Ph.D. Defense Announcement
Erin Dougherty
June 26, 2020 at 10:00 a.m.

Erin Dougherty
Ph.D. Defense

Friday, June 26, 2020
10:00 a.m.

Defense
Virtually through Teams

Post Defense Meeting
Virtually

Committee:
Kristen Rasmussen (Adviser)
Eric Maloney
Russ Schumacher
Ryan Morrison (Civil and Environmental Engineering)

Characteristics of Current and Future Flood-Producing Storms in the Continental United States

Understanding the changes to extremes in the hydrologic cycle in a future, warmer climate is important for better managing water resources and preventing detrimental impacts to society. The goal of this dissertation is to contribute to this understanding by examining the precipitation and hydrologic characteristics of flood-producing storms in the current climate over the continental United States (CONUS) and how these will change in a future, warmer climate. Numerous storm types are responsible for floods over the CONUS so quantifying how their characteristics will change among a large number of flood-producing storms in the future provides a spectrum of possible changes and impacts to flood-prone regions across the country.

To understand flood-producing storms in the current climate over the CONUS, a climatology of these storms from 2002–2013 is created by merging storm reports, streamflow-indicated floods, and Stage-IV precipitation data. From this climatology, it is observed that flash flood-producing storms preferentially occur in the warm-season in the Mississippi River Basin, with intense rain rates and short durations. Slow-rise floods occur mostly during the cool-season, concentrated in the Ohio River Valley and Pacific Northwest, and are long-duration, low-intensity rainfall events. Hybrid floods, having characteristics of both flash and slow-rise flood-producing storms, tend to occur in the spring and summer notably in the central CONUS and Northeast, with moderate durations and rain rates. Examining these floods on a sub-basin scale in the Wabash and Willamette basins shows that precipitation and instantaneous streamflow correlations are spatially variable, with strong positive correlations in areas of complex terrain and urbanization. These studies show that in the current climate, flood-producing storm precipitation characteristics and their hydrologic response is nuanced, which is critical to document in order to understand their behavior in a future climate.

A subset of nearly 600 flash flood-producing storms from the climatology are examined using high-resolution convection-permitting simulations over the CONUS to understand how these historical storms might change in a future, warmer climate. Both precipitation and runoff show widespread increases in the future over the CONUS, increasing by 21% and 50%, respectively, with maximum hourly rain rates becoming more intense by 7.5% K-1. In California, 45 flood-producing storms associated with atmospheric rivers also display a future increase (decrease) in precipitation (snow water equivalent) leading to increased runoff, particularly over the Sierra Nevada Mountains, implying a shift in future water resources in California. In the Mississippi River Basin–a flash flood hotspot in the CONUS—nearly 500 flash flood-producing storms exhibit a 17% average increase in precipitation and 32% average increase in runoff primarily associated with warm-season convection, and to a lesser extent, tropical cyclones. When stratified by vertical velocity, the storms with the strongest vertical velocity in the current climate exhibit the greatest (least) increase (decrease) in future rainfall (vertical velocity), suggesting a potential role of storm dynamics in modulating future rainfall changes.