GUY CARPENTER

MANAGING CATASTROPHE MODEL UNCERTAINTY

ISSUES AND CHALLENGES

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MARSH & McLENNAN COMPANIES

EXECUTIVE SUMMARY

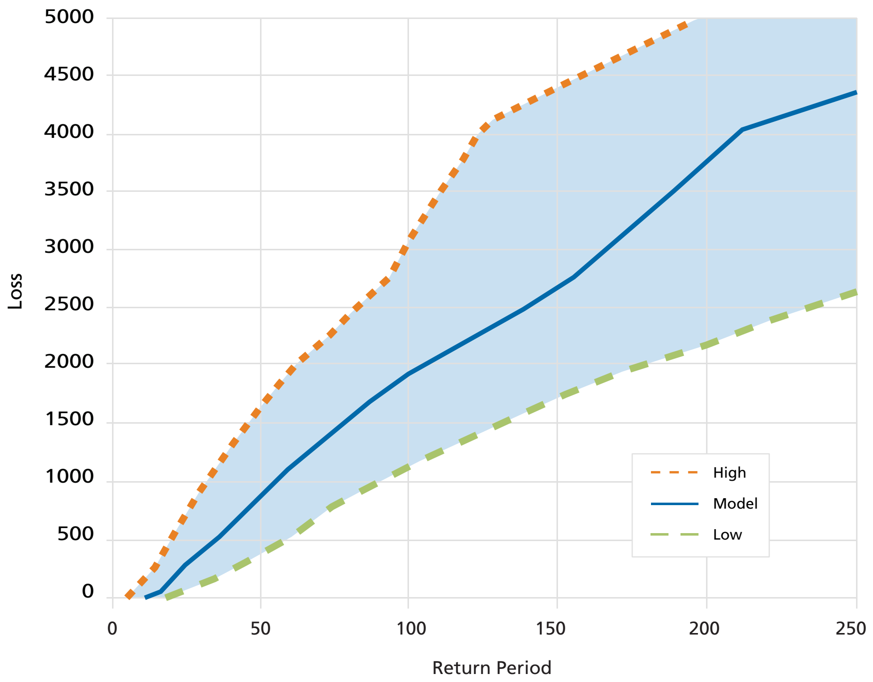
Uncertainty is ever present in the insurance business, and despite relentless enhancements in data gathering and processing power, it is still a large factor in risk modeling and assessment. This realization, driven home by model changes and recent unexpected natural catastrophes, can be disconcerting – even frightening – to industry participants. But companies that understand the vagaries of model uncertainty and take a disciplined, holistic approach to managing the catastrophe modeling process are well positioned to adapt and outperform the competition.

In this report, we examine effective modeling management as it relates to property catastrophe models used by primary writers of property insurance. We advocate adopting a multiple catastrophe-model approach to better estimate risk and control uncertainty. A broader discussion follows, suggesting how the industry should incorporate model uncertainty in its consideration of catastrophe risk.

Since the introduction of the first commercially available catastrophe (cat) models in the late 1980s, models have evolved, driven by improved science and the knowledge acquired from more recent catastrophes. Today, there are several major commercial vendors of modeling services, and virtually every insurer or reinsurer uses some model – their own, a vendor's, or, in many cases, more than one.

Despite considerable refinement of the models over the decades, uncertainty remains – and it is a significantly bigger factor than many users may recognize. In 1999, Guy Carpenter & Company published estimates of the amount of uncertainty in U.S. hurricane risk models. The conclusion: a two standard error interval (a plausible range that has a 68 percent chance of including the true, but unknown, value) for a national writer's 100-year or higher probable maximum loss (PML) goes from 50 percent to 230 percent of the PML estimate produced by the model.

FIGURE 1: CATASTROPHE MODELING: AN IMPRECISE SCIENCE



Source: RMS and Guy Carpenter

The "uncertainty band" around a typical PML curve paints a more realistic – and much less precise – picture of catastrophe model output.

Advances within the modeling industry since 1999 have indeed reduced the width of the uncertainty band, but the consideration of smaller areas of geography only introduces additional uncertainty. Today, we may crudely estimate confidence intervals as:

Geographic Scale	Lower Value of Range	Upper Value of Range
National	60% of PML estimate	190% of PML estimate
State	40% of PML estimate	270% of PML estimate
Localized	25% of PML estimate	430% of PML estimate

While models have considerable uncertainty associated with them, they are still valuable tools, taking their place with scenario analysis and exposure accumulation studies. In fact, they can be viewed as extensions of both of these types of analyses.

