Extreme Hurricane Winds in the United States

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Abstract

Coastal hurricanes create tremendous environmental change and generate huge financial losses. The relative infrequency of severe coastal hurricanes implies that empirical probability estimates of the next big catastrophe will be unreliable. Here we model hurricane activity and resulting insured losses using extreme value theory and Bayesian models.

The occurrence of a hurricane above a specified threshold intensity is assumed to follow a Poisson distribution and the distribution of the maximum wind is assumed to follow a generalized Pareto distribution. The likelihood function is the product of the generalized Pareto probabilities for each wind speed estimate. Model parameters are first estimated using a maximum likelihood (ML) procedure. Results estimate the 100-year return level for the entire coast at 157 kt (+/-10 kt), but at 117 kt (+/- 4 kt) for the East coast region. Highest wind speed return levels are noted along the Gulf coast from Texas to Alabama.

We also examine how the extreme wind return levels change depending on climate conditions including the El Nino-Southem Oscillation, the Atlantic Multidecadal Oscillation, the North Atlantic Oscillation, and global temperature. The mean 5-year return level during La Nina (El Nino) conditions is 125 (116) kt, but is 140 (164) kt for the 100-year return level. This indicates that La Nina years are the most active for the occurrence of strong hurricanes, but that extreme hurricanes are more likely during El Nino years. Although El Nino inhibits hurricane formation in part through wind shear, the accompanying cooler lower stratosphere appears to increase the potential intensity of hurricanes that do form.

To take advantage of older, less reliable, data the models are reformulate using Bayesian methods. Gibbs sampling is used to integrate the prior over the likelihood to obtain the posterior distributions for the model parameters conditional on global temperature. Warmer temperatures are conditionally associated with a greater frequency of strong hurricanes and higher return levels for the strongest hurricanes. Results compare favorably with a ML approach as well as with recent modeling and observational studies. The maximum possible near-coastal wind speed is estimated to be 208 kt (183 kt) using the Bayesian (ML) approach.

Although wind speed is directly related to damage potential, the amount of damage depends on both storm intensity and storm size (spatial extent). Insured losses provide a direct measure of storm damage. As anticipated we find climate conditions prior to the hurricane season provide information about possible future insured hurricane losses. We exploit this information to model the distribution of likely annual losses and the distribution of a worst case catastrophic loss aggregated over the entire U.S. coast.