Pricing the Hurricane Peril—Change is Overdue

by David R. Chernick, FCAS

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Introduction

The hurricane peril is currently a very hot topic at Casualty Actuarial Society meetings and seminars. The advent of this interest occurred in the aftermath of Hurricane Andrew, which made landfall in Homestead, Florida on August 24, 1992. Hurricane Andrew damaged or destroyed thousands of buildings and caused an estimated $16 billion in insured losses. Insured damage of this proportion was unprecedented, and could have been much greater had the hurricane taken a slightly different but equally likely track. In response, actuaries began to seriously reevaluate their ratemaking procedures for this peril.

In this paper I will document the history of ratemaking techniques used for the hurricane peril. Non-insurance data will be presented to show that historical techniques and typical insurance incurred loss data are inappropriate to properly price this peril. I will concentrate on expected loss costs for hurricanes, or in other words the mean of the potential loss distribution. The concept of risk load will be left to other authors in our society.

History

The hurricane peril has historically been covered under various property insurance products, including but not limited to extended coverage, commercial multi-peril and homeowners. The first reference to wind ratemaking that I found in the Casualty Actuarial Society journals was in 1951. Mr. M.H. McConnell wrote: "Similar exposure to catastrophic losses exists with respect to other coverages written by Fire Insurance Companies such as Extended Coverage. The November 25, 1950 windstorm affecting thousands of policyholders in New England and the Middle Atlantic States is a recent example of such a catastrophe. The estimated losses for this storm are almost $200,000,000 and the number of claims may reach 500,000. Because of low frequency, slavish adherence to indicated rate levels might result in violent fluctuations in rates as well as violent fluctuations in relativity. To achieve a desirable degree of stability, exercise of underwriting judgment is required in selecting rate levels." [1]

Hurricanes are definitely low frequency, potentially high severity events. Even though the November 25, 1950 storm was not officially a hurricane, there is evidence that members of the society were concerned with the impact this type of event could have on ratemaking. Although it is difficult to determine how many years of ratemaking data were used to generate rate level indications for extended coverage policies at that time, it appears that the number of years used to price the wind peril was small. Mr. McConnell's solution is that underwriting judgment be used in selecting rate levels to account for the low frequency of severe storms.

In 1949, Mr. J. H. Finnegan documents the beginning of catastrophe coding. "For the purpose of obtaining information on the losses paid for the various tornadoes, hurricanes and similar catastrophes which occur each year, the National Board began in April, 1949 the practice of assigning a catastrophe serial number for all such occurrences. Such numbers are assigned whenever preliminary estimates indicate that the loss will amount to $1,000,000 or more in any state." [2] Clearly, insurance data for hurricanes is not available prior to 1949. Even after 1949, it has been my experience that detailed company data for individual hurricanes has not been kept until recently. In any case, historical ratemaking data for the hurricane peril is limited.

In 1959, Laurence H. Longley-Cook documents for the first time in the records of our society the number of years used in pricing the "windstorm" peril for extended coverage policies. Ten years of historical experience was used. "Rate making for extended coverage abounds with interesting actuarial problems many of which have received little attention. Since windstorm is by far the major peril, it is important to realize that owing to the correlation between losses - one storm involving many thousands

[1] M. H. McConnell - "A Casualty Man Looks at Fire Insurance Rate Making" PCAS Volume XXXVIII, 1951, pp. 103-104.
[2] J. H. Finnegan - "Statistics of the National Board of Fire Underwriters" PCAS Volume XLIII, 1956, pp. 93.

of losses - normal standards of credibility do not apply. This is being recognized by using 10 years rather than 5 years loss experience for rate adjustment. However, in states exposed to hurricanes, the 10-year loss experience may have an abnormal or subnormal number of such storms, and even longer term weather studies make it difficult to establish the normal frequency of hurricanes. The problem is further complicated by the conflicting views of weather men on the relative bearing on trends of sunspot cycles and longer term climatic changes." [3] Mr. Longley-Cook cautions that a 10 year experience period for hurricanes is not long enough for ratemaking, but does not offer a solution.

In 1960 Ernest T. Berkley wrote, "The seminar concentrated on a Homeowners policy on an indivisible premium basis as a prime example of a multiple peril policy.... The removal of the restrictions of the Appleton Rule in 1949 made it possible to combine fire and extended coverage, theft and liability coverages in a single policy which could be written by either a casualty or a fire company.... After covering the foregoing historical aspects the seminar proceeded with a discussion of the principal points brought out in the paper and review, which may be summarized as follows: 1. ... ... 5. Several miscellaneous points including the variation in loss frequency for windstorm versus other coverages and the associated windstorm catastrophe hazard." [4]

In this paper we learn that prior to 1949 the Appleton rule prevented combining coverages, and removal of restrictions led to the creation of multi-peril policies which included the hurricane peril. Mr. Berkeley writes about a seminar that concentrated on homeowners multi-peril policies and stated that there were concerns regarding windstorm frequency and windstorm catastrophe potential. Again, the issue of the wind peril was discussed, but no solutions were offered.

Prior to 1957, rates for multi-peril policies were developed by combining rates for the component coverages. Beginning in 1957, at least one company began using its own homeowners only data for ratemaking. Today, many companies use company specific data for homeowners ratemaking.

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[3] Laurence H. Longley-Cook - "Notes on Some Actuarial Problems of Property Insurance" PCAS Volume XLVI, 1959, pp. 80.
[4] Ernest T. Berkeley - "Rate Making and Statistics for Multiple Peril Policies" PCAS Volume XLVII, 1960, pp. 231-233.

A cite of LeRoy J. Simon from his 1961 paper follows: "Referring to Homeowners rating history, it started as a sum of components and remained this way for some time. As component rates changed, so did the Homeowners rate change. In 1957 at least one company swung over to using Homeowners experience to set the Homeowners rates.... Two important features that couldn't be discussed too thoroughly were reinsurance problems and the catastrophe problem. The latter question arose in connection with rate making for all the property coverages as a single unit. The presence of a hurricane in two years would distort the figures, so would the absence of a hurricane in two years distort the figures." [5] Again frequency variation for the hurricane peril was a major concern. Yet again, no solution was offered.

In 1962 Edward S. Allen described another seminar on package policy ratemaking. "A discussion of principles for package policy ratemaking at the present stage of package policy development will obviously produce more questions than answers....Since discussions in the two sessions of the seminar developed in quite different directions, it might be of interest to the participants as well as others, to list some of the comments and opinions expressed incidental to the general conclusions as summarized above. An abbreviated list is as follows:

1. ...

