Catastrophe Modeling in an Environment of Climate Change

AIR Worldwide Corporation

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If you have any questions regarding this document, contact:

AIR Worldwide Corporation

131 Dartmouth Street

Boston, Massachusetts 02116

USA

Tel: (617) 267-6645

Fax: (617) 267-8284

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By Dr. Jayanta Guin, Senior Vice President, AIR Worldwide Corporation

Introduction

The Earth's climate is changing. Indeed the consensus today among most scientists is that "...warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[1] While there is uncertainty in the magnitude and rate at which warming will occur and debate continues over its precise causes, it is clear that the consequences of a warmer climate will have profound societal impacts worldwide.

Since the advent of catastrophe modeling, which is used to support risk management decision-making in general and insurance and reinsurance pricing in particular, the focus has been on assessing current and, more recently, "near term" risk. Modelers do this by leveraging the long-term historical record to perform tens of thousands of simulations of what may occur this or next year. Things become more complicated, however, if the current risk environment is distinctly different from what it has been historically.

Catastrophe models incorporate the frequency and severity characteristics of the modeled peril as of today's climate regime. Therefore, basic questions for the modeler to answer are: (1) does the historical record of the peril—the most dependable portion of which is generally 50 to 150 years long—have a signature that is clearly distinguishable from what we are experiencing today, and; (2) how is the signature going to change in the future if the earth continues to warm? To date,

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[1] Intergovernmental Panel on Climate Change. The complete IPCC Summary for Policymakers released in 2007 is available at http://www.ipcc.ch/.

however, the scientific community is still some way off from consensus on these questions. While there is general agreement that global temperatures are increasing, as yet no consensus exists on their impact on weather-related perils, such as tropical and extratropical cyclones, severe thunderstorms, and floods.

It is also important to distinguish between time scales: what is the influence of climate change on natural catastrophes today[2], and; what will be the nature of these perils fifty or a hundred years from now. This is obviously a nontrivial task. One of the many major challenges for the catastrophe modeler in deciphering the puzzle is how to interpret the historical data, which may be contaminated by underreporting, population biases and changes in the technology used in recording measurements.

The clear separation of time scales is important because it has profound implications for the practical application of catastrophe modeling results, the conclusions drawn and appropriate mitigation strategies to adopt. Should a homeowner's insurance premium reflect current hurricane risk in the Atlantic or what the risk will be in 2050? Few would argue the latter.

Making matters more complex, for each of the two time scales modelers need to understand not only the influence of climate on an individual peril, but also its impact on the correlation between perils. Thus questions like "Is severe thunderstorm activity over the US correlated with Atlantic hurricanes?" and "Are European extratropical cyclones correlated with Atlantic hurricanes?" and "Will climate change be manifested as an increased frequency and/or intensity of El Niño episodes, which are correlated with tropical cyclone activity in both the Atlantic and eastern Pacific, albeit in opposite directions?" become quite relevant to the discussion.

Although some recent studies suggest some degree of correlation between these perils, the limitations of the historical data and the current state of science make it

[2] Note that there are two views of the risk today: the risk as modeled using the historical record of the last 50-150 years and the risk (sometimes called "near term") as modeled using current sea-surface temperatures, which are elevated over the long-term historical average. The time scales referenced in this and the subsequent paragraph do not address this question, but rather treat these two views of the current risk as one, and materially different from the time scale on which the impacts of climate change are projected to be felt—i.e., the next 50 to 100 years.

difficult to incorporate them. The Earth's atmosphere and oceans make up a very complex, dynamic environmental system, with several known teleconnections[3], and it would be reasonable to assume that a warmer future is likely to alter existing climate relationships and correlations. Continued research into these relationships as they exist today and how they may change going forward will be critical to understanding the nature of the risk.

Finally, it is important to note that there are drivers of catastrophe risk other than climate. Indeed, two are far more certain and have a far greater impact on insured losses today, namely, the continued growth in the number and value of insured properties in areas of high hazard, and the poor quality and coarse granularity of exposure information that insurers currently rely on to assess their risk. These will be further discussed later in the paper.

Influence of Climate on Atlantic Hurricanes

In recent years, the influence of climate change on Atlantic hurricanes has received a lot of attention in the scientific community. Following the very active 2004 and 2005 hurricane seasons, the topic became the focus of attention of the insurance industry and, indeed, of the population at large.

