

SEA LEVEL SCENARIO SKETCH PLANNING TOOL TECHNICAL TRAINING

OCTOBER 9, 2017
TALLAHASSEE, FL



TODAY'S AGENDA

10:00am – 11:00am	Introductions, Background SLR, Projections, Impacts Overview of Sketch Tool Methods and Uses
10:45am – 11:00am	Local Case Study, Denise Embler, ARPC
11:00am – 11:45am	Sketch Tool Demo
11:45am – 1:00pm	Lunch Break (on your own)
1:00pm – 1:45pm	Guided Training Exercises
1:45pm – 2:30pm	Group Exercise: Vulnerability Assessment
2:30pm – 3:00pm	Report out/ Surveys/ Closing

INTRODUCTIONS

The **GeoPlan Center** is a Geographic Information Systems (GIS) research and teaching center, housed in the School of Landscape Architecture and Planning at the University of Florida.

The UF GeoPlan Center works to support land use, transportation, and environmental planning in the State of Florida by providing geospatial and planning expertise, data, training, and education to the stakeholders involved in the planning process.

UF GeoPlan Center Sketch Tool Training Team

- Crystal Goodison – Project Lead + Associate Director, GeoPlan Center
- Reginald Pierre-Jean – Geospatial Software Developer
- Erik Finlay – GIS Analyst

THANKS: CRTPA and ARPC!



SEA LEVEL RISE IN FLORIDA

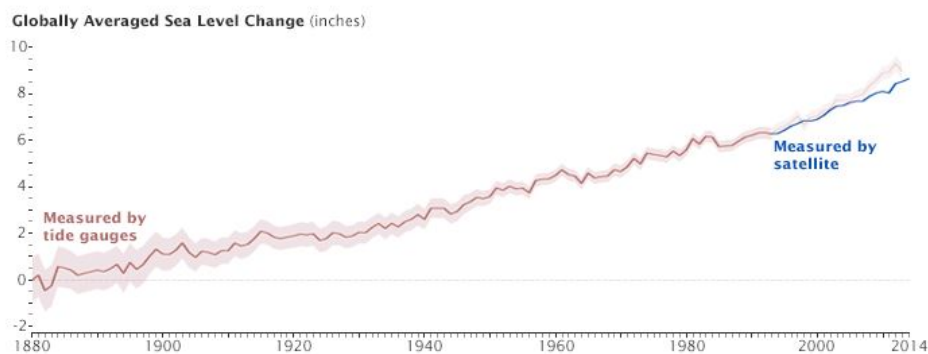
WHY ARE SEA LEVELS RISING?

The earth is warming (global temps rose ~ 1.53 degrees F from 1880 to 2012, IPCC) due to greenhouse gases trapped in atmosphere \rightarrow Oceans absorb over 90% excess heat

Two primary drivers of sea level rise (SLR):

1. **Thermal expansion:** as the ocean waters warm, they expand up and out ($\sim 40\%$)
2. **Glacial melt:** Rising temperatures cause melting of glaciers and land-based ice sheets ($\sim 60\%$)

HOW MUCH HAVE SEA LEVELS ALREADY RISEN?



Global SLR has risen about **8 inches over the past century.**

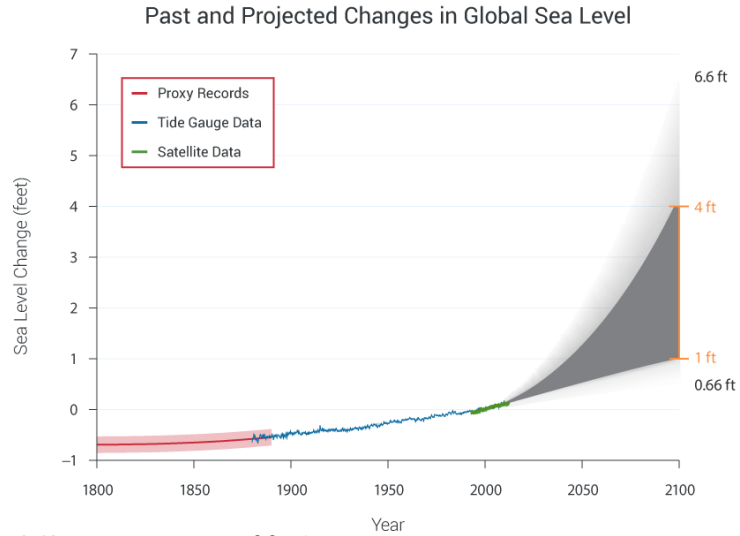
Rate of SLR ~ 1.7 mm/yr over the last century.

Over the last few decades, higher rate of SLR ~ 3.2 mm/yr

HOW MUCH MORE AND WHEN WILL SEA LEVELS RISE?

