SE MAPS PROJECT

Climate Change Activity #2

(Southeastern Coastal Zone Region)

Hurricanes & Storm Surge

The SE MAPS Project is a NSF-funded project that evolved from a South Carolina model for inquiry-based classroom instructional modules proposed by South Carolina K-12 teachers participating in a series of Professional Development Courses designed to help educators better understand and appreciate the natural environment of their state. Each activity was reviewed by content specialists at Clemson University before final publication. Funding support for the 'Climate Change' series of activities was provided by the NASA REAP program administered by the South Carolina Space Grant Consortium. Contact Jackie Gourdin, SE MAPS Project Manager, 445 Brackett Hall, Clemson University, Clemson SC 29634-0919; [864-656-1560 (voice) or <jackieg@clemson.edu> (e-mail)] with questions about any SE MAPS materials or programs.

Hurricanes & Storm Surge

Steven Pruitt and John Wagner [based on an activity written by Sarah Disario, Nick Hill, and Alexandra McIntyre]

INSTRUCTIONAL FOCUS: Students will recognize how hurricanes impact shorelines and how storm surge is correlated to the intensity of storms. Students will investigate the physical factors that influence storm surge and the impact that geography can play in amplifying these effects.

SUGGESTED TARGET AUDIENCE: high school earth/environmental studies classes

CORRELATION TO SOUTH CAROLINA ACADEMIC SCIENCE STANDARDS (2014):

EARTH'S ATMOSPHERE – WEATHER AND CLIMATE

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

H.E.5A.5 Construct explanations for the formation of severe weather conditions (including tornadoes, hurricanes, thunderstorms, and blizzards) using evidence from temperature, pressure and moisture conditions.

EARTH'S HYDROSPHERE

Standard H.E.6: The student will demonstrate an understanding of earth's freshwater and ocean systems.

H.E.6A.8 Develop and use models to describe how waves and currents interact with the ocean shore.

Other Curriculum Connections

"SE MAPS (SouthEast Maps and Aerial Photographic Systems) – Regional Study Sites #9B, 9D, 10B"

PRIOR SKILLS REQUIRED: ability to read and use map scales, symbols, and legends including contour intervals. Specifically, students should know how to use distance and elevation data to calculate slope. Also, students should feel comfortable navigating to different websites and using a variety of search engines (Google^{TM}, etc.) to search for information on different topics.

LOGISTICS: The basic activity is designed for a 50-minute class, but can be extended to several class sessions if supplemental materials are used. Large tables or flat work areas are needed to work with large-format maps - students should work in cooperative groups. Internet access is required.

KEY VOCABULARY AND CONCEPTS:

- continental shelf
- hurricane
- Saffir-Simpson hurricane scale
- storm surge
- storm tide

CONTENT OVERVIEW: [more detail is provided in the "Teacher Answer Key."]

1. Storm surges are influenced by many physical factors associated with hurricanes
   - *Stronger winds generate higher storm surges, especially on the northeastern side of an ocean-based hurricane where the counterclockwise wind circulation is pushing seawater towards the land.*
   - *Hurricanes (cyclones) are lower air-pressure zones which allow the ocean water level directly under the storm to rise higher than water levels would rise under normal air-pressure conditions.*
   - *High winds can generate large ocean waves and surf zones on top of any existing storm surge. The new 'surf zone' impacts areas inland of the normal shoreline which are now flooded because 'sea level' is higher.*
   - *Storm surge usually causes more property damage along shorelines during a hurricane than does wind. The actual amount of damage is highly dependent on local features and barriers that affect the flow of water.*
2. Storm surges are affected by the geography of the off-shore continental shelf underneath the storm
   - *Steep-sloped continental shelves generate lower storm surges because deeper water allows freer circulation.*
   - *Gently-sloped continental shelves generate more severe storm surges because the wind pushes seawater into shallow zones in which the water has nowhere else to go except 'up'.*
   - *The angle at which a storm approaches a coastline can also affect the height of storm surges. Storms moving perpendicular to the coast usually produce higher surges than ones moving parallel to the coastline.*

MATERIALS: internet access, 6 @ SE MAPS laminated lithographs ["Map #9B - Grand Strand", "Map #9D - Mississippi Gulf Coast", & "Map #10B - South Florida"]; 6 @ 'wet-erase' markers

