298. A CLIMATOLOGY OF INFRARED-BASED TROPICAL CYCLONE WIND RADII, INTEGRATED KINETIC ENERGY, AND DAMAGE POTENTIAL

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1. INTRODUCTION

The destructive potential of a tropical cyclone and the storm intensity as typically measured by maximum wind speed or minimum central pressure are not necessarily well correlated. Currently described by the Saffir-Simpson Hurricane Scale, the intensity of a tropical cyclone can also be quantified in terms of the area-integrated kinetic energy (IKE) of the wind field. Where the area-integrated kinetic energy is computed as:

$$IKE = \int_V \frac{1}{2} \rho U^2 dV$$

This study examined IKE values using statistical approximations based on estimated wind radii from Kossin et al. (2007) where, in lieu of aircraft reconnaissance, storm wind structure was estimated from satellite data. The satellite data were used to compute azimuthally averaged brightness temperature profiles. The principal components of these profiles were then used to estimate the radii of various wind speeds based on linear regression against extended best track data. Future studies will use the entire two dimensional gridded wind fields to calculate IKE using the continuous equation instead of quadrant radii approximations.

IKE was calculated for each of 84,000+ observation points in tropical storms and tropical cyclones (1982 – 2006) within a buffer of 90 nm of land. The resulting maps are shown in Figure 1.

Both the customary measures of storm intensity and the structure of the wind field affect kinetic energy. As such, IKE captures the physical processes most relevant to a tropical cyclone's damage potential, namely the spatial effects of the wind and the shear stress of the wind on the ocean surface, driving storm surge and wave destruction.

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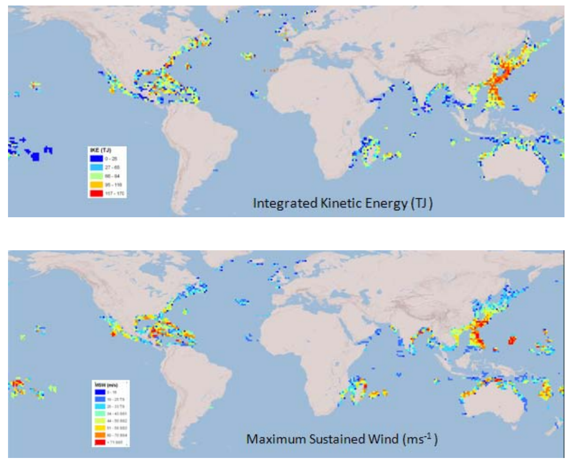

Figure 1: IKE and MSW calculated for 84,000+ points in TS and TC (1982-2006) within a buffer of 90 nm of landfall.

2. DAMAGE POTENTIAL

The damage process is extremely complex to estimate and depends on the interactions of the natural and built environments with the wind profile of the storm. The gust and lull cycles, turbulence structure and amount of debris are highly variable as are the inundation preparations, strengths of local building codes, enforcement of those codes and the interactions between all of these components. The direct losses of life and property and the indirect losses of use, power outages, and money depend on the population and wealth density in the area impacted by the storm. Forecasting the impacts from the wind begins with understanding the physical processes underlying the destructive processes.

Kinetic energy can be a useful predictor of wind damage because it is proportional to the wind load stressing the environment (ASCE, 2005.) The shear stress of the wind on the ocean is also proportional to the wind loading making IKE useful in predicting storm surge as well. In their 2007 article, Powell and Reinhold propose a continuous scale (ranging in values from zero to five) of Storm Surge and Wave Destruction Potential (SDP) based on IKE.

$$SDP = 0.676 + 0.43\sqrt{IKE_{TS}} - 0.0176(\sqrt{IKE_{TS}} - 6.5)^2$$

where (r^2=0.91, n=23.)

In the equation, the IKE of the tropical storm force wind field is calculated so as not to preclude the possibility that a large, strong tropical storm might engender a larger storm surge and wave threat than a smaller, weaker tropical cyclone.

Results using this regression equation are shown in the Storm Surge Damage Potential vulnerability map shown in Figure 2 below.

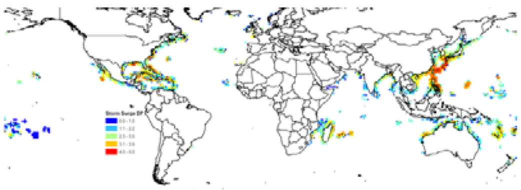

Figure 2:Storm Surge Damage Potential calculated for 84,000+ points in TS and TC (1982-2006) within a buffer of 90 nm of landfall.

3. RESULTS

Statistically speaking, the correlation coefficient of IKE and MSW is r^2=0.1000, n= 84,938. Storm intensity (wind speed) is important in predicting storm track and exposure, but an estimate of storm damage seems to depend on the area-integrated kinetic energy.

The Box Plot – Five-Number Summaries (in Figure 3) show the range of MSW to be 125 ms^{-1} with mean = 64, median = 55, and interquartile range = 70. For IKE, the range= 170 TJ, with a mean = 35, median = 28, and interquartile range = 86.

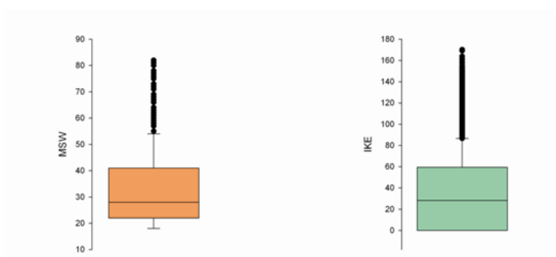

Figure 3: Box Plot – Five-Number Summaries showing the range of MSW to be 125 ms^{-1} with mean = 64, median = 55, and interquartile range = 70. For IKE, the range= 170 TJ, with a mean = 35, median = 28, and interquartile range = 86.

4. REFERENCES

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