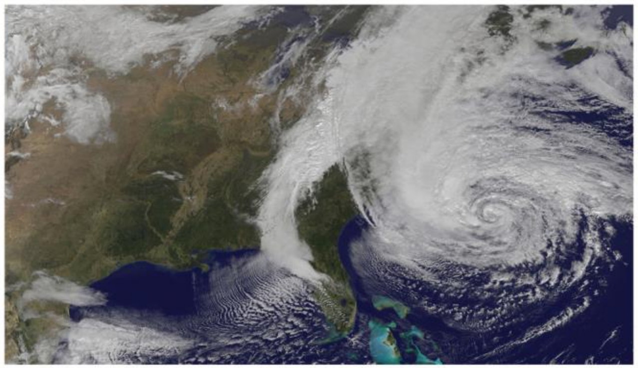
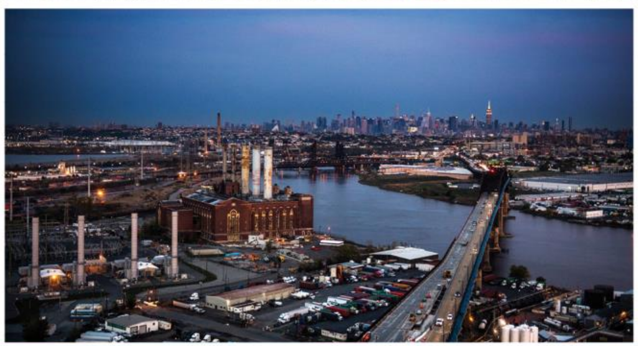
The sea, cities and rivers: living at the edge

Julie Pullen





(Title design courtesy of BNL)

Key Points

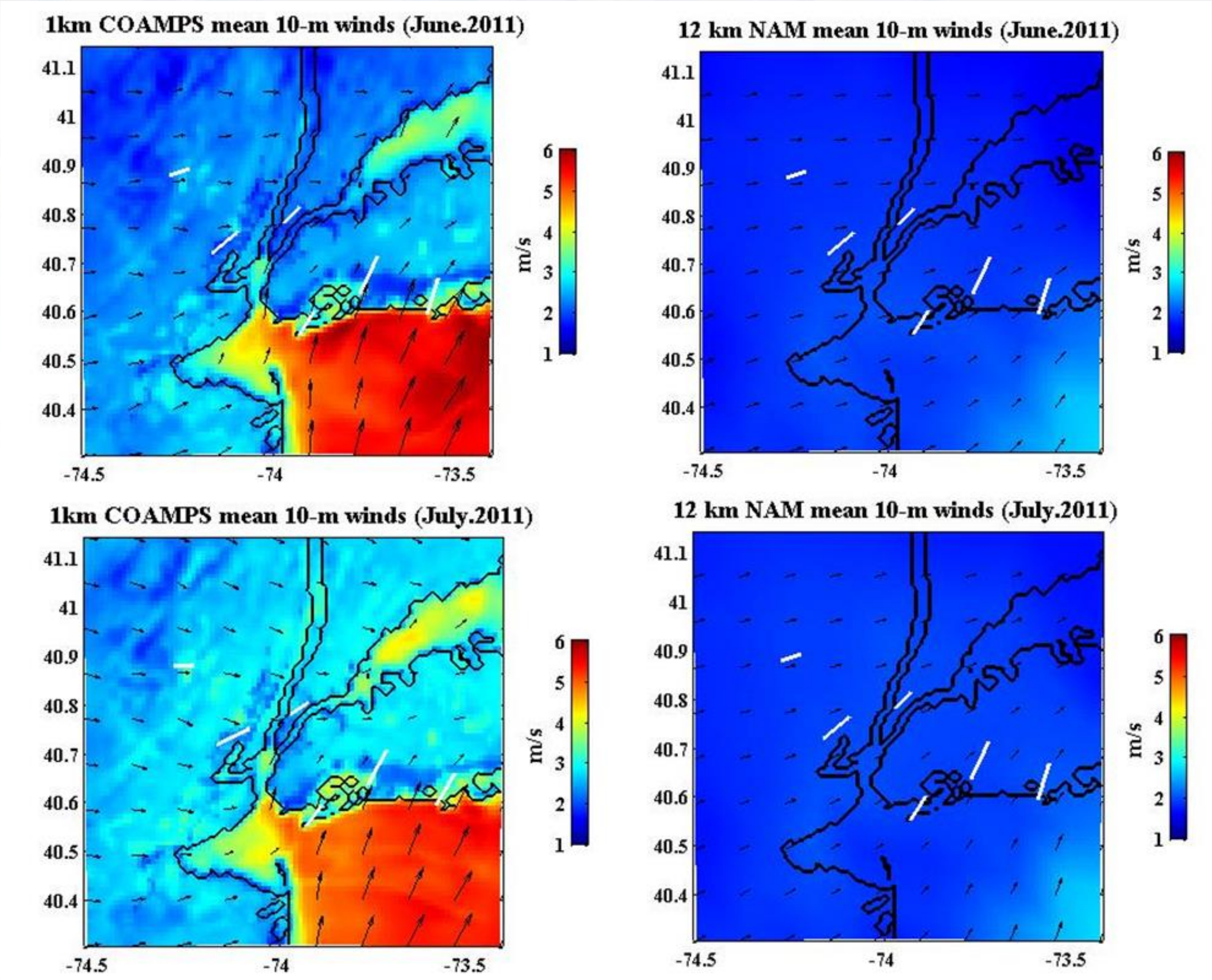
- Cities are like islands
- Coastal effects: heat waves & sea breezes
- Storm surge & hydrology stressors on urban infrastructure
- Increasing trends in precipitation
- Coupled earth system (unified) modeling
- Science input to resiliency
- Community engagement in design criteria

Cities as Islands

- Concentrate populations, microclimates, and hazards
- Enhanced exposure to risk
- Represent key urban sustainability challenges encompassing:
- Extreme rain/flooding, fires/air pollution, and coastal vulnerability