8. Catastrophe coverage and small loss coverage should be treated differently." [6]

Consistent with prior authors Mr. Allen suggested that catastrophe coverage be treated differently.

Frederic J. Hunt, Jr.'s paper "Homeowners - The First Decade" was published in the Proceedings in 1962. This paper gives an excellent overview of the actuarial perspective of the first ten years of the homeowners policy. A relevant section follows: "The question of credibility and the treatment of catastrophes in Homeowners rate-making, together with some related problems, need actuarial study

[5] LeRoy J. Simon - "Rate Making for Package Policies" PCAS Volume XLVIII, 1961, pp. 205-206.
[6] Edward S. Allen - "Package Policy Ratemaking" PCAS Volume XLIX, 1962, pp. 66-67.

and I am hopeful that, at least when the history of the second decade of Homeowners is written, it will include an account of the satisfactory disposition of these items." [7]

The challenge of Mr. Hunt to find solutions to the problems of credibility and treatment of catastrophes was not answered. Maybe the lack of major hurricanes or other catastrophes caused this or maybe our Society had more pressing issues to address. Surprisingly, in the twenty five years between 1963 and 1989, only one property insurance paper was published in the journals of the CAS. That was Michael A. Walters' paper, "Homeowners Insurance Ratemaking", published in 1974. This paper is near and dear to actuaries of my generation since it was the major property insurance article on the principles of ratemaking exam syllabus. "By the same token, if no hurricanes or other catastrophes have occurred during the experience period under review (now five years in Homeowners insurance), it would also be a mistake to assume that the potential for catastrophe has vanished. Therefore, an averaging process is utilized whereby the actual incurred losses from catastrophic events during the experience period are removed and substituted by the expected value of such losses based upon a long range view of at least twenty years experience for that state." [8]

Mr. Walters continued the caution from the 1960's. He articulated the hurricane frequency problem quite well. In 1974 the standard homeowners ratemaking base was 5 years of data. However, Mr. Walters stressed that for catastrophes, at least 20 years of ratemaking type data should be used.

An attempt to address the ratemaking problems of the hurricane peril was ISO's excess wind procedure. This procedure was developed by ISO and first used in ratemaking sometime prior to 1990. Simply described, the ISO excess wind procedure developed an expected wind pure premium by splitting actual data into basic wind and excess wind components. The expected basic wind component is derived by a long term average (Non excess wind losses / Non wind losses). The expected excess wind component is derived by taking the ratio of excess wind to non-excess wind losses over a longer period

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[7] Frederic J. Hunt, Jr. - "Homeowners - The First Decade" PCAS Volume XLIX, 1962, pp. 39.
[8] Michael A. Walters - "Homeowners Insurance Ratemaking" PCAS Volume LXI, 1974, pp. 23-24.

of time and supplementing state data with regional data. The ISO excess wind procedure is just a slightly more sophisticated technique that still uses a limited historical period of time.

The following quote is from Mark Homan's 1990 paper, "Homeowner Insurance Pricing." "The first adjustment made to these losses is for catastrophic losses. Catastrophe losses are relatively infrequent and do not affect each year similarly. The indicated rate level should include a provision for expected catastrophes, instead of those that happened to occur in the experience period. To make this adjustment, a longer time period, and possibly a larger body of data, is used to compensate for the infrequent nature of these losses. The procedure described here is very similar to the ISO excess wind procedure." [9]

Mr. Homan, although not directly referring to the hurricane peril, again warns a longer period of time is needed in the development of a ratemaking provision for catastrophes. He goes on to state for the first time in our actuarial literature that "a larger body of data" is "possibly" a solution. I believe it is self evident that a larger body of data (i.e. non-insurance data) is necessary to properly price the hurricane peril. Note that even after Hurricane Hugo in 1989, Mr. Homan advocated using the ISO excess wind procedure to price the hurricane peril.

Also in 1990, David H. Hays and W. Scott Farris directly addressed the hurricane peril in their paper "Pricing the Catastrophe Exposure in Property Insurance Ratemaking". A specific adjustment is suggested to bring the actual hurricane frequency to the frequency level indicated by 120 years of meteorological data and to bring the recorded severity to current cost and exposure levels.

"A company's hurricane data may be sparse. Therefore, it may be appropriate to modify company data or to substitute data from other sources. External data can be either historical or simulated.... One easy adjustment to a company's hurricane data that can be made is to adjust the frequencies of the various hurricanes in the company sample to reflect known historical frequencies over a longer period. The number of hurricane occurrences by wind speed and landfall is available from

[9] Mark J. Homan - "Homeowners Insurance Pricing" Casualty Actuarial Society 1990 Discussion Paper Program, pp. 727.

various sources for at least 122 years. If a company can identify the wind speed and the landfall for the hurricanes in its data, the adjustment to known frequencies can be accomplished by the following formula:

$$E(h) = H * \frac{F * Y}{N * 100}$$

Where,

E(h) = Expected Dollars of loss for an individual hurricane

H = Dollars of loss for the hurricane adjusted to current inflation and exposure distribution

Y = Number of years in the sample data

N = Observed number of occurrences by intensity and windspeed

F = Expected 100 year frequency from external sources."[10]

I will comment on this procedure more specifically in the frequency section of this paper.

In 1992, John Bradshaw and Mark Homan in their paper "Homeowners Excess Wind Loads" wrote: "The ISO procedure has its flaws. However, due to the difficulty in obtaining a sufficient volume of credible data for any other method, it remains the most widely used method. The adjustment outlined in this paper allows for the elimination of one of the major flaws in the ISO procedure, namely its reliance on past history as a representative sample of possible losses....

An additional shortcoming of the ISO procedure is that it fails to adjust for demographic shifts. In particular, it does not consider the increase in coastal exposures. The adjustment of the model

[10] David H. Hays & W. Scott Farris - "Pricing the Catastrophe Exposure in Property Insurance Ratemaking," Casualty Actuarial Society 1990 Discussion Paper Program, pp. 491-492.

reflects the current distribution of a company's book and can be updated periodically to reflect any shifts. This does not eliminate the ISO shortfalls since many of the years are still based purely on history. However, the additional year from the model will dampen this problem with the ISO procedure."[11] Messers. Bradshaw and Homan's contribution to CAS ratemaking procedures is basically that the ISO excess wind procedure can be improved by adding a year that represents a one in 50 year storm. The authors point our many flaws in the ISO wind procedure and there are other limitations not mentioned in this paper. Even the authors admit the adjustment will only "dampen" the "problem" with the ISO procedure. Simply put, the ISO excess wind procedure is not an appropriate tool for pricing the hurricane peril.

