Level 2: Hurricane Sandy's Impacts on Hudson River Conditions

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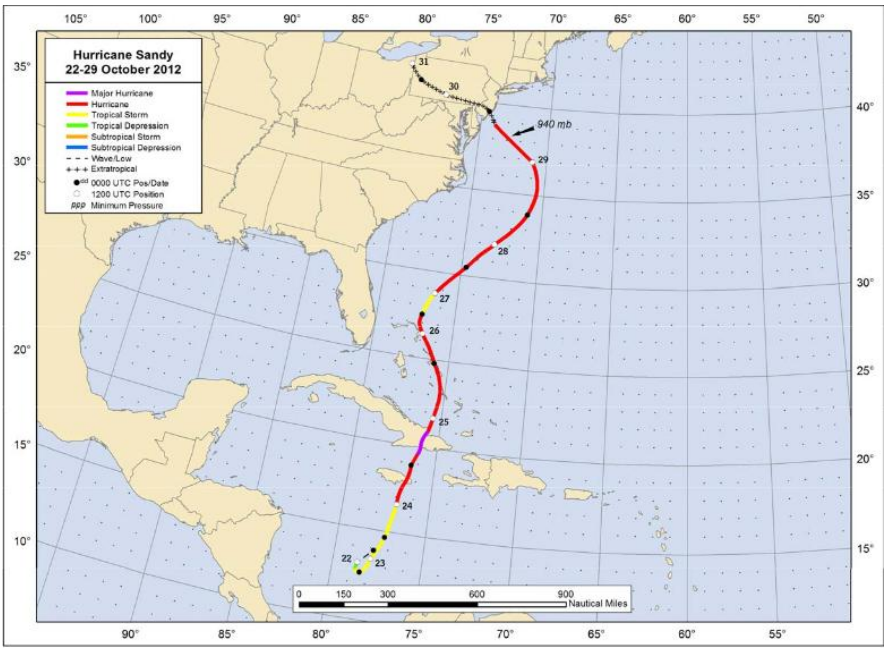
***Note: Data and Metadata referenced in this file are from:**

"Hudson River Environmental Conditions Observing System." 2012. Various stations. Accessed August 18th, 2017. http://www.hrecos.org/

and from "NOAA Tides and Currents." 2012. Battery Park Station. Accessed August 18th, 2017. https://tidesandcurrents.noaa.gov/stationhome.html?id=8518750



Track followed by Hurricane Sandy. Source: National Weather Service.

❖ Background Information:

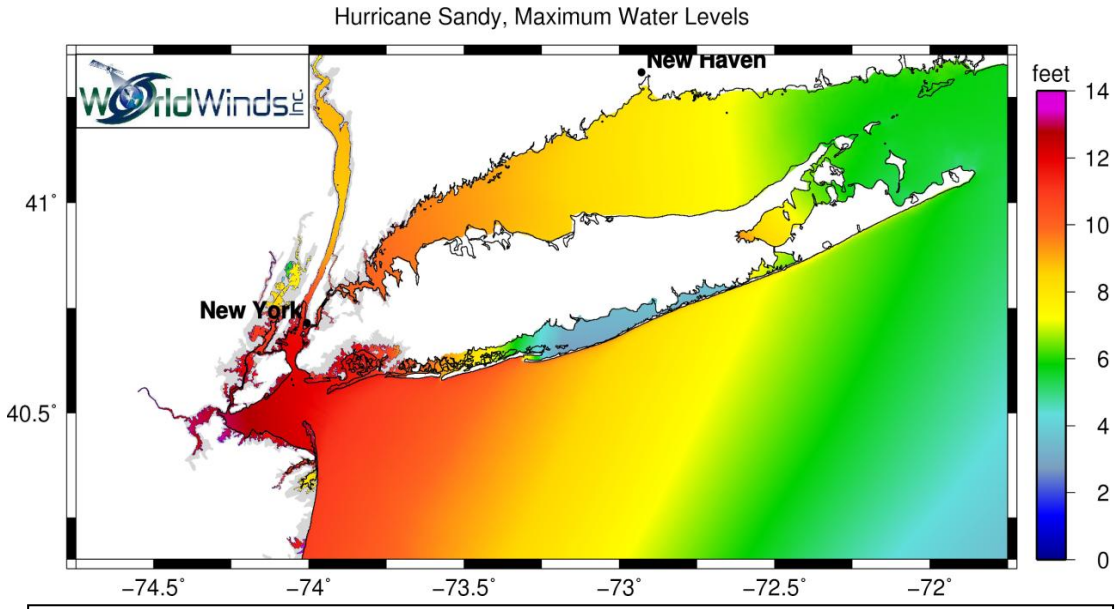
Hurricane Sandy formed in the Caribbean and intensified as it traveled across Jamaica and Cuba. Hurricane Sandy hit landfall on the eastern coast of the United States near Atlantic City, New Jersey on October 28th, 2012.

