THE WARM SEA SURFACE TEMPERATURE CATALOG, RECONSIDERED

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EDITOR'S NOTE: Since the early 1990's, AIR has conducted research exploring the relationship between elevated ocean temperatures and tropical cyclone activity. In 2007, AIR introduced in its U.S. hurricane model an alternative view of U.S. hurricane risk—one conditioned on those years since 1900 with warmer-than-average sea surface temperatures (SSTs). Three years later, Dr. Peter S. Dailey, AIR Director of Atmospheric Science, takes a step back to discuss the relative performance of the standard and so-called WSST catalogs thus far.

By Dr. Peter S. Dailey

SEAS OF CHANGE

Hurricane activity (in terms of both frequency and intensity) has fluctuated during the past century, alternating between periods of high and low activity that correlate with long-term warming and cooling trends in the Atlantic Ocean. In the previous cool period, approximately lasting from 1971 to 1994, there were on average 9 tropical storms and 5 hurricanes per year, compared to 11 tropical storms and 6 hurricanes in a typical season. Seasonal accumulated cyclone energy (ACE)[1] values were likewise lower for this period, averaging 65 per year compared to a long-term (1900 to 2009) average of about 90 per year. In contrast, during the current warm period, which began in 1995, there have been on average 15 tropical storms, 8 hurricanes, and 4 major hurricanes per season, and an average seasonal ACE of 138.

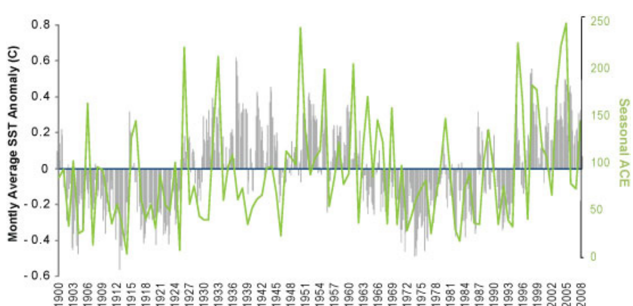

Figure 1. Sea Surface Temperature Anomalies, Jun–Nov (left axis, in black) and Seasonal ACE Index Values (right axis, in green) (Source: NOAA/CPC)

In the 1980s, Dr. William Gray at Colorado State University put forth a theory proposing that an ocean circulation pattern, termed the Atlantic Multidecadal Oscillation (AMO), produces extended periods of anomalously warm or anomalously cool SSTs that are correlated with several atmospheric phenomena, including hurricane activity. Other researchers believe instead that human-induced global warming has played the predominant role in the increased activity in recent years. Regardless of the underlying mechanisms at work, statistical analysis of Atlantic storms since 1900 has shown that basin activity is positively correlated with sea surface temperature anomalies, which is expected given that tropical cyclones derive their energy from warm waters. Furthermore, it is likelier than not that the Atlantic will remain warm at least for the next several years, given the thermal inertia that results from the enormous volume and heat capacity of the ocean.

TWO LONG-TERM VIEWS OF HURRICANE RISK

Near-term forecasts of hurricane activity in recent years, spurred in part by highly active seasons in 2004 and 2005, are characterized by considerable uncertainty because the scientific knowledge and technological skill in predicting specific SSTs for an upcoming period is still quite limited. The periodicity of the cool and warm periods itself is irregular but in addition, as Figure 1 shows, even during longer trends, SST anomalies can swing back and forth between cool and warm. Thus it is not known with 100% certainty whether the near future will remain consistently warm. In addition, while sea surface temperatures are undoubtedly influential, several other climate signals are known to affect hurricane activity, including the El Niño Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), and the Saharan Air Layer (SAL). As was the case in the 2009 Atlantic hurricane season , these factors can sometimes oppose the effects of warm SSTs.

While there is no clear consensus yet in the scientific community of what the future holds—particularly with respect to U.S. hurricane landfall activity—AIR has taken an ensemble approach by offering multiple credible views of risk, which is scientifically preferable to adopting a single opinion. In 2007, AIR introduced a warm SST stochastic catalog in addition to the standard catalog. Both catalogs are long-term and fully probabilistic views of hurricane risk based on scientifically sound and transparent methodology. The standard catalog is derived based on all years of hurricane activity since 1900, while the alternative WSST catalog is derived, or conditioned, on those years since 1900 with anomalously warm SSTs. Neither is designed to forecast activity or losses for upcoming seasons, as near-term catalogs attempt to do. Instead, the warm SST catalog estimates the sensitivity of U.S. landfall risk to a "typical" warm ocean condition. Because the standard catalog is developed from more years of data, while the WSST catalog is conditioned only on warm years, there is inherently more uncertainty in the WSST catalog.

PERFORMANCE OF THE CATALOGS

As discussed in last month's AIR Current article, the reduced North Atlantic hurricane activity in 2009 can be attributed to the moderate El Niño that began earlier in the year. Much like in 2006 and 2007, even in an environment of elevated ocean temperatures, hurricane losses can be below average. The reverse holds true as well; years with unfavorable SST conditions can produce catastrophic losses, as Hurricane Andrew demonstrated in 1992, a year with cooler than average SSTs. Given the variability and uncertainty in year-to-year activity, how have the standard and warm SST catalogs performed thus far?

