NYC Town & Gown: Climate Vulnerability, Impact, and Adaptation Analysis (VIA)

VIA Interim Findings

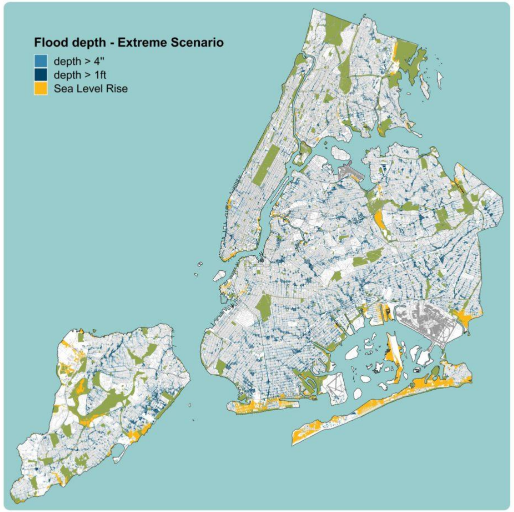
Climate Knowledge Exchange, August 2nd, 2023

Project Objective

Develop a comprehensive analysis of future potential climate conditions and associated socio-economic impacts in NYC.

Key elements include:

- Develop climate projections for the NYC region, including high resolution heat risk and exposure projections, storm surge risk analysis, and coastal flood mapping,
- Characterize current and future extreme heavy rainfall in New York City,
- Conduct a systematic assessment of health-related economic costs from climate-sensitive events in New York City, and
- Create a Coastal Flooding Vulnerability Index for New York City



OVERVIEW OF VIA TASKS

Task 2: Climate Projections for NYC Region

- Sea level rise and coastal flood projections; High resolution heat projections
- Tropical Cyclone (TC) Sensitivity assessment report
- Compound climate events

Task 3: Current and Future Extreme Heavy Rainfall in NYC

- Intensity-duration-frequency (IDF) curves for NYC
- Event Ranking and Historical Trends Analysis of observed heavy rainfall events in NYC
- Climate model recommendations

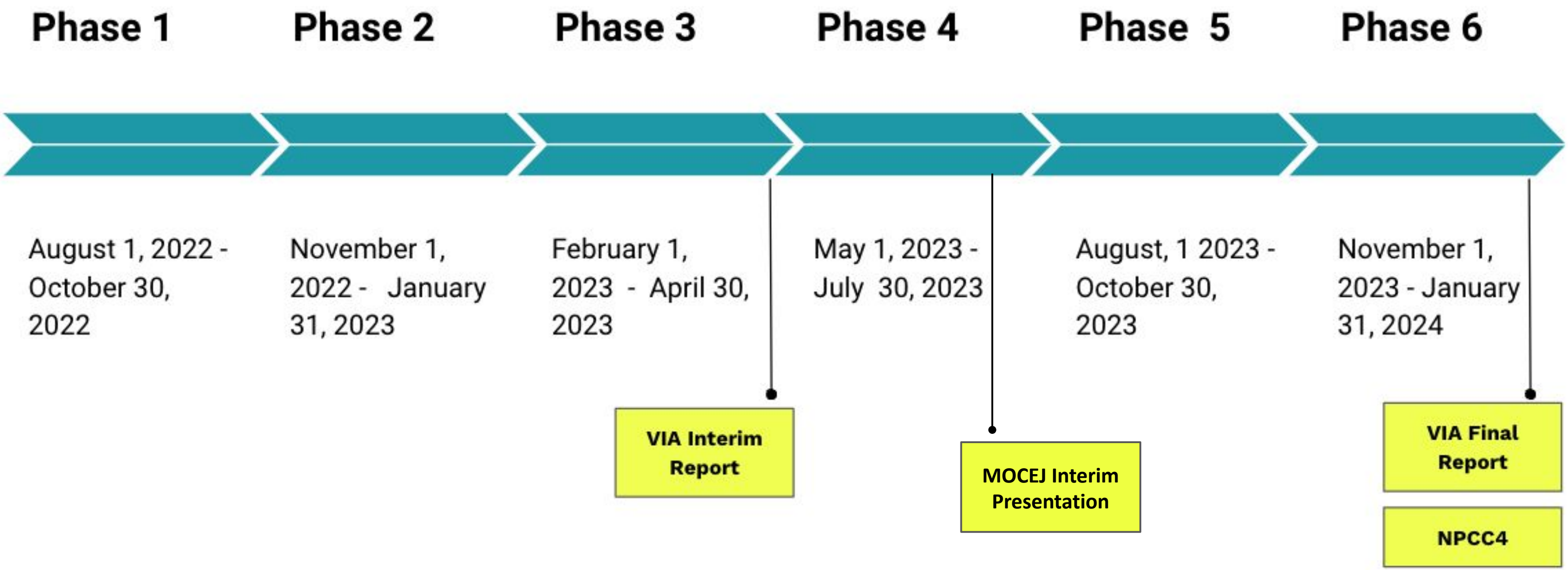
Task 4: Systematic Assessment of Health-Related Economic Costs

- Spatial distributions of vulnerability
- Distribution of economic costs
- NPCC Health Working Group

Task 5: Flooding Vulnerability Index for NYC

- Develop a flood vulnerability index (FVI) for NYC that reflects each of the three components of vulnerability: exposure to a hazard, harm from the exposure, and capacity to recover.

VIA Timeline



TASK 2

Goal: Synchronize and apply outputs from the NYSCIA assessment to NYC. Develop new climate projections based on the needs and gaps identified by the Client team, and related stakeholder workshops.

Task 2: Climate Projections for NYC Region

Task Team

Core Team Members:

- Radley Horton, Co-Lead (Columbia University)
- Philip Orton, , Co-Lead (Stevens Institute of Technology)
- Franco Montalto (Drexel University)
- Luis Ortiz (George Mason University)
- Timon McPhearson (The New School)
- Christian Braneon (CUNY)

NYC ICAT Advisors:

- Lauren Smalls-Mantey (Department of Health)
- Jarrod Sims (Department of Office of Management and Budget)
- Alan Cohn (NYC DEP)
- Jennifer Garigliano (NYC DEP)
- Erika Jozwiak (MOCEJ)

Interim Findings :

A. Coordination with NYSCIA Spring 2022

B. Sea Level Rise and Coastal Flood Projections

C. Tropical Cyclone (TC) Sensitivity Assessment

Ongoing research:

D. Compound Rain-Surge Hazard

E. Sensitivity Study

F. High Resolution heat projections

Sea Level Rise and Coastal Flooding

- Updated sea level rise projections (decennial data will be included in final VIA report) for New York City based on IPCC 6th Assessment report
- Projections are based on the CMIP6 models and SSP framework

	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	ARIM
2030s	6 in.	7 in.	9 in.	11 in.	13 in.	
2050s	12 in.	14 in.	16 in.	19 in.	23 in.	
2080s	21 in.	25 in.	30 in.	39 in.	45 in.	81 in.
2100	25 in.	30 in.	36 in.	50 in.	65 in.	114 in.
2150	38 in.	47 in.	59 in.	89 in.	177 in.	

