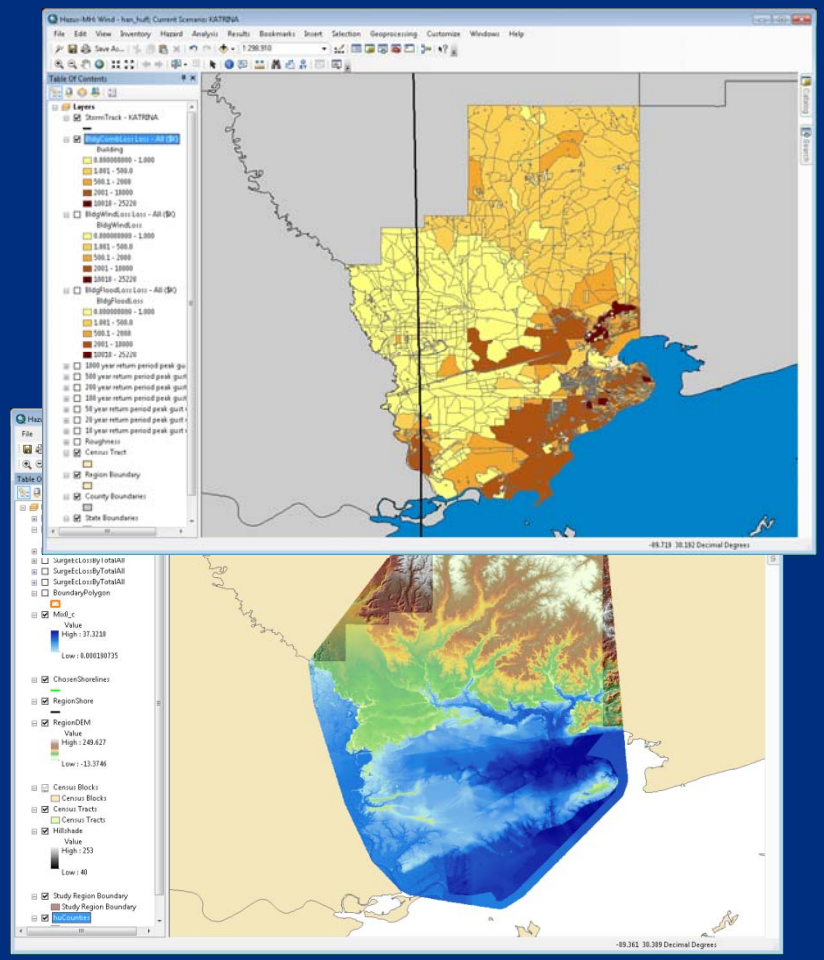
Hazus-MH Coastal Surge Model



Presenter:

Frank Lavelle
Applied Research Associates, Inc.
flavelle@ara.com

FEMA

HAZUS MH
EARTHQUAKE • FLOOD • WIND

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

FEMA

User Work Flow

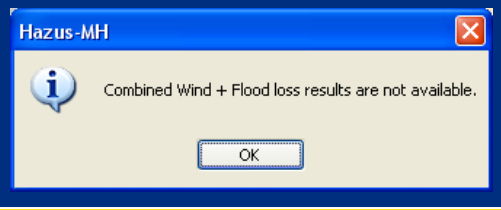
Define/Select Hurricane Scenario

↓

Run Analysis with Surge-Only or Surge & Waves

↓

Display Wind-Only Losses



Display Combined Losses

Select Coastal Surge

↓

Define Topography (DEM)

↓

Define Scenario

↓

Delineate Floodplain

↓

Run Flood-Only Analysis

↓

Run Combined Loss Analysis

↓

Display Combined Losses

FEMA

Hurricane Model

Flood Model

Hurricane Model: Scenario Options

- X Probabilistic
- ✓ Historic
- X H*Wind Import

Pre-Defined Wind Fields

- ✓ User-Defined
- ✓ HurrEvac Import*
- ✓ Hazus Import

Wind Fields Computed from Hurricane Track Parameters

* Less than 24 hrs before landfall

✓ = Coastal surge analysis allowed

X = Coastal surge not supported

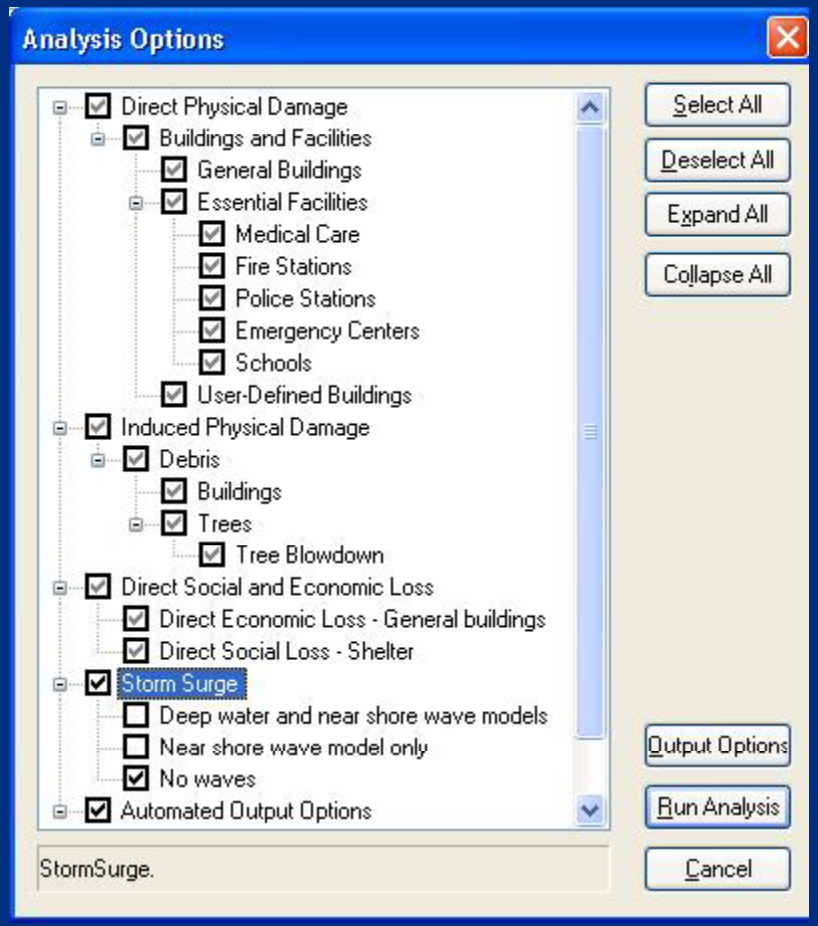
FEMA

Hurricane Model: Analysis Options

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

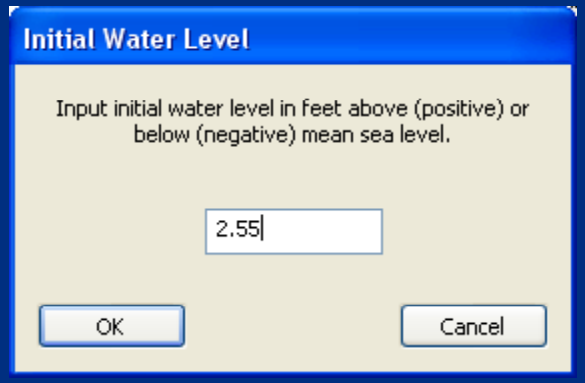
Surge with coupled near shore waves (SLOSH+SWAN)

