Weather Analysis and Visualization for Everyone

REU/IUSE Interns: Kester Todd[1], Charith Jayasekerage[2], Arhum Aamir[2], Joseph Moise[1]
HIRES Interns: Grace Lee[3], Benjamin Kreitzer[3], Hope Menachery[3], Kelly Huang [3]
Graduate Mentor: Richard Rivera[4]
Faculty Advisors: Dr. Reza Khanbilvardi[4], Dr.Shakila Merchant[4]
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Introduction

Our objective is to develop a forward-looking coastal flood map for New York City (NYC) in the years 2050 and 2100, utilizing the bathtub methodology. This map will incorporate three key components: existing sea level rise data, newly acquired information regarding the sinking of NYC conducted by Tom Parsons and his team, and the elevation map of NYC. By integrating these components, we aim to construct an informative and visually appealing predictive map. Traditionally, the sea level rise data and NYC sinking information have been presented in a format that is primarily comprehensible to the scientific community and experts in the field. However, our goal is to transform this information into a more accessible and visually engaging format that can be easily understood by the people of NYC. We want to provide the residents with a clear picture of what the future holds for their communities, empowering them to make informed decisions and take necessary actions.

Method

The first phase of the project is to research flood data history in NYC from the year 1950 to 2023. The second phase of this project is to find New York City's land elevation data, its land subsidence rates and its sea level rise by using (1) a digital elevation map of NYC displaying different elevations in different boroughs. (2) Information on NYC's subsidence rates that were calculated using 5 years of InSAR data between 2015-2020 which maps the average land subsidence rates in mm/year across ~20,000 coordinates within the five boroughs of New York City. (3) Information on the sea level rise GIS data for NYC from NOAA's website. The final phase is to incorporate the subsidence data into projections for sea level rise for the years 2050 and 2100, thus providing us with new coastal floodplain maps for New York City in the future.

Procedure: Making the Models

Floodplain zones were classified using NPCC's methodology based on high sea level rise estimates. Figures were created using ArcGIS Pro and Photoshop, using a "bathtub approach" with consideration to topography and hydrodynamics of the 5 boroughs. Note that gray infrastructure, transit systems, future construction and such may impact subsidence rates in NYC. The maps depict NYC's 100-year floodplain, considering sea level rise and flood heights for such an event. InSAR subsidence data extended flood areas for 2050 and 2100, excluding certain regions with insufficient data (e.g., western Staten Island). The floodplain resolution is lower due to data interpretation in ArcGIS Pro, using NOAA's 2017 DEM. InSAR data for 2050 and 2100 was transformed to feet, and interpolated filled data gaps.

Results

Incorporating subsidization into flood map projections has led to expanded inundation beyond expectations. Two time points are assessed, using the 2020s floodplain as baseline (navy blue). The left map depicts the 2050 projected floodplain (light blue), notably surpassing the current extent. The right map shows the 2100 projection (navy blue). While vulnerable areas like Jamaica Bay and Coney Island are submerged as anticipated, heightened vulnerability is observed in the Financial District, Red Hook, and Long Island City. These regions could experience near-total flooding by century's end, posing catastrophic risks to city residents.

NYC Elevation Map

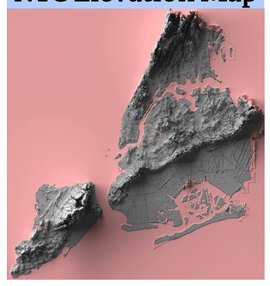


Figure 4: The map on the left showcases Scott Reinhard's version of a historic topographic map of New York City, blending old geological survey maps with elevation data.

