundwater supplies.
> https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-117HR5118RH-RCP117-57.pdf
>
> www.grist.com

4. In the red – Insured losses in the first half (H1) of 2022

https://www.artemis.bm/news/secondary-perils-driving-insured-losses-globally-swiss-re

"The severe weather events of the past six months once again highlight that natural catastrophes, particularly secondary perils, are increasing in frequency and severity in all regions," Swiss Re said.

> Secondary perils driving insured losses globally: Swiss Re
>
> Swiss Re reports an estimated $35 billion of insured losses from natural catastrophes through the first half of 2022, as well as another $3 billion of man-made disaster losses.
>
> This figure of $35 billion of nat cat losses that are covered by insurance and reinsurance is slightly above Munich Re's estimate of $34 billion, but below the estimate from insurance and reinsurance broker Aon, which recently said the H1 tally would be around $39 billion, which is some 18% above the average.
>
> www.artemis.com

5. Insurability and Affordability of Reinsurance Coverage

https://www.ft.com/content/cac643b3-dd22-4e85-befb-e1b8b153445b

Price of coverage is going up and options are shrinking for insurers looking to pass on risks

> Climate, war, and inflation jolt reinsurers into action
> Life has not been easy for reinsurers in the past few years. Claims for natural catastrophes and pandemic-related losses have wiped out a large part of their profits.
>
> But the latest set of global problems — war in Ukraine, galloping inflation and the ever-increasing risks of climate change — have jolted them into action. In some areas, they are putting up the price of coverage, in others they are retreating altogether.
> www.ft.com

6. Atlantic hurricane season – is above-normal the new normal?

https://www.noaa.gov/news-release/noaa-predicts-above-normal-2022-atlantic-hurricane-season

Atmospheric and oceanic conditions still favor an above-normal 2022 Atlantic hurricane season, according to NOAA's annual mid-season update issued by the Climate Prediction Center, a division of the National Weather Service.

> NOAA still expects above-normal Atlantic hurricane season
>
> NOAA forecasters have slightly decreased the likelihood of an above-normal Atlantic hurricane season to 60% (lowered from the outlook issued in May, which predicted a 65% chance). The likelihood of near-normal activity has risen to 30% and the chances remain at 10% for a below-normal season.
>
> "We're just getting into the peak months of August through October for hurricane development, and we anticipate that more storms are on the way," said NOAA Administrator Rick Spinrad, Ph.D. "NOAA stands ready to deliver timely and accurate forecasts and warnings to help communities prepare in advance of approaching storms."
>
> www.noaa.gov

7. Climate driven diseases - are we prepared?

https://grist.org/health/the-disease-after-tomorrow/

This field guide to **tomorrow's climate-driven diseases** introduces you to some of the carriers that are growing in number and expanding into new parts of the U.S. as the environment changes. The viruses, bacteria, fungi, and parasites they spread can cause joint pain, skin lesions, long-term memory problems — even death.

> The disease after tomorrow
>
> With global temperatures rising, well-known vector-borne illnesses are becoming more common, and other, lesser-known diseases are spreading into new areas.
>
> These illnesses will "continue to tax our public health and medical care systems for years to come," experts from the Centers for Disease Control and Prevention, or CDC, wrote in a 2016 analysis. "The question remains whether we will be prepared.
>
> www.grist.com

8. Summer Droughts in Europe – hotter, drier

https://www.theguardian.com/the-new-normal-how-europe-is-being-hit-by-a-climate-driven-drought-crisis

Water shortages across the continent, from France through Italy, Spain and beyond, are creating a critical situation.

