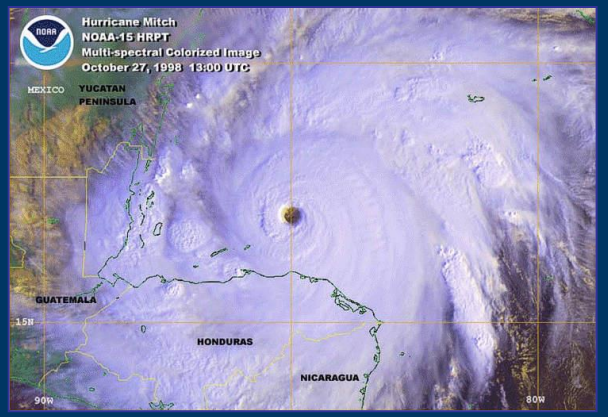
6 – Hurricanes

Coastal Construction Manual

https://www.fema.gov/sites/default/files/2020-08/fema55_voli_combined.pdf

6 - Tropical Cyclones

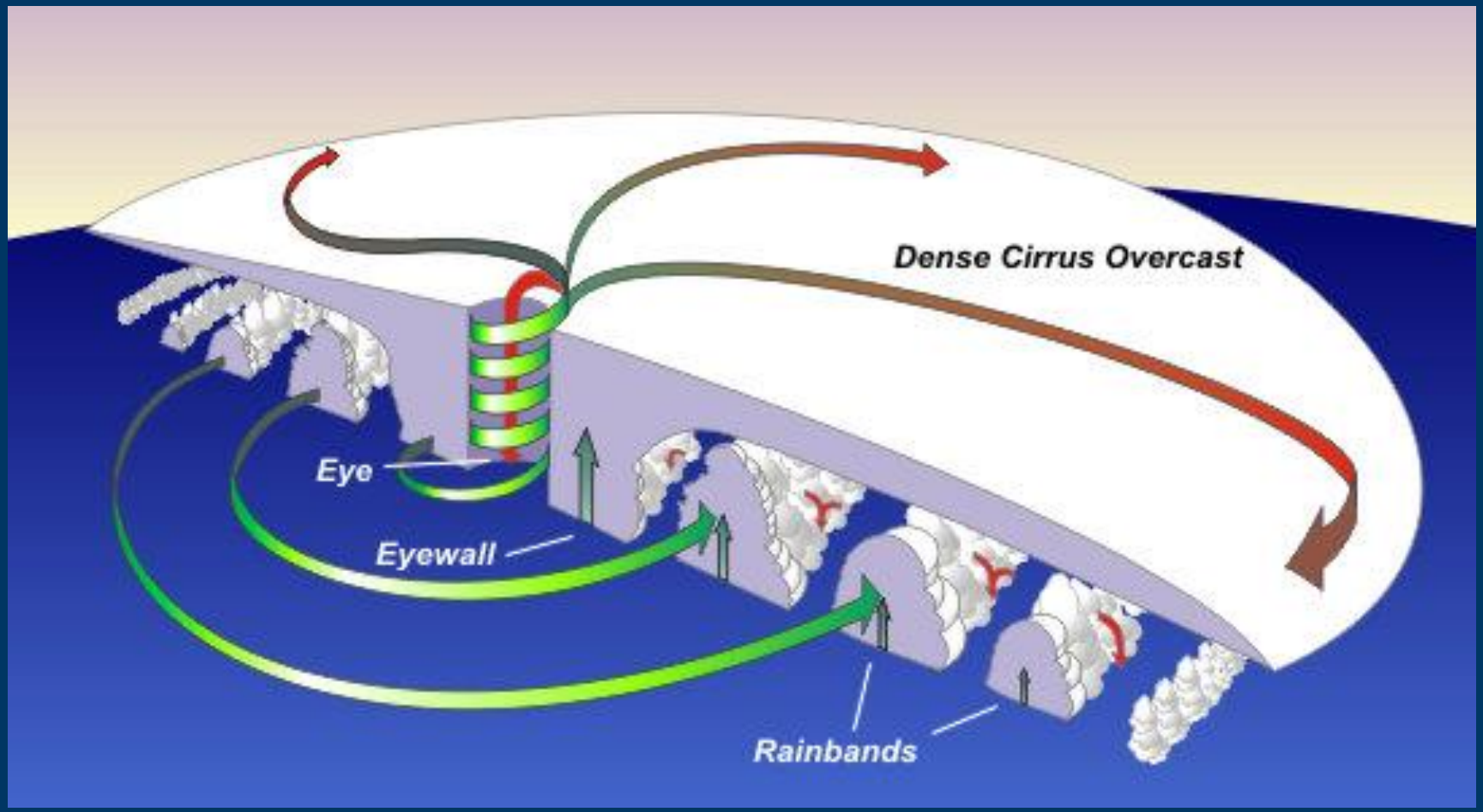
- A tropical cyclone is a warm-core, low pressure system without any "front" attached, that develops over the tropical or subtropical waters, and has an organized circulation. Depending upon location, tropical cyclones have different names around the world.
- Atlantic/Eastern Pacific Oceans - *hurricanes*
- Western Pacific - *typhoons*
- Indian Ocean - *cyclones*



6 - Tropical Cyclones

- Tropical Depression: A tropical cyclone with maximum sustained winds of 38 mph or less.
- Tropical Storm: A tropical cyclone with maximum sustained winds of 39 to 73 mph.
- Hurricane: A tropical cyclone with maximum sustained winds of 74 mph or higher.

6 - Tropical Cyclone Structure



https://www.nhc.noaa.gov/

6 - Tropical Cyclone Structure

Eyewall / Wall Cloud:

An organized band or ring of cumulonimbus clouds that surround the eye, or light-wind center of a tropical cyclone.

Eyewall and wall cloud are used synonymously

6 - Safir-Simpson Hurricane Wind Scale

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 64-82 kt 119-153 km/h	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph 83-95 kt 154-177 km/h	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph 96-112 kt 178-208 km/h	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph 113-136 kt 209-251 km/h	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157 mph or higher 137 kt or higher 252 km/h or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

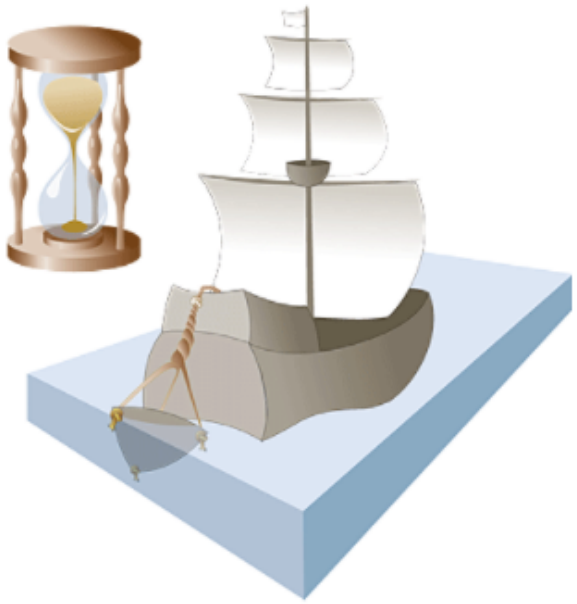
https://www.nhc.noaa.gov/aboutsshws.php

National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Knots

Knots, on the other hand, are used to measure speed. One knot equals one nautical mile per hour, or roughly **1.15 statute mph**.