Team WAVE's Predictive Hydrodynamic Floodplain Models

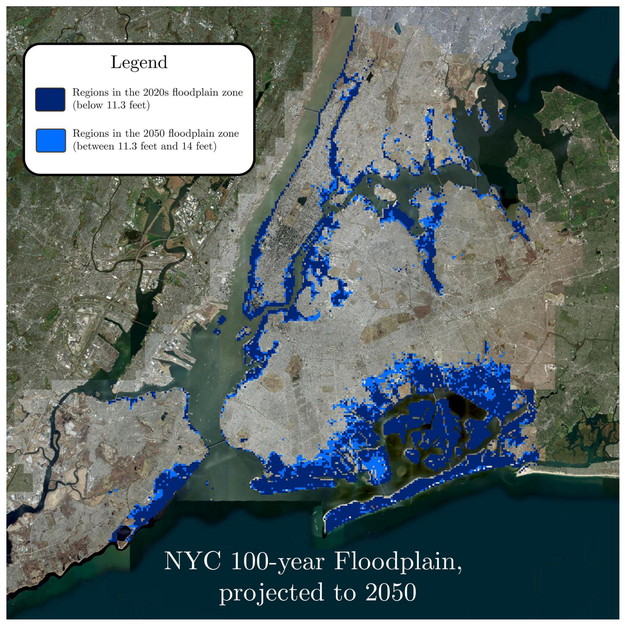
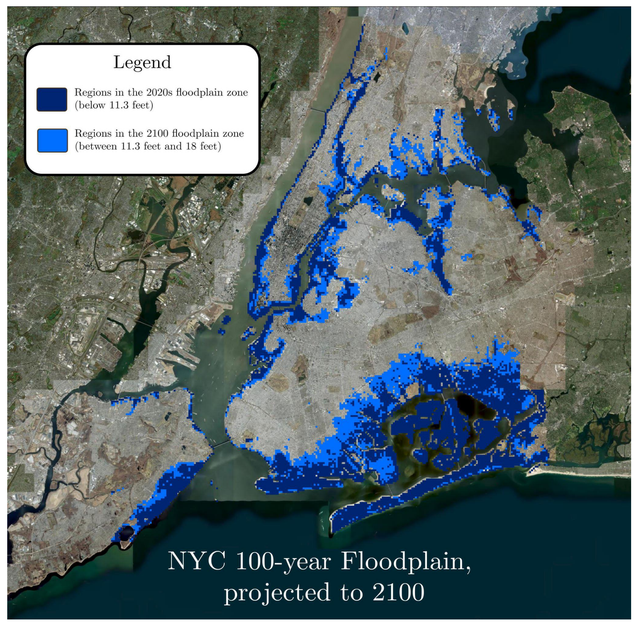


Figure 1: NYC 100-year Floodplain, projected for the year 2050. The image depicted highlights the areas In dark blue, the areas that fall within the 2020s floodplain elevation (< 11.3 ft) are highlighted. In lighter blue, the areas that fall within the 2050s floodplain elevation (between 11.3 and 14 ft) are highlighted.



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Seasonal Temperature at Central Park, with Future Projections through 2100 (using baseline temperatures from 1970-2000)

Season \ Decade	1870s	1880s	1890s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s	2020s (Projected)	2050s (Projected)	2080s (Projected)	2100s (Projected)
Spring	48.4 °F	48.4 °F	49.3 °F	50.0 °F	50.4 °F	50.5 °F	51.0 °F	51.8 °F	51.6 °F	51.7 °F	52.5 °F	53.2 °F	52.8 °F	52.8 °F	53.8 °F	55.9 °F	59.2 °F	61.7 °F	62.4 °F
Summer	73.2 °F	72.4 °F	73.3 °F	73.3 °F	72.6 °F	72.6 °F	74.6 °F	74.2 °F	74.4 °F	74.2 °F	74.6 °F	75.0 °F	75.0 °F	74.3 °F	75.8 °F	78.2 °F	81.5 °F	85.4 °F	86.2 °F
Fall	54.4 °F	54.4 °F	56.1 °F	57.0 °F	56.5 °F	56.7 °F	57.4 °F	58.3 °F	58.0 °F	57.7 °F	57.6 °F	57.8 °F	57.8 °F	58.1 °F	59.0 °F	61.3 °F	64.5 °F	68.5 °F	70.1 °F
Winter	31.2 °F	30.9 °F	33.2 °F	32.1 °F	32.3 °F	32.7 °F	34.4 °F	33.0 °F	35.2 °F	33.0 °F	33.5 °F	34.4 °F	36.8 °F	35.3 °F	36.1 °F	38.6 °F	41.7 °F	45.4 °F	47.7 °F
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Figure 3: The table displays average seasonal temperatures (in °F) by decade, sourced from Central Park records, complemented by projected temperature increases for the 2020s, 2050s, 2080s, and 2100s. To align with the 2015 New York City Panel on Climate Change (NPCC), we used Central Park's average temperatures from 1970-2000 as baselines for the projections. The NPCC's seasonal projections, found in Appendix IIA of their report, were then added to the averages. Since 2100 projections were absent, we derived them using linear interpolation based on changes from the 2020s to the 2080s.

