DVRPC Climate Adaptation Forum

November 18, 2019

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PHILADELPHIA WATER DEPARTMENT

Photo by Randy Calderone

PHILADELPHIA WATER DEPARTMENT

Overview

1. Introduction & Context
2. Actionable Science: Precipitation
3. Current PWD Priorities

Philadelphia Water Department

One Water Utility

Drinking Water

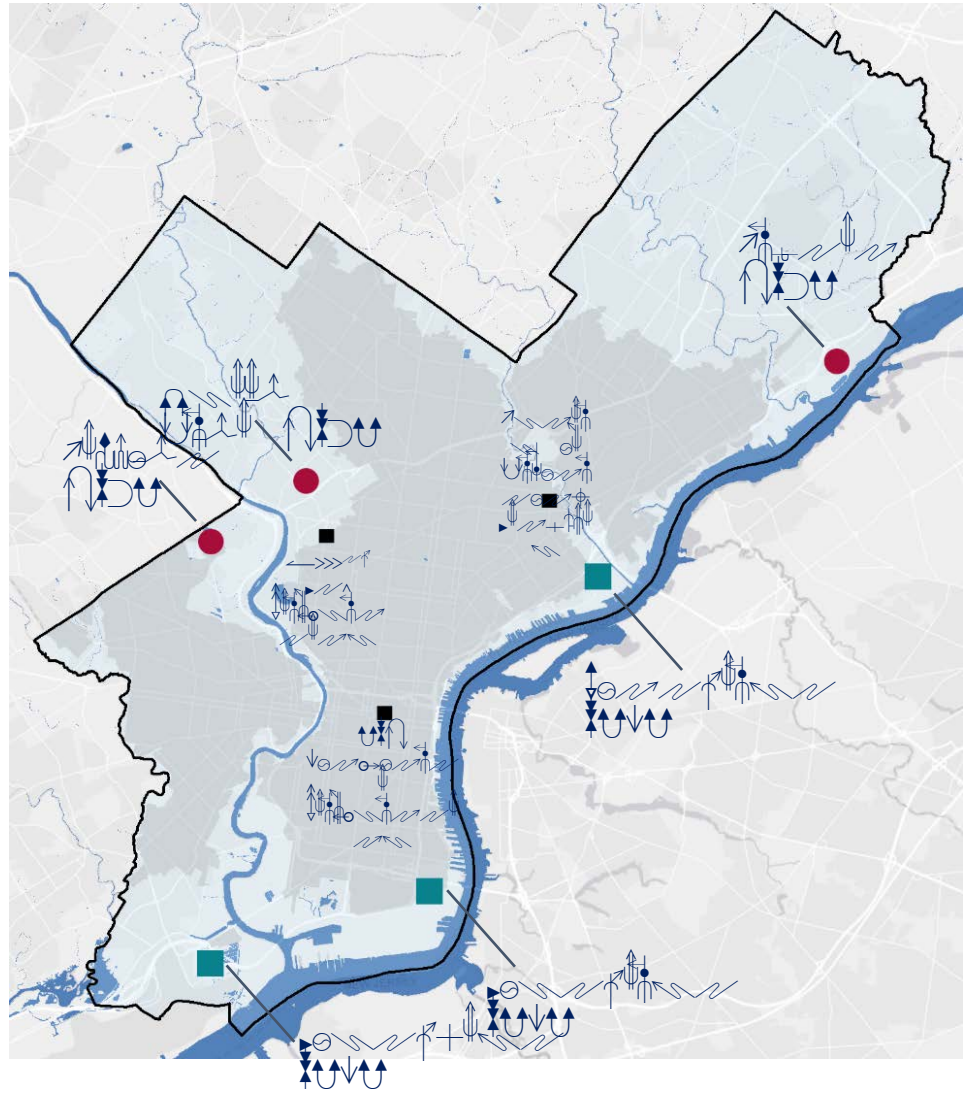
- Source: Delaware and Schuylkill Rivers
- 1.7 million drinking water customers
- Three Water Treatment Facilities
- Over 300 million gallons treated per day
- 3,000 miles of water mains, 25+ pumping stations

Wastewater

- 2.2 million wastewater customers
- 3 Water Pollution Control Plants
- Over 522 million gallons treated per day
- 3,716 miles of sewers, 19 pumping stations
- Biosolids handling facility

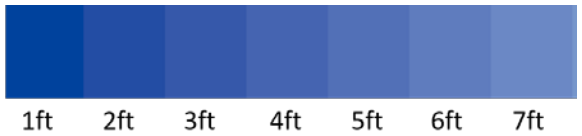
Stormwater

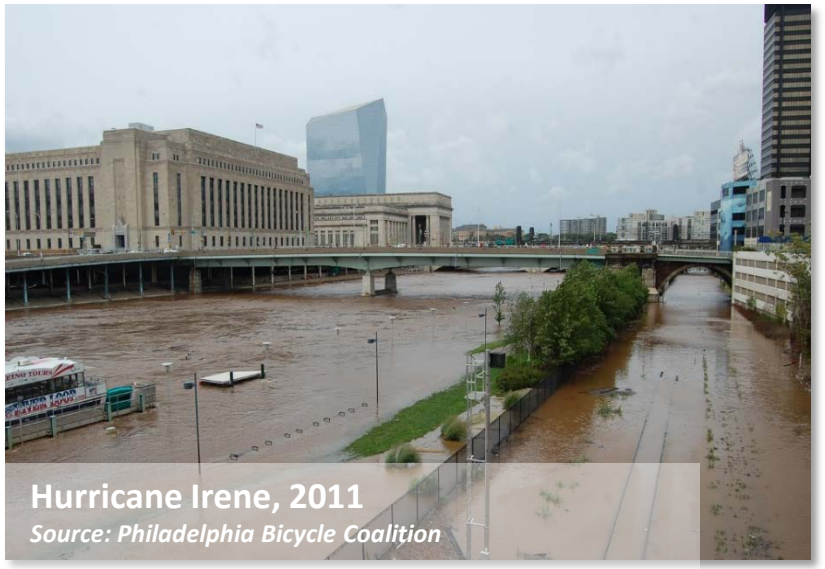
- Roughly 60% Combined Sewer, 40% Separate Sewer
- Green City, Clean Waters - Large-scale green stormwater infrastructure program to reduce CSOs



