Microclimatology of hurricanes: The value of weather stations in understanding local effects of Hurricane Sandy

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INTRODUCTION

Weather stations can be used to analyze long-term weather patterns or to look at data from particular weather events (e.g. hurricanes), among other things. Records of these data are important to scientists because weather patterns are changing as a result of climate change.

Broad-scale weather stations are designed to measure the conditions of the atmosphere for a large, general area under a set of conditions – long open area, no obstructions, standard height, etc while microclimate stations are weather stations that capture the conditions of a specific area near the ground.

Hurricane strength is characterized by weather station measurements of the magnitude of wind speed generated. Category 5, the strongest hurricanes, have the lowest pressures (Sheets 1990). Inside the structure of these storms, the point of lowest pressure designates the eye wall location, where the storm is most intense (NASA Earth Observatory).

On October 29, 2012, Hurricane Sandy became the lowest pressure storm in recorded history to make it north of Cape Hatteras, North Carolina with barometric pressure of 940 millibars (mb) topping the record of 941 mb from the 1938 Great New England Hurricane (Blake et al. 2013).

In this study we used data from weather stations in southern New Jersey to assess storm intensity for specific locations and compare the difference between data from microclimate stations and broad-scale stations. Hurricane Sandy was most intense in Atlantic City (where it made landfall) and the placement of the weather station was important to the data. These results indicate that microclimate stations can provide important information into local weather events and their impacts on a neighborhood scale that may be overlooked by a broad-scale station.

METHODS

The data used in this study were from broad-scale and microclimate stations in southern New Jersey. Two stations were independently maintained while the others were maintained by the US Geological Survey (USGS) or the International Civil Aviation Organization (ICAO). The two independent microclimate stations were located at the Drexel Barnegat Bay Field Station (39.77274, -74.19330) and a residential location in Haddonfield (39.90380, -75.03657) respectively. For all stations, data were recorded for 48 h at 15 min intervals on October 29-30, 2012.

To assess storm intensity for Barnegat and Haddonfield, we compared barometric pressure, wind speed, gust speed, and rainfall data for each to data from Atlantic City Marina USGS station (39.37750, -74.42333). We chose this location because it was located close to where Hurricane Sandy made landfall.

To assess microclimate impacts of Hurricane Sandy we compared data from Barnegat and Haddonfield to data collected at weather stations located at Barnegat Lighthouse USGS station (39.76111, -74.10806) and Philadelphia International Airport ICAO station (39.87222, -75.24083).

RESULTS

Storm Intensity

Barometric Pressure:

Figure 1:

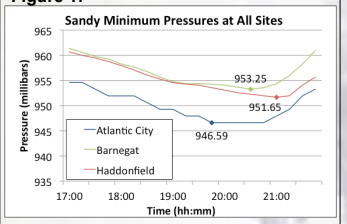

Figure 1 (above): Minimum pressures in millibars at Atlantic City, Barnegat, and Haddonfield stations on October 29, 2012.

Minimum barometric pressure of Hurricane Sandy was 946.6 mb at 19:45, 953.2 at 20:30, and 951.6 mb at 21:00 on October 29 for Atlantic City, Barnegat, and Haddonfield respectively.

Rainfall and Pressure:

Figure 2:

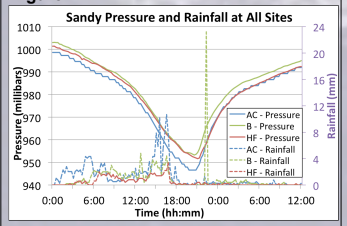

Figure 2: Minimum pressures in millibars and total rainfall in mm at Atlantic City, Barnegat, and Haddonfield stations from October 29 through 12:00 on October 30.

Total rainfall for Atlantic City, Barnegat, and Haddonfield was 190.0 mm (~7.5 in), 136.0 mm (~5.4 in), and 64.0 mm (~2.5 in). In all locations most rain fell before the eye passed and then rain per 15 min sharply decreased. However in Barnegat, shortly after the eye passed, there was a dramatic increase in rain of 23.2 mm between 22:00 and 22:15.

Pressure, Wind and Gust Speed:

Figure 3:

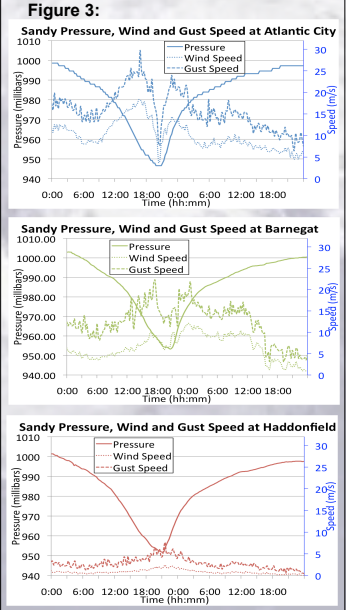

Figure 3: Minimum pressures in millibars and wind and gust speed in m/s at Atlantic City (top), Barnegat (middle), and Haddonfield (bottom) stations from October 29-30

In Atlantic City and Barnegat, wind and gust speeds peaked before and after the eye passed. In Atlantic City wind and gust speeds peaked at 18.3 m/s and 29.7 m/s before the eye passed and 14.3 m/s and 24 m/s after the eye passed. In Barnegat wind and gust speeds peaked at 10 m/s and 22.3 m/s before the eye passed and 12.1m/s and 21.9 m/s after the eye. In Haddonfield, wind and gust speeds peaked once at 2.4 m/s and 7.6 m/s when the eye passed. The station was sheltered from wind.

Weather Station Placement and Implications of Local Storm Effects

Data from USGS and ICAO weather stations from Barnegat Lighthouse and Philadelphia International Airport were similar to data from the microclimate weather stations. Minimum barometric pressure, and maximum wind and gust speeds for Barnegat Lighthouse were 950.0 MB at 20:30, 25.21 m/s and 35.5 m/s at 16:30 on October 29 respectively. Total rainfall was 166.4 mm. Minimum barometric pressure and maximum wind and gust speeds for Philadelphia International Airport were 952.6 MB at 21:32, and 22.64 m/s and 30.35 m/s at 20:44 on October 29 respectively. Total rainfall was 77.7 mm.

CONCLUSIONS

Comparison of all stations show that the minimum pressure was the lowest in Atlantic City, followed by Brigantine and then Haddonfield. The weather station in Atlantic City also recorded the most rainfall and highest wind and gust speeds. These data indicate that Hurricane Sandy was most intense in Atlantic City, where it made landfall.

Comparison of microclimate stations to nearby broad-scale stations showed that placement of the instrument can affect some climate measurements. The Barnegat station was sheltered by a shed between it and the water and the Haddonfield station was in a backyard, sheltered by houses and evergreen trees. The USGS station was on an open dock and the Philadelphia International Airport station was located in an elevated area out in the open. While barometric pressure and rainfall were similar between compared microclimate and broad-scale stations, the wind and gust speeds were much higher at the broad-scale stations.

The Haddonfield station recorded its peak wind gust (7.6 m/s) when the eye-wall was passing through, just as the wind above ground knocked down a large oak tree within 20 m of the station.

Figure 4:

Figure 4: Picture of a large oak tree that blew down within 20m of the weather station.

Although official broad-scale weather stations in the region provided data on overall storm intensity, local weather stations provided important data on microclimatic effects at particular sites of interest to ecologists. These data can improve response to local impacts and events from storms.

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