P2H.5 THE EFFECTIVENESS OF MEASURED AND DERIVED TROPICAL CYCLONE PARAMETERS IN PREDICTING COASTAL DAMAGE

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1. INTRODUCTION

Recent hurricanes have exposed shortfalls of the Saffir-Simpson hurricane scale (SS) in gauging the severity of tropical cyclone (TC) impacts at landfall. The SS uses a single intensity measurement taken at one location within a TC to describe a storm covering thousands of square miles. Considering TC size, structure, forward speed, strength, alternate measures of intensity, and the persistence of these variables prior to landfall might prove crucial in building a more effective rating scale.

2. DATA & METHODS

This study examines 26 unique atmospheric parameters and the persistence of these parameters up to 3 days prior to TC landfall in storms from 1988-2005. The aim of this research is to determine each parameter's effectiveness at predicting TC damage costs in affected coastal counties. Raw data for this study were obtained from the Extended Best Track (EBT) dataset (DeMaria et al 2004).

Table 1 shows how all atmospheric parameters can be categorized as either intensity parameters, which describe the power of a TC, or size parameters, which describe the extent of a TC's effects. A third group of duration parameters describe the persistence of intensity and size parameters. Duration parameters are formed by averaging subsequent six-hourly observations of each atmospheric parameter within one of four duration periods defined as follows: 24-48 hours prior to landfall, 48-72 hours, 24-72 hours, and 36-72 hours. To insure equal weight is given to each observation, data from TCs missing one or more observations from a given duration period are eliminated from the study.

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Pielke and Landsea (1998) and Pielke et al (2008) provide a method of normalizing TC damage costs to current U.S. dollars to compare TCs from different years on an equal-value dollar. A series of multipliers accounts for changes in inflation (I_y), changes in personal wealth ($RWPC_y$), and changes in population ($P_{2005/y}$) in affected coastal counties since a given TC has occurred. In the following formula, D_y represents damage costs in dollars for the year the TC occurred, while D_{2005} denotes the dollar value of TC damages in 2005 dollars.

$$D_{2005} = D_y * I_y * RWPC_y * P_{2005/y} \quad (1)$$

Scatterplots for this study are generated by plotting normalized TC damage totals (y) against intensity, size, and duration parameters (x). Individual points represent TCs in the EBT. The scatterplots are subjected to regression tests for a comparative analysis.

Intensity Parameters	**Description**
Maximum Wind Speed	V_{max}
Forward Speed	(m s^{-1})
Mean Pressure Gradient	(POCI – P_{min}) / ROCI
Strength	Azimuthally averaged wind speed from 100 km to 250 km
Quadrant Strength	NE, SE, SW, NW
Size Parameters	**Description**
Radius of the Eye	REYE
Radius of Maximum Wind	RMW
Radius of Outermost Closed Isobar	ROCI
Symmetrical Size Parameters	R17, R26, R33
Quadrant Size Parameters	R17, R26, and R33 for NE, SE, SW, and NW

Table 1 lists all atmospheric parameters contained in or derived from the EBT.

3. RESULTS

The coefficients of determination (r^2) from fit lines in the V_{max} plot at landfall (0 hours) are compared with r^2 values from other parameters. The mean pressure gradient at 18 hours (prior to landfall) is a superior predictor of storm damages (linear r^2 = 0.33) compared to 0-hour V_{max} (linear r^2 = 0.24); quadratic and cubic fit lines for these two plots show similar trends. While no single parameter is isolated as a better predictor of TC damage at the 0-hour time than V_{max}, when considering measurements from the most destructive TCs in the EBT, several parameters demonstrate superior predictive quality two to three days prior to landfall when intensity provides no nuance of a TC's future structural changes or damage potential.

At two and three days prior to landfall (24-72 hours), the most destructive TCs have small wind radii (ROCI ≤ 400 km) and moderate strength (20 – 30 m s^{-1}). The mean pressure gradient ranges from 0.1 – 0.225 hPa km^{-1}, and V_{max} has exceeded hurricane strength.

Major structural changes occur in the costliest TCs in the last day prior to landfall (0-24 hours). A loosening of the mean pressure gradient is observed in all of these TCs except Andrew (1992) and Charley (2004), which show a tightening in their pressure gradients. Vmax increases beyond 45 m s^{-1} in all TCs, and size parameters show a general broadening of the wind field (Figures 1-2). Omitting Charley and Andrew, ROCI values range from 400 to 700 km; these two storms are small outliers.

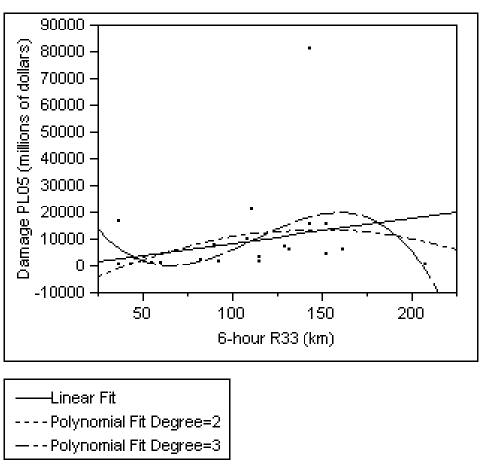

Figure 1: R33 at 6 hours before landfall vs. normalized damages.

The most destructive TCs in this study are experiencing either weakening or rapid strengthening upon landfall. During these transformation phases, often caused by dry air entrainment and / or baroclinic interaction, the western side of a TC is more likely to undergo structural changes than the eastern side.

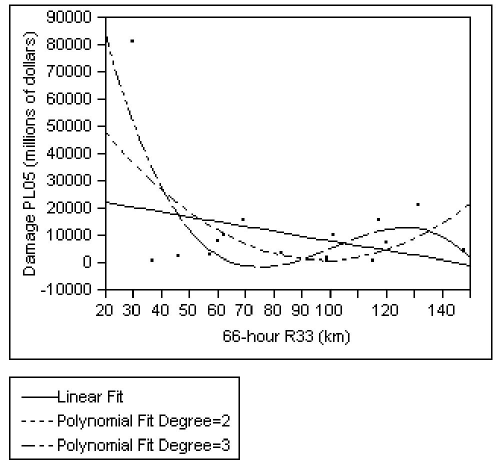

Figure 2: R33 at 66 hours before landfall vs. normalized damages.

Tables 2-3 show that better correlation does in fact exist between damage totals and western size parameters than between damage totals and eastern size parameters. Therefore, the phase of a TC's life cycle may be more indicative of a storm's damage potential than the strength or intensity on its eastern flank.

Fit Type	24-48 hours	48-72 hours	24-72 hours	36-72 hours
Linear	2.8	0.08	6.85	0.5
Quadratic	3.5	13.94	11.04	13.22
Cubic	9.41	14.52	11.4	16.67

Table 2: Coefficients of determination (r^2) for R26 southeast duration vs. normalized damages.

Fit Type	24-48 hours	48-72 hours	24-72 hours	36-72 hours
Linear	5.59	0.56	3.1	0.39
Quadratic	5.66	14.37	22.18	14.22
Cubic	11.16	18.83	25.22	15.19

Table 3: Coefficients of determination (r^2) for R26 southwest duration vs. normalized damages.

4. REFERENCES

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