Extreme Precipitation in a Warmer World

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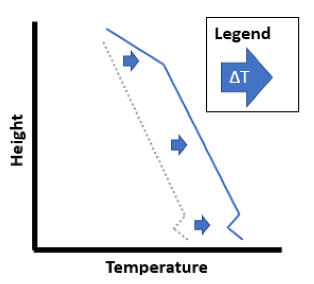
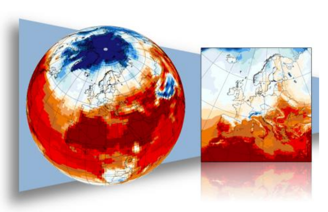
Overview

The urban environment is especially vulnerable to extreme precipitation events due to the density of infrastructure and population. The stochasticity of extreme precipitation creates a technical barrier to producing outcomes in these high-density locations. ***This project blends downscaling methods through a storylines lens to provide multiple scenarios and levels of information to decision makers and community members.*** Collaborating with municipal practitioners defined the parameters of the study and conversations with community leaders provided a much needed lived-experience perspective.

A Brief Introduction to Future Extreme Precipitation Data

Pseudo-global Warming (PGW)	Statistical Downscaling	Dynamical Downscaling
Perturbing current or historical weather model analysis by an ***informed*** future change. 	Constructing a statistical relationship between historical GCM output and fine resolution climatology data sets, then applying that relationship to projected GCM output. **Examples include data** CMIP5 sources such as **BCCA, MACA, or LOCA.** $y = b_0 + b_1x_1 + b_2x_2 + \cdots$	Using GCM output as initial and lateral boundary conditions of a numerical weather/climate model based on solving physical equations. 

Storylines

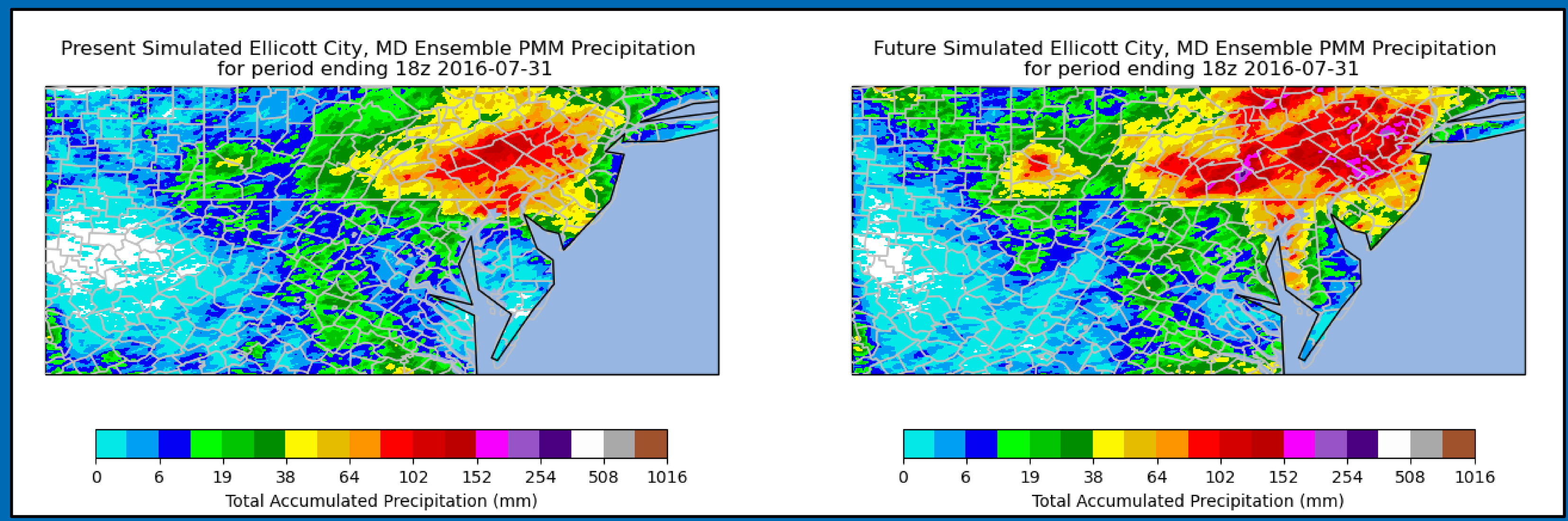
This study explores three examples of fluvial flooding in the urban environments of *Ellicott City, MD, Portland, OR, and Phoenix, AZ*. The Weather Research and Forecasting (WRF) model is used to simulate the storm events for both historical and pseudo-global warming (PGW) projected scenarios.Each storm event serves as a personal story to communicate how climate change may worsen severe events that we are already experiencing today**. Analysis between the historical and PGW simulations shows that the warmer environmental temperature alters duration, intensity, and the spatial distribution of precipitation.**