> The new normal': how Europe is being hit by a climate-driven drought crisis
>
> The EU European Drought Observatory has calculated that 45% of the bloc's territory was under drought warning by mid-July, with 15% already on red alert, prompting the European Commission to warn of a "critical" situation in multiple regions.
>
> In **France,** the prime minister, Élisabeth Borne, last week activated a crisis unit to tackle a drought Météo-France described as the country's worst since records began in 1958.
>
> **Spain's** water reserves are at all-time low of 40% and have been falling at a rate of 1.5% a week through a combination of increased consumption and evaporation, according to the government, in what is likely to be the driest of the past 60 years.
>
> **Belgium**, meanwhile, forecasters reported the driest July since 1885.
>
> The **Netherlands** declared an official water shortage last week.
>
> Scientists have said climate breakdown could soon lead to summer droughts becoming frequent in western Europe, with extreme heat events that once occurred once a decade happening every two or three years unless governments around the world radically cut carbon emissions.
>
> www.theguardian.com

9. Monster cloud – the 'fire-breathing dragon of clouds'!

https://www.theguardian.com/world/2022/aug/05/pyrocumulonimbus-clouds-wildfire-mckinney-fire

> 'Fire-breathing dragon clouds': a wildfire-fueled phenomenon explained
>
> Nasa calls them the "fire-breathing dragon of clouds".
>
> Aerial images of the McKinney fire taken this week captured an increasingly common phenomenon: a nearly 50,000ft plume known as a pyro-cumulonimbus.
>
> Pyro-cumulonimbus clouds are feared for several reasons. When they form above fires, the clouds can make the blaze below spread even faster. Sometimes they can also create their own lightning, which can spark more fires.
>
> www.theguardian.org

10. Middle Eastern temperatures coming to the mid-west

https://www.theguardian.com/us-cities-risk-middle-eastern-temperatures-by-2100-climate-crisis

Unchecked global heating will bring once unthinkable extreme heat, with 16 US cities to rival summer highs seen in Middle East

> Hotter than Dubai: US cities at risk of Middle Eastern temperatures by 2100
>
> An analysis of temperature trends by Climate Central found that summer temperatures in 2100 for many cities will be more like conditions farther south, 437 miles to the south on average, with Washington DC having summers more like Austin, Texas; Boston becoming more like Philadelphia; and Billings, Montana, resembling El Paso, Texas.
>
> Researchers gathered temperature data from 1990 to 2020 to establish today's "normal" temperature and looked at 20 different projections of temperatures this century under different climate change scenarios. They decided to compare the status quo to a scenario where planet-heating emissions are not radically reduced, and the global average temperature rises by about 3.6C by the end of the century.
>
> www.theguardian.com

11. Billion Dollar Question – can the cloud cash the raincheck?

https://news.yale.edu/2022/07/07/when-it-rains-climate-models-may-underestimate-future-floods

Climate models may be significantly underestimating how extreme precipitation will become in response to a rise in greenhouse gases in the atmosphere, a new Yale-led study finds.

> When it rains... Climate models may underestimate future floods
>
> It all comes down to raindrop physics, researchers Ryan Li and Joshua Studholme explain in the journal Nature Climate Change. Even a slight change in the percentage of each falling raindrop to reach the Earth's surface can mean the difference between a climate of light drizzles and one that creates unprecedented deluges.
>
> Whether the rain a cloud produces over its lifetime will increase or decrease in warmer climates is a research question from over half a century ago. We are still searching for the answer," said Li, a graduate student in Yale's Department of Earth and Planetary Sciences, and first author of the new study.
>
> "What we've shown is that the answer to this seemingly isolated question in fact has a big role in projections of global climate change."
>
> www.yale.edu

12. Building Seawalls – zero sum game

https://www.theguardian.com/us-news/2022/aug/03/seawalls-erosion-neighbors-wisconsin

"Once we start building structures on the shoreline, armoring the shoreline, [creating] harbor structures, we change the shoreline dynamic," Meadows said.

> Seawalls ease property owners' fears of erosion – but not for their neighbors
>
> Damage from one revetment can cause neighbors to armor their shoreline, which can damage the next beach, and so on, said Guy Meadows, a professor at Michigan Tech University and director of its Marine Engineering Laboratory.
>
> www.theguardian.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.

