

Overview of Climate Change in New York City

A Teacher's Guide and Classroom Resource NYC DEP Climate Change Module

Weather vs. Climate



<u>Weather</u> describes current and nearterm conditions



<u>Climate</u> describes weather patterns over a longer term



"Weather is what you get; climate is what you expect."





Climate variability occurs **independent** of climate change.

Climate variability is generally measured over **30 years** of atmospheric variables.

"Seasonal variations and multi-year cycles (for example, the El Niño Southern Oscillation) that produce warm, cool, wet, or dry periods across different regions are a natural part of climate variability. They do not represent climate change."

-NOAA, Climate.gov



How do we know the global climate is changing?

The Greenhouse Effect



Sunlight passes through the atmosphere and warms the Earth's surface. This heat is radiated back toward space.

> Most of the outgoing heat is absorbed by greenhouse gas molecules and re-emitted in all directions, warming the surface of the Earth and the lower atmosphere.

Source: NASA

Scientists have understood this pattern for over a century. 5





Humans are tipping the balance.

Source: NASA

Where are these emissions coming from?





Based on 2010 global statistics, emissions from electricity, heat production, agriculture, forestry and other land use account for approximately half of greenhouse gas emissions globally.

Emissions from "Industry":

"Greenhouse gas emissions from industry primarily involve fossil fuels burned on site at facilities for energy."

Emissions from "Other Energy":

Includes "all emissions from the Energy sector which are not directly associated with electricity or heat production, such as fuel extraction, refining, processing, and transportation."

-EPA Global Greenhouse Gas Emissions Data



New York City Emissions

CITYWIDE ANNUAL GHG EMISSIONS BY SECTOR



NYC's GHG emissions come almost entirely from the combustion of fossil fuels to provide energy. However, this energy is delivered in many different forms.

Breakdown of New York City Emissions By Source



2017 CITYWIDE STATIONARY ENERGY GHG EMISSIONS BY SOURCE



2017 CITYWIDE TRANSPORTATION GHG EMISSIONS BY SOURCE

2017 CITYWIDE WASTE GHG EMISSIONS BY SOURCE



Breakdown of GHG Emissions



Carbon dioxide (CO₂) emissions from fossil fuel combustion and industrialization is the primary cause of climate change. We can't forget about the other GHGs

- U.S. vs. Global GHG Emissions
- Different greenhouse gases are linked to different activities •
- For example, methane is most closely linked to livestock



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Methane



Impacts of Methane and Livestock

Methane (CH4) has a higher **global warming potential** (GWP) than carbon dioxide (CO2).

According to the EPA:

- CO2 has a GWP of 1, and remains in the climate system for a very long time
- CH4 is estimated to have a GWP of 28–36, and remains in the climate system for over 100 years
- CH4 emitted today lasts about a decade on average, which is much less time than CO2
- CH4 also absorbs much more energy than CO2



U.S. METHANE EMISSIONS BY SOURCE

METHANE EMITTED PER ANIMAL PER YEAR



Infographic: LiveScience 2015

SOURCES: NASA GODDARD INSTITUTE FOR SPACE SCIENCE; ENVIRONMENTAL PROTECTION AGENCY; U.S. DEPT. OF ENERGY TECHNOLOGY LABORATORY; SHUTTERSTOCK



Global Temperature Ranking, 1880-2018



Source: NOAA

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Ten Indicators of a Warming World





These indicators are embedded into global climate models.

Understanding Anthropogenic Forces



Separating Human and Natural Influences on Climate





Are we seeing climate change today?

Observed Trends



Temperature Change (°F)

>15 **Changes in Heavy Precipitation Events** 1.0 to 1.5 **Northeast** 0.5 to 1.0 **Temperatures** 0.0 to 0.5 0.5 to 0.0 are rising -1.0 to -0.5 -1.5 to -1.0 <-1.5 12% Northeast Ê, 16% 37% 5% 27% . 1900s 20s 40s 60s 80s 00s Decade Observed temperature change in the United States over 1991-2012 compared to the 1901-1960 average. 33% Change (%) <0 0-9 10-19 20-29 30-39 40+ Percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2012. Increasing populations in many **US Coastal Watershed Counties** (1970-2010)-49.000 - 01 - 49.99950.000 - 249.999250.000 - 499.999 500.000 - 2.850.000 -846.000 - -50.000

Source: National Climate Assessment, 2014

Number of People

Average vs. Extreme Events



Shifts in average conditions lead to more frequent extreme events.