Adaptation planning is essential to reduce risks

Coastal, riverine and infrastructure-based flooding



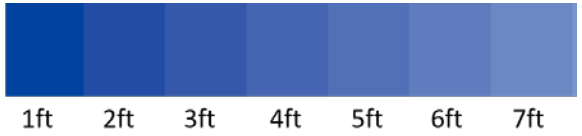


Hurricane Irene, 2011
Source: Philadelphia Bicycle Coalition

Water quality impacts

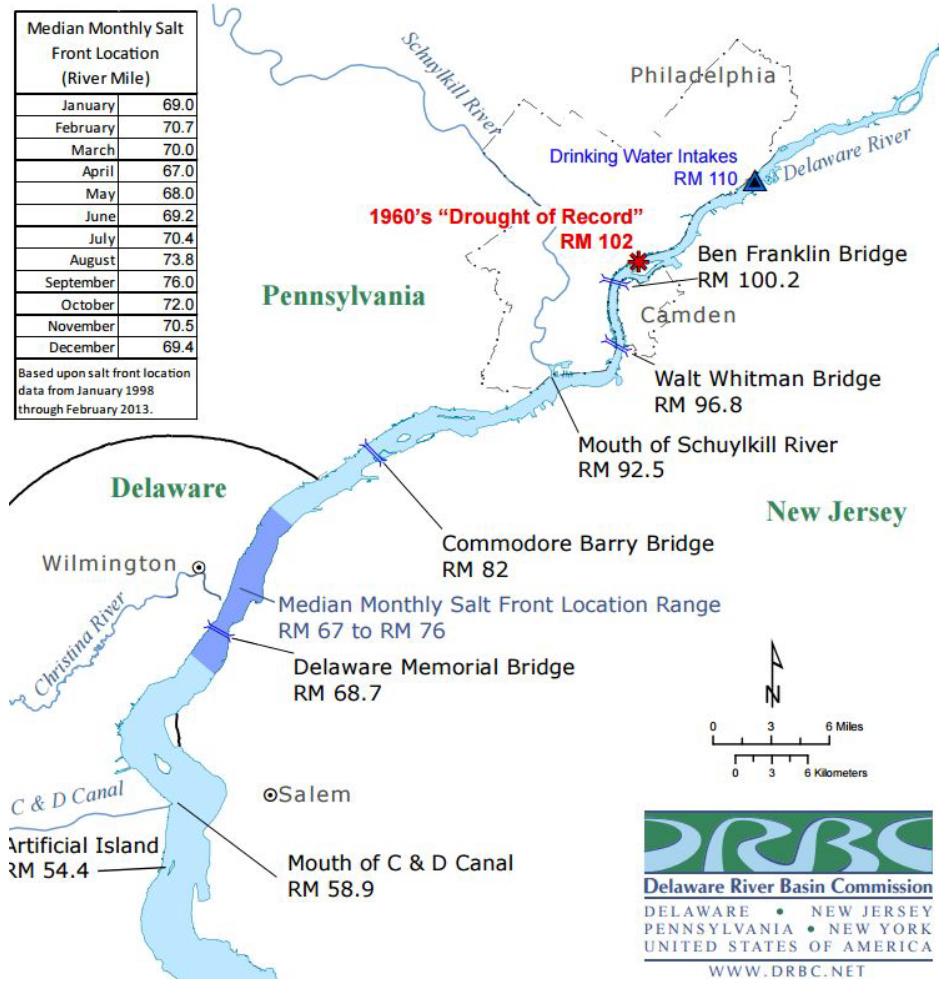
Adaptation planning is essential to reduce risks

Coastal, riverine and infrastructure-based flooding



Median Monthly Salt Front Location (River Mile)	
January	69.0
February	70.7
March	70.0
April	67.0
May	68.0
June	69.2
July	70.4
August	73.8
September	76.0
October	72.0
November	70.5
December	69.4

Based upon salt front location data from January 1998 through February 2013.



Water quality impacts

Climate Change Adaptation Program (CCAP)

Est. 2014

PHILADELPHIA WATER DEPARTMENT

Program Goal

Reduce the risks and associated expenses PWD will face from the impacts of climate change by identifying and implementing effective and feasible adaptation strategies