The term knot dates from the 17th century, when sailors measured the speed of their ship using a device called a “common log.” The common log was a rope with knots at regular intervals, attached to a piece of wood shaped like a slice of pie. Mariners would lower the wood piece into the water and allow it to float freely behind the ship for a specific amount of time (often measured with an hourglass). When the time was up, they would count the knots between the ship and the piece of wood, and that number estimated their speed.



Measuring the knot in the 17th century.

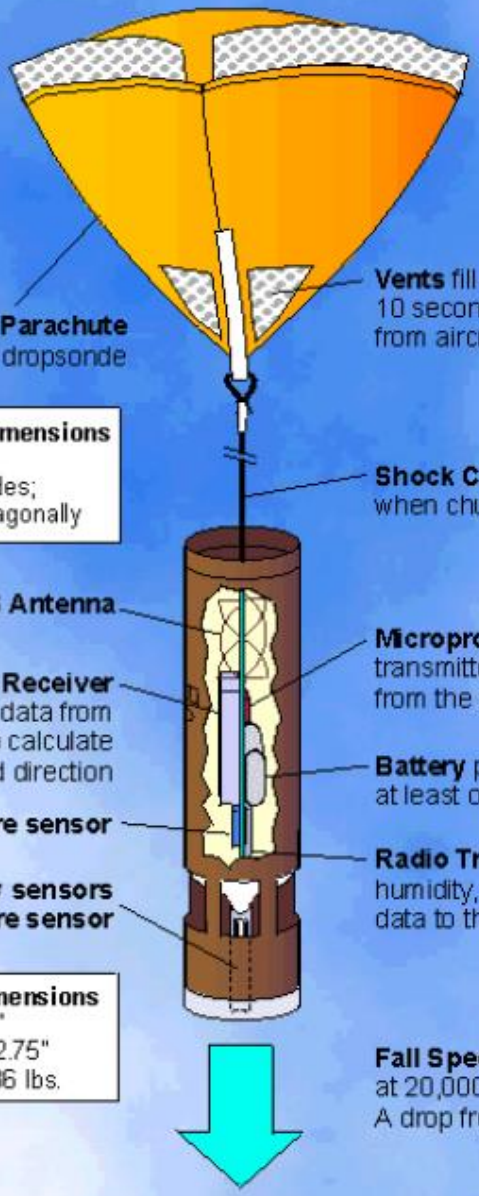
https://oceanservice.noaa.gov/facts/nautical-mile-knot.html

6 - How well do we know the Wind

- Hurricane Data
  - Satellites
  - Aircraft
  - Dropwindsonde
    (1000's are dropped every year)
  - Ship and Buoy Data
  - Doppler Radar
- National Hurricane Center
  - They want to know intensity
  - They want to forecast the path
  - They want to issue accurate warnings

NCAR GPS Dropsonde

the definitive atmospheric profiling tool



Square-cone Parachute increases stability of dropsonde

Parachute Dimensions
Height: 10"
Width: 12" sides;
16" diagonally

Vents fill chute within 10 seconds after release from aircraft

Shock Cord reduces stress when chute opens

GPS Antenna

GPS Receiver collects the data from GPS satellites used to calculate wind speed and direction

Pressure sensor

Humidity sensors and **temperature sensor**

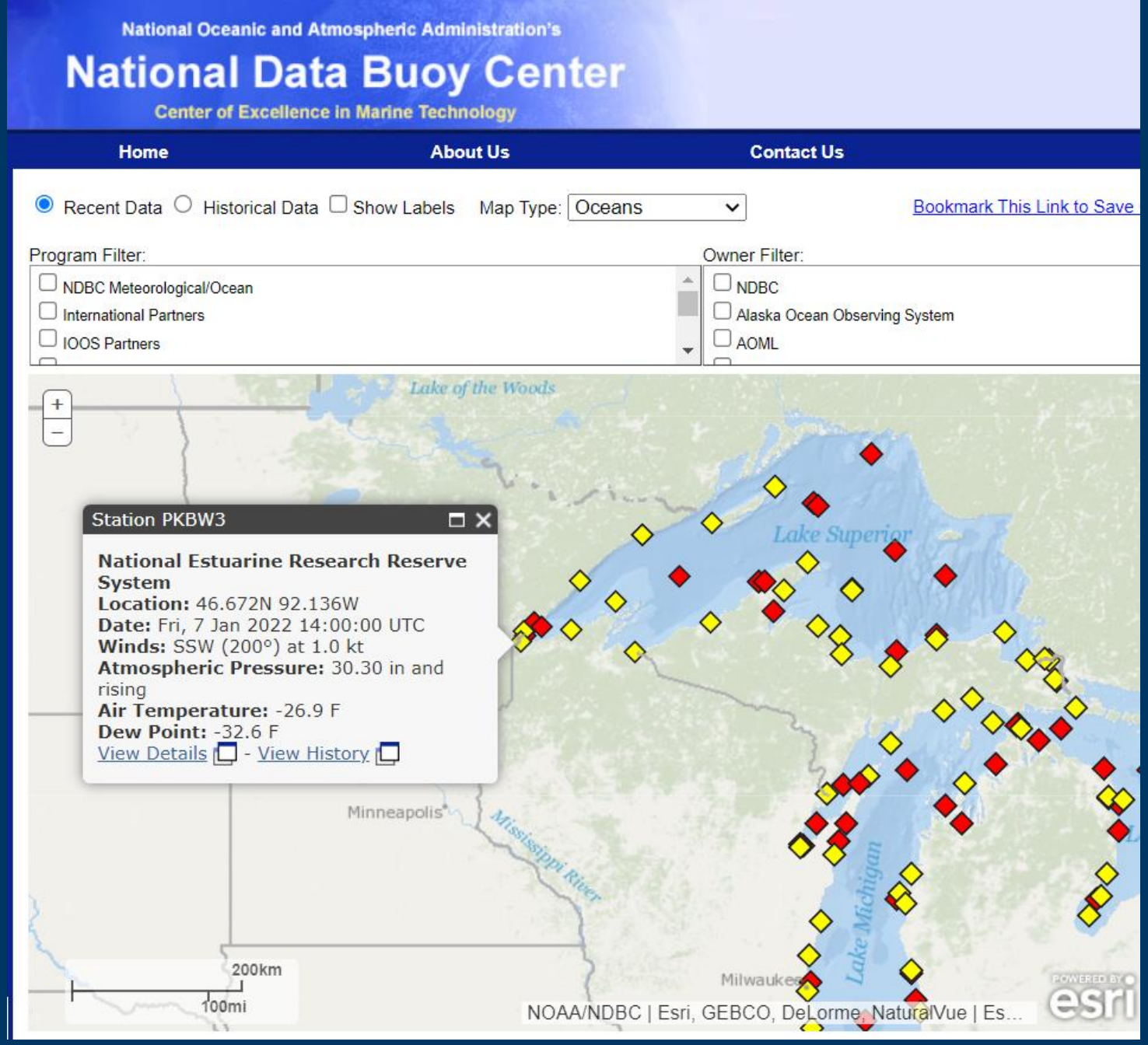
Sonde Dimensions
Length: 16"
Diameter: 2.75"
Weight: 0.86 lbs.

