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Wild variations

With modeled loss estimates spitting out divergent results, you need expert help. That's why we dialled 911 and asked for **Karen Clark**

The competition between modelers has led to an ongoing quest to find the 'right' model or the 'best' model. Some have thought that over time, the models would simply converge — hopefully to the right answer. But even in Florida, where there is perhaps the least amount of model uncertainty because of the relative abundance of historical data, and a standard model review process for over 10 years, the model results still differ by more than a factor of two.

In other regions and for other perils, the model results can differ by wider margins.

For models that have been updated and enhanced for 10 to 20 years, such as the US hurricane models, the remaining model differences are good indications of the uncertainty inherent in the system.

Modeling companies deserve a lot of credit for the enormous investments they have made in developing models that incorporate current scientific and engineering knowledge. However, that knowledge is limited. The catastrophe models are inherently limited by limitations in the scientific knowledge and information upon which they are based.

Since 1900, there have been nine hurricanes to directly impact the Northeast. Figure 1 shows the tracks of these storms. While the exact intensity is not known, the Great New England Hurricane of 1938 is believed to be the strongest in terms of wind speed, with estimated peak winds in excess of 120mph. It was also the largest in terms of geographic extent with structural damage occurring as far inland as Worcester, Massachusetts and minor damage experienced up into Canada.

Different models project insured losses from this event ranging from $15bn to over $30bn if it were to occur again today. This range reflects uncertainty around the hurricane model intensity and vulnerability components, and there is additional uncertainty around the frequency of a storm like this in the Northeast.

Dr Nicolas Coch, professor at Queens College on Long Island and leading authority on Northeast hurricanes, has painstakingly researched and compiled detailed accounts of the notable storms that have impacted the Northeast since the 1635 Great Colonial hurricane. His body of scientific work suggests a return period of about 75 years, on average, for a major storm like the 1938 event.

Dr Jeffrey Donnelly of the Woods Hole Oceanographic Institute in Falmouth, Massachusetts studies sediment cores from coastal marshes to determine when major hurricanes have occurred in the past. When major hurricanes occur, powerful storm surges push sand back from the shoreline over dunes and into marshes. By examining the sediment cores to find these distinctive layers of sand and bits of shells between the normal layers of soil, Dr Donnelly put together a record of hurricane activity stretching back 1000 years. Based on this record, he estimates a return period of 111 years, on average for a major storm like the 1938 event in the Northeast.

It's easy to see there is a significant degree of uncertainty around these estimates and this is for just one type of event. The catastrophe models must estimate the entire exceedence probability (EP) curve that captures all possible types of events in this region. To do this, the models incorporate probability distributions for the dozens of model parameters representing the important hurricane characteristics such as wind speed, track and forward speed.

Unfortunately, the data for estimating many of these important model distributions is sparse, inaccurate and inconsistent. For most hurricanes, meteorologists do not even know the peak wind speed over land. This is because wind measuring equipment is not uniformly installed along the coast and anemometers fail before peak winds are measured due to power outages and other problems. Available wind measurements are subject to significant error and peak winds are typically inferred from other information.

A vivid example

Hurricane *Andrew* provides a very vivid example of this uncertainty — 10 years after the event, in 2002, a team of NOAA scientists upgraded this storm to a category 5 from a category 4 event. Scientists now believe *Andrew*'s peak winds over land were closer to 165 mph versus the 145 mph originally estimated. For Hurricane *Katrina*, there are very few reliable wind observations and while this storm is officially classified as a category 3 hurricane, reports indicate there could have been category 4 winds either just prior to or after landfall. Going back further in time, the available data is even less reliable and the process of assigning a category to a hurricane is more subjective.

Not only is the hurricane data sparse and subject to error, when the available data is prepared for modeling, it does not conform to smooth, easy-to-work-with statistical distributions. Figure 2 shows a histogram of the nine Northeast hurricanes by Saffir-Simpson category} Because catastrophe modelers must simulate not only what's happened in the past, but more importantly, what could happen in future, they need to fit probability distributions around the hurricane data. Under the assumption that the past 100 years is not sufficient to project the future, modelers must make assumptions about where the historical data is under-sampled and where it is over-sampled.