So what do we currently know with a high degree of certainty? We know that:

- Basinwide tropical cyclone activity in the Atlantic has been higher than the long-term climatological average since 1995.
- There are problems with the historical data in terms of completeness and technological changes. (The data challenges are perhaps more severe in other ocean basins and are most apparent in the early part of the 20th century.)
- Certain climate factors influence tropical cyclone activity from both a meteorological and physical point of view, among them sea surface temperatures

[3] A *teleconnection* is a known relationship between two distinct climate mechanisms supported by the historical record and a physical understanding of the environment. For example, the ENSO cycle (more commonly known as the El Niño / La Niña cycle) which is a periodic warming and cooling of the Pacific Ocean has been shown to influence wind shear in the Atlantic, and can therefore modulate tropical activity well away from the origin of the ENSO signal.

(SSTs), the El Niño Southern Oscillation, the North Atlantic Oscillation and the Saharan Air Layer.

The data indeed indicate that, since 1995, tropical cyclone activity in the Atlantic basin has been elevated over the long-term average. Scientists at the National Oceanic and Atmospheric Administration (NOAA) have linked this above-average activity to elevated SSTs which, they say, are in turn linked to the positive (warm) phase of the Atlantic Multidecadal Oscillation (AMO) (Goldenberg et al., 2001), a naturally occurring cycle that oscillates over periods of decades.

In fact, a number of climate signals other than elevated SSTs affect hurricane activity and storm track, and these may dominate and even counter their impact. In 2006, for example, the onset of El Niño conditions produced increased wind shear in the Atlantic, which had a mitigating effect on hurricane activity despite the presence of anomalously warm Atlantic sea surface temperatures.

There are other complexities. For example, scientists also credited the Saharan Air Layer (SAL) for the low rate of storm formation in 2006. Storms over Africa's Sahara Desert can carry significant amounts of dry, dusty air westward over the Atlantic Ocean, depriving incipient tropical cyclones the moisture and heat they need to develop.

Nevertheless, 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 along the US. Gulf and East Coasts will be similarly elevated and that catastrophe models should adjust accordingly. However, significant caveats apply to this argument. In 2000, 2001 and 2006—all years in which SSTs have been warmer than the long term average—no hurricanes made landfall in the US. In three other years—1997, 2002 and most recently in 2007—only one tropical cyclone made landfall as a hurricane, which is below the long term average.

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. The correlation between landfalling hurricane numbers and SST is very weak and models that do not recognize this fact are likely to understate the uncertainty in their risk estimates.

This uncertainty is perhaps most evident in seasonal forecast models, which have been around for about twenty years. While the forecasts have improved over the years, uncertainty remains quite high, particularly in relation to landfall activity.

Sources of Uncertainty

Although by now there is a substantial body of research in projecting the impact of a warmer climate on tropical cyclone frequency and intensity, there is as yet no clear consensus. In its latest report the IPCC states:

> Based on a range of models, it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical SSTs. There is less confidence in projections of a global decrease in numbers of tropical cyclones.

However, a careful evaluation of currently competing theories highlights the uncertainty in the IPCC's conclusion as voiced by that word "likely." The uncertainty arises from broadly two sources: the assumptions required in dynamical climate models and the quality of the historical Atlantic hurricane data.

One study based on the output from dynamical climate models (Knutson, 2004) concludes that the *frequency* of tropical cyclones will likely remain constant, though Knutson's analysis also predicts an increase in the *intensity* of Atlantic hurricanes later in the century. Another study (Vecchi and Soden 2007) actually predicts a decrease in frequency as a result of increasing wind shear in the main development region of the Atlantic. Increases in vertical wind shear combined with a warming ocean are competing factors for tropical cyclone development, and their interaction is not fully understood, especially under conditions of a future climate regime.

Several statistical studies based on analysis of historical hurricane data in the Atlantic have concluded that hurricanes are likely to be more intense in the future.

Emanuel (2005) demonstrates a strong correlation in the destructive power of hurricanes with Atlantic SSTs. However other scientists (Landsea 2006 and 2007) argue this conclusion is at least partly an artifact of shortcomings in the widely accepted HURDAT database. As discussed above, there are questions concerning the completeness of HURDAT (Figure 1) and the accuracy of the intensity measurements of the earlier storms.