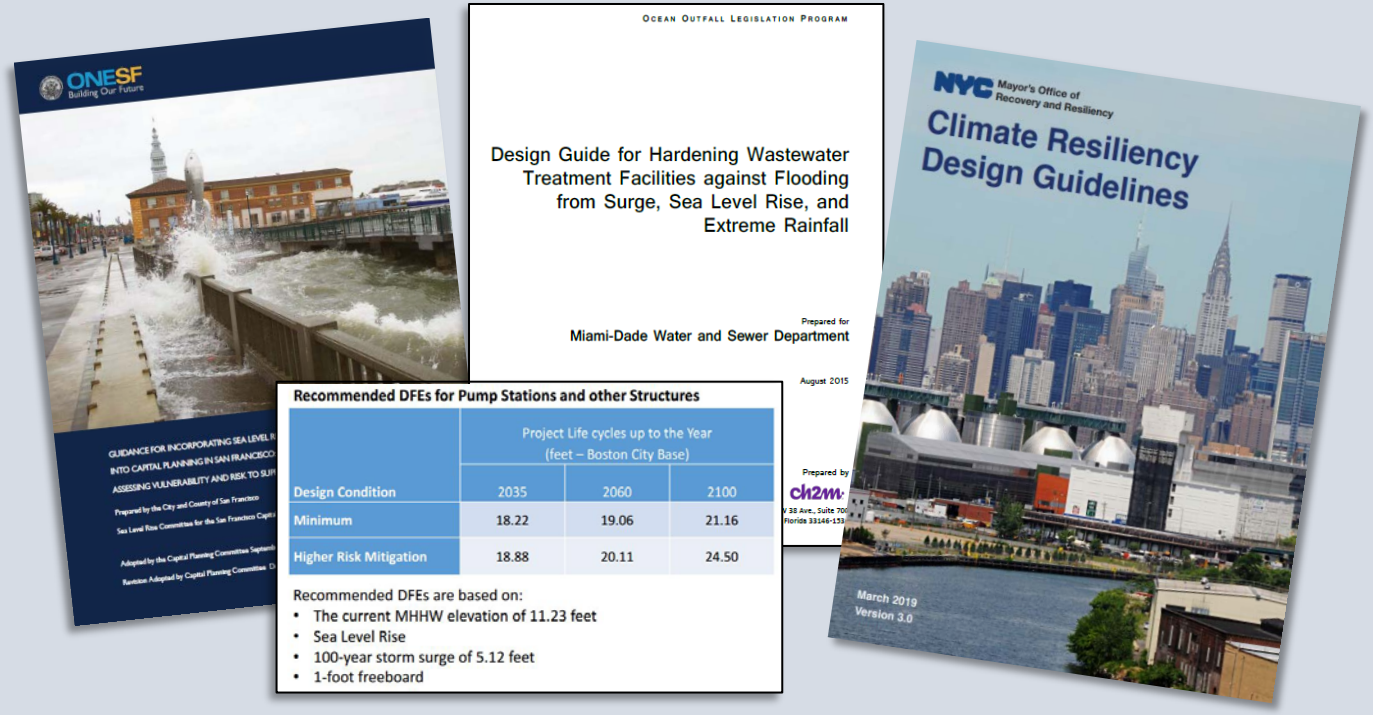
How do we adapt?

Adaptation requires **mainstreaming** the use of climate information

Existing assets: Consider short and long-term strategies to protect existing assets from climate change impacts

New Assets: Ensure the impacts of climate change are being considered during the planning and design of new projects and the process to make capital decisions

- Perform on-the-ground risk assessments to identify strategies & investments to protect existing assets
- Implement Climate Change Planning & Design Guidelines for new assets
- Inform long-term infrastructure plans (water, wastewater, stormwater)
- Integrate climate information into the capital planning process



…and mainstreaming requires actionable science

"…data, analyses, projections, or tools that can support decisions regarding the management of the risks and impacts of climate change." *(ACCCNRS, 2015)*

Water Utility Climate Alliance

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Precipitation Analysis

What risk does increasing precipitation pose to PWD?

- Will rainfall events will become more intense, more frequent, and/or longer in duration?
- What assets and systems are most at risk with increasing precipitation?
- What strategies can we employ to protect existing assets at risk?
- What policies and guidelines will ensure the long-term resilience of new assets?

Precipitation Analysis

How do we use precipitation data at PWD?

System Performance

- Hydrologic & hydraulic (H&H) models use precipitation time series to simulate system performance (combined & separate systems)

Planning Assessments

- Flood management planning and flood risk analyses rely on up-to-date precipitation information

Infrastructure Design

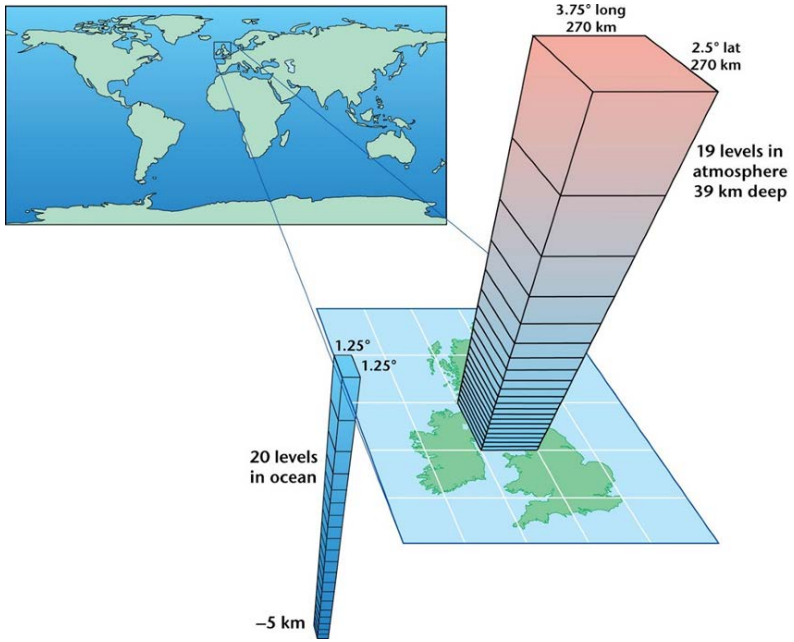
- Sewer system design and green stormwater infrastructure (GSI) design, for example, are directly informed by precipitation data