Very Likely:
 2030: 0.3 - 0.6 ft
 2050: 0.5 - 1.2 ft
 2100: 1.0 - 4.0 ft

4th National Climate Assessment, 2017



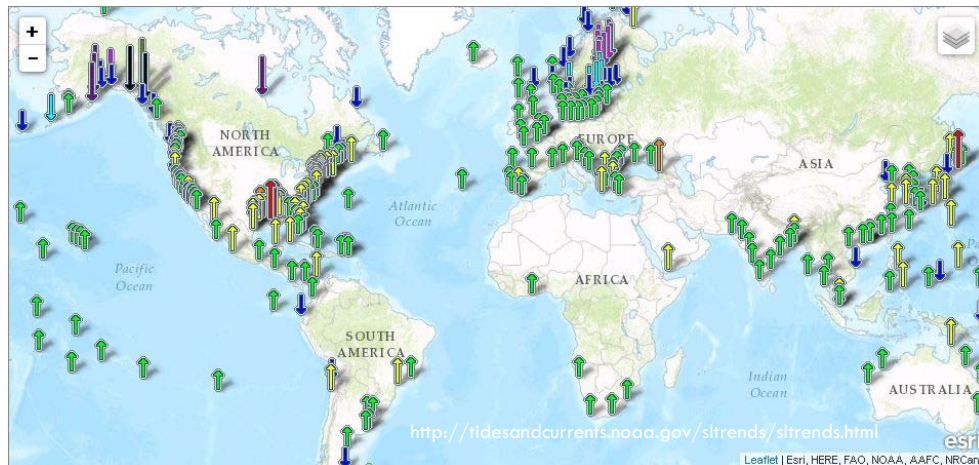
Graph: The Third National Climate Assessment, 2014

GLOBAL SLR PROJECTIONS

Agency	Range of SLR (in Feet) by 2100
IPCC - Intergovernmental Panel on Climate Change AR5	0.85 - 2.7 ft
USACE - U.S. Army Corps of Engineers (2013)	0.66 - 5.0 ft
NOAA – National Oceanic and Atmospheric Administration/ 3 rd National Climate Assessment (2012)	0.66 - 6.6 ft
NOAA (2017)	1.0 – 8.2 ft

WHERE AND HOW MUCH SLR DEPENDS ON YOUR LOCATION

GLOBAL SEA LEVEL TRENDS

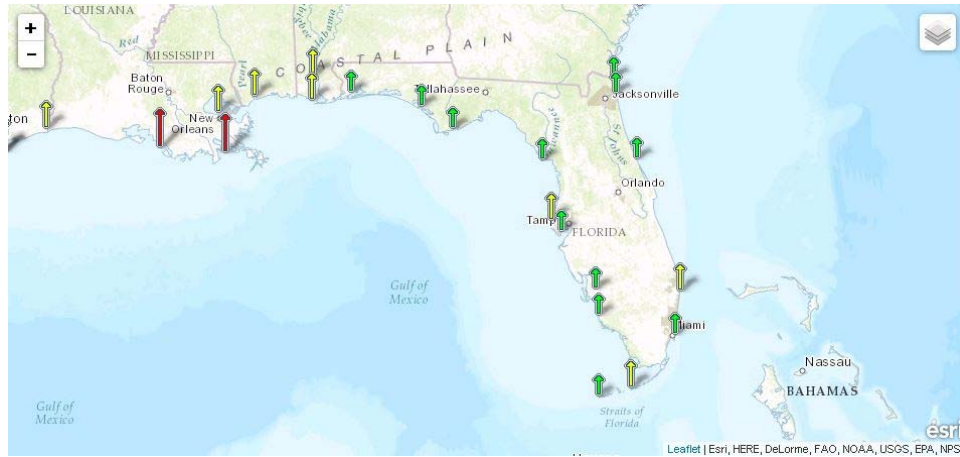


Sea Level Trends
mm/yr (feet/century)

Source: NOAA Sea Level Trends

■ 15 to 21 (5 to 7)	■ 6 to 9 (2 to 3)	■ -3 to 0 (-1 to 0)	■ -12 to -9 (-4 to -3)
■ 12 to 15 (4 to 5)	■ 3 to 6 (1 to 2)	■ -6 to -3 (-2 to -1)	■ -15 to -12 (-5 to -4)
■ 9 to 12 (3 to 4)	■ 0 to 3 (0 to 1)	■ -9 to -6 (-3 to -2)	■ -18 to -15 (-6 to -5)

FLORIDA SEA LEVEL TRENDS



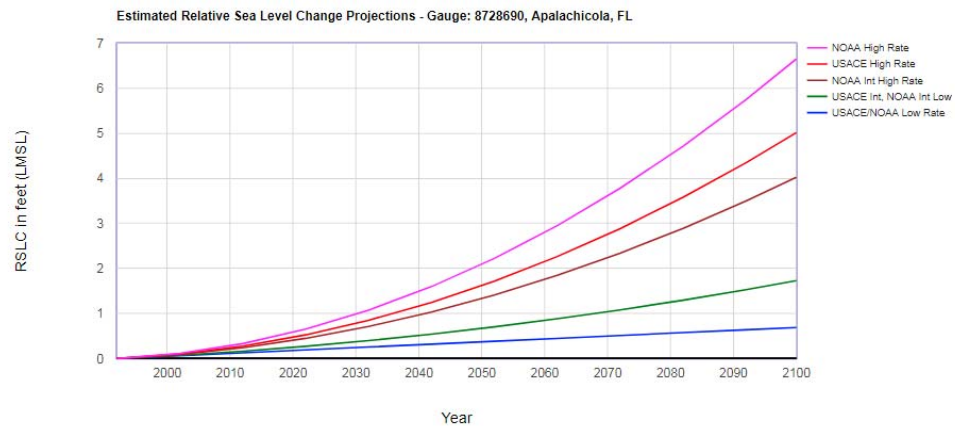
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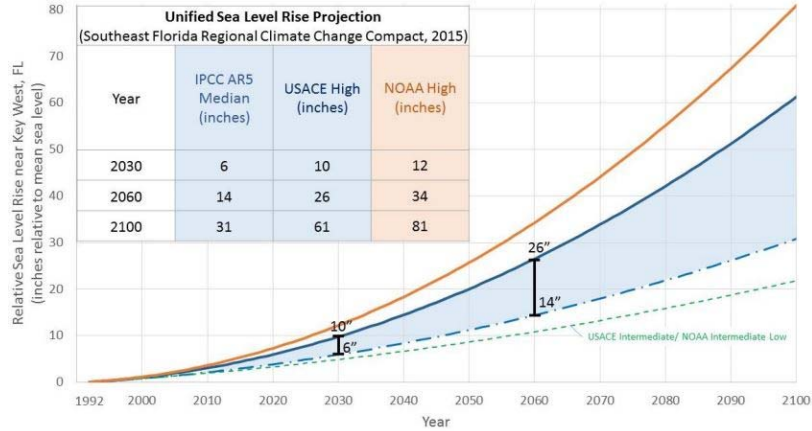
USACE (2013) & NOAA (2012) SLR PROJECTIONS