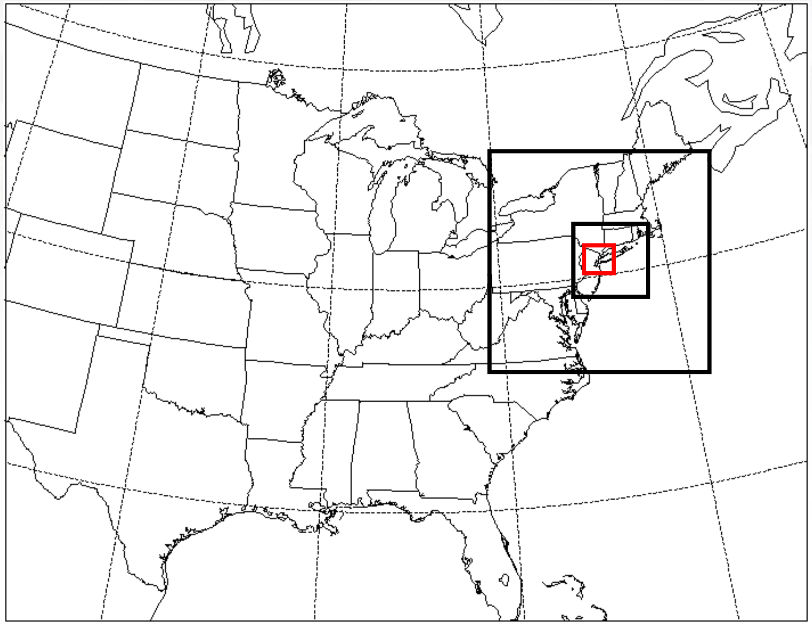
Heat Islands & Sea Breezes

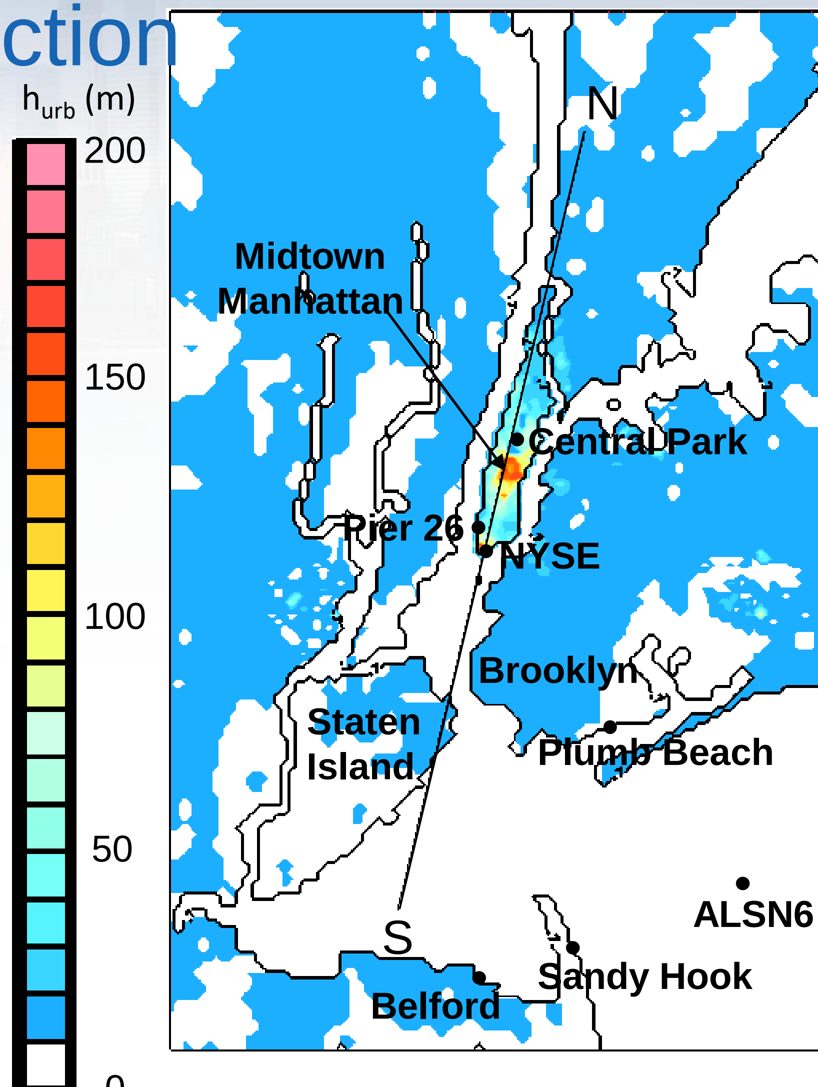
T. Meir, P. Orton, J. Pullen, T. Holt, W. Thompson and M. Arend, **"Forecasting the New York City urban heat island and sea breeze during extreme heat events,"** *Weather and Forecasting*, 28, 1460- 1477, 2013



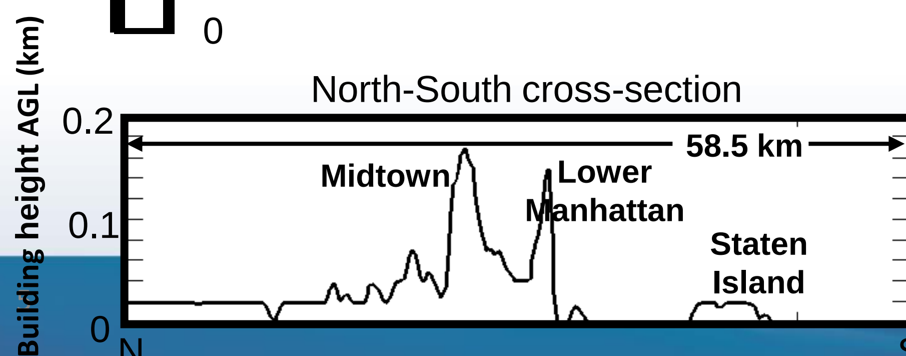
1 km resolution urbanized weather model develops sea breeze as observed

