KAREN CLARK & COMPANY

Near Term Hurricane Models

Performance Update

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Introduction

A year ago, Karen Clark & Company released a report titled "Near Term Hurricane Models – How Have They Performed?" [1] The purpose of that report and this update is to make more transparent to model users how actual results have compared to the model projections. It is essential that users of catastrophe models understand the key assumptions that are driving the projections that come out of "the black box." It is equally important to periodically compare actual results against predicted results to test model credibility. In this report we will also comment on the Hurricane Frequency Paradox – is Atlantic hurricane frequency trending upwards or are we becoming better at detecting storms?

The 2009 Season

The 2009 hurricane season was a relatively quiet one by historical standards, with the number of named storms, hurricanes and major hurricanes all below the long term averages. One has to go back to 1997 to find a season with a frequency as low as 2009. There were only three Atlantic hurricanes in 2009 – the long term historical seasonal average is 5.9 hurricanes.

Of the nine named storms recorded during the season, only two storms, Claudette and Ida, reached the U.S., and both were tropical storms at the time of landfall. No hurricanes reached the U.S. mainland. As a result, U.S. insured property losses associated with the hurricane season were minimal.

According to NOAA, the reduced Atlantic storm activity in 2009 *"was expected and reflects the development of El Nino during the summer. El Nino produced strong wind shear across the Caribbean Sea and western tropical Atlantic, which resulted in fewer and shorter-lived storms compared to some recent very active seasons."* [2] NOAA did not initially expect an El Nino event for 2009, adding that forecasts of such events *"generally have limited skill during the spring and early summer."* [3] By June, a moderate El Nino event had developed, resulting in a reduction of NOAA's forecast from a "near-normal" hurricane season to a "near-normal or below normal" hurricane season.

In contrast to NOAA's forecasts for a normal to below normal hurricane season, the near term models produced by each of the three major catastrophe modeling firms still projected hurricane losses well above the long-term average.

The Track Record of the Near Term Models

Each of the three major modeling companies – AIR Worldwide (AIR), EQECAT, and Risk Management Solutions (RMS) – introduced near term hurricane models in 2006. The new models, based on short term assessments of the frequency of hurricanes, were intended to be reflective of expectations for the five year period 2006 - 2010. Each of the near term models initially projected Atlantic tropical cyclone loss levels at least 35% above the long term average for the five year period.

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[1] Karen Clark & Company, "Near Term Models – How Have They Performed," December 2008, http://www.karenclarkandco.com/pdf/KCC_NearTermHurricanes.pdf

[2] National Oceanic and Atmospheric Administration, "Slow Atlantic Hurricane Season Comes to a Close," November 30, 2009, http://www.noaanews.noaa.gov/stories2009/20091130_endhurricaneseason.html

[3] National Oceanic and Atmospheric Administration, "NOAA: 2009 Atlantic Hurricane Season Outlook," May 21, 2009, http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane2009/May/hurricane.shtml

In 2007, AIR modified its near term model, reducing its increases in risk relative to the long term model to about 16%. In 2009, RMS introduced a modification to its near term model following its annual elicitation of expert opinions. While this resulted in a reduction in RMS' near term model loss estimates, the model still implied a level of loss activity 25% above the long term historical average. EQECAT has made relatively minor adjustments to its near term model estimates since its introduction in 2006.

The three tables below compare actual results to the implied projections from each of the three models since the introduction of the near term models. As shown in Tables 1 and 2, the last four years of Atlantic hurricane frequency have been a mixed bag compared to the long term averages. In terms of storm frequency, 2006 and 2007 can be characterized as average years, 2008 can be characterized as an above average year, and 2009 can be characterized as a below average year. For the four year period, the aggregate number of hurricanes was below the long term average, and well below the elevated level of activity implied by the near term models.