Example: Apalachicola, FL

Graph generated using USACE Sea-Level Change Curve Calculator



SOUTHEAST FLORIDA SLR PROJECTIONS



Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group
October 2015. Unified Sea Level Rise Projection for Southeast Florida.

CURRENT & FUTURE IMPACTS

CURRENT & FUTURE IMPACTS OF SLR TO COASTAL AREAS

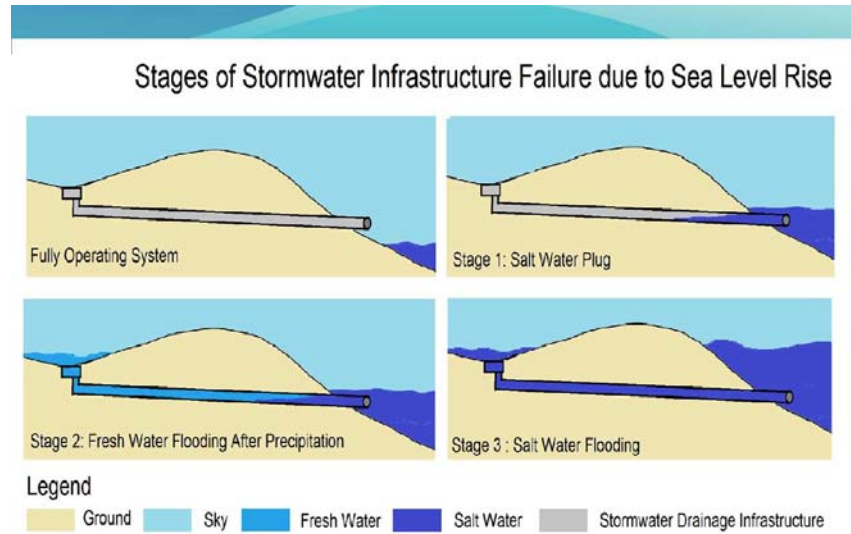
- Failure of drainage & stormwater systems
- Increase in coastal flooding and nuisance flooding
- Higher storm surges
- Beach Erosion
- Loss of coastal habitats and natural protection
- Deterioration of coastal infrastructure
- And more...

TRANSPORTATION IMPACTS

- More frequent flooding of transportation facilities
- More temporary road closures due to flooding
- Saturation of roadbeds, potential for collapse
- Increased damage to infrastructure from storm surge and waves (loss of natural protection from waves)
- Eventual permanent inundation/ submersion for some transportation facilities

STAGES OF STORMWATER SYSTEM FAILURE

Graphic credits:
Emily Niederman &
Dr. Jason Evans,
Stetson University



INCREASED COASTAL FLOODING

Failure of stormwater systems to drain → flooded streets and properties

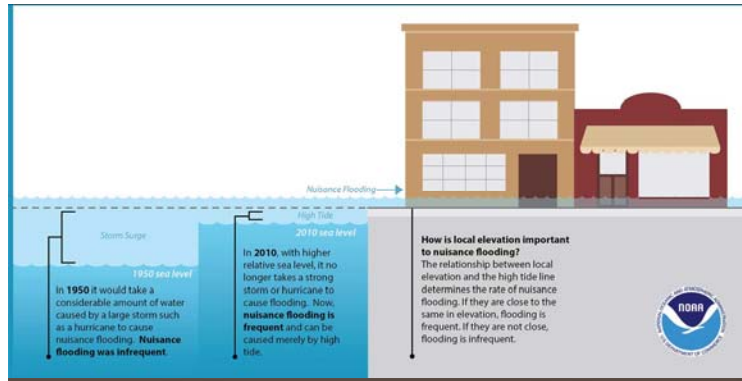
Saturation of road beds, potential for collapse

Deterioration of coastal infrastructure

Image: NOAA, National Oceanic and Atmospheric Administration



INCREASE IN NUISANCE FLOODING



Graphics: NOAA, National Oceanic and Atmospheric Administration

WHAT ARE THE IMPACTS??



ROAD CLOSURES



OVERWHELMED STORM WATER SYSTEMS



DAMAGE TO TRANSPORTATION INFRASTRUCTURE



COASTAL EROSION

HIGHER STORM SURGES

Damage to infrastructure exacerbated by loss of natural protection (dunes, marshes, mangroves, etc).

