Slide 1

Improved Coastal Resiliency through the use of Storm Surge Models

Slide 2

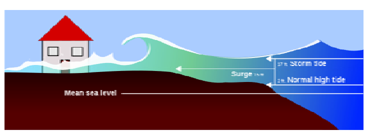
What Is Coastal Resiliency ?

- For the purpose of this presentation “Coastal Resiliency” is:
  - The ability to make informed decisions during a storm/storm surge event
    - Understanding the threat
    - Evacuation decisions
      - Should I evacuate ?
      - Do I have to evacuate ?
      - Where do I evacuate to ?
      - In which direction do I evacuate ?

Slide 3

What is Storm Surge?

A “piling up” of water along a coastline



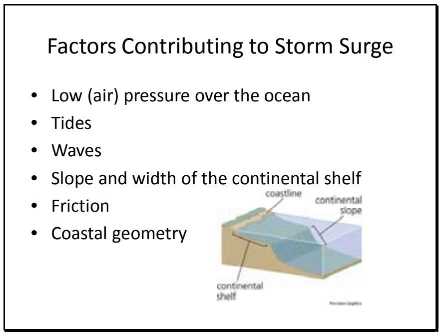
Slide 4

Factors contributing to storm surge

- Wind – usually associated with a tropical storm or hurricane
- Wind direction
- Wind speed
- Fetch – the distance over which the wind interacts with the surface of the ocean
- Time – the length of time wind blows over an area of the ocean

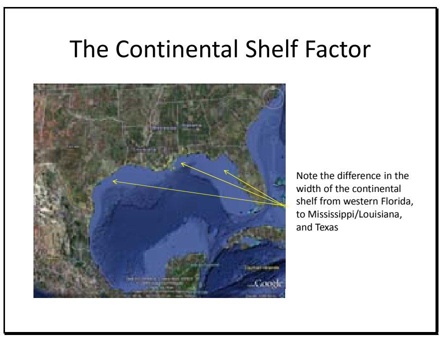
Strong wind+large fetch+long time=highest surge

Slide 5

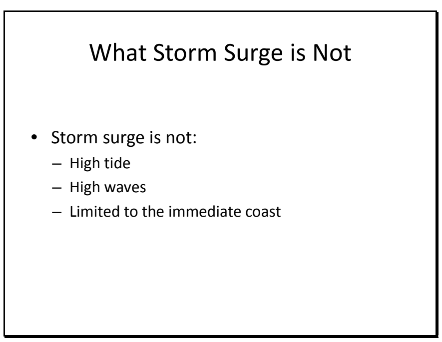


Low pressure actually allows the sea surface to rise above its normal level but only slightly. Tides cause the water surface to rise and fall as the gravitational pull of the sun and the moon varies. Waves will form on the surface of the surge. Long continental shelves with a gentle slope enhance the “piling up” of the water more so than narrow shelves with steep continental slopes. Friction allows the wind to push the sea surface and water below the surface in a given direction and coastal geometry can focus the water’s energy (as in a beach cove) or it can decrease the energy as with water approaching a peninsula.

Slide 6



Slide 7

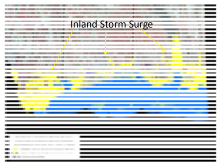


This is a major point of confusion. High and low tides occur every day regardless of the weather. High waves are generated by winds that can be thousands of miles away. The high waves in Hawaii for example are generated by winter storms in the North Pacific Ocean. Surge has a spill over effect causing waters in adjoining rivers, bays and bayous to rise to unusual heights as well.

Slide 8

Not Limited to the Coast ?

- Katrina showed us that surge can impact inland areas



Storm surge along the coast also forced adjoining waters in bays and bayous to rise. As a result residents as far as 10 miles inland were flooded. Some areas were flooded from the south (coastal ocean water) and from the north (overflowing bays and bayous).

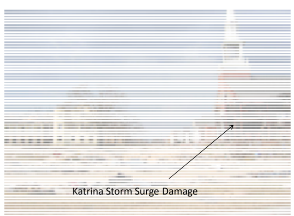
Slide 9

Factors Contributing to Storm Surge

- How it all piles up:
  - *low pressure system* (storm) generates wind
  - *wind* blows across the sea surface
  - *friction* between the wind and water pushes the water in the direction of the wind
  - *tides* caused by the gravity of the sun and moon cause the ocean surface to rise
  - the ocean starts to pile up along the coastline
  - *waves* form on top of the newly arisen sea

Slide 10

Is Storm Surge a Real Threat ?



This is a photo of a church in Gulfport Mississippi that was gutted to a height of twenty feet by the storm surge generated by Hurricane Katrina in August 2005.

Slide 11

Is Storm Surge a Real Threat ?