Coping successfully with cat model uncertainty involves a number of approaches. In many cases, multiple models can be engaged to help narrow the uncertainty band. Multi-model techniques include "blending" (averaging) the model outputs, "morphing" one model's output to reflect the characteristics of another model's, or "fusing" model components (or at least outputs) into what is in effect a new model. In each case the correct selection of specific weight parameters and methodologies is critically important and needs to be informed by the adequacies and shortcomings of each model.

In addition to helping to reduce some (but not all) sources of uncertainty, a multiple model approach can also help smooth out the impact of individual model changes – which seem to have an increasingly acute effect on the industry.

More broadly, we encourage companies to embed awareness of model uncertainty into their overall enterprise risk management (ERM) process, and make catastrophe-risk-oriented decisions with a conscious eye towards the possibility of model error.

The issues of model uncertainty and change pose many difficult challenges for the industry. The "black box" should no longer be left to make the decisions. Rather, it should be considered a tool to help inform decisions made by (human) professionals. This is an intuitive and straightforward prescription, but making it happen will require the consideration and engagement of virtually every group in the industry.

- Modeling firms need to step up and lead the discussion about uncertainty despite the apparent competitive disadvantage of transparency.

- Primary writers need to be smarter consumers of models and model output, curtailing the blind application of "portfolio optimization" in favor of a broader ERM-based multi-model approach. They also need to rethink their attitudes about nontraditional risk transfer products.

- Reinsurers, already sophisticated model users, should not take advantage of information asymmetry, but rather explore which new products might make sense.

- Rating agencies and solvency regulators need to equally investigate the models to determine when a model is being appropriately utilized. They need to understand that "the map is not the territory" – model output is relative information, not absolute gospel, and firms need time to absorb and act upon this information when model changes occur.

- Boards of directors, investors and stock analysts need to understand cat risk in the same terms – being estimated with significant uncertainty – as other financial risks. Insureds and the public need to understand that no one really knows the right answer.

- Brokers, finally, need to stay out in front to facilitate education, communication and fair dealing.

INTRODUCTION: NATURAL CATASTROPHE MODELING

Computerized simulation modeling of the potential impact and risk of natural disasters – from multiple perils – was pioneered by Dr. Don G. Friedman at the Travelers Insurance Company in the 1960s[1] . Figure 2, below, is an example of one of his simulated wind speed maps, circa 1974. In 1987, Karen Clark founded the first cat modeling firm, AIR, and three more firms, RMS, EQECAT and ARA, came on the scene in 1988, 1994 and 1999, respectively. By the early 1990s Guy Carpenter had become a "power user" of cat models and augmented its capabilities by acquiring the intellectual property – and hiring some colleagues – of the retiring Dr. Friedman.

FIGURE 2: HURRICANE SPEED WIND MAP BY DR. DON FRIEDMAN, 1974

GUY CARPENTER

Source: Guy Carpenter & Company, LLC

Today, both the cat modeling industry and Guy Carpenter's deep involvement with cat models continue to evolve.

Since the introduction of the first commercially available cat models in the late 1980s model updates have occurred regularly. There are many reasons that the models change. They include advances in computer technique and capabilities, improved scientific understanding of natural perils, expanded coverage of phenomena included in the models, improved understanding of the physical response of buildings and other property to the impact of catastrophes and enhanced knowledge of the residential and commercial building stock in the countries being covered. Many of these improvements are driven by experience in recent catastrophes. Modeling firms go to extraordinary lengths to collect and process as much data as possible.

1 Friedman, Don G. (1984) *Natural Hazard Risk Assessment for an Insurance Program,* The Geneva Papers on Risk and Insurance, Proceedings of the First Meeting of the International Working Group on Natural Disasters and Insurance (I), Vol. 9, No. 30, January.

Early cat model users were distressed to discover that models from different vendors were likely to produce materially different risk estimates for the same set of insured exposures. As model builders' experience – and data – increased over time, the models have tended to converge – somewhat. There are still material, sometimes dramatic, differences between models, especially when examined at a geographically localized level.

Cat model users might be tempted to use the differences between the models as benchmarks of uncertainty in the model results. This is natural. This is also incomplete, because model developers share (some of) the same scientific methods and data. They are by no means entirely independent.

Uncertainty is widely recognized within the modeling community and has long been a prominent topic at modeling conferences. In a 1997 conference in Bermuda, cat modeling representatives were pressed for a quantitative measure of uncertainty around 100-year return periods. No modeler was willing or able to do so.