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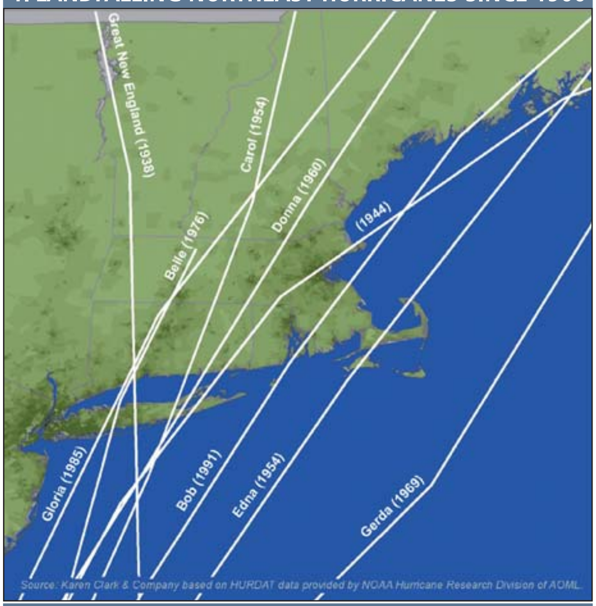
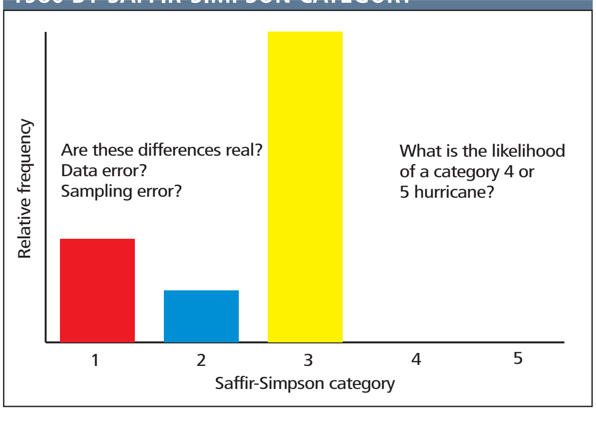
Many different curves could be assumed around the Northeast hurricane intensity data and there is no 'right' curve or answer. Unfortunately, relatively small changes in the shape and parameters of these probability distributions can lead to very significant differences in model results, even if all other model assumptions were identical. (Note that modelers don't actually fit curves to Saffir-Simpson category but rather the wind speeds or minimum pressures that determine the category.)

There are many other model assumptions and they will not be identical between the different catastrophe models. These different sets

1. LANDFALLING NORTHEAST HURRICANES SINCE 1900



2. LANDFALLING NORTHEAST HURRICANES SINCE 1980 BY SAFFIR-SIMPSON CATEGORY



of scientifically valid assumptions combined with differences in intensity and vulnerability functions, typically lead to EP curves that are very far apart as the two curves for a sample Northeast portfolio in Figure 3 demonstrate.

Another sobering fact is that even if a model is updated, it's not clear that the updated model is any more valid or better than the previous version. (Exceptions to this are model updates reflecting added sources of loss or damage functions fine-tuned using actual claims data.) In general, different models and different model versions can be thought of as providing members of an ensemble of possible future states.

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Since no one or no model knows what the future will be with respect to catastrophe losses, insurance companies must make decisions that are robust to many possible future states. This means not relying on one model-generated EP curve or even a mathematical combination of multiple curves. It certainly does not mean always selecting either the lowest or the highest curve. While picking the highest numbers may seem like the prudent thing to do, particularly to some rating agencies, companies with better information will be able to capture the market with prices that better reflect the risk, and the conservative companies will end up losing good business or even going out of business altogether.

Reducing uncertainty by benchmarking

Because the limitations in scientific information and knowledge do not allow much reduction in the underlying model uncertainty, the only way to reduce the uncertainty in decision-making is to go beyond the models and bring other information to bear on the catastrophe risk assessment process. Companies can use other information to benchmark the model results and to develop independent views of the risk that effectively reduce the uncertainty around the expected future loss potential. The added value of an independent benchmarking process is it leads to more robust decisions that don't have to change every time a model changes.