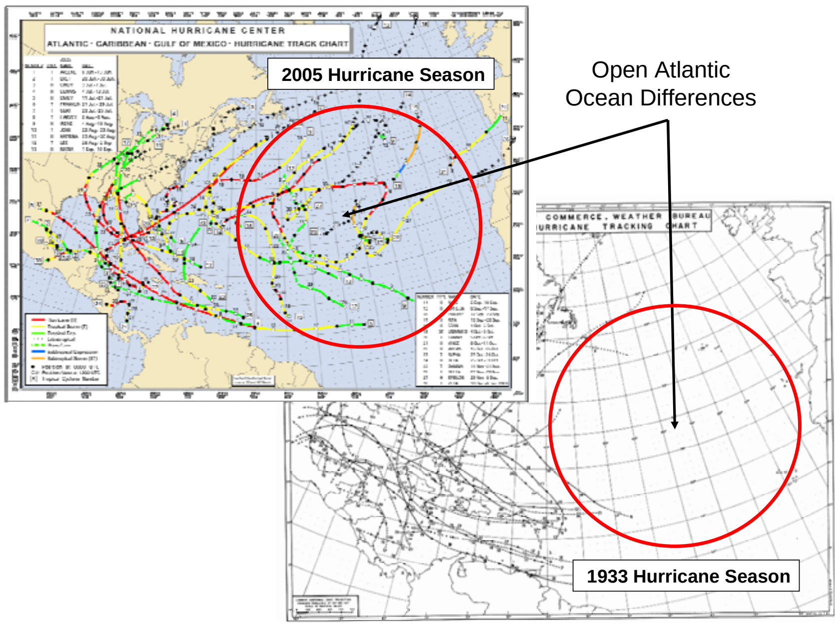

Figure 1. Apparent differences in tropical cyclone frequency in the open Atlantic between the first and second half of the century suggest the possibility of underreporting (Source: Landsea, 2007)

In addition, the primary driver (or "forcing") upon which theories regarding climate change are based revolve around the release of greenhouse gases. Most of the release, in the form of carbon dioxide emissions, has occurred over the last few decades—a timeframe that makes it exceedingly difficult to quantify the impact even if the data is relatively accurate.

What Can We Glean from the Historical Data?

If we expect climate change to alter the frequency of storms in the Atlantic basin, as well as the number of hurricanes that impact the US, it is useful to examine the historical record and look for trends in hurricane frequency that may have appeared in the past. The period since 1900 is sufficiently long to include past decadal fluctuations in SSTs and hurricane activity, shorter El Niños and La Niñas, and a range of other climate signals of varying duration, all of which can provide insight into how climate signals, in general, and SSTs, in particular, affect tropical cyclone activity in the Atlantic.

Activity in the Atlantic

Data on Atlantic tropical cyclone frequency over the period 1900-2006 shows a clear upward trend (Figure 2). A linear trend line fitted to this data set has a positive slope with a slope coefficient that differs significantly from zero. This would suggest an increase in Atlantic storm frequency during this period. However, as previously discussed, some scientists (Landsea 2007) believe that Atlantic basin data prior to the advent of aircraft reconnaissance and satellites is likely missing some storms, since without direct or remote sensing many are likely to have gone undetected. Such limitations on the historical data make it difficult to reach firm conclusions about trends in Atlantic storm frequency.

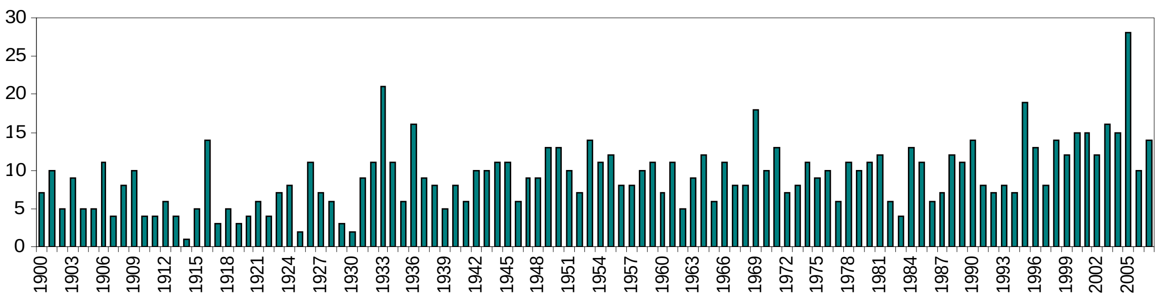

Figure 2. Annual Frequency of Tropical Storms in Atlantic Basin

Activity along the US Coast

The number of hurricanes and major hurricanes (SS category 3 and greater) that make landfall in the US over the period 1900-2006 are shown in Figure 4. The data shows no clear trend and a linear trend line fitted to this data set has a slope coefficient that is not significantly different from zero, signaling no increase in the landfall frequency during this period. As for issues regarding data completeness, historical data on landfalls is likely to be much more robust than basinwide data based on the premise that coastal residents are unlikely to have overlooked a landfalling hurricane.