PROCEDURES:

1. Ask students to list as many features or properties of hurricanes as they can. List (project) answers on the board (screen). Add and describe any important features that students leave out. Ask students if they recall how hurricanes form and how they are classified or categorized. Review the stages of hurricane formation and the categories on the Saffir-Simpson Hurricane Scale as needed. See 'Teacher Answer Key' for details or view <http://www.nhc.noaa.gov/aboutsshws.php> .
2. Lead a discussion on what type(s) of damage hurricanes might cause to coastal areas when they make landfall. Use the following websites: <http://www.npr.org/news/specials/hurricane/ap/>, <http://www.nhc.noaa.gov/surge/>, and [optional] the first half of the video "Engineering Nature: Engineering Hurricanes" and slide shows of flooding in Charleston, SC. Show students the first animation on the NOAA website and be sure students understand the difference between a 'storm surge' and a 'storm tide'. [On the NOAA website, skip the surge animations dealing with steep vs shallow slope of continental shelf.] Be sure students understand how storm surges are generated.
3. Ask students to predict how storm surges will affect different types of coastlines, including the South Carolina coast. Also ask them to think how the path of the storm (relative to the shoreline) might affect the severity of the surge. Then go back to the website <http://www.nhc.noaa.gov/surge/> and view the two 'surge' animations and compare those results to the class predictions.
4. Give each student group a set of topographic maps (SE MAPS #9B, #9D, and #10B) and a wet-erase marker. Ask groups to follow instructions on the Student Work Sheet to calculate the slope of the continental shelf for each location and also the predicted landward extent of the storm surge. Review strategies for calculating slope on a contour map as needed. Ask students to assess whether South Carolina's coastline is more similar to Mississippi's or Miami's.
5. Discuss with the class what other factors (besides slope of continental shelf) might affect the amount of storm surge at each of these three locations, and which factor(s) would have the most impact.
6. Mention that many global climate change models predict rising sea-levels and a higher frequency of severe hurricanes. Assuming these predictions are accurate, ask what advice students would give communities in coastal Mississippi and South Carolina to prepare for future storm events.

SAMPLE CULMINATING ASSESSMENT:

- Ask students to write a 100 word essay explaining the causes and effects of 'storm surges' that occur during hurricanes, being sure to include information gathered during the classroom activities.
- Ask students to predict the atmospheric, geographic, and hydrologic conditions necessary to create the highest possible storm surge along the Myrtle Beach, South Carolina coastline.

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STUDENT WORK SHEET

Part I – Observations from Hurricane/Storm Surge Websites

a. Write down some observations about the photographs of storm-surge destruction [noaa.gov/surge/].

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b. Write down some observations about the scale of hurricane damage [news/specials/hurricane/ap/].

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c. What features of a hurricane cause storm surges to occur[noaa.gov/surge/]?

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d. Where is a storm surge most likely to occur geographically [noaa.gov/surge/]?

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e. Predict which type of continental shelf configuration [**shallow** slope vs **steep** slope] will generate the higher storm surge. HIGHER STORM SURGE = _______________ SLOPE
Explain your reasoning.

Part II – Effect of Slope of Continental Shelf on Storm Surge

SLOPE = VERTICAL RISE ÷ HORIZONTAL DISTANCE

HYPOTHETICAL STORM SURGE CHART FOR A CATEGORY 4 HURRICANE

CONTINENTAL SHELF SLOPE ↦ WIND DIRECTION ↓	SHALLOW (<1m/km)	INTERMEDIATE (1m/km – 3 m/km)	STEEP (>3 m/km)
wind blows toward land	surge = 6m ~ 20 ft	surge = 3.5 m ~ 11 ft	surge = 1m ~ 3 ft
wind blows away from land	surge = 1m ~ 3 ft	surge = .6 m ~ 1.7 ft	surge = .2m ~ .5 ft

a. Calculate the slope of the continental shelf off the coast of Gulfport, Mississippi [use MAP #9D]. Note that the bathymetric (underwater) contour interval for Map 9D is 2 meters. For finding the slope [in meters per kilometer] of the continental shelf off Mississippi draw a straight line south from the letter 'B' in Biloxi (top center of map) to the second '6' in 676 (red number located in water near the 'Intracoastal Waterway' directly south of Biloxi).

