CLIMATE AND HURRICANES

What

After the disastrous years of 2004 and 2005, everybody expected 2006 to be more of the same.

So what happened?

By David A. Lalonde

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Happened in 2006 ?

SINCE THEY WERE INTRODUCED almost 20 years ago, catastrophe models have all taken a similar approach: Large catalogs of potential future events are developed based on data from decades of past events. AIR's standard U.S. hurricane catalog, for example, uses information about the meteorological characteristics of historical Atlantic tropical cyclones since 1900—a period sufficiently long to include past decadal fluctuations in hurricane activity, shorter El Niños and La Niñas, and a range of other climate signals of varying duration. One significant advantage of this approach is stability in the catastrophe loss estimates and, hence, stability in insurance pricing.

After the two hurricane seasons of 2004 and 2005—seasons characterized by above-average hurricane activity and above-average losses—many in the industry challenged catastrophe models and called for change. The 2006 season, in which no hurricanes made landfall in the United States, spawned a host of additional questions. Our analysis indicates there is still too much uncertainty to support radical changes in the approach that has provided the industry with reliable results for almost 20 years.

Hurricanes in the North Atlantic

Of course, oceanic and atmospheric systems do not undergo radical change in the span of two years. Since 1995, tropical cyclone activity in the Atlantic basin has been elevated over the long-term, or climatological, average. Scientists at the National Oceanic and Atmospheric Administration (NOAA) have linked this above-average activity to elevated sea surface temperatures (SSTs), which are in turn linked to the positive, or warm, phase of a naturally occurring cycle that oscillates over decades: the Atlantic Multidecadal Oscillation, or AMO.

The consensus at NOAA is that the current warm phase is likely to continue "for years to come." Therefore, it might seem reasonable to assume that hurricane losses will be similarly elevated and that models should adjust accordingly. However, there are significant problems with this argument.

One is that within any given window—such as a near-term (five-year) time horizon—there are a number of climate signals other than the AMO that influence Atlantic hurricane activity and that may indeed dominate and even counter any influence of the AMO.

The second reason for circumspection is that the primary focus to date of scientific investigation into climatological influences on tropical cyclones has been on basinwide activity. Making the leap from increased hurricane activity in the Atlantic to increased landfall activity and, ultimately, to the effect on insured losses requires significant additional research.

In addition to the AMO, there are at least three other climate signals that seem to correlate with Atlantic hurricane activity. The periodicity of each of these signals is shown in Fig. 1.

Briefly, the AMO is a climate signal measuring the change in the SST (and salinity) of the North Atlantic. The AMO received particular attention in light of the 2004 and 2005 hurricane seasons and is thought by some to hold the key to recent elevated levels of hurricane activity. The problem with using the AMO as a predictor of near-term hurricane activity in the basin is that its periodicity is the least regular of the climate signals that have been associated with tropical cyclones. Thus, forecasts using the AMO are characterized by significant uncertainty.

The El Niño Southern Oscillation (ENSO) measures temperature anomalies in the Pacific Ocean off the coast of Peru. The effect of ENSO on hurricane activity stems from its impact on wind shear—which is generally destructive to hurricanes—over the tropical Atlantic. La Niña years are typically characterized by increased hurricane activity, while activity is lower in El Niño years.

The period of ENSO, however, is too irregular to make it very useful for forecasting hurricane activity over a five-year time horizon. During that period, the opposing effects of La Niña and El Niño could largely cancel each other out, or the ENSO signal could remain relatively neutral.

It's interesting to note that in their forecast issued in May 2006, NOAA scientists said explicitly that "neither El Niño nor La Niña

FIGURE 1: *Periodicity of Climate Signals Affecting Conditions in the Atlantic*

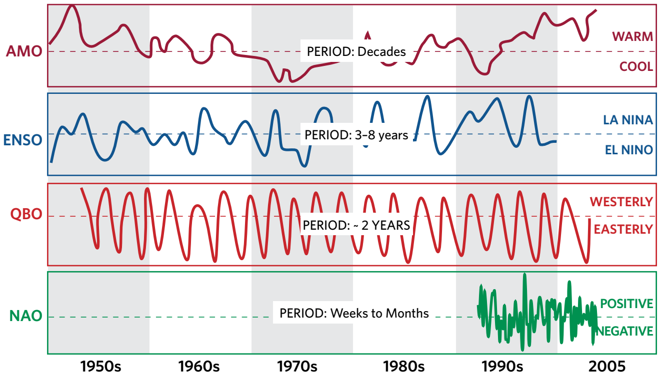


FIGURE 2: *Evolution of 2006 Hurricane Forecasts From Public and Private Forecast Organizations*