A1A, Ft. Lauderdale
Hurricane Sandy
October 2012

Photo Credits: Susan Stocker, Sun Sentinel



HURRICANE MATTHEW STORM SURGE A1A DAMAGE: FLAGLER BEACH



Photo credits: Action News Jax

HURRICANE MATTHEW STORM SURGE

A1A DAMAGE: FLAGLER BEACH



Photo credits:
Washington Post

HURRICANE IRMA SEPTEMBER 2017



Downtown
Jacksonville
WJCT News



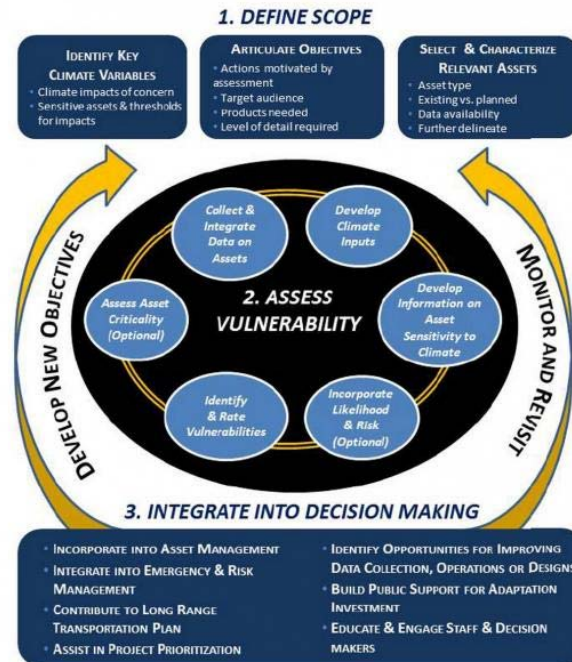
I-4 Longwood. Orlando
Sentinel/ AP.



Downtown
Jacksonville
NBC News

HOW TO PREPARE?

FHWA CLIMATE CHANGE & EXTREME WEATHER VULNERABILITY ASSESSMENT FRAMEWORK



FHWA RESILIENCE WEBINAR SERIES



Thursdays, September 28 - November 16, 2017: Learn about four different resilience-focused projects conducted with State and local partners. FHWA has developed information, examples, and lessons learned on integrating resilience concerns into planning, project development and project engineering.

1. Approaches for addressing Resilience in Project Development (9/28, 1:00 – 3:00 EST).
2. Lessons Learned in Transportation Engineering Related to Coastal and Riverine Flooding (10/5, 1:00 – 3:00 EST).
3. Lessons Learned in Transportation Engineering Related to Pavement/Soils and Mechanical/Electrical Vulnerabilities (10/12, 1:00 – 3:00 EST).
4. Post-Hurricane Sandy Transportation Resilience Study: NY, NJ, & CT (10/26, 1-2:30pm EST)
5. Green Infrastructure Pilots I (11/2, 1:00-2:30 EST)
6. Green Infrastructure Pilots II (11/9, 1:00-2:30 EST)
7. FHWA's Climate Change & Extreme Weather Vulnerability Assessment Framework (11/16, 1:00-2:30 EST)

<https://www.fhwa.dot.gov/environment/sustainability/resilience/webinars/>



SKETCH TOOL: BACKGROUND

FDOT'S SLR RESEARCH

FAU's Research Report (completed Jan 2012)

Comprehensive analysis of SLR projections, studies, models and methodologies used in Florida. Resulting recommendations:

UF GeoPlan Center Research

Phase 1: Feb 2012 - Oct 2013:

Implement FAU recommendations. Initial build of Sketch Planning Tool

Phase 2: Dec 2013 –October 2015:

Work with FHWA Climate Pilot to test tools

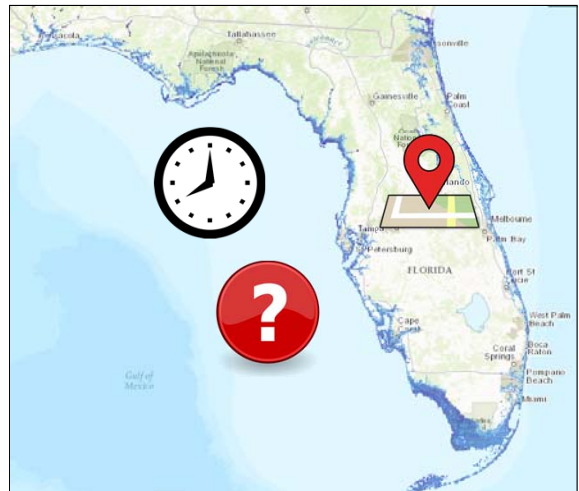
Phase 3: Dec 2015 – April 2017:

Update tools based on feedback from Phase 2

SKETCH TOOL: PURPOSE AND INTENT

A starting place to assess potential impacts of sea level rise on the transportation system

- Map **where** and **when** sea level rise is projected to occur in Florida
- Use **local tide gauge data** to develop **regional projections** of sea level rise
- Develop a **planning-level tool** for quick assessment of potential **transportation impacts** under various SLR scenarios



PHASE 1: SEA LEVEL SCENARIO SKETCH PLANNING TOOL



Map Viewer

- Visualize areas of inundation and affected infrastructure
- *Low technical expertise needed, no GIS software needed*