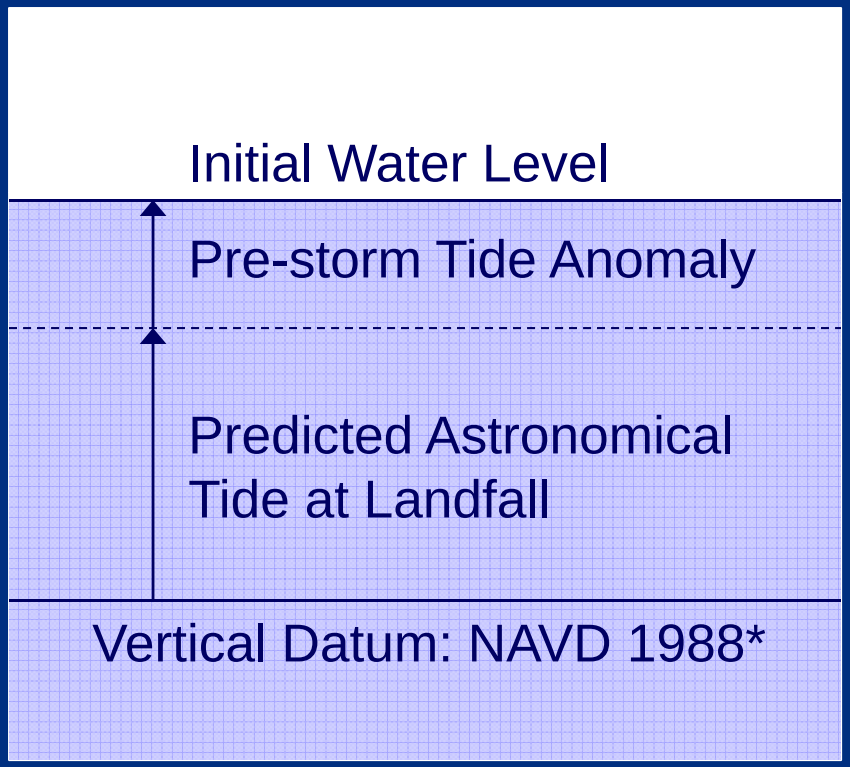
Surge only (SLOSH Only)



FEMA

Hurricane Model: Initial Water Level



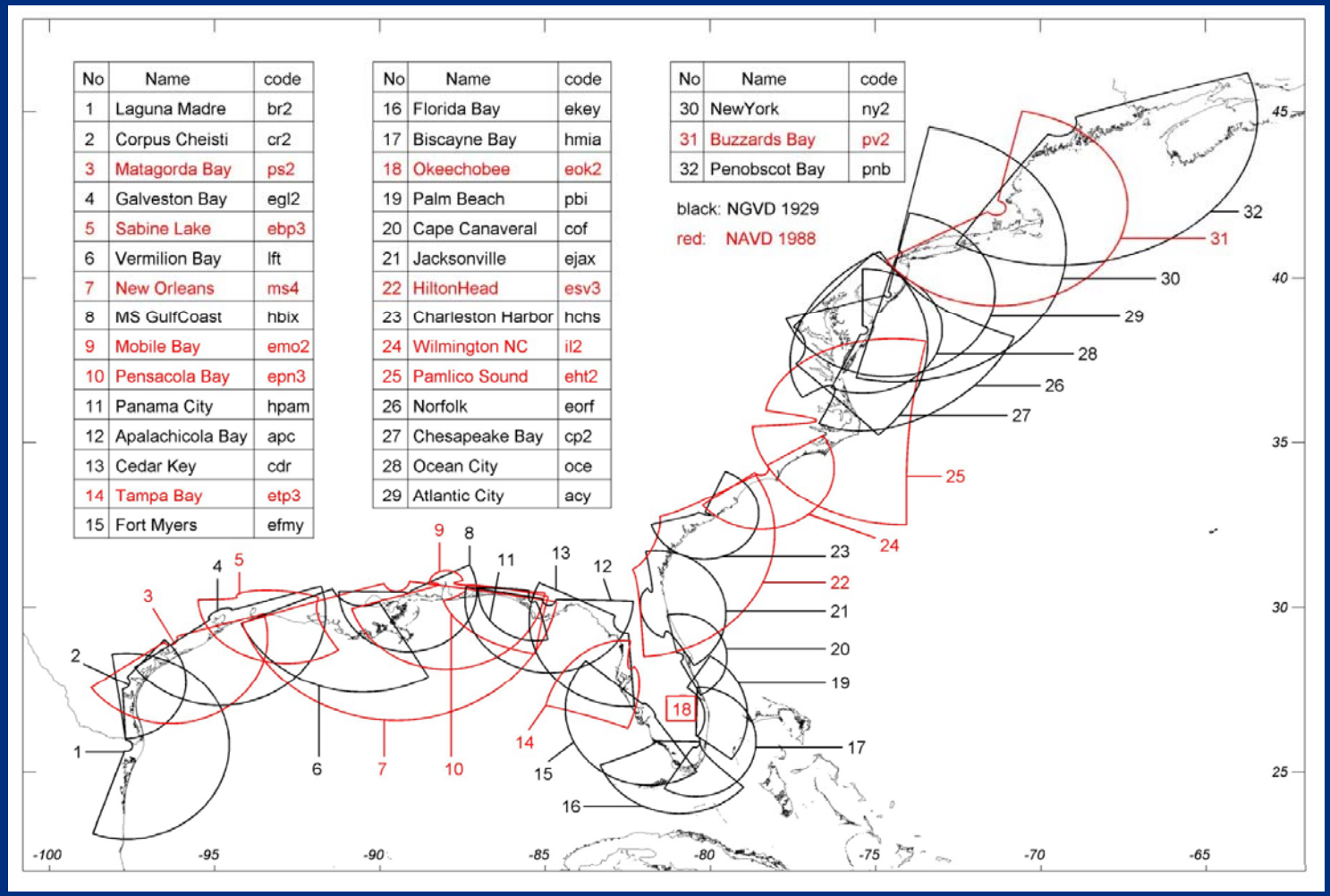


Pre-storm tide anomaly is the difference between the observed tide and the predicted tide approximately two days before landfall (i.e., before the effects of storm surge or waves reach the study region)