SMALL CHANGE IN AVERAGE BIG CHANGE IN EXTREMES



CLIMATE CO CENTRAL

Climate Extremes Worldwide





Cyclone Nargis in Myanmar, 2008 (Neryl Lewis, RRT)



Famine in Somalia, 2017 (New York Times)



Severe flooding in Pakistan, 2015 (Reuters/London)



Extreme Heat Wave in India, 2015 (CNN)

Changes in Floods and Drought



Projected change in flood hazard in the 2080s



Source: IPCC AR5 WG2 Ch. 3, 2014

There is wide uncertainty in the models about the direction of change.

A warmer atmosphere can hold more water.

Extreme rainfall and drought are projected to increase globally.

Examining Our Personal Actions



Our daily actions have significant environmental impacts, which are measured as our **ecological footprints** or **carbon footprints**

Ecological Footprint: The measurement of our impact on the Earth based on the activities we do every day

Carbon Footprint: The amount of carbon dioxide that is emitted by the activities we do every day and the fossil fuels associated with them

Factors that inform our footprint:

- Water use
- Diet
- Travel
- Consumption habits
- Energy use

CONSERVE WATER

Watch your water usage by turning off faucets when not in use, taking shorter showers, and avoiding unnecessary water consumption.

REDUCE WASTE

Help reduce greenhouse emissions by practicing regular recycling, buying recycled goods, and buying less or in bulk to lessen packaging waste.



SAVE ENERGY

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Use less energy by turning off appliances when not in use, switching to energy saving bulbs, and investing in energy saving appliances/objects.

TRAVEL GREEN

3

I/3 of the world's gas emissions are because of vehicles, therefore, ditching your car and walking or riding public transport helps lessen them.



Try to

CLEAN ENERGY

Try using renewable energy from timeto-time by installing solar panels and generating your own energy. Use of solar-powered objects are good too.

START SMALL

he little things make a difference planting trees, and buying local produce helps lesson carbon footprint.



Source: CEA Energy



How will climate change affect New York City?

New York City Panel on Climate Change



- New York City Panel on Climate Change (NPCC) convened in August 2008 as a collaboration of leading climate and social scientists and risk management experts who work to identify climate risks facing New York City and guide OneNYC policies
- In 2010, the Panel produced the first full report detailing a set of climate projections specific to the New York City region, published by the New York Academy of Sciences
- New York City Codified NPCC in August 2012 with Local Law 42, requiring regular climate science updates to the Mayor's Office of Resiliency
- Research is used to help decision-makers plan for resiliency according to the climate risks that are specific to New York City
- NPCC's most recent publication is the 2019 Special Issue: Advancing Tools and Methods for Flexible Adaptation Pathways and Science Policy Integration



NEW YORK



Temperature*

Mean **annual temperature** has **increased** at a rate of **0.3°F per decade** (total of 3.4°F).



Precipitation*

Mean **annual precipitation** has **increased** ~0.8 inches per decade (total of 8 inches).

Year-to-year (and multi-year) **variability** of precipitation has become **more pronounced**, especially since the 1970s.



Sea Level

Sea level rise in New York City has averaged **1.2 inches per decade** (total of 1.1 feet), nearly twice the observed global rate over a similar time period.

Source: NPCC, 2019 * Observations made in Central Park.



NPCC Climate Projections – Heat



* Middle range (25th to 75th percentile) of model-based projections. Source: NPCC, 2015

Mean annual temperatures to increase

- 4.1 to 5.7°F* by the 2050s
- 5.3 to 8.8°F* by the 2080s

Heat waves: Triple by 2080s from 2 to 6 per year

Hot days above 90°: Triple by 2050s from 18 to 57 days



Heat Vulnerability in NYC

Depicted in the darker purple are the portions of NYC's population that are most vulnerable to high temperatures, by neighborhood.



The Urban Heat Island Effect



- We experience **higher temperatures in big cities**, this is due to the Urban Heat Island Effect.
- Urban Heat Island Effect: "a regional elevation in air temperature that represents the difference between air temperatures in urban and built up areas and nearby rural areas." -The Mayor's Office of Resiliency
- "The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C)." -EPA Heat Island Effect



Urban Heat Island



Temperature (°F)

NPCC Climate Projections – Rain





Warmer temperatures cause more moisture in the air, which leads to significant shifts in precipitation.

Mean annual precipitation is projected to increase

- -4 to 11 percent* by the 2050s
- -5 to 13 percent* by the 2080s
- * Middle range (25th to 75th percentile) of model-based projections.