GIS Data Layers

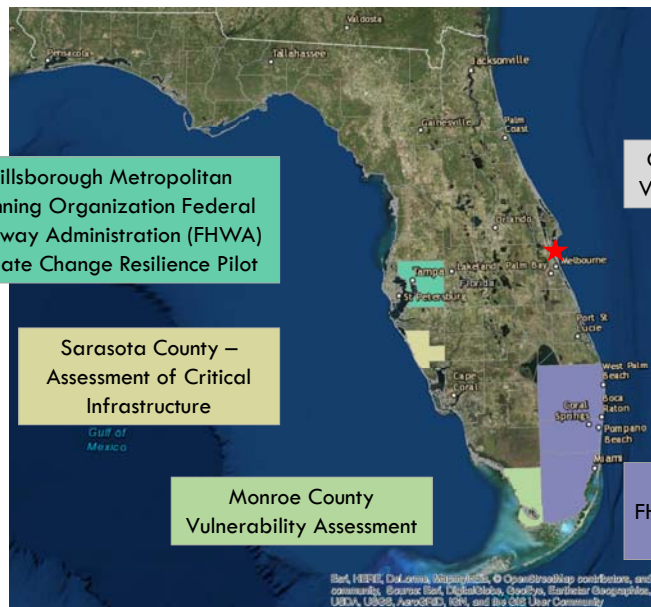
- SLR Inundation Surfaces & Affected Infrastructure layers
- *GIS Software and intermediate GIS expertise needed*



SLR Inundation Surface Calculator

- Create custom inundation layers
- *Intermediate/Advanced technical/ GIS expertise needed*

PHASE 2: TESTING THE TOOLS - CASE STUDY LOCATIONS



PHASE 2 FEEDBACK

- What about Storm Surge?
 - SLR will increase surge extent/ depth of flooding/ intensity of damage
- What about Flooding?
 - “Nuisance Flooding”/ “Sunny Day Flooding”/ “King Tides”: High tide events causing an increase in flooding frequency in coastal communities. Due to SLR increasing high tide levels
- What about NOAA curves?
 - Higher projected SLR than USACE (2m SLR by 2100 vs 1.5m for USACE)
- Update user interface/ design of map viewer

SKETCH TOOL PHASE 3 (2016-17)

Update Data

- ❖ Re-run of inundation layers with latest elevation data, updated sea level trends, tidal surfaces, added NOAA 2012 upper curves
- ❖ Update analysis of affected transportation facilities
- ❖ Add analysis of current flood risks (100-year & 500-year floodplains)

Investigate Storm Surge Modeling

- ❖ Hazus-MH Modeling, 100-year storms + SLR, coastal surge analysis of historical hurricanes. Resilient Volusia FDEP CPI pilot.

Tool Enhancements

- ❖ Map Viewer – major update and modernization
- ❖ SLR Calculator – update for newer ArcGIS versions

PROJECT TEAM

Florida Department of Transportation, Office of Policy Planning

Jennifer Carver, Project Manager
Maria Cahill and Dennis Smith, Prior Project Managers



University of Florida GeoPlan Center

Crystal Goodison, Principal Investigator
Alexis Thomas, Co-Principal Investigator
Katherine Norris, Co-Principal Investigator, GIS Analyst
Reginald Pierre-Jean, Geospatial Software Developer
Dr. Paul Zwick, Professor & Hazus-MH Practitioner
Sam Palmer, GIS Analyst
Daniel Downing, Web GIS Specialist
Erik Finlay, GIS Analyst
Lance Barbour, Systems Administrator
Adam Carr, Graduate Assistant

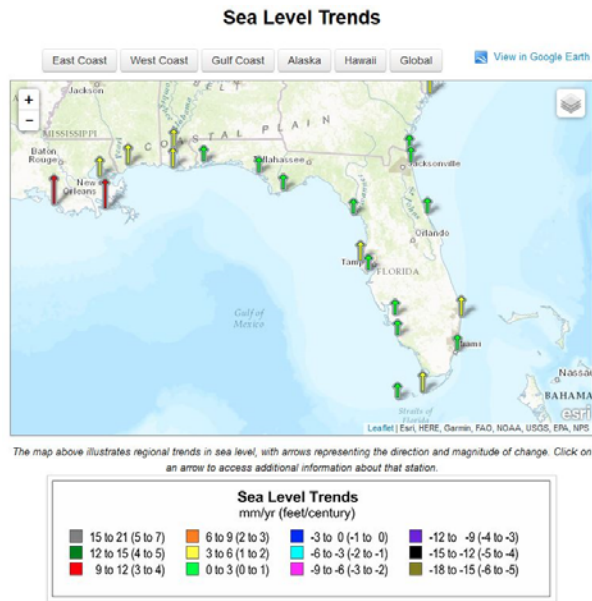
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**UNIVERSITY of
FLORIDA**