Over half of known human pathogenic diseases can be aggravated by climate change

Camilo Mora, Tristan McKenzie, Isabella M. Gaw, Jacqueline M. Dean, Hannah von Hammerstein, Tabatha A. Knudson, Renee O. Setter, Charlotte Z. Smith, Kira M. Webster, Jonathan A. Patz and Erik C. Franklin

It is relatively well accepted that climate change can affect human pathogenic diseases; however, the full extent of this risk remains poorly quantified. Here we carried out a systematic search for empirical examples about the impacts of ten climatic hazards sensitive to greenhouse gas (GHG) emissions on each known human pathogenic disease. We found that 58% (that is, 218 out of 375) of infectious diseases confronted by humanity worldwide have been at some point aggravated by climatic hazards; 16% were at times diminished. Empirical cases revealed 1,006 unique pathways in which climatic hazards, via different transmission types, led to pathogenic diseases. The human pathogenic diseases and transmission pathways aggravated by climatic hazards are too numerous for comprehensive societal adaptations, highlighting the urgent need to work at the source of the problem: reducing GHG emissions. Over half of known human pathogenic diseases can be aggravated by climate change (nature.com)

Preparing for Hurricane Season: What to Expect in 2022

This is a webinar conducted by *Steve Bowen, from AON* talking about what is expected from 2022 Atlantic hurricane season. Given the meteorologist still expecting it to be an above-average season, the idea is to gain better understanding of what we will face throughout the season, where the storms may occur and travel. How many storms/hurricanes to expect and what are the driving factors. The goal is to help organizations better prepare for what could be another challenging year for hurricane activity in the Atlantic Basin.

Preparing for Hurricane Season: What to Expect in 2022 Webinar | Aon

Interviews of James Lovelock

"Life does more than adapt to the Earth. It changes the Earth to its own purposes". James Lovelock

The Gaia hypothesis underscored the importance of taking a holistic view of ecosystems and web of interactions that maintain the delicate balance in sustaining the circle of life. The following interviews reveal the breadth of his contribution to the fields of science and humanity. No criteria were applied to this selection.

BBC Hardtalk – James Lovelock, July 2021

(607) BBC Hardtalk - James Lovelock - YouTube

James Lovelock: 'The biosphere and I are both in the last 1% of our lives' with Jonathan Watts, July 2020

On the eve of his 101st birthday, the father of the Gaia theory discusses Covid-19, extreme weather… and freezing hamsters. https://www.theguardian.com/james-lovelock-the-biosphere-and-i-are-both-in-the-last-1%-of-our-lives

Gaia Hypothesis – James Lovelock by Naked Science, May 2019 - https://youtu.be/GIFRg2skuDI

James Lovelock talks to David Freeman - A Rough Ride to the Future, April 2014 - https://youtu.be/yc4IzFWVC50

Questions for Actuaries – *Interview with Patrick Wiese*

"Questions for Actuaries", this is a new section of the Newsletter starting 2022. Here we will be conducting a series of interviews with actuaries in different stages of their career, who are at the frontlines addressing Climate risk and managing the shift towards a more sustainable and resilient future for their respective organizations. Like many of us, if you feel overwhelmed by the pace of information in this domain, please keep an eye out for subsequent editions of our Newsletter. We hope you find answers to some of your questions and benefit from the experience of fellow actuaries in this evolving and exciting area.

Also, if you have 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

With extreme weather events making headlines globally, climate risk analysis is becoming critical for everyone. Many of us are either already entrenched in climate and catastrophe models, reviewing weather data and predictions, or are curious and want to get started with exploring and evaluating the data. For this edition, we reached out to ***Patrick Wiese, ASA*** *the SOA Lead Modeling Researcher. He has been instrumental in many SOA Research studies spanning diverse practice areas of insurance and has helped develop various analytical tools and simulation models for analyzing risks over a range of timescales. Over the last seven years, he has been involved with various initiatives related to climate change analysis – developing tools, mentoring, and speaking on the related topics to educate and support fellow actuaries. He is an active member of the Actuarial Climate Index (ACI) working group and has been vital to the development of the tool since its initiation. Among his many initiatives, a few that immediately come to mind are A Tool for Extracting Subsets of Data from GHCN Daily Dataset, an excel/VBA based tool that he created and published in 2020 and the Actuarial Weather Extreme Series, to identify and examine extreme weather events in North America.*

Could you please introduce yourself and share your background and practice area?

I am an actuary and computer programmer employed by the Society of Actuaries Research Institute, where I build models and database tabulation/visualization tools that cover a diverse range of areas, including retirement security and climate change analysis. Prior to joining the SOA in 2012, I worked for 15 years overseas, developing long-range forecasting models of social security systems in developing economies in Eastern Europe, the former USSR, Asia, Africa, and South America.