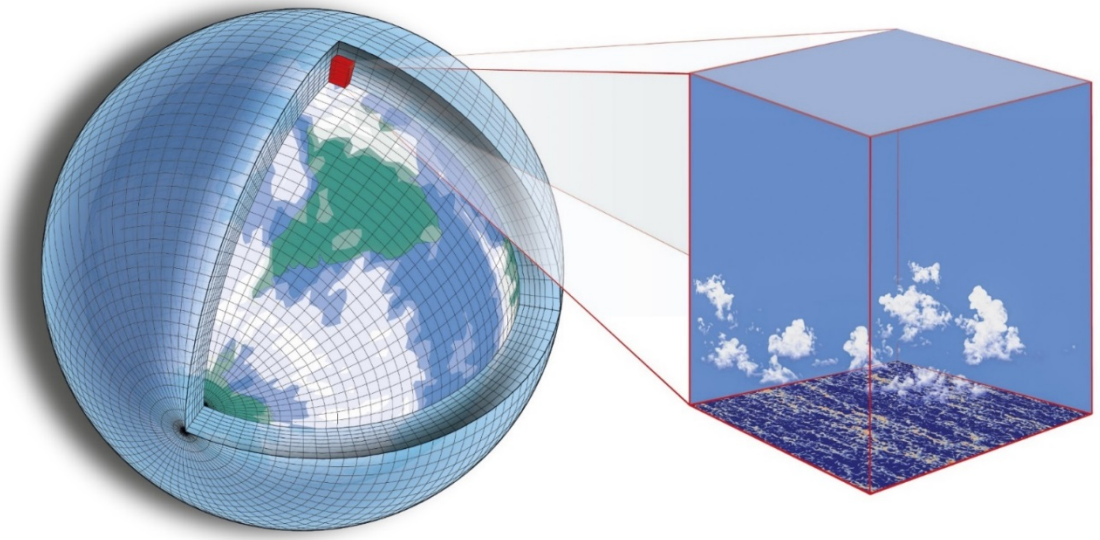
PWD Hydraulic Model, 2019

High resolution precipitation input needed

Global Climate Models (GCMs)

Gridded models based on physical laws & principles





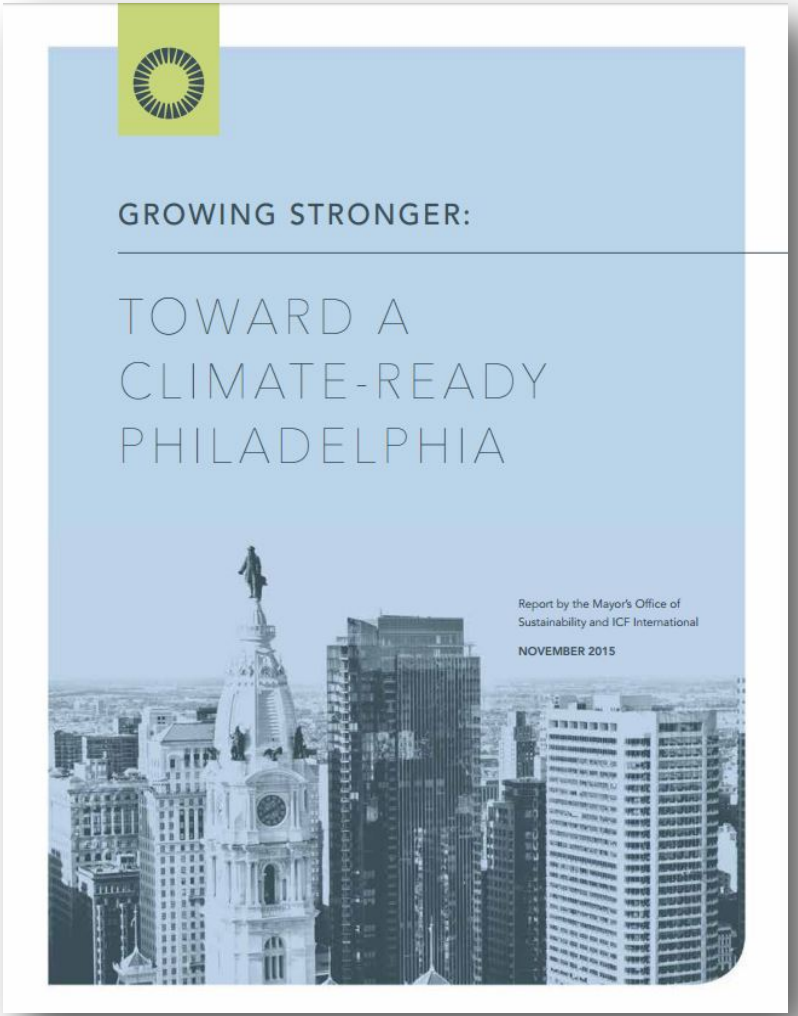
- Conservation of mass

$$\frac{\partial \rho}{\partial t} = -(\vec{V} \cdot \nabla)\rho - \rho(\nabla \cdot \vec{V})$$

- Conservation of H_2O (vapor, liquid, solid)

$$\frac{\partial q}{\partial t} = -(\vec{V} \cdot \nabla)q + \nabla \cdot (k_q \nabla q) + S_q + E$$

Downscaled Projections



- GCM projections are made relevant to local scales through various methods, including statistical downscaling

Statistically downscaled air temperature and precipitation projections:

RECLAMATION NCAR USGS
Santa Clara University CIRES CLIMATE CENTRAL
SCRIPPS INSTITUTION OF OCEANOGRAPHY

Localized sea level rise projections:

CUSP Climate & Urban Systems Partnership
THE EARTH INSTITUTE COLUMBIA UNIVERSITY
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