1. Ellicott City, MD on July 30th, 2016
   – Mesoscale Convective Storm
2. Portland, OR on October 31st, 2015
   – Atmospheric River
3. Phoenix, AZ on September 8th, 2014
   – Hurricane-induced convective storm

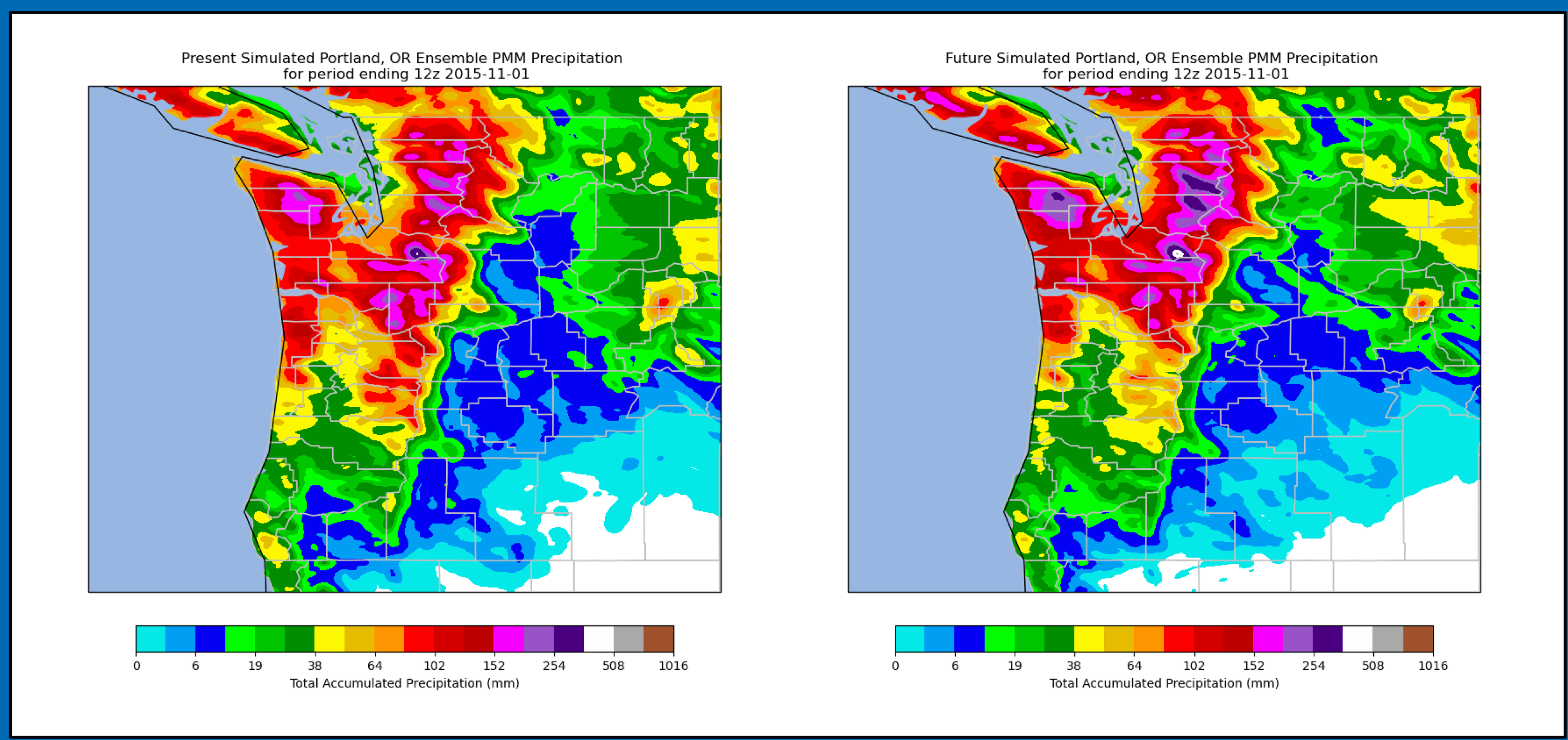
Probability Maximum Mean (PMM) precipitation is aggregated from 10 ensemble members. The figures below show ***more extreme precipitation and larger spatial extent of rainfall in the future (PGW) storm simulations.***