Urbanized Weather Prediction





High resolution urbanized modeling produces forecasts down to ~300 m resolution

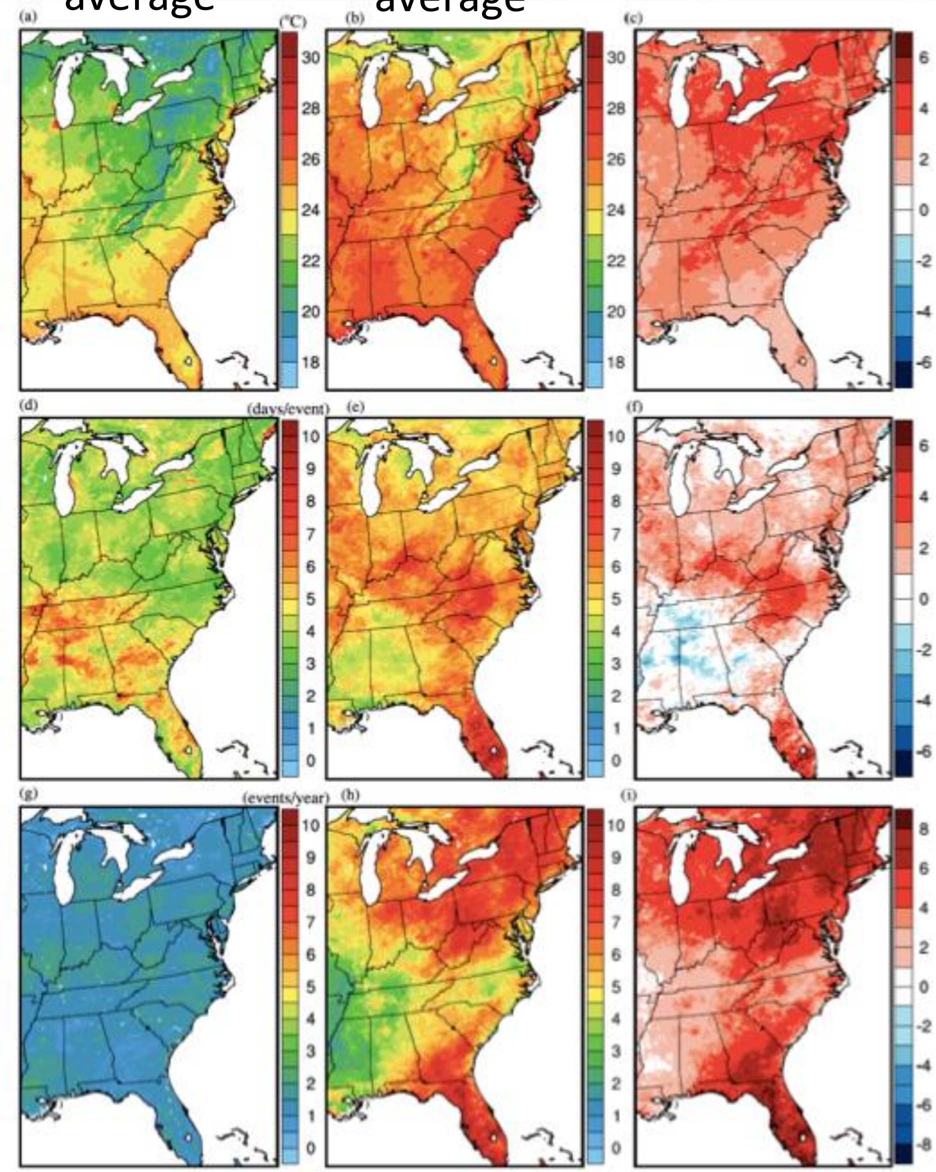


Prediction of Future Heat Waves

2001-2004 average

2057-2059 average

difference



Heat wave intensity

Heat wave duration

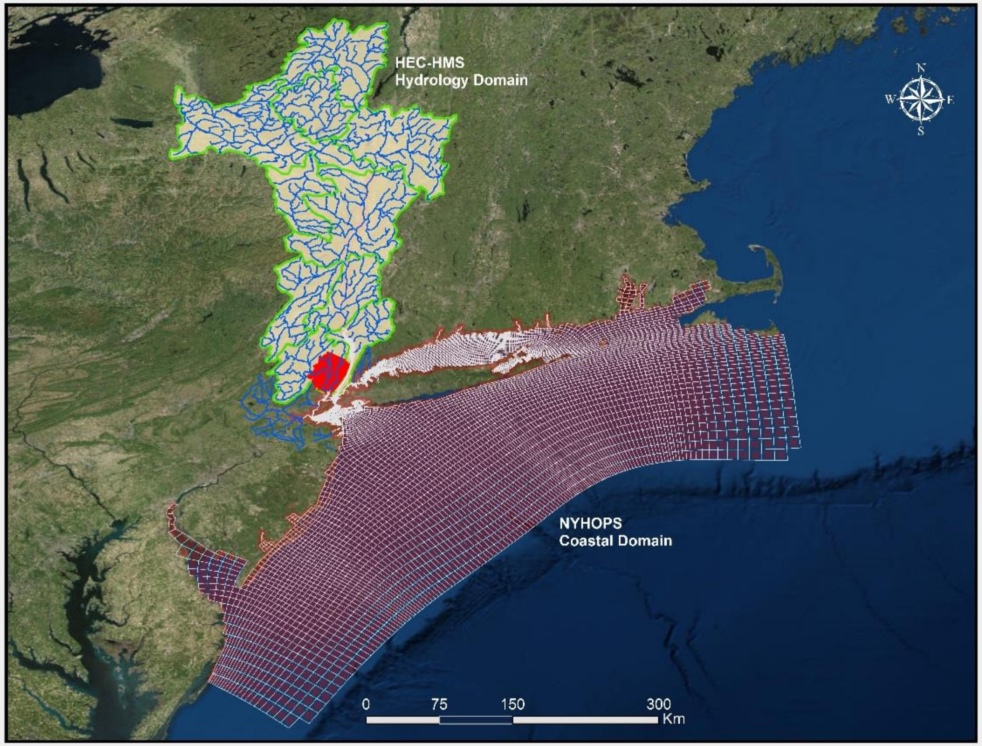
Heat wave frequency

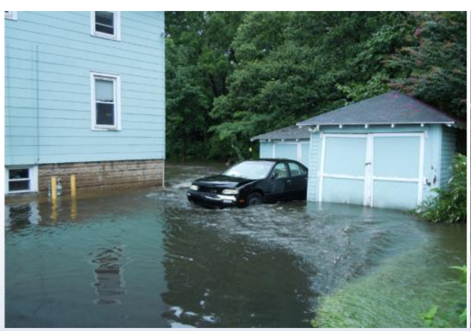
"Projected changes of extreme weather events in the eastern United States based on a high resolution climate modeling system," Y. Gao et al., 2012, Environ. Res. Lett.

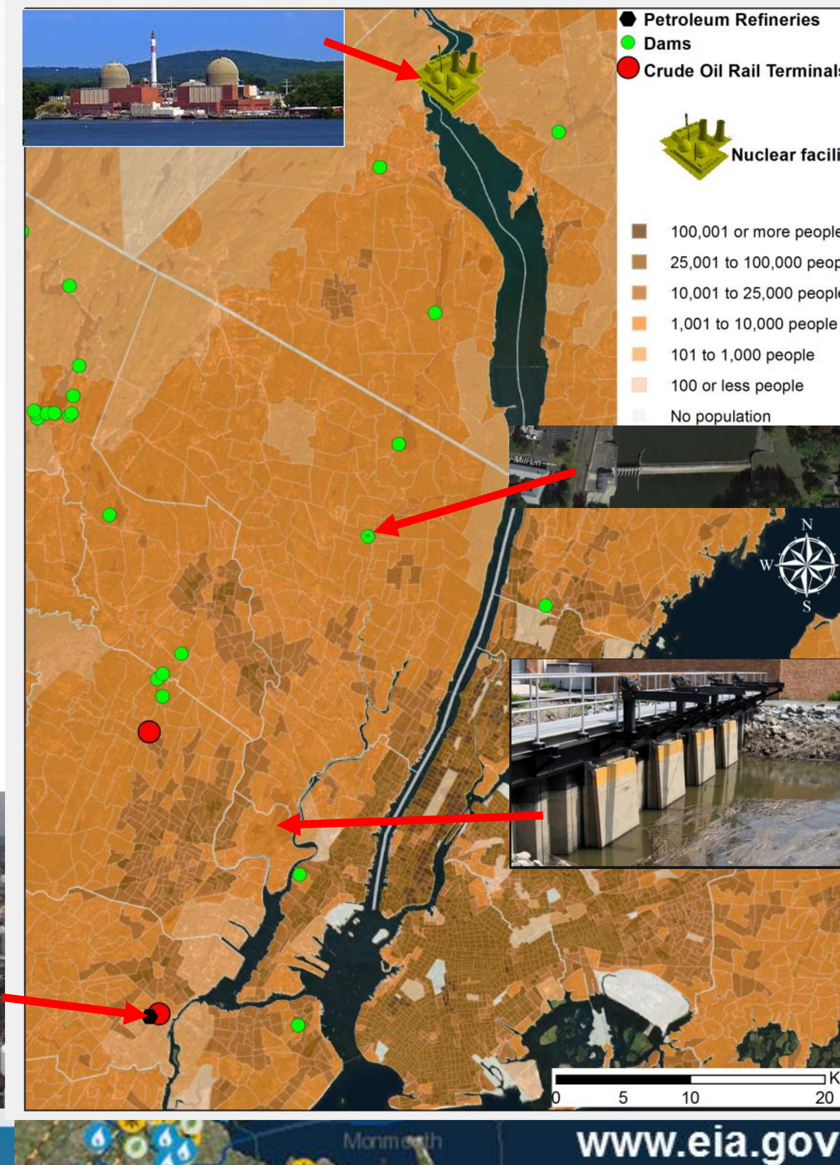
See also: P. L. Kinney, T. Matte, K. Knowlton, J. Madrigano, E. Petkova1, K. Weinberger, A. Quinn, M. Arend and J. Pullen, "New York City Panel on Climate Change 2015 Report Chapter 5: Public health impacts and resiliency," *Annals of the New York Academy of Sciences*, 1336, 67–88, 2015.