Since then, discussion of uncertainty has not advanced much. We are aware of only one public instance where modelers explicitly quantified uncertainty levels in their results: this occurred for the Florida Commission on Hurricane Loss Projection Methodology. That was a welcome development because it provided an effective "caveat" to model results and helped users put them into an appropriate context. However, standards for how to measure this uncertainty are in their infancy. We will return to this concept in the next section.

UNCERTAINTY IN CAT MODEL RESULTS

In 1999 Guy Carpenter's Dr. David Miller published a study[2] that determined lower bounds on the amount of uncertainty that ***had to be present*** in U.S. hurricane risk models. He wrote, "because hurricane records in the Atlantic basin span only the past 100 years, any simulation of hurricane activity in this region will ultimately be limited by this finite number of historically observed hurricane events." He concluded that, for a large, nationally distributed portfolio of insured exposures, the uncertainty around an estimate of high (100 years or more) return period losses amounts to multiples, not fractions, of the estimate.

Guy Carpenter subsequently issued a white paper entitled *Uncertainty in Catastrophe Models*[3], expanding on these results. It considered other components of missing knowledge and scientific uncertainty that could only add to the overall uncertainty.

That paper explained that uncertainty arises from four types of potential errors:

1. Sampling error: Inaccuracy arising from a limited data sample. This is the type of error quantified in Dr. Miller's study.

2. Model specification error: Uncertainty as to whether the correct type of formula has been chosen. Included in this concept is the lack of understanding of physical chaotic phenomena underlying catastrophic behavior and the lack of understanding of building structure behavior under severe loads.

3. Nonsampling error: Uncertainty as to whether all relevant factors have been considered. This includes the still debated effects of the El Niño-La Niña cycle and global climate change on the rate of landfalling hurricanes. It also includes known

2 Miller, David (1999) *Uncertainty in Hurricane Risk Modeling and Implications for Securitization,* Casualty Actuarial Society Discussion Paper Program.
3 Major, John A. (1999) *Uncertainty in Catastrophe Models Part I: What is It and Where Does It Come From?* (February); *Uncertainty in Catastrophe Models Part II: How Bad is It?* (March), Financing Risk & Reinsurance, International Risk Management Institute.

phenomena not modeled (for example, tree damage, cleanup costs, looting), novel legal interpretations of liability or post-event regulatory actions, interaction of follow-on events such as freeze following a hurricane and the disruption and slow economic recovery that follows a very large disaster.

4. Numerical error: Arises through the use of approximations in calculations. The Monte Carlo technique, which involves running thousands to millions of simulated events and is widely used in cat modeling, is one such approximation.

What has not been addressed and needs to be emphasized here, is that additional, external, uncertainties come in to play when one uses a model. These principally arise from the quality of the data being fed into the model, but also include the use of "switches" (model option settings) that might not be set appropriately for the analysis at hand.

Uncertainty in Catastrophe Models made certain assumptions about the additional three types of model-inherent errors and concluded that, for a national portfolio of exposures and a typical return period of interest, a two standard error interval for a probable maximum loss (PML) goes from 50 percent to 230 percent of the PML estimate produced by the model. This interval can be understood as representing a 68 percent chance of the true answer lying within the indicated range. So, in other words:

> If the (1999) cat model says:
> **"Your 100 year return period loss is $1,117,243,572,"**
> what it really means is:
> **"Your 100 year return period loss is about a billion dollars; but it could be 500 million dollars or maybe two and a half billion dollars... something like that."**

This applies to national portfolios. The uncertainty for geographically localized portfolios, not analyzed in that white paper, must of necessity be larger.

The assumptions in *Uncertainty in Catastrophe Models* about model specification and nonsampling error reflect conditions prevalent a decade ago when it was published. The cat modeling industry should be credited with advances in model structure and the use of better underlying science – perhaps, now, model specification and nonsampling error factors should be smaller. However, the underlying limitations of sampling error and numerical approximation error still apply (another 11 years of hurricane experience have hardly made a difference here), and when one moves to smaller geographic units, the sampling error increases. (The nonsampling error probably increases as well, but we will give the modelers the benefit of the doubt on that.)

In statistics, the rule is: less data means more uncertainty. Consider, for example, Florida and Texas. They have experienced about 30 percent and 16 percent, respectively, of the major recorded U.S. landfalling hurricanes. Because sampling error is inversely proportional to the square root of the number of observations, the sampling error-driven uncertainty bands associated with PMLs on state-concentrated portfolios should be 1.8 and 2.5 times wider, respectively, than they would be for a national portfolio.