In 1996 Burger, Fitzgerald, White and Woods published a paper titled "Incorporating a Hurricane Model into Property Ratemaking," where they explain that ISO had decided to replace their excess wind procedure with data from a computer simulation model. They concluded: "After evaluating the limitations of the traditional loss smoothing approaches, ISO decided to use a computer simulation modeling approach for measuring the hurricane catastrophe peril."[12]

Also in 1996, Michael A. Walters and Francois Morin published "Catastrophe Ratemaking Revisited." They endorse using computer simulation models as a ratemaking tool, and conclude: "In summary, computer models are now capable of simulating catastrophic events and creating probabilistic models of reality that can be used to generated expected loss costs for catastrophe perils."[13] In the next sections of this paper I will expound on the limitations of using traditional insurance data to price the hurricane peril.

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[11] John Bradshaw & Mark J. Homan - "Homeowners Excess Wind Loads: Augmenting the ISO Wind Procedure," Casualty Actuarial Society Forum, Spring 1992, pp. 49.
[12] Burger, Fitzgerald, White and Woods - "Incorporating a Hurricane Model into Property Ratemaking," Casualty Actuarial Society Forum Winter 1996, pp. 141.
[13] Michael A. Walters & Francois Morin - "Catastrophe Ratemaking Revisited (Use of Computer Models to Estimate Loss Costs)," Casualty Actuarial Society Forum Winter 1996, p.364.

Non-Insurance Data

Various meteorological data exists on Atlantic hurricanes since the late 1800's. The primary source of this meteorological data is the National Weather Service, specifically, publications NOAA Technical Report NWS23[14] and NOAA Technical Report NWS38[15]. In addition, "Tropical Cyclones of the North Atlantic Ocean 1871-1980"[16] was valuable. The quality and amount of data available is more extensive and more accurate for recent storms. Messers. Hays and Farris in their paper referred to 122 years of data, implying back to 1871. My analysis requires accurate landfall locations and identification of Saffir/Simpson category. Hurricanes prior to 1899 are not covered in the NWS reports, and thus I have decided to use the 98 years from 1899 to 1996 for this paper. Using National Weather Service reports and several other sources, I compiled Exhibit 1.

Exhibit 1 is a chart of the number of hurricanes that made landfall on the Gulf or Atlantic coasts of the United States for each year since 1899, broken down by Saffir/Simpson category. Some hurricanes made landfall more than once. For the purpose of this exhibit, a hurricane is counted each time it made landfall at hurricane strength. For example, Hurricane Andrew was counted twice, once in Florida and once in Louisiana. The assignment of a Saffir/Simpson category at landfall cannot be determined precisely and often requires some judgment. In addition, two storms listed in the National Weather Service publications were not counted in this list because it was determined that one actually made landfall in Mexico and the other in Canada.

In many years there were no hurricanes making landfall in the United States. In 1985, the most landfalls occurred (seven). In the 98 years listed, there were 176 landfalls or an average of 1.8 landfalls per

[14] NOAA Technical Report NWS 23, "Meteorological Criteria for Standard Project Hurricane and Probable Maximum Hurricane Windfields, Gulf and East Coasts of the United States," Washington, DC, September 1979, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service.
[15] NOAA Technical Report NWS 38, "Hurricane Climatology for the Atlantic and Gulf Coasts of the United States," Silver Spring, MD, April 1987, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service.

year. Only two storms were categorized as 5 on the Saffir/Simpson scale. These were a 1935 storm that made landfall in Monroe County, Florida and Camille in 1969 which made landfall in Hancock County, Mississippi.

Frequency

Is 10 or 20 or 30 years of typical ratemaking data enough to accurately price the hurricane peril? To test this, the data on Exhibit 1 was analyzed. Exhibit 2 was created from the data on Exhibit 1 and shows the number of landfalling hurricanes by decade. The 1990's are not yet a full decade and the two 1899 storms were not included in Exhibit 2. Even though we would not directly use this data for individual state ratemaking since it is for all states combined, it clearly demonstrates the variability of hurricane frequency. The number of hurricane landfalls in a decade varies from a high of 27 to a low of 14. Most experts agree that more intense storms cause proportionally more damage than less intense storms. Thus, from a ratemaking perspective a large portion of the loss cost will be attributable to the more intense storms. For the purpose of categorization, a major hurricane is defined as one of category 3 or higher on the Saffir/Simpson scale. The variation in hurricane landfall frequency is even more pronounced for major hurricanes, ranging from a low of 4 to a high of 10.

Turning now to state data, the variation in hurricane frequency is even greater. In the United States, rates are regulated by state. Ideally, from a ratemaking perspective rates should be made for homogeneous subsets of a state, (i.e. territories). Exhibit 3 is included for reference, and is a consolidation of all storms listed in Exhibit 1 by state of landfall. Hurricane landfall frequency differs significantly by state. To analyze this further I have selected Texas and South Carolina. Exhibits 4 and 5 show the hurricane landfall data for these states in the same format as Exhibit 2. For my simple analysis I have not counted hurricanes making landfall outside of Texas or South Carolina but causing damage to

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[16] "Tropical Cyclones of the North Atlantic Ocean", NOAA, Asheville, NC, June 1978, Revised July 1981, Prepared by the National Climatic Center, Asheville, NC in cooperation with the National Hurricane Center and National Hurricane Research Laboratory, Coral Gables, FL.

properties located within those states. However, the potential for hurricanes making landfall outside the state being priced but causing damage in that state should be considered in determining rates.

I have added several rows of summary data to Exhibits 4 and 5. I have shown the total number of hurricanes making landfall in the latest 27 years (1970-1996). Also shown are rows labeled high and low. These are the sum of the three consecutive decades that had the highest and lowest number of hurricane landfalls, respectively. In order to more easily compare frequency I have added a row showing the annual frequency for the 97 year total and each of the three time periods just described. In 97 years there have been 32 hurricanes making landfall in Texas for an annual frequency of .330, or just less than 1 every 3 years. If we were to use historical insurance data from 1920 to 1949 the underlying frequency was .433 or 31.2% greater than the 97 year history. From 1950 to 1979 the underlying frequency was .200 or 39.3% less than the 97 year history.

Exhibit 5 displays the same type of data for South Carolina. The variation in frequency is similar to Texas, but the overall frequency is much lower. On average, a hurricane makes landfall in South Carolina once every eight years, and a major hurricane occurs about once every twenty years. As in Texas, when the shorter time periods are compared, there is significant variation in hurricane frequency.