Benchmarking the model results involves examining all parts of the model-generated EP curves to see if the numbers are credible for a particular portfolio of business. Even in the Northeast, an area of relatively low hurricane frequency, there have been loss-producing hurricanes in the recent past, such as *Bob* (1991) and *Gloria* (1985). These hurricanes, and more specifically, the losses they would cause today, provide good benchmarks for the low return period loss estimates generated by the models. Even if Northeast hurricanes are 30% more frequent in the future, which many scientists consider unlikely, hurricane losses will be experienced in the Northeast only about once every eight or nine years on average.

Scenario analysis is another effective way for companies to bring more transparency to the model results. Scenarios can be recurrences of significant major events or hypothetical future events. In the Northeast, notable historical storms include the 1938 Great New England hurricane, *Donna* (1960), *Carol* (1954) and the 1944 category 3 event. Since these storms did happen, similar events can occur in the future and it is insightful for companies to estimate what the losses are likely to be if they do.

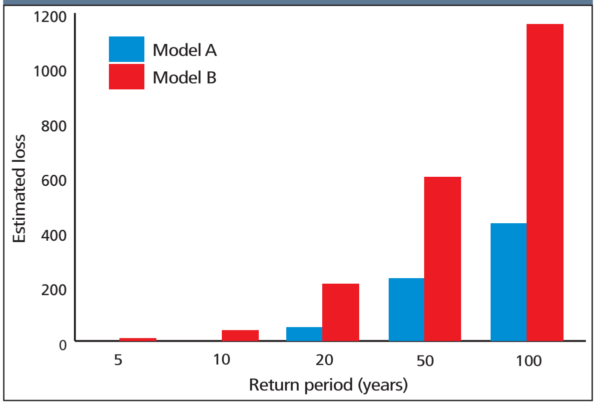
Of course, future hurricanes will not necessarily be similar to historical events, so hypothetical events can also be benchmarked. There are multiple ways to do this. We have developed a dynamic benchmarking process to create events reflecting the characteristics of hurricanes that could happen in the future and that are more extreme than what's been observed in the historical record. Furthermore, rather than being static scenarios, these events are created dynamically for each company to reflect a company's unique concentrations and types of property exposures.

The dynamic benchmarking process is also being used to test the effects of climate change. Many scientists believe the peak wind speeds of hurricanes may increase from 2% to 5% over the next 20 years due to global warming. Scenario events have been created to reflect these intensity increases so that companies can perform their own climate change stress tests.

While the scenario events that result from the dynamic benchmarking process do not replace the thousands of simulated events in the catastrophe models, they do provide very valuable information for testing the credibility of the model-generated loss estimates. These events along with historical losses and other benchmarking information bring more transparency to the process and the potential catastrophe losses a company may face in the future. It is not sufficient for companies to use model output alone to understand and manage their catastrophe risk.

In conclusion, while the catastrophe models will continue to evolve and be fine-tuned over time, the inherent uncertainty and model differences are not likely to reduce significantly. This is because scientific information is limited, there are different sets of scientifically-valid assumptions, and the model loss estimates are highly sensitive to even small changes in these assumptions. Given these facts, (re)insurance companies need to go beyond the models and develop their own independent views of risk in order to make robust catastrophe risk management decisions sustainable over time. re

3. MAJOR VARIANCE BETWEEN MODELS



4. THE DISTANCE TO COAST (DTC) PROBLEM

WHICH COAST DO YOU MEAN?

Karen Clark explains why coastlines are always complicated

Individual location level losses are subject to even more uncertainty than portfolio level loss estimates. One of the most important calculations in the hurricane models is distance to coast (DTC). The model-generated wind speeds are highly dependent on this calculation because hurricane wind speeds decrease rapidly as the storm moves inland. It's also important because at certain wind speed ranges, a change of only a few miles per hour can cause loss estimates to change by a large percentage.

In the Northeast, the coastline is quite complex as Figure 4 shows and, in many locations, there is not one 'correct' DTC calculation. This is because the model does not need to know distance to the actual closest coastline but rather the distance to the coastline where the hurricane force winds will first come ashore for the events likely to impact that location.

To make things more complicated, the direction of the hurricane force winds will influence the DTC for each specific event. While the catastrophe modelers have developed sophisticated, scientific methods to make these calculations, it's easy to see why the calculations will be different between different modelers, and more important, why there is no one correct answer for many locations.