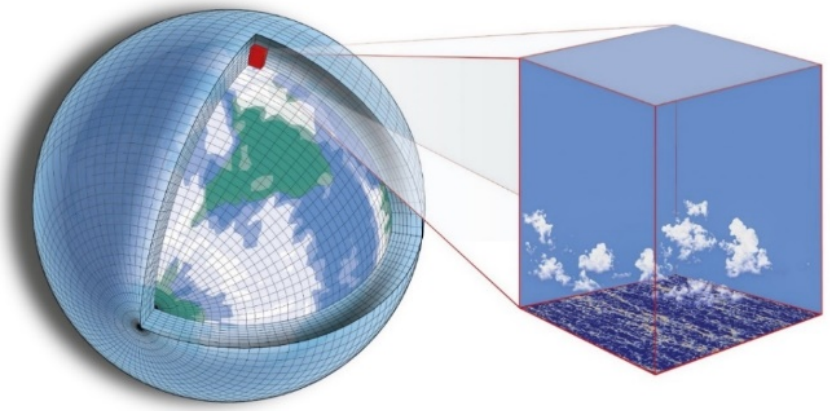
Precipitation Analysis

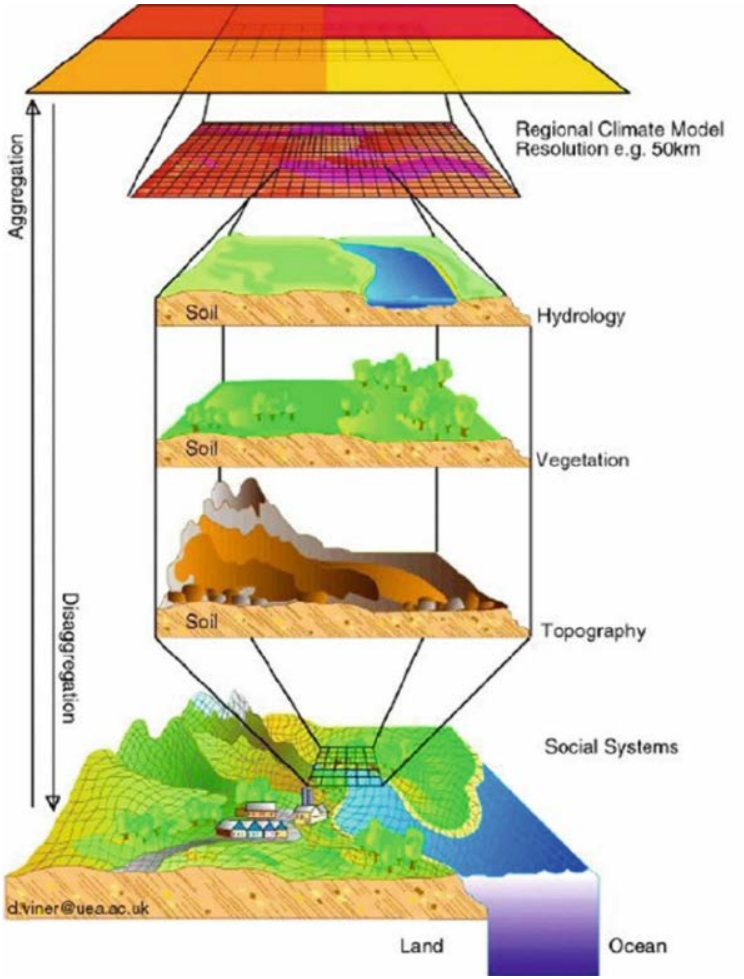
GCM Precipitation Projects: Issue #1

Inadequate Resolution

The resolution of statistically downscaled GCM output is not sufficient for urban stormwater applications because **high temporal resolutions are required**

- GCM output: daily
- Stormwater applications: hourly or sub-hourly





Source: David Viner, Climatic Research Unit, University of East Anglia, UK

Precipitation Analysis

GCM Precipitation Projects: Issue #2

Unrealistic Rainfall Patterns

‘GCM Philly’