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

FEMA

Hurricane Model: SLOSH Basins



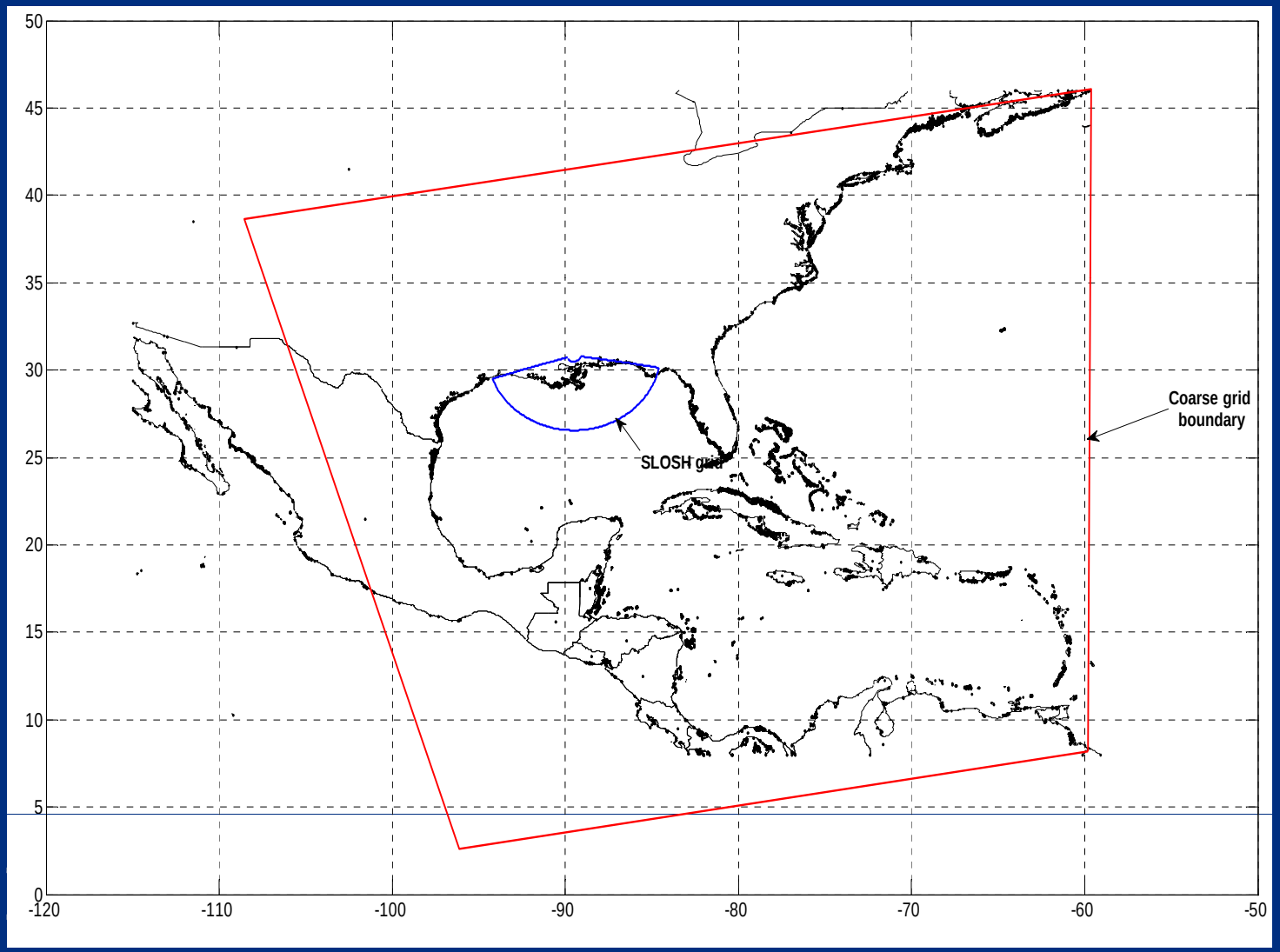
No	Name	code
1	Laguna Madre	br2
2	Corpus Cheisti	cr2
3	Matagorda Bay	ps2
4	Galveston Bay	egl2
5	Sabine Lake	ebp3
6	Vermilion Bay	lft
7	New Orleans	ms4
8	MS GulfCoast	hbix
9	Mobile Bay	emo2
10	Pensacola Bay	epn3
11	Panama City	hpam
12	Apalachicola Bay	apc
13	Cedar Key	cdr
14	Tampa Bay	etp3
15	Fort Myers	efmy

No	Name	code
16	Florida Bay	ekey
17	Biscayne Bay	hmia
18	Okeechobee	eok2
19	Palm Beach	pbi
20	Cape Canaveral	cof
21	Jacksonville	ejax
22	HiltonHead	esv3
23	Charleston Harbor	hchs
24	Wilmington NC	il2
25	Pamlico Sound	eht2
26	Norfolk	eorf
27	Chesapeake Bay	cp2
28	Ocean City	oce
29	Atlantic City	acy

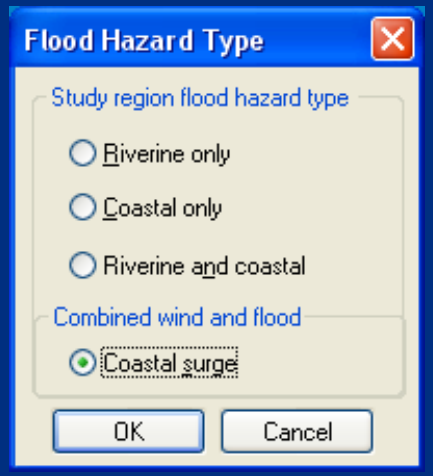
No	Name	code
30	NewYork	ny2
31	Buzzards Bay	pv2
32	Penobscot Bay	pnb