What prompted you transition into this new area of Climate risk and Sustainability and what was the path to your current role?

I wouldn't describe myself as a specialist in Climate Risk and Sustainability. Rather, I'm a generalist who has experience analyzing historical weather data to identify trends that may have an impact on actuarial risks. I began working with weather data about seven years ago. At that time, the Society of Actuaries, the Canadian Institute of Actuaries, the Casualty Actuarial Society, and the American Academy of Actuaries were working together to develop the Actuaries Climate Index (ACI), an educational tool for actuaries, policymakers, and the public that tracks various climate trends in North America. The ACI working group needed help from somebody with good computer programming skills and experience working with very large databases, and I fit that bill. My experience with the development of the ACI, in turn, led me into other projects – such as the SOA's Actuarial Weather Extremes – that involve weather data and/or weather-related loss data.

Has the scope of your work expanded to incorporate these new risks/ practices or are you now focusing on completely new risks?

Seven years ago – when I joined the ACI working group -- the analysis of weather data and climate change was an entirely new professional area for me. However, some members of the working group had significant experience analyzing the risks posed by climate change, and their knowledge – shared through our weekly conference calls -- helped me to get up to speed.

How relevant have been the classic actuarial skills, tools and techniques to your current role?

Basic statistical skills – which are one component of the actuarial skillset – have been helpful with respect to analyzing weather data. For example, I frequently use regression analysis to identify statistically significant long-term trends in weather data. In addition, techniques for modeling rare events, and for assessing whether the probability of a rare event has changed across time, have been useful.

What challenges have you faced in this area of work and how were you able to tackle them?

The biggest challenge has been data storage and data processing issues associated with very large weather datasets.

For example, the Global Historical Climatology Network daily (GHCNd) dataset is about 30 gigabytes, containing hundreds of millions of daily temperature and precipitation observations collected from over 100,000 weather stations worldwide. GHCNd is large compared to datasets typically used by actuaries, but it relatively is small compared to some weather datasets. The ERA5 dataset, for example, contains hourly weather data for more than one million geographic locations. For each of the dozens of weather variables included in ERA5, there are more than one million observations (worldwide) per hour. And because the hourly data runs from 1950 to the present, there are over 600 billion total historical observations per weather variable.

Despite the massive size of some weather datasets, I've managed to perform my research using a standard laptop, to which I've attached 4-terabyte external solid state hard drive. I store the datasets on the external drive, my computer programs read and analyze these files, and output — such as a summary of long-term trends — is directed to a folder on my internal hard drive.

Generally, I store weather data in NetCDF4 format. This format is frequently used for weather datasets both because it compresses the data, thereby conserving storage space, and because a NetCDF4 file can be read by a computer program without the need to first decompress the data.

Some of the NetCDF4 files that I work with are over 100 gigabytes, greatly exceeding the RAM of most laptops and desktops. For this reason, the data must be processed and analyzed in chunks, rather like dividing a meal into separate bite-sized portions. There are various ways to define a "chunk". For example, a large geographic region can be divided into many smaller subregions, and each subregion can be processed as a separate chunk.

To analyze weather data, a programming language is essential. I frequently use R, C++, and VBA in my own work. Many climate scientists use Python, but I haven't yet given it a try. If you are working with NetCDF4 data, you'll need a library or add-in that makes it easy to read NetCDF4 files. It would be time-consuming to write such code yourself. I use R's "ncdf4" library and have found it to be both powerful and easy to use.

When working with a large weather dataset, I generally perform a "step zero" that precedes my mathematical analysis. The purpose of step zero is to reduce the size of the data that will be fed into the computer program that performs the analysis. For example, if the raw data is in hourly time units but the mathematical analysis can be successfully performed using daily data, then it may make sense to first generate a daily dataset, derived from the hourly data. Going forward, the daily dataset (which is merely $1/24^{th}$ the size of the hourly dataset) becomes the

focus of the analysis, while the hourly data is "mothballed" for use in future projects. In addition, I use "step zero" to exclude geographic regions that aren't needed for the analysis. For example, if my research task is focused solely on the Gulf Coast of the U.S. while the full dataset spans North America, then I use step zero to create a compact data file that includes only the Gulf Coast.