Hurricane Sandy brought tropical storm and gale force winds to the Mid-Atlantic and New England regions of the United States. Record storm surge flooded areas along New Jersey, New York, Connecticut, Rhode Island and Massachusetts. Over $50 billion dollars worth of property damage occurred in these areas.

Flooding in Manhattan during Hurricane Sandy. Source: BusinessInsider.com

For estuarine rivers like the Hudson that enter the ocean, one of the major risks associated with an incoming hurricane is storm surge moving up the river from the ocean. New York Harbor, where the Hudson River meets the Atlantic Ocean, was flooded by storm surge. This bulge of salt water traveled up the Hudson River with the tide. Using data from the Hudson River Environmental Conditions Observation System (HRECOS) you can track the storm and its effect on the river. HRECOS uses automated sensors to record real-time data on Hudson River conditions (temperature, dissolved oxygen, etc) and weather (rainfall, wind speed, etc.), although you will find that not all of the HRECOS sensors survived Hurricane Sandy's wrath.

You can compare this to our related dataset on Hurricane Irene to examine how hurricanes can affect the river differently through oceanic storm surge or watershed-derived flooding.



Map of maximum storm surge elevations caused by Hurricane Sandy. Source: World Winds Inc.

❖ Dataset Timeframe

These data were collected at 15 minute intervals by the Hudson River Conditions Observing System (HRECOS) from 10/28/12 until 11/3/12.

❖ Data Collection Methods:

The Hudson River Conditions Observing System (HRECOS) operates a number of hydrological and meteorological monitoring stations in and near the Hudson River. The monitoring stations use multi-probe sondes to collect continuous data every 15 minutes for many variables, such as water temperature, dissolved oxygen, turbidity, and salinity. Not all stations collect both hydrological and meteorological data and not all stations monitor all variables.

Norrie Point Station.
Source: Dr. Stuart Findlay.

❖ **Locations:**

From North to South, this dataset includes results from the Port of Albany, Schodack Island, Norrie Point, Piermont, and the Battery.

<u>Monitoring Stations</u>

Port of Albany NY

42.61954 N, 73.75890 W

The Albany HRECOS station is mounted on the concrete piling on the western shoreline of the Hudson River at the Port of Albany, just to the south of the Cargill Grainery. The channel depth at this location is 32 feet. **Note: The wind sensor was offline during Hurricane Sandy, so we instead provide wind data from Schodack Island, which is just south of Port of Albany at Schodack Island State Park (42.501200 N, 73.780381 W).*

Norrie Point NY

41.831876 N, 73.941606 W

Norrie Point Station is located at the headquarters of the Hudson River National Estuarine Research Reserve within the Margaret Lewis Norrie State Park, operated by the Taconic Region of New York State Office of Parks, Recreation, and Historic Preservation. **Note: The Norrie Point Hydrological Station was down from 13:00-15:15 on 11/2.*

Piermont Pier, NY

41.043 N, 73.896 W

Piermont station is located on Piermont Pier, which is owned and operated by the village of Piermont. The pier stretches one mile out into the Hudson River and is regularly used by the public for recreation. The pier is located just north of the tidal Piermont salt marsh.