FEMA

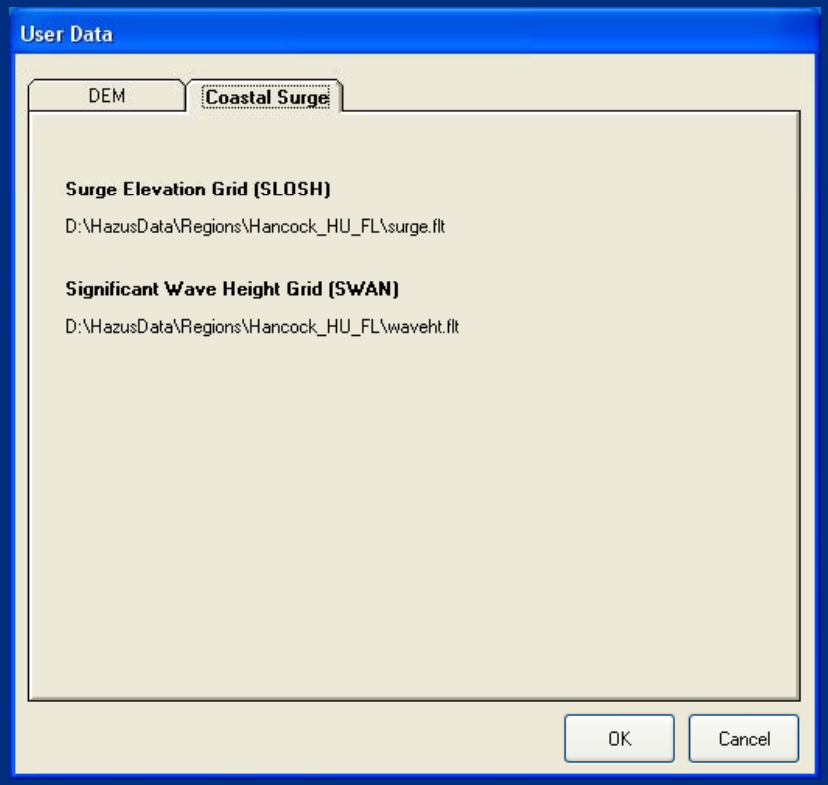
Hurricane Model: Deep Water (red) and Near Shore (blue) Wave Grids Used in SWAN



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’

FEMA

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

FEMA

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)

FEMA

Coastal Surge Analysis Demonstration

Hurricane Katrina

Hancock County, MS

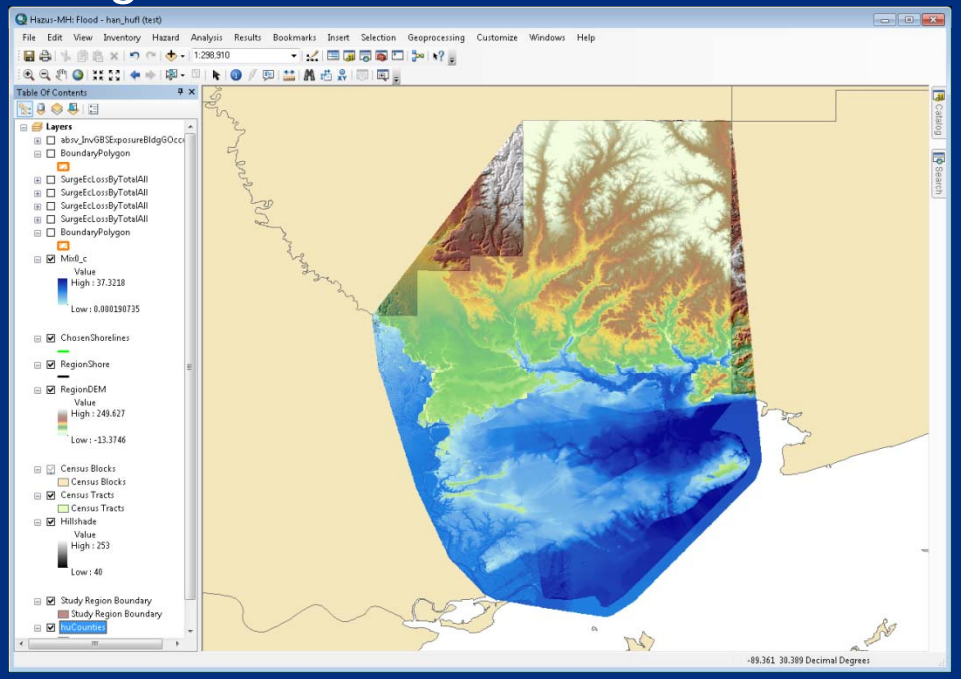
HAZUS® MH

EARTHQUAKE • FLOOD • WIND

FEMA

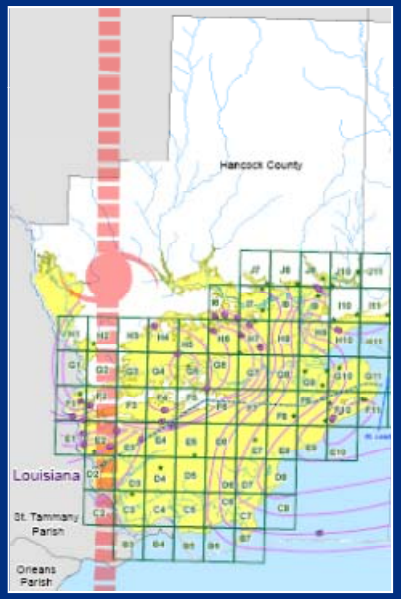
Modeled vs. Observed Inundation Limits

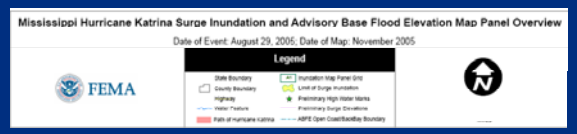
Blue area shows the modeled inundation levels for Hancock County, Mississippi using Hazus 2.1



SLOSH model results are consistent with field-observed inundation limits of Katrina