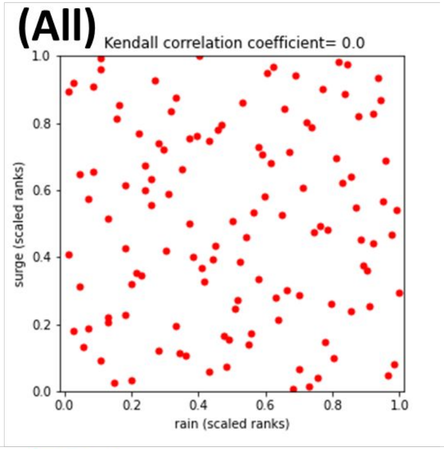
Table 1. Projections are relative to the 1995 to 2014 base period. The 10th, 25th, 50th, 75th, and 90th, percentiles are shown.

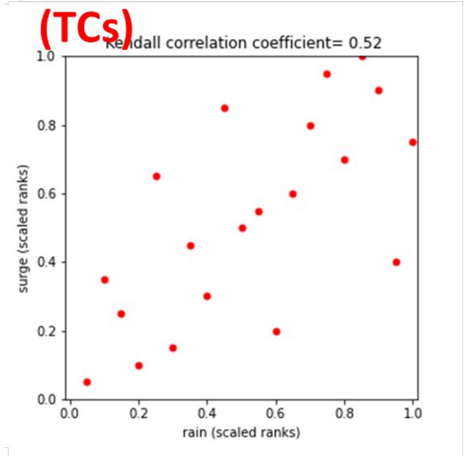
Compound rain-surge hazard

Preliminary results include these findings:

- NYC rain and NTR (storm surge) have low, but non-zero correlations ("**ALL**"). While heavy rainfall can co-occur with a large storm surge (e.g. Hurricane Irene), the combination of extreme rain and extreme surge has a very low probability
- However, the dependency of NTR and rainfall during tropical cyclones (**TCs**) is quite different from other events at NYC, suggesting that TC events may need separate assessment
- For top-ranked TC rain events, Simultaneous hourly rain-surge rank correlations are relatively high (0.52) for TCs, much higher than for other storm types (extratropical or convective)
- For top-ranked TC rain and surge events, there are moderate negative correlations between rain intensity and the lag to peak surge, **indicating that the most intense TC rain and surge events (e.g. 100-year) have the most potential for compounding.**

Normalized Rank (0 to 1) of rain and surge for top-ranked historical rain events.





High Resolution Heat Projection including Heating and Cooling Days

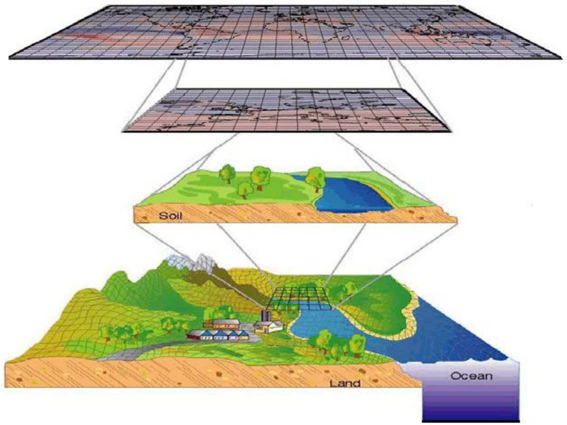


Figure 3. Schematic of the dynamical downscaling workflow using coarse resolution data to resolve finer scale domains (top to bottom). Creative Commons license, Khan and Pilz (2018).

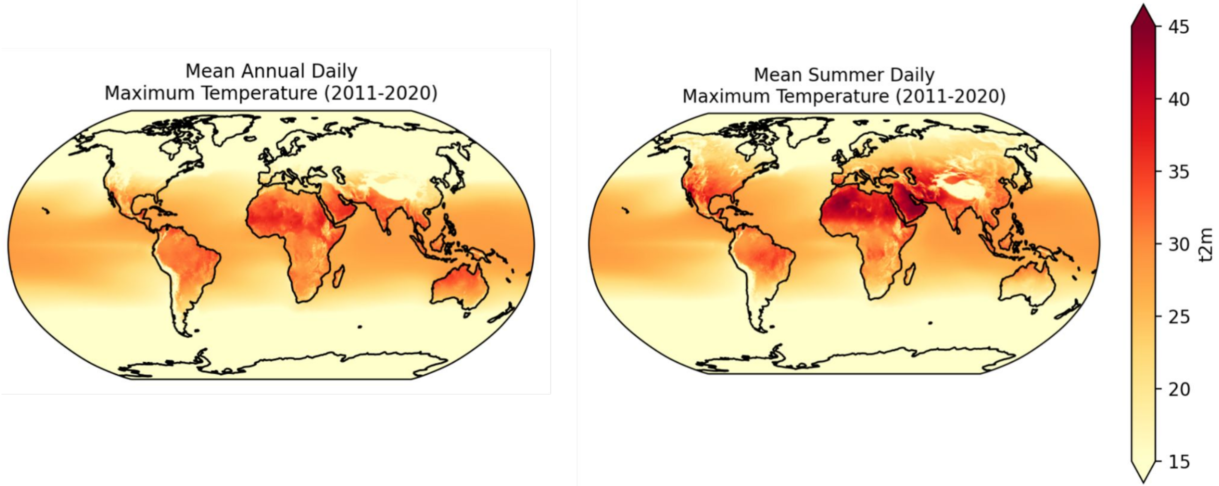


Figure 4: ERA5 Mean Annual (left) and Summer (right) daily maximum temperature for the years 2011-2020.

TASK 3

Goal: Produce new preliminary IDF curves. Apply IDF curves to simulate flood dynamics in hotspots deemed socioeconomically significant by the Stormwater Sub-committee. Merge empirical and model-based approaches to projecting extreme precipitation that are better suited to characterizing low-probability/high consequence events.