Katrina Storm Surge Damage – Coastal Mississippi

An aerial view of Bay St. Louis Mississippi following Hurricane Katrina. Much like a tsunami or tidal wave the surge from Katrina came ashore, destroyed thousands of structures, and carried much of the debris back in to the Gulf of Mexico as the waters receeded.

Slide 12

How is Storm Surge Predicted

- Numerical models are used for prediction
- What is a numerical model?
  - Mathematical equations describing the physics of the ocean in four dimensions
    - North/South (y)
    - East/West (x)
    - Up/Down (z)
    - Time (t)
- The equations are solved starting with ocean and atmospheric observations (past and present) and then run forward in time
- Supercomputers are used for the calculations

Slide 13

Storm Surge Prediction Models

- Two surge forecast models are used today
  - SLOSH (Sea, Lake, and Overland Surges from Hurricanes)
  - SLOSH – Principal users National Weather Service/National Hurricane Center
  - ADCIRC – (Advanced CIRCulation)
  - ADCIRC Principal users - US Navy, Army Corps of Engineers
  - ADCIRC is a newer higher resolution model but its accuracy is a topic of scientific debate when compared to SLOSH

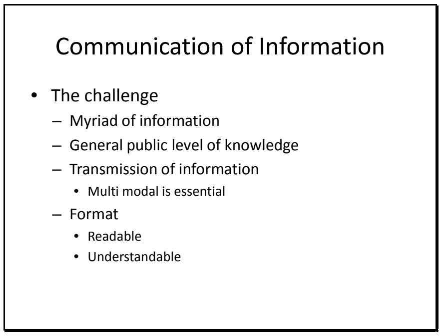
The important point here is to learn that there are two surge models being used operationally today. They both have strengths and weaknesses but that discussion is beyond the scope of our lesson. If you are interested search the internet and you will find plenty of additional detail.

Slide 14

The Next Challenge

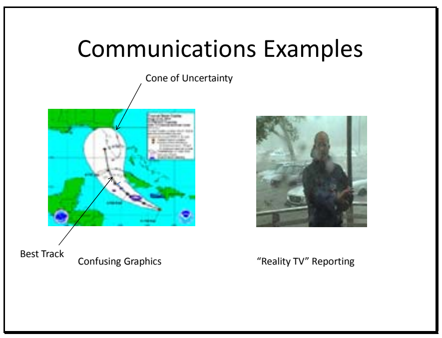
The observations have been taken for days, the computer based surge forecast models have been running for days. Now what do you think is the next very important step in the forecasting process?

Slide 15



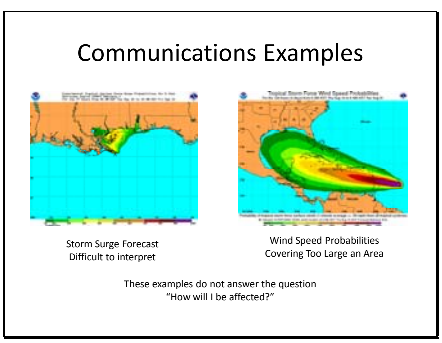
If you have gone through the hurricane evacuation decision making process this slide is one you are familiar with. If you have not you must realize that although hurricanes take days to make land fall it gives the public plenty of time to get very anxious about what may or may not happen. As the storm draws closer this anxiety level increases dramatically so any information relating to the hurricane must be easily understood and readily available. Remember not eveyone has a computer and internet access.

Slide 16



Graphics of the "best track" and the cone of uncertainty may not be well understood. The cone is an area where the storm my be located in 12, 24, 48, and 72 hour intervals. In this case at 72 hrs the storm could be east of Florida or in the middle of the Gulf of Mexico. While TV reporting has improved over the years there is a degree of sensationalism that arises as reporters "hang on for dear life" as the winds increase. People who are being affected by a storm aren't interested in reality TV….they just want to know what to expect.

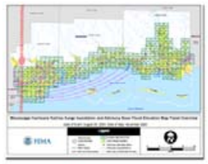
Slide 17



The storm surge forecast covers a very broad area and will not adequately address how things will be in a particular city or neighborhood. The wind speed probability chart covers a very broad area and shows lots of uncertainty.

Slide 18

Communications Examples



Along the Mississippi coast evacuation advisories are based on one's location relative to a flood zone (A,B, or C). The maps used to display the zones are not unlike this chart – illegible especially when it occupies the lower third of the TV screen.

As recently as the 2008 hurricane season evacuation advisories for coastal Mississippi are still being made in terms of which "flood zone" one lives in. I had to refer to my deed for my home to reacquaint myself with which zone I was living in.

Slide 19

What Do People Really Need ?

- Accurate information
- Information that is relevant to:
  - My neighborhood
  - My evacuation route
- Information that is easy to understand
  - Decisions are being made under great stress

Slide 20

A New Approach

- Visualization of pertinent data
  - With respect to storm surge
    - Where will the surge strike ?
    - How deep will the water be ?
    - How will it affect adjacent areas (evacuation planning)?
    - How will it affect my business ?
    - How will it affect my home ?