Historical Storm | **Future Simulated Storm**

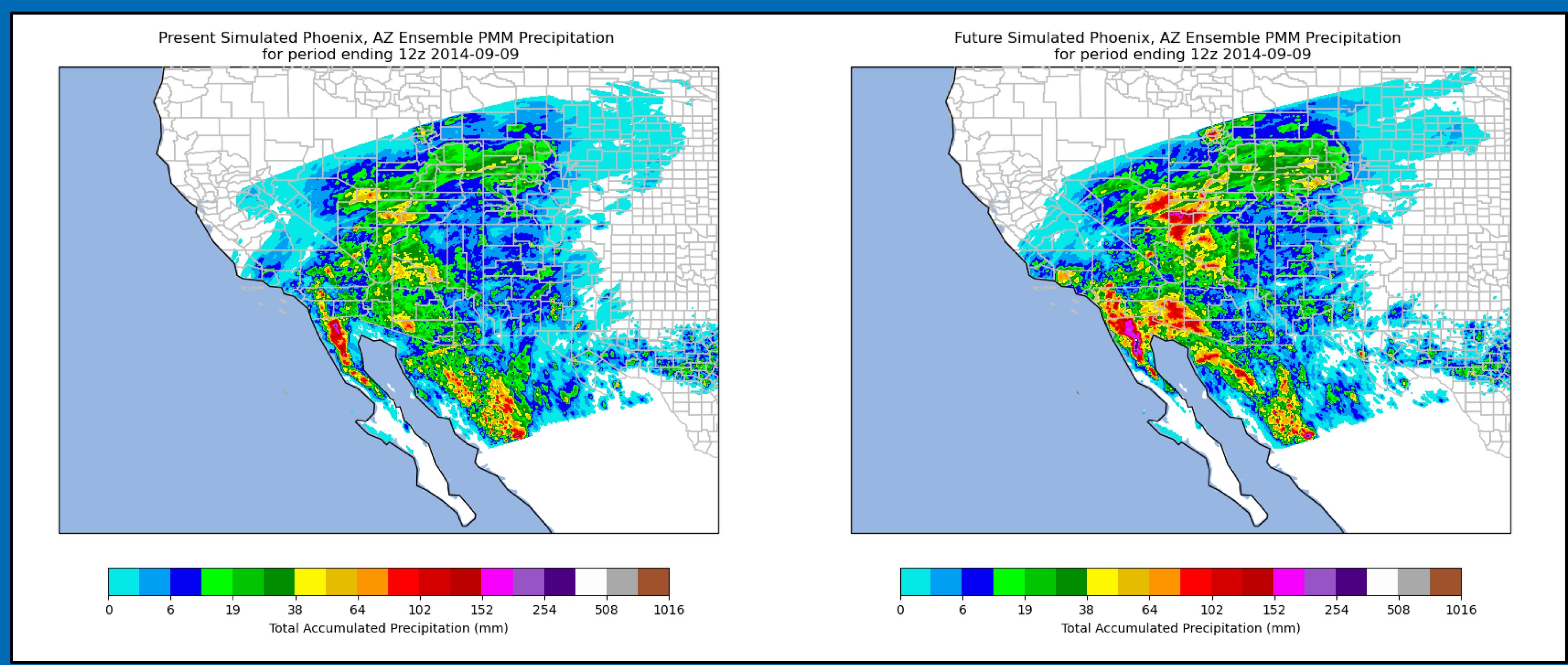
Ellicott City, MD



Portland, OR

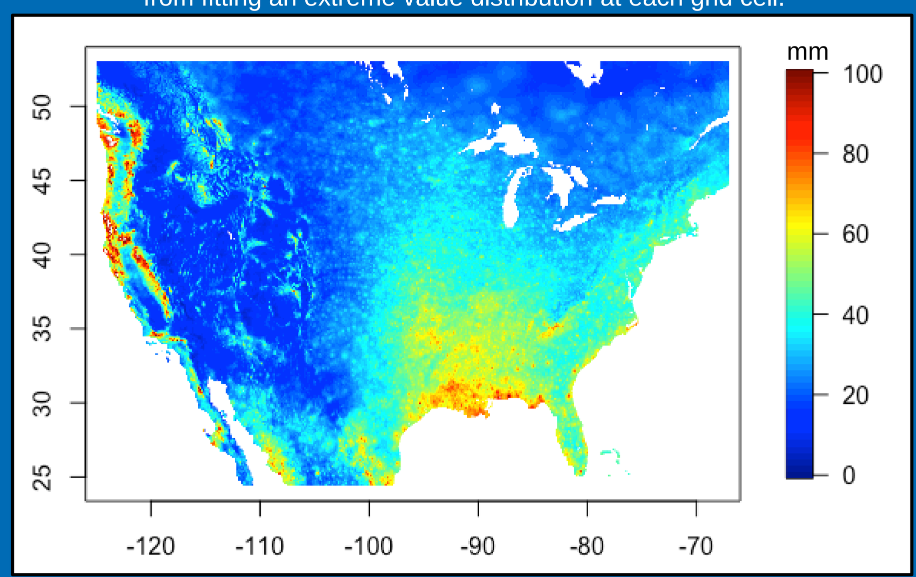


Phoenix, AZ



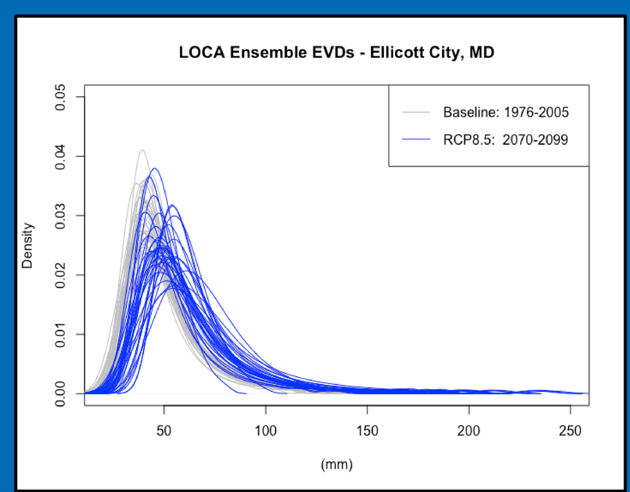
The figures above show the storm-scale response to warmer environments. ***These storylines provided needed context to the climate-scale data from sources like LOCA***, see below.

The Location* parameter for the HADGEM2-CC (Historical) LOCA calculated from fitting an extreme value distribution at each grid cell.