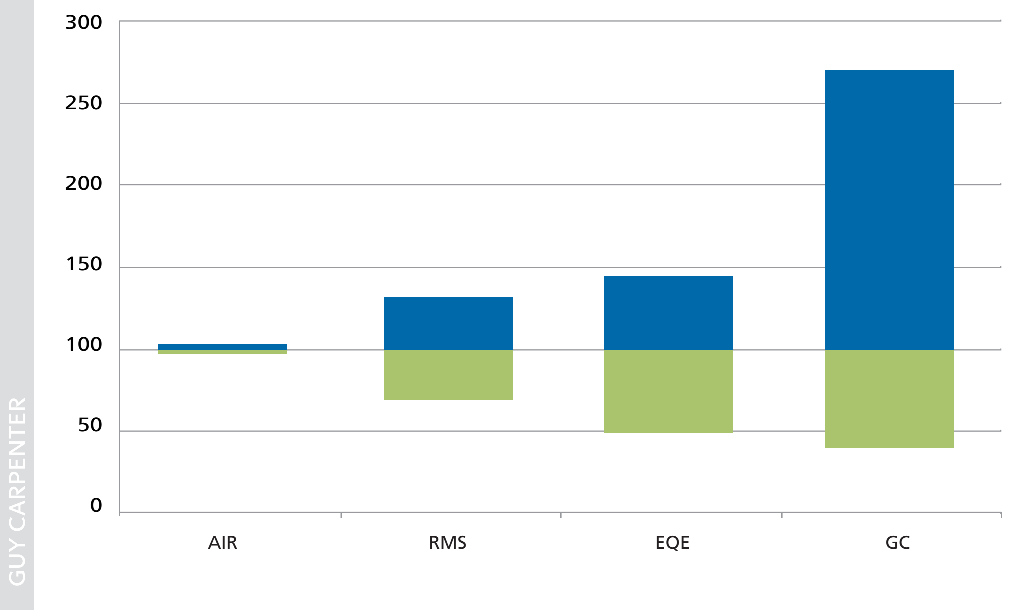
It is not as simple at the county level. Adjacent counties' experience is not "independent" (in statistical parlance) so there should be an effort to carve the coastline into a meaningful number of relatively independent zones. There are perhaps four such zones in a typical coastal state. With that assumption, the county-level sampling error contributions should be about double the state error.

Combining all of the above assumptions, we can update the 1999 white paper and crudely estimate two standard error intervals for U.S. national, state and localized hurricane PML estimates as follows:

Geographic Scale	Lower Value of Range	Upper Value of Range
National	60% of PML estimate	190% of PML estimate
State	40% of PML estimate	270% of PML estimate
Localized	25% of PML estimate	430% of PML estimate

Figure 3 shows the two standard error uncertainty bands implied by reports given by the three principal model vendors. They were given to the Florida Commission for the 100-year hurricane PML of the Florida Hurricane Catastrophe Fund. It also shows the band implied by the above table. Each two-color bar represents one model's estimates. The PML estimate in the center has been scaled to 100 percent. The top of the bar represents the upper uncertainty bound and the bottom represents the lower uncertainty bound. Evidently, the three vendors used dramatically different assumptions and/or methods for computing the uncertainties, and none of them are as wide as we calculate they must be.

FIGURE 3: NO CONSENSUS ON UNCERTAINTY



Source: AIR, RMS, EQECAT and Guy Carpenter

The three major model vendors report widely varying levels of uncertainty in their outputs. We believe it is underestimated in all cases – in one instance, by a huge margin. GC bar is based on Guy Carpenter's own analysis.

While the analyses discussed above focused on hurricane models in the United States, much of the same considerations apply to other perils and other countries, perhaps with more force. Atlantic hurricanes are represented by many decades of data and intense study. Surely the uncertainties surrounding earthquake risk in the New Madrid region of the United States or less well-documented perils in other parts of the world must be larger.

In 1974, Dr. Friedman described his work as "providing an order of magnitude measure of overall loss potential associated with natural hazards." This simple humility is worth emulating.

USING CAT MODELS

Scenario analysis has a long history in risk management. By examining a set of hypothetical extreme events and asking "what if this were to happen?" management can begin to get a sense of vulnerabilities in the business. But it is hard to assess how realistic a particular scenario might be. Using historical events as the basis for scenarios incorporates the fact that those events did, in fact, occur. They are realistic by definition. And their relative occurrence over time gives a sense of probability.

A cat model can be viewed as an extension of the historical event scenario method. The history of events is smoothed and interpolated (and, to some extent, extrapolated) to create a large number of might-have-been events of comparable realism.

Exposure mapping and accumulation analysis tools are also widely used for assessing concentrations of risk. These have the advantage of dealing with concrete, unequivocal reality. But it is difficult to compare the risk implications of exposure concentrations in different geographic areas or across different building types.