Microprocessor controls the transmitter and digitizes data from the sensors

Battery pack provides power for at least one hour

Radio Transmitter sends temperature, humidity, pressure, and GPS (wind) data to the aircraft every 0.5 seconds

Fall Speed ranges from 36 mph at 20,000 feet to 24 mph at sea level. A drop from 20,000 feet lasts 7 minutes.



https://www.ndbc.noaa.gov/

National Oceanic and Atmospheric Administration's

National Data Buoy Center

Center of Excellence in Marine Technology

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Recent Data | Historical Data | Show Labels | Map Type: Oceans | Bookmark This Link to Save C

Program Filter:

- NDBC Meteorological/Ocean
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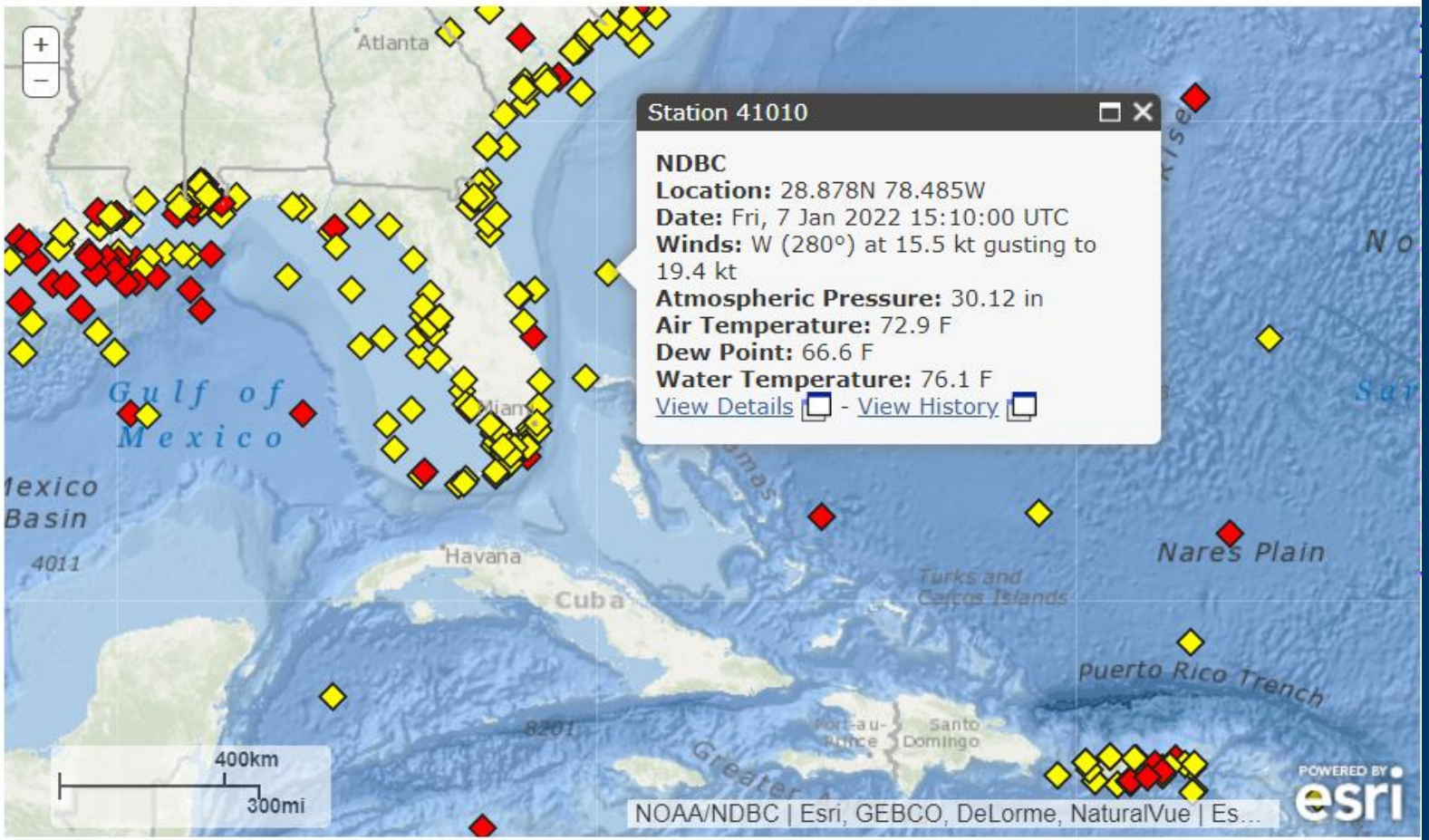
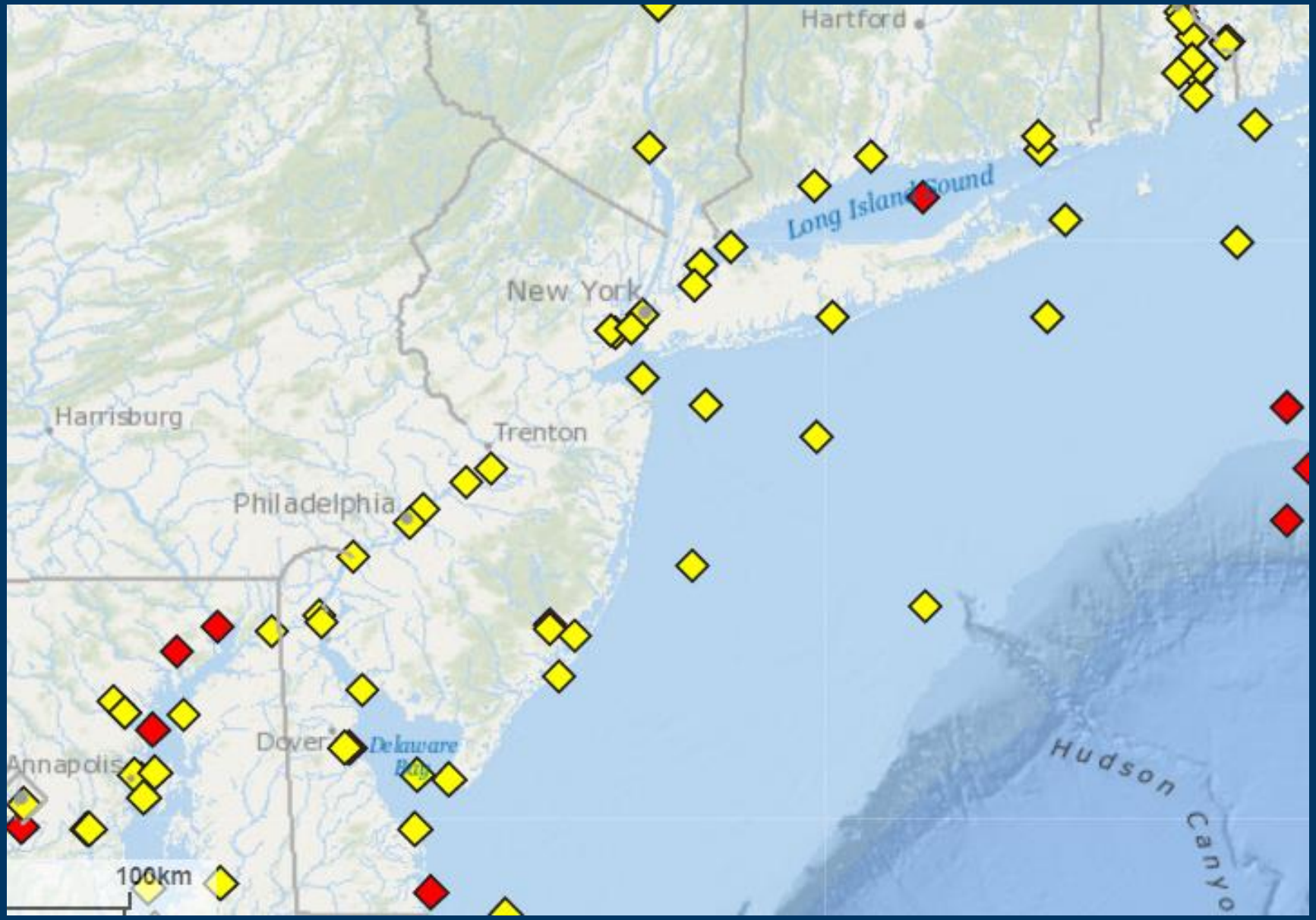
- IOOS Partners