The bullseye spatial pattern is an artifact from point source observations in the LOCA interpolation process.

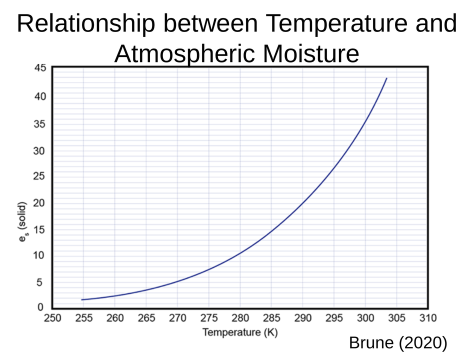
Extreme Value Distributions for LOCA Ensemble Ellicott City, MD



**Location is the placement of the peak on the x-axis in Extreme Value Distributions like the one above.*

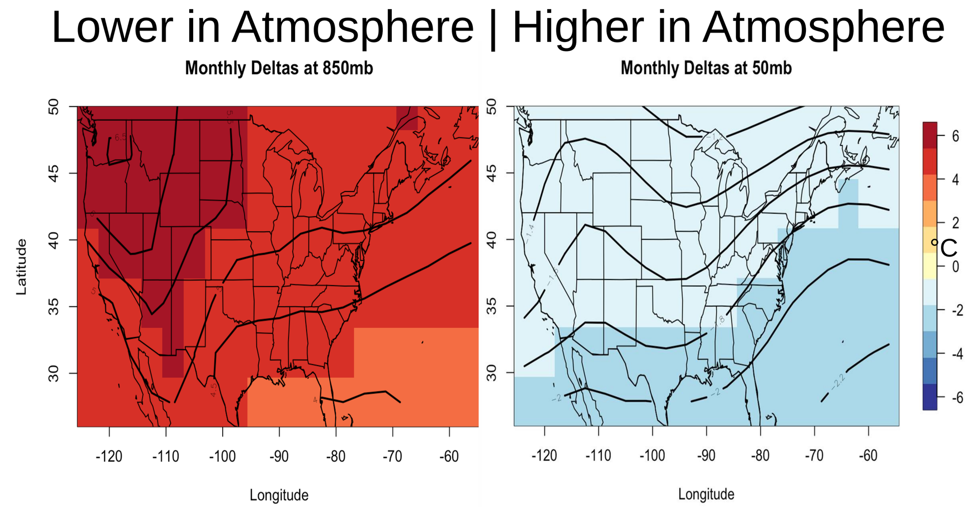
How does PGW work?

PGW consists of applying a pre-determined change in temperature to the environmental temperature of historical climates or weather events. An ensemble average approach is used and variables such as atmospheric temperature, surface temperature, skin temperature, sea-surface temperature, and sea ice extent are considered. PGW can explore how specific storms respond to a warmer environment by utilizing the Clausius-Clapeyron equation which states that **every 1°C increase in temperature, results in a 7% increase in atmospheric water vapor capacity**.



The change for the future environment is calculated from a 17-member CMIP5 ensemble. Monthly average temperature from the Historical (1990-1999) and RCP8.5 (2090-2099). This produces a temperature delta that varies in x, y, and z.

Temperature Delta
Lower in Atmosphere | Higher in Atmosphere



The Big Picture

Different data sources and modeling techniques answer different science and application questions. Combining multiple methods in a storylines approach gives a fuller picture of how extreme precipitation may change in a warmer world. Data sets like LOCA can offer insight into how climate scale variables may change. PGW offers finer temporal resolution and event-based precipitation change. Understanding the benefits and drawbacks of each data source is an integral part of any adaptation and resilience project.

Acknowledgment

The first author is supported by an appointment to the ORISE participant research program supported by an interagency agreement between EPA and DOE. Parts of this research are supported by the National Science Foundation under award number SES-1444755. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the U.S. Environmental Protection Agency.

EPA United States Environmental Protection Agency

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