A cat model can be viewed as an extension of exposure mapping as well. But it adds to that picture a model of the other factors that come together to produce losses.

Models also serve as tools for communication. By providing a benchmark for risk, they enable market participants to "take a position" relative to that risk. This is especially important in securitization.

The fact that cat models have a degree of uncertainty around them is not a defect of the models – it is an inescapable aspect of reality. Uncertainty affects all risk assessment tools. The challenge is to recognize that uncertainty and cope with it.

There are several avenues to coping with uncertainty in cat models. One is to utilize a multi-model approach. Others include making decisions that are robust with respect to uncertainty, and formally recognizing uncertainty as an element of risk – model risk – within the firm's ERM framework.

In every case, users need to remember that the catastrophe model isn't a magic black box that will generate a definitive answer. Cat models are one type of tool and take their place alongside several others.

REDUCING UNCERTAINTY WITH A MULTI-MODEL APPROACH

We advocate, in most (if not all) cases, the use of multiple models when assessing catastrophe risk. By examining the previously discussed four sources of uncertainty one by one, we can see how a multi-model approach can help reduce uncertainty.

Sampling error from limited data: More data means less uncertainty, but there is a limited amount of data in the historical record. While different models are founded on this common data, they are not founded on identical data. They have different interpretations of the historical record, different interpretations of detailed scientific data (for example, wind fields or earthquake propagation), different sources of vulnerability (damageability) data and different data on site conditions. Using multiple models effectively increases the amount of data bearing on the analysis.

Model specification error from choice of mathematical forms and assumptions: Different vendors use different methodologies in developing their models. They have different estimation, fitting and smoothing techniques as well as different representations of scientific details. Using multiple models "diversifies" the risk of error from these choices by allowing for independent errors to cancel each other.

Nonsampling error from missing influential factors and numerical error from simulation procedures: Model vendors differ somewhat in the factors they consider in calculating cat risk. This can be seen, for example, in how they utilize the various climate cycles in developing "near term" versus "long term" frequency assumptions. Using multiple models diversifies these sources of error to some degree.

While the use of multiple models does not address the fundamental issue of uncertainty identified in Dr. Miller's seminal paper (because it is based on the historical data common to all modelers), it does diversify many other sources of uncertainty and error identified in *Uncertainty in Catastrophe Models.*

There are several ways to utilize multiple models. The simplest approaches involve some sort of "blending." More complex forms are "morphing" and "fusion."

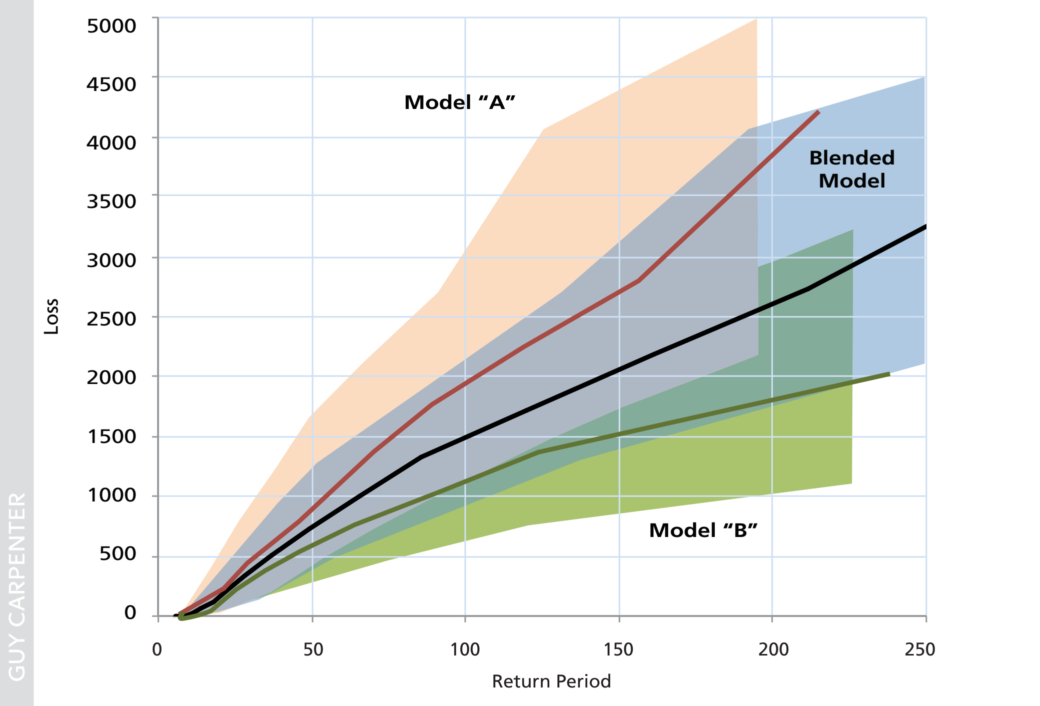
Model blending can involve model outputs or simulated scenarios.