The bottom line in deciding to evacuate is that if you wait too long you may not be able to flee!

Slide 21

A New Approach

- The Center of Higher Learning Visualization Center (University of Southern Mississippi) has developed a way to link storm surge forecasts to existing geographic, topographic, and structural imagery to create broad area over views and neighborhood specific views of the forecast impact of the surge.
- The technique answers all of the questions on the previous slide

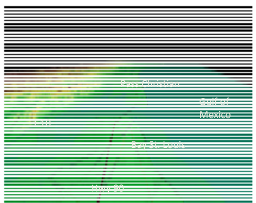
Slide 22

A New Approach

- On the following slides:
  - Irregular objects are data artifacts
  - Buildings that appear to be cloth covered are airborne laser images that have not been replaced with digital photographs
  - Regularly shaped building are digital photography superimposed on laser imagery
  - Work to remove artifacts and cloth apperances is underway at CHL

Slide 23

A New Approach

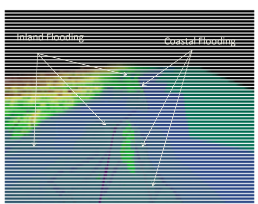


Coastal Mississippi Prior to Storm Surge

You can see the blue waters of the Gulf of Mexico are where they are supposed to be.

Slide 24

A New Approach



Coastal Mississippi at Peak Storm Surge

At the high water mark of Hurricane Katrina all but the highest points of ground in Bay St. Louis MS were underwater as were many areas well inland – again this is the “spillover” effect we mentioned earlier.

Slide 25

A New Approach

Coastal Video Clip

This video shows the rising of the waters from sea level to the high water marks as determined by FEMA. This is not surge model output – that is the next step in our project.

Slide 26

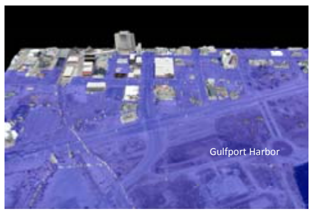
A New Approach

Gulfport Mississippi Prior to Surge

We found that if we focused on particular cities we could give people the ability to see what will or did happen in their neighborhoods.

Slide 27

A New Approach



Gulfport Mississippi at Peak of Storm Surge

Not the harbor area in Gulfport is entirely under water.

Slide 28

A New Approach

High Resolution Downtown Gulfport

Slide 29

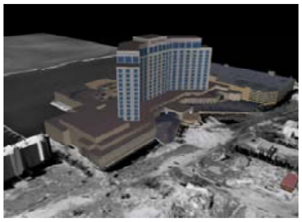
A New Approach

Gulfport Video Clip

Gulfport with waters rising from sea level to roughly 25 ft. above sea level.

Slide 30

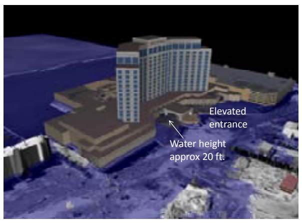
A New Approach



Beau Rivage Hotel Biloxi Mississippi Prior to Storm Surge

Slide 31

A New Approach



Beau Rivage Hotel Biloxi Mississippi High Water from Surge

The elevated entrance to the Beau Rivage hotel is approximately 30 ft above sea level. It was nearly submerged by the storm surge.

Slide 32

A New Approach

Biloxi Video Clip

Slide 33

A New Approach

- Scientifically accurate information
  - Surge model output to be linked with visual images
  - This project is in progress
- Tailored view of your area of interest
- Shows you the information you need most
  - In a format that leaves little to interpret
  - In a format that is easily understood

The Center of Higher Learning is developing a technique that will use the numerical output of storm surge models and overlay that forecast information on city scapes. The examples shown here were taking the ocean from sea level to highest water levels recorded….it is not the actual onset of the surge. That will be the next development.

Slide 34

A New Approach

- Dissemination of information:
  - TV
  - Internet (PC, laptop)
  - Internet (Blackberry, PDA)
  - Pre packaged video of storm surge simulations
    - CD
    - Internet

Slide 35

Storm Surge Visualization

- Can also be used for:
  - Emergency planning
  - First responder training
  - Insurance coverage determination
  - Reclassification of designated flood zones
  - Educating the general public

Slide 36

Summarizing

- Storm surge is very destructive
- Communication of surge forecasts is inadequate
- People need to quickly understand the potential danger of storm surge in order to make good evacuation decisions
- Tools such as the CHL visualization products are being developed to effectively communicate storm surge information

Slide 37

Acknowledgements

- The following resources were used in preparing this lesson
  - National Oceanic and Atmospheric Administration
  - National Hurricane Center
  - The Weather Channel
  - Precision Graphics
  - Google
  - Center of Higher Learning
    - Visualization Center
    - Geospatial Information Systems Laboratory