Another way to examine the presence of a trend is to compute moving averages of the landfall frequency over periods of several years. In addition to revealing trends in the hurricane frequency, these moving averages will help answer questions such as (1) How does the landfall frequency during the current warm period, which started in 1995, compare to the landfall frequency that has been observed during periods of similar lengths in the past, and (2) How does landfall frequency observed since 1970, when a global warming trend may have emerged, compare to the frequency observed earlier in the century for periods of similar length. In other words, is there anything unusual about landfall frequency during the current active period that started in 1995 or the frequency during the last 35 year period when the global warming effect may have set in?

The 12-year and 35-year moving averages shown in Figure 3 (all landfalling hurricanes) and Figure 4 (major landfalling hurricanes) fail to demonstrate a trend in the two data series. Moreover, the frequency of hurricanes and major hurricanes during the last 12-year or 35-year periods, although high, is not unusual compared to the hurricane frequency during periods of similar lengths in the past.

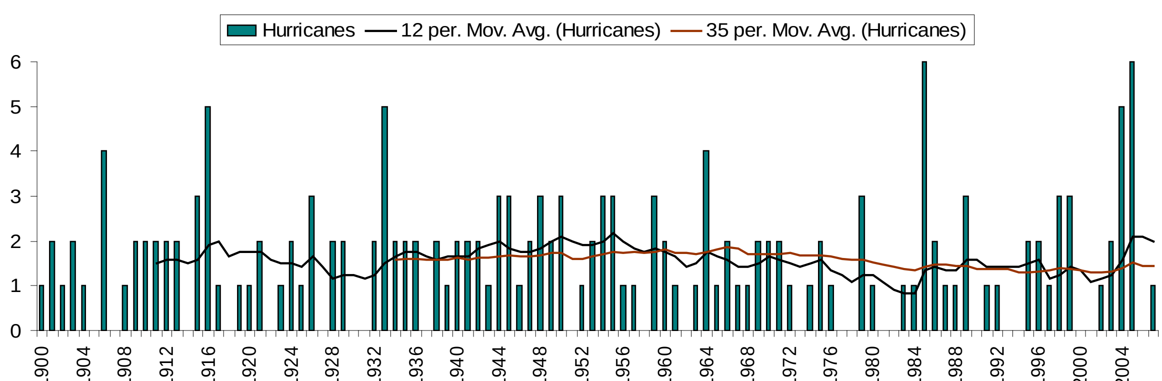

Figure 3. Annual Frequency of Landfalling Hurricanes in the US

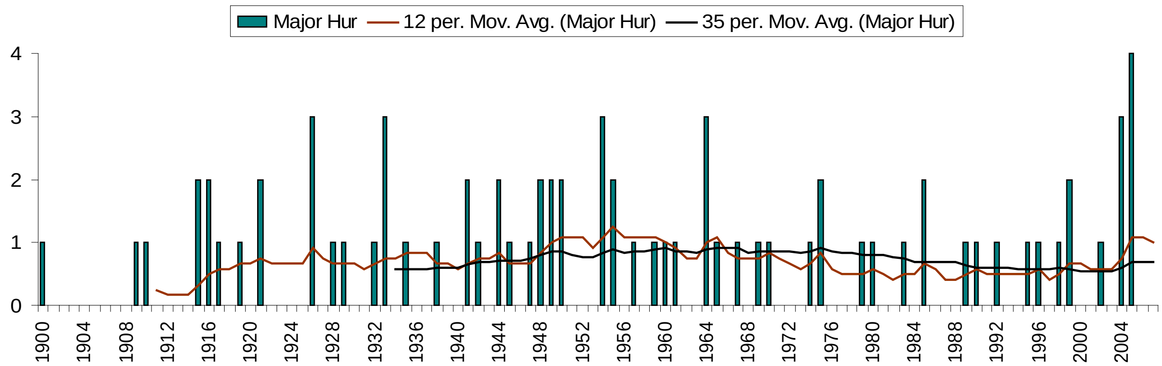

Figure 4. Annual Frequency of Landfalling Major (≥Cat 3) Hurricanes in the US

Given that Atlantic storm frequency shows a clear upward trend while the trend is not present in US landfall frequency, there are two possible arguments that could be made. One is that if the relationship between basin activity and landfalling activity has not changed in the past century, then reverse inference would support the idea of an incomplete dataset in the Atlantic, especially in the early part of the last century. If this is the case, it would call into question the trend itself, or at least its strength.

On the other hand, if one assumes that the Atlantic dataset is fairly complete and the underreporting is not severe, then it implies that some physical mechanisms that underlie the relationship between basin activity and landfalling activity have changed over the course of the last century. Theories that could possibly explain this change include an eastward shift in the genesis locations of storms, thereby increasing the probability that storms will recurve in the open Atlantic, or changes in the circulation patterns that steer storms across the Atlantic. These are areas that require further research.

AIR's Approach to Addressing the Current (Warmed) Climate in the Face of Uncertainty

Over the course of the last two years, AIR scientists have undertaken extensive analyses of the link between elevated SSTs in the Atlantic and regional landfall frequency. The research has also included a critical evaluation of the historical data and its quality.

As a result of this research, AIR released a near-term catalog of stochastic storms in 2006 and an updated version in 2007 (AIR 2007, Dailey et al 2007). The approach used to develop the near-term catalog— which represents potentially increased hurricane risk over the next several years— explicitly quantifies the uncertainty in the estimates of near-term risk. AIR has provided the near-term catalog to clients as a supplement to, rather than a replacement for, the standard catalog, which is based on more than 100 years of historical data and 20 years of research.

