ESTIMATING NEAR-SURFACE TORNADIC WIND FIELD USING DAMAGE PATTERNS AND AN IDEALIZED TORNADO

Daniel M. Rhee*[1], Franklin T. Lombardo[1]

[1]University of Illinois at Urbana-Champaign, Urbana, IL 61801 USA

*rhee16@illinois.edu

In the past decades, tornadoes have been causing significant property damages and casualties in the United States. Consequently, tornado-based design has been gaining traction in the engineering community in recent years, which requires an accurate estimate of near-surface wind speed of tornado. However, despite the recent advancement of remote sensing technique, the near-surface wind speed estimation of tornado remains elusive due to ground clutter and signal blockage. Moreover, the current method using structural damage (e.g. Enhanced Fujita scale) is subjected to inconsistency due to the complicated relationship between wind speed and structural damage. As a result, a novel method of near-surface wind field estimate of tornadic wind speed is developed using tree and crop patterns. The method utilizes an idealized tornado model (e.g. Rankine Vortex) and its parameters that describe characteristics of tornado and trees. The observed tree damage is used to estimate parameters and a numerically simulated wind field of the tornado is then reproduced.

This study uses the above method to estimate near surface wind fields in different tornado cases. The post-storm observed tree-fall patterns of the EF-5 Joplin, MO and the EF-4 Tuscaloosa tornado were identified from aerial photos and ground survey was conducted for other cases to obtain the tree-fall pattern. In addition to tree-fall patterns, one tornado case displayed ‘soybean-fall’ patterns and yet another case failure of street signs were utilized in addition to tree damages. The near-surface wind fields of these tornado were estimated, and fragility functions of structural and tree damage are eventually established using the estimated wind speeds.