NOAA

	MAY	AUGUST
Named Storms	13–16	12–15
Hurricanes	8–10	7–9

Colorado State University

	APRIL	AUGUST	SEPTEMBER	OCTOBER
Named Storms	17	15	13	11
Hurricanes	9	7	5	6

WSI

	MAY	AUGUST	SEPTEMBER
Named Storms	15	14	13
Hurricanes	9	7	6

Tropical Storm Risk (TSR)

	APRIL	AUGUST	SEPTEMBER
Named Storms	15	16	13
Hurricanes	8	8	5

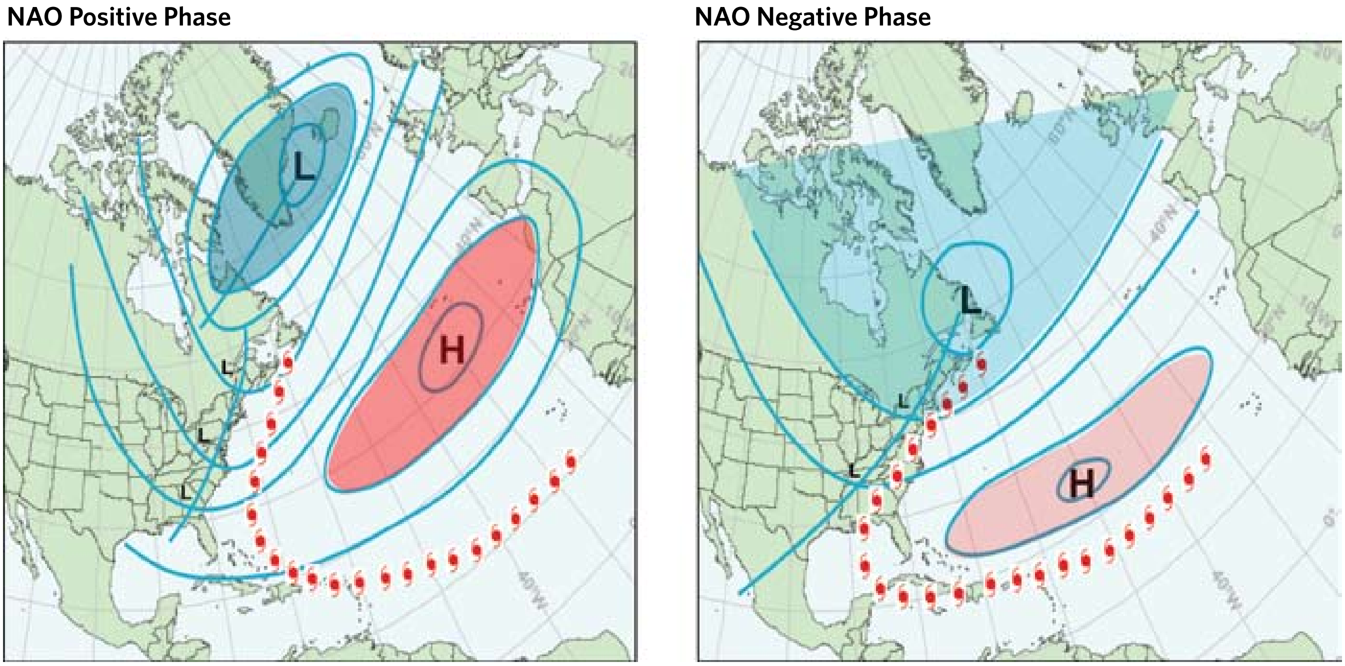
Catastrophe Modelers and the Larger Scientific Community

THE SCIENTIFIC CONSENSUS is that there is a link between currently elevated SSTs and basinwide tropical cyclone activity. Some scientists believe the elevated SSTS are driven by the naturally occurring AMO, a climate signal with an irregular periodicity that spans decades. Others believe that surface temperatures are elevated because of the accumulation of greenhouse gases and that the observed variability in SSTs is caused by episodic events, such as volcanic activity.