On a statewide basis the hurricane frequency in a single 20 or 30 year period of data can differ significantly from the longer term mean. If the data for hurricane frequency is refined further to county or rating territory, the variation is even greater. There are many areas that had devastating damage from a hurricane in one year and long periods of no storms. This variation in landfall frequency is shown graphically on Exhibits 6 through 10, which display the tracks of major hurricanes by decade, beginning with the 1940's.

In the 1940's, 5 of the 8 major hurricanes made landfall in Florida (Exhibit 6). In the 1950's most of the activity was on the East Coast with only two storms making landfall in Florida (Exhibit 7). In the 1960's the activity moved to the Gulf of Mexico, with only Donna moving up the east coast after an initial landfall in the Florida Gulf (Exhibit 8). All four major hurricane landfalls occurred in the Gulf of Mexico during the 1970's (Exhibit 9). In fact, between 1961 and 1983 no hurricane made landfall on the eastern coast of the United States north of Monroe County, Florida. Finally, in the 1980's the six major storms were well dispersed (Exhibit 10).

Where will the next Atlantic hurricane make landfall? Going back to the hurricane history of South Carolina, Exhibit 11 displays the tracks of the 3 major hurricanes prior to 1989. No major hurricane on record made landfall near Charleston, SC. Exhibit 12 shows what the South Carolina major hurricane landfalls look like after 1989. This demonstrates that new and unique landfalls are possible, presenting an exposure to loss which historical ratemaking data will never capture.

Clearly, hurricane landfall frequency varies widely over time. The smaller the geographic area being considered, the greater the variation. Ten or twenty or even thirty years of historical data will not adequately capture the true underlying probability of a hurricane making landfall. In addition, for smaller geographical areas such as rating territories, 98 or even 122 years will not capture the true underlying frequency potential.

In their paper, Messers. Hays and Farris state that we can adjust for hurricane frequency. Essentially, their method adjusts the observed frequency for a finite number of years of rate making data to a long term frequency. The "adjusted" frequency is then applied to "current level" losses for each hurricane in the experience period. This procedure is clearly better than blindly using ratemaking data, yet it is still inadequate. Strictly from a frequency perspective, this adjustment method may produce appropriate frequency estimates for large geographic regions. However, if used for smaller geographic areas such as rating territories, even 122 years of data is not enough to capture the true underlying frequency. This method will also fail to account for new and unique landfalls. More importantly, this frequency adjustment does not account for the even greater variation in storm severity and the impact of a changing exposure base.

Severity

Reliance on historical ratemaking data to price the hurricane peril fails to accurately reflect expected severity for two major reasons. These are a changing exposure base and the large variation in severity of hurricanes. Several authors have presented possible techniques to adjust for the changing exposure base. I will not specifically comment on the adjustments suggested. However, in general if historical traditional ratemaking data is used in pricing the hurricane peril, the issue of a changing exposure base requires attention by the ratemaking actuary.

Traditional ratemaking techniques developed a catastrophe provision by using historical ratios of catastrophe losses to non-catastrophe losses. More recently I have seen the catastrophe provision calculated by comparing catastrophe losses to amount of insurance years. The second method is more responsive to one aspect of a changing exposure base (i.e. total amount of insurance). However, neither of these methods can properly capture the expected loss of the hurricane peril.

No book of business stays the same over a 10 year period, let alone 20 or 30 years. For illustrative purposes, assume you are using 25 years of actual insurance ratemaking data to price the hurricane peril. Assume further that the only hurricane to produce losses in this period in the state being priced was Zelda, a category 3 storm 20 years ago. Would the exact same storm today cause the same insured losses relative to either non-catastrophe losses or amount of insurance years? The answer is no.

A company's distribution of business by distance to the coast changes over time. The amount of insured damage Zelda caused twenty years ago is known, and it is related to the amount of business that was in areas of high winds. If a greater percent of the total business is closer to the coast today than it was when Zelda made landfall, then the loss per exposure will be greater (all other things equal). The loss per exposure will be less, if a lower percent of the total business is closer to the coast than it was at the time of Zelda.

Population density in coastal areas is increasing. Since windspeeds of a hurricane are greater closer to the coast, and the number of dwellings closer to the coast is increasing, it follows that solely because of this factor Zelda will cause more damage today than it did twenty years ago.

The type and quality of construction change over time. This can have both positive and negative effects on the amount of damage Zelda will cause today relative to 20 years ago. Building materials are different today, some of which are more wind resistant and some are less. Building codes change over time, as does their enforcement. If Zelda were to make landfall today it would have a different effect on any dwelling built in the last twenty years than is captured in the loss data from twenty years ago.

The amount and type of coverage provided in a policy change over time. Recent examples include guaranteed replacement cost, law and ordinance coverage, and exclusions to non-attached structures. There has also been a movement to higher wind-only deductibles or hurricane-only deductibles. These include both percentage options and higher dollar deductibles. Any of these changes to coverage will make the losses caused by Zelda less predictive of the potential loss for today's book of business. The true exposure to the hurricane peril in a current book of business can be far different than it was twenty years ago. While adding more years of experience may improve the ability to estimate hurricane frequency, it will also introduce significant exposure changes.

The changing exposure base issues are important reasons historical ratemaking data is inappropriate for pricing the hurricane peril. Just as important is the potential variation in the strength of a hurricane and how much damage a single storm will cause. History tells us that hurricanes making landfalls vary in strength from Category 1 storms with sustained wind speeds of 74 mph to Category 5 storms like Camille with sustained wind speeds in excess of 150 mph. At any given landfall, a full spectrum of possible storm strengths exists, which translate into a tremendous range of possible damage to property. Even within a given Saffir/Simpson category of storms, other factors also introduce variability into the potential total damage to property. These include the radius of maximum winds, track direction, forward speed and surrounding meteorological conditions. Additionally, similar storms can cause significantly different damage to property when they make landfall at different locations. This is where factors such as population density, building codes, construction quality, terrain, and other geographic features come into play. In any given state it would take thousands of storm observations to begin to approach a sample of storms that reflected the true potential distribution of storm severity over all potential landfalls.

Each hurricane is unique. No two storms, no matter how similar, will cause the same amount of damage relative to the exposure base. In a 25 year traditional ratemaking data base, will one storm such as Zelda be representative of potential future hurricane damage in the state? Can one or two, or even ten storms in a given experience period ever truly reflect the complete spectrum of possible event severity? Absolutely not.