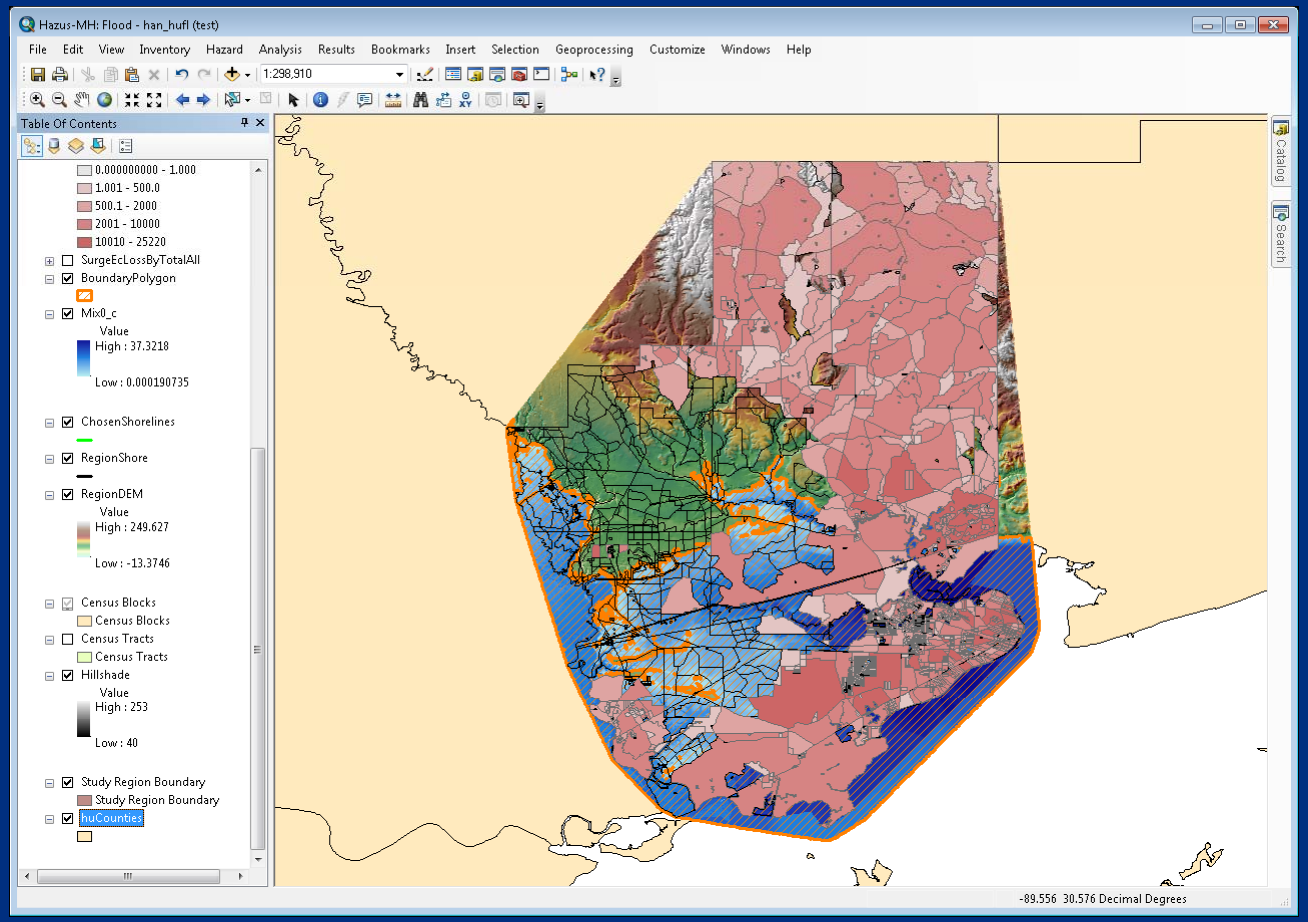
Yellow area shows the actual observed limits of inundation





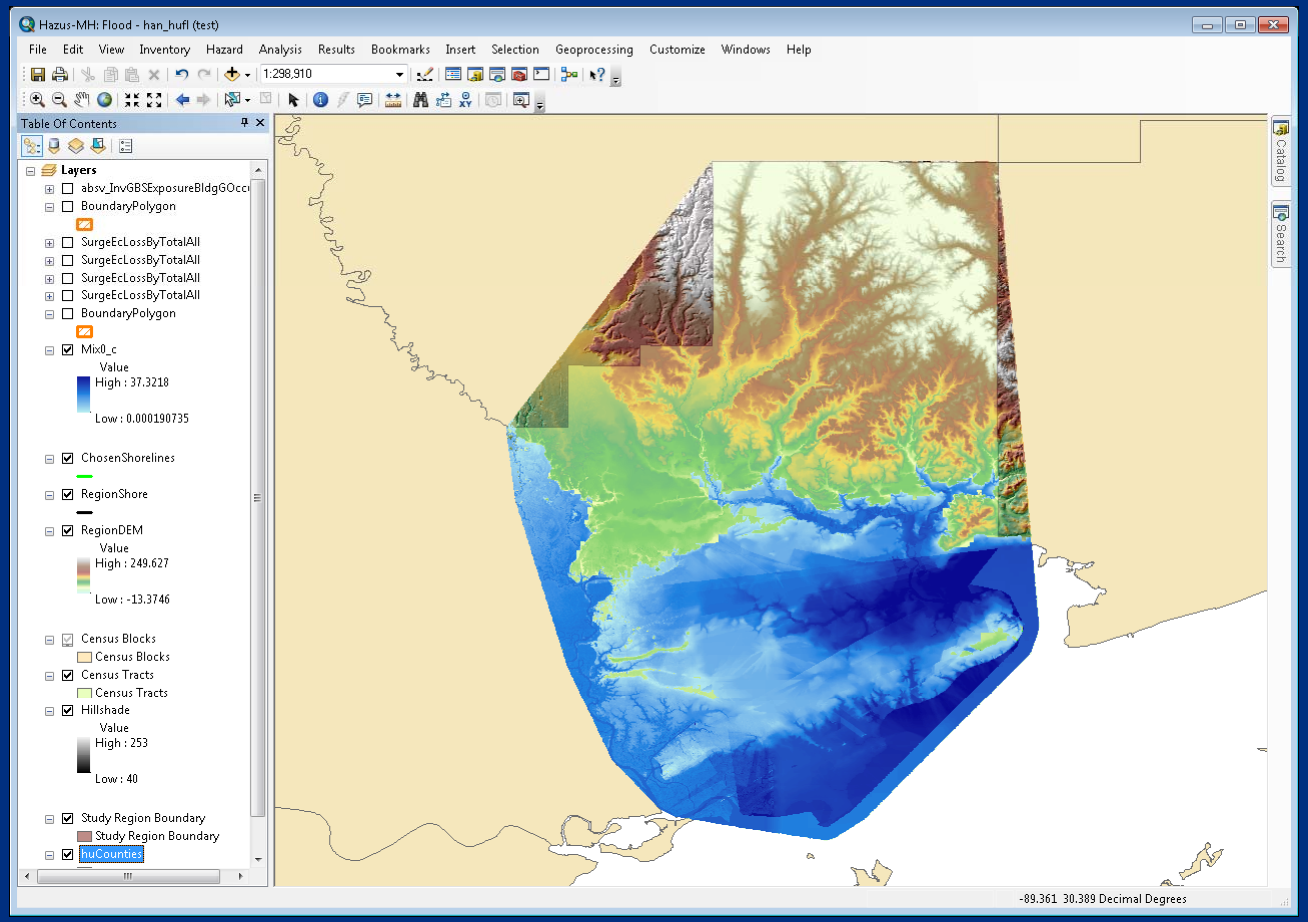
FEMA

Building Exposure ($k)