Table 1: **Number of Atlantic Hurricanes**

			Near Term Predictions		
	Long-Term Average	Actual	AIR	EQECAT	RMS
2006	5.9	5	8.4	8.0	8.4
2007	5.9	6	6.8	8.0	8.4
2008	5.9	8	6.8	8.1	8.4
2009	5.9	3	6.8	8.1	7.6
Total	23.6	22	28.8	32.2	32.8

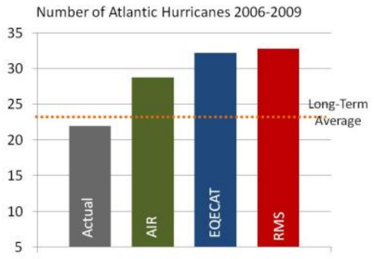


Table 2: **Number of U.S. Landfalling Hurricanes**

			Near Term Predictions		
	Long-Term Average	Actual	AIR	EQECAT	RMS
2006	1.7	0	2.4	2.3	2.4
2007	1.7	1	2.0	2.3	2.4
2008	1.7	3	2.0	2.3	2.4
2009	1.7	0	2.0	2.3	2.2
Total	6.8	4	8.4	9.2	9.4

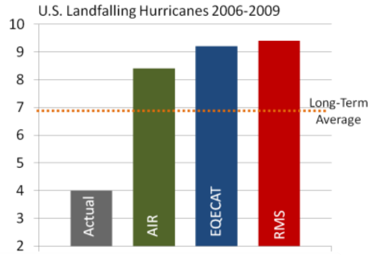
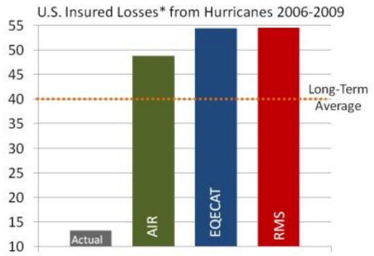


Table 3: **U.S. Insured Losses from Hurricanes ($ Billions)**

			Near Term Predictions		
	Long-Term Average	Actual	AIR	EQECAT	RMS
2006	10	0	14.0	13.6	14.0
2007	10	0	11.6	13.5	14.0
2008	10	13.3	11.6	13.7	14.0
2009	10	0	11.6	13.7	12.6
Total	40	13.3	48.8	54.5	54.6



What is very clear from Table 3 is that, contrary to the near term model predictions, insured losses have been well below average. Insured losses in the United States from Atlantic tropical cyclones were negligible in 2009, for the third time in the last four years.

Implications for Model Users

Four years into the five year projection period, the near term models have not performed well as predictive tools. Hurricane activity changes markedly from year to year, and the active hurricane seasons of 2004 and 2005 have not proven to be harbingers of a continuing trend for 2006 through 2009. The frequency of Atlantic tropical cyclones causing significant loss in the U.S. has in fact been below average for the period at hand, even for those years where the number of observed storms was at or above average. An article published by Drs. Dailey and Zuba of AIR in 2007 concluded that even if tropical storm frequency could be projected to be at an elevated level, *"that does not necessarily translate to either more hurricanes or more hurricane landfalls."* The authors went on to state, "*To the degree that predictions are necessary, the long-term historical record is an essential part of the process. Not only does it provide more data upon which to base an analysis, but it also provides more perspective as to the true nature of a climate system that is, above all, extremely complex."*[4]

Hurricane activity is very difficult to project because the earth's atmosphere is very complex and has many feedback mechanisms. As an illustration, a warming atmosphere can be expected to result in increased surface sea temperatures (SSTs), increased tropical wind shear, and increased water vapor cloud processes. Increased SSTs are generally expected to result in the formation of more hurricanes, while increased tropical wind shear is generally expected to result in the formation of fewer hurricanes. Increased water vapor in the atmosphere is generally expected to result in more rainstorm formation, leading to lower SSTs and the formation of fewer hurricanes. With such interrelated and contradictory forces, even the most sophisticated climate models cannot capture precisely every variable and physical process in the atmosphere.