SLOPE = ________________________

b. Determine the height of the storm surge in Gulfport from the "Hypothetical Storm Surge Chart" on the previous page. Assume the path of the Hurricane crosses Ship Island heading directly for Gulfport. Use the wet-erase marker to trace on the topographic map the hurricane path and the expected landward extent of the storm-surge flooding on either side of Gulfport. Note that the contour interval on land is 50 feet. Note also that the map shows spot elevations for numerous locations.

c. Calculate the slope of the continental shelf off the coast of South Florida [use MAP #10B]. Note that the bathymetric (underwater) contour interval for Map10B is 10 meters (at least until you reach a depth of 200 meters - at which point the contour interval changes to 50 meters). For finding the slope [in meters per kilometer] of the continental shelf off South Florida, locate the southernmost corner of the 'John Pennekamp Coral Reef State Park' boundary line (lower-right corner of map) and draw a straight line southeast to the lower-right edge of the South Florida map.

SLOPE = ________________________

d. Determine the height of the storm surge in the South Florida area from the "Hypothetical Storm Surge Chart" on the previous page. Assume the path of the hurricane crosses over John Pennekamp State Park heading for the Everglades. Use the wet-erase marker to trace on the topographic map the hurricane path and the expected landward extent of the storm-surge flooding on either side of the Park. Note that there are no land contour lines shown on this map and spot elevations are given only for Key West, Miami, Fort Lauderdale, and Palm Beach. You can assume that nearly all land shown on this map ranges from 1 to 6 meters (~ 3 to 20 feet) above sea level. Populated areas generally occupy higher elevations. For example, the highest elevation around Miami is a little over 5 meters (15.5 feet). The swamp symbol on the map is associated with lower elevation areas.

e. Calculate the slope of the continental shelf off the coast of Myrtle Beach, South Carolina [use MAP #9B]. Refer to the map legend to determine the bathymetric (underwater) contour interval. For finding the slope [in meters per kilometer] of the continental shelf off Myrtle Beach, draw a line from the letter 's' in 'Pawleys' (Pawley's Island is near the map center) due east to the map edge.

SLOPE = ________________________

f. Determine the height of the storm surge in Myrtle Beach from the "Hypothetical Storm Surge Chart" on the previous page. Assume the path of the Hurricane makes direct landfall just a few miles southwest of Myrtle Beach, heading northwestward. Use the wet-erase marker to trace on the upper-left hand corner inset map (Myrtle Beach, SC) the expected landward extent of the storm-surge flooding in Myrtle Beach. Note that the land contour interval on this inset map is 2 meters. Note also that the map shows spot elevations for numerous map locations.

g. Which of these three locations (Mississippi, South Florida, South Carolina) would likely receive the most damage from a hurricane storm surge? ___________________________________

Explain your answer.

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TEACHER ANSWER KEY

KEY VOCABULARY AND CONCEPTS:

- continental shelf = the area of seabed adjacent to a large landmass (a continent) that is relatively shallow compared to the open ocean. The 'shelf' is geologically part of the continental crust.
- hurricane = a tropical cyclone with sustained winds of at least 74 miles per hour (measured at an elevation of 10 meters). Note that winds in most hurricanes will be much stronger.
- Saffir-Simpson hurricane scale = the division of hurricanes into five categories based on wind speed
- storm surge = the abnormal rise of ocean levels generated by storms, over and above predicted astronomical tides. Rising water level can cause extreme flooding in coastal areas especially when storm surges coincide with normal high tides. Storm surges can exceed 20 feet in severe storms.
- storm tide = the total water level rise due to a combination of storm surge and the astronomical tide.

PROCEDURES:

1. Ask students to list hurricane features; recall how hurricanes form; review hurricane categories.

Answers may vary, but any list of features should include: 'high winds', 'torrential rainfall', 'counterclockwise (in northern hemisphere) circulation', 'very low air pressure at center', 'very large areal coverage', 'often has "eye" in center of storm', 'storm track sometimes unpredictable', 'storm usually lasts several days', 'may spawn tornadoes'.

Hurricanes usually begin forming over an ocean as a small tropical low-pressure zone of clouds, rain showers, and thunderstorms. The chart below details the stages of hurricane formation.