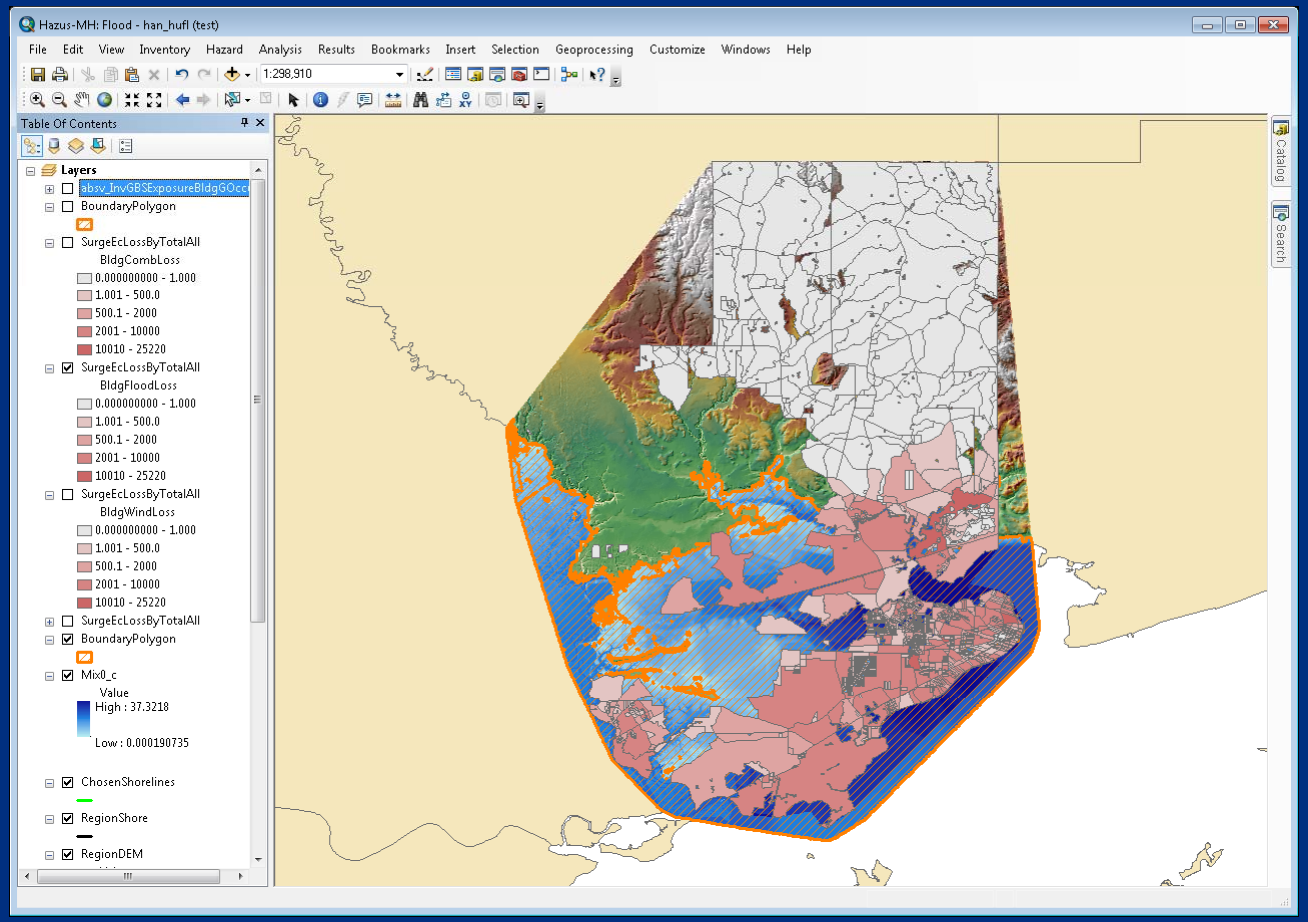
FEMA

Inundation Limits



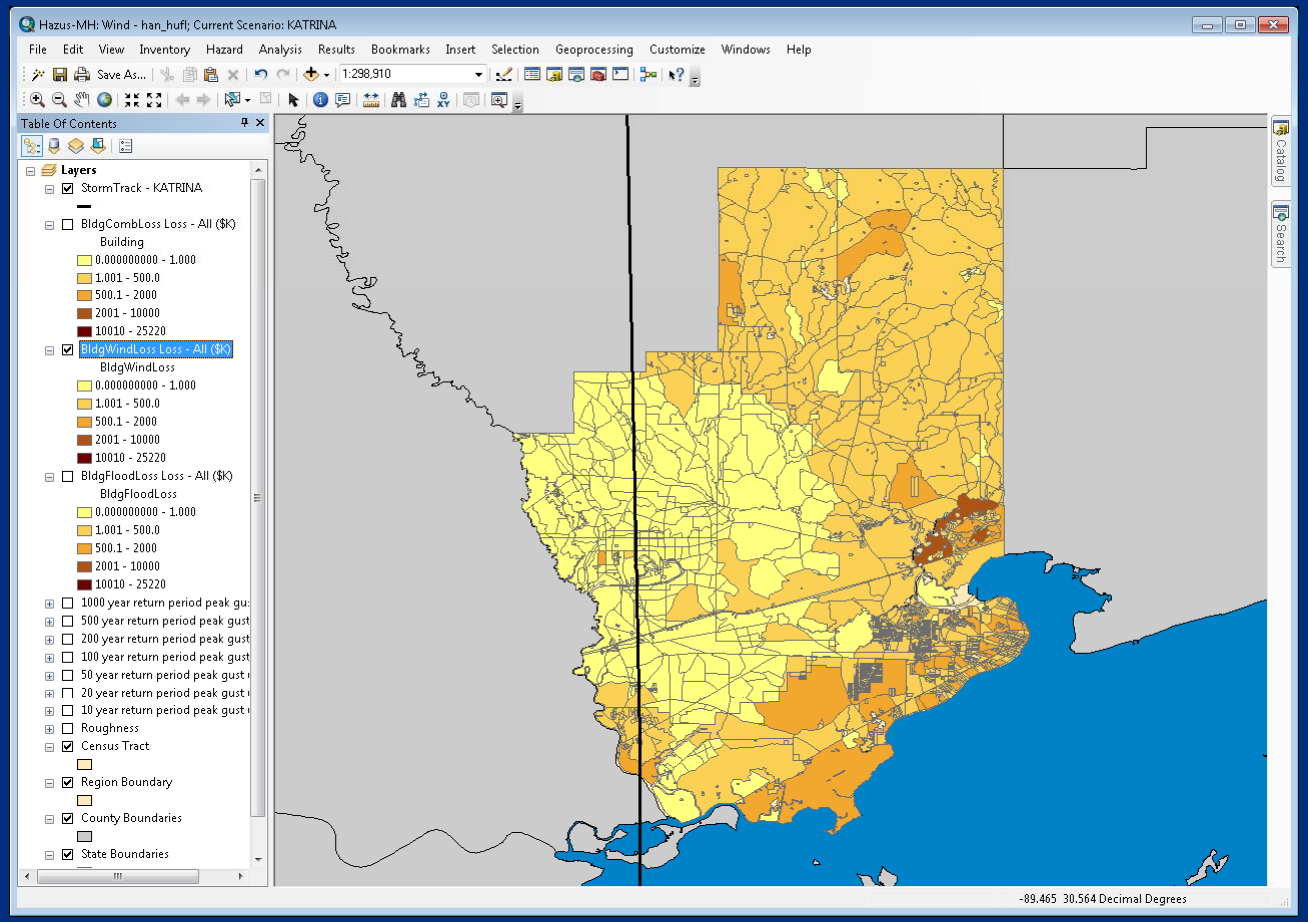
FEMA

Flood-Only Building Loss



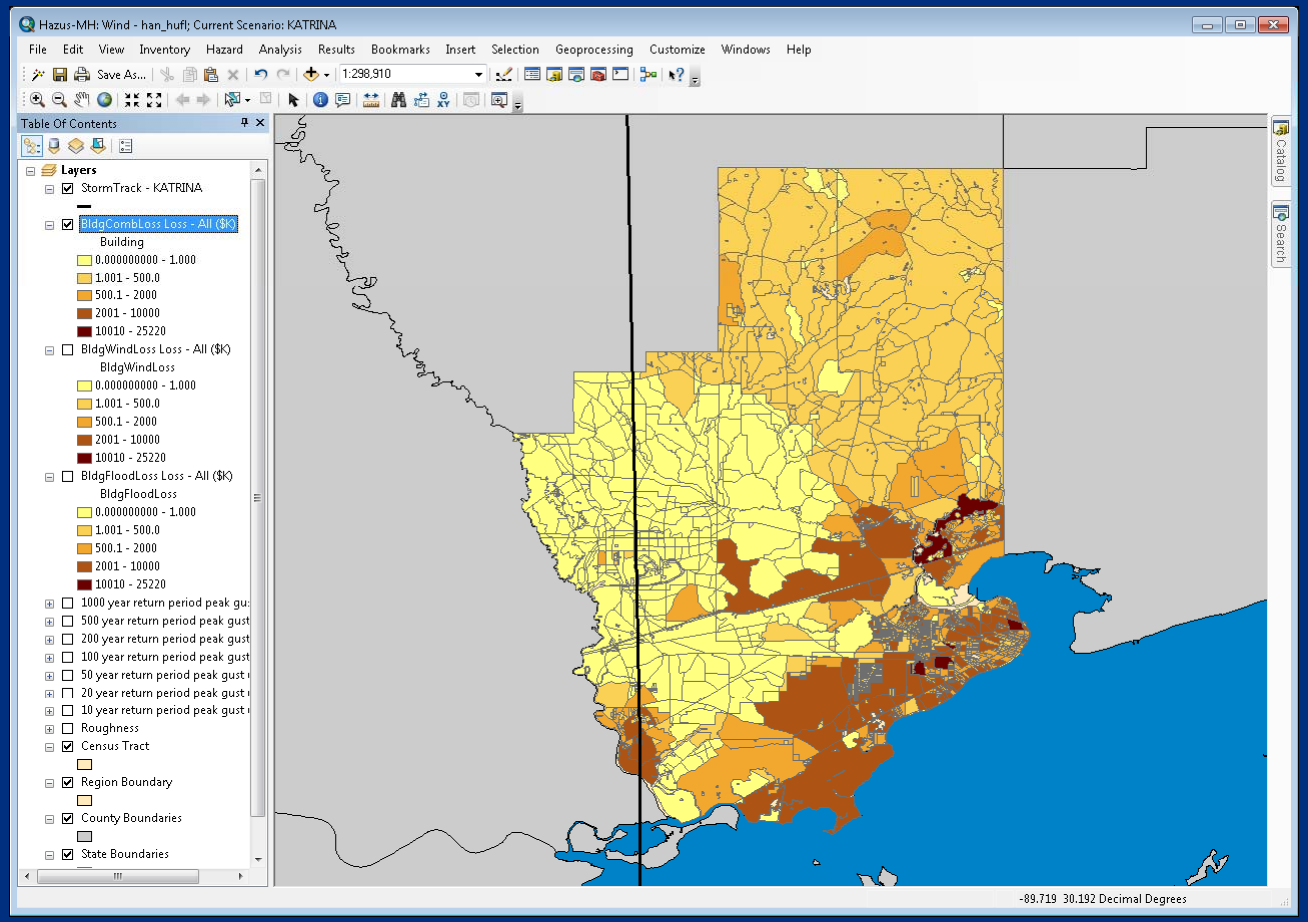
FEMA

Wind-Only Building Loss



FEMA

Combined Wind and Flood Loss



FEMA

Direct Economic Loss Table

Combined FL/HU Surge Direct Economic Losses For Full Replacement Value

By General Occupancy | By Specific Occupancy | By General Building Type | Total

Results for

Scenario: Hancock_Katrina_NoWaves

Return period: Mix0

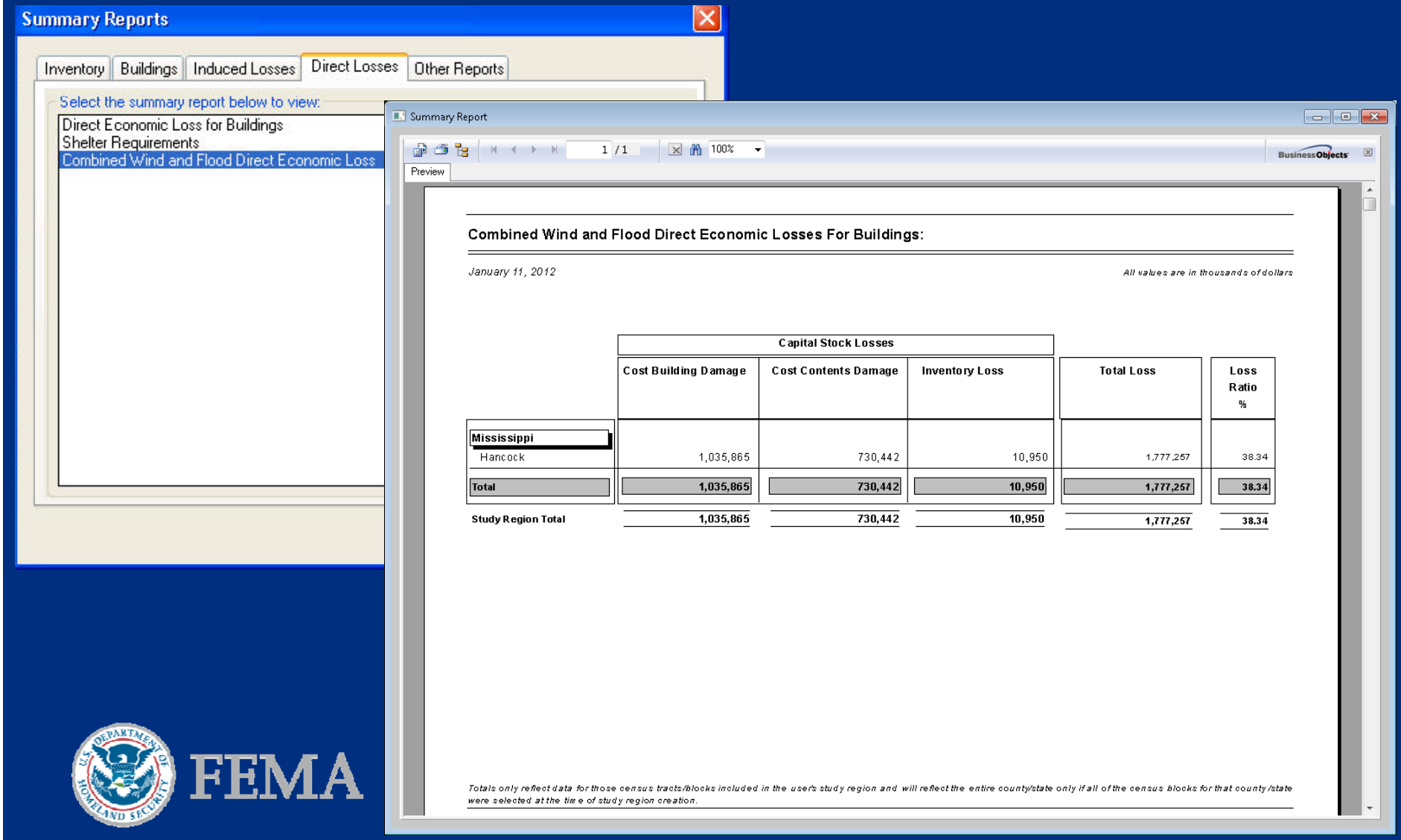
Total

	CensusBlock	BldgFloodLoss	BldgWindLoss	BldgCombLoss	ContFloodLoss	ContW
1	280450303005091	168.00	15.41	174.79	107.00	
2	280450303006000	4,737.00	299.48	4,857.17	5,449.00	