New York City's Sea Level Rise, (1856-2022)

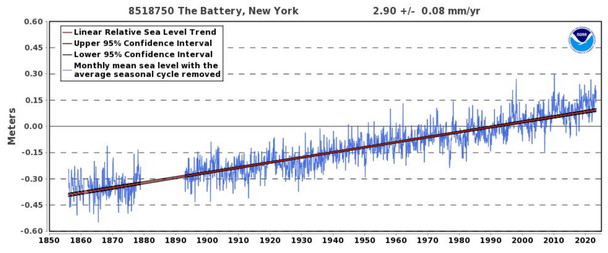

Figure 5: The above chart presents relative sea level trends from data at The Battery, NYC. As per a NOAA study, sea levels around NYC's coastline have increased by an average of 9 inches since 1950. The chart shows monthly average sea levels, filtering out typical seasonal variations influenced by factors like coastal ocean temperatures and wind. It also displays the relative sea level trend with its 95% confidence interval. Note: A negative trend indicates the land is rising faster than the ocean, while trends near zero suggest both are rising at similar rates.

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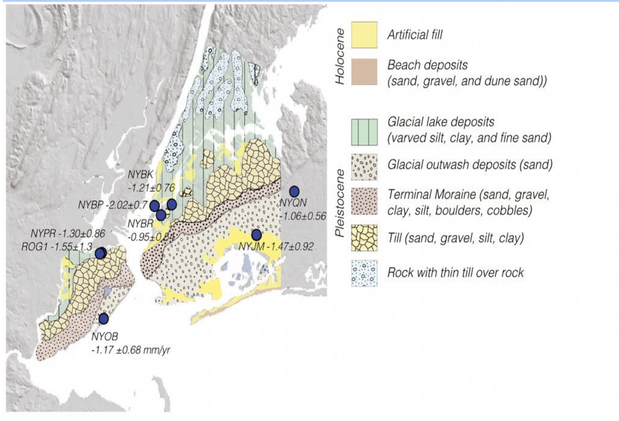

Figure 6: The above map depicts GPS station locations, which are marked with blue dots across New York City, with their according measured subsidence rates and standard deviations listed in mm/year. The map illustrates the geological makeup of New York City, with a legend indicating the types of material deposited over the land.

Future Works

Our primary objective is to subject our predictive floodplain models, pertaining to the years 2050 and 2100, to peer review by esteemed experts in the field. To achieve this, we specifically intend to solicit analysis and evaluation from reputable institutions such as the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA). The purpose of this evaluation is to critically assess the accuracy, robustness, and reliability of our findings in relation to projected floodplain conditions.
Our future research endeavors will involve collaborative efforts with fellow scientists to investigate the influence of additional factors on flood risk dynamics. Specifically, we will focus on the quantification and analysis of factors such as precipitation patterns, the impact of gray and green infrastructure, the effectiveness of the city's resiliency measures, and the efficacy of the flood protection program. Through systematic and interdisciplinary collaborations, we aim to enhance the understanding of complex floodplain dynamics and contribute to the advancement of flood risk assessment methodologies for the betterment of society and the environment.

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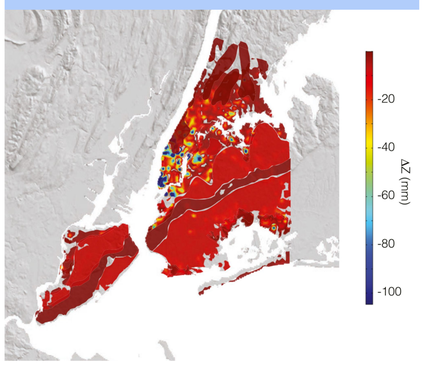

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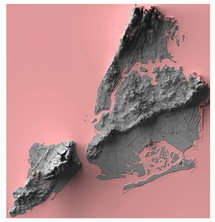

