Introduction to Oceanography, Spring 2015
Exercise 7 – Hurricanes and Superstorms

Date: April 16, 2015 **Names:**_____

Find yourself a group of 3-5 people. To begin the exercise, go to the following webpage: http://education.oceanobservatories.org/node/300/detail. First you will read a short introduction and then analyze some online data that were collected during recent hurricane Irene and Superstorm Sandy.

The goal of this investigation is to write up a description and analysis of the provided datasets. As you work through the exercise, complete the tables below, this will help you to answer the five questions at the end of this exercise.

Instructions
Using the datasets provided, describe the impact that Hurricane Irene and Superstorm Sandy had on the ocean by answering the five questions on the next page. Include an analysis of how the oceanic response varied between the two storms.

Glider data	**Hurricane Irene**		**Superstorm Sandy**	
	Before	*During/after*	*Before*	*During/after*
Date of storm impact	August 27th 2011		October 29th 2012	
Maximum wind speed (km/h)	137 km/hr		130 km/hr	
Mixed layer depth (m)	12m	28m	30m	Homogenous water column
Mixed layer water temperature (°C)	24 C	17 C	16 C	(14 C)
Deep water temperature (°C)	10 C	9 C	10 C	(14 C)
Mixed layer backscatter (m^{-1})			0	0.01

Examines buoy data from **all** available stations, comparing northern and southern buoy data. In the table report the data for the buoy offshore NY/NJ.

Buoy data	**Hurricane Irene**			**Superstorm Sandy**		
	Before	*Peak*	*After*	*Before*	*Peak*	*After*
Air pressure (hPa)	1013.5	967.3	1009	1020	960	1005
Date of minimum air pressure		8/27			10/29	
Wind speed (m/s)	6 m/s	20 m/s	8 m/s	6 m/s	25 m/s	10 m/s
Wave height (m)	0.75m	6.36m	1m	0.75m	9.65m	1m
Sea surface temperature (°C)	25 C	20.7 C	22 C	16.6 C	15.3 C	15.7 C

Introduction to Oceanography Exercise 4 – Hurricanes and Superstorms

1. As Hurricane Irene moved closer to shore, what changes did you notice in the ocean?

   The mixed layer deepened from ~10m to ~30 meters. At the same time, the temperature in the surface layer decreased from ~24°C to ~18°C. The deep water got slightly cooler (from ~12°C to ~10°C).

2. As Superstorm Sandy moved closer to shore, what changes did you notice in the ocean?

   The initial mixed layer depth was similar to hurricane Irene, but after the storm had passed, the mixed surface layer had disappeared and the water column became homogenous. The surface water temperature decreased slightly from ~18°C to ~15 °C. The deep water was initially similar to hurricane Irene (~12°C), but once the water column was homogenized, deep water was indistinguishable from surface water temperatures. Backscatter was initially low in the surface mixed layer, but after Superstorm Sandy, the backscatter In the entire water column increased significantly.

3. Based on your observations, what is the relationship between storms and the ocean?

   The strong winds associated with the hurricane causes the water column to become more mixed. Deep water was initially isolated from the surface, but as the storm passes, deep water is mixed into the surface. This affects the amount of energy that can be generated from the ocean in the form of latent heat, and the cooling of the surface slows the hurricane down.

4. Explain the differences in mixed layer depths between the two storms as they moved closer to land. Why are they different?

   During Irene the mixed layer deepened, but it did not disappear completely. Surface temperatures dropped enough to slow the hurricane down, but not enough to stop the hurricane.
   During Sandy, the mixed layer disappeared completely and the entire water column was homogenized. The surface waves generated by the hurricane could reach all the way to the bottom and mix suspended sediments into the surface ocean, causing an increase in backscatter. The colder temperatures from the deep water were critical in changing the storm from hurricane strength to slower wind speeds (tropical storm category) before it hit the land.

5. If Hurricane Sandy had occurred a couple weeks earlier in the season when atmospheric temperatures were warmer, how do you think the storm would have been different?

   Had the storm hit earlier in the season, the surface temperature would likely have been higher, and the stratification would have been more intense. This would have made it harder for the storm to mix up the entire water column and to erase the mixed layer. Since upwelling of colder deep water is a major factor in slowing down a hurricane, higher temperatures and stronger stratification would have meant that the storm would have had much more strength when it hit land.

   Note that Sandy was named a superstorm rather than a hurricane because it was a rare occasion when a hurricane met up with a Nor'easter. Usually these two types of storm are well separated by season and latitude, but climate change and ocean warming makes it more likely that these types of storms meet and combine forces.