Real Philly

Precipitation Analysis

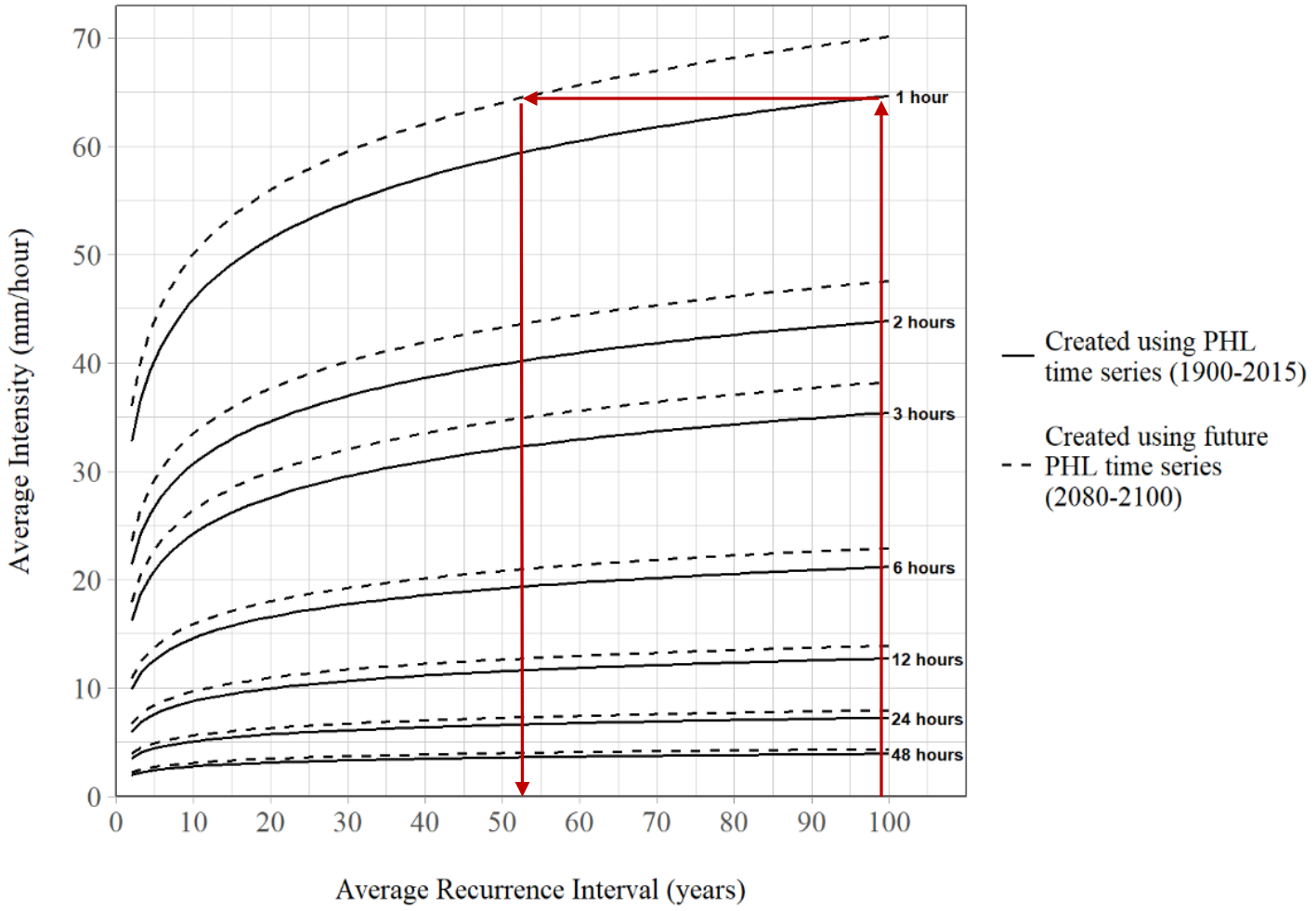
CCAP developed a method to:

- ✓ Generate future hourly or sub-hourly precipitation time series that preserve local precipitation patterns
- ✓ Evaluate extreme storm events (>100-year storm)
- ✓ Explore variability in current & projected precipitation patterns (stochastic rainfall generator)

Precipitation Analysis

Findings include:

- Precipitation **averages and extremes will increase**
- Projected **increases differ by season**
- Projected change from current to future precipitation amounts is not uniform across storm size; in general, **larger storms will increase in volume more than smaller storms**

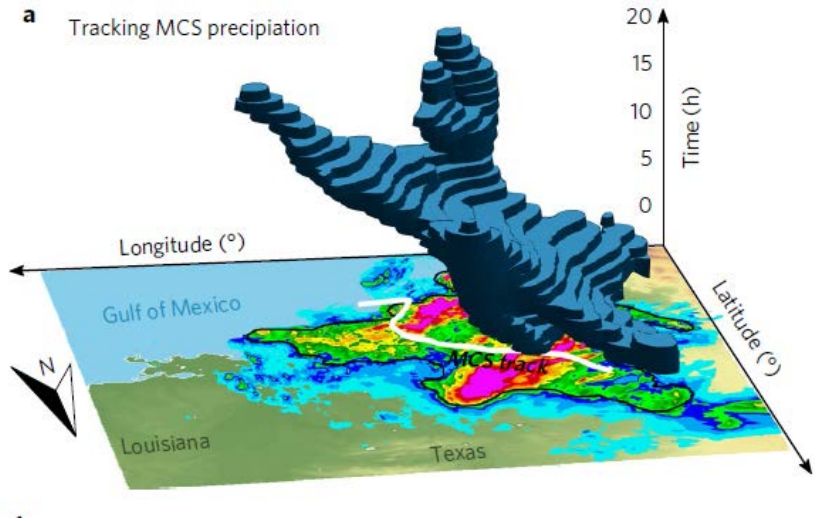


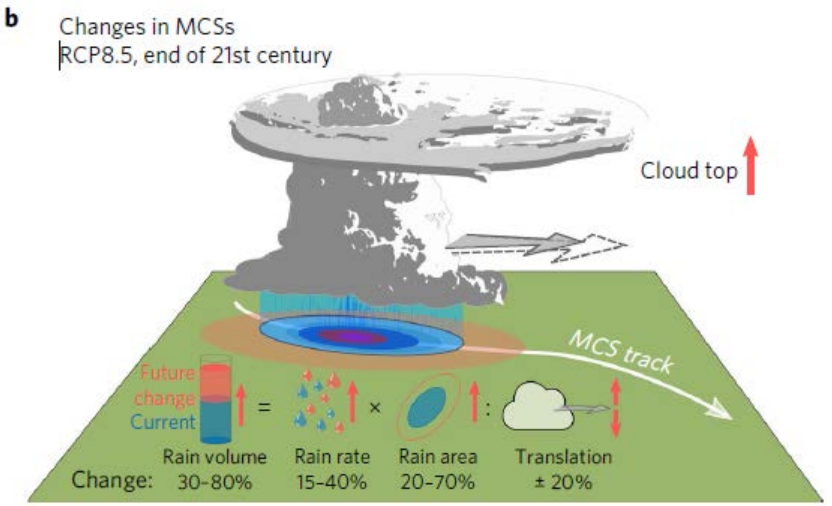
Comparison of IDF curves generated by fitting GEV Type II distribution on AMS using PHL data (1900-2015) with future PHL time series based on the 2080-2100 storm set for RCP8.5

Precipitation Analysis

Limitations

- The approach relies on the ability of GCMs to simulate precipitation intensities in current and future climates. **Currently, GCMs do not simulate extreme precipitation events well, leading to potential underestimation of future extreme precipitation intensities.**
- CCAP keeping track of emerging research on the topic of extreme rainfall projections





Prein et al. 2017

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Current Priorities

Mainstreaming Climate Information & Moving from Planning to Implementation

- On-the-ground, facilities-based risk assessments
- Draft Climate-Resilient Planning and Design Guidance
- Continue to inform long-term infrastructure plans and the capital planning process
- Inform local, regional and national adaptation efforts and collaborate with water resource practitioners
- Stay up-to-date on climate science and determine when new science should be adopted

Southwest WPCP – Risk Assessment Pilot Area

Storm Sewer Improvements

Thank You!