Built Environment and Water Infrastructure

Telescoping capabilities to the operational level of individual facilities

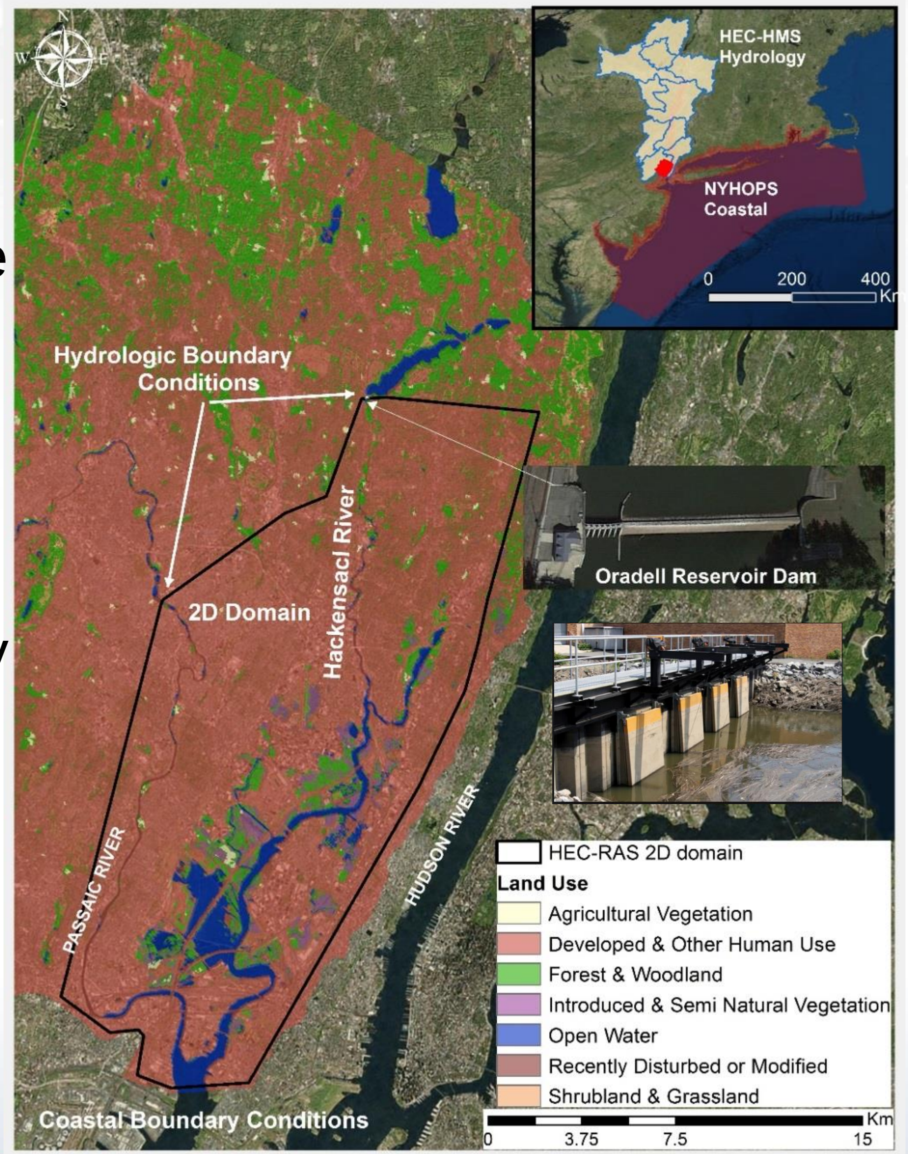




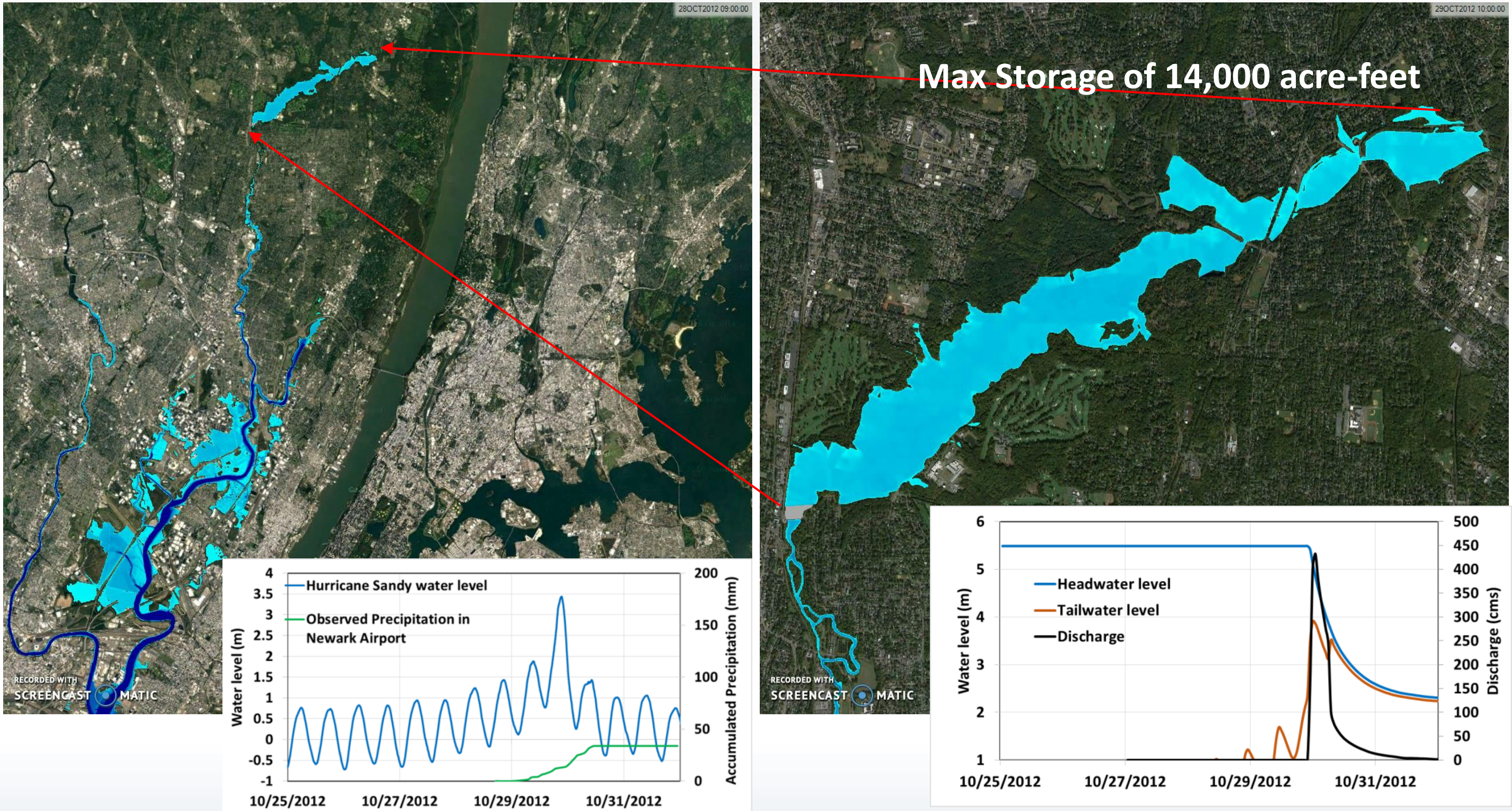


Infrastructure Impacts Case

- Combined influence of riverine and tidal components
- Tidal wetlands
- Highly urbanized watershed, more than 2 million people
- Critical facilities (e.g., Teterboro Airport, NJ Transit, Passaic Valley Sewerage Commission)
- Oradell reservoir, storage capacity of 14,000 acre-feet
- Vulnerable to inland and coastal flooding
- <u>Modeling Approach</u>: integrated ocean-meteorology-hydrology-hydraulics model suite