AIR's updated near-term catalog is conditioned not on point forecasts of SSTs, which are highly uncertain, but rather on scientists' projections that sea-surface temperatures are likely to remain elevated for the next several years. There is more certainty in the proposition that SSTs will be warmer than average over the next several years than in the proposition that they will be warmer by a specific number of degrees. One advantage of this approach is that the inclusion of one additional season of hurricane landfall experience will not significantly change estimates of near-term risk, lending stability to model results.

AIR is committed to bringing not only advanced science, but also robust and reliable models to market. In doing so, the meteorologists and climate scientists at AIR have resisted the temptation to push the state of the science beyond the limitations of the data. The AIR US hurricane model provides two credible views of potential hurricane activity and by doing so captures, in essence, model uncertainty. By providing two credible estimates of the hurricane risk today, AIR is providing clients with more information and an expanded toolset to aid risk management decisions. The underlying uncertainty in developing a near-term view is clearly borne out by the lack of landfalling hurricanes in the US in 2006 and in the below average season in 2007.

The Importance of Time Scale

The most dire scenarios of climate change are those projected well into the future (> 50 years). Policymakers and society as a whole must begin to grapple with the implications and develop effective mitigation strategies based on sound science.

In order to attempt to assess some of the implications for the insurance industry, the Association of British Insurers commissioned a study (ABI 2005) in which the financial risks under various future climate scenarios defined by ABI for the year

2080 were quantified. AIR was provided with several scenarios ranging from increases in the intensity of tropical cyclones in the Atlantic and the Northwest Pacific, to changes in the frequency of extreme extratropical cyclones impacting Western Europe.

Using the probabilistic loss estimation models AIR has developed, the impact on insurance losses were quantified as shown in the tables below. The study did serve to highlight the highly nonlinear relationship between damage to property and wind speed. Consider, for example, the median scenario of a hypothetical 6% increase in wind speed for tropical cyclones in the Atlantic by year 2080, which results in an increase of about 70% in financial risk at the 1% annual exceedance probability (EP) level (100 year return period).

Scenario	% Increase in Wind Speed	Increase in Average Annual Insured Loss (USD bn)	Increase in Insured Losses with Exceedance Probability of 1% (once every 100 years)	Increase in Insured Losses with Exceedance Probability of 0.4% (once every 250 years)
Lower-bound Sensitivity Analysis	4%	+2.5	+27	+42
Potential Impact of Climate Change[a]	6%	+4.0	+41 (+Δ70%)	+62 (+Δ75%)
Upper-bound Sensitivity Analysis	9%	+6.5	+68	+98

Figure 5. Results of sensitivity testing of impact of increased US hurricane intensity as performed for ABI by AIR. A 6% increase in wind speeds, for example, results in a 70% increase in insured losses at the 1% exceedance probability.