Note: Hurricane Sandy knocked out the hydrologic sensors at Piermont, so there are a few gaps in the data and turbidity, depth, and dissolved oxygen are not recorded after 2:30 AM on 10/29.

Battery Park, NY- 40.706 N, 74.018 W (Non-HRECOS data)

The southernmost HRECOS stations went offline during the storm. Instead, we show water level data from the NOAA Tides & Currents real-time monitoring system, which records measurements every hour. Battery Park is located at the southernmost tip of Manhattan.

Additional real-time and archived data are available for the Battery here: https://tidesandcurrents.noaa.gov/stationhome.html?id=8518750

- **Dataset Variables:**
  - **Date:** Day and time of sampling.
  - **Depth (feet):** A measure of water depth above sensor, which is an indication of tide and rainfall.
  - **Rainfall Daily Accumulation (inches):** The amount of rain that cumulatively fell over a 24 hour-period. The data points you see here reflect the daily total up to that hour of the day. The count resets every day at 1:00 AM EST.
  - **DO (ppm):** amount of oxygen dissolved in the water measured in parts per million.
  - **Turbidity (NTU):** amount of suspended particulates in the water measured in nephelometric turbidity units. This helps us to see how cloudy the water was.
  - **Wind Speed (knots):** wind speed measured in knots.

- **Sources of Datasets:**
  - Hudson River Environmental Conditions Observing System (HRECOS) http://hudson.dl.stevens-tech.edu/hrecos/d/index.shtml
  - NOAA Tides and Currents from the National Oceanic and Atmospheric Administration's Center for Operational Oceanographic Products and Services (CO-OPS) https://tidesandcurrents.noaa.gov/stationhome.html?id=8518750

- **Inquiry Idea Starters:**

Here are some sample questions you could ask using these data. These are just suggestions and we hope you'll come up with many interesting questions of your own. The questions are organized into categories with variables listed for each. Additional data and graphs can be obtained through HRECOS and teacher materials.

  - **Evidence of storm (Rainfall and Depth)**
    - How do rainfall levels vary over the days before, during and after the storm?
    - How does water depth vary over the days before, during and after the storm?

  - **Impact of storm (D.O. and Turbidity)**
    - Do dissolved oxygen and turbidity correlate at sites along the river?
    - At which locations do dissolved oxygen and/or turbidity change the most during the storm?

  - **How does this extreme weather event compare to other extreme weather events?**

If students want to compare Hurricane Sandy to Hurricane Irene, there is an additional background information sheet for Hurricane Irene.

❖ **Additional Resources:**

- Source of images and charts showing storm track and storm surge
  - https://www.weather.gov/okx/HurricaneSandy

- Sea and Sky NY web article on Hurricane Sandy
  - https://seaandskyny.com/2013/10/28/hurricane-sandy-storm-surge-map-animations/

- Watch an animation of Sandy impacting storm surge around the NYC area.
  - https://vimeo.com/78022421

- Hudson River Environmental Conditions Observing Systems (HRECOS)
  - http://www.hrecos.org/index.php

- National Weather Service/NOAA publication reviewing Hurricane Sandy
  - http://www.nhc.noaa.gov/outreach/presentations/Sandy2012.pdf

❖ **References:**

Blake, Eric. "**Hurricane Sandy**." National Hurricane Center, NOAA, National Hurricane Center, 28 Mar. 2013, www.nhc.noaa.gov/outreach/presentations/Sandy2012.pdf.

"**Hurricane Sandy Maximum Water Levels**." ADCIRC Hydrodynamic Modeling, Worldwinds Inc., 2017, www.worldwindsinc.com/services/adcirc-hydrodynamic-modeling.htm.

Sharp, Tim. "**Superstorm Sandy: Facts about the Frankenstorm**." LiveScience, 27 Nov. 2012, https://www.livescience.com/24380-hurricane-sandy-status-data.html