Two exceedance probability (EP) curves can be averaged either by averaging dollars across common return periods, or averaging probabilities or return periods across common thresholds. Averaging can be a straight 50 percent - 50 percent mix, or some other weighting if there is reason to apply it, and be done on an arithmetic (additive) or geometric (multiplicative) basis.

If one has access to the underlying simulated loss scenarios, then a composite EP curve can be developed by combining scenarios from two models. The frequencies of the scenarios need to be re-weighted so that the overall combined scenario set represents the original total frequency.

Figure 4 shows a simple example of model blending. Two EP curves were combined by taking the arithmetic mean of probabilities over a set of dollar intervals. The figure shows the uncertainty "funnels" for each individual curve, and the corresponding funnel for the combined curve. The combined funnel is a bit narrower than the others due to the diversification effects discussed previously.

FIGURE 4: MODEL BLENDING REDUCES UNCERTAINTY



Source: Guy Carpenter & Company, LLC

The decision of how to apply weights and which weights to apply across multi-model opinions is complex. It requires, first, a deep understanding of the individual models and their relative adequacy to the risk/region being assessed, which can then inform which model results to over or underweight in that assessment. The specific methodology for optimally determining and applying the weights is still unresolved. This is an area of ongoing focus for Guy Carpenter's research team and we will be publishing our findings as they are established.

Model morphing means changing shape. In model morphing, one wants to change some aspect of model A to resemble that of model B, typically, because of implementation difficulties in using both models.

Morphing can be done on a frequency or severity basis. As an example, model B might have more credible estimates of landfall frequency in a particular region. Model A's frequencies for relevant events can be multiplied by some factor to make the total frequency in the region equal to that of model B.

Morphing severity, however, is more challenging. There, an entire severity curve – not just one number – must be reshaped.

It is incumbent on the user, at the very least, to delve into the model to determine the extent to which the model adequately reflects the underwriting and claims handling practices of the firm. Suggestions to gain comfort include: post event analysis of actual claims to modeled losses, a review of vulnerability sensitivity with claims or loss control staff and analysis of the spatial loss gradient. It is not uncommon for certain models to perform better for certain perils, regions or classes of risk.

Model fusion is akin to building one's own model. Cat models consist of multiple modules. The hazard or science module expresses the probabilistic occurrence of events. There are multiple components for different perils and for different aspects of the same peril. The vulnerability or engineering module translates events into damages to insured properties. There are multiple components for the various types of properties.

If one has access to model components they can be used as modules in a customized framework. Typically, this is not possible because of licensing restrictions. However, it often can be possible to achieve the effect of this, in some ways, by recombining model outputs. For example, results for different lines of business or different property types from different models can be combined. Naturally, the complexities of coordinating multiple model outputs make this very challenging.

It is important to remember what can and cannot be achieved by using multiple models. It cannot overcome the limitations of historical data, which is the primary driver of uncertainty. Nor can it overcome data errors. Using multiple models can, however, "diversify" and therefore reduce the other types of errors. An additional benefit is its tendency to smooth out the disruptive impact of model changes.

INCORPORATING "THE UNCERTAINTY FACTOR"

Another important element in successfully coping with uncertainty is to craft decisions that are "robust" with respect to model error. Sensitivity or "what-if" testing and other techniques can be used to determine, for example, how well a particular reinsurance program or underwriting initiative would appear if the model results were different. Statistical techniques are required to determine how far it is reasonable to "bend" the model results in this assessment.

A third key element is to recognize uncertainty formally within the company's ERM process. At the very least, this means managing the expectations of the consumers of model output: management, external stakeholders or rating agencies. It also means managing their understanding of the model results – whether derived from a single or multi-model approach. The firm's understanding of its absolute level of risk transcends catastrophe risk. It is the proper subject of ERM, and encompasses financial, operational and strategic risks as well as catastrophe risks. Many of these other types of risks cannot be quantified even to within cat modeling's order of magnitude uncertainty. Indeed, some are hardly subject to quantification at all.

In particular, the ERM framework should be cognizant of modeling uncertainty and the prospects for model change, namely *model risk*.

