Into the Multiverse

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Introduction

Our own universe is just one among many different realities according to the Multiverse theory. The theory is having a moment in popular culture. The movie “Everything, Everywhere, All at Once” brings this quantum mechanics concept to life (with a 95% on Rotten Tomatoes at the time of writing). While it makes for an entertaining film, the Multiverse is rooted in quantum physics which considers that observed events appear definite but actually have a probability attached to them.

> Thinking about the events which didn’t happen but could have — that is, other realities in the multiverse — offers a way to help us better understand insurance risk.

Either by spinning out different potential futures, or looking at histories which didn’t happen, or by imagining events which could occur, more insight into the nature of risk is realized.

What if...?

Insurance is designed to answer one question: **What if**? Insureds ask, What if my business catches fire, What if my company suffers a cyber-attack, What if my firm is sued? Insurance is there to ensure that that client is protected should a What if become reality.

Insurers (and reinsurers) try to address the *What if* by thinking about: **What could**. What could cause a policy or treaty to be triggered and What could the outcome be?

Our analytic processes to quantify *What could* happen are generally based on **What did** happen. Historical data, either claims data for actuarial work or event data for catastrophe models, forms the basis of most, if not all, insurance analytics.

Today’s world demands consideration of both **What did happen** and **What didn’t happen but could have**.

Ensemble Modeling of the Future

More data and data which is better representative of the current insurance environment is necessary. The models used to predict the weather (and climate) are complex, and, crucially, chaotic – a small change in the input can result in a very major change in the output. This is a manifestation of the so-called 'butterfly effect', first coined by Edward Lorenz [1] , which is short-hand for 'sensitive dependence on initial conditions' (famously, Lorenz initially thought of a seagull flapping its wings effecting the weather but felt that butterflies leading to tornadoes was more poetic). The idea of chaotic systems predates Lorenz by almost 100 years, Henri Poincaré first noted chaotic behavior in the three-body problem in 1890, but it was Lorenz who started the formalization of dynamically chaotic systems in relation to weather modeling.

At first blush, chaos seems to be a problem for weather modeling – slightly different inputs can cause very different weather to be modelled – but, in fact, it has been a useful tool for the prediction of weather. Ensemble modelling is running the same weather model multiple times with slightly different inputs (usually within the error of the measurements) and seeing how they evolve over time. If the different runs give a similar answer, one can be fairly confident that the atmosphere is dynamically stable and the forecast is reliable. If the different runs are divergent, there's low confidence in the weather forecast. This is one way that forecasters use to assign a probability to weather occurring: the difference between whether rain is 'likely' or only 'possible' is, in part, based on whether the different models runs agree or disagree.

These differences are most directly seen in hurricane forecasting. Figure 1 shows the 20 different ensemble members from the Global Forecast System (GFS)[2] model for Hurricane Irma as of 0000UTC on 08 September 2017.

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[1] "Predictability: Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?" by Edward N. Lorenz, presented before the American Association for the Advancement of Science, December 29, 1972

[2] The Global Forecast System (GFS) is a National Centers for Environmental Prediction (NCEP) weather forecast model that generates data for dozens of atmospheric and land-soil variables, including temperatures, winds, precipitation, soil moisture, and atmospheric ozone concentration. The system couples four separate models (atmosphere, ocean model, land/soil model, and sea ice) that work together to accurately depict weather conditions.