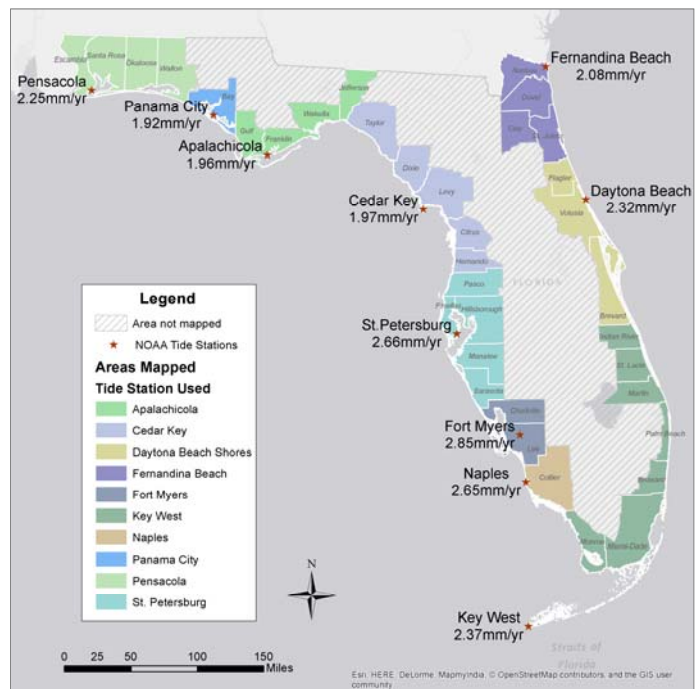
DATA & METHODS

SLR MAPPING DATA INPUTS

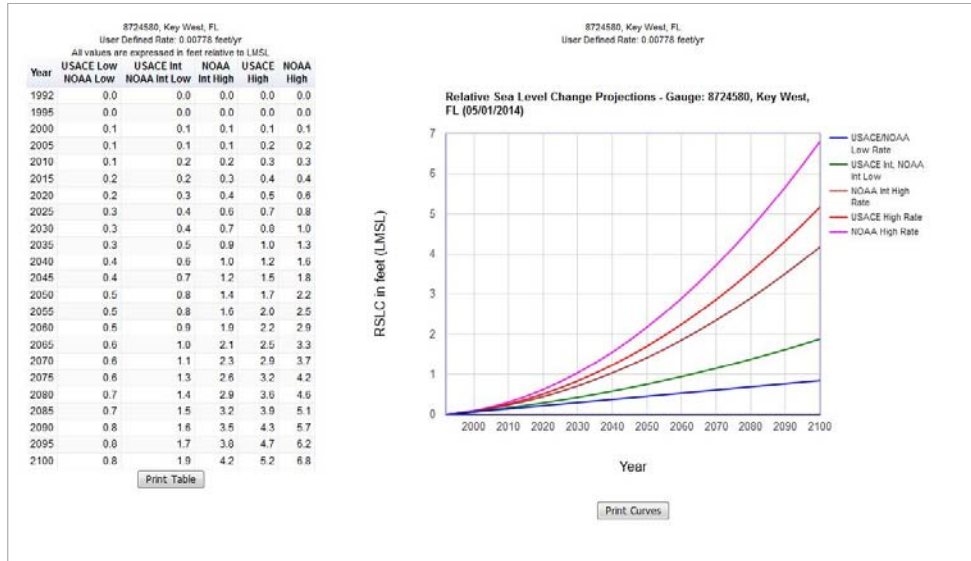
1. NOAA Sea Level Trends
2. NOAA Tidal Grids (regional tidal conditions)
3. USACE Sea Level Change Calculator (calculates USACE & NOAA SLR Projections – 5 total projections)
4. High resolution elevation data



NOAA SEA LEVEL TRENDS & TIDE STATIONS USED IN SLR MAPPING

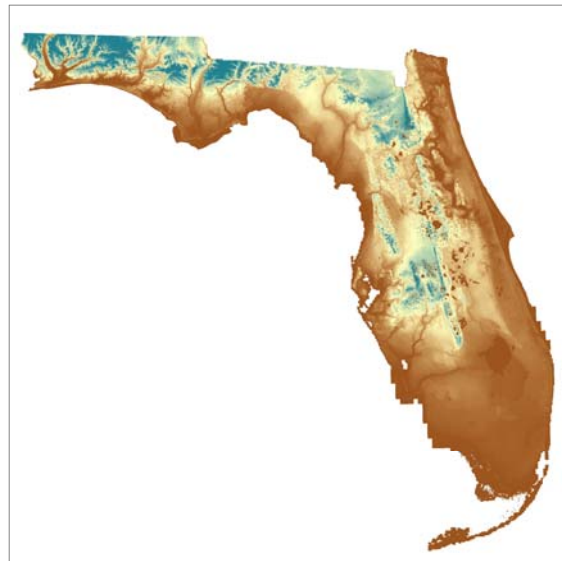
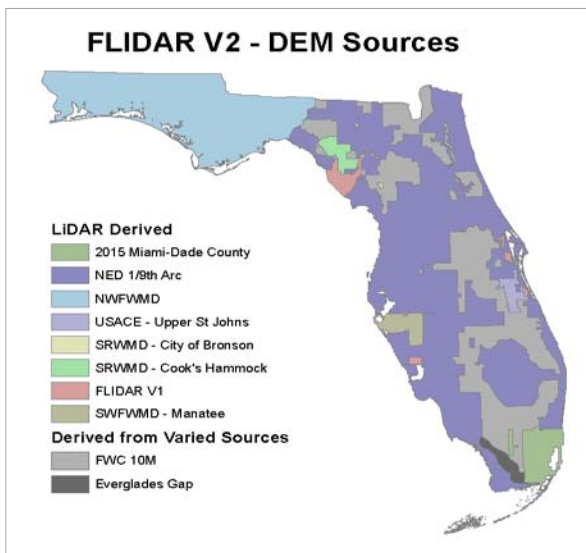