External stakeholders also will absorb cat model uncertainties and changes better if they see it as embedded in an ERM framework. The more comprehensive and structured the ERM framework – and the more it is actually used in the firm's operations – the more will model changes be seen as routine "information updates" that occur regularly to the firm's understanding of its risk.

CHALLENGES FOR THE INDUSTRY

As Karen Clark, founder of AIR and now an independent consultant, has said, "the black box started out as a useful tool for decision making, but then it grew to be very big and very powerful; the black box now makes the decisions[4]." While somewhat hyperbolic, there is also much truth to this aphorism. Models are tools, and a good tool user understands the strengths and limitations of the tool.

Dispelling the "black box" effect, though, will require a change in approach and attitude across the industry among the various stakeholders.

Modeling firms need to be more open about uncertainty. They are in an ideal position to lead the discussion. Unfortunately, competitive realities work against this. Like a statistical Gresham's Law, bad (low) estimates of uncertainty threaten to drive out good (high) estimates; the first firm to reveal the true extent of uncertainty in its model risks suffering for it in the marketplace. Perhaps now is the time for an independent, blue ribbon panel – funded by a consortium of model users – to study the uncertainty issue in general and publish a guide to the amount of uncertainty that should apply to all state-of-the-art models.

Primary writers need to become better users of models and consumers of their output, knowing what to ask, when to question and how to interpret the results in the context of material uncertainties. Being in the best position to understand the details of their own portfolios, they should begin tailoring model output to better fit their way of doing business. They need to take control back from the black box. Underwriters should be informed by, not controlled by, model results. Portfolio optimization, applied blindly, must give way to a nuanced approach to portfolio management, robust to the underlying uncertainties.

As insurers' appreciation of the magnitude of model uncertainty increases, they might find that non-indemnity (index-linked or parametric) risk transfer products appear more attractive than they had in the past. Basis risk will appear to be much less significant when put against a background of the uncertainty in the true level of coverage provided by indemnity products.

Reinsurers, in comparison, are already relatively good catastrophe model users/consumers. They (better) understand the uncertainties, use multiple commercial models and augment those with models of their own. They should not take advantage of their informational advantage over insurers to extract economic rents, however, by disingenuously pointing to a model change and acting surprised. Rather, they should consider what kinds of new products will create value as their customers' understanding of uncertainty deepens. A robust trade in index-linked products, for example, would allow cat risk to be "sliced and diced" in a manner similar to that of other financial risks – facilitating more liquid trading and placing the ultimate risk (and uncertainty) where it belongs – in the portfolios of well diversified investors.

4 Clark, Karen (2008) *Thinking Outside the Black Box™: Catastrophe Risk Management Best Practices,* 2008 Southeastern Regulators Association Conference, Orlando, FL, Oct 19-21.

Rating agencies and solvency regulators, being somewhat behind in their understanding of the nuances of uncertainty and risk, need to become better educated. They need to understand that model results are indicative, not conclusive, and that changes in models should be treated as information, not structural changes to the way insurers and reinsurers do business. They must understand that model changes, as information, provide a noisy signal against the background din of uncertainty; that such information needs to be filtered, scrutinized and gradually absorbed. They should not encourage insurers to engage in meaningless and harmful optimization exercises to meet precise, but ultimately, fictional, targets.

Boards of directors, investors and stock analysts need to appreciate the comparisons between uncertainty in cat modeling results and other forms of uncertainty in the financial markets. Dr. Miller's study is a good place to start, as it explicitly puts cat model uncertainty on a par with corporate bond default rate volatility. Also, the place of cat risk within the enterprise-wide spectrum of risk needs to be appreciated.

Insureds (homeowners and business owners) and other interested parties who do not routinely see cat model results need to understand that there is a considerable amount of uncertainty and that no one knows precisely how much risk is present in a given situation.

Brokers, finally, need to stay out in front to facilitate education, communication and fair dealing.

CONCLUSION

Uncertainty permeates the catastrophe modeling enterprise. When a cat model says "Your 100 year return period loss is $1,117,243,572," what it really means is that your 100 year return period loss is about a billion dollars, but it could be 600 million dollars or maybe two billion dollars...or something like that.

While models have considerable uncertainty associated with them (even under a multi-model approach), they are still valuable tools. Model outputs must be assessed against this background of uncertainty, however, and blind reliance on model output should become a historical footnote. Portfolio management needs to understand the details of model uncertainties, and board level risk assessment needs a rigorous ERM framework for guidance.