Task 3: Current and Future Extreme Heavy Rainfall in New York City

Task Team

Core Team Members:

- Franco Montalto (Drexel University)
- Bernice Rosenzweig (Sarah Lawrence College)
- Arthur DeGaetano (Cornell University)
- Philip Orton (Stevens Institute of Technology)
- Jerry Kleyman (Arcadis)
- Joel Katz (Arcadis)
- Patrick Gurian (Drexel University)
- Dan Bader (Columbia University)

NYC ICAT Advisors:

- Alan Cohn (NYC DEP)
- Greg Mayes (NYC DEP)
- Erika Jozwiak (MOCEJ)

Interim Findings :

A. CMIP5 vs CMIP6 Comparison (LOCA Downscaling)

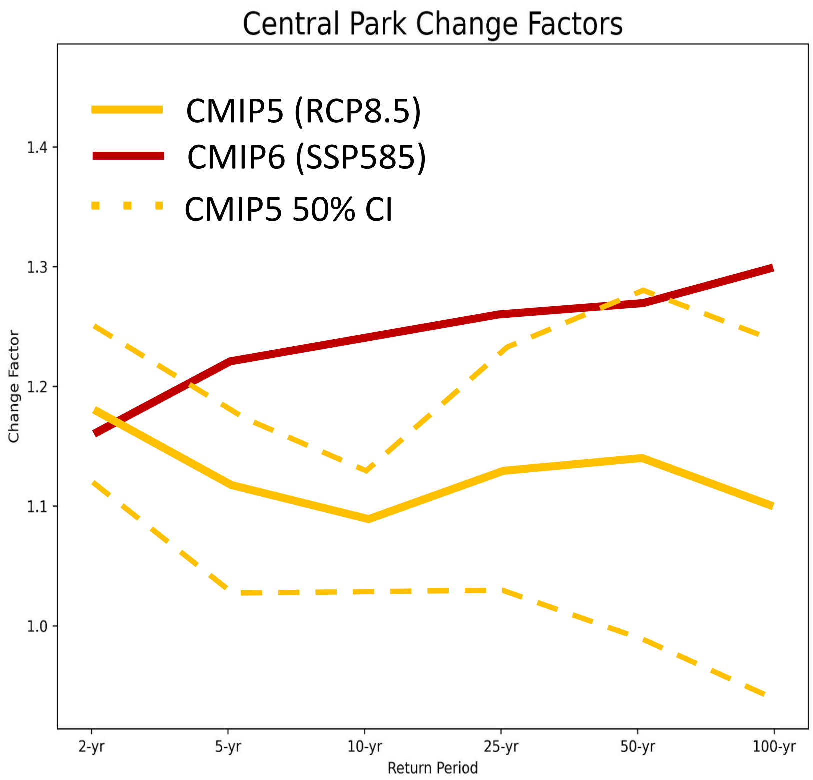
B. Observed Changes in Hourly vs Daily Return Periods

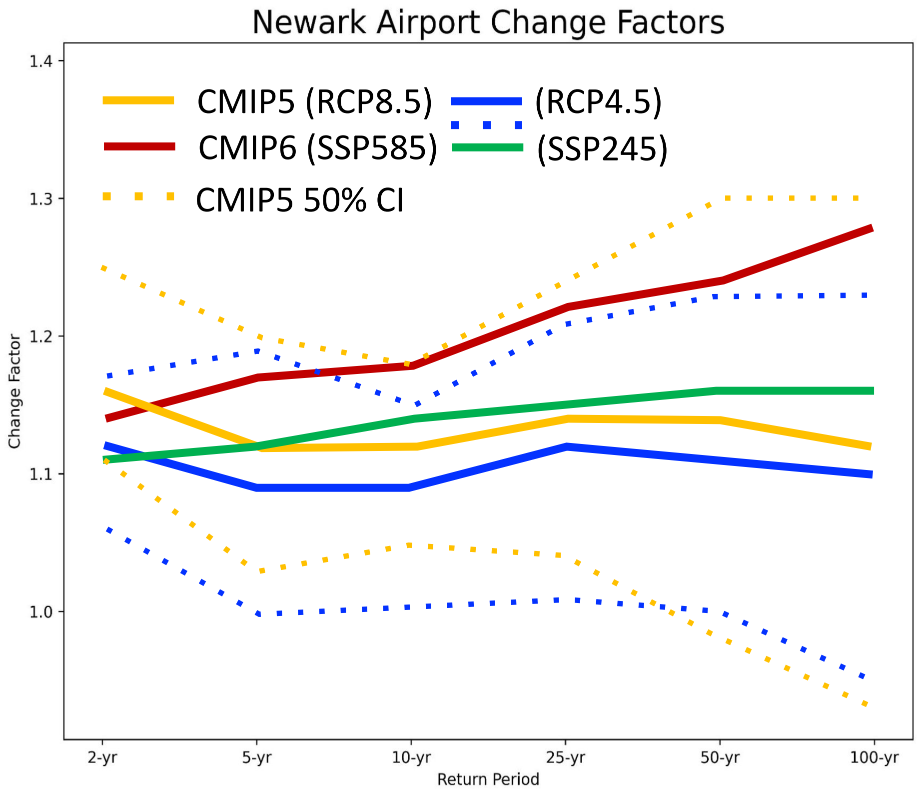
C. Proportion of n-hour PDS Events Overlapping Daily PDS Events

Ongoing research:

D. Preliminary IDF Curve refinement

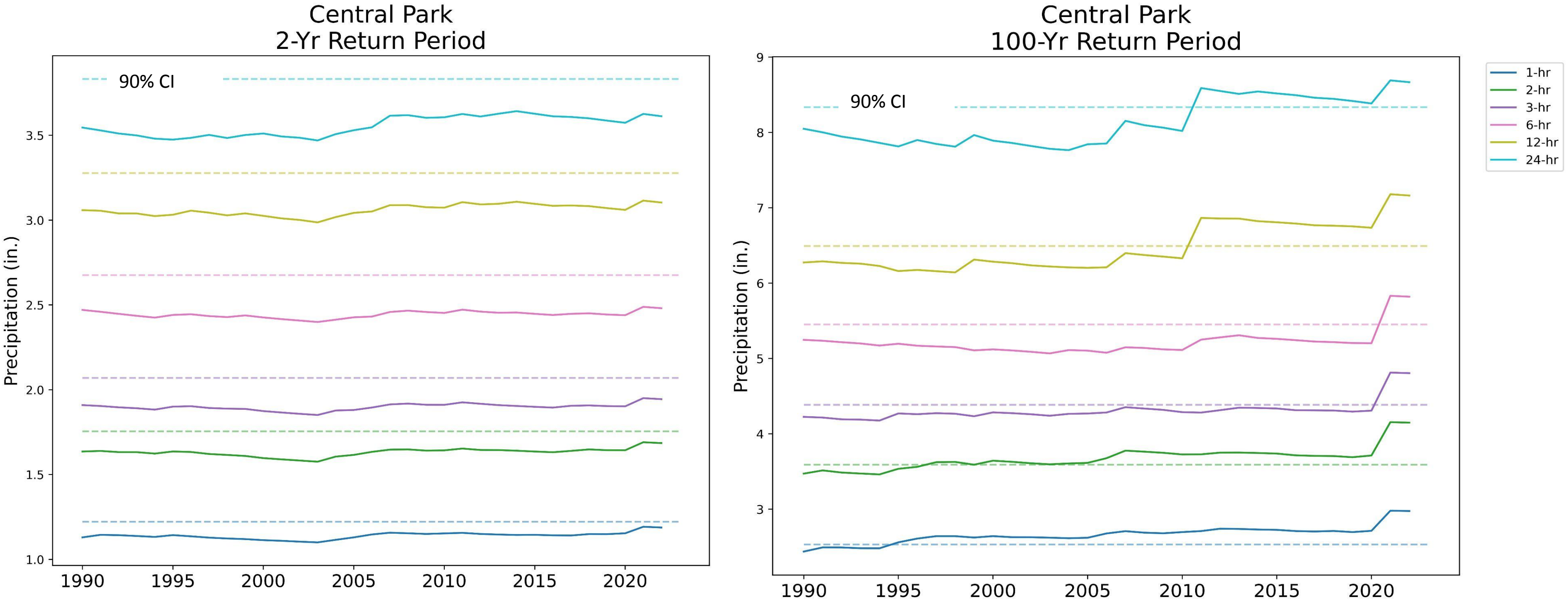
CMIP5 vs CMIP6 Comparison (LOCA Downscaling)





Take Home Message: CMIP6 Extremes tend to be **LARGER** than CMIP5, especially at high return periods.
Significance is Marginal

Observed Changes in Hourly vs Daily Return Periods



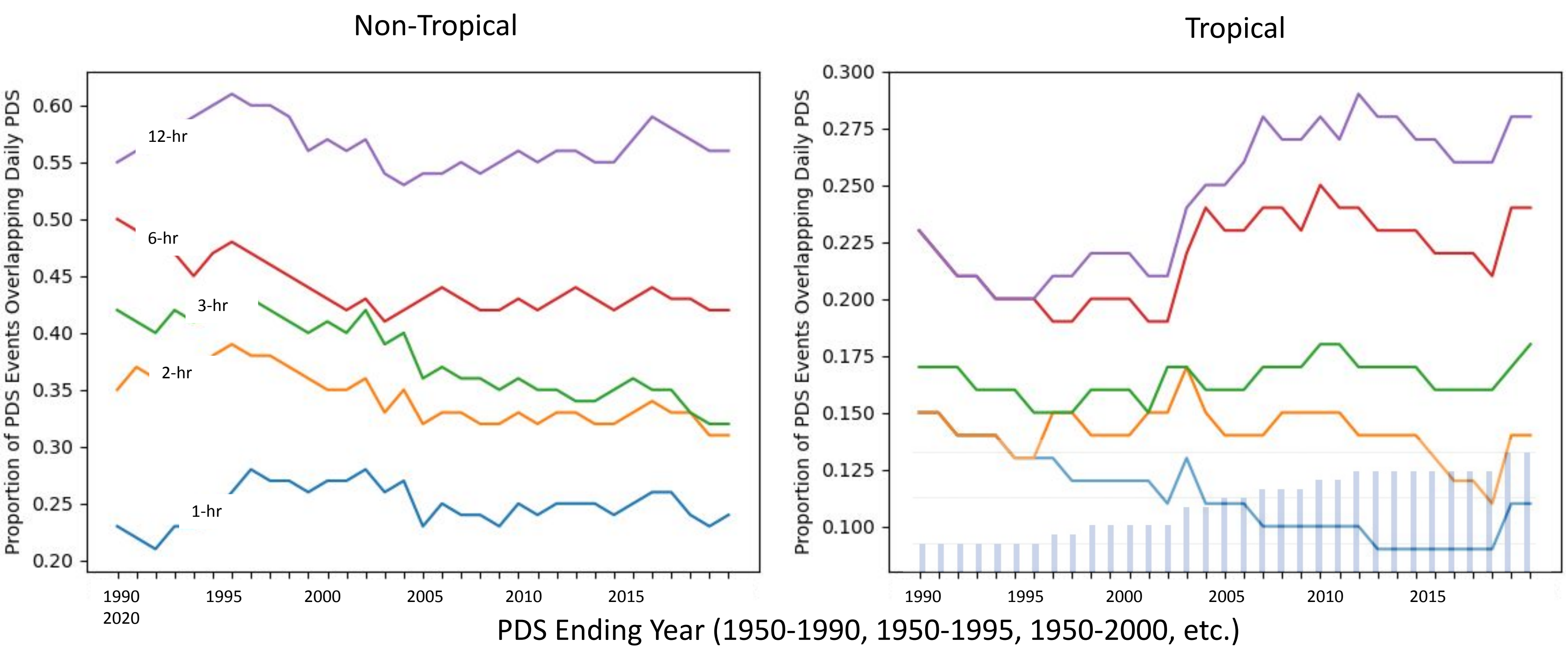
PDS Ending Year (1950-1990, 1950-1995, 1950-2000, etc.)

Take Home Message: Since 1990 the observed change in **Hourly** extremes has been **Similar** to **Daily** extremes

Proportionally changes are a bit **higher**

Proportion of n-hour PDS Events Overlapping Daily PDS Events

Central Park



Take Home Message: Since 1990 there has been a jump in the number of 12- and 6-hr events from tropical storms Prior to 2003 about 21% of 6-hr PDS overlapped 24-hour PDS events. Now it is 27%

TASK 4

Goal: Conduct systematic assessment of health-related economic costs attributable to climate-sensitive events in NYC with a emphasis on equity and climate justice.

