Observing Hurricane Sandy like a Meteorologist - Program Outline

Introduction: On October 22, 2012 a tropical wave formed into a Tropical Storm within six hours in the western Caribbean Sea and moved slowly towards the Greater Antilles. Intensifying into a Hurricane, Sandy made landfall first near Kingston, Jamaica on October 24th and after reaching Category 2 Hurricane status struck Cuba the next day. After killing 70 people in Haiti, Dominican Republic, Puerto Rico, Cuba and the Bahamas, Hurricane Sandy pointed north and moved towards the East Coast of the United States. Sandy eventually moved ashore near Atlantic City, New Jersey and New York City on October 29th as a post-tropical cyclone with hurricane force winds. All said and done Superstorm Sandy (as it was termed after it joined a cold-core low pressure system moving eastward at the same time) affected an astounding total of 24 U.S. states. Most of the damage occurred in the Mid-Atlantic States. Sandy even caused the formation of an intense snowstorm in the high altitude regions of West Virginia.

The Supreme Court, New York City Stock Exchange, Amtrak, and nearly all airports and railways near the East Coast were closed for two days; nearly 20,000 flights were canceled in all. The New York City Subway was still trying to repair the damage six weeks later. Total damage in the US is estimated at over $63 billion.

NOAA Hurricane Predication Center based in Miami, Florida tracks and forecasts hurricanes. This program is intended to provide a more data-intensive view of a memorable severe weather event and visually explain how observation platforms make a meteorologist's job easier.

Datasets:

Hurricane Sandy (Real-Time Linear IR)

- IR Satellite images from GOES show clouds by measuring the infrared radiation emitted, which is directly proportional to the temperature
- Bright white clouds are higher and colder whereas grey clouds are lower and warmer
- Hurricane Sandy:
    - Developed in place in the Caribbean Sea
    - Made landfall in Jamaica, Haiti, Dominican Republic, Puerto Rico, Cuba and the Bahamas as a Category 1 & 2 hurricane
    - Lost its shape in southern Atlantic ocean heading northward but held its strength
    - Turned west and slowly came ashore near Atlantic City, NJ, the highest storm surge reached 13 feet in Lower Manhattan

Hurricane Sandy - SST Anomaly

- Warm temperatures in the ocean drive hurricane intensity – ocean temperatures typically are above 80°F (26.5°C) for hurricane formation

- 3° C (5.4°F) higher than average SST in the Gulf Stream of which 0.6° C (1.08°F) is thought to be as a result of global warming
- Red is higher than normal, white is normal, blue is cooler than normal
- You can see a trail of cooler water following a hurricane once the heat has been transferred as energy for the storm

Hurricane Sandy - GLAPS 500mb Height + Wind + Windspeed (kt)

- Contour lines show lines of equal height at the 500mb pressure level which is roughly the halfway point in the atmosphere
- The 500 mb pressure level is around 18,000 feet above the surface and varies in height based on pressure. High heights equal high pressure at the surface and low heights represent low pressure.
- The color variation shows wind speed in knots (1 knot = 1.15 mph)
- Red/yellow represent high wind speeds and blue/purple low
- The jetstream, a river of fast moving air, is very well highlighted in red, yellow and green
- Wind barbs are included to show wind speed and wind direction. The barbs point in the direction the wind is blowing and each half tickmark represents 5 knots, full tickmarks are 10 knots and a flag is 50 knots.
- Wind barbs around Hurricane Sandy show counterclockwise rotating winds as the air moves quickly in and up around an area low pressure (L), notice the opposite around the areas of high pressure (H)
- Numbers inside the H's & L's describe the height of the 500mb pressure varying between about 5300 – 5900 meters above the surface

Hurricane Sandy - GLAPS SFC Pressure + Wind + Windspeed (kt)

- Contour lines show lines of equal pressure at the surface
- The color variation shows wind speed in knots (1 knot = 1.15 mph)
- Red/yellow represent a high wind speeds and blue/purple low
- Wind barbs are included to show wind speed and wind direction
- Wind barbs around Hurricane Sandy show counterclockwise rotating winds as the air moves quickly in and up around an area low pressure (L), notice the opposite around the areas of high pressure (H)
- Notice that faster winds occur when the lines of pressure are closer together
- Just before making landfall in the US, Hurricane Sandy dipped to a record low surface pressure (for the region) of 940mb

Hurricane Sandy - GLAPS SFC Temperature (F) + Wind (kt)

- The color variation shows surface temperature in °F of land and sea surfaces
- The wind barbs are included to show wind speed and wind direction
- It's possible to track Hurricane Sandy by following the circular pattern of the wind barbs pointing counterclockwise and inward as the air moves in toward the tropical warm-core low

Hurricane Sandy - GLAPS Radar Reflectivity (dBZ)

- Radar – Radio Detection And Ranging - data comes from the National Weather Service for the United States (including Puerto Rico) and is a ground-based observation system
- Radar detects precipitation that is falling, such as rain or snow
- Radar is a good example of the limits of ground-based observations - it only detects Hurricane Sandy when it is close to the coast or over land

Hurricane Sandy –Enhanced IR Sat

- IR Satellite images from GOES show clouds by measuring the infrared radiation emitted, which is directly proportional to the temperature
- Teal indicate the highest, coldest clouds followed by magenta then white and grey indicate the lowest, warmest clouds
- Color Enhancement gives a clearer picture of the height and intensity of Hurricane Sandy and the precipitation it carried

<u>*Bonus - Layered datasets for iPad users on SOS version 4.0</u>

Hurricane Sandy – IR over SST

Select Layers and decrease the *Transparency* of *Sandy IR* to view both datasets at once

- Linear IR Satellite on top of sea surface temperature provides a clear picture of the underlying physics at play during the disastrous Hurricane Sandy event
- Warm temperatures in the ocean drives hurricane intensity – ocean temperatures typically are above 80°F (26.5°C) for hurricane formation
- 3° C (5.4°F) higher than average SST in the Gulf Stream of which 0.6° C (1.08°F) is thought to be as a result of global warming
- Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises and condenses

Hurricane Sandy - Radar over Satellite 10/23 – 10/30/12

Select Layers and decrease the *Transparency of Satellite* to view both datasets at once

- Linear IR Satellite on top of Radar Reflectivity provides a clear picture of the differences between ground-based and satellite-based observations
- Radar only picks up precipitation and only when Hurricane Sandy is near the coast or over land
- IR Satellite data helps the National Weather Service Hurricane Predication Center see where Hurricane Sandy is tracking across the ocean
- Example of hurricane devastation before satellite observations: 1900 Galveston hurricane caused more than 2,500 deaths because it was not possible to track and monitor inside the Gulf of Mexico