**Multivariate statistical methods for spatially compound extremes**

**Charlotte A. Love1, Brian E. Skahill2, Amir AghaKouchak3**

1 Department of Civil and Environmental Engineering, University of California, Irvine, Irvine, CA 92697, USA. Email: calove@uci.edu

2 US Army Corps of Engineers, Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Portland, OR 97205

3 Departments of Civil and Environmental Engineering and Earth System Science, Univ. of California, Irvine, Irvine, CA 92697, USA

**Abstract**

We present multivariate statistical methods that are increasingly being used for the modeling of spatially compound events that result in extreme impacts. The variables that combine to drive extreme events do not necessarily need to pose a severe threat on their own since extreme impacts can be driven by a combination of non-extreme drivers. While univariate extreme value analysis methods have been extensively used to study the magnitude of extreme events and the frequency of their occurrence, they are based on a single variable or event and are unable to fully characterize events that have multiple drivers with spatiotemporal dependencies. Univariate methods often involve significant simplifying assumptions (e.g., spatial independence among extreme observations) that overlook the individual drivers that contribute to spatially compound extreme events, which can result in the underestimation or overestimation of risk. Therefore, multivariate analysis methods that incorporate a set or combination of drivers over space and/or time are better suited for modeling these types of extreme events. As expected, the modeling of extreme events with multiple drivers is not always straightforward. Such methods must be able to systematically take the correlation structures between variables into account and sufficiently deal with an inherently small number of observed extremes. We discuss multivariate extreme approaches, including max-stable process models and Bayesian modeling, and their implications.