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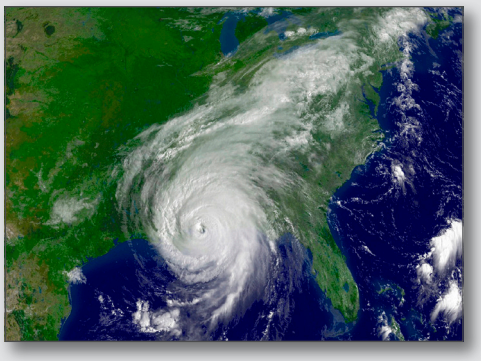

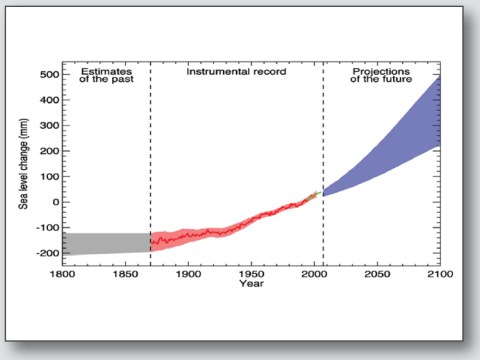

Climate Change and Hurricane Loss: Perspectives for Investors

By Karen Clark and John Lummis

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2 COPLEY PLACE • BOSTON, MA 02116 • T: 617.423.2800 • F: 617.423.2808

The Big Picture

Climate change gets a lot of attention: warmer temperatures, melting icecaps, rising oceans. What doesn't get as much attention is whether — or when — these trends will impact catastrophe reinsurance contracts and related securities. Will hurricanes be more frequent? Will they be more severe? Or both? Will insurance losses be greater?

Has the changing climate reached a tipping point? Should investors in the Cat Market continue to invest?

This paper provides some needed context for investors. We provide evidence that despite the pervasive buzz in the media, despite the documentary films, despite even the high-profile hit on New York, climate change has had no measurable effect on the North Atlantic hurricanes that drive Cat Market losses. Loss levels have gone up over time primarily due to increases in the value of building stock standing in the way of hurricanes. These are the conclusions of the most recent report of the Intergovernmental Panel on Climate Change.

It is important to note that investors and climatologists operate under very different time horizons. Investors tend to consider recent asset class performance, then look ahead, say, three to five years, or even less. Climatologists, on the other hand, look back over the previous century and ahead to the next. Climate change is detectable over decades. So while the climate is certainly changing, a meaningful difference in the frequency and severity of hurricanes will not be perceptible anytime soon.

In short, the loss potential of the Cat Market is pretty much the same this year as it was last year and five years ago, the same as it will be next year and five years from now after adjusting for increases in insured property values.

Our explanation takes a three-part approach. First, we examine more than 100 years of historical hurricane data to provide some basic perspective on the frequency and severity of insurance loss. Second, we look at the considerable challenges of predicting hurricanes in the short term. We see that it is, at best, an inexact science. Finally, for investors interested in the Cat Market over the next several decades, we look at the long-term outlook. Based on current trends, the global climate models are predicting a somewhat different hurricane profile by the end of the century. Will they prove accurate? We will probably not know for another 50-60 years.

Please note: While the relevant time horizon for investors may be only a few years, the time horizon for policymakers and others may be — and should be — considerably longer. Also, the climate is changing. How much of that change is caused by human actions is an important issue, but one that is beyond the scope of this paper.