Scenario	% Increase in Wind Speed	Increase in Average Annual Insured Loss (USD bn)	Increase in Insured Losses with Exceedance Probability of 1% (once every 100 years)	Increase in Insured Losses with Exceedance Probability of 0.4% (once every 250 years)
Lower-bound Sensitivity Analysis	4%	+1.0	+7	+9
Potential Impact of Climate Change[a]	6%	+1.5	+10 (+Δ67%)	+14 (+Δ70%)
Upper-bound Sensitivity Analysis	9%	+2.5	+17	+25

Figure 6. Results of sensitivity testing of impact of increased Japan typhoon intensity as performed for ABI by AIR. A 6% increase in wind speeds, for example, results in a 67% increase in insured losses at the 1% exceedance probability.

Scenario	% Increase in Wind Speed	Increase in Average Annual Insured Loss (USD bn)	Increase in Insured Losses with Exceedance Probability of 1% (once every 100 years)	Increase in Insured Losses with Exceedance Probability of 0.4% (once every 250 years)
Potential Impact of Climate Change[a]	20%	+0.5	+2.0 (+Δ5%)	+2.5 (+Δ5%)

[a]The impact of climate change on the majority of less intense storms was not modeled because quantitative information about the changes is limited.

Figure 7. Results of sensitivity testing of impact of increased European extratropical cyclone frequency as performed for ABI by AIR. A 20% increase in frequency of the most severe storms, for example, results in a 5% increase in insured losses at the 1% exceedance probability.

Just how useful are such studies? For most businesses, planning cycles revolve around a much shorter time frame (< 10 years), so in any discussion of the impact of climate change, it is essential that the time horizon be made explicit. Furthermore, for insurers it is equally important to consider other factors that are driving their risk profiles, again in order to put the issue of climate change in the appropriate perspective.

Consider again the ABI study. Let's assume that the future climate scenario of a 6% increase in hurricane wind speeds is realistic, there are no other feedback loops that alter hurricane climatology and the modeling of its impact on insured loss is accurate as well. If we further assume the increased financial loss (70% at 1% EP, Figure 5) follows a process that has a constant annual rate of increase, it is equivalent to roughly 0.7% increase in insured losses each year. How does an 0.7% annual increase compare with other risk factors?

There are two far more certain risk drivers that the insurance industry is currently facing. The most important is the increase in the number and value of insured properties in areas of high hazard. AIR estimates that 38% of the total exposure in Gulf and East Coast states is currently located in coastal counties, which accounts for 16% of the total value of properties in the US (Figure 8). Further, AIR estimates that the value of properties in coastal areas of the United States has roughly doubled over the last decade and there is, as yet, no sign that the rate of growth is slowing. That translates directly to a doubling every ten years (~7.0% annual rate) in insured losses *exclusive of any effect of climate change*.

The second risk driver is the quality and granularity of data that insurers capture about the properties they insure, including accurate replacement values and other construction characteristics. In 2005 analysis of client data performed in 2005, AIR found significant and widespread undervaluation of the properties in insurers' portfolios. A property's replacement value is the full cost to replace the building in the event of a total loss. Since catastrophe models estimate loss by applying vulnerability functions to the replacement value before applying insurance policy terms and conditions, accurate replacement values are essential for obtaining accurate catastrophe loss estimates. If a property's replacement value is understated by 25 percent, for example, the estimated ground up loss will be understated by that much. Which means that companies will be managing to a much lower level of risk than their true risk.

