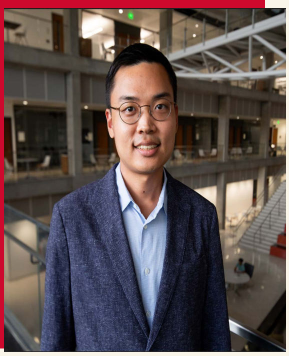
September 5, 2025

Modeling Coastal Flood Risk: From Physics-Based Simulations to Data-Driven Digital Twins



Jun-Whan Lee

Assistant Professor, University of Texas at Austin

Seminar Details

Friday, Sept 5, 2025

2:30pm – 4:00pm

UH Campus
Classroom & Business Building
Room CBB 104

Online via Teams https://www.cive.uh.edu/research/beyer-distinguished-lecture

ABSTRACT: Coastal flooding caused by hurricanes and tsunamis is among the most destructive natural hazards, placing growing coastal populations at increasing risk. To address the increased uncertainty and risk, digital twins have emerged as a promising solution. These dynamic virtual models integrate real-time data and simulations to support monitoring, prediction, and decision-making. However, creating effective digital twins requires flood models that are not only accurate but also rapid and reliable. Despite advances in computational power, no single modeling approach has fully achieved this balance. This seminar presents four research directions that advance toward this goal. The first is a physics-informed static flood model that can produce high-resolution coastal compound flood maps (5 m, more than 500 million cells) in under ten minutes, while reducing the systematic overestimation common in traditional static approaches through enhanced inundation algorithms and calibration methods. The second is a hybrid modeling framework that combines machine learning with static models to generate flood maps even when water level observations are unavailable. The third introduces a Shapley value–based framework for quantifying the spatiotemporal contributions of multiple flood drivers in hurricane-induced compound flooding, demonstrated with Hurricane Beryl (2024) in the Houston–Galveston region. The final research effort uses the Material Point Method to simulate interactions between coastal forests, waves, and debris, showing how natural features that can reduce flooding may simultaneously amplify damage through debris damming. Together, these efforts illustrate how physics-based simulations and data-driven methods can be integrated into coastal digital twins, moving us closer to resilient communities that can withstand the growing risks of coastal flooding.

BIOGRAPHY: Jun-Whan Lee is an Assistant Professor in the Maseeh Department of Civil, Architectural, and Environmental Engineering at The University of Texas at Austin. His research focuses on compound flood risk, with particular attention to extreme events such as hurricane-induced flooding and tsunamis. He integrates machine learning, numerical modeling, and remote sensing to advance real-time forecasting and flood assessment. His work also explores nature-based solutions, vulnerability analysis, and multi-hazard risk modeling to strengthen community resilience. By bridging engineering, socioeconomic perspectives, and disaster risk management, Dr. Lee advances fundamental knowledge that connects human systems, infrastructure, and the environment to reduce flood risk. Dr. Lee earned his Ph.D. in Civil and Environmental Engineering from Virginia Tech in 2021, following B.S. (2012) and M.S. (2014) degrees from Hanyang University in South Korea. From 2014 to 2017, he was a coastal hazard researcher at the National Institute of Meteorological Sciences in South Korea. After completing his doctorate, he served as a postdoctoral associate at the Center for Coastal Studies at Virginia Tech before joining UT Austin.