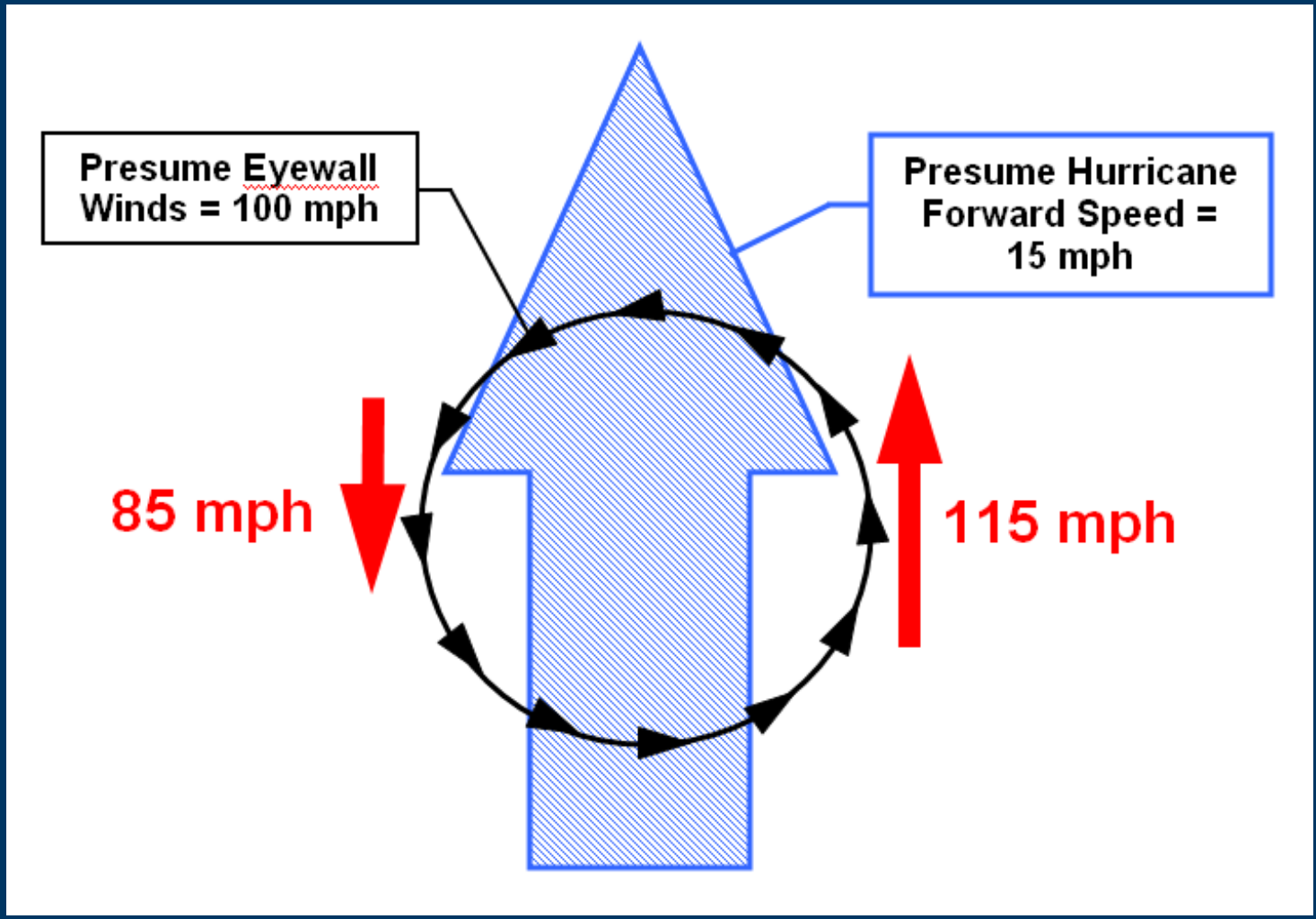
Owner Filter:

- NDBC
- Alaska Ocean Observing System
- AOML

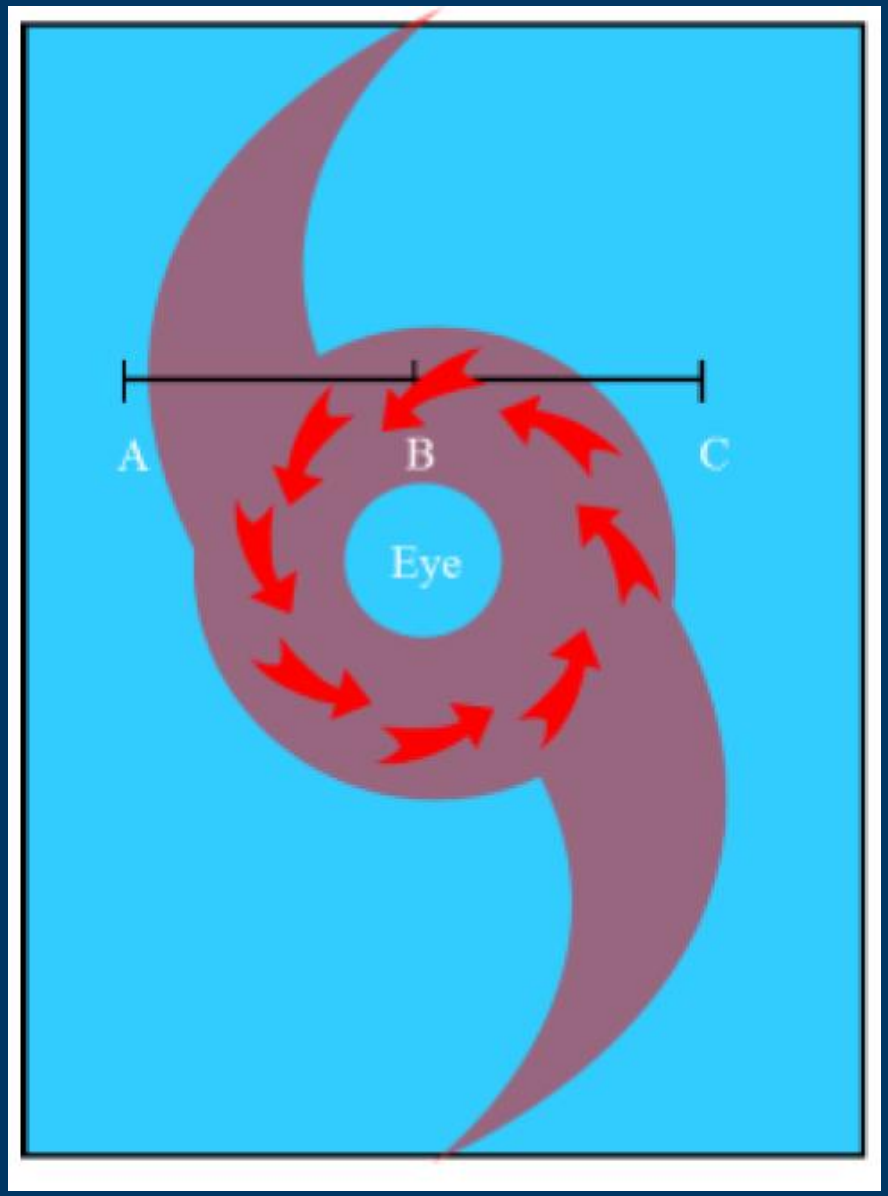


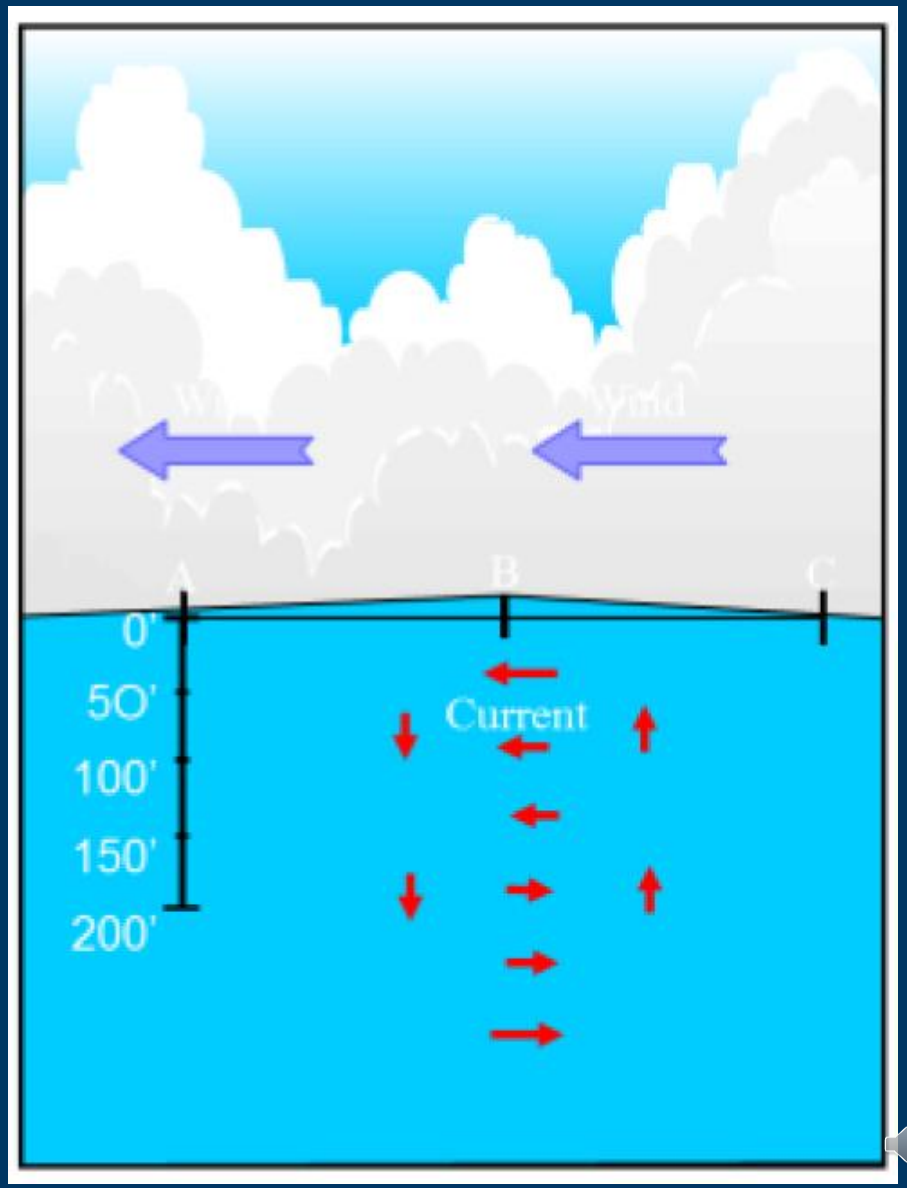

Hartford
Long Island Sound
New York
Harrisburg
Trenton
Philadelphia
Dover
Delaware
Annapolis
Hudson
100km

6 - Cumulative Speed Effect



6 - Flood & Wind - What is Storm Surge?