Given all of the uncertainties, near term projections do not have sufficient credibility to be used for important insurance applications such as product pricing and establishing solvency standards.
In the case of pricing catastrophe exposure, the insurer or reinsurer is faced with the challenge of settling on a specific price for a specified time period for an exposure that has a highly uncertain expected value. While the near term models might be a useful tool for adding insight with respect to the potential range of expected outcomes for the upcoming policy period, the actual results of the last four years indicate that relying exclusively on the near term models to determine a rate can bring an extra level of instability and volatility to an already challenging pricing exercise. Individual insurers and reinsurers should instead consider the complete range and likelihood of possible outcomes in determining product pricing, taking into account the need for both stability and responsiveness in setting a strategy for pricing their products.

In the case of managing solvency margins, the considerations are similar, as finding the right blend of stability and responsiveness is important. Solvency margins are frequently determined in terms of return periods, e.g. the ability to withstand an estimated 100-year event. The return periods are determined by analyzing the long term occurrence of events, and then statistically extrapolating to estimate results beyond the period of observation. It should be recognized that the long term models and their implied range of loss scenarios already reflect time periods of higher and lower surface sea temperatures. Even if one accepts the premise that current atmospheric conditions might indicate a greater short term

[4] Dailey, Peter S, and Gerhard Zuba, "Examining U.S. Hurricane Landfall Probability," October 10, 2007, http://www.air-worldwide.com/PublicationsItem.aspx?id=14550

expected value of annual hurricane losses, that premise does not necessarily mean that the measure of the 100-year return period should change at all.

Alternatively, solvency margins can be determined in terms of a probability of ruin in a given time period. It is important to note that the estimated probability of ruin is a function of the context in which the probability is estimated. Using a simplistic example, the probability of ruin from a Florida hurricane occurring in the month of January is obviously significantly less than the probability of ruin from a Florida hurricane occurring in the month of September. No rational insurer would suggest that it should carry significantly less capital in January than it does in September, and likewise no rational regulator would require a company to carry significantly more capital in September than in January. The result in either case would be chaos in the capital markets supporting the insurance industry. Yet, the use of the near term models to determine solvency margins can change the context in which the probability of ruin is estimated. A company which has been managing its capital base to withstand a 100-year event as determined through the long term catastrophe models may, if forced to rely solely on the near term catastrophe models for determining its solvency margins, suddenly find itself forced to enhance its capital base to withstand what had previously been estimated as a 150-year to 250-year event. It is one thing to propose that current atmospheric conditions make the occurrence of the 100-year event more probable in the near term; it is quite another thing to then require a higher margin of protection to withstand such an event.

Insurers and regulators should consider a more stable and robust approach for establishing solvency margin requirements in the context of catastrophe exposure. A stable set of catastrophic loss scenarios could be identified and set as the basis for evaluating the company's potential losses at a given point in time. The stable set of scenarios should be relevant to the insurer's geographic operations, and should reflect a severity of events consistent with the insurer's target return period for measuring its solvency requirements. This approach has the advantage of being more transparent and more robust than the current PML-driven approaches used by most insurers and regulators for determining solvency margins.

The Hurricane Frequency Paradox: Mystery Solved?

There has been significant debate in the scientific community over whether Atlantic tropical cyclone frequency is trending upwards or if we are just detecting more storms over time.

Some scientists have suggested that we are experiencing an increase in Atlantic tropical cyclone activity, based on a trend in tropical cyclone counts from data going back to the late 19^{th} century. See Figure 1.

Paradoxically, the apparent increase in Atlantic tropical cyclone activity has not resulted in an increase in hurricane landfalls in the United States, as shown in Figure 2. This is the Hurricane Frequency Paradox. If we are in fact experiencing more Atlantic storms, then over the past four decades the percentage of storms making landfall has declined to about 60%, compared to an average of about 75% prior to 1965. Why would this happen?