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Additional Slides

Climate Change Communication

- Developing and using effective communication strategies is a CCAP priority

Climate Change Impacts in Philadelphia

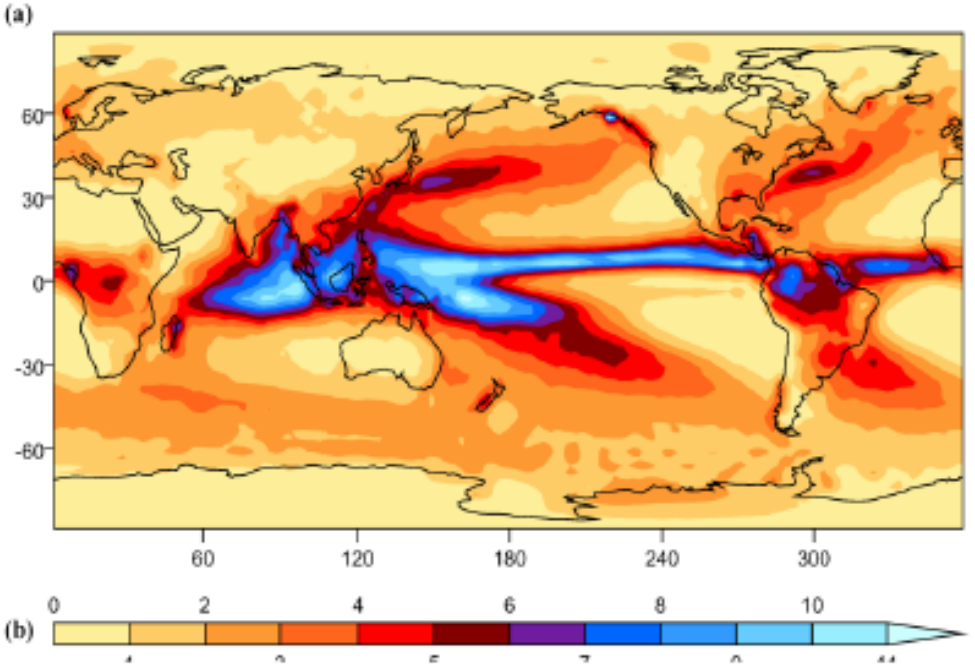
- Precipitation ⬆
- Sea level ⬆
- Air temperature ⬆
- Extreme storm events* ⬆
- Droughts ? ⬆ ⬇ ➖

*this is referring to the **number of heavy & extremely heavy precipitation events per year** only

Global Climate Models

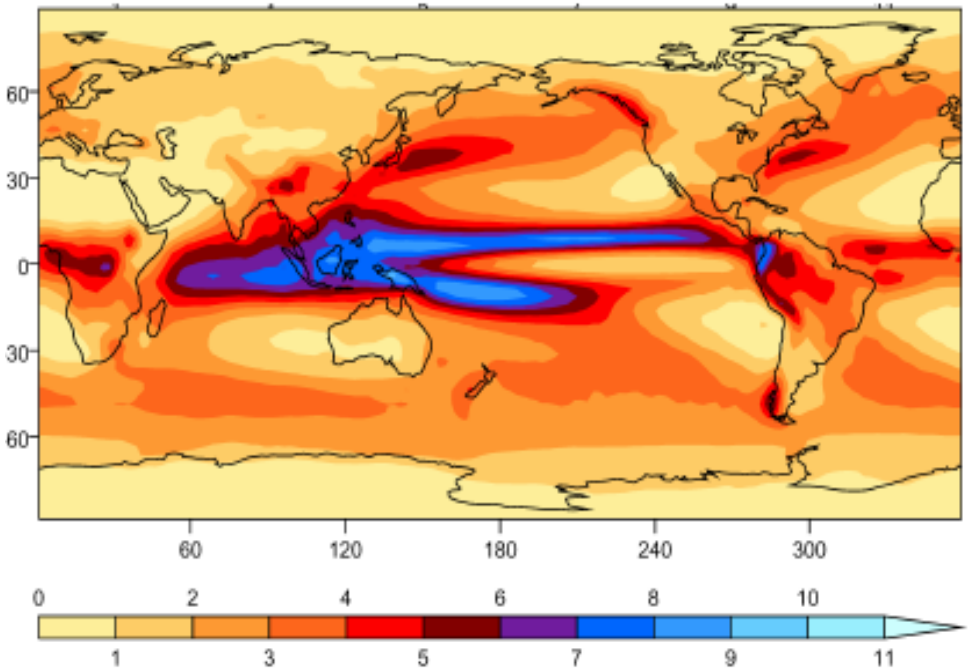
Global Climate Model Projections

Climate models perform well at large spatial scales (regional to global) and long time scales (seasonal to multi-annual averages)



Observed Rainfall (1980-1999)

Source: *IPCC, 2007*



Modeled Rainfall (1980-1999)