South Carolina history is a good example of the problems with using historical data and methods to price the hurricane peril. If property insurance rates made in 1988 in South Carolina included a catastrophe provision based on 25 years of insurance data, the only hurricane reflected in the rates would have been Bob, a small category 1 storm in 1985. The next year Hurricane Hugo made landfall just north of Charleston as a category 4 storm resulting in unprecedented property damage.

<u>Loss Costs</u>

Before addressing the solution, there is one other problem with using traditional ratemaking techniques and data. Using historical insurance ratemaking data to price the hurricane peril can cause large swings in rates simply because a significant event occurred in the recent past. The best example of this is Hurricane Andrew. Using data from a 1991 Allstate rate filing, I have estimated the impact on rates the year before and after Andrew. The average premium for homeowners insurance in Florida prior to Andrew was approximately $260. Of this, $4 was the provision for the hurricane peril. The catastrophe provision was based on twenty years of data, a period when there were no major hurricane losses. The catastrophe provision was calculated by using a ratio of catastrophe losses to non-catastrophe losses. If the same rate level indication methodology was used, only updating for one additional year of catastrophe data, the indicated average rate would be $434, including a hurricane provision of $170. The true underlying loss cost for a given exposure does not change when a hurricane makes landfall. Our actuarial techniques need to change.

More History

Before concluding, there are two more references I would like to make. In 1981, David A. Arata wrote, "This paper argues that computer simulation is an underappreciated and, therefore, underutilized casualty actuarial resource".[17] Further in his paper Mr. Arata wrote, "Computer simulation can also be used to improve pricing of exposures for which historical information is unavailable or not indicative of future experience."[18] The second published paper, "A Formal Approach to Catastrophe Risk Assessment in Management", written by Karen M. Clark makes the following conclusion: "The model-generated expected loss estimates can be used to calculate Catastrophe premium loadings."[19] As early as 1981 the concept of using models to help ratemakers price insurance products was contained in the Proceedings of the CAS. For the next decade actuaries continued to rely on the historical techniques using historical ratemaking data to price the hurricane peril.

Conclusion

After considering the techniques currently used to price the hurricane peril, I conclude that the only tool available that captures a reasonable estimate of average annual costs is a computer simulation model. From a frequency perspective, short periods of historical data do not give accurate estimates of

[17] David A. Arata, FCAS, "Computer Simulation and the Actuary: A study in Realizable potential," PCAS LXVIII, 1981, Page 24.
[18] Ibid., page 43.
[19] Karen M. Clark, "A Formal Approach to Catastrophe Risk Assessment in Management," PCAS LXXIII, 1986, page 88.

the true underlying storm frequency. This problem exists on a statewide basis, but is even more acute for rating territories.

Also, new and unique landfalls are not captured by using historical experience. Computer simulation models can adequately address these issues.

The 98 year history of storm frequency displayed in Exhibits 1 through 10 demonstrates that there is great year to year variation in hurricane landfall frequency at all levels of geographic detail. I conclude that all available hurricane data should be used to compute hurricane frequency. This is easily accomplished in a hurricane simulation model. Any good model will incorporate a probability distribution at many landfall locations that is derived from the available history. The models can easily reflect the fact that new and unique landfalls are possible. Estimates for geographic areas as small as rating territories will be accurate if enough iterations are accounted for in the model.

From a severity perspective, the major problems with using a limited period of historical data to price the hurricane peril are a changing exposure base and the almost infinite possible severity of storms. Under the category of changing exposure base are the issues of distance to coast, density, coverage in force, type of construction, building codes, enforcement of building codes and policy provisions. Computer simulation models are able to eliminate or account for all of the problems associated with a changing exposure base.

Exposure changes over time become moot because the current distribution of business is the input for any model. Thus, the model output is reflective of the current distribution of business. The issues of distance to coast, density and coverage in force changing over the experience period become non-issues because all model output is reflective of the current book of business.

The models can account for type of construction, the effect of new construction and building codes, and the enforcement of building codes. These factors impact damage ratios for individual buildings in different ways. As an input to computer models, geo-coding of a company's current book of business will allow the impact of these factors on individual buildings to be reflected . Changes in policy provisions are also easily handled by models. The models can be run for current policy provisions and can also be run to estimate the impact of changes in policy provisions by comparing the output of different input assumptions. In fact, the models can be used to approximate the value of any type of mitigation effort.

Most importantly the problems of variation in severity are easily overcome by computer simulation models. A whole spectrum of possible storms with a full range of severities can be generated at any landfall. There is no longer a need to base a rate on only one or two observations.

The problem of rate instability discussed in the loss cost section is solved by using computer simulation models. If properly incorporated into base rates, the hurricane portion of individual rates based on computer simulation models will be stable. The occurrence of a major storm will not cause large rate increases, as it would if actual data were used to make rates.

Our profession has been extremely slow to react to a problem first documented in our literature in 1951. An analogy comes to mind between any ratemaker that continues to rely on historical ratemaking data and techniques and the ostrich that sticks its head in the sand. The time to change our methodology is now.

Ref: 9197draftpaper

EXHIBIT 1

LANDFALLING HURRICANES 1899-1996
EASTERN AND GULF COASTS OF THE UNITED STATES

YEAR	SAFFIR/SIMPSON CATEGORY 1	2	3	4	5	TOTAL HURRICANES	MAJOR HURRICANES
1899		1	1			2	1
1900				1		1	1
1901	1	1				2	0
1902						0	0
1903	2	1				3	0
1904	1					1	0
1905						0	0
1906	1	1	2			4	2
1907						0	0
1908	1					1	0
1909			2	1		3	3
1910		1	1			2	1
1911	1	1				2	0
1912	2					2	0
1913	2					2	0
1914						0	0
1915	1			2		3	2
1916	3	1	2			6	2
1917			1			1	1
1918			1			1	1
1919				1		1	1
1920	1	1				2	0
1921		1	1			2	1
1922						0	0
1923	1					1	0
1924	2					2	0
1925	1					1	0
1926		1	2	1		4	3
1927						0	0
1928		1		1		2	1
1929	1	1	1			3	1
1930						0	0
1931						0	0
1932	1			1		2	1
1933	1	1	3			5	3
1934		1	1			2	1
1935		2			1	3	1
1936	1	1	1			3	1
1937						0	0
1938	1		1			2	1
1939	2					2	0
1940		2				2	0
1941		2	1			3	1
1942	1		1			2	1
1943		1				1	0
1944	1		3			4	3
1945	1	1	1			3	1
1946	1					1	0
1947	2	1	1	1		5	2
1948	1	1	1			3	1
1949	1	1	1			3	1
1950	1		2			3	2
1951						0	0
1952	1					1	0
1953	2					2	0
1954	1	1	2	1		5	3