Figure 1: Trends in Atlantic Basin Tropical Cyclone Storm Counts[5]

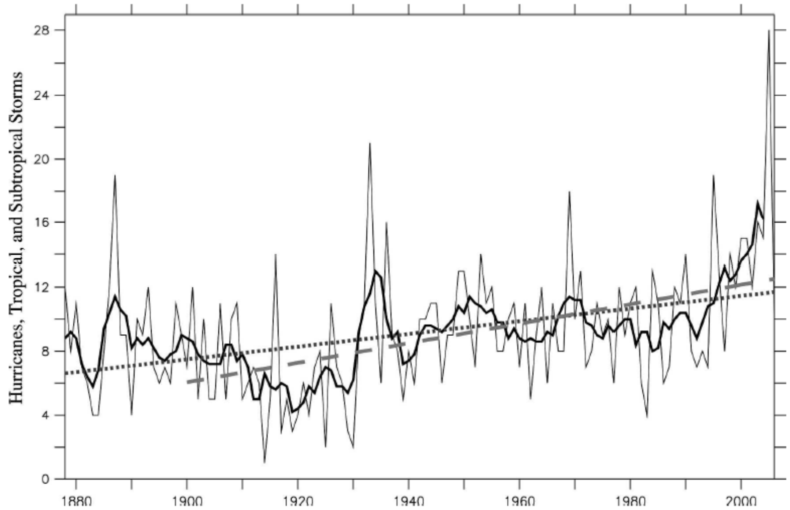
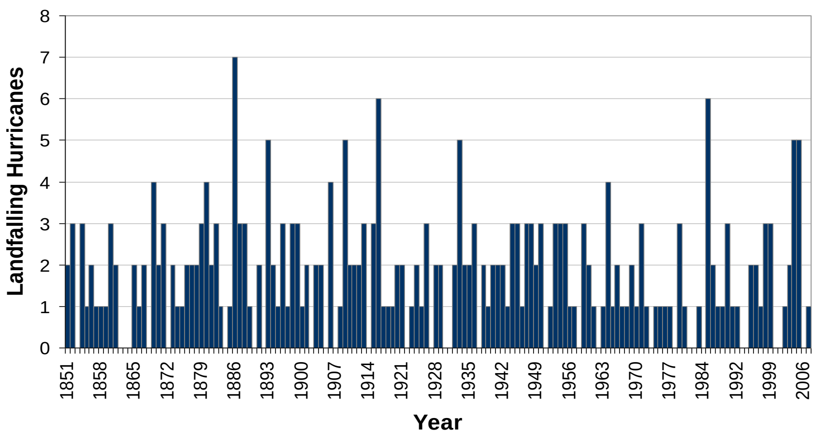


FIG. 1. Time series of unadjusted HURDAT Atlantic basin TC counts over the period 1878–2006. Black line shows the annual count of tropical and subtropical storms, and hurricanes in the HURDAT database. Dashed lines indicate the linear least squares trends computed over the periods 1878–2006 and 1900–2006.

Figure 2: United States Hurricane Landfalls by Year[6]



Scientists at NOAA have now concluded that the increase in annual storm frequency is in large part attributable to improvements in observational technology leading to the increased detection of tropical storms. This is particularly true for short duration storms originating in the Eastern Atlantic, far removed from potential landfall. Prior to the introduction of satellite technology, such storms were dependent upon oceangoing ships for detection.

Figure 3 shows that the occurrence of short-lived storms (durations of two days or less) has been increasing dramatically over time. Figure 4 shows that for moderate to long-lived systems (durations in excess of two days), there has been minimal increase in frequency. If one then makes an estimate of the number of storms prior to 1970 that were not detected due to limitations in detection technology, there appears to be a nominal decreasing trend in storm frequency, as shown in Figure 5.[7]

[5] Vecchi, Gabriel A. and Thomas R. Knutson, "On Estimates of Historical North Atlantic Tropical Cyclone Activity," *Journal of Climate*, 21, 3580 - 3600

[6] Blake, E.S., E.N. Rappaport, C.W. Landsea, "The Deadliest, Costliest and Most Intense United States Tropical Cyclones from 1851 to 2006 (and Other Frequently Requested Hurricane Facts)," NOAA, Technical Memorandum NWS-TPC-5, 43 pp, and National Hurricane Center Tropical Cyclone Reports. Updated to 2007 by Karen Clark & Company.

