Hazus-MH Coastal Surge Model

Presenter:

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Hazus-MH Coastal Surge Model

Objectives:

Implement a **coupled storm surge and wave hazard** modeling capability in Hazus-MH using existing, publicly available models:

- SLOSH for storm surge
- SWAN for wave heights

Develop a new capability for combining currently available Hazus-MH wind-only and flood-only loss estimates into an overall estimate of **combined coastal wind and flood losses** for a single hurricane event
User Work Flow

1. Define/Select Hurricane Scenario
2. Run Analysis with Surge-Only or Surge & Waves
3. Display Wind-Only Losses
4. Select Coastal Surge
5. Define Topography (DEM)
6. Define Scenario
7. Delineate Floodplain
8. Run Flood-Only Analysis
9. Run Combined Loss Analysis
10. Display Combined Losses
11. Run Combined Loss Analysis
12. Display Combined Losses

FEMA  Hurricane Model  Flood Model
Hurricane Model: Scenario Options

- Probabilistic
- Historic
- H*Wind Import
- User-Defined
- HurrEvac Import*
- Hazus Import

- Pre-Defined Wind Fields
  - Wind Fields Computed from Hurricane Track Parameters

* Less than 24 hrs before landfall

✓ = Coastal surge analysis allowed
X = Coastal surge not supported
Hurricane Model: Analysis Options

Surge with coupled deep water and near shore waves (SLOSH+SWAN)

Surge with coupled near shore waves (SLOSH+SWAN)

Surge only (SLOSH Only)
### Hurricane Model: Initial Water Level

Pre-storm tide anomaly is the difference between the observed tide and the predicted tide approximately two days before landfall (i.e., before the effects of storm surge or waves reach the study region).

* Note: Text in initial water level dialog should be “NAVD 1988” instead of “mean sea level”.

<table>
<thead>
<tr>
<th>Initial Water Level</th>
<th>Pre-storm Tide Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predicted Astronomical Tide at Landfall</td>
</tr>
<tr>
<td></td>
<td>Vertical Datum: NAVD 1988*</td>
</tr>
</tbody>
</table>
Hurricane Model: SLOSH Basins
Hurricane Model: Deep Water (red) and Near Shore (blue) Wave Grids Used in SWAN
Flood Model: Hazard Type & User Data

NOTE: Don’t forget the DEM

Coastal surge Hazard Type (FL) will become enabled upon completion of hurricane portion of the coastal surge analysis.

The Flood model will find the SLOSH and SWAN water surfaces (.FLT) produced by the Hurricane model in the Scenario folder.

FEMA
Flood Model: Delineate Floodplain

Still Water Elevation (SWEL)
- Using the surge surface from SLOSH, subtract the DEM to determine the SWEL grid

Wave Height determination
- Using the wave surface from SWAN, which is generally accurate in offshore grid cells but not in grid cells that are intersected by the coastline or landward of the coastline, sample wave heights along the transects up to 1 km off the shoreline

Wave Heights (continued)
- Determine Wave Height grid using simplified Wave Height Analysis for FIS (WHAFIS) model
  - No Dune Erosion
  - No Wave Run-up
  - No Regeneration
  - No Dissipation

Zone determination
- A-zone: waves <1.5’
- Coastal A-zone: [1.5’, 3’]
- V-zone: waves > 3’
Flood Model: Coastal Surge Damage and Loss Estimates

Damage estimated for:
- General Building Stock (GBS)
  - Flood-only
  - Combined wind and flood
- Essential facilities
- Bridges
- Selected utility facilities
- Vehicles
- Agriculture products
Combined Wind and Flood Losses

Compatible with existing wind-only and flood-only loss methodologies

Losses combined at the building sub-assembly loss level

Addresses order in which losses accumulate
  • Wind and flood losses are not independent
    ▪ Wind → Top-down
    ▪ Flood → Bottom-up

Relative contributions of foundation and exterior wall sub-assembly flood losses relative to interiors is higher when wave action is present (V-zone or CA-zone)
Coastal Surge Analysis Demonstration
Hurricane Katrina
Hancock County, MS
Modeled vs. Observed Inundation Limits

Blue area shows the modeled inundation levels for Hancock County, Mississippi using Hazus 2.1