LANDFALLING HURRICANES 1899-1996
EASTERN AND GULF COASTS OF THE UNITED STATES

	SAFFIR/SIMPSON CATEGORY					TOTAL	MAJOR
YEAR	1	2	3	4	5	HURRICANES	HURRICANES
1955	1		2			3	2
1956		1				1	0
1957				1		1	1
1958						0	0
1959	2		1			3	1
1960	1		2	1		4	3
1961				1		1	1
1962						0	0
1963	1					1	0
1964		3	1			4	1
1965			2			2	2
1966	1	1				2	0
1967			1			1	1
1968		1				1	0
1969	1				1	2	1
1970			1			1	1
1971	2	1				3	0
1972	2					2	0
1973						0	0
1974			1			1	1
1975			1			1	1
1976	1					1	0
1977	1					1	0
1978						0	0
1979	1	2	1			4	1
1980			1			1	1
1981						0	0
1982						0	0
1983			1			1	1
1984			1			1	1
1985	3	1	3			7	3
1986	2					2	0
1987	1					1	0
1988	1					1	0
1989	2			1		3	1
1990						0	0
1991		1				1	0
1992			1	1		2	2
1993						0	0
1994						0	0
1995	1	1	1			3	1
1996		1	1			2	1
TOTAL	64	40	55	15	2	176	72

EXHIBIT 2

U.S. HURRICANE LANDFALLS BY DECADE 1900 THROUGH 1996

DECADE	SAFFIR/SIMPSON CATEGORY					TOTAL	MAJOR
	1	2	3	4	5	HURRICANES	HURRICANES
1900's	6	3	4	2	0	15	6
1910's	9	3	5	3	0	20	8
1920's	6	5	4	2	0	17	6
1930's	6	5	6	1	1	19	8
1940's	8	9	9	1	0	27	10
1950's	8	2	7	2	0	19	9
1960's	4	5	6	2	1	18	9
1970's	7	3	4	0	0	14	4
1980's	9	1	6	1	0	17	7
1990's	1	3	3	1	0	8	4
TOTAL	64	39	54	15	2	174	71

EXHIBIT 3

U.S. HURRICANE LANDFALLS BY STATE
1899 THROUGH 1996

STATE	SAFFIR/SIMPSON CATAGORY 1	2	3	4	5	TOTAL HURRICANES	MAJOR HURRICANES
TEXAS	12	6	9	5		32	14
LOUISIANA	9	4	9	3		25	12
MISSISSIPPI			1		1	2	2
ALABAMA	3	1	2			6	2
FLORIDA	19	19	17	5	1	61	23
GEORGIA		2				2	0
SOUTH CAROLINA	5	3	3	2		13	5
NORTH CAROLINA	10	4	8			22	8
VIRGINIA						0	0
MARYLAND						0	0
DELAWARE						0	0
NEW JERSEY	1					1	0
NEW YORK	2		5			7	5
CONNECTICUT						0	0
RHODE ISLAND		1				1	0
MASSACHUSETTS	1		1			2	1
NEW HAMPSHIRE						0	0
MAINE	2					2	0
TOTAL	64	40	55	15	2	176	72

TEXAS HURRICANE LANDFALLS BY DECADE 1900 THROUGH 1996

	SAFFIR/SIMPSON CATAGORY					TOTAL	MAJOR
DECADE	1	2	3	4	5	HURRICANES	HURRICANES
1900's	0	0	1	1	0	2	2
1910's	2	1	1	2	0	6	3
1920's	1	1	0	0	0	2	0
1930's	1	1	1	1	0	4	2
1940's	2	3	2	0	0	7	2
1950's	1	0	0	0	0	1	0
1960's	1	0	1	1	0	3	2
1970's	1	0	1	0	0	2	1
1980's	3	0	2	0	0	5	2
1990's	0	0	0	0	0	0	0
TOTAL	12	6	9	5	0	32	14
AVERAGE	0.124	0.062	0.093	0.052	0.000	0.330	0.144
1970-1996	4	0	3	0	0	7	3
AVERAGE	0.148	0.000	0.111	0.000	0.000	0.259	0.111
HIGH*	4	5	3	1	0	13	4
AVERAGE	0.133	0.167	0.100	0.033	0.000	0.433	0.133
LOW*	3	0	2	1	0	6	3
AVERAGE	0.100	0.000	0.067	0.033	0.000	0.200	0.100

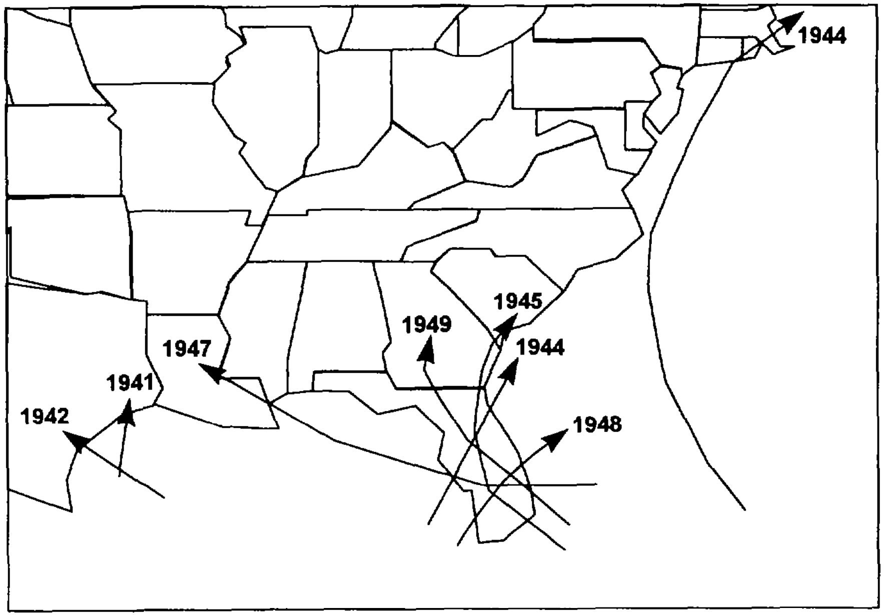
*Based on total hurricane landfalls for three consecutive decades