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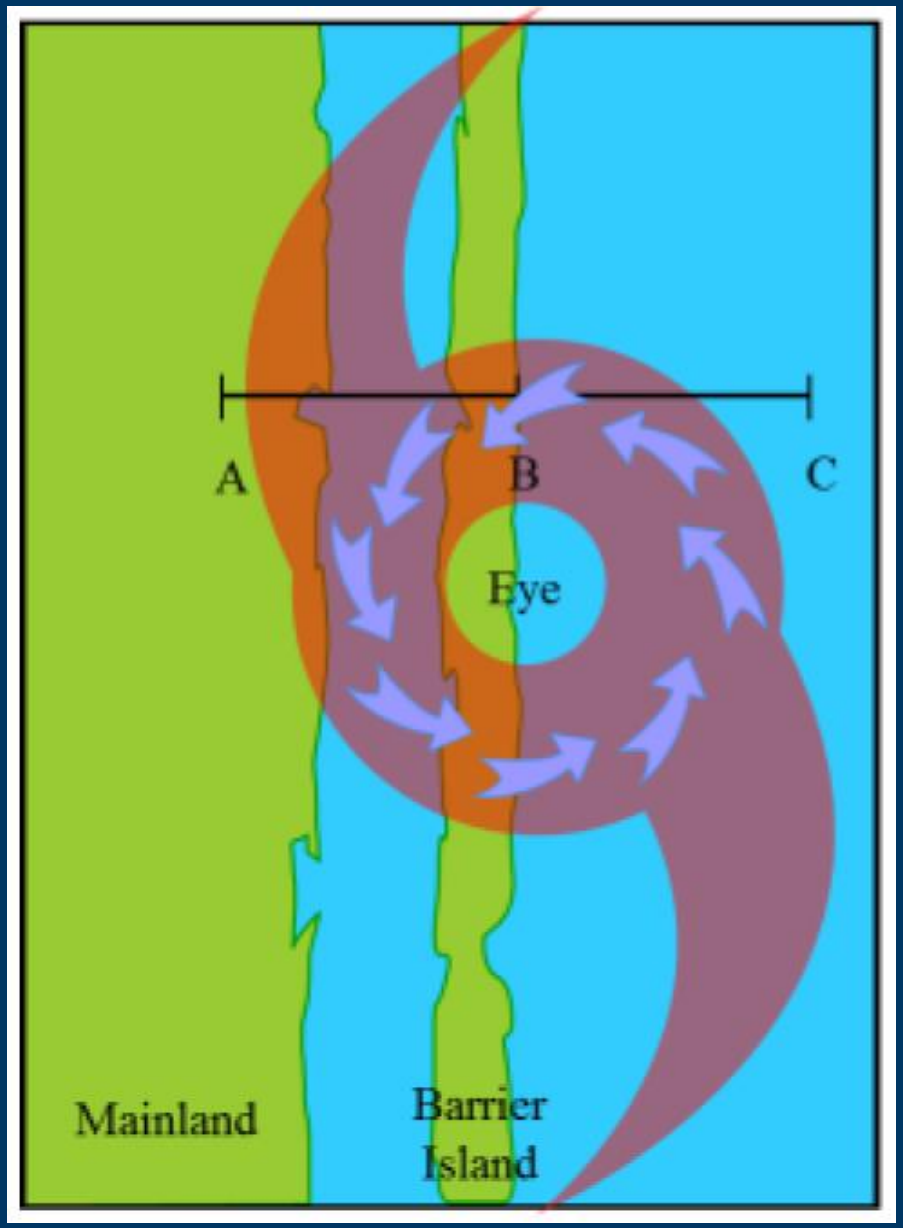
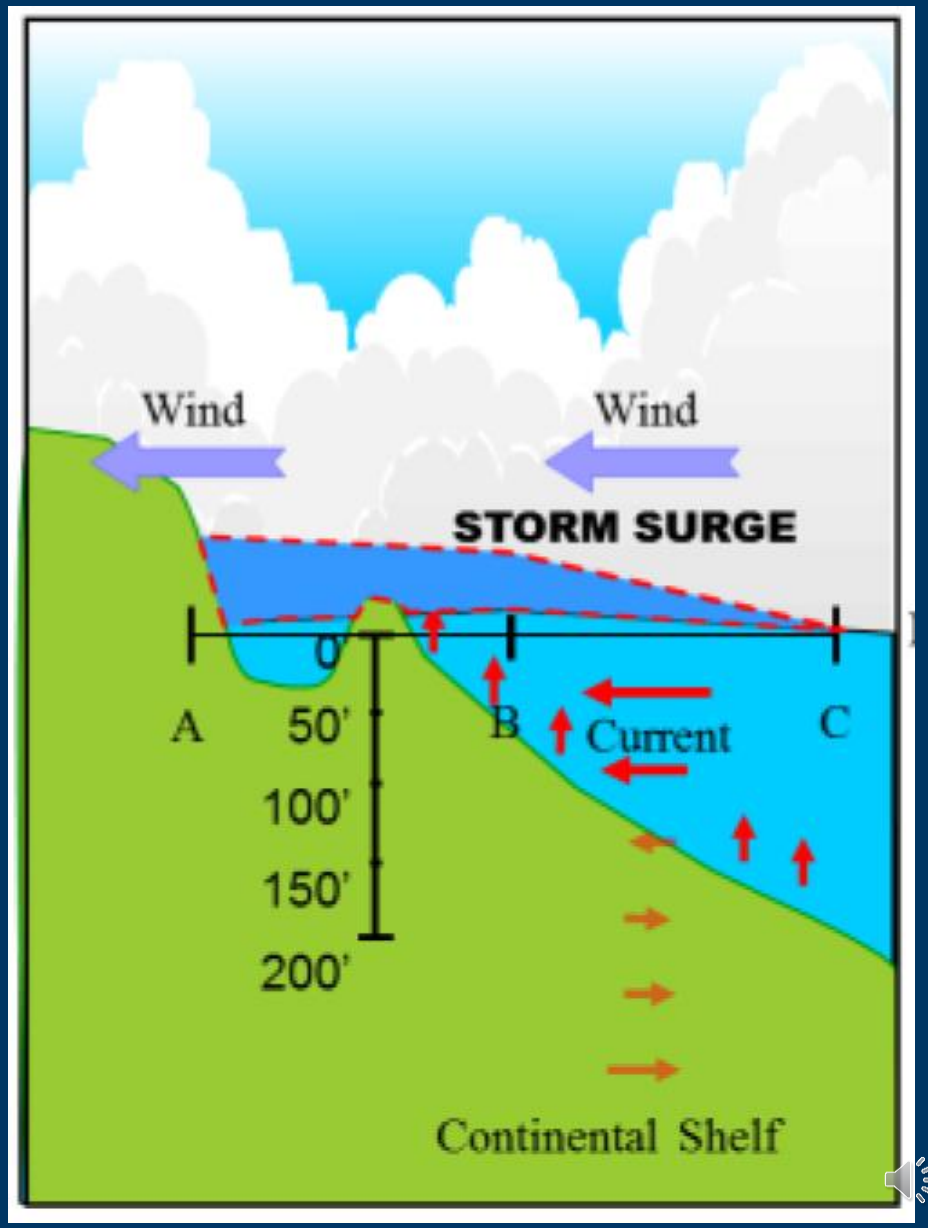