Yellow area shows the actual observed limits of inundation

SLOSH model results are consistent with field-observed inundation limits of Katrina
Building Exposure ($k)$
Inundation Limits
Flood-Only Building Loss
Wind-Only Building Loss
Combined Wind and Flood Loss
## Direct Economic Loss Table

![Combined FL/HU Surge Direct Economic Losses For Full Replacement Value](image)

**Results for**

**Scenario:** Hancock_Katrina_NoWaves  
**Return period:** Min 0

### Table: Direct Economic Losses

<table>
<thead>
<tr>
<th>CensusBlock</th>
<th>BldgFloodLoss</th>
<th>BldgWindLoss</th>
<th>BldgCombLoss</th>
<th>ConflfloodLoss</th>
<th>Conw</th>
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<tbody>
<tr>
<td>1</td>
<td>166.00</td>
<td>15.41</td>
<td>174.79</td>
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</tbody>
</table>
Combined Loss Summary Report

Combined Wind and Flood Direct Economic Losses For Buildings:

January 11, 2012

All values are in thousands of dollars

<table>
<thead>
<tr>
<th>State</th>
<th>Cost Building Damage</th>
<th>Cost Contents Damage</th>
<th>Inventory Loss</th>
<th>Total Loss</th>
<th>Loss Rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mississippi</td>
<td>1,035,805</td>
<td>730,442</td>
<td>16,950</td>
<td>1,777,267</td>
<td>11.34</td>
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<tr>
<td>Total</td>
<td>1,035,805</td>
<td>730,442</td>
<td>16,950</td>
<td>1,777,267</td>
<td>11.34</td>
</tr>
<tr>
<td>Study Region Total</td>
<td>1,035,805</td>
<td>730,442</td>
<td>16,950</td>
<td>1,777,267</td>
<td>11.34</td>
</tr>
</tbody>
</table>

Notes: only reflects data for those census block groups included in the users study region and will reflect the entire study area only if all the census block groups that county/states were selected as the area of study region creation.
Helpful Tips

Coastal surge analysis is not permitted for forecast/advisories issued more than 24 hours prior to landfall because storm track uncertainty beyond this time frame compromises the analysis.

When a coastal surge analysis is required, the storm track should extend beyond the outer limits of the applicable SLOSH basin(s) if near shore waves are enabled and all the way out to 60 degrees west longitude if both deep water and near shore waves are enabled.

To run a coastal surge analysis, the study region must have been created for both Hurricane and Flood Hazard analysis and the Hurricane Analysis | Set Optimized Analysis Mode must be “Off”.

FEMA
Helpful Tips (continued)

To confirm that the hurricane portion of the coastal surge analysis has run successfully, click on the **Analysis | Show Coastal Surge Status** menu in the Hurricane model:

When the GBS analysis is complete in the Flood model, remember to select the “Combined Wind and Flood…” item in the **Analysis** menu to combine the losses from the hurricane and flood hazards.
The final combined wind and flood results are stored in the study region database in the following tables:

- hzSurgeFRCombSOccupB (losses by specific occupancy)
- hzSurgeFRCombByBldgTypeB (losses by general building type)

Combined wind and surge loss estimates are not yet available for income losses. As an interim solution, we recommend summing the wind-only and flood-only income losses to estimate the combined wind and surge income losses.
Helpful Tips (continued)

In general, we recommend limiting coastal surge study regions to about 1 county. In some cases, a single county may need to be split into two regions. Typical reasons:

- More than ~5,000 census blocks
- Near shore waves included in analysis
- Regions that span multiple SLOSH basins
- Windows XP is less effective than Windows 7 at sharing memory between SQL, ArcGIS, SLOSH, and SWAN
Hazus Coastal Storm Surge Summary

Coastal surge capability links the Hurricane Wind and Coastal Flood models

- Single, consistent hurricane wind field model drives storm surge (SLOSH), waves (SWAN), and wind damage (Hazus Hurricane)
- Surge and wave models are coupled (waves are optional)
- Wind and flood building losses are apportioned to building sub-assemblies and then combined by sub-assembly

Analysis begins in Hurricane model and finishes in Flood model

Upon completion, results can be viewed in either model
Questions?