SOUTH CAROLINA HURRICANE LANDFALLS BY DECADE
1900 THROUGH 1996

DECADE	SAFFIR/SIMPSON CATAGORY 1	2	3	4	5	TOTAL HURRICANES	MAJOR HURRICANES
1900's	1	0	1	0	0	2	1
1910's	1	1	0	0	0	2	0
1920's	0	0	0	0	0	0	0
1930's	0	0	0	0	0	0	0
1940's	0	1	0	0	0	1	0
1950's	2	0	1	1	0	4	2
1960's	0	0	0	0	0	0	0
1970's	0	0	0	0	0	0	0
1980's	1	0	0	1	0	2	1
1990's	0	0	1	0	0	1	1
TOTAL	5	2	3	2	0	12	5
AVERAGE	0.052	0.021	0.031	0.021	0.000	0.124	0.052
1970-1996	1	0	1	1	0	3	2
AVERAGE	0.037	0.000	0.037	0.037	0.000	0.111	0.074
HIGH*	2	1	1	1	0	5	2
AVERAGE	0.067	0.033	0.033	0.033	0.000	0.167	0.067
LOW*	0	1	0	0	0	1	0
AVERAGE	0.000	0.033	0.000	0.000	0.000	0.033	0.000

Based on total hurricane landfalls for three consecutive decades

MAJOR U.S. HURRICANES

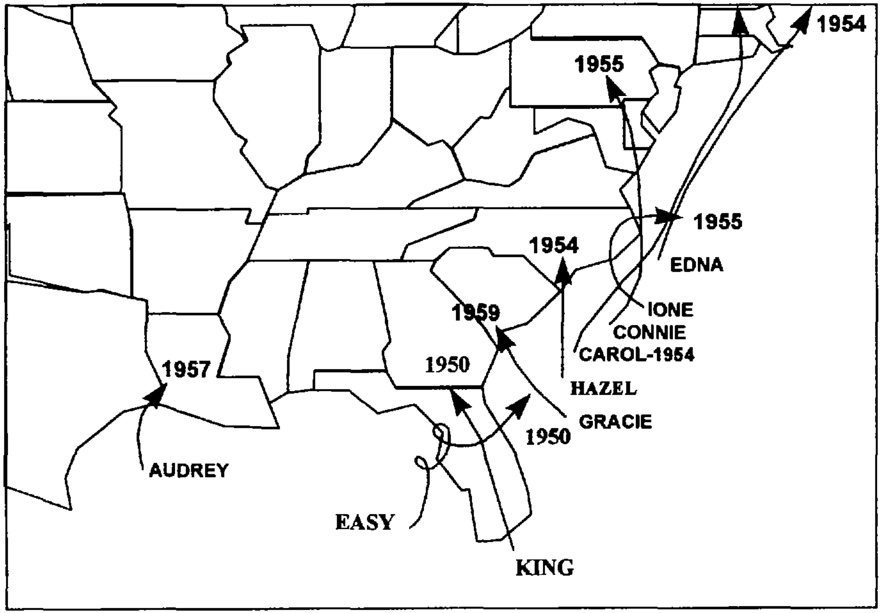


1940-1949

Major Hurricanes Defined As Saffir-Simpson Categories 3, 4 and 5

EXHIBIT 7

MAJOR U.S. HURRICANES