All the players in the property-casualty (re)insurance industry need to understand, discuss and act upon the reality of cat model uncertainty – as well as the certainty of continued changes to the models themselves. Until these models can measure risk with perfect precision – a Utopian ideal unlikely to be achieved – they will continue to evolve and at least bring it into clearer focus.

HOW GUY CARPENTER CAN HELP

Clearly, there are large changes occurring in major cat models – and clearly, these changes are going to continue to occur on a regular basis. To keep up with the implications of change takes a dedicated fulltime staff, not just to ensure rational use of models, but to stay abreast of all the possible knock-on effects, for example, primary pricing, reinsurance pricing or interaction with regulators/rating agencies.

Guy Carpenter is committed to offering industry-leading analytical and advisory services to our clients based on superior analytical skills, theoretical understanding and practical know how. Our dedicated professional staff works daily with multiple cat models and modeling firms as well as Guy Carpenter's own proprietary cat models and analysis tools. In fact, we have more experience running models than many of the modeling firms themselves.

Guy Carpenter advises clients to consider a multi-model approach. In particular, we can show our clients how to combine the results from multiple models in a scientifically credible fashion, taking into account the individual characteristics of the client's portfolio of exposures and historical loss experience. Additionally, we can advise clients about the relative strengths and weaknesses of models in their various aspects, for example, perils or geography, and how "model blending" can combine the best from multiple models.

In particular, Guy Carpenter provides significant access to, and frequent technical discussions with, cat model vendors. Since the release of the RMS model version 11 in early 2011, Guy Carpenter has performed extensive analyses to help clients understand the impact of model changes on their portfolios.

MetaRisk®

In today's challenging environment, your ability to clearly see an evolving landscape, assess options and make proactive risk and capital management decisions will set you apart from competitors. Guy Carpenter's MetaRisk®, the industry's most transparent risk and capital decision tool, delivers unprecedented clarity. It gives you the power to see, understand and interact with the drivers of risk, so you can make business-critical decisions with confidence.

MetaRisk puts transparent and auditable information into your hands so you can validate your risk and capital management position with all of your constituents. MetaRisk provides a wide range of standard financial metrics as outputs so you can clearly understand the impact to your bottom line. Furthermore, its integrated, comprehensive capabilities can assist you in meeting the rigorous demands of ERM, Solvency II and other regulatory requirements.

MetaRisk is an ideal tool to implement model blending.

i-aXs®

Quickly and easily managing vast amounts of data is critical to your success. Guy Carpenter's i-aXs® provides a full suite of tools to help you translate your data instantly, allowing for faster and better informed decisions. Delivered via an easy-to-use homepage, the award-winning platform integrates sophisticated data analyses systems, cutting-edge spatial technology and satellite imagery. In a few quick keystrokes, you can view, graph and map your data. i-aXs enables you to assess one portfolio, combine multiple portfolios or drill down into the data to individual locations. And with access via the Web 24 hours a day, seven days a week, your data can support you whenever, wherever you want. With the latest technology and a unique set of tools, i-aXs offers unprecedented features.

Portfolio management, as applied to exposure to loss from natural and man-made catastrophes, is a mission-critical pillar in an ERM framework. In addition to managing and controlling catastrophe losses and producing stable results over time, adequate pricing for property exposures (including cat and non-cat losses, plus the cost of reinsurance, expenses and capital) plays a key role in demonstrating a firm's risk management acumen and strategy.

Guy Carpenter's portfolio management tools – Policy Ranking, Gradient and Reinsurance Cost Allocation – can operate on modified or blended model results. A Guy Carpenter team can show you how to combine the power of MetaRisk and i-aXs tools into a robust portfolio management strategy.

FOR MORE INFORMATION, PLEASE CONTACT:

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About Guy Carpenter

Guy Carpenter & Company, LLC is the world's leading risk and reinsurance specialist and a member of the Marsh & McLennan Companies. With over 50 offices worldwide, Guy Carpenter creates and executes reinsurance solutions and delivers capital market solutions* for clients across the globe. The firm's full breadth of services includes line of business expertise in Agriculture; Aviation; Casualty Clash; Construction and Engineering; Excess and Umbrella; Life, Accident and Health; Marine and Energy; Medical Professional Liability; Political Risk and Trade Credit; Professional Liability; Property; Retrocessional Reinsurance; Surety; Terrorism and Workers Compensation. GC Fac® is Guy Carpenter's dedicated global facultative reinsurance unit that provides placement strategies, timely market access and centralized management of facultative reinsurance solutions. In addition, GC Analytics℠ utilizes industry-leading quantitative skills and modeling tools that optimize the reinsurance decision-making process and help make the firm's clients more successful. Guy Carpenter's website address is www.guycarp.com.

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