10A.1 UNITED STATES LANDFALLING HURRICANE PROBABILITY WEBPAGE

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1. INTRODUCTION

The United States landfalling hurricane probability webpage was created to provide high wind probabilities for the entire United States coastline from Brownsville, Texas to Eastport, Maine. Many individuals along the coastline are unaware of the probabilities of being affected by a hurricane landfall in a given year, and this webpage provides them with this information based on historical landfalls during the 20th century. The webpage is a joint project between the Tropical Meteorology Research Project of Prof. William Gray at Colorado State University and the GeoGraphics Laboratory at Bridgewater State College. It went live on June 1, 2004 and is available at http://www.e-transit.org/hurricane.

2. STORM LANDFALL PROBABILITIES

Climatological probabilities of a named storm, hurricane, and major (Category 3-4-5) hurricane making landfall have been calculated for eleven regions (Figure 1) along the United States coastline based upon major hurricane landfall frequency during the 20th century.

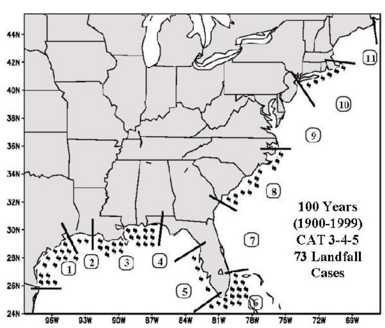

Figure 1: The eleven coastal regions for which landfall probabilities have been calculated.

Intensities of storms at landfall are taken from the Atlantic HURDAT files (Jarvinen et al. 1984). The total number of named storms, hurricanes and major hurricanes making landfall for each region were tabulated. Then the probabilities of landfall were calculated utilizing a Poisson distribution, since more than one storm can make landfall in a hurricane season.

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3. SUSTAINED WIND PROBABILITIES

Probabilities of tropical storm-force, hurricane-force, and major hurricane-force winds were created for each of the eleven coastal regions. In addition, these eleven coastal regions were subdivided into 55 subregions based upon population density, and these subregions were further divided into 205 coastal and near-coastal counties.

Maximum wind speeds at landfall were taken from the Atlantic HURDAT database. For hurricanes from 1851-1914 and 1980-2004, maximum landfalling wind speeds were taken from the HURDAT database (available online at http://www.aoml.noaa.gov/hrd/hurdat/ushurrlist.htm). For 1915-1979, landfalling wind speeds were interpolated from the Saffir-Simpson category listed in the HURDAT database at landfall.

For tropical storm landfalls from 1851-1914, maximum landfalling wind speeds were taken from the HURDAT database. For 1915-1994, tropical storm landfall intensities were taken from the 6-hour intensity of the storm prior to landfall, and from 1995-2004, tropical storm landfall intensities were taken from the National Hurricane Center Tropical Cyclone Reports.

Wind swath radii were calculated based upon the storm's intensity at landfall. This is a very crude approximation, since a tropical cyclone's wind radii are only marginally correlated with its intensity (Weatherford and Gray 1988). However, when considering all landfalling tropical cyclones over the entire 20th century, it was considered to be reasonable. Wind radii were calculated using the following equation:

$$V_T r^x = \text{constant} \quad (1)$$

where V_T is the maximum wind at landfall, r is the radius from the center of the storm, and x is a constant which is defined to be 0.5 for hurricane-force winds and 0.65 for major hurricane-force winds. Figure 2 displays the wind speeds at various radii away from the center of tropical cyclones using the above-discussed approximation. The radii of tropical-storm force winds are assumed to be three times the radii of hurricane-force winds.

Utilizing these approximations, damaging wind swaths for all tropical cyclones making landfall in a region were calculated. Then all swaths were summed and divided by the coastline length of the region to determine the climatological probability of each region receiving winds of tropical storm-force, hurricane-force and major hurricane-force.

Likewise, for the probability of each subregion and county being affected by damaging winds, the region probability was divided by the ratio of the coastline distance of the region to the coastline distance of the subregion or county.