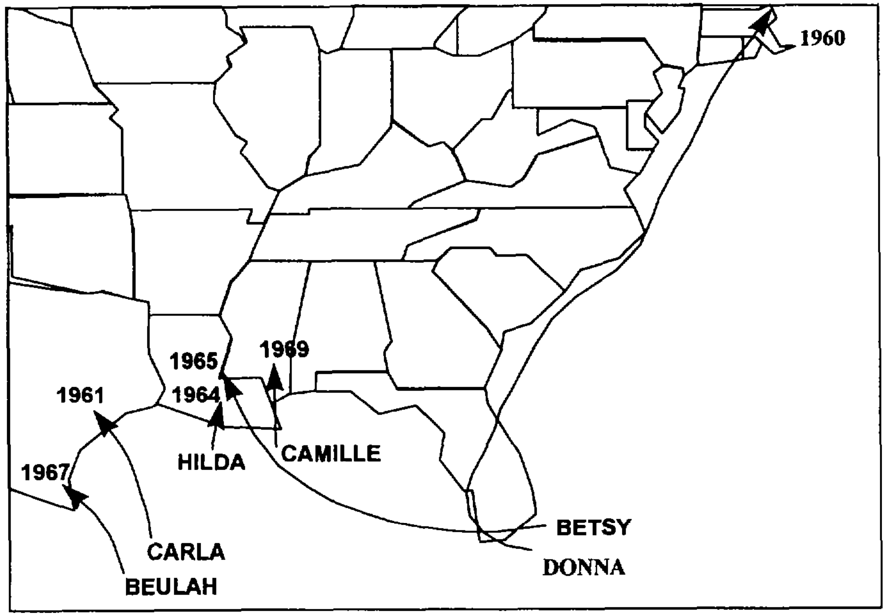


1950-1959

Major Hurricanes Defined As Saffir-Simpson Categories 3, 4 and 5

EXHIBIT 8

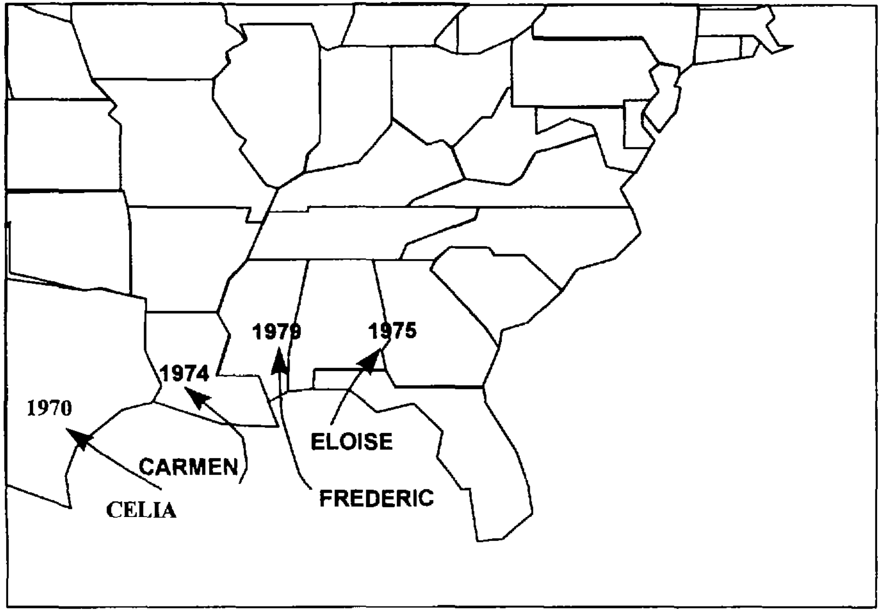
MAJOR U.S. HURRICANES



1960-1969

Major Hurricanes Defined As Saffir-Simpson Categories 3, 4 and 5

MAJOR U.S. HURRICANES

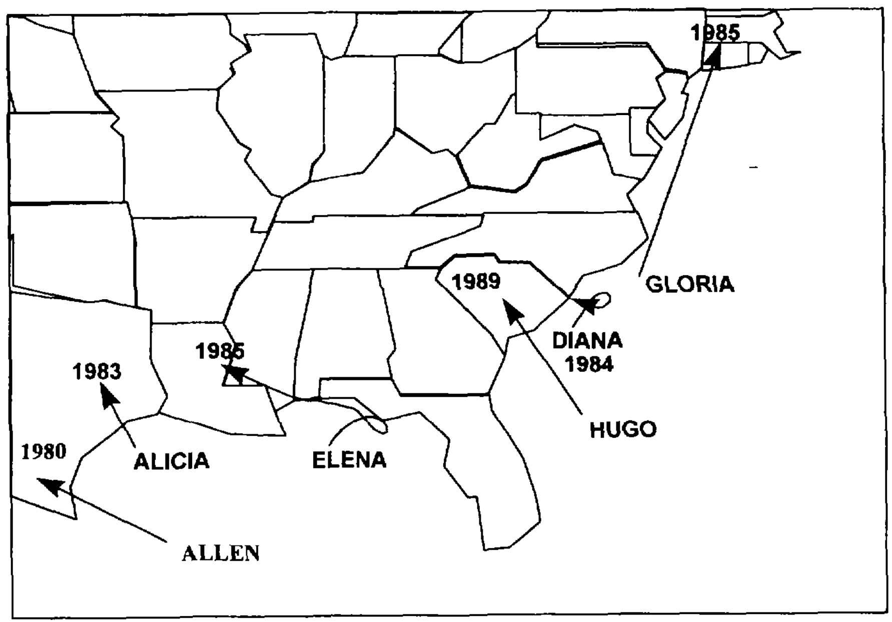


1970-1979

Major Hurricanes Defined As Saffir-Simpson Categories 3, 4 and 5

EXHIBIT 10

MAJOR U.S. HURRICANES



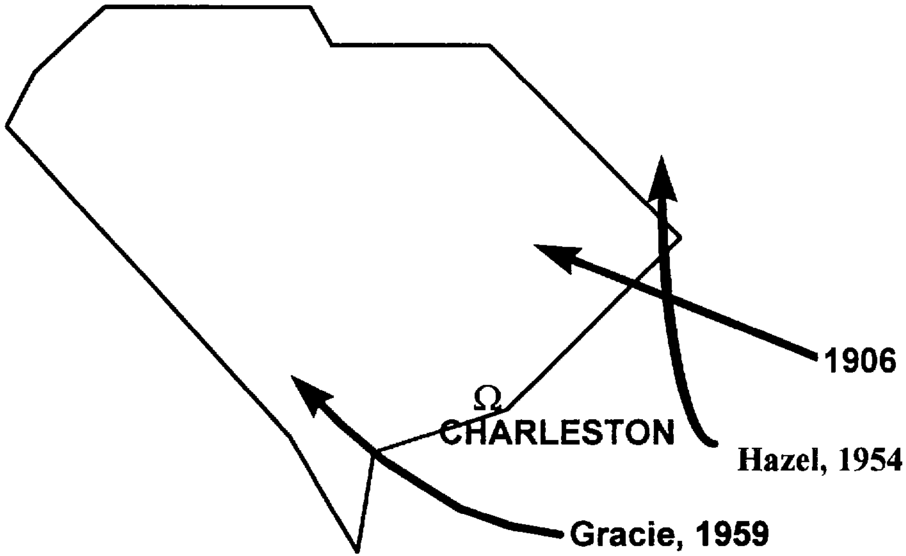
1980-1989

Major Hurricanes Defined As Saffir-Simpson Categories 3, 4 and 5

EXHIBIT 11

LANDFALL FREQUENCY MAJOR SOUTH CAROLINA HURRICANES

AS OF 1988

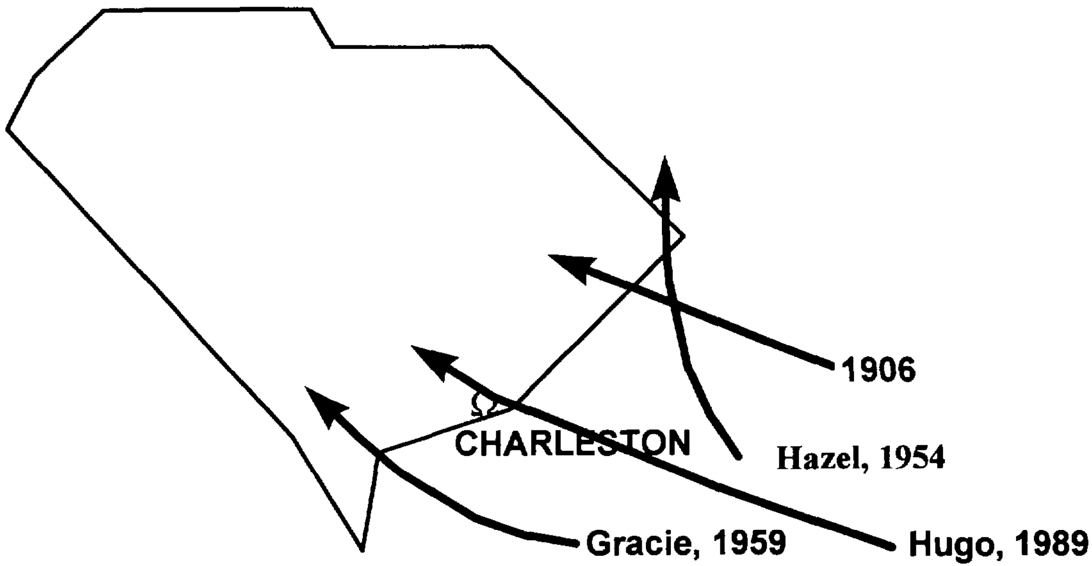


Major Hurricanes Defined As Saffir-Simpson Categories 3, 4 and 5

EXHIBIT 12

LANDFALL FREQUENCY MAJOR SOUTH CAROLINA HURRICANES

AS OF 1989



Major Hurricanes Defined As Saffir-Simpson Categories 3, 4 and 5