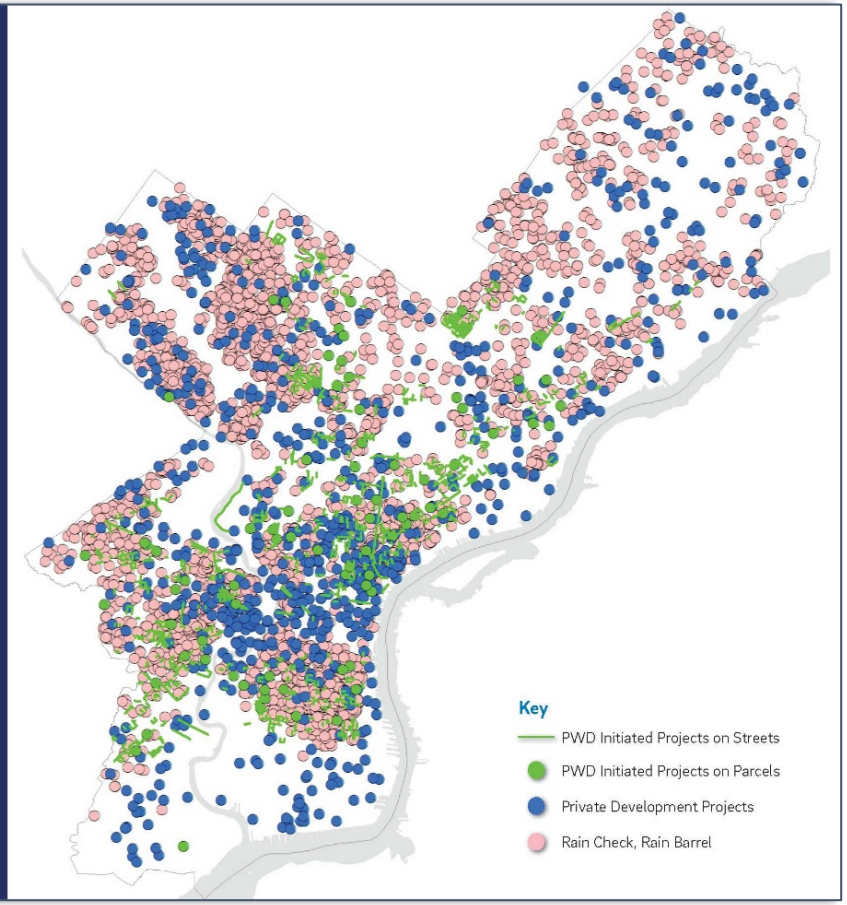
Source: *IPCC, 2007*

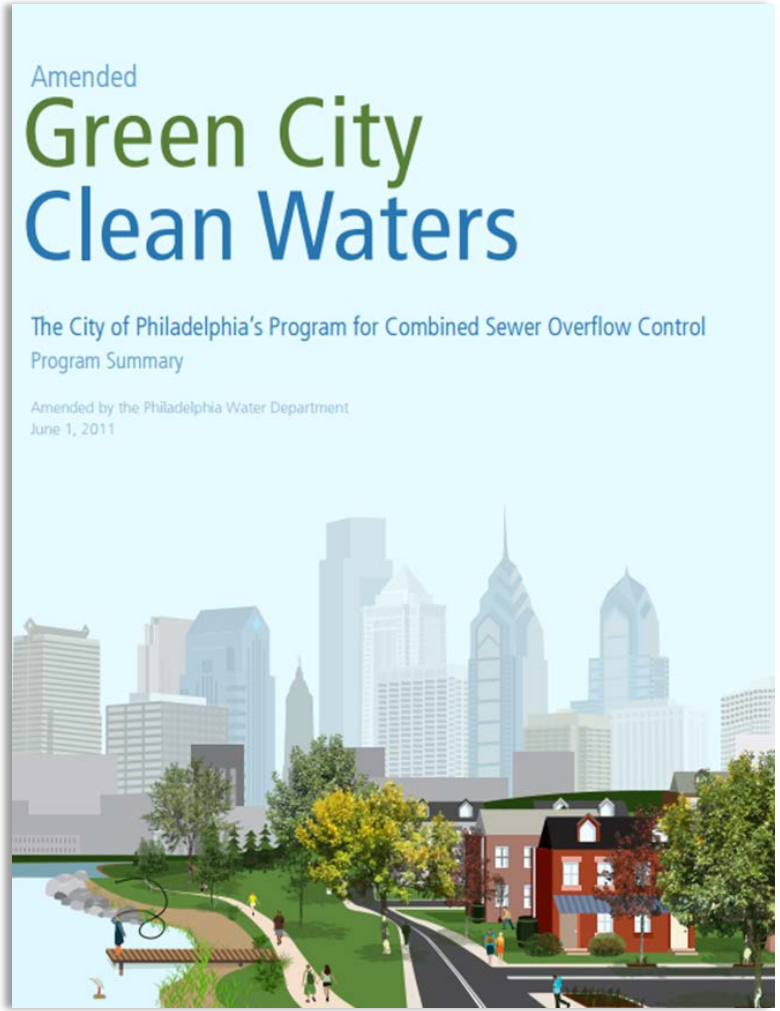
Building Resiliency

The Green City, Clean Waters Program

440+ GSI SITES

The *Green City, Clean Waters* program was established in 2011. Today, hundreds of green stormwater sites across the city help to manage millions of gallons of runoff every time it rains in Philadelphia. This widely distributed green infrastructure network currently reduces pollution from sewer overflows by 1.5 billion gallons per year, and is set to grow tenfold by 2036.





Hurricane Sandy

- Up to 9 foot storm surges
- **NYC water and wastewater systems saw $3 billion in damage**
- Over 10 billion gallons of raw and partly treated sewage overflowed