Stage	Definition
Tropical disturbance	a discrete system of clouds, showers, and thunderstorms that originates in the tropics and remains intact for 24 hours or more.
Tropical depression	when a tropical disturbance develops a closed circulation (for example, counter-clockwise winds blowing around a center of low pressure). It contains maximum sustained one-minute winds of 38 mph or less, at an elevation of 10 meters.
Tropical Storm	maximum sustained one-minute winds of 39-73 mph, at an elevation of 10 meters.
Hurricane	have sustained one-minute winds of at least 74 mph, at an elevation of 10 meters.

Hurricanes are typically categorized according to the Saffir-Simpson Hurricane Wind Scale (see chart below). Alternatively, you may access the chart on the NOAA website <http://www.nhc.noaa.gov/aboutsshws.php>.

Category	Sustained Wind Speed (mph)	Extent of Damage at Landfall
1	74-95	minimal
2	96-110	moderate
3	111-130	extensive
4	131-155	extreme
5	Over 155	catastrophic

2. Lead a discussion on what type(s) of damage hurricanes might cause to coastal areas . . . .

Dangers are excessive rainfall, wind, and storm-surge flooding. Results include structural damage to buildings, loss of electrical power and other utilities, downed trees, impacts from flying objects, and water damage to beaches, roadways, and buildings. Along the coast, flooding from storm surges usually causes more damage than wind.

[OPTIONAL] The websites: <http://www.charlestoncitypaper.com/TheBattery/archives/2012/08/28/rafters-take-to-flooded-streets-in-kayaks-air-mattresses> and <http://www.live5news.com/slideshow?widgetid=82659> show the effects of flooding in Charleston, SC during storm events in 2012, including some people kayaking through the Charleston Market. The first half of the video "Engineering Nature: Engineering Hurricanes " [available at <http://scetv.org/education/streamlinesc/index.cfm>], can also be used to generate further student interest.

It is important to emphasize the role of storm surge in causing damage along the coast, as students usually attribute most hurricane damage to wind. Explain that the sheer force that the surge of water brings, and the fact that raised water levels make it possible for wave action to extend much farther onshore than normal, can undermine building foundations or simply push buildings off their foundations. Be sure students achieve a conceptual understanding of how the mechanics of a hurricane can generate storm surges and that the storm surge occurs on top of any sea-level rise caused by high tides at the time the hurricane makes landfall. Although the basic generator of storm surge is the piling up of water along the shore by the force of cyclonic winds (counterclockwise in the northern hemisphere), other factors can influence the final height and duration of the storm surge:

- Atmospheric pressure is the force exerted by the weight of air in the Earth's atmosphere. The pressure is higher at the edges of any low-pressure weather system (cyclone) than it is in the center. This pressure differential pushes water from the outer boundaries of the storm towards the center, causing the water to bulge upward at the eye (center) of the storm.
- The larger and stronger the storm, the lower the atmospheric pressure will be and the higher the water 'bulge' at the eye will become. Also, larger storms will affect bigger geographic areas, encompassing much more available water, for a longer period of time.
- In general, slower moving storms will generate larger storm surges than fast moving storms of the same strength because the winds have a longer time to push on the water; and the surge will also last longer.
- The angle at which a storm approaches a coastline can affect how much surge is generated. This highest storm surge usually occurs when the storm path is perpendicular to the coastline. The minimum storm surge usually occurs when the path of the hurricane parallels the coastline.
- The impact of any storm surge is highly dependent on local features and barriers that affect the flow of water. One primary factor is the slope of the submerged continental shelf (covered in the next paragraph), but more local features such as land topography, presence of seawalls and jetties, and the number and type of structures built behind the beach, also serve to impede, deflect or channel storm surge flooding.

3. Ask students to predict how storm surges, and path of storm, affect different types of coastlines.

Shorelines in the southeastern United States, including South Carolina, are characterized by low-slope coastal plain landforms (sand beaches, barrier islands, spits, lagoons, etc.). Contrast this situation with the rocky and/or erosional shorelines in the New England states or along the Pacific Ocean coastline. The gently sloping Coastal Plain continues underwater where it is referred to as the continental shelf. The slope of the continental shelf may vary considerably depending on underwater topography (bathymetry) and the presence or absence of major ocean currents. The slope of a continental shelf can be determined using bathymetric (underwater) contour lines.