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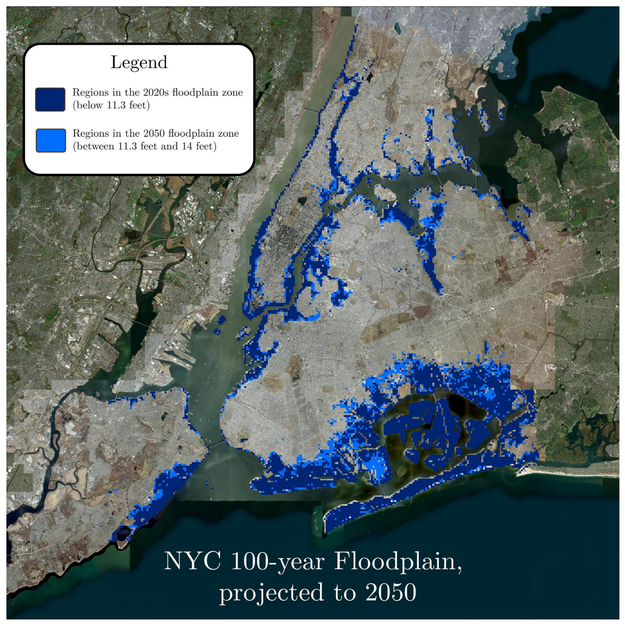

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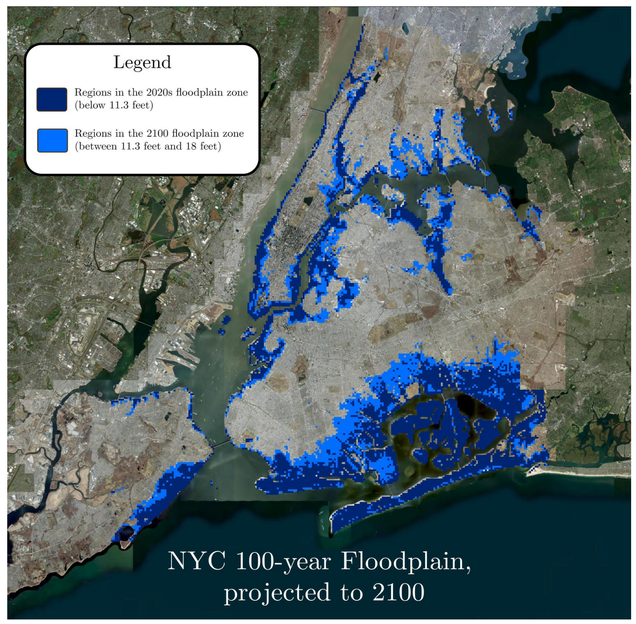

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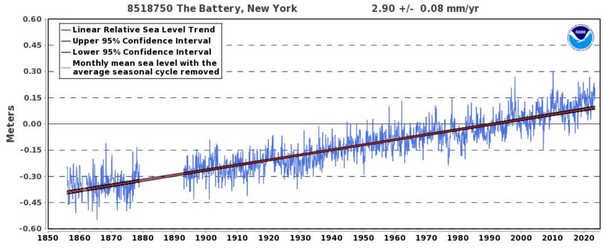

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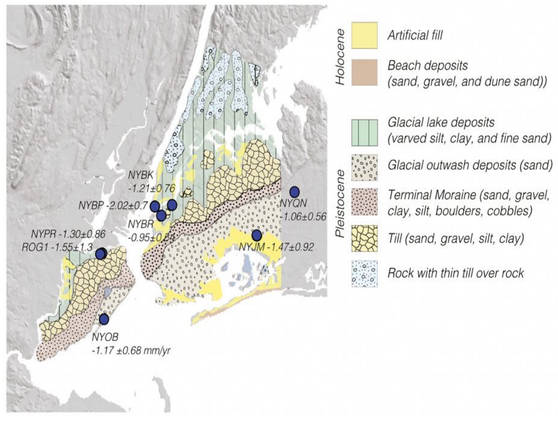

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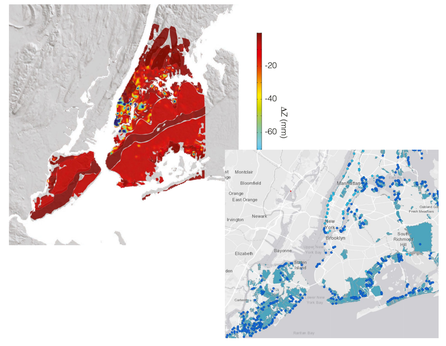

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