Feasibility of Estimating Wind Speed from Tornado-Induced Vehicle Movements

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Current knowledge of tornado risk in the United States is largely based on indirect estimates of surface wind speeds from observations of tornado impacts to surface objects. This method is known as the Enhanced Fujita (EF) Scale, in which wind speeds have been related, through expert elicitation, to physical damage conditions (termed Degrees of Damage) observed to surface objects (termed Damage Indicators). Damage Indicators (DIs) include various types of buildings and even trees, but not vehicles despite their near ubiquitous distribution and high likelihood of being within the path of a tornado. Reliable wind speed estimates from vehicle behavior during tornadoes could potentially expand the number of available DIs in many tornado paths and improve tornado wind speed estimates and ensuing tornado climatology and risk-based assessments.

This study explores the feasibility of reliably estimating wind speeds from vehicle movements during extreme wind events using past experiments in a tornado simulator and observations from extreme wind events, namely the 2011 Joplin, MO tornado. The experimental work was performed by the first author (Haan et al. 2017) using the tornado simulator at Iowa State University, resulting in estimates of the wind speeds necessary to shift, flip or loft a typical minivan. The empirical analysis utilizes peak gust wind field maps of the Joplin, MO tornado developed by Lombardo et al. (2015) and 3 centimeter ground sampling distance imagery of the tornado damage path provided by Surdex Corporation. Using the aerial imagery, three transects are taken through the tornado path and shifted, flipped and lofted vehicles are identified and geospatially referenced. Over 600 vehicles were classified in this way. Using the location of the vehicle, the peak gust wind speed (3 second gust at 10 m height in open terrain) inducing the vehicle movement is estimated from the tree-fall conditioned wind field model. These data are used to develop empirically-based probabilistic models of tornado-induced vehicle movements for comparison against the experimental results.

The experimental and empirical analysis demonstrate considerable uncertainty in the wind speeds necessary to induce movement in vehicles. A number of factors contribute to this uncertainty, including weight and aerodynamics of the various vehicles, localized shielding and terrain, and presence of objects to restrict or alter vehicle movements. Ultimately the goal of this research is to produce identifiable DODs for vehicles with associated, reliable wind speed estimates for inclusion in a proposed Wind Speed Estimation Standards document. The feasibility of this goal in light of the observed uncertainties will be discussed.

References:

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