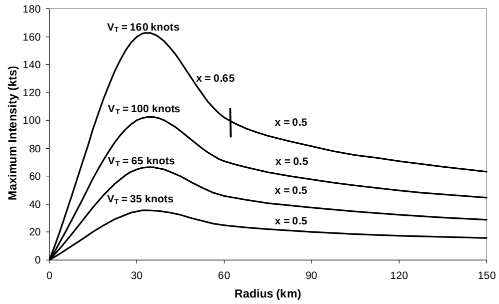

Figure 2: Intensity of winds at various radii away from the center of tropical cyclones with maximum intensities of 35, 65, 100 and 160 knots respectively.

4. VICINITY AND 50-YEAR PROBABILITIES

Probabilities of being in the vicinity of damaging winds are calculated due to the fact that there is considerable uncertainty in tropical cyclone intensity and track prediction. Because of this, tropical storm and hurricane watches and warnings are often issued for larger areas than actually experience winds of a particular force. Also, individuals located near a watch or warning area may take some hurricane preparations as a precautionary measure.

Vicinity probabilities for a region and subregion are calculated by taking the probability of actually receiving winds of a particular force and multiplying that value by 9. Then these probabilities are fit to a Poisson distribution to obtain the final values. Each county in a subregion has the same vicinity probability as the subregion itself, since all counties in a subregion are within the vicinity of the storm.

50-year probabilities are also provided, since the probability of being affected by a storm in any one year is quite small. However, when considering construction of a home or business, longer periods need to be taken into account. The 50-year probability is calculated using the following formula:

$$\text{50-Year Prob.} = 1 - (1 - \text{One-Year Prob.})^{50} \qquad (2)$$

5. CURRENT-YEAR PROBABILITIES

Perhaps the most powerful part of the United States landfalling hurricane webpage is the current-year probabilities. These probabilities are calculated based upon the latest forecast of Net Tropical Cyclone (NTC) activity (Gray et al. 1994) as well as a weighted measure of current and prior-year North Atlantic sea surface temperatures in the area from 50-60°N, 10-50°W. NTC is an aggregate measure of total seasonal activity. The premise behind using NTC to weigh landfall probabilities is that the more activity there is in the Atlantic, the more likely a storm is to make United States landfall. Also, it is generally found that when North Atlantic sea surface temperatures are warmer than normal, the Atlantic thermohaline circulation is running strongly (Goldenberg et al. 2001). When this is the case, hurricane landfall is more likely. For the webpage display, current-year probabilities are presented to the left of the climatological probabilities which are given in parentheses. Figure 3 shows the way that the data is currently presented.

Subregion:1	2c
Subregion - Coastline Distance (km)	145
Subregion - 2000 Population	337,671
Subregion - Prob. TS Force	8.9% (7.7%)
Subregion - Prob. TS Vicinity	55.0% (50.0%)
Subregion - 50 Year TS Prob.	98.2%
Subregion - Prob. H Force	2.0% (1.7%)
Subregion - Prob. H Vicinity	16.3% (14.3%)
Subregion - 50 Year H Prob.	58.0%
Subregion - Prob. IH Force	0.2% (0.2%)
Subregion - Prob. IH Vicinity	1.9% (1.7%)
Subregion - 50 Year IH Prob.	8.9%

Figure 3: Example of data currently available for subregion 2C (western Louisiana) from the United States landfalling hurricane webpage.

6. FUTURE WORK AND CONCLUSIONS

In the next few months, we intend to implement additional functionality by creating weekly and monthly probabilities. An interface is planned where the user can select a time period and county and obtain the odds of landfall during the specified period.

The United States landfalling hurricane webpage provides a powerful tool for coastal residents and emergency managers to determine current-year and climatological probabilities of being affected by a tropical cyclone. Since its inception in June of 2004, it has received over 500,000 hits.

7. REFERENCES

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