3	280450303006054	209.00	20.17	216.05	93.00	
4	280450303008020	414.00	45.47	435.54	231.00	
5	280450304002016	173.00	15.51	180.24	96.00	
6	280450306001027	0.00	16.27	16.27	0.00	
7	280450306004031	0.00	172.14	172.14	0.00	
8	280450302003016	356.00	54.49	387.09	216.00	
9	280450304002028	140.00	11.94	145.56	76.00	
10	280450301004036	147.00	48.99	182.39	88.00	
11	280450302002009	772.00	202.36	908.43	496.00	
12	280450302003025	984.00	146.21	1,063.01	605.00	
13	280450303001003	906.00	111.52	958.74	440.00	
14	280450303005106	119.00	10.17	123.56	54.00	
15	280450303007037	400.00	37.86	414.06	180.00	

Close | Map | Print

FEMA

Combined Loss Summary Report



FEMA

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.

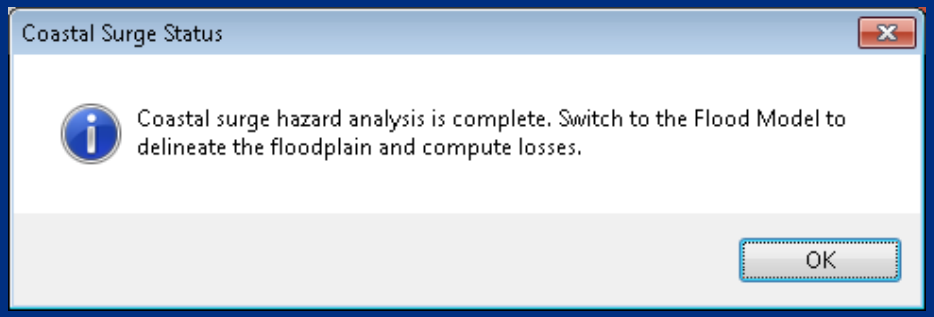
When a coastal surge analysis is required, the storm track should extend beyond the outer limits of the applicable SLOSH basin(s) if near shore waves are enabled and all the way out to 60 degrees west longitude if both deep water and near shore waves are enabled.

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".**

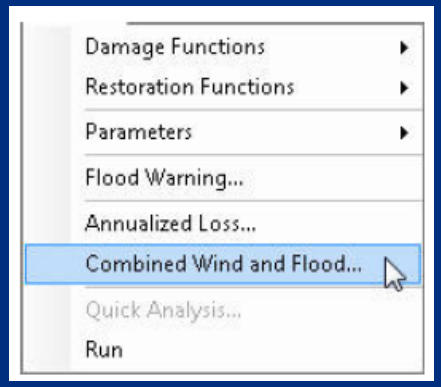
FEMA

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.



FEMA

Helpful Tips (continued)

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.

FEMA

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

FEMA

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

FEMA

Questions?

HAZUS® MH

EARTHQUAKE • FLOOD • WIND

FEMA