Answers may vary, but students should try to envision how different slopes could affect the flow of large masses of water. Friction between moving water and the ocean floor is a factor, as is the total volume of ocean available to accommodate the local storm surge. Storms moving parallel to the coastline are less affected by slope conditions.

A shallow-sloped continental shelf will generally produce a greater storm surge than a steep continental shelf. When a hurricane approaches, seawater is forced landward into shallower and shallower water. The wider and shallower the shelf, the higher the water will pile up and the further inland the surge will travel. On a steeper continental shelf, the deeper waters permit easier circulation of seawater, due to less friction with the ocean floor, and more of the storm surge can be dissipated sideways instead of being forced to pile up on shore.

4. Use Student Work Sheet to calculate slope of shelf and extent of storm surge. Review strategies for calculating slope and compare South Carolina's shelf to Mississippi and South Florida.

To calculate slope, draw your line on the map and measure the horizontal distance covered by that line. Then determine the difference between the highest and lowest elevation (or depth) along that line. Divide the elevation difference by the horizontal distance. Slope can be expressed as "meters per kilometer", "feet per mile", or as a percentage.

The "Hypothetical Storm Surge Chart for a Category 4 Hurricane" has been constructed specifically for this activity and is not valid for hurricanes in general, although the numbers are reasonable for many category 4 storms. Answers to the 'slope' questions may vary within reason, and 'landward extent of storm surge' answers (because they are based on a very limited number of data points) must be estimated and therefore will be highly subjective and variable. Contour line tracings should be extrapolated between spot-elevation points. The most important consideration is that students are able to explain their calculations and problem-solving strategies effectively.

MISSISSIPPI COAST: Slope ~ between .3 and .4 meters per kilometer [~ 1.5 to 2.1 feet per mile] [.02 - .04%]

Because the storm path hits Gulfport, the coastline east of that city (wind blowing towards land) will experience higher storm surges and the coastline west of the city (wind blowing towards ocean) will experience much lower storm surges. There is only one contour line (the 50-foot contour line) visible on this portion of the map, so the spot elevations provide the best markers. East of Gulfport, the storm-surge line follows a 20 ft. elevation contour; west of Gulfport, the storm surge line follows a 3 ft. elevation contour.

SOUTH FLORIDA: Slope ~ between 11 and 15 meters per kilometer [~ 58 to 79 feet per mile] [1.1 – 1.5%]

Because the storm path targets the Everglades, the coastline north of that path (wind blowing towards land) will experience higher storm surges and the coastline southwest of the path (wind blowing towards ocean) will experience much lower storm surges. There are no contour lines on this map; and the only spot elevations provided are for Key West (7 ft.), Miami (8 ft.), Fort Lauderdale (6 ft.), and Palm Beach (25 ft.); so there is a lot of guesswork needed to decide which areas would be flooded. A 3 ft. surge would spare most of the populated areas along the mainland, for example the City of Miami, but nearby areas like Miami Beach or Key Biscayne would likely experience major flooding. The Florida Keys would likely be spared major flooding because they are located to the southwest of the storm center. Other maps of the area may provide more data.

MYRTLE BEACH COAST: Slope ~ .5 meters per kilometer [~ 2.6 feet per mile] [.05%]

Because the storm path makes landfall west of Myrtle Beach, the whole coastline shown here will experience the maximum storm surge (wind blowing towards land). The map shows several contour lines as well as many spot elevations, so tracing a hypothetical 6 meter contour line is much easier than on previous maps.

South Carolina's coastline is more similar to that of the Mississippi Gulf Coast than South Florida, even though South Florida and Myrtle Beach are both on the Atlantic Ocean and the Mississippi coast is on the Gulf of Mexico. The primary reason for the relative steepness of the South Florida continental shelf is that the Gulf Stream ocean currents run very close to land in this area and carry away sediment that would otherwise build up.

5. Discuss what other factors might affect storm surge at these locations and their impact.

As previously discussed, storm path, storm size, storm speed, storm strength, and storm direction (compass direction) all can impact storm surge. For each of the three locations studied, discuss how changing any or all of these variables would impact the size and/or duration of the storm surge. For example, a Category 1 hurricane moving eastward just south of the Florida Keys would produce a minimal storm surge, while a Category 5 hurricane moving westward in the same location would generate a much higher storm surge. A reasonable (but not absolute) ranking of factors from most importance to least important might be: 'strength', 'size', 'path', 'speed', 'direction'.

