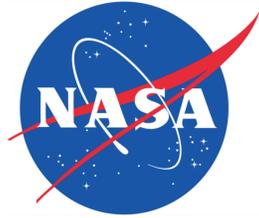


Effects of Hurricane Sandy on New York City Air Quality

(October 26 - November 9, 2012)



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Category 2 Hurricane Sandy strikes Cuba north, crosses the Bahamas, and begins to turn north.

New York City's Metropolitan Transportation Authority (MTA) begins flood protection work.

5:34 PM EDT: National Weather Service Forecast Office, New York, NY issues a Coastal Flood Warning.

4:35 AM EDT: National Weather Service Forecast Office, New York, NY issues a High Wind Warning.

7:00 PM EDT: MTA suspends NYC subway, LIRR & Metro-North service.

9:00 PM EDT: MTA suspends NYC bus service.

2:00 PM EDT: HIGH TIDE CATEGORY 2 HURRICANE SANDY STRIKES LAUREL GOSSES.

7:00 PM EDT: all MTA & NYNJ Port Authority bridges close.

8:45 PM EDT: Queens Midtown Tunnel Closes.

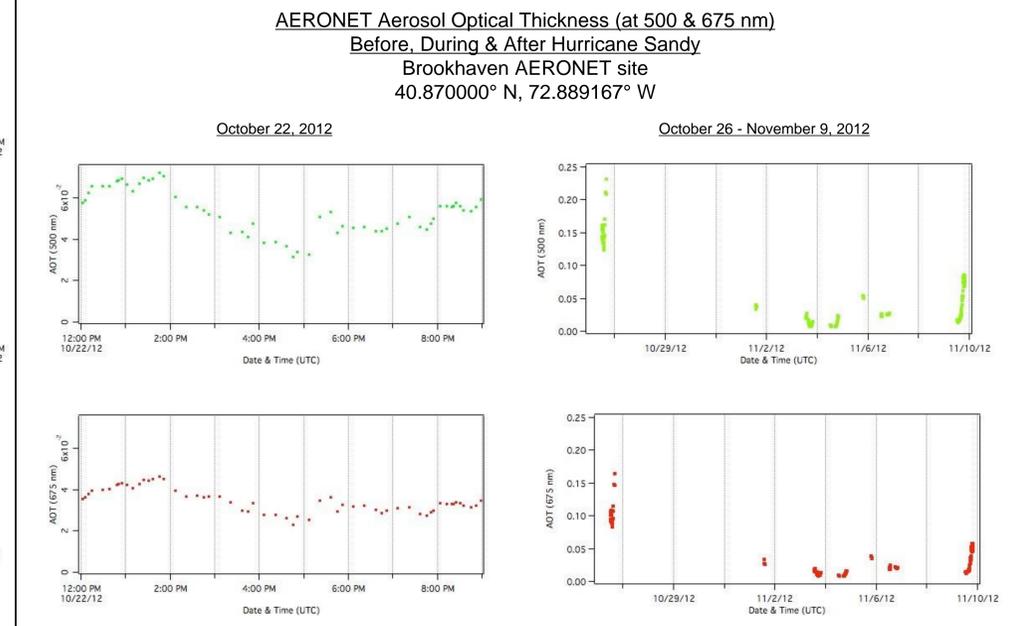
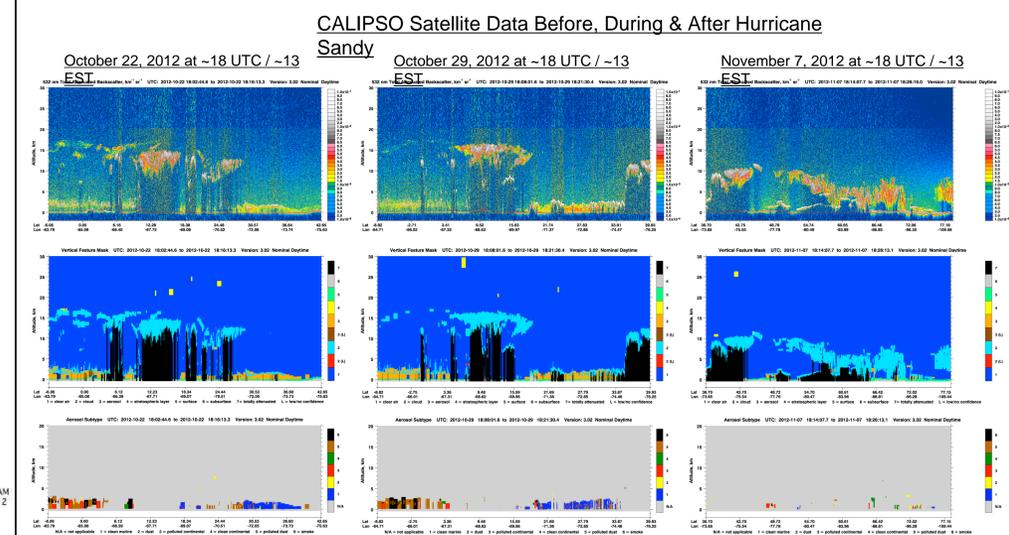
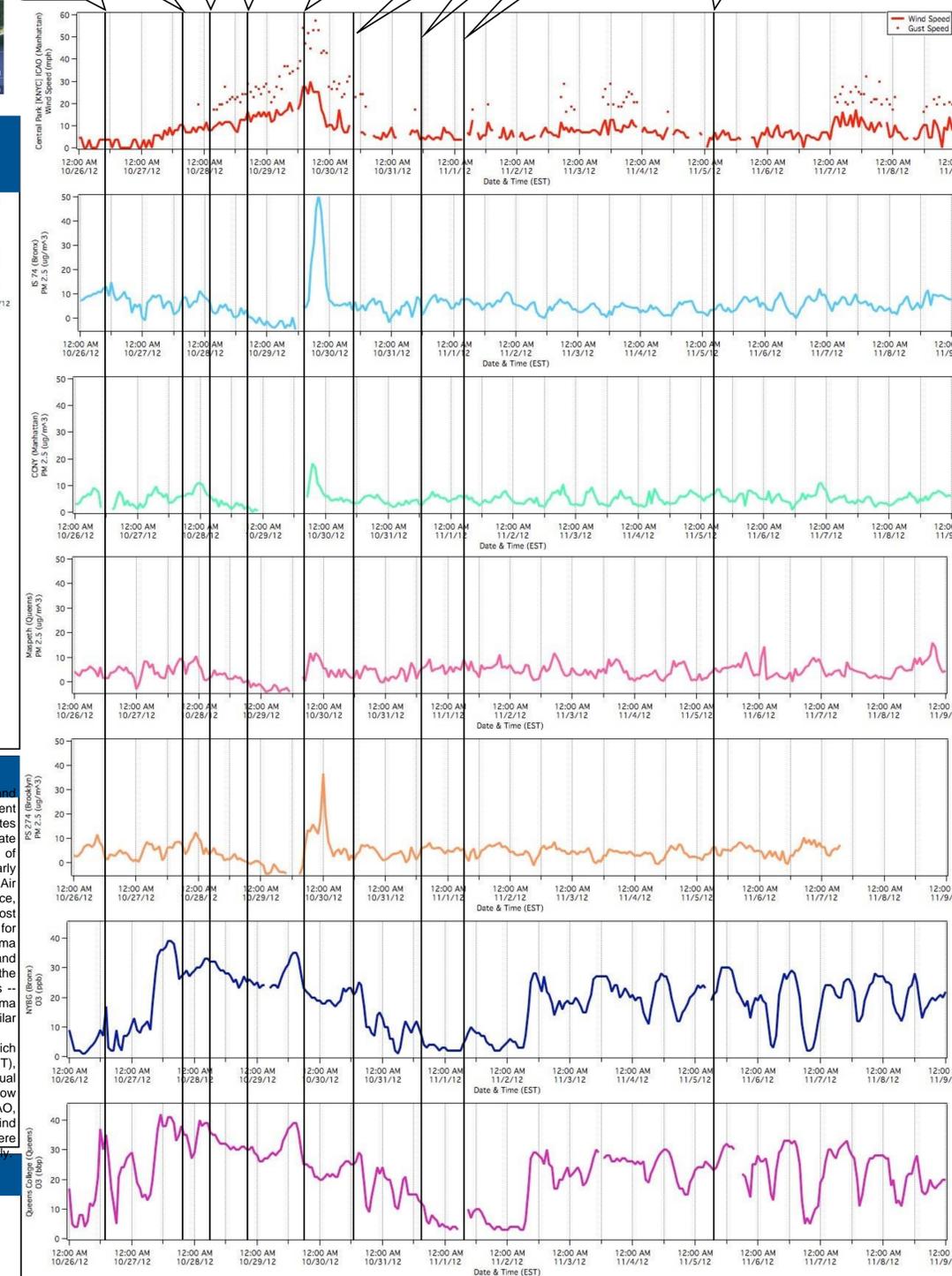
Storm surge of 13.8 feet reported at the battery.