What skillset and mindset you would recommend to practitioners to succeed in such a role?

The climate risk projects that I've been involved with at the SOA have required both statistical skills and computer programming skills. Knowledge of at least one programming language is essential. With respect to mindset, you need to enjoy the challenge posed by a massive dataset, rather like a mountaineer who is excited by the prospect of a difficult ascent up a steep peak.

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What would be your advice to young actuaries who want to focus on Climate risk and Sustainability? Do you have a view as to how they should plan and prepare for such a career? Also, if you had to recommend a resource(s) for educational purposes what would that be?

I don't have a good sense of how many actuarial jobs are presently focused on climate change. I think the number is relatively small, although it is growing across time. Aiming your career path at a small target is challenging. If your dream actuarial job is 100% focused on climate risk, your best bet, in my opinion, would be to get a PhD in actuarial science, and to focus your dissertation on actuarial risks that will be affected by climate change. This will create a good foundation to launch your career in the desired direction.

Gather as much information as you can before making any career-path decisions. Reach out to at least several actuaries who do climate change research and learn as much as possible about their jobs and the required skillset. There are variety of roles that an actuary can play with respect to analyzing climate risks; the more people you talk to, the better will be your understanding of the range of possibilities.

If your goal is to perform "hands-on" research using historical weather data or forward-looking weather models, then knowledge of at least one programming language is essential. "R" and Python are great choices both because they can both read and write NetCDF data, and because they provide good statistical computing capabilities. If you

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don't yet know a programming language, a good place to start is "YouTube" through which you can find many excellent tutorials. Also, if you run into programming obstacles or questions and need some help or guidance, I've found "Stackoverflow.com" to be a helpful resource.

In what ways can the actuaries support or facilitate the transition to net-zero, sustainable and resilient economy?

I have no professional experience with net-zero analysis but would like to offer my two cents.

Atmospheric concentrations of CO2 and other greenhouse gasses continue to increase without any sign of deceleration. Not only has atmospheric CO2 continued to rise, but the pace may be quickening. Atmospheric CO2 increased by about 20 ppm between 2000 and 2010, and by about 24 ppm between 2010 and 2020. Clearly, we are a long way from net-zero[3].

While a growing number of countries, cities and companies are making net-zero pledges, many of these involve only vague plans to achieve distant long-term targets, without any short and intermediate range targets. If the price of fossil fuels continues to exclude "negative externalities" (the negative effect of CO2 emissions on the environment), strong financial incentives will continue to exist for business as usual.

Governments and societies just don't have a good track record of dealing with long-range problems. The tendency is to kick the can down the road, postponing difficult changes. Perhaps new technologies will come riding to our rescue, but it is risky to assume, with a high level of confidence, that the rescue party will arrive in time.

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Actuaries have the skills needed to reprice risk to reflect the impact of climate change. This is a valuable service to society, but it may have little or no impact on the future trajectory of climate change. However, insurers do have the ability to favorably impact the trajectory of climate change by managing their investments according to environmentally and socially responsible principles. Increasingly, companies with financial assets are using ESG (environment, social and corporate governance) to guide their investment decisions. Under ESG, profits and rate-of-return remain key factors in investment decisions, but the environment and a desire to reduce global warming are additional key factors. Thus, actuaries can play a role in mitigating climate change by supporting, encouraging, and participating in their employers' efforts to implement an ESG investment policy.

Also, consider volunteering some of your time to organizations, committees, or local governments that are focused on achieving net-zero targets. Our math and modeling skills are a flexible toolkit that can be applied to many real-world problems associated with the goal of a net-zero economy. For example, a local government might wish to recalibrate its bus routes and frequencies to balance the need for timely service against the need to reduce the city's fossil fuel consumption. Making intelligent choices with respect to bus routes could help to reduce CO2 emissions. This type of problem strikes me as one in which an actuary could potentially make a valuable contribution. At the very least, an actuary could read a report produced by an outside consulting firm, review the methodology, assumptions, and conclusions, and, to the extent they feel comfortable, offer feedback.

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[3] https://gml.noaa.gov/ccgg/trends/data.html

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.

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