The gray dots shown in Figure 2 represent the cumulative count of actual U.S. loss-causing hurricanes (both landfalling and bypassing) in the extended 15-year period of warm Atlantic temperatures that began in 1995. The dotted green line represents the (cumulative) mean frequency in the AIR model's standard catalog, and the orange line represents the modeled (cumulative) mean frequency conditioned on warm ocean temperatures The difference between the two is approximately 10%. Which is correct? If we look first at the 11-year period from 1995 to 2005, one would expect 11 times the long-term annual frequency to be observed. Making use of both frequency views, one can say that assuming average to above-average SSTs, one would expect between 20 and 22 loss-causing hurricanes to occur over an 11-year period.

In fact, 26 landfalls were actually observed over this period. However, this does not mean the warm SST frequency is more accurate. Note that in several years, the observed count falls closer to the green line than the orange, and in some years, actually falls below the green. Thus, applying long-term statistics to any particular year does not yield much value. Knee jerk reactions to anomalous seasons like 2005 can lead to model adjustments that are not justified by the data and objective science. Note that, extending the analysis through 2009, the observed cumulative count of 30 loss-causing hurricanes is in line with the range indicated by both the standard and warm SST catalogs.

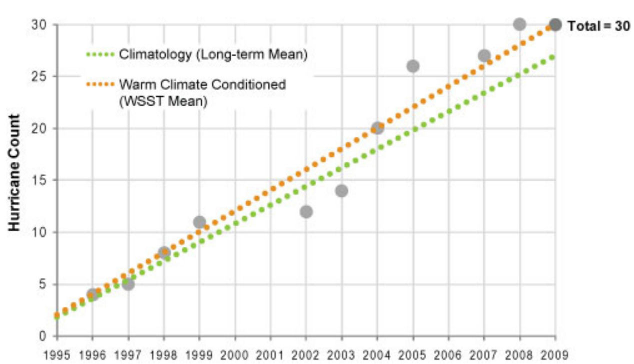

Figure 2. Cumulative Count of Loss-Producing Hurricanes (Source: AIR)

A similar analysis can be done for high impact events, namely major (Saffir Simpson Category 3 and higher) hurricane landfalls (Figure 3). It is important to note that because the annual frequency is less than one storm, such an analysis really requires many years in order to draw any meaningful conclusion. Nevertheless, looking again at the period 1995 to 2005, the standard and warm SST catalogs would be expected to produce eight and ten storms, respectively, while the actual observed frequency of major hurricane landfalls over that period was ten. Again, this does not mean that the warm SST catalog is more accurate. In fact, extending the analysis to 2009, 2005 was the only year that sits above the orange line. For most other years in this period, the standard view of risk would be preferred, given a choice of only one.

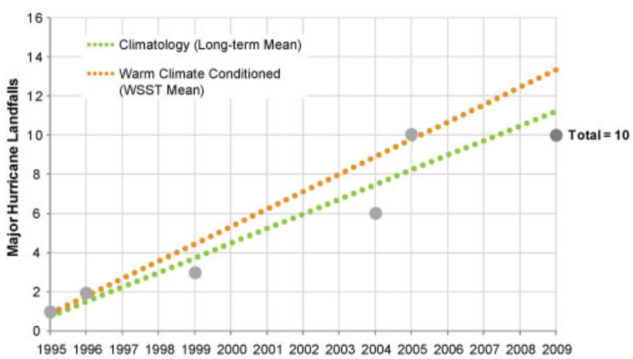

Figure 3. Cumulative Count of Major Hurricanes Landfalls (Source: AIR)

CONCLUSION

In the end, the standard and the climate-condition WSST catalogs are both scientifically valid. The standard catalog is based on over 100 years of data and over 20 years of development research at AIR. While the WSST catalog is newer and based on roughly half as many years, the methodology by which it was developed—both from a meteorological and statistical viewpoint—has been thoroughly peer-reviewed by experts in the field and subsequently published in the Journal of Applied Meteorology and Climatology.

The difference between the two stochastic catalogs reflects of the sensitivity of hurricane risk to warm ocean temperatures. While a warm ocean increases the mean risk, a whole range of scenarios can play out, and 2009 is a good example of how elevated baseline risk does not necessarily translate to elevated losses. The catalogs provide a fully probabilistic view of risk and are not meant to forecast losses for an upcoming season. Weather forecasters know all too well that a single forecast from a single model has little value. A probabilistic forecast from a single model is more helpful, but multiple probabilistic forecasts—an ensemble—is the most robust method for managing future risk. As AIR continues to explore the role of climate change in catastrophe risk, our models will continue to reflect the latest research so that companies can better understand the risk to their own portfolios.

1 ACE IS USED TO GAUGE THE ACTIVITY LEVEL OF A PARTICULAR HURRICANE SEASON BY SUMMING THE ENERGY USED BY EACH TROPICAL CYCLONE OVER ITS LIFETIME. IT TAKES INTO ACCOUNT BOTH THE STRENGTH AND DURATION OF THE STORM.

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