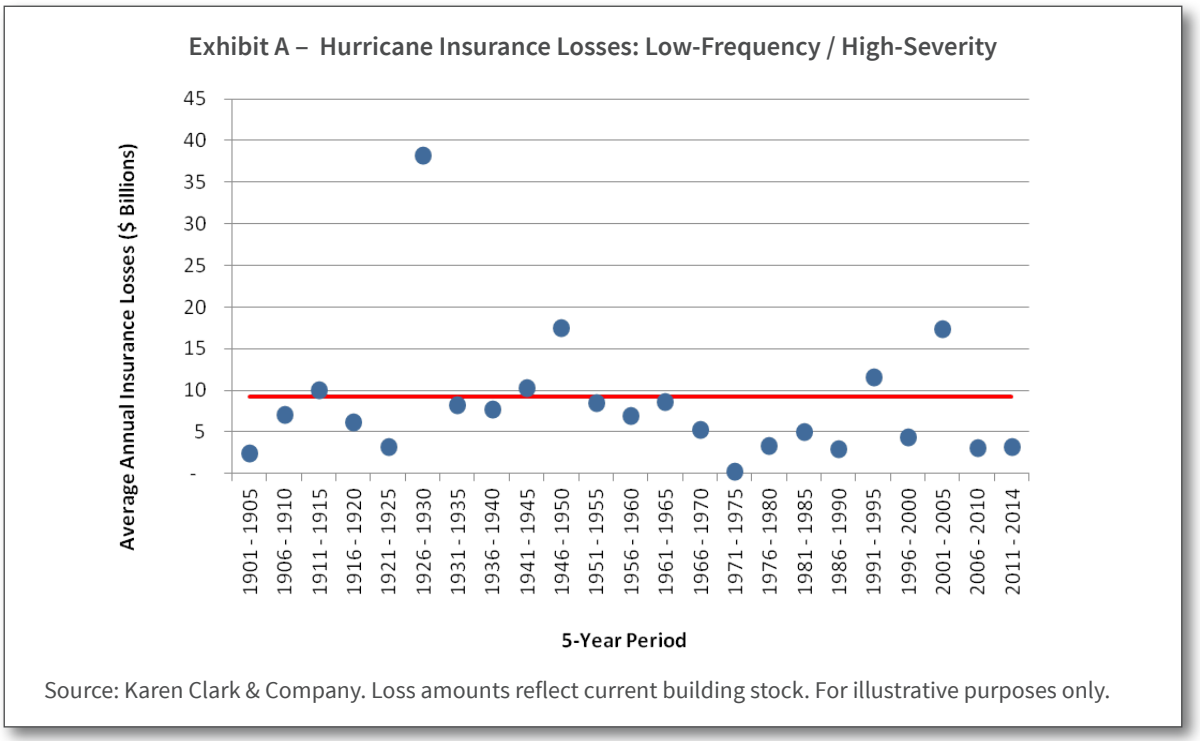
1. Hurricane Losses Since 1901

Hurricane scientists are fortunate to have more than a century of data on the frequency and severity of North Atlantic hurricanes. On average, six hurricanes form each year. Most peter out before making landfall, have wind speeds that are not widely destructive, or make landfall in areas with limited insured building stock. Significant insured losses occur when a severe storm strikes a highly populated area, which is a relatively infrequent occurrence.

The chart below shows the estimated losses that historical hurricanes would cause today, based on the current building stock, and groups them into five-year periods, averaging annual losses over those five years. The use of a five-year averaging window is somewhat arbitrary, representing the time horizon over which an investor might seek to have an allocation to this sector.

This much is clear: only a few five-year periods have losses significantly above the average of about $10 billion per year. The losses for two of these periods resulted from a major event impacting a highly populated area — the 1926 Great Miami Hurricane and Hurricane Katrina in 2005. Long-run averages are weighted to the tail events, and therefore above-average losses are driven primarily by severity, not frequency. Over any five-year period, investors have a very good chance of experiencing only limited losses.

There is nothing in the current scientific literature to indicate that this basic low-frequency/high-severity profile of hurricane risk will change. Catastrophe simulation models, used in assessing the risk levels associated with reinsurance, reflect this basic profile. Used prudently, these models are useful tools for understanding loss potential and constructing a well-diversified portfolio.



Source: Karen Clark & Company. Loss amounts reflect current building stock. For illustrative purposes only.

2. The Limited Success of Short-term Predictions

The climate is warming. And the basic physics of hurricanes indicates that higher sea temperatures generate more energy in the atmosphere and thus more powerful hurricanes, everything else held equal. Much is affecting hurricanes beyond sea temperatures though, and especially in the short term. The development of a hurricane depends on how unstable the atmosphere is, for example. That includes the so-called vertical wind shear, which essentially measures how different the winds are at high altitude versus the surface. On time scales of one to several seasons, various elements may come into play:

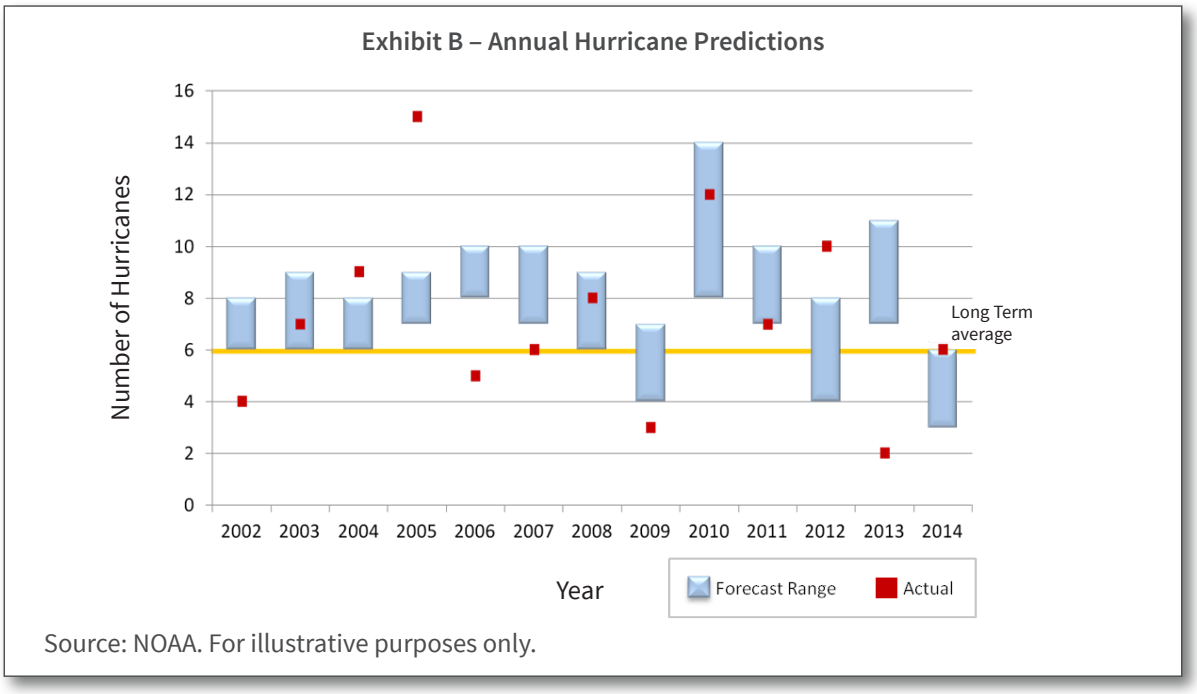
- For instance, the *Atlantic Multi-Decadal Oscillation (AMO)*, which measures the natural variability in sea surface temperature (and salinity) of the North Atlantic, is thought of as a decadal regulating valve for Atlantic storm frequency.
- The *El Niño Southern Oscillation (ENSO)* measures cyclical temperature anomalies in the Pacific Ocean off South America. ENSO significantly impacts hurricane frequency in the Atlantic, yet its state cannot be confidently predicted beyond a few months.
- The *North Atlantic Oscillation (NAO)* is a fluctuation in pressure differences between the Icelandic and Azores regions. The NAO affects the westerly winds in the Atlantic, which may influence where storms are more likely to track.
- *Other factors* seem to affect hurricane development, including the Saharan Air Layer (SAL) and the strength of the African Jet Stream.

The interaction of these factors, as well as the inherent complexity of weather systems, makes short-term predictions of hurricane frequency and severity extremely difficult. Every year, organizations, including the National Oceanic and Atmospheric Administration (NOAA), produce North Atlantic tropical storm forecasts but with limited success. The 2013 hurricane season is a case in point. All forecasts were for an above-average number of storms, particularly major storms. As it turned out, only two hurricanes formed, and neither was major. By contrast, the forecasts for 2014 were closer to the mark. Exhibit B shows NOAA's forecast range versus actual numbers of hurricanes since 2002.

The early 2000s included three hurricanes with at least $10 billion in insurance losses, most prominently Hurricane Katrina. In 2006, as a reaction, hurricane modelers became concerned that frequency was increasing as a function of warmer sea surface temperatures, and changed the models to weight this recent frequency more heavily. All leading models projected greater than 20% increase for the years 2006 to 2010. Actual activity was well below average for both land-falling hurricanes and insured losses.

Many practitioners now question the merits of short-term models given the many complexities, inherent uncertainties and marginal track record. Instead, they rely more heavily on the full range of longer-term time series of event data, rather than weighting more heavily toward some recent short-term activity. Periods of low activity (more common) and periods of high activity (less common) each have a chance to occur over any time horizon.

As a final point it is important to see that, for insurance contracts, it is not storm forecasts generally, but landfall forecasts in particular, that are most relevant. Predicting landfalls is even more difficult, in part because there is even less data available and in part because of the variability in weather systems that influence storm tracks on a day-to-day basis.



Source: NOAA. For illustrative purposes only.

3. Long-Term Predictions: Lower Frequency, Greater Severity

In its influential 2013 report, the Intergovernmental Panel on Climate Change stated that over the course of the 21st century, "it is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged."

To the layperson, this prediction would appear counterintuitive given the widely accepted prediction of rising sea surface temperatures. However, various countervailing factors may be relevant, notably increased vertical wind shear, a greater difference in speed and direction between winds in the upper atmosphere and at the surface, a detrimental factor for storm development and intensification.

The report reaches a different conclusion regarding intensity: "Average tropical cyclone maximum wind speed is likely to increase, although increases may not occur in all ocean basins."

