Modeling Evacuation Strategies in Response to Compound Hazards: Lessons Learned from a Major Hurricane Event in the US

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Hurricanes are among the most frequent and devastating natural disasters in tropical regions. These events often necessitate massive evacuations when warnings are issued, which often place a significant burden on transportation systems. The situation becomes even more complex and challenging when hurricanes coincide with other disruptive events, such as pandemics or compounded infrastructure damages. These compound scenarios not only dramatically increase community vulnerability but also add layers of complexity to emergency management, particularly in coastal communities with direct impacts. Understanding individual responses to such emergencies is vital for developing effective emergency management strategies. The focus of this study is to enhance our understanding of how individuals react and respond to emergencies in the face of such compound hazards. We concentrated specifically on the evacuation behaviors of residents in the state of Florida, U.S., during a major hurricane event. To this end, an activity-based model was developed. The model employs the Metropolis-Hastings algorithm, to generate a simulated population. The simulated population, characterized by diverse socioeconomic attributes, is designed to reflect the demographics and behaviors of the actual population in the study area. We integrated information from a local household hurricane evacuation survey and aggregated evacuation data to measure the evacuation decisions, timing, and destinations of individuals. We then applied the model to examine three distinct evacuation scenarios: a standalone hurricane, a hurricane coinciding with a pandemic, and a hurricane combined with storm surge flooding on the transportation systems. Our findings underscore the profound impact that compound hazards on transportation systems. We observed that the average travel time for evacuation could potentially double under compound hazard conditions. This highlights the potential inadequacy of current infrastructure resilience in handling complex emergency situations under compound hazards. This developed model offers valuable insights for assessing system-wide impacts of natural disasters in coastal regions and can be adapted for various scenarios to aid in disaster preparedness and response planning.