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Predicting tornado count distributions by damage rating

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The science of forecasting where and when an outbreak of severe convective weather might occur is well developed. But more work is needed to anticipate specific characteristics of the outbreaks. Here we develop a statistical model that can be used to predict the probability distribution of tornado counts by damage (EF) rating on days expected to produce an outbreak of tornadoes. The model is fit using the historical tornado database in the United States and includes demographic data to condition on the fact that damage ratings are related to the number (and type) of damage targets. The model quantifies the importance of these data relative to data describing local environmental factors known to influence tornadoes, including convective available potential energy (CAPE) and bulk shear. As a test case, the model controls for distance to nearest city while quantifying the percent increase in the chance of at least one tornado rated EF3 or higher for a unit increase in CAPE and bulk shear. The model is an ordered logistic regression and the coefficients are determined using the method of Hamiltonian Monte Carlo with the Stan language. Stan code is generated from R through the 'rethinking' package. The flexibility of this approach allows easy modifications based on domain-specific knowledge.