Vulnerability to Storm Surge and Hypothetical Upland Dam Break



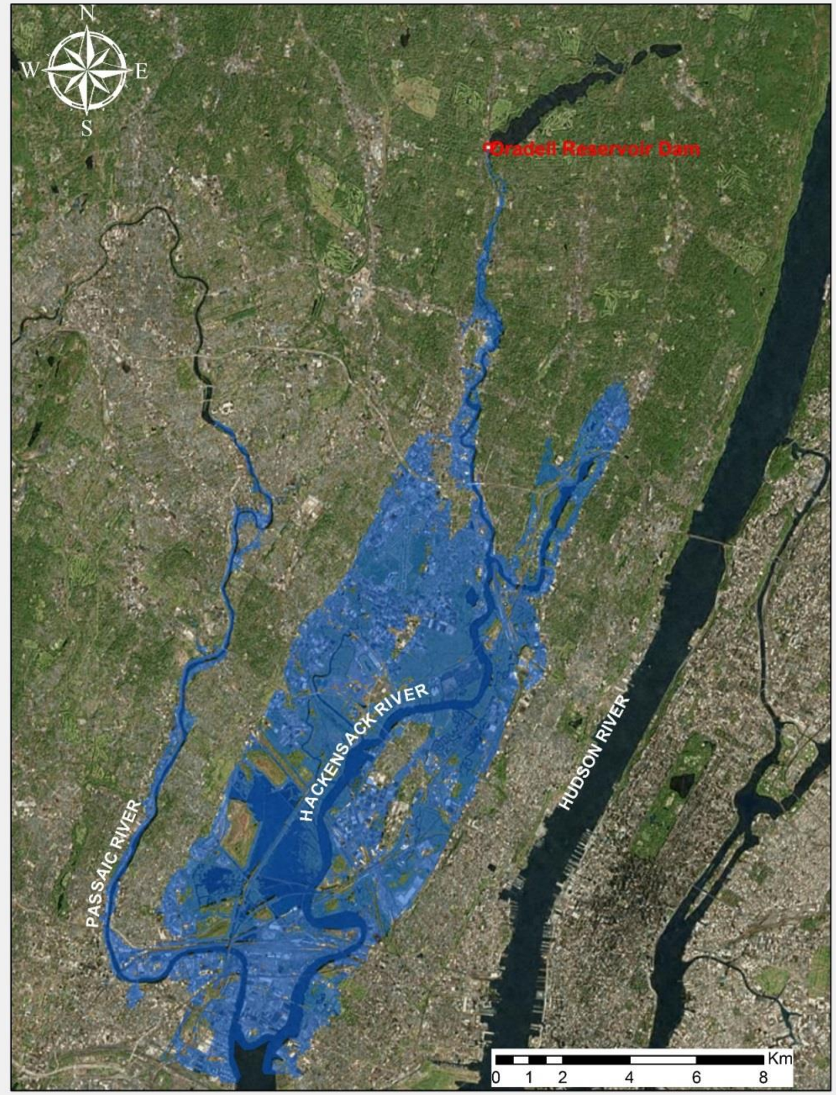
Failure of 100-year old dam designed under climate stationarity and risk to energy/water infrastructure

Saleh, F., Ramaswamy, V., Wang, Y., Georgas, N., Blumberg, A. F., and Pullen, J.: A Multi-Scale Ensemble-based Framework for Forecasting Compound Coastal-Riverine Flooding: The Hackensack-Passaic Watershed and Newark Bay, ***Advances in Water Resources*** (in review, ADWR_2017_243)

Storm Flooding Fingerprints

Irene inundation extent (2011)

Sandy inundation extent (2012)



Increasing Trends in Precipitation

Heavy precipitation events in most parts of the United States have increased in both intensity and frequency since 1901 (*high confidence*). There are important regional differences in trends, with the largest increases occurring in the northeastern United States (*high confidence*). In particular, mesoscale convective systems (organized clusters of thunderstorms)—the main mechanism for warm season precipitation in the central part of the United States—have increased in occurrence and precipitation amounts since 1979 (*medium confidence*).

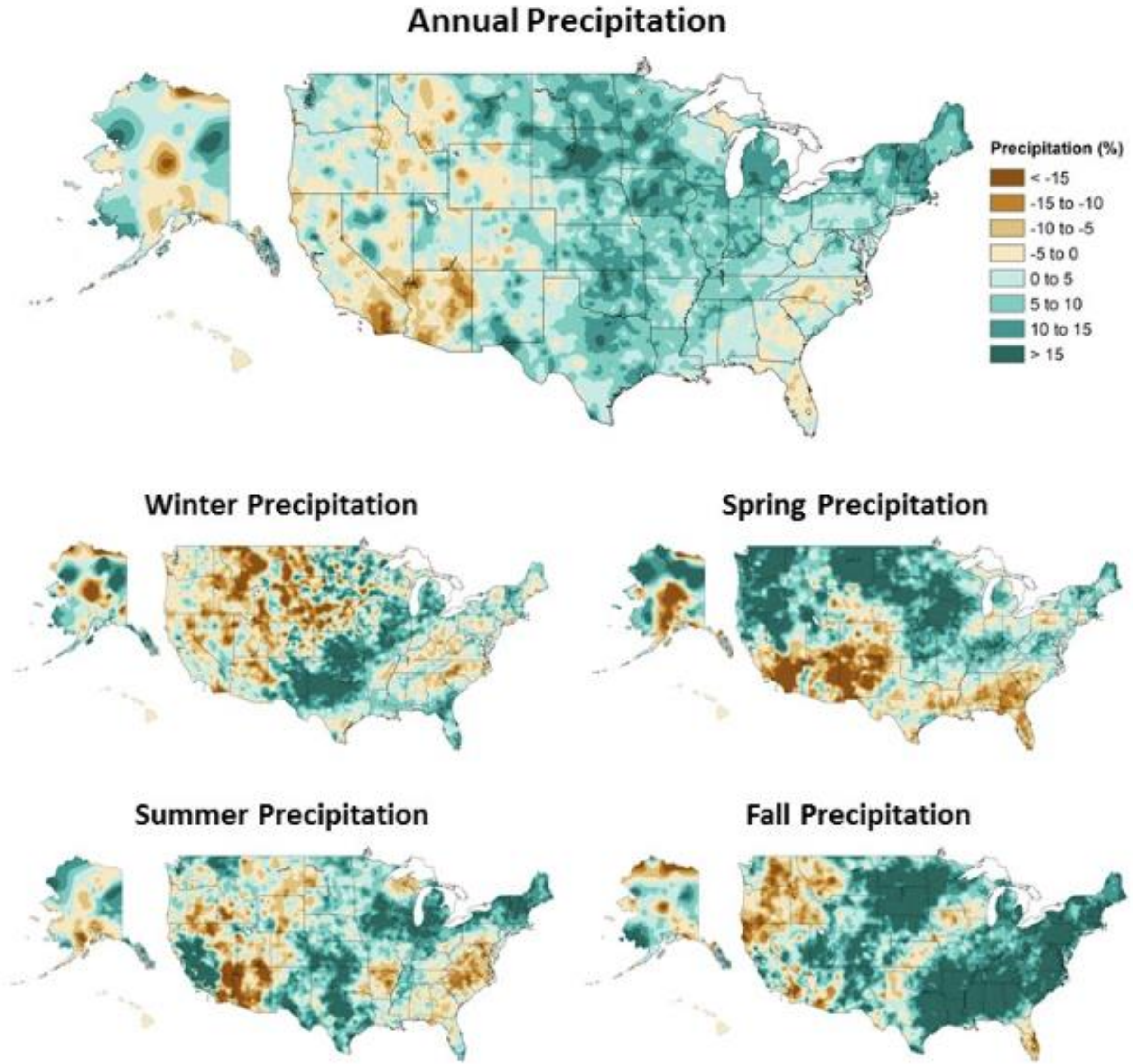


Figure 7.1: Annual and seasonal changes in precipitation over the United States. Changes are the average for present-day (1986–2015) minus the average for the first half of the last century (1901–1960 for the contiguous United States, 1925–1960 for Alaska and Hawai'i) divided by the average for the first half of the century. (Figure source: [top panel] adapted from Peterson et al. 2013,[78] © American Meteorological Society. Used with permission; [bottom four panels] NOAA NCEI, data source: nCLIMDiv].