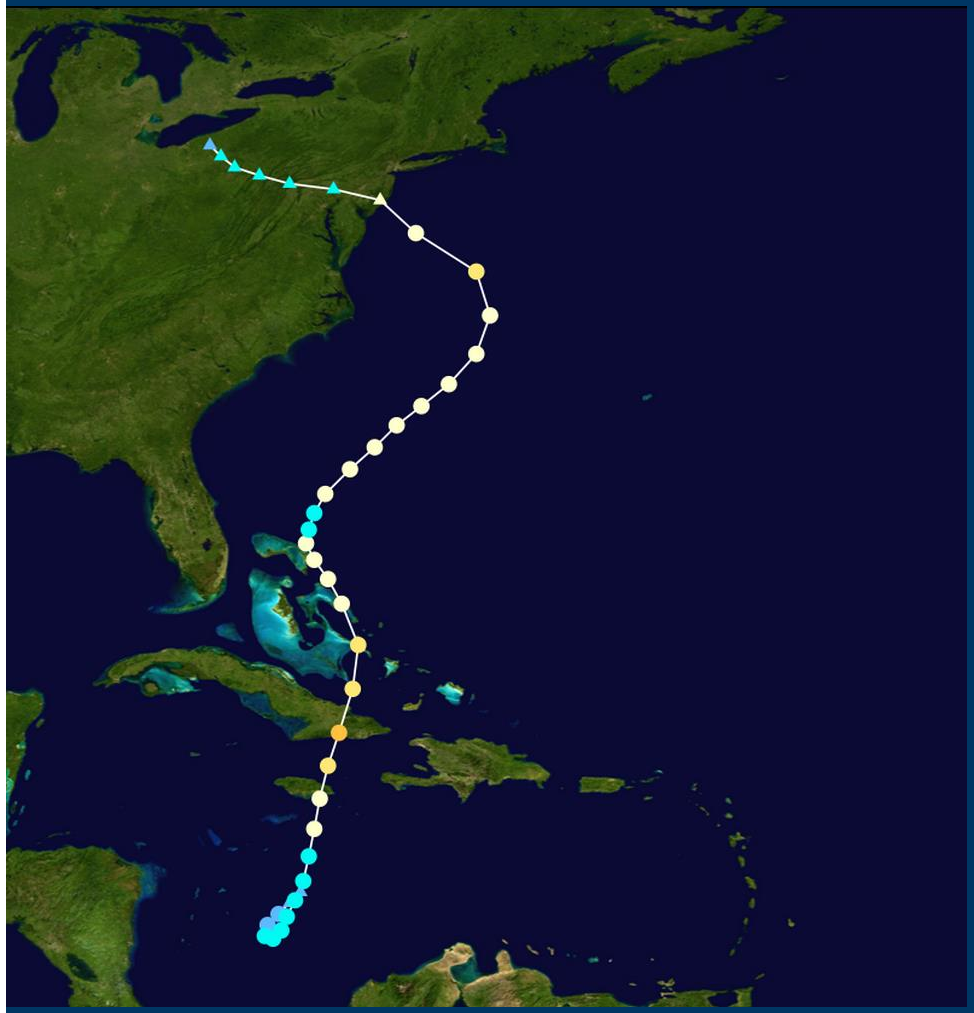
6 - Flood & Wind - Hurricane Sandy

Costliest U.S. Atlantic hurricanes

Cost refers to total estimated property damage

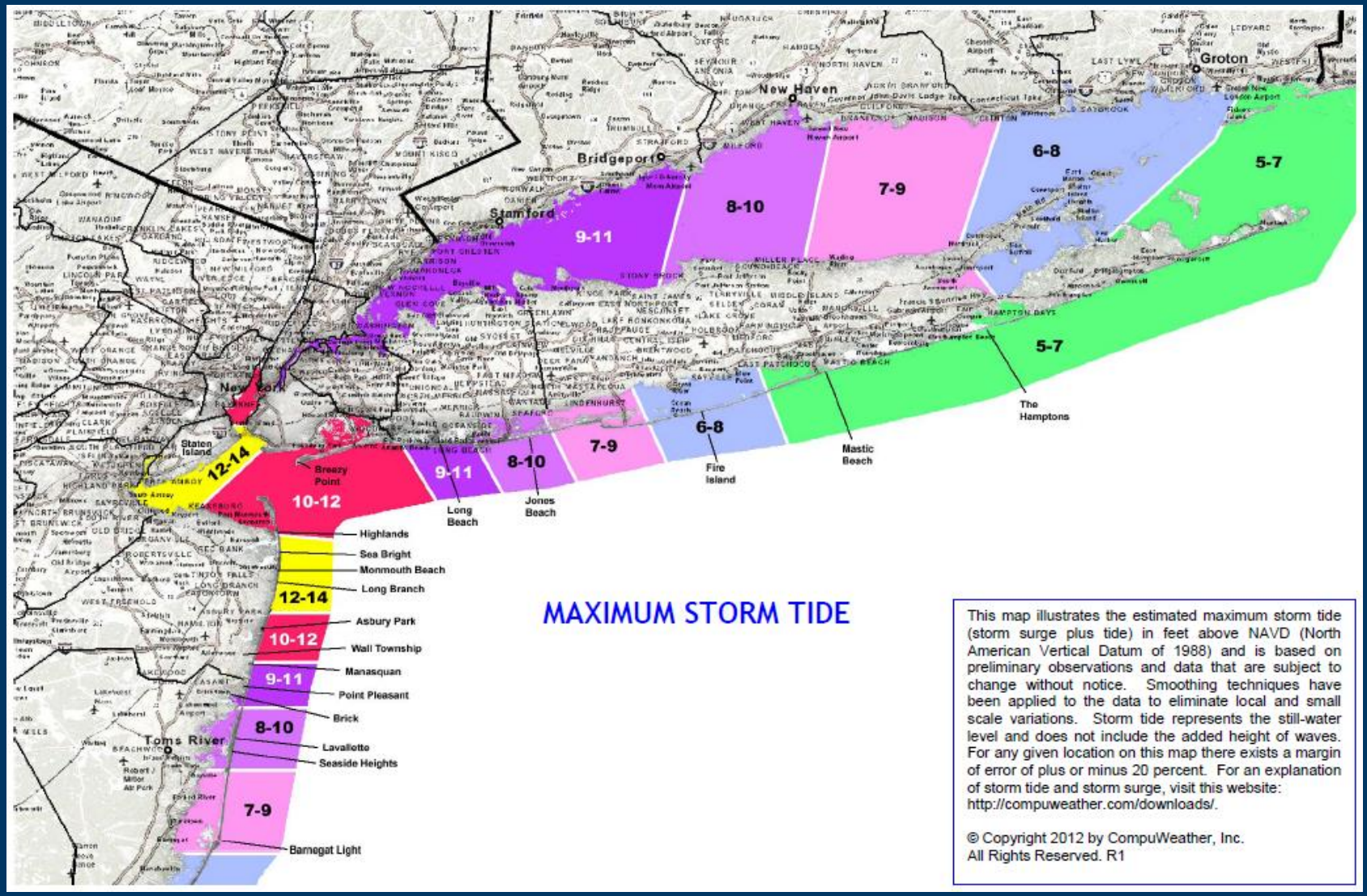
Rank	Hurricane	Season	Damage
1	Katrina	2005	$108 billion
2	**Sandy**	2012	$71.4 billion
3	Ike	2008	$29.5 billion
4	Andrew	1992	$26.5 billion
5	Wilma	2005	$21 billion
6	Ivan	2004	$18.8 billion
7	Irene	2011	$15.6 billion
8	Charley	2004	$15.1 billion
9	Rita	2005	$12 billion
10	Frances	2004	$9.51 billion

Source: National Hurricane Center[189][1][190][nb 1]



