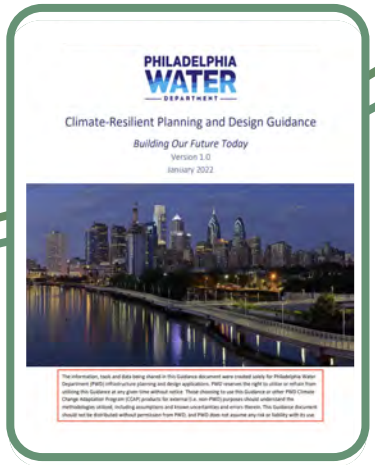
Scaling and Application of Climate Projections to Stormwater and Wastewater Resilience Planning

Case Study: Philadelphia Water Department

Transforming Global Climate Model Precipitation Output for Use in Infrastructure Planning and Design Applications



Summary

Philadelphia Water Department (PWD) led an initiative to develop guidance based on in-depth analysis of climate projections. The Guidance is informing a department-wide revamp of standards and criteria for resilience planning.

The Backstory

The Philadelphia Water Department formed a Climate Change Adaptation Program (CCAP) in 2014 to study and address PWD's vulnerabilities and risks to climate change impacts. In preparation, a department-wide survey gathered input from staff on perceived PWD vulnerabilities related to climate change to help identify the most immediate, or primary, planning needs for adaptation. Sea level rise and increasing precipitation were identified as the climate risks with the biggest potential consequences to employee and customer health and safety and PWD core services, including the provision of clean and safe drinking water. To address the primary planning needs, CCAP developed actionable climate change science and information.

The Challenge

While statistically downscaled global climate model (GCM) precipitation output is available for Philadelphia, the temporal resolution is too low for direct use in model-based urban stormwater applications and GCM output for Philadelphia does not accurately represent local storm intensities and durations. In addition, there were challenges related to climate risk planning at PWD given the evolving science and lack of a regulatory driver.

Project Timeline
2018-2021

Project Area/ Geographic Scale
City of Philadelphia

Study Focus
Precipitation Projections, Climate Impacts

Lead Agency
Philadelphia Water Department (PWD)

Target Audience
PWD staff, various City departments

Type of Data Used
Observed precipitation data, statistically downscaled Global Climate Model (GCM) output.

Types of Precipitation Inputs Used
Timeseries and design storms (IDF curves)

The Approach

To address the challenges, PWD completed a study (Maimone et al. 2019) that used an innovative approach to transform GCM output into actionable science that can directly inform planning, design, and engineering applications, including hydrologic and hydraulic (H&H) modeling and intensity-duration-frequency (IDF) curve development. The approach uses GCM output for current (1995–2015) and future (2080–2100) conditions under the Representative Concentration Pathway (RCP) 8.5 greenhouse gas emission trajectory to develop delta change factors based on season and storm size. These factors were then used to create a plausible future hourly time series. A stochastic generator was used to explore potential variability in projected precipitation patterns to better understand the range of uncertainty. The approach used is practical and transferable, addressing the need for locally relevant and actionable climate change information in the field of water resource management.

The Barriers

The climate projections and planning recommendations are captured in the first iteration of the PWD Climate-Resilient Planning and Design Guidance (January 2022), the culmination of the effort. The Guidance provides staff across multiple departments with the information and tools necessary to make decisions in the face of uncertainty and to include forward-looking climate risk information in all planning and design efforts, including those related to structural and non-structural systems. Official PWD policy requiring use of the Guidance in infrastructure planning and design efforts, to the extent feasible, was adopted in January 2022.

Practical Applications

Several projects have been informed by the Guidance since its release, including PWD stormwater and wastewater drainage system projects, a Water Pollution Control Plant (WPCP) effluent pump station design, and planning associated with raw water pump stations at risk of riverine flooding during extreme rainfall events.

Flooded roadway in Philadelphia. (Photo courtesy of Philadelphia Water Department.)