[7] Landsea, Christopher W., Gabriel A. Vecchi, Lennart Bengtsson, Thomas R. Knutson, "Impact of Duration Thresholds on Atlantic Tropical Cyclone Counts," *Journal of Climate,* http://ftp.nhc.noaa.gov/users/landsea/landsea-etal-final-jclimate.pdf

Figure 3: Short Duration Storm Frequency[8]

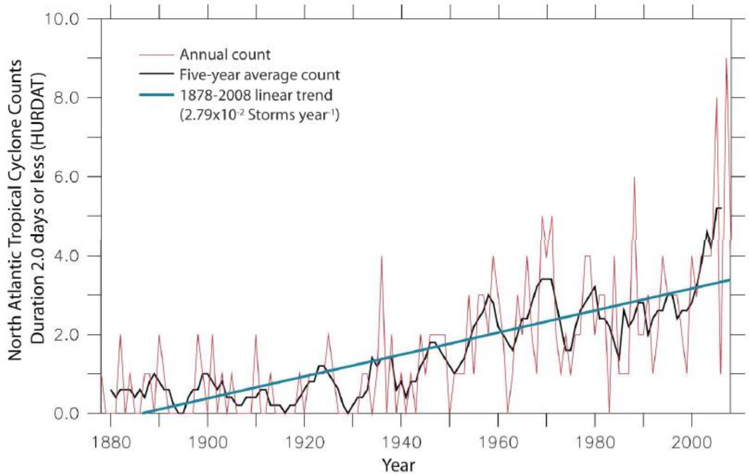


Figure 4: Moderate to Long-Lived Storm Frequency[9]

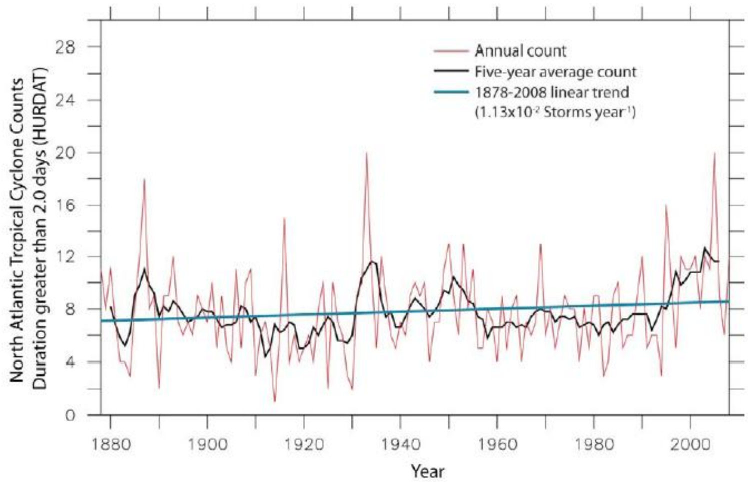
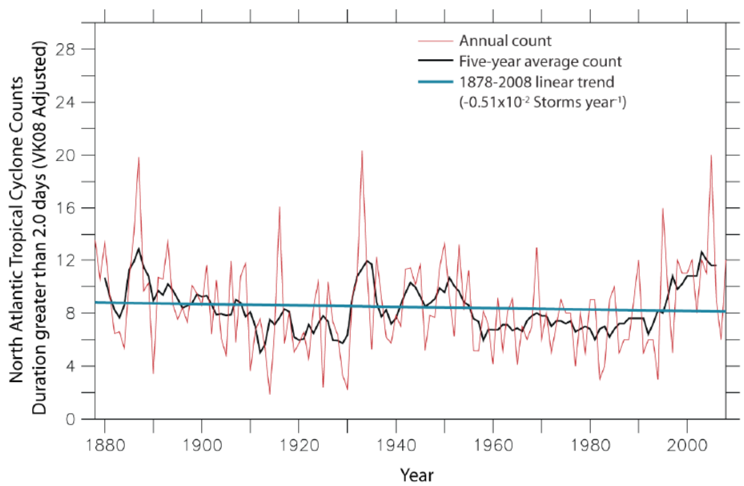