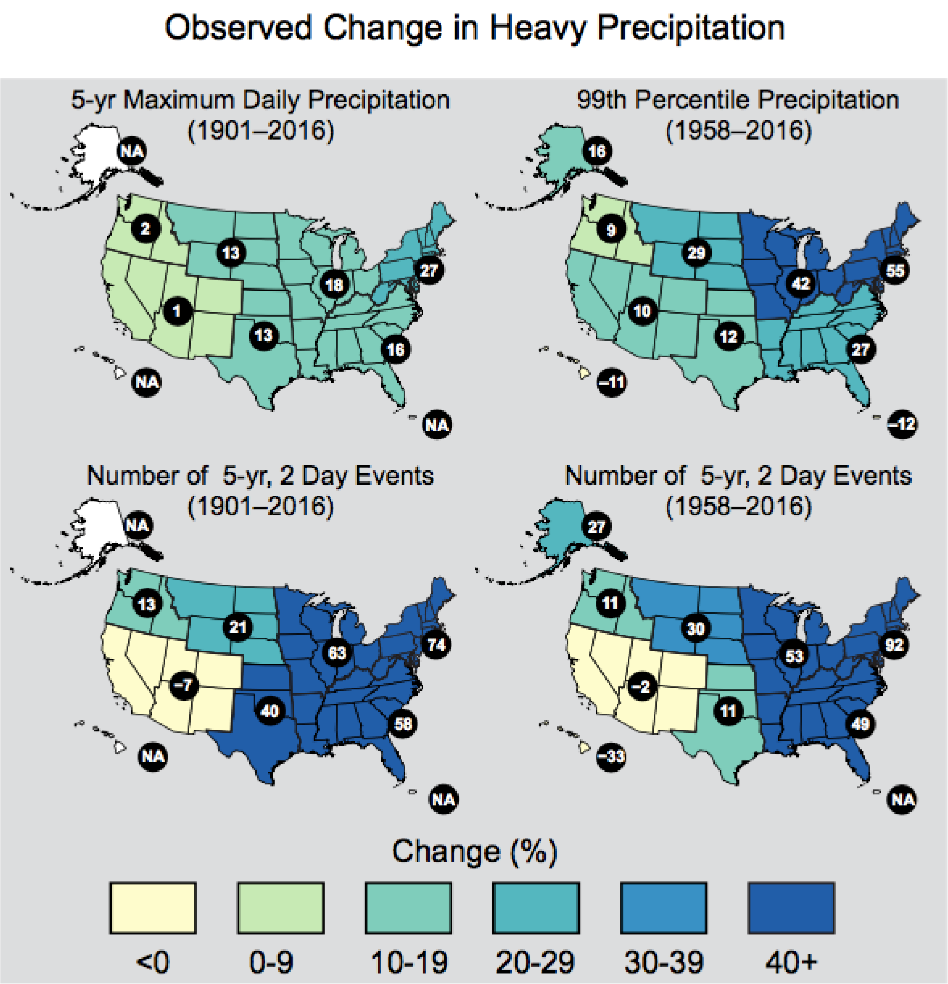


Figure 7.4: These maps show the change in several metrics of extreme precipitation by NCA4 region, including (upper left) the maximum daily precipitation in consecutive 5-year blocks, (upper right) the amount of precipitation falling in daily events that exceed the 99th percentile of all non-zero precipitation days, (lower left) the number of 2-day events with a precipitation total exceeding the largest 2-day amount that is expected to occur, on average, only once every 5 years, as calculated over 1901–2016, and (lower right) the number of 2-day events with a precipitation total exceeding the largest 2-day amount that is expected to occur, on average, only once every 5 years, as calculated over 1958–2016. The numerical value is the percent change over the entire period, either 1901–2016 or 1958–2016. The percentages are first calculated for individual stations, then averaged over 2° latitude by 2° longitude grid boxes, and finally averaged over each NCA4 region. Note that Alaska and Hawai'i are not included in the 1901–2016 maps owing to a lack of observations in the earlier part of the 20th century. (Figure source: CICS-NC and NOAA NCEI).

Projected Trends in Precipitation

"Extreme precipitation intensities have increased in all regions of the Contiguous United States and are expected to further increase with warming at scaling rates of about 7% per degree Celsius"

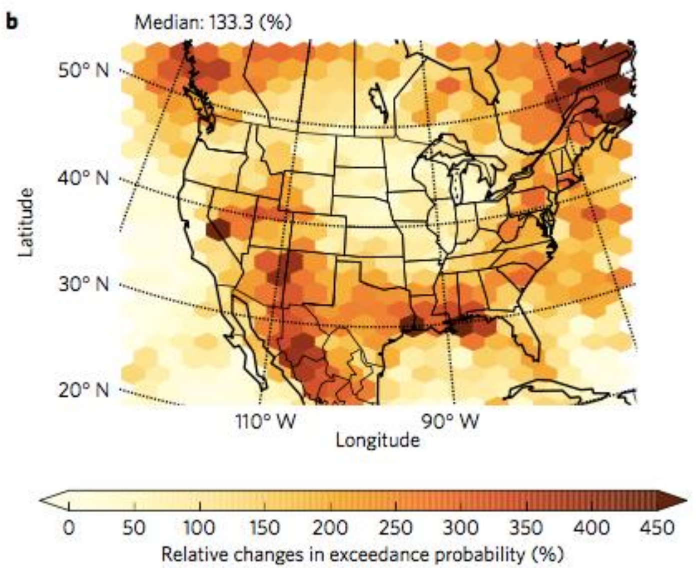


Figure 2 | Relative changes in the exceedance probability of the control period 99.95th percentile of hourly precipitation intensities. A value of zero indicates no changes in the probability of extreme precipitation while, for example, 300% means a fourfold higher chance of an extreme occurring. Results are shown for December, January and February (**a**) and June, July and August (**b**) for the period January 2001 to September 2013.