12:00 PM EDT: MTA & Port Authority bridges open.

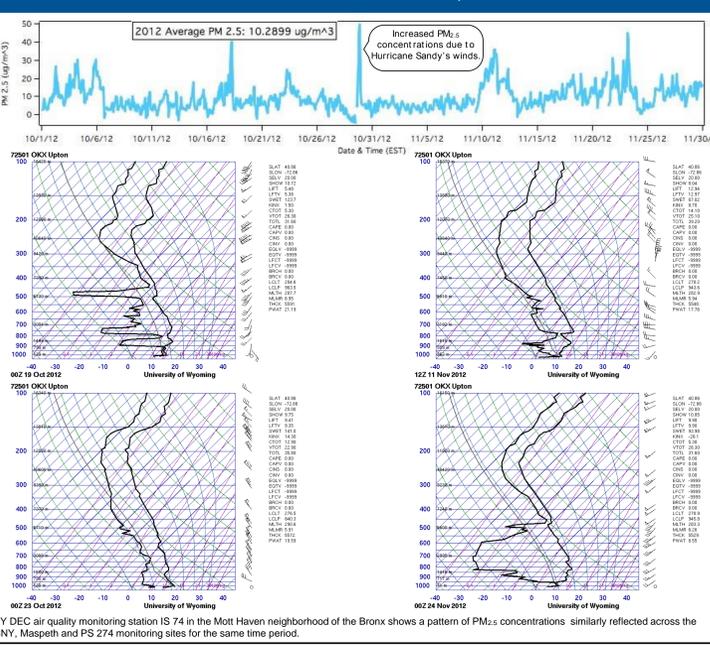
2:00 PM EDT: limited LIRR & Metro-North service resumes.

6:10 AM EDT: limited NYC subway service resumes.

First rush hour since Sandy with all major transportation services resumed.



"Typical" New York City Air Quality* October - November, 2012



Project Background

This work is a continuation of a prior investigation into the correlation between asthma incidence in New York City and elevated levels of 2.5µm Particulate Matter (PM_{2.5}). In New York City, PM_{2.5} is monitored by the New York Department of Environmental Conservation (NY DEC), which maintains seventeen air quality monitoring sites. Thirteen sites measure PM_{2.5}; the remainder monitor ozone (O₃). Currently, only one monitoring site measures both particulate matter and ozone concentrations: City College of New York (CCNY) in the Morningside Heights neighborhood of Manhattan. Time series plots of this hourly data show clear episodes of elevated PM_{2.5} levels. However, when yearly averages are computed, differences between sites are shown to be relatively small (see "Typical" New York City Air Quality, above). While there is some correlation between elevated average PM_{2.5} and elevated asthma incidence, there are also air quality monitoring sites in neighborhoods with low levels of asthma incidence. Analysis of the most recent Statewide Planning and Research Cooperative System (SPARCS) data on Emergency Department visits for asthma (2008 - 2010) reveal that the boroughs of the Bronx and Manhattan have much higher rates of asthma incidence (408.6 and 303.6 per 10,000, respectively) than Brooklyn, Queens (219.5 per 10,000) and Staten Island (118.6 per 10,000). However, delimiting the data by neighborhood reveals a clearer picture. For example, while the entire borough of Manhattan appears to have an elevated level of asthma incidence, only three neighborhoods -- Washington Heights, Central Harlem/Morningside Heights and East Harlem -- have elevated levels of asthma incidence; the remaining seven neighborhoods have far fewer Emergency Department visits for asthma. Similar patterns appear at monitoring stations at Brooklyn and Queens.

Extending the investigation into PM_{2.5} concentrations (through 2013) includes the landfall of Hurricane Sandy, which struck the New York/New Jersey area as an extratropical cyclone on October 29, 2012 at 23:30 UTC (18:30 EST), with maximum sustained winds of 70 knots (81 mph). While Sandy had a large wind field, likely due to unusual interaction with an upper-level trough, sustained hurricane-force wind speeds were constrained to a relatively narrow band around Sandy's "eye". Maximum sustained wind speeds in New York City (see Central Park [KNYC] [CAO], right) were therefore considerably lower, just below tropical storm force, at 33 knots (38 mph). These wind measurements were likely reduced due to KNYC's location in the City proper; higher maximum sustained winds were measured at both LaGuardia [KJGA] and Kennedy [KJFK], of 56 knots (65 mph) and 49 knots (56 mph), respectively.