USACE SEA LEVEL CHANGE CALCULATOR

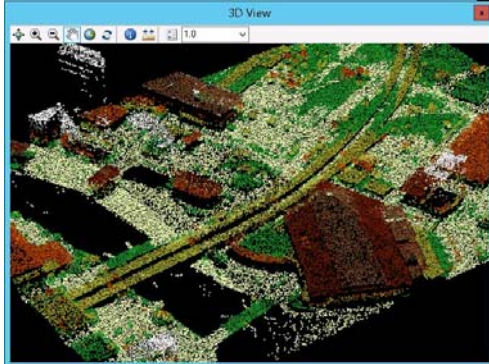


<http://www.corpsclimate.us/ccaceslcurves.cfm>

ELEVATION DATA



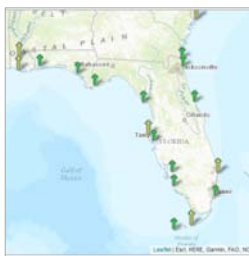
BRIDGE CORRECTIONS



Bridge DSMs were created for the following counties: Bay*, Brevard, Broward, Calhoun*, Charlotte, Clay, Collier*, Dixie, Duval*, Escambia, Flagler*, Franklin*, Gilchrist, Glades, Gulf*, Hendry, Highlands, Hillsborough, Indian River, Jefferson, Lafayette, Lee*, Leon, Levy, Liberty, Manatee*, Martin, Miami-Dade*, Monroe, Nassau, Okaloosa, Okeechobee, Palm Beach*, Pasco, Pinellas, Putnam, Santa Rosa, Sarasota*, St. Johns*, St. Lucie, Taylor, Wakulla, Walton*, and Washington*
 * Partial coverage of county

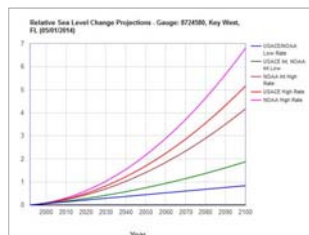
SLR MAPPING PROCESS

Tide station data
(Historical Mean
Sea Level Trends)



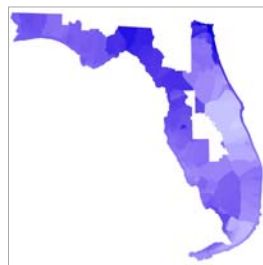
How much
has it risen?

USACE Calculator
(Generate SLR
values by decade)



How much more and
when will it rise?

Add SLR to Tidal
Surfaces (MHHW
& MSL)



Adjusting SLR to local
tide conditions

Find low-lying
elevations, evaluate
hydro connectivity &
correct for bridges



Lidar & high resolution
elevation data

SLR MODEL OUTPUTS

Hundreds of GIS layers, each representing a **SLR Scenario**:

Where Scenario =

County, Year, Projection, Tidal Datum

County: Coastal counties (36)

Year: decadal intervals, 2040 – 2100

Five Projections: USACE & NOAA

Tidal Datums: MHHW, MSL

Model output: Bathtub and hydro-connected inundation

WHY DO WE NEED SO MANY PROJECTIONS?

LOW/ HISTORIC

- Applicable when designing low risk projects
- Easily replaceable infrastructure with short design lives
- Not critical infrastructure/ Limited interdependencies with other infrastructure

INTERMEDIATE

- Applicable to projects with short –to-mid term planning horizon

HIGH CURVE

- High risk projects constructed in longer time frames (many decades out)
- Critical infrastructure for services and connectivity
- Not easily replaceable
- Long design life

SLR MODEL OUTPUTS

SUBSET OF OLD TAMPA BAY AREA
 CLEARWATER BEACH TIDE GAUGE
 2060, HIGH CURVE, MHW
 1-METER INUNDATION

- Inundation with Hydro-connectivity filter
- Bathtub Inundation



SLR MODELS FOR DOWNLOAD

Outputs - Filename	Data Type	Model	Layer Descript
VOL_2040_C1_MHHW_BATH	Raster	Bathtub	SLR Inundation Extent, 2040, USACE Low/NOAA Low, MHHW, Bathtub, Raster
VOL_2040_C1_MHHW_BATH_D	Raster	Bathtub	SLR Inundation Depth, 2040, USACE Low/NOAA Low, MHHW, Bathtub, Raster
VOL_2040_C1_MHHW_BATH_P	Vector	Bathtub	SLR Inundation Extent, 2040, USACE Low/NOAA Low, MHHW, Bathtub, Vector
VOL_2040_C1_MHHW	Raster	Hydro-connectivity	SLR Inundation Extent, 2040, USACE Low/NOAA Low, MHHW, HC model, Raster
VOL_2040_C1_MHHW_D	Raster	Hydro-connectivity	SLR Inundation Depth, 2040, USACE Low/NOAA Low, MHHW, HC model, Raster
VOL_2040_C1_MHHW_P	Vector	Hydro-connectivity	SLR Inundation Extent, 2040, USACE Low/NOAA Low, MHHW, HC model, Vector

TRANSPORTATION INFRASTRUCTURE

Building base data. Need consistent statewide, data.

FDOT Roads Characteristics Inventory (RCI) Data – 2016

- On and Off System Roads
- Average Annual Daily Traffic (AADT) information
- Lane Count information
- Roads receiving federal aid
- Evacuation routes

Strategic Intermodal Systems (SIS)

- Highways
- Rails
- Facilities (Airports, Freight Terminals, Seaports, Spaceports)

INCORPORATE CURRENT FLOOD RISK LAYERS

RCI database

Added analysis of current flood risk for every RCI Road segment:

- % and feet of roadway in 100-year floodplain
- % and feet of roadway in 500-year floodplain
- % and feet of roadway in Category 1-5 Storm Surge Zones

SLR POTENTIALLY AFFECTED TRANSPORTATION INFRASTRUCTURE

Intersected SLR inundation layers with:
RCI roadways, SIS airports, seaports,
spaceports, freight terminals, rails.