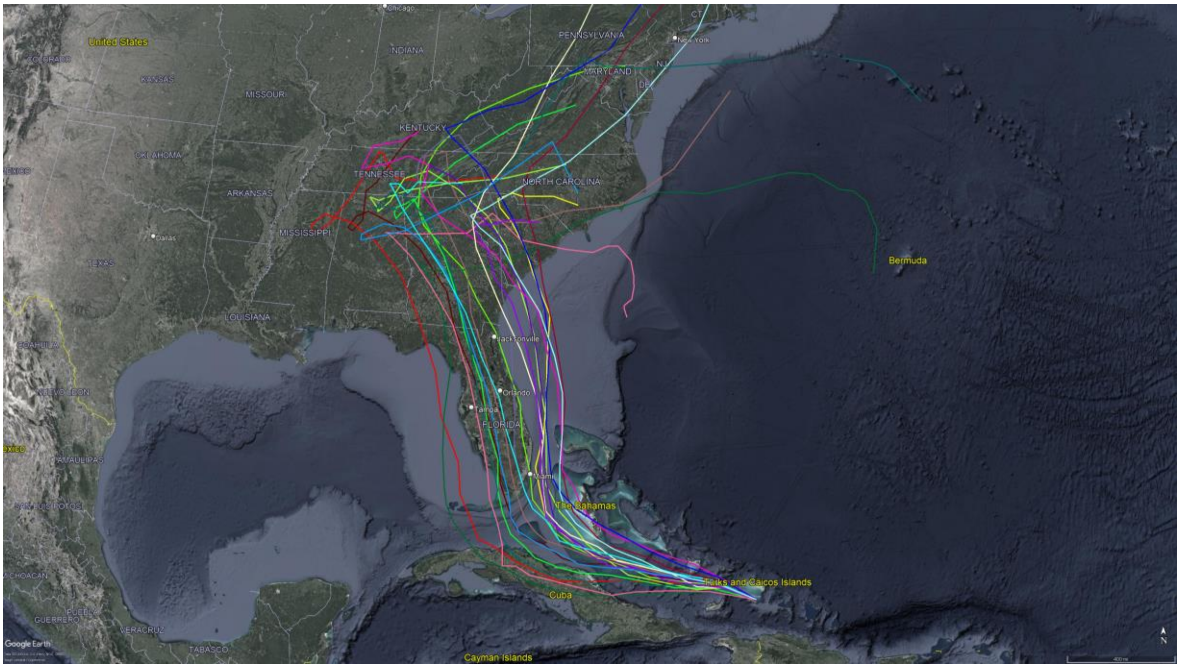

Figure 1: Ensemble model output from GFS for Hurricane Irma as at 0000UTC on 08 September 2017

The different models runs are saying broadly the same thing – Irma will start to turn to the north near Cuba and then travel up Florida – but there is significant variation: Irma could miss Florida to the left or the right, track up the Atlantic side or the Gulf side of Florida. For forecasting purposes, this led to considering that the atmosphere was unstable and the forecast was not reliable (ultimately, of course, Irma traveled up the Gulf coast of Florida causing significant damage). The National Hurricane Center (NHC) actually uses a super-ensemble to inform its forecasts; not just the multiple runs of one model but considering multiple ensembles from multiple models.

To get back to the problem of getting more data, how can this technique be applied? Think about the Irma modeling above – some of the model tracks were right, some were wrong, but at the time forecast was made, all of the tracks were valid. They used the same model with only very slight differences in initial conditions. Any one of those model tracks could have been right. Normally, the ensemble runs are discarded but could they be used in a cat model? They contain valuable information.

If the scope was broadened a little more, could a climate model be used to examine the following 12-36 months multiple times using slightly different initial conditions and see how many hurricane landfalls occur in each run and estimate the potential variability? That might result in a better idea of what the next hurricane season might look like based on the actual climate conditions observed today rather than the static base cases the catastrophe models use (the 'all years' and 'heightened activity' event sets).

Ensemble Modeling of the Past

Looking backward seems to work adequately, but there are a number of issues with a historical approach to modeling risk:

- History may not be a good predictor of the future.

  Systemic issues, for example climate change, step changes in exposure, or changes in legal environments, can cause disconnects between historical data and the current or future environment.

- History may be incomplete or subject to error.

  There are many cases where data need to be revised or updated. For example, in a prior paper, we noted that Hurricane Andrew was initially pegged as a Cat 4 storm at landfall, only being upgraded to Cat 5 ten years later.

- History may be too short.

  There are roughly 150 years of reliable hurricane landfall data. Can one be truly confident in an estimation of, say, a 1-in-500 year hurricane loss?