Figure 5: Adjusted Long Duration Storm Frequency[10]



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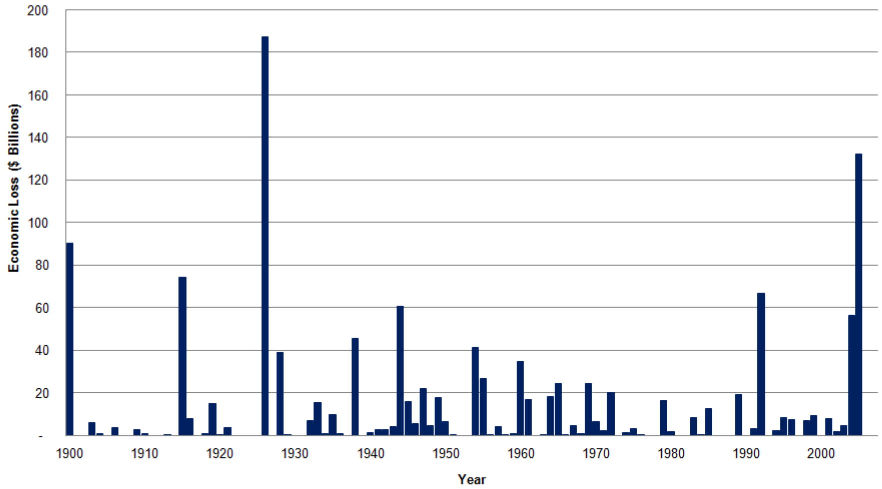
[8] Ibid.
[9] Ibid.
[10] Ibid.

Neither is there a trend in hurricane losses when historical losses are normalized to current exposure values. Figure 6 summarizes the findings of Pielke, et al.

Figure 6: Normalized Hurricane Damage in the United States[11]



All of the foregoing demonstrates that there is no clear basis for concluding that we are currently in a period where losses associated with hurricanes should be expected to be well above the long term average.

Conclusions

We are now four years into the application of the near term hurricane models, and actual insured loss experience has been well below the level of the model predictions. Three of the past four years have had minimal insured property loss from the Atlantic tropical cyclones, well below both the long term average and the (much higher) near term projections. It is becoming clear that a five year period is simply too short a time horizon for hurricane loss estimation.

It is important for model users to keep in mind what catastrophe models can and cannot do. Catastrophe models are powerful, broad-based tools that are very good at:

- Providing a framework for tying together the principal components of catastrophe risk: hazard, engineering, and exposure
- Providing numerous scenarios that produce estimates of losses from different types of events
- Determining approximate estimates of losses associated with events of different magnitudes
- Providing a general indication of relative risk

[11] Methodology based on Pielke, Jr., Roger A., Joel Gratz, Christopher W. Landsea, Douglas Collins, Mark A. Saunders, and Rade Musulin," Normalized Hurricane Damages in the United States: 1900-2005," *Natural Hazards Review*, Vol. 9, No. 1, February 1, 2008, 29-42. Karen Clark & Company updated economic loss estimates through 2007.

Despite the illusion of precision, catastrophe models are characterized by high degrees of uncertainty, and thus cannot:

- Produce accurate point estimates of improbable events, such as the 1 in 100-year loss
- Produce credible, robust estimates of losses at specific locations
- Predict near term catastrophic losses

Catastrophe models are typically used by insurers and reinsurers both for determining the price of their products and determining their solvency margins. In both of these exercises, model users must recognize that there can be a very wide range of estimates associated with a given model metric, such as average annual loss. Model users should be "thinking outside the black box" and focusing more on understanding the range of estimates for a given metric, and the factors that can influence the outcomes in those ranges, rather than automatically relying on one or two highly uncertain point estimates from the models. This will facilitate more transparent and robust catastrophe risk management decision making.

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