Acknowledgements

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- Thanks to Sam Ahmed, Alex Gilerson, Rick Wagener and their staffs for establishing and maintaining the LISCO and Brookhaven AERONET sites used in this investigation.

Data & Analysis

Typically, elevated PM_{2.5} concentrations in New York City are correlated with temperature inversions. Particulate matter can become "trapped" under the inversion, leading to "spikes" in PM_{2.5} levels. Examples of these "spikes" can be seen in the graphs of "Typical" New York City Air Quality (far left). Elevated PM_{2.5} concentrations on 10/18, 10/22, 11/11 and 11/23 are all correlated with temperature inversions (see Skew-T charts, far left). In addition, data from the Brookhaven AERONET site shows elevated returns at 500 nm and 675 nm, at the 2.5 µm range. Analysis of the CALIPSO LIDAR returns (above) for a nearby flyover (36.60 - 42.65°N, 73.73 - 75.63°W) indicates that these elevated PM_{2.5} concentrations may be polluted dust. However, the elevated PM_{2.5} concentrations evident at 1:00 UTC on 10/30 (20:00 EST on 10/29) are not correlated with a temperature inversion; rather, they are correlated with the elevated wind speeds from Hurricane Sandy as she made landfall to the south. A nearby profile from the CALIPSO LIDAR at approximately 18:00 UTC (13:00 EST) on 10/29 (33.87 - 39.93°N, 72.85 - 76.25°W) shows elevated returns at 532 nm, identified as a layer of clouds between 8 km and 10 km altitude -- Hurricane Sandy. Although neither direct measurements from CALIPSO or the Brookhaven AERONET instruments are available, it is likely that the "spike" in PM_{2.5} concentrations was caused by airborne sea salt, blowing dust and/or fine debris. These "spikes" are unlikely to have been caused by either traffic or point sources of emissions. Information from the New York City Metropolitan Transportation Authority (MTA) (narrative bubbles, above right), shows that all mass transit services in the City had been suspended 24 hours previously, and most MTA and Port Authority of New York/New Jersey (PATH) bridges and tunnels were closed once sustained winds exceeded 39 mph. While sustained wind speeds at Central Park (KNYC) of 39 mph were never reached (likely due to the station's location, in the City, surrounded by tall buildings), sustained winds over 39 mph were reached by 17:00 UTC (12:30 EST) at Kennedy Airport (KJFK) and by 18:00 UTC (13:00 EST) at LaGuardia Airport (KJGA). Post Hurricane Sandy, PM_{2.5} concentrations at air quality monitoring stations across the City quickly returned to typical levels. This is likely due to the quick restoration of mass transit services and the fact that the majority of New York City did not lose power, allowing most normal activities to resume almost immediately. This can also be seen in the available Brookhaven AERONET data from 10/31 through 11/7. A nearby CALIPSO LIDAR profile at approximately 18:00 UTC on 11/7 (36.70 - 42.70°N, 73.65 - 75.54°W) shows a cloud layer between 8 and 10 km altitude, which does not allow for identification of possible sources of PM_{2.5}; however, this explains the lack of AERONET data for the same time period.

Resources

- NASA LaRC CALIPSO LIDAR data & imagery. (http://www-calipso.larc.nasa.gov/tools/data_avail/)
- NASA GSFC AERONET data & imagery. (http://aeronet.gsfc.nasa.gov/new_web/data.html)
- NASA GSFC AQUA MODIS imagery. (<http://modis.gsfc.nasa.gov/>)
- New York Department of Environmental Conservation air quality data. (<http://www.dec.ny.gov/airmon/>)
- New York City Metropolitan Transportation Authority's "Timeline of the Storm and Restoration of Service". (<http://web.mta.info/sandy/timeline.htm>)
- National Weather Service Forecast Office New York, NY Hurricane Sandy products. (<http://www.weather.gov/okx/HurricaneSandy>)
- Weather Underground data archives for KJFK, KJGA and KNYC. (<http://www.wunderground.com/>)
- NOAA Earth System Research Laboratory. (<http://www.esrl.noaa.gov/>)