It's the job of scientists to investigate and posit theories to explain physical phenomena. Competing theories nourish scientific debate, but arriving at a consensus can be a long process. Until a consensus is reached, considerable uncertainty exists.

Catastrophe model users expect and pay for rigorous science from the modelers in at least equal measure to advanced technology. The most important job of catastrophe modelers is to keep abreast of the scientific literature, evaluate the latest research findings, and conduct original research of their own—to determine whether competing scientific approaches are credible and how much weight to assign to them.

Catastrophe modelers should not outsource the science that underlies their models. In the case of the relationship between elevated SSTs in the Atlantic and insured losses in the United States, investing in in-house scientific expertise is critical, in part because that particular link hasn't been the focus of investigation by the wider scientific community.



NAO Positive Phase

NAO Negative Phase

FIGURE 3: *The North Atlantic Oscillation (NAO) Impacts Hurricane Tracks*

likely will be a factor in [the 2006] hurricane season." By the end of the 2006 season, most scientists credited the onset of a mild El Niño for inhibiting storm formation in September and October. Fig.2 shows the evolution of hurricane forecasts for 2006, along with the season's ultimate outcome.

The Quasi-Biennial Oscillation (QBO) is a climate signal that tracks the direction of the equatorial winds in the stratosphere—currents that have been linked to hurricane formation. As Figure 1 shows, the periodicity of the QBO is the most regular. While the QBO is the easiest signal to forecast, however, it has the weakest correlation with hurricane activity.

Finally, air currents at a level a few kilometers above the ocean surface steer tropical storms. These currents respond to the distribution of atmospheric pressure. In particular, an area of high pressure in the mid-Atlantic known as the "Bermuda High"—closely related to the North American Oscillation (NAO)—tends to steer tropical storms to the west and eventually to the north. When the Bermuda High is in a more southwesterly position, hurricanes are more likely to make landfall than when the high is farther north and east, off the northern African Coast (Fig. 3).

Because the NAO has a significant impact on atmospheric steering currents and, therefore, hurricane tracks, it's theoretically a valuable metric for forecasting the geographical distribution of hurricane landfall locations. Indeed, the northeasterly position of the Bermuda High throughout much of the 2006 season was largely responsible for keeping storms well away from the U.S. coast.

The NAO varies in response to the atmospheric pressure distribution over the Atlantic, however, which changes on a very short time scale (weeks to months). Thus, the predictability of the NAO decays quickly, rendering it virtually useless for forecasting hurricane activity five years out.

Beyond these relatively large-scale influences on Atlantic hurricane activity, there are more localized influences. In research first published in the early 1990s, for example, Christopher Landsea and William Gray posited a link between West African rainfall and Atlantic hurricanes. More recently, the possible inhibiting effect of dust storms swirling off the Sahara has garnered considerable attention. Many scientists agreed with the judgment of Dr. Gray's team at Colorado State that "large amounts of African dust… greatly reduced August [2006] activity."

Basinwide Hurricanes and Insured Losses

If forecasting hurricane activity in the near term is fraught with uncertainty, translating that forecast into insured losses is even more so. NOAA scientists identify 1995 as the start of the current warm phase of the AMO and, as shown in Figure 4, tropical cyclone activity since 1995 has been elevated—an average of just above 15 named storms per year as compared with the long-run average of 11. But in the nine years before 2004, the number of hurricane landfalls was about average, and this nine-year stretch of above-average basinwide activity actually produced below-average losses, primarily as a result of where the storms made landfall.

The 2006 hurricane season—nine named storms, five hurricanes, and two major hurricanes (Saffir-Simpson Category 3 and above)—was actually slightly below average. Moreover, the 2006 season was far below average from an insurance perspective, with no hurricane landfalls in the United States.

It's widely reported that seven of the top 10 hurricane losses in the United States occurred in 2004 and 2005. While this may be true from an actual insured-loss perspective, it's a very misleading statistic since the number and value of properties have increased dramatically since 1900—well beyond general inflation rates.