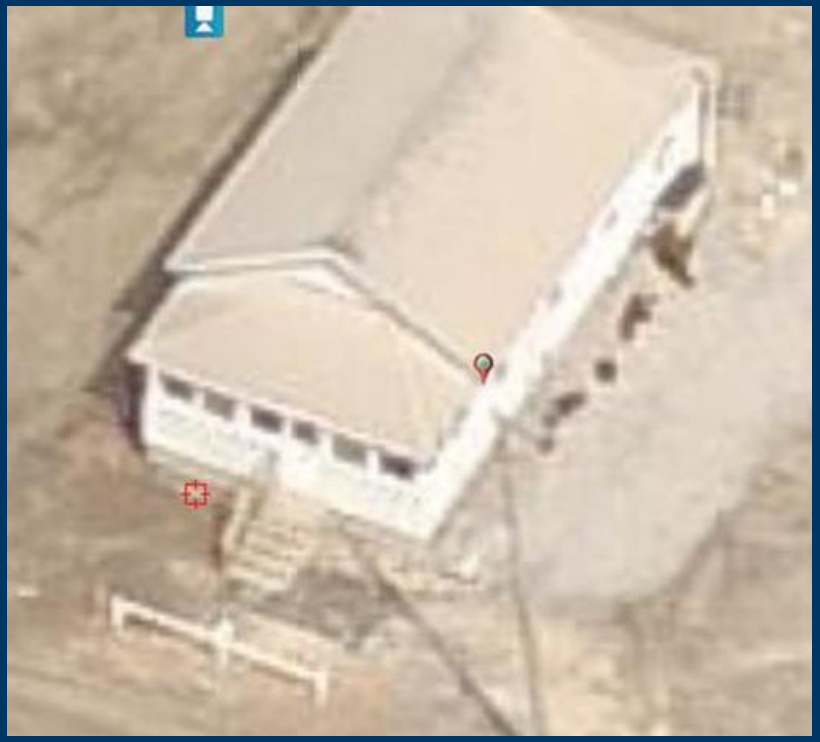
6 - Flood & Wind - Hurricane Sandy

6 - Flood & Wind - Storm Surge



https://www.compuweather.com/services/

Example : Sandy Total Loss

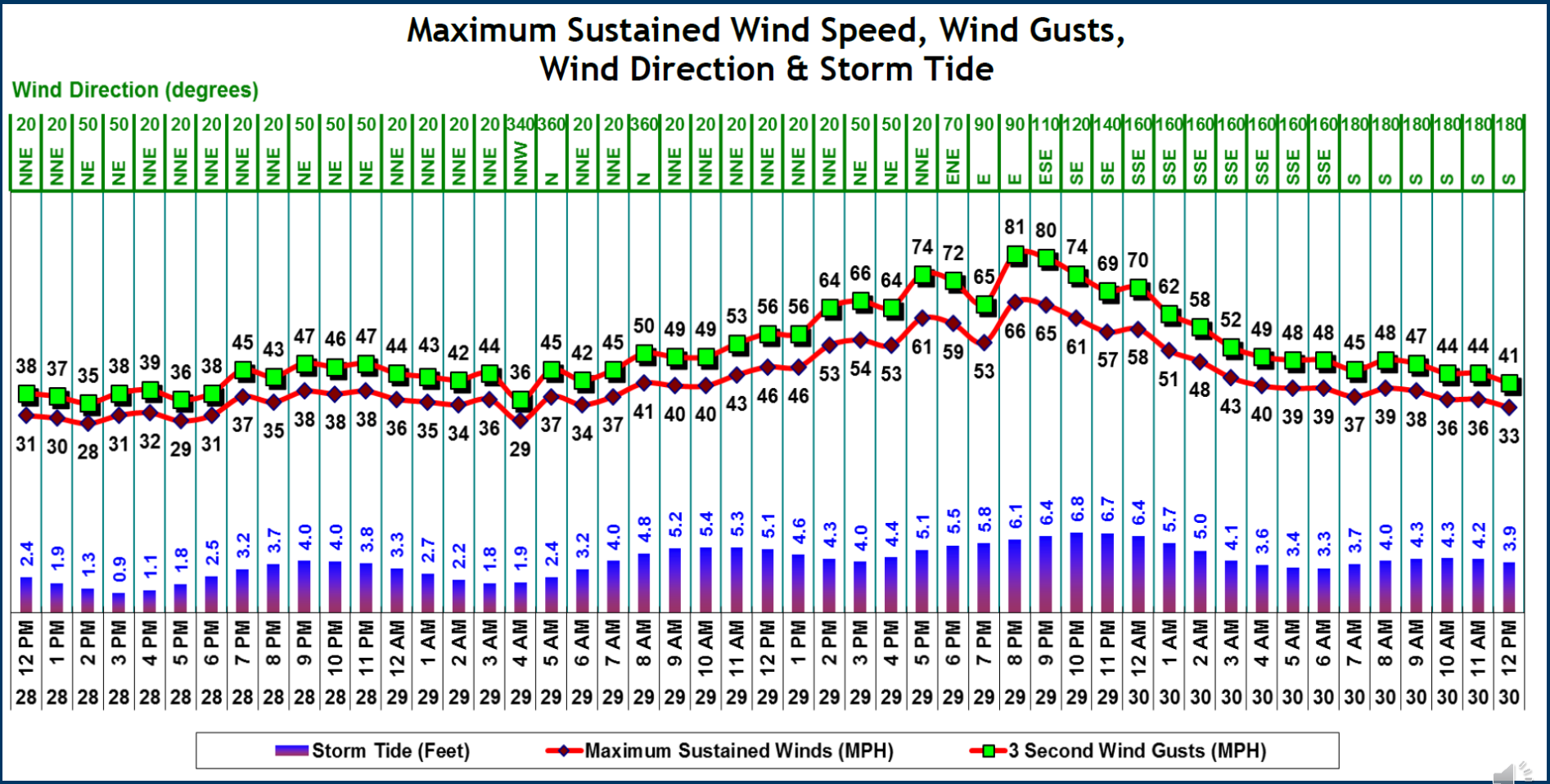


Scientific Method

1. Propose or define a non-biased question.
2. Information Gathering Stage –site observations of damaged and not damaged conditions, surrounding area observations, and storm data information.
3. Construct a Hypothesis
4. Test the individual hypothesis one by one. Analyze the data and draw conclusions, and accept or reject the hypothesis.
5. Communicate the results.

Hurricane Sandy

Site Specific Weather Data



Source: CompuWeather

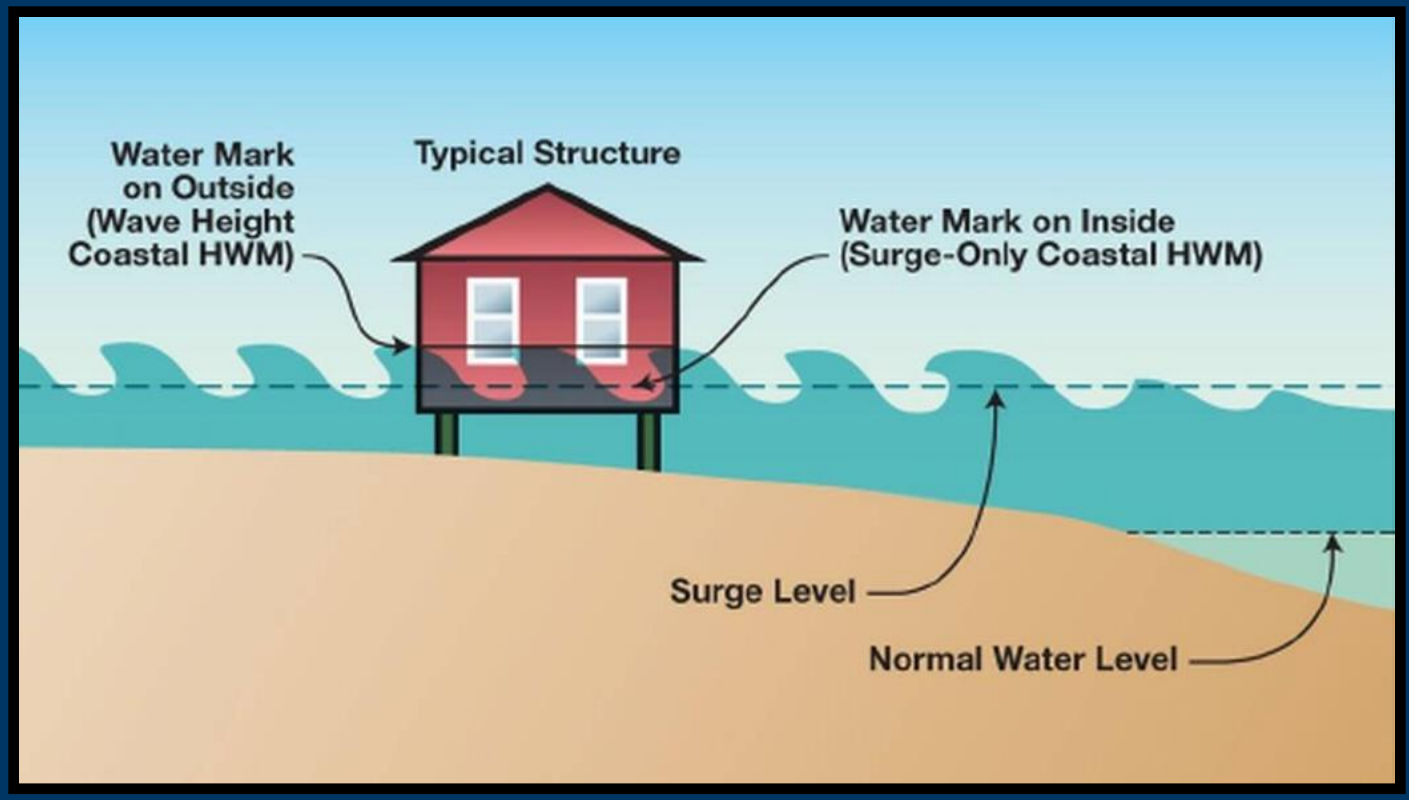
Example : Sandy

Example : Sandy

Example : Hurricane Sandy

Example : Hurricane Sandy

Hurricanes - High Water Marks



1. Hydrostatic pressure - force that water at rest exerts on any submerged object
2. Hydrostatic vertical force (buoyancy)
3. Hydrodynamic forces - is the force exerted on a vertical obstruction (foundation wall) by flowing water and debris
4. Waves

Summary

The Scope of Work needs to be clearly defined.

1. What is the cause of the reported damage?
2. What is the extent of wind damage?
3. What are the repair recommendations?

    1. Historical Weather History
    2. Collateral Evidence of Wind
    3. Eyewitness Testimony
    4. Damage Consistent with Science

(Physics & Fluid Mechanics & Material Strength)