nature climate change

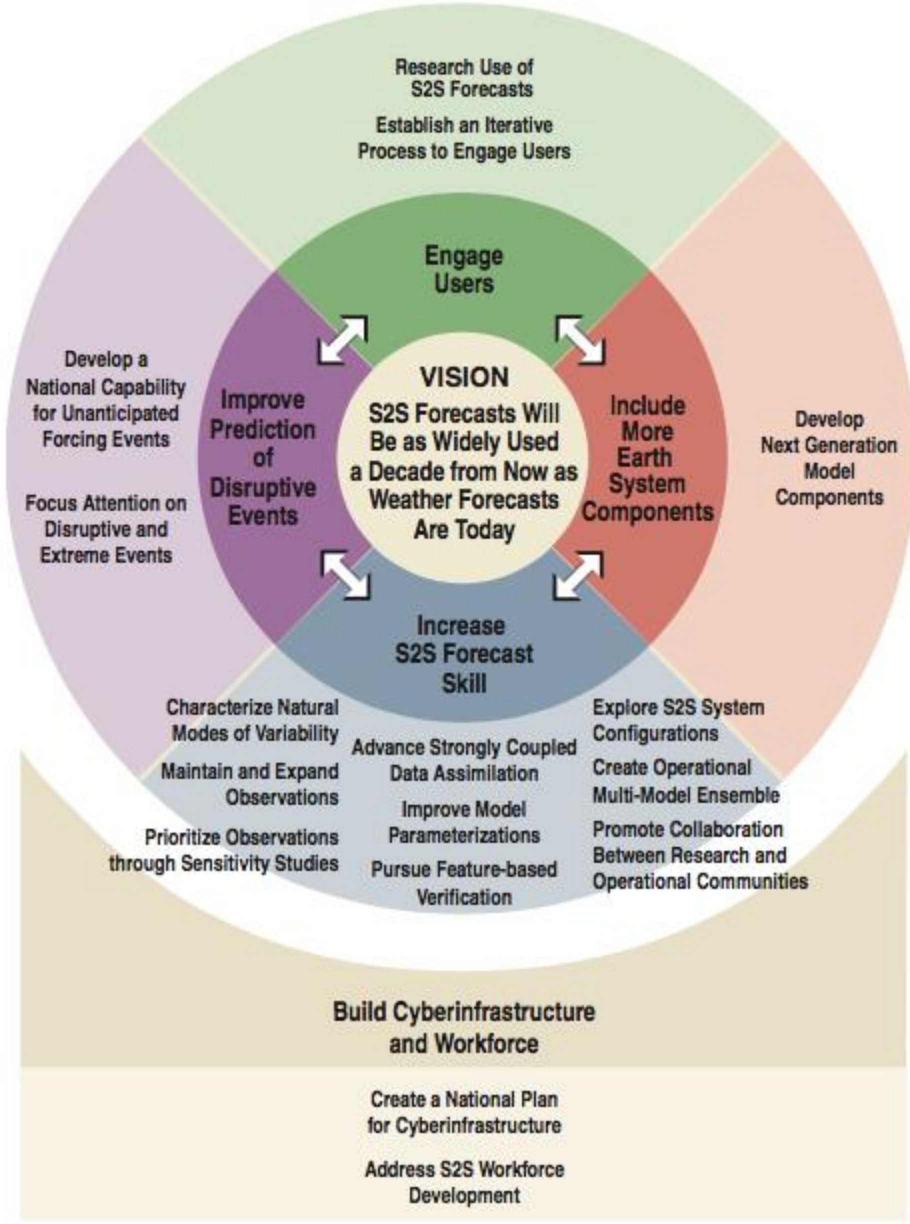
LETTERS

PUBLISHED ONLINE: 5 DECEMBER 2016 | DOI: 10.1038/NCLIMATE3168

The future intensification of hourly precipitation extremes

Andreas F. Prein*, Roy M. Rasmussen, Kyoko Ikeda, Changhai Liu, Martyn P. Clark and Greg J. Holland

National Academy study, 2016



Harbor Scorecard

New York is surrounded by water, a reminder that we live among nature and share the risks of global climate change. Our rivers, bays, canals, and inlets are interconnected, flowing in and out with the tide—**but how connected are we to them?**

The Waterfront Alliance has produced a waterfront scorecard measuring **waterfront access, water quality, and coastal flood risk**, to find out:

How safe are you from a major storm?
How healthy is the water near you?
Can you get to and on the water?

- Interactive web tool
- Community-level index: Flood risk, water quality, and public access

WATERFRONT ALLIANCE

STRONG

Are you protected from coastal flooding?

STATISTICS

408k
New Yorkers have a **50%** chance of a major flood in their homes by **2060**

41%
of those are **economically and socially vulnerable**

HEALTHY

Are your waterways fishable and swimmable?

STATISTICS

23%
of water samples **fail** EPA safe swimming standards

17.3B
gallons of **raw sewage** were discharged in 2015, down from 28B in 2006

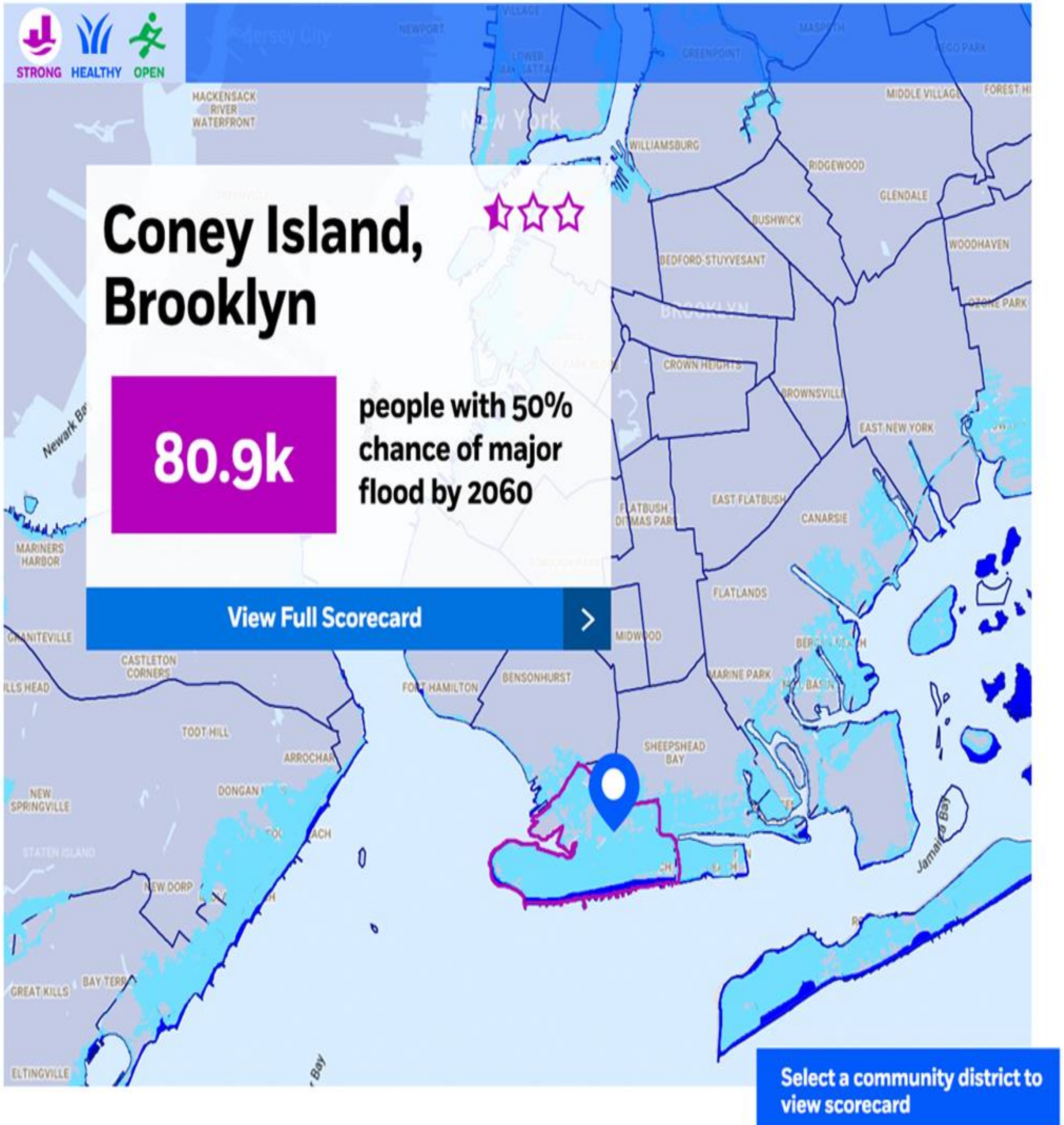
OPEN

Are your waterways accessible for people and boats?