Task 4: Systematic Assessment of Health-Related Economic Costs from Climate-Sensitive Events in New York City

Core Team Members:

- Matthew Neidell (Columbia University)
- Deborah Balk (CUNY)
- Marianthi-Anna Kioumourtzoglou (Columbia University)
- Christian Braneon (NASA)
- Leiwen Jiang (Population Council)
- Hamid Zoraghein (Population Council)
- Thomas Matte (Columbia University)
- Vijay Limaye (NRDC)
- Kim Knowlton (NRDC and Columbia University)
- Santiago Munoz Perez (Columbia University)

NYC ICAT Advisors:

- Katie Lane (Department of Health)
- Kaz Ito (Department of Health)
- Melissa Umberger (Department of Emergency Management)
- Billy Pappas (Department of Emergency Management)
- Mallory Rutigliano (Office of Management and Budget)

Interim Findings :

A. Engagement with NPCC and ICAT

B. Literature Review

Ongoing research:

C. Spatial Distributions of Vulnerability

D. Distribution of economic costs

Spatial Distributions of Vulnerability

In order to continue to understand and monitor equity dimensions of vulnerability, future population distributions must be understood by major race and ethnicity subpopulations in NYC and the time horizon of population projections for a demographic forecast. The analysis will include 2 components:

1. A **demographic model of population projections** using a multi-state model consistent with the City's own shorter-term projection but which is also consistent with the Shared Socio-economc Pathways (SSP) framework used in the climate projection community and is consistent with the RCPs used in the NPCC projections.
2. **Spatial distribution of future vulnerability** comes from spatial downscaling on population

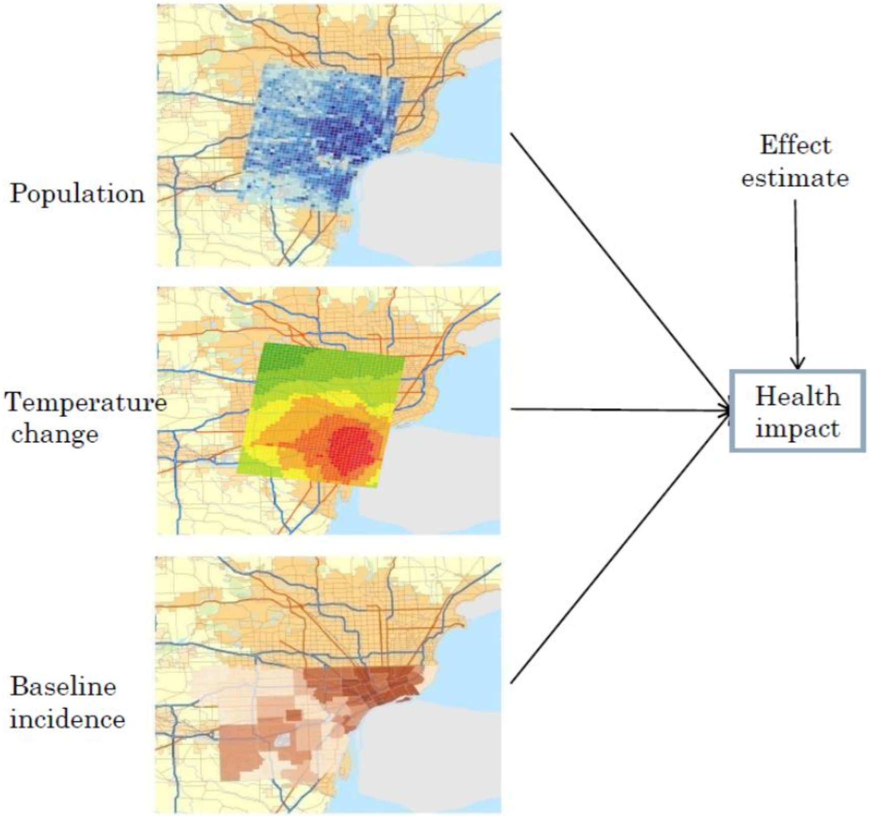
Calculating Health Impacts

Formula for change in impacts ΔY:

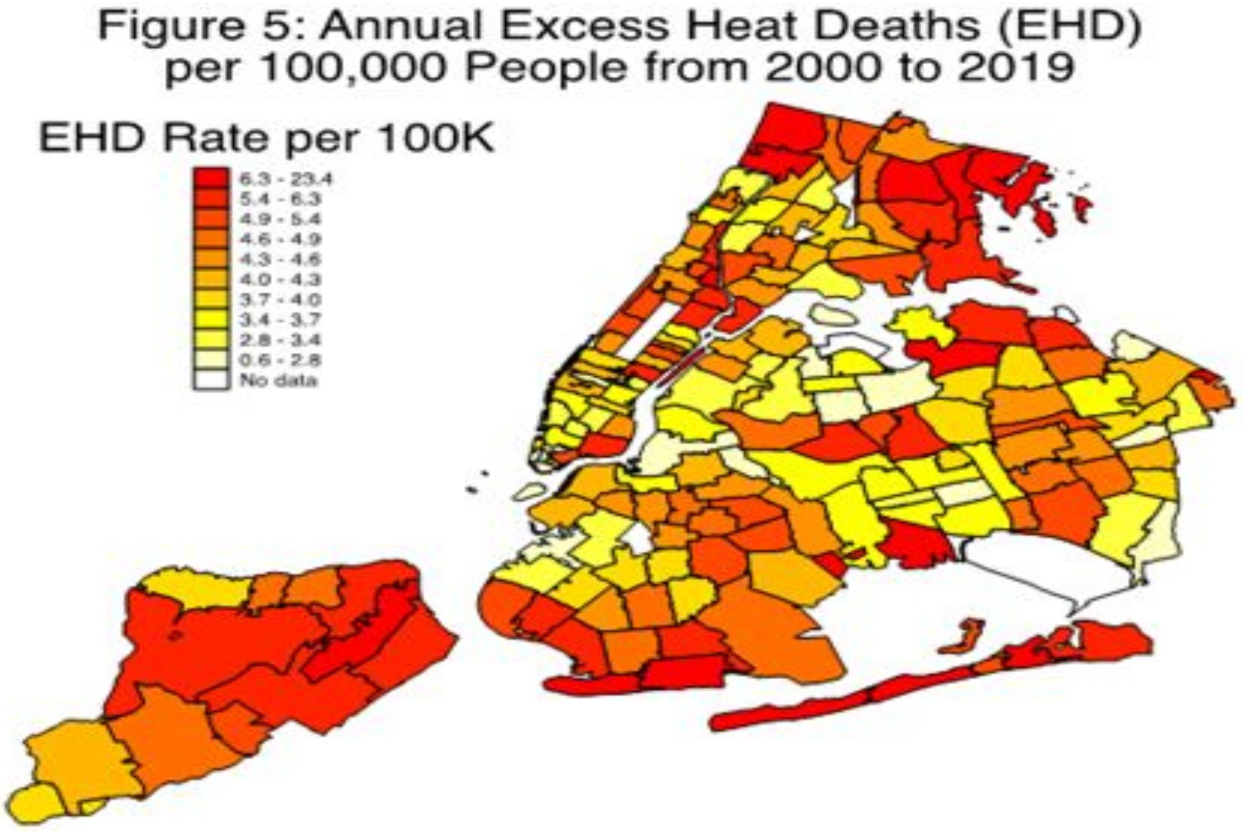
$$\Delta Y = Y_0 \left(1 - e^{-\beta \Delta \mathrm{Tem}}\right) Pop$$

with variables:

Y_0	baseline incidence
ΔT	temperature change
Pop	exposed population
β	epidemiologic effect estimate



Annual Excess Heat Deaths (EHD)



Monetizing health impacts

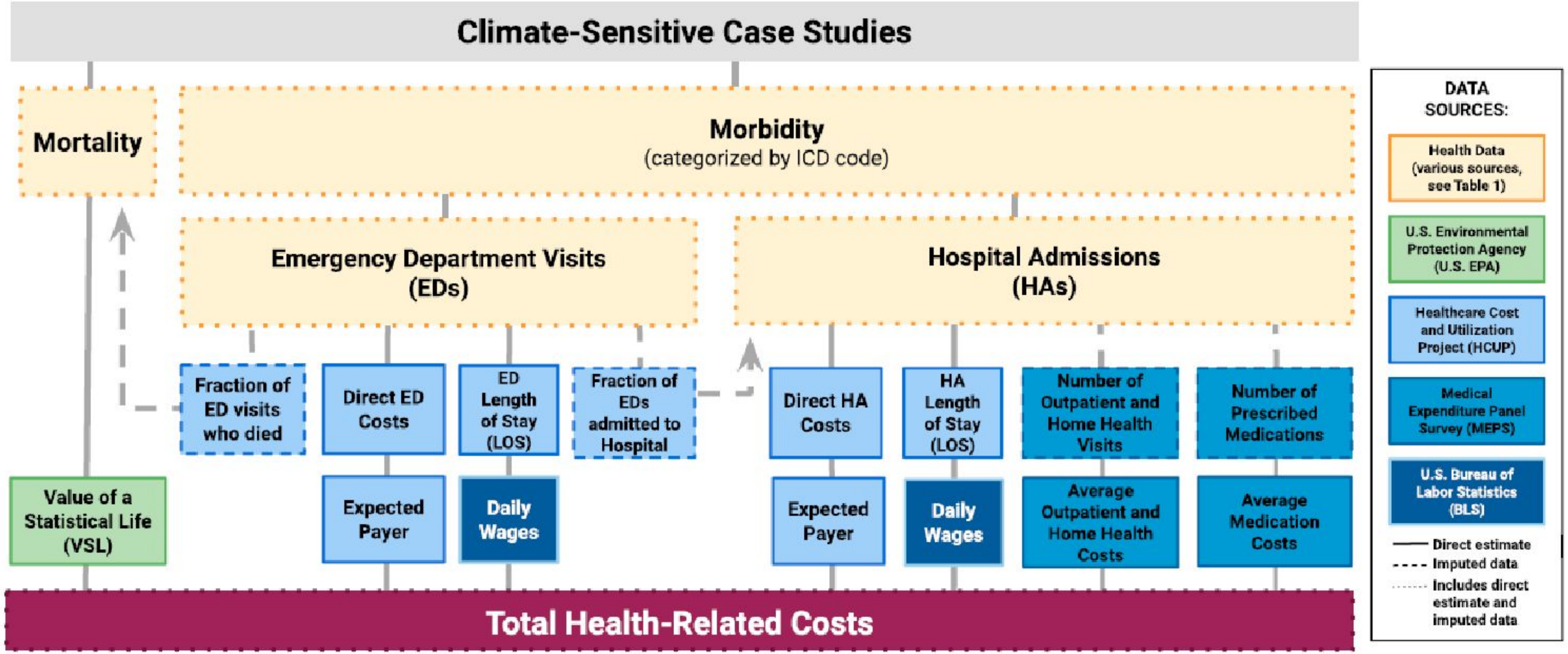


Figure 8. Data sources for health-related cost estimates for all case studies. Yellow boxes represent health incidence data, the green box represents the VSL estimate (U.S. Environmental Protection Agency, 2014), light blue boxes represent data from HCUP (U.S. Agency for Healthcare Research and Quality, n.d.-a), medium blue boxes represent data from MEPS (U.S. Agency for Healthcare Research and Quality, n.d.-b), and dark blue boxes represent wage data from the BLS (U.S. Bureau of Labor Statistics, 2016). Solid lines are direct estimates, dashed lines are imputed data, and dotted lines denote a combination of direct and imputed data. (Limaye et al., 2019)

TASK 5

Goal: Develop a flood vulnerability index (FVI) for NYC that reflects each of the three components of vulnerability: exposure to a hazard, susceptibility to harm, and capacity to recover.

Task 5: Flooding Vulnerability Index for New York City

Core Team:

- Timon McPhearson (Co-lead, The New School)
- Malgosia Madajewicz (Co-lead, Columbia University)
- Pablo Herreros-Cantis (The New School)

Advisory Team

- Jerry Kleyman and Mary Kimball (Arcadis)
- Franco Montalto (Drexel University)
- Bernice Rosenzweig (Sarah Lawrence)
- Brett Branco (CUNY/SRIJB)
- Katie Graziano (Sea Grant/Cornell)
- Lindsay Campbell, Dr. Erika Svendsen
- Michelle Johnson (US Forest Service)

NYC ICAT Advisors:

- Katie Lane (Department of Health)
- Kaz Ito (Department of Health)
- Novem Auyeung (NYC Parks and Recreation)
- Melissa Umberger (Department of Emergency Management)
- Billy Pappas (Department of Emergency Management)
- Sarit Platkin (Department of Housing Preservation and Development)
- Arielle Goldberg (Department of Housing Preservation and Development)
- Erika Jozwaik (MOCEJ)
- Jessica Colon (MOCEJ)

Interim Findings :

A. Literature Review

B. Data Collection, Analysis, and DRAFT FVI

Ongoing research:

C. NYC Flood Vulnerability Index (FVI) Development
D. Interactive Spatial Planning Tool

Literature Review

- **NYC experiences multiple types of flooding, including storm surge, tidal, and pluvial flooding.** The data sources suggested for each flood hazard type given current data are FEMA's 100 and 500 year flood zones for storm surge, Mean Monthly High Water (MMHW) projections released by the NPCC for tidal flooding, and the moderate and extreme stormwater scenarios released in the city's Stormwater Resiliency Plan for pluvial flooding
- **Vulnerability defined as exposure to hazard, susceptibility to harm, and capacity to recover.**
- **Include susceptibility to harm, and capacity to recover in FVI, while exposure will be separate layers provided in the interactive decision support tool** since it is moderated by the intensity, frequency, and typology of a flooding event, as well as the uncertainties linked to the modeling methods used to develop hazard layers.
- iVI Indicators based on literature, with emphasis on validation studies, and ICAT feedback.

NYC Flood Vulnerability Index (FVI) Development

Indicators currently used in the preliminary FVI:

- **Black, Indigenous, People of Colour** (%)
- **Per Capita Income** (%)
- **Disability** (% with a disability)
- **Language isolation** (% speaking English less than “well”)
- **Children** (% below 5 years old)
- **Elderly** (% Above 60 years old)
- **Elderly population living alone** (% living alone above 65 years old)
- **Healthcare access** (% without health insurance)
- **Poverty rate** (% living below 2x the federal poverty rate)
- **Household income** (% households making less than $75,000)
- **Home ownership** (% households that are owner occupied)
- **Cost burdened households** (% households spending 30% or more in their living costs)
- **Rent burdened households** (% households spending 30% or more in their rental costs)

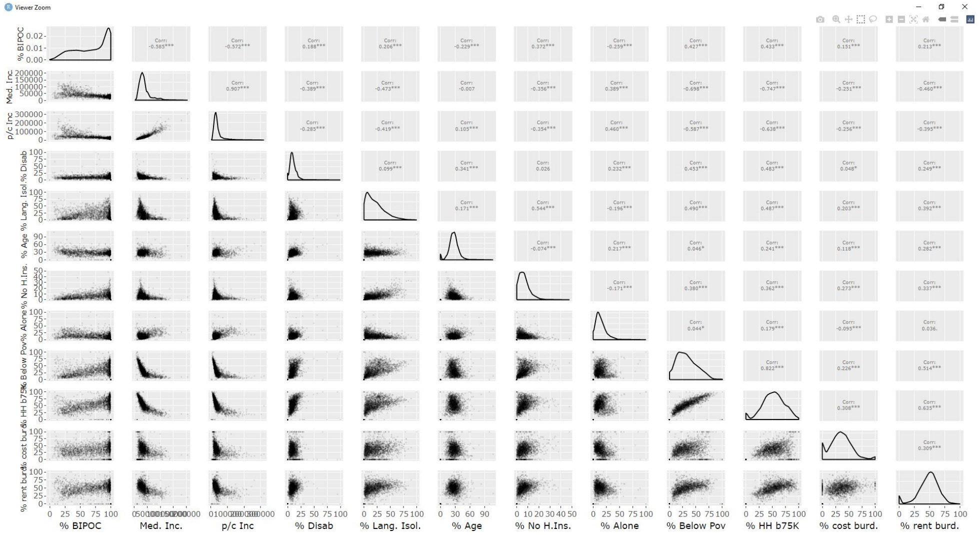


Figure 9: Correlation matrix of the indicators initially proposed. Based on this correlation matrix, the indicator “Median Income” (Med. Inc) has been approved for removal by the Task 5 Team and ICAT due to its high correlation with “per capita income” (p/c. Inc).