The ability to take historical weather data and resimulate the past has been a very useful tool for atmospheric science. Known as *reanalysis data*, it provides a systematic way to create a consistent and canonical view of what the atmosphere looked like on any given day (or any given 6-hour slice of a given day) back to about 1950 by taking the weather observations on that day and running that data through a climate/weather model. Reanalysis data has, for example, been a primary source for identifying climate change trends.

Like the concept above, the reanalysis data can be used as the jumping off point for ensemble modeling – taking a point in time, perturbing the reanalysis output at that time, and then simulating forward. This technique has been used by cat modelers to generate events for their models (European windstorm is the most common use for this).

The idea of ensemble modeling the past also answers a question which might seem slightly esoteric but is actually fundamental – how representative is the past we observed? Put another way, are the trends we see in historical data real and robust or are they artifacts of the limited history we have? Richard Dixon set out to answer this question while a visiting research fellow at the University of Reading[2] . He found, by resimulating European windstorms and windstorm losses 100 times and combining the results, there was a gradual increase in windstorm risk in Europe between 1951 and 2011; this contradicted the analysis of the observed data between 1951 and 2011, which shows a decrease in risk. While not proving that the observed downward trend is wrong, it certainly gives us pause and makes us reevaluate whether the application of a downward trend in European windstorm risk is appropriate.

Counterfactuals

Counterfactuals or alternative histories have long been grist for the mill for many fiction authors – what would happen if Napoleon had triumphed at Waterloo, or if Archduke Franz Ferdinand had not been assassinated in Sarajevo, and so on. Counterfactuals, as well as providing this intellectual entertainment, also form the basis of scenario analysis used widely in insurance and reinsurance. In fact, the Lloyd's Realistic Disaster Scenarios (RDS) can be considered counterfactual scenarios.

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[2] https://www.catinsight.co.uk/

In their 2017 white paper, Reimagining History[3] , Lloyd's and RMS discuss the creation of counterfactual scenarios and define two different types:

- **Downward counterfactuals** – events which did occur but what would happen if they were worse.
- **Upward counterfactuals** – events which did occur but what would happen if they weren't as bad as realized.

To these types of scenario, add another:

- **True counterfactuals** – events which did not occur but which are conceivable.

Counterfactual scenarios are particularly useful for classes of business where losses are very low frequency but very high severity/complexity, or for examining systemic issues which cross multiple classes of business.

Some examples of (downward and true) counterfactual scenarios could include:

- 9/11-type terror attacks occurring in other cities
- Nuclear/radiological terror attacks
- Eruptions from previously dormant volcanoes
- Aircraft collisions
- Prolonged stock market crash/bear market
- Housing market collapse
- Prolonged trade war between China and the US
- Severe product failure/liability

Counterfactual scenarios are limited only to one's imagination and the requirement that they are plausible (or at least not entirely unrealistic).

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[3] Reimagining History; counterfactual risk analysis, Emerging Risk Report 2017, Lloyd's

Conclusion

The old ways of looking at risk no longer apply. Yesterday can no longer sufficiently predict today or tomorrow.

The multiverse may seem somewhat implausible, but it’s a useful construct to help the re/insurance industry break free from its current habituation to outdated modes of thinking about risk. The movie title “Everything, Everywhere, All At Once” may be in fact an apt description for creating a sustainable future of risk solutions.

At Vantage, we bring a relentless curiosity and creative approach to see risk differently. We’re blending new data, predictive analytics and leading expertise to shape the future of risk management.

About the author

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Steve has spent over 20 years in re/insurance in analytic roles. He is a Fellow of the Royal Meteorological Society, a Certified Catastrophe Risk Management Professional, a Chartered Physicist, and holds a doctorate in atmospheric physics and a first-class honors degree in physics, both from the University of Oxford.

He was the 2007 recipient of The Review Worldwide Reinsurance Future Industry Leader award and a 2008 recipient of a Risk & Insurance Risk Innovator award.

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