State	Coastal ($B)	Total ($B)	Percent Coastal
Alabama	75.9	631.3	12%
Connecticut	404.9	641.3	63%
Delaware	46.4	140.1	33%
Florida	1,937.4	2,443.5	79%
Georgia	73.0	1,235.7	6%
Louisiana	209.3	551.7	38%
Maine	117.2	202.4	58%
Maryland	12.1	853.6	1%
Massachusetts	662.4	1,223.0	54%
Mississippi	44.7	331.4	13%
New Hampshire	45.6	196.0	23%
New Jersey	505.8	1,504.8	34%
New York	1,901.6	3,123.6	61%
North Carolina	105.3	1,189.3	9%
Rhode Island	43.8	156.6	28%
S. Carolina	148.8	581.2	26%
Texas	740.0	2,895.3	26%
Virginia	129.7	1,140.2	11%
All Above States	7,203.7	19,041.1	38%
All Above States as % of Total U.S.	7,203.7	43,665.6	16%

Figure 8. AIR estimates that fully 38% of the total property value in Gulf and East Coast states is located in coastal counties, which accounts for 16% of the total value of properties in the U.S. (Source: AIR, data as of 2005)

The inaccuracy in loss estimates as a result of poor data quality is at least, if not more, than 0.7%. This is not to say that an 0.7% increase in risk as a result of a warming climate should be ignored, but rather to underscore the importance of addressing issues that are less uncertain and *more manageable*.

Conclusion

We are at a critical juncture in the field of risk modeling given that it is almost certain that the Earth's climate is warming. All stakeholders in the risk transfer chain need to be aware of the consequences of climate change. But at the same time we need to be objective in our analysis and recognize the uncertainties associated with current risk projections.

While the larger scientific community is advancing the state of knowledge on the impact of climate change, the catastrophe modeler needs to incorporate clearly established findings into the models to reflect risk in the *current* climate regime. AIR will continue to integrate advanced physics-based models with data-driven statistical models to develop unbiased estimates of risk.

Should new modeling approaches and science support the existence of a trend in the intensity or frequency of atmospheric perils that impact the built environment, then the catastrophe modeler can confidently incorporate this trend. However, it is important to point out that such an approach would have to be approached holistically, by accounting for mitigative factors, such as advances in the wind resistivity of structures and the enforcement of improved building codes.

Perhaps most importantly, the explicit quantification of the uncertainty in risk estimates will be critical to informed and effective risk-management decisions.

Acknowledgements

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References

2007 IPCC Summary for Policymakers (http://www.ipcc.ch/). The full report is expected to be released later this year.

AIR Worldwide, 2005: "The Coastline at Risk," (http://www.air-worldwide.com/_public/NewsData/000797/The_Coastline_at_Risk-AIR_Worldwide.pdf), AIR white paper.

AIR Worldwide, 2005: Exposure Data Quality, (http://www.air-worldwide.com/_public/NewsData/000829/AIR_Data_Quality.pdf), AIR white paper.

AIR Worldwide, 2007: "Near-term Hurricane Risk in the US: The 2007 Update to the AIR New-term US Hurricane Risk," AIR white paper.

Dailey, P., Ljung, G, Zuba, G, and Guin, J, 2007,"On the Relationship between North Atlantic Sea Surface Temperatures and U.S. Hurricane Landfall Risk", submitted to the *Journal of Applied Meteorology and Climatology*.

Emanuel, K., 2005: Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*, 436, 686-688. doi: 10.1038/nature03906.

Goldenberg, S.B., C.W. Landsea, A.M. Mestas-Nuñez, and W.M. Gray, 2001: The recent increase in Atlantic hurricane activity. Causes and implications. *Science*, 293, 474-479.

Knutson, T. K., and R. E. Tuleya, 2004: Impact of CO2-induced warming on simulated hurricane intensity and precipitation: Sensitivity to the choice of climate model and convective parameterization. *Journal of Climate*, 17(18), 3477-3495.

Landsea,C.W., B.A.Harper, K.Hoarau, and J.A.Knaff, 2006: Can we detect trends in extreme tropical cyclones? *Science*, 313, 452-454.

Landsea,C.W., 2007: Counting Atlantic tropical cyclones back to 1900. Eos 88, 197-202

ABI, 2005 "Financial Risks of Climate Change," Association of British Insurers (ABI) Summary Report

Vecchi G. and J Soden, 2007. "Increased tropical Atlantic wind shear in model projections of global warming," *Geophysical Research Letters*, Vol 34, 2007.

About AIR Worldwide Corporation

AIR Worldwide Corporation (AIR) is the scientific leader and most respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 50 countries. More than 400 insurance, reinsurance, financial, corporate and government clients rely on AIR software and services for catastrophe risk management, insurance-linked securities, site-specific seismic engineering analysis, and property replacement cost valuation. AIR is a member of the ISO family of companies and is headquartered in Boston with additional offices in North America, Europe and Asia.