AIR's U.S. hurricane model can be used to estimate the insured losses from each historical event were it to recur today

FIGURE 4: *Tropical Cyclone Activity in the Atlantic Basin*

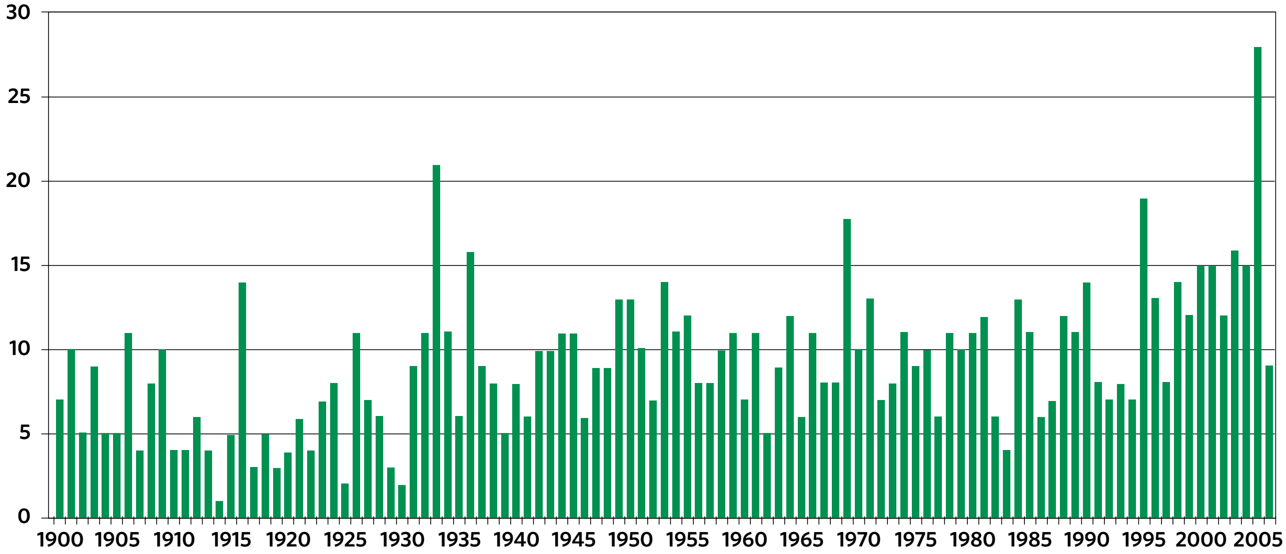
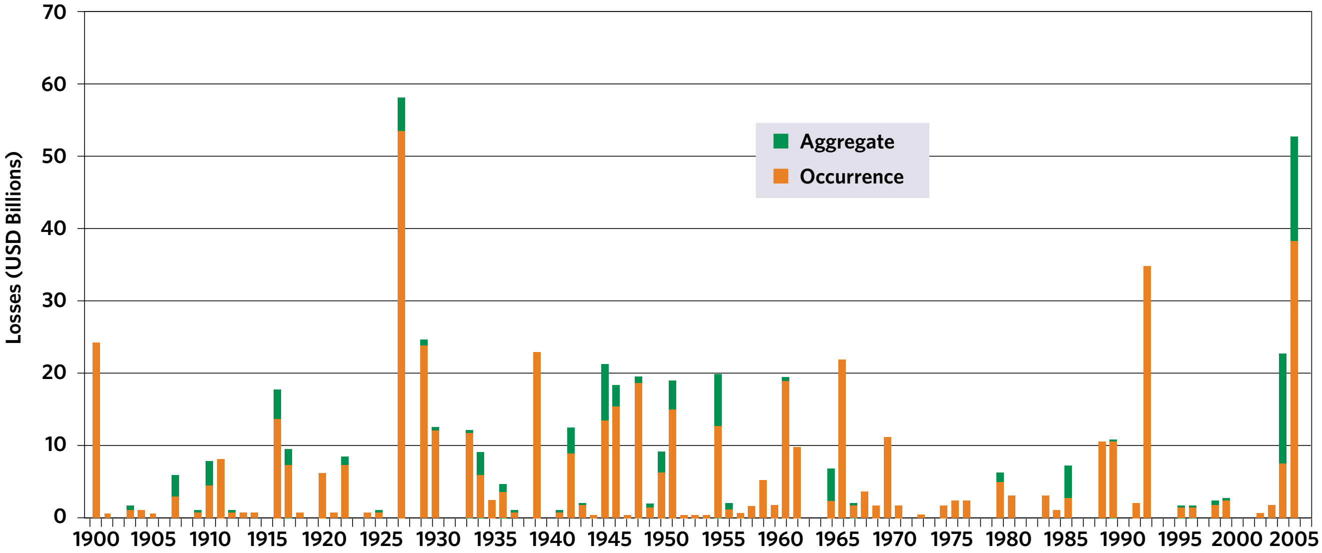


