**Quantifying key uncertainties surrounding nonstationary precipitation intensity - duration-frequency (IDF) curves**

**Summary**

Precipitation intensity-duration-frequency (IDF) estimates provide a design basis for flood-sensitive infrastructures. However, current precipitation IDF estimates, published as NOAA Atlas 14, assume stationary climate conditions. In the context of changing climate extremes, infrastructure designs based on the current IDF standards may be unreliable. Our objective is to develop an improved IDF estimation framework by considering nonstationary distribution models and characterizing deep uncertainty surrounding IDF estimates. The results will support a more science-based decision-making process of urban planning under changing climate.

# Introduction

Engineering infrastructure design to withstand precipitation and flood risk is based on local precipitation Intensity-Duration-Frequency (IDF) curves [(Cheng & AghaKouchak, 2014; Moglen Glenn E. & Rios Vidal Geil E., 2014; Sandink et al., 2016; Skahill et al., 2016; Wright et al., 2019)](https://paperpile.com/c/FbRC36/EFsL+6oJA+w9tX+oe8l+HgeD). In the United States, the Hydrometeorological Design Studies Center within the Office of Hydrologic Development of the National Oceanic and Atmospheric Administration (NOAA)’s National Weather Service produces IDF curves, published as NOAA Atlas 14 [(Cheng & AghaKouchak, 2014; Sarhadi & Soulis, 2017; Wright et al., 2019)](https://paperpile.com/c/FbRC36/EFsL+aKLM+oe8l). The NOAA Atlas 14 IDF curves are widely used by federal, state and local agencies to inform urban planning, the design of critical infrastructure, and decisions about flood risk management [(DeGaetano et al., 2015; DeGaetano & Castellano, 2017; Moglen Glenn E. & Rios Vidal Geil E., 2014; Sandink et al., 2016; Skahill et al., 2016)](https://paperpile.com/c/FbRC36/jEZD+6oJA+w9tX+JhFB+HgeD). Currently, NOAA Atlas 14 provides precipitation frequency estimates for 5-minute through 60-day durations at average recurrence intervals of 1-year up to 1,000-year. The Atlas 14 relies on Monte Carlo Simulation to produce upper and lower bounds at the 90% confidence level. The results are published through the Precipitation Frequency Data Server (<http://hdsc.nws.noaa.gov/hdsc/pfds> ).

The current NOAA Atlas 14 precipitation frequency estimates are based on the analysis of historical Annual Maximum Series (AMS) data, use L-moments estimators for generalized extreme value (GEV) distribution parameters, and do neglect possible temporal non-stationarity [(Cheng & AghaKouchak, 2014; Sarhadi & Soulis, 2017; Wright et al., 2019)](https://paperpile.com/c/FbRC36/EFsL+aKLM+oe8l). A stationary assumption in a changing climate may lead to unreliable estimation of extreme precipitation, and therefore underestimation of flood risk [(Cheng & AghaKouchak, 2014; Ragno et al., 2019; Sarhadi & Soulis, 2017; Wright et al., 2019)](https://paperpile.com/c/FbRC36/EFsL+aKLM+oe8l+8TFI). Thus, if the properties of extreme precipitation have changed in recent decades, current NOAA ATLAS 14 IDF estimates may yield poor hydrologic designs. Also, the precipitation extreme value distribution contains deep uncertainty that arises, for example, from uncertain model structure and parameters. Quantifying these uncertainties is critical to provide decision-relevant tail information for which the infrastructures will be designed to withstand during their lifetime.

With the observed increase in weather and climate extremes, there is a pressing need to update existing IDF estimates to account for nonstationarity of extreme precipitation [(Butcher & Zi, 2019; Cheng & AghaKouchak, 2014; DeGaetano & Castellano, 2017; Sarhadi & Soulis, 2017; Skahill et al., 2016; Wright et al., 2019)](https://paperpile.com/c/FbRC36/rN3u+EFsL+jEZD+aKLM+oe8l+w9tX). One of the first attempts to derive nonstationary IDF curves was by [(Cheng & AghaKouchak, 2014)](https://paperpile.com/c/FbRC36/EFsL). [(Cheng & AghaKouchak, 2014)](https://paperpile.com/c/FbRC36/EFsL) analysis is based on GEV distribution combined with Bayesian inference for uncertainty assessment. In particular, [(Cheng & AghaKouchak, 2014)](https://paperpile.com/c/FbRC36/EFsL) constructs a nonstationary IDF curves by introducing time-varying component in the location parameter of the GEV distribution using time covariate. [(Sarhadi & Soulis, 2017)](https://paperpile.com/c/FbRC36/aKLM) incorporates trend in the GEV location and scale parameters using time covariate for analysing nonstationarity in IDF curves. [(Wright et al., 2019)](https://paperpile.com/c/FbRC36/oe8l) performs a regional-scale trend estimates to demonstrate that the rainfall events that exceed common engineering design criteria have increased in frequency in most parts of the US. These studies suggest that stationary IDF curves can underestimate hazards given the nonstationary behavior of extreme rainfall events. There is hence a need for a comprehensive analysis of climate-informed nonstationarity precipitation IDF curves.

We will provide a generalized framework for constructing nonstationary IDF curves to help inform infrastructure design decisions. Specifically, we will

1. Review the current NOAA Atlas 14 method for modeling extreme precipitation,
2. Provide alternatives that account for possible nonstationarity in extreme value distribution, and quantify deep uncertainty surrounding IDF curve estimates.

References

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