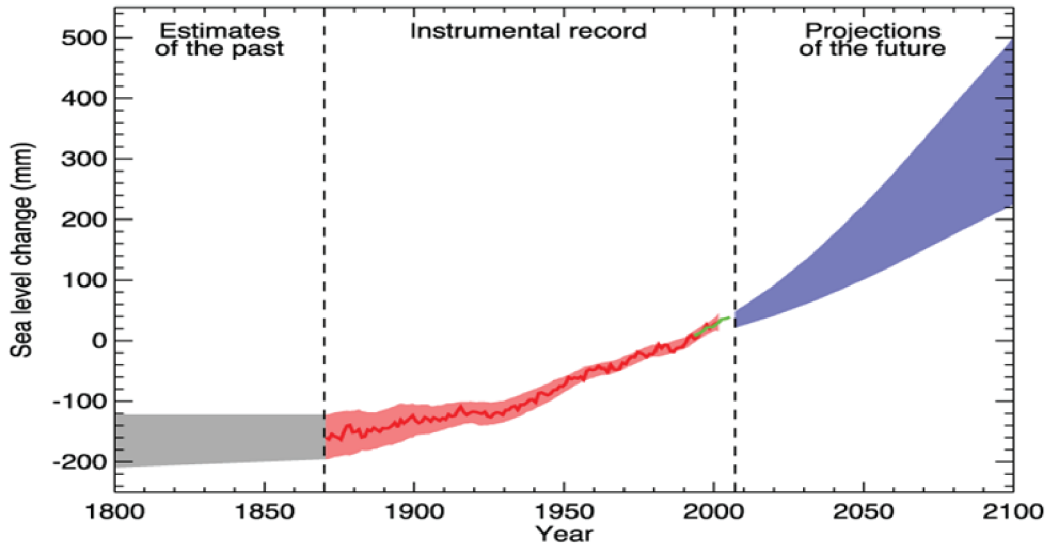
Specifically — by the end of the 21st century — hurricanes could be more intense with maximum wind speeds 2% to 11% higher than current averages. There will likely be an increase in the frequency of very intense hurricanes, the main driver of losses. The global climate models also project substantially higher rainfall rates. Assuming these changes carry over to the subclass of U.S. landfalls, insured losses will likely increase as a result, though the catastrophe models cannot say anything definitive, not surprisingly given the number of factors and time horizon.

To help estimate future insurance losses, we conducted sensitivity analyses for both increasing wind speeds and rising sea levels, for hurricanes in the Gulf and along the East Coast. Our result: a 2% increase in wind speed may lead to a nearly 15% increase in average losses, while an 11% increase may lead to an almost doubling of hurricane losses.

In addition to concerns about increased wind speeds, it is important to recognize the long-term trend of sea levels rising over the past century, and most projections are for sea levels to rise faster over the next 100 years. Properties closer to the water may be more vulnerable to storm surge flooding, as shown in Exhibit C.

Thus, we believe there should be real concern about climate change over longer-term time horizons (e.g., 20-30 years), where the impact of rising sea levels and increased wind speeds, compounded by increases in hurricane-exposed building stock, can be expected to generate increasing economic losses.

Exhibit C – Long-Term Rise in Sea Levels May Significantly Increase Loss



Source: Intergovernmental Panel on Climate Change (IPCC); Climate Change 2007: Working Group I: The Physical Science Basis; http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-5-1.html

Conclusion

Some Cat Market investors are concerned about the apparent increase in frequency and severity of North Atlantic hurricanes. This concern may be best explained by the dramatic increase in media coverage of severe weather events. However, the data show that recent hurricane activity — no matter how one chooses to define "recent" — has been well within the pattern observed over more than 100 years, normalizing for growth in the value of building stock.

The world is warming, and warmer temperatures are a factor in hurricane formation and intensity. Yet, over the short-term (one-to-five year) time horizon relevant to most investors, multiple other factors appear to be more important. Unfortunately, accurate predictions based on these factors are very difficult. In any case, the severe hurricanes that drive insurance losses remain a rare occurrence. We believe that, in the hands of skilled professionals, the catastrophe simulation models are very useful tools to assess the risk profile and, in general, they sensibly represent the risk profile looking out over the next five years.

For the long term, global climate models are currently predicting lower frequency and greater severity in overall tropical storm activity, though this may vary from ocean to ocean. Because of rising sea levels, storm surge may be a bigger factor in a shorter time frame. And increasing building stock in hurricane-prone areas will inevitably increase economic losses over time. We advise long-term investors to periodically reassess the risk-reward profile of the Cat Market against their investment criteria and goals — just as we would with any asset class. It appears likely that there will be increasing demand for catastrophe reinsurance over the long term.

Related Studies

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Karen Clark & Company
2 Copley Place
Boston, MA 02116
T: 617.423.2800
F: 617.423.2808

Info90410@karenclarkandco.com