6. Discuss impact of rising sea level and higher frequency of hurricanes on coastal communities.

Almost all climate models predict a rise in global sea level over the next century. Likewise, climate models predict that global warming will likely generate more frequent and more severe hurricanes. The primary impact on coastal areas would be greater damage from more frequent storm surges. The storm surge is measured based on normal sea level. If the sea level is higher, then the storm surge will also be that much higher, flooding additional property that today might be spared. Also, as the height of the storm surge is strongly correlated to storm strength, a greater number of severe hurricanes would produce more frequent and greater storm surge and wind damage.

There are no really good or effective solutions to preventing hurricane damage. However, some engineering practices and restrictions on development can limit the damage. Buildings along the coast can be raised above anticipated flood levels; sand dunes along the beach can be restored and protected to create a partial barrier to wave action; and beaches can be widened and protected from additional commercial development.

Another good website reference for this topic is <http://bit.ly/1rjkMsv>. Interactive maps at this site show impacts of sea-level rise and storm surge for coastal areas throughout the United States, including South Carolina.

<u>SAMPLE CULMINATING ASSESSMENT</u>:

- Ask students to write a 100-word essay explaining the causes and effects of 'storm surges' that occur during hurricanes, being sure to include information gathered during the classroom activities.

A complete answer should mention all of the factors associated with hurricanes that influence the size of the storm surge. A sample 100-word essay is included below:

Storm surges are caused by the piling up of water along the shore by the cyclonic winds of a Hurricane/tropical storm. Other factors impacting its severity include: atmospheric pressure, size and strength of the storm, the speed of the storm, the angle at which the storm is hitting the coast, tides, and local topography and barriers. The slope of the continental shelf off the coast of an area also can impact the storm surge that area receives. In general the shallower the continental shelf is, the greater the impact of storm surge will be.

- Ask students to predict the atmospheric, geographic, and hydrologic conditions necessary to create the highest possible storm surge along the Myrtle Beach, South Carolina coastline.

The atmospheric/hydrologic conditions that would give Myrtle Beach, SC the highest storm surge would be an extremely large storm with very low pressure that is traveling very slowly at a perpendicular angle to the coast and making landfall at high tide. The geography also impacts the size of the surge; an extremely shallow continental shelf off the coastline and a city with no sea walls or beach dunes would create the worst possible case scenario.

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Websites Used - Hurricanes/Storm Surge Activity

1. **Saffir-Simpson Hurricane Wind Scale**
   <http://www.nhc.noaa.gov/aboutsshws.php>
   - describes five categories of hurricanes with animation correlating wind speed to damage
2. **Hurricane Season 2006: How the Storms Destroy**
   <http://www.npr.org/news/specials/hurricane/ap/>
   - graphic animation correlating hurricane damage to Saffir-Simpson category
3. **National Hurricane Center: Storm Surge Overview [NOAA site]**
   <http://www.nhc.noaa.gov/surge/>
   - excellent graphics describing wind and pressure components of storm surge
   - excellent animations showing progression of storm surge during the storm
   - excellent animations showing affect of slope of Continental Shelf on storm surge
   - pictures of destruction from storm surge during hurricanes
4. **Flooding in Charleston, South Carolina**
   <http://www.charlestoncitypaper.com/TheBattery/archives/2012/08/28/rafters-take-to-flooded-streets-in-kayaks-air-mattresses>
   - slide show of the Market area in downtown Charleston, SC during flooding in 2012
   <http://www.live5news.com/slideshow?widgetid=82659>
   - slide show of Market area during flooding event in Charleston in 2012
5. **Climate Central [non-profit group of scientists based in Princeton, NJ]**
   <http://bit.ly/1rjkMsv>
   - excellent analysis of predicted impacts of sea-level rise and storm surge along the coast
   - interactive map lets you adjust level of storm surge to view impact area in coastal cities
6. **Video = Engineering Nature: Engineering Hurricanes [Discovery, 2009]**
   <http://store.discoveryeducation.com/product/show/91342 >
   - this site has ordering information if you want to purchase the video
   <http://scetv.org/education/streamlinesc/index.cfm>
   - South Carolina teachers can downloaded this video free of charge from this SCETV site.