STATISTICS

1 in 4
boating access points per miles of NYC's coastline

53%
of waterfront districts have **one or fewer** places to touch the water


STRONG
HEALTHY
OPEN
Coney Island, Brooklyn
80.9k
people with 50% chance of major flood by 2060
View Full Scorecard
Select a community district to view scorecard
HACKENSACK RIVER WATERFRONT
WILLIAMSBURG
GREENPOINT
RIDGEWOOD
GLENDALE
MIDDLE VILLAGE
BUSHWICK
BEDFORD-STUYVESANT
WOODHAVEN
OZONE PARK
BROOKLYN
CROWN HEIGHTS
BROWNSVILLE
EAST NEW YORK
EAST FLATBUSH
CANARSIE
FLATLANDS
MIDWOOD
MARINE PARK
BENSONHURST
FORT HAMILTON
SHEEPSHEAD BAY
MARINERS HARBOR
GRANITEVILLE
CASTLETON CORNERS
TODT HILL
ARROCHAR
NEW SPRINGVILLE
STATEN ISLAND
NEW DORP
GREAT KILLS
BAY TERR
ELTINGVILLE
Newark Bay
Jamaica Bay

LEGEND

Lo Hi

Coney Island, Brooklyn

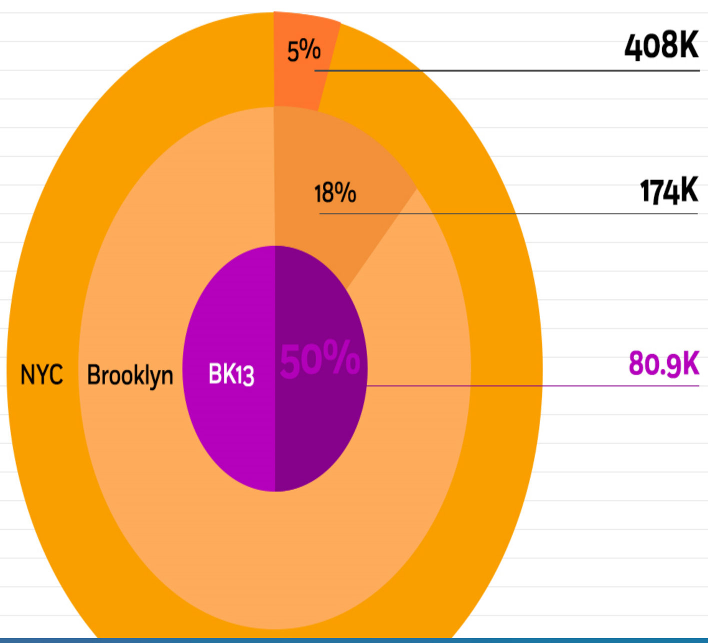
BROOKLYN CB 13

Brighton Beach, Coney Island, Gravesend, Homecrest, Sea Gate, West Brighton

STRONG | **HEALTHY** | **OPEN**

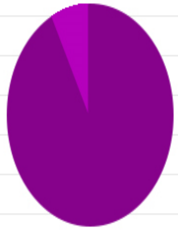
STAY DRY

How many people have **50% chance by 2060** of a major flood in their homes?

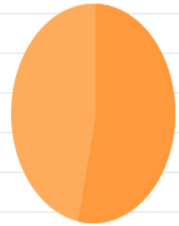


What percent of those are **economically and socially vulnerable?**

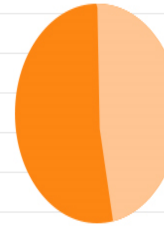
BK13
87%



Brooklyn
52%



NYC
41%



% of population facing 50% cumulative risk of flooding by 2050 rated 'high' on the Social Vulnerability Index of Hazards and Vulnerability Research Institute

How many sites pose **risk of contamination** if flooded at this level?

BK13	Brooklyn	NYC
80	213	547

% of sites in the EPA's Facilities Registry System within land area facing 50% cumulative risk of flooding by 2050

Waterfront Edge Design Guidelines (WEDG)

- Menu of best practices for all types of waterfront; modeled after LEED program for green buildings
- Created with input from more than 100+ different stakeholders

SCORECARD
Residential/Commercial Project Type
401 POSSIBLE POINTS

CATEGORY 1: Site Selection & Planning (SS & P)

Y	?	N			POSSIBLE POINTS: 43
			Credit 1	(Priority) Use a Multi-Disciplinary Project Team and Design Process	4
			Credit 2	(Priority) Conduct Assessment of Site's Vulnerability to Climate Change and Sea Level Rise	4
			Credit 3	(Priority) Avoid "Bluefield" Development	4
			Credit 4.1	Project Siting: Site Near Existing Waterborne Transportation	1
			Credit 4.2	Project Siting: Site Near Area Underserved by Open Space	1
			Credit 4.3	Project Siting: Site in Area Participating in FEMA's Community Rating System	1
			Credit 4.4	Project Siting: Clean a Brownfield	5
			Credit 5.1	Building Siting: Avoid Development in High Potential Erosion Area	2
			Credit 5.2	Building Siting: Avoid the 100-Year Floodplain	6
			Credit 5.3	Building Siting: Maximize Upland Views	2
			Credit 6	Raise Elevation: Increase Freeboard of Buildings	4
			Credit 7.1	Building-Scale Protection: Provide Wet Floodproofing	2
			Credit 7.2	Building-Scale Protection: Provide Dry Floodproofing	2
			Credit 8	Site Perimeter Protection: Provide Deployable Flood Barriers	1
			Credit 9	Incorporate Streetscape Enhancements to Mitigate Elevation Changes	2
			Credit 10	Participate in FEMA's National Flood Insurance Program	2

Introducing Waterfront Edge Design Guidelines

WEDG

How does WEDG work?

The Waterfront Alliance developed WEDG as a way to achieve real and necessary change at the waterfront. With input from hundreds of waterfront experts, we created guidelines and an incentive-based ratings system. We earned the support of all major government regulators. And the result is a logical, easy-to-use tool for any type of waterfront, with scorecards tailored for three types of uses:

- RESIDENTIAL / COMMERCIAL
- PARKS
- INDUSTRIAL / MARITIME

Within these three types of uses, waterfront projects earn credits in seven categories:

- SITE SELECTION & PLANNING
- PUBLIC ACCESS & INTERACTION
- EDGE RESILIENCY
- ECOLOGY & HABITAT
- MATERIALS & RESOURCES
- OPERATIONS & MAINTENANCE
- INNOVATION

WEDG IS FOR THE EDGE

It is intended to be used for properties directly touching a water body. The program does not involve guidance on individual building design (such as LEED® does) but does include recommendations for water-dependent infrastructure and measures for improved resiliency for any type of structure one would build at the edge.

Residential Case Study: Domino Sugar

Key Points

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