Heavy Rainfall Events aka "Cloudbursts"



Heavy rainfall events are often associated with relatively brief but intense warm season events (e.g., summer thunderstorms). Heavy rainfall is projected to increase in New York City.

Flooding transportation networks

- Roadways
- Subway stations
- Railways
- Airport runways

Overwhelming sewer systems

- Combined Sewer Overflows (CSOs)
- Drainage capacity
- Harbor water quality



Heavy rains caused flooding on the 86th Street Transverse on July 7, 2017



NY State record flash flooding occurred on August 12-13, 2014 in Islip, NY where 13.57 inches of rain fell in one day (Long Island Patch, 2014)

NPCC Climate Projections – Sea Level Rise



Sea level is expected to rise

- 11 to 21 inches* by the 2050s
- 18 to 39 inches* by the 2080s
- 6 feet by 2100 (high estimate)

* Middle range (25th to 75th percentile) of model-based projections.

Projected sea level changes alone would **increase the frequency and intensity of coastal flooding** (absent any change in storms themselves)



Map showing the difference between water levels for 90th percentile SLR in 2100 28

Sea Level Rise





As a coastal city, NYC is uniquely vulnerable to sea level rise and storm surge.

Coastal Flooding and Climate Change





100-year flood map developed using the static approach

- For the 100-year flood, the highestimate sea level rise by 2100 roughly doubles the affected area compared to the December 2013 FEMA Preliminary Flood Insurance Rate Maps (FIRMs).
- For the 500-year flood, the highestimate sea level rise by 2100 increases the affected area by 50% compared to the December 2013 FEMA FIRMs 500-year flood area.
- Queens is the borough with the most land area at risk of future coastal flooding due to sea level rise, followed by Brooklyn, Staten Island, Bronx, and Manhattan.
- "100-year flood" does not refer to a flood that occurs "once every 100 years," it actually refers to the size of the flood itself and the percent probability of it occurring in any given year (e.g. 1%).

Vulnerability of Water Resources



- Nearly 10 million people are served by the NYC water supply system
- All of the City's 14 wastewater resource recovery facilities will, by 2050, have at least some of their equipment located below the Base Flood Elevation.
- Of the City's 96 sewage pumping stations, 58 are located in the 100year floodplain indicated in the Federal Emergency Management Agency (FEMA) Preliminary Flood Insurance Rate Maps.
- Base Flood Elevation refers to the "height that flood waters are expected to reach in a high risk area." <u>here</u>.



Wastewater facilities at-risk of storm surge inundation

Source: FEMA; CUNY Institute for Sustainable Cities

Hurricane Sandy was the Tipping Point





had to be evacuated



without telecommunications in areas with critical facilities

weekday riders were displaced from subway shut down

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Source: PlaNYC, 2013

Lessons from Sandy



- New York City is vulnerable to the impacts of climate change from sea level rise and coastal storms. Extreme weather events can present unforeseen impacts that must be included in future resiliency planning.
- The **impacts from climate change will be distributed unevenly** across City neighborhoods as a result of land-use, economic status, age, and exposure.
- The cascading impacts from extreme events on interdependent infrastructure systems highlights the need to account for interconnected vulnerabilities in New York City.
- New York City's history of climate action was critical in the Hurricane Sandy rebuilding process.
- Utilizing the co-generated science created by the NPCC to understand the specific local risks that climate change poses to the metropolitan region, New York City is already engaging in planning for resiliency over the coming century.



Rockaway Beach Playground in Queens post-Sandy



Rockaway Beach Playground in Queens following recovery efforts

Conclusions



- We know climate change is happening based on observed evidence.
- Scientists project future climate changes by using computer models.
- Climate change is affecting New York City through changes in temperature, precipitation, sea level rise, and extreme weather events.
- New York City is leading the effort to mitigate and adapt to climate change.
- We, as individuals and as a city, need to take action!



Source: NYC DEM Clean and Renewable Energy

Source: Eagle Street Rooftop Farm

Taking Action: What can we do to help?



- Get involved in the global student climate action
 movement
- Learn about your water footprint and water conservation
- Help plant school gardens and maintain green spaces
- Dispose of waste and recyclables properly, reduce litter
- Conserve energy
- Learn about your carbon footprint and resource conservation
- Learn about your personal food consumption and ways to reduce your impact
- Team up with local environmental groups
- Get to know community leaders and register to vote
- Learn about internship and career opportunities



Greta Thunberg, 16 year old Swedish climate activist calls for global student climate strikes, "Fridays For Future" (Source: TEDx)