Data inputs and outputs	Observed precipitation data and statistically downscaled Global Climate Model (GCM) data. Outputs include future high resolution timeseries and future IDF curves (extreme precipitation).
Data source	NOAA PHL (Philadelphia Airport) rain gauge, PWD rain gauge network (citywide), CMIP5 statistically downscaled output (LOCA) (https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html).
Time Horizons / Climate Scenarios Used	Since most of PWD's assets have a very long service life the department is currently planning to at least mid-century and usually end-of-century (2100). PWD is considering changes in the intensity and frequency of future storms, as well as the increasing occurrence of cloudburst events (i.e., extreme precipitation). The RCP8.5 climate projections are generally used because PWD is a critical service provider with a low risk tolerance.
Updates to model runs with the latest IPCC GCM data?	Current Clean Water Act and Safe Drinking Water Act regulations do not require PWD to account for climate change; therefore, some modeling applications/ simulations have yet to be updated with the latest climate projections. Despite the lack of a regulatory driver, this effort produced future condition precipitation timeseries for use in PWD H&H models, and department-wide policy requires the use of future condition precipitation inputs in project and program planning, to the extent feasible and per information contained in the Guidance. Some capital projects on both the water and wastewater side, as well as some planning efforts related to the drainage system, have already incorporated future condition precipitation and/or sea level rise projections based on the new Guidance.
Use of Precipitation Projections	Hourly or sub-hourly precipitation timeseries are required for most urban stormwater modeling applications; design storms and IDF curves are required for planning and design of sewers.
Objective for Using Future Precipitation Projections	Incorporate future condition information into planning and design of infrastructure systems/assets, including H&H modeling of combined sewer system and alternatives analyses for flood risk management projects.
Application	For various capital projects, the planning and design process is accounting for climate change projections, per the Guidance document.
Events Driving Action	Hurricane Ida impacted the PWD service area during the final stages of rolling out the Guidance, serving as an "eye-opener" as to what can happen as extreme events become more extreme under a warming climate. This attested to the immediate need for this Guidance and helped support acceptance.

Lessons Learned

1. Do not let perfect become the enemy of progress and focus on actionable information
In developing the Guidance document, PWD accepted that there will always be uncertainty associated with climate projections and developing a singular and 'certain' projection is not practical or feasible in a field that is based on continually evolving science. The important aspect is to gain agreement that there is enough certainty in the projections to use them for making decisions and recommendations. To better understand what uncertainties do exist and how science can be made actionable, prioritize engaging with federal agencies, like NOAA and NASA, as well as climate scientists from the academic community and National Labs.

2. Involve staff early and continuously on climate change related discussions; identify and rely on climate champions
PWD recognized the importance of involving staff from the beginning. This program began in 2014 by engaging staff (with a survey reaching multiple units and programs) to understand their impression of PWD's primary climate change vulnerabilities. The feedback gathered helped to identify the climate-related consequences associated with various climate impacts, including increasing precipitation. When developing the Climate-Resilient Planning & Design Guidance, staff provided input and review of the content at multiple points in the development process (for example, CCAP asked the questions: What tools would be most helpful? What output format would support your work? What hesitations do you have in terms of using this information and how can we help address those?). CCAP also worked to identify and develop relationships with 'climate champions' in various programs throughout the Department.

3. Stress that climate change is happening here and now
When it came to generating support and buy-in, PWD learned the importance of highlighting that climate change is happening here and now by drawing focus to recent extreme events. For example, in engaging with Executive Staff on the Guidance and the need for a department-wide policy, CCAP highlighted the devastating local impacts of Hurricanes Isaias and Ida, and the fact that climate change will make these extreme events more likely. Based on these recent events, it is already evident that PWD needs to account for increasing storm intensities and climate projections in infrastructure planning and design.

4. Top-Down directives are needed to empower staff
PWD used a 'bottom-up' approach to develop the Guidance document and gain staff buy-in, but ultimately top-down directives (e.g., a new policy) were needed to empower staff to use climate projections in their work and support the consistent application of the information in existing and long-standing programs/processes.