FIGURE 5: *Estimated Losses From Historical Storms Based on Current Numbers and Values of Exposed Properties*



using AIR's industry-property exposure database, which contains detailed information on more than 60 million residential and commercial properties. Fig. 5 shows that, based on current property exposures, the only 2004/2005 storm to crack the top 10 is Hurricane Katrina. It's also worth noting that, with the exception of Hurricane Katrina, the five costliest historical hurricanes have occurred in years with either average or below-normal activity. Hurricane Andrew, for example, occurred in a year (1992) that saw just seven named storms in the Atlantic.

The Near-term Sensitivity Catalog

While recognizing the challenges of forecasting insured losses for a near-term (five-year) time horizon based on data characterized by significant uncertainty, in 2005, AIR undertook an exhaustive review of the scientific literature and conducted an extensive internal analysis of the link between elevated SSTs in the Atlantic and landfall frequency and location (a research effort that is still ongoing).

The result, released in April 2006, indicated potentially increased hurricane risk for most regions of the U.S. Gulf and East coasts for the next five years—as much as 40 percent higher than the long-term average in some regions. The 95 percent confidence band around the mean increase was very wide, however, reflecting the considerable uncertainty inherent in the limited data. For seven of the 11 coastal regions defined for purposes of the analysis, the lower end of the 95 percent confidence band actually indicated that a decrease in frequency was also possible.

We at AIR released a near-term catalog that can be used to conduct sensitivity analyses or to fine-tune portfolio optimization strategies. We continue to believe, given the current state of the science, that the standard model based on over 100 years of historical data and over 20 years of research and development remains the most credible model.

The 2007 hurricane season is just three months away. While forecasts aren't yet available, data continue to confirm the importance of SST anomalies. But as discussed above, there are other variables whose forecast is too uncertain (e.g., ENSO, NAO) to determine whether 2007 will be an active season. ●

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INTERPRETING MODEL PROBABILITIES

Did the Models Get It Wrong in 2004 and 2005?

AFTER THE 2005 hurricane season, catastrophe models were taken to task by senior management at a number of reinsurance companies. Comments such as "the probabilities must be higher than we thought," and "I got whacked by two back-to-back 250 year events!" appeared in the press.

Catastrophe models, and catastrophe modelers at insurers and reinsurers, need to provide senior management with reliable information about the potential for large losses before they occur. Therefore, companies should be sure that the catastrophe models they use incorporate potential events that represent the likelihood of losses similar to and even exceeding those caused by Hurricane Katrina.

Long before Katrina, the AIR U.S. hurricane model had hundreds of loss scenarios larger than Katrina. In fact, in the pre-Katrina AIR hurricane loss distribution, a Katrina-size loss had about a 3 percent annual probability of exceedance. Even the probability of a $100 billion industry loss was within the range to which most companies manage their risk.

Although catastrophe modeling results are commonly discussed in terms of return periods, doing so can lead to misperceptions. The industry should instead think in terms of exceedance probabilities. If one says Katrina is a 30-year return period for the United States, then the tendency is to conclude that such a loss won't be experienced for another 30 years. However, a 3 percent exceedance probability indicates that there is a 3 percent chance that this size loss or greater could occur in any year. Using exceedance probabilities rather than return periods will help avoid the misleading notion that it's impossible to experience two low-probability losses in back-to-back years.

In addition, companies must look beyond a single loss level such as the 1 percent loss estimate. In fact, insurers should know their tail-value-at-risk (TVAR), their modeled TVAR-to-surplus ratios for various loss probabilities, and the regions and perils driving their large-loss scenarios.

FIGURE 6: *AIR Hurricane Loss Distribution Before Katrina and Representative Scenarios From the AIR Stochastic Catalog*