NYC Flood Vulnerability Index (FVI) Development

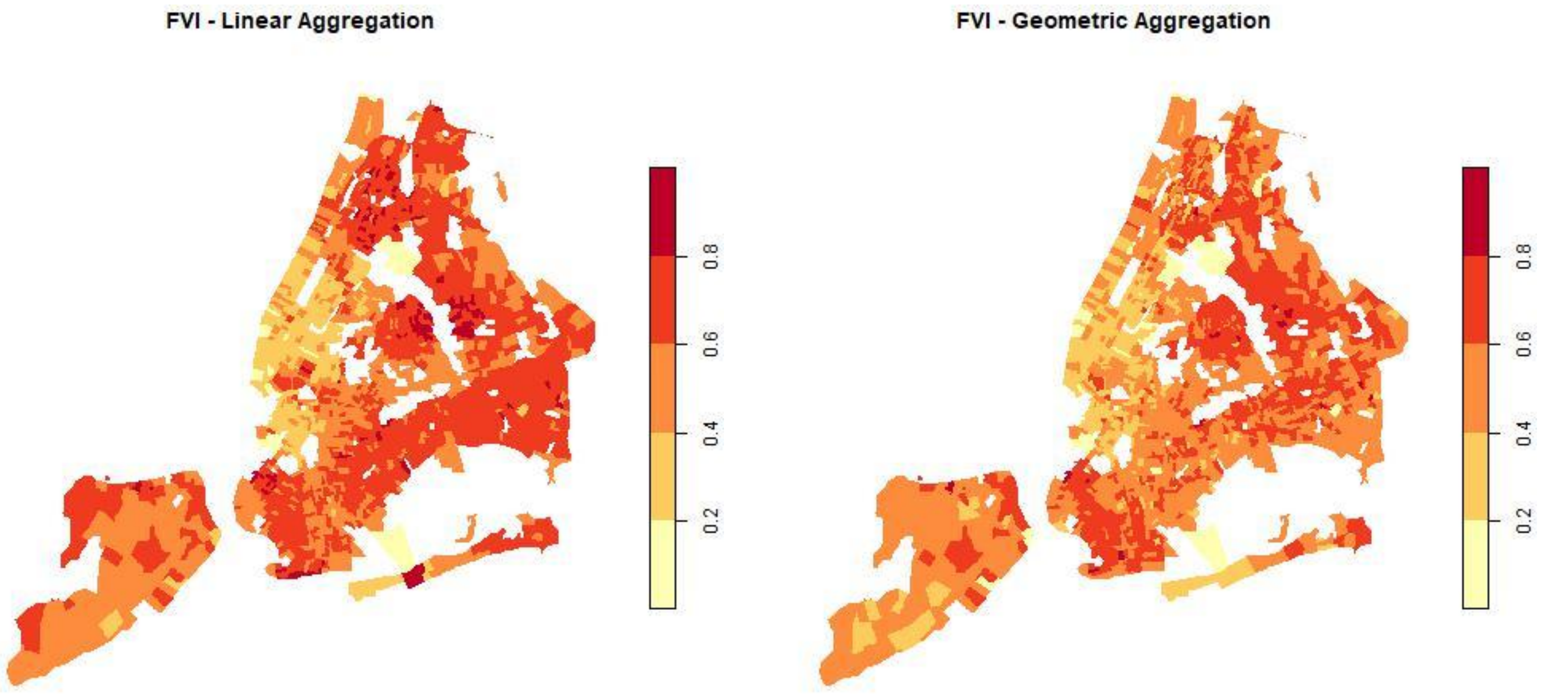


Figure 10: Preliminary FVI results, comparing the two data aggregation approaches considered. As shown in the maps, the geometric aggregation method shows a lower density of tracts earning a high index value as it limits the influence of individual indicators in the final result.

NYC Flood Vulnerability Index (FVI) Development

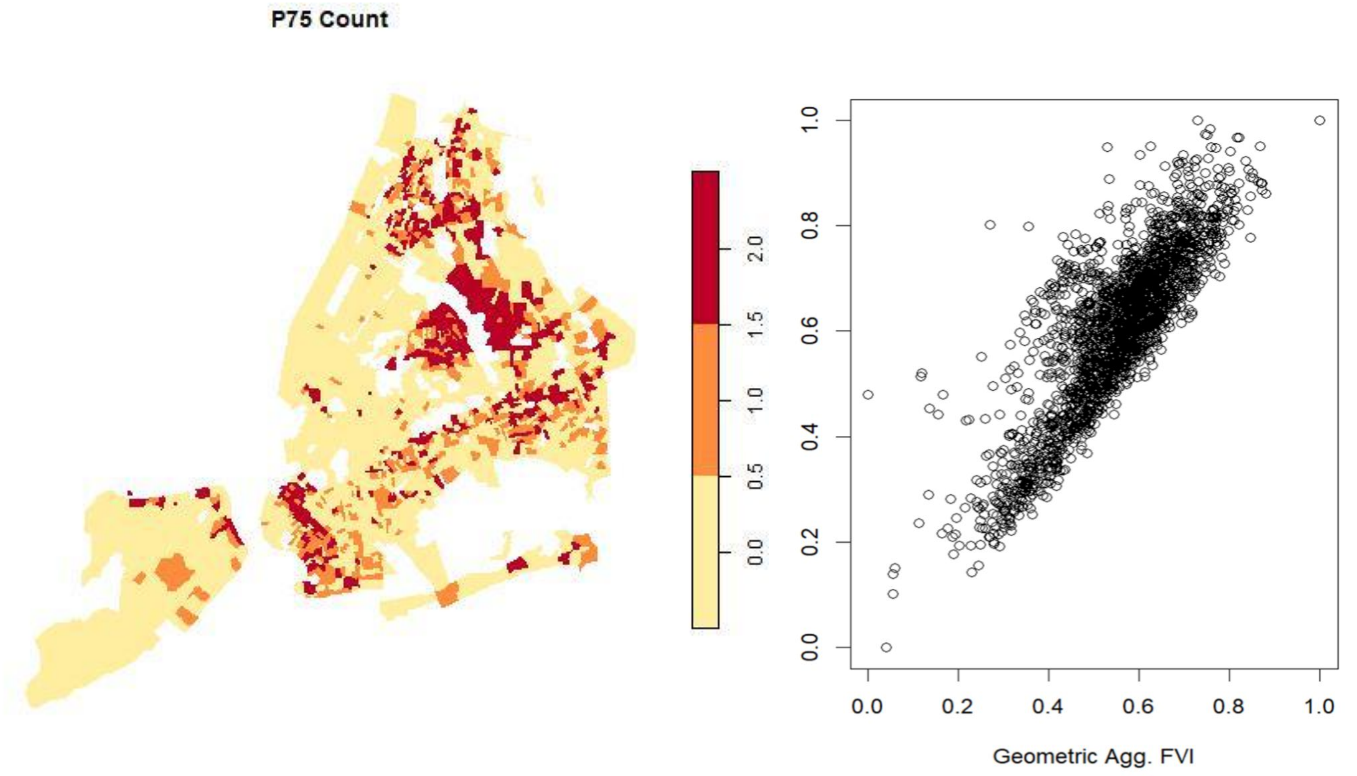


Figure 11: Map showing the number of aggregation methods in which Census Tracts scored an FVI within the highest quartile. A value of 2 indicates that a CT scored a high FVI under both aggregation scenarios, while a value of 1 indicates that only 1 aggregation method produced a high FVI. On the right, a scatterplot comparing both aggregation methods.

Data Collection & Analysis

Neighborhood	Type of flooding	Per Capita Income	% BIPOC	% under 2X poverty level	% with Disability	% Who Speak English Less than Well	% without Health Insurance
Woodside/ Elmhurst, Queens	pluvial	$26,716	90%	36%	8%	25%	12%
Hollis, Queens	pluvial	$30,361	98%	20%	10%	5%	8%
Gowanus, Brooklyn	pluvial	$56,361	46%	19%	8%	7%	4%
Northern Staten Island	pluvial	$34,010	63%	25%	10%	5%	6%
Arverne/ Edgemere, Queens	high tide	$24,830	86%	44%	15%	7%	7%
Rosedale, Queens	high tide and pluvial	$34,002	97%	16%	10%	2%	5%
All of NYC		$43,952	69%	35%	11%	12%	7%

Table 3: Proposed data collection sites. Note - The types of flooding refer to experience within the last three years. The socioeconomic data are 5-year averages for 2016-2021 from the American Community Survey.

Gaps In VIA Research
+
VIA & NPCC Crosswalk

Gaps for Future Research

Drought

Drinking Water
Urban Agriculture
SLR and Salinity
Urban Forest Health/UHI

Air Quality

Wildfire

Other…

VIA Research Coordination with NPCC4

Ready for Integration

Task 2:

- CMIP6
- Tropical Cyclone Sensitivity Assessment

Task 3:

- Event Ranking and Historical Trends Analysis
- Updated IDF Curves

Progress Toward Integration

Task 4:

- Spatial Distribution of Vulnerability
- Distribution of Economic cost

Task 5:

- Flood Vulnerability Index - Spatial Analysis and map production

Feedback, Questions, and Concerns