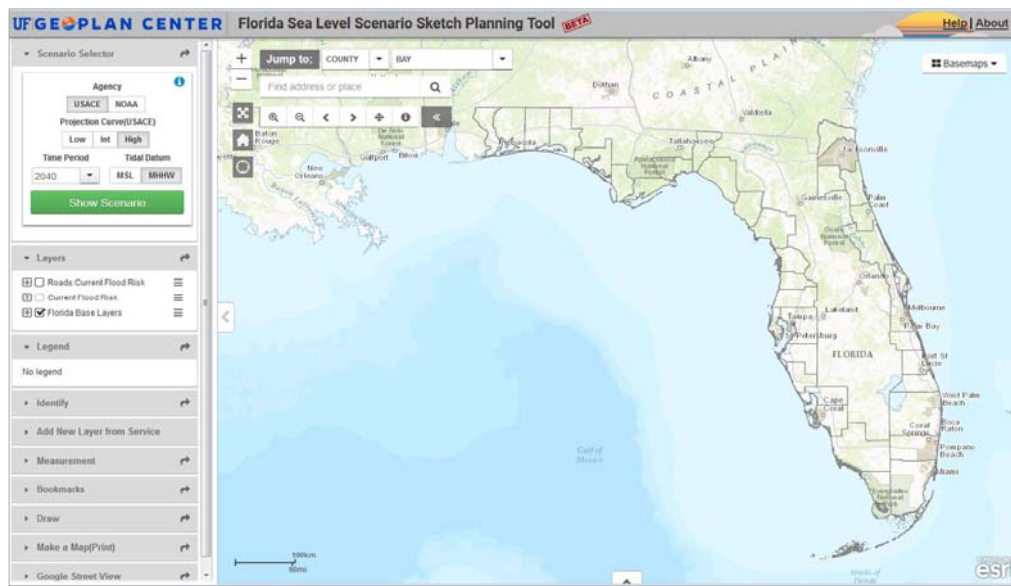
Focus on State owned facilities

Outputs: GIS layers identifying potentially at-risk transportation facilities w/
approximate miles or area affected/
inundated

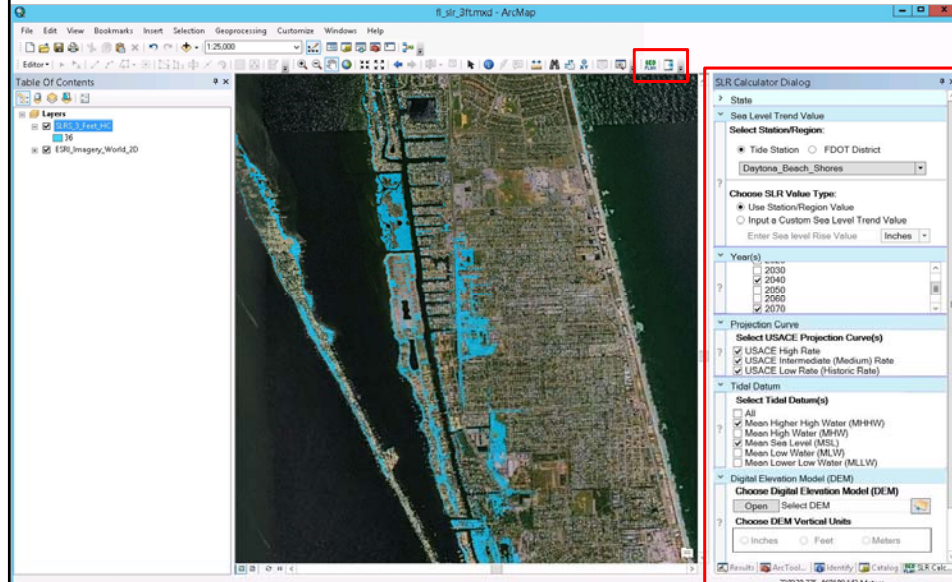
- Full and partial/ affected segments



NEW MAP VIEWER



SLR INUNDATION SURFACE CALCULATOR: ARCGIS ADD-IN



VERSIONS

Calc	ArcGIS
v1.5.2	10.1, 10.2.2
v1.6	10.3.1, 10.4
v1.7	10.4, 10.5 (beta)

v1.6 & v1.7

Custom SLR value input. Input SLR amount (ex. 1-m) and creates tidally adjusted inundation layer.

Added help pop-ups w/ info on calculator parameters.

v1.7: beta release

Added NOAA curves. Updated SLT. Updated model with MHHW tidal surface (NOAA).

SKETCH TOOL — WHY AND HOW TO USE IT?

Uses (to name a few...):

- Evaluate regional SLR scenarios and impacts to transportation over time
- Identify a broad timeline for tipping points (when do SLR impacts get really bad?)
- Match timing of impacts with planning horizons
- Match timing of impacts with type of infrastructure improvements/ investments
- Engage community in discussion
- Utilize information to prioritize transportation improvements
- Analyze evacuation routes for susceptibility to permanent inundation
- Use base GIS layers of inundation for community vulnerability assessments

Target Audience/ Users

- MPOs, RPCs, counties & municipalities doing regional level community resilience planning

SKETCH TOOL: NOT INTENDED FOR

- Not to be used for site specific analyses or site design.
- Not specific to a year. Projections are by decade.
- Not intended to be used for stormwater or drainage design.
- Does not include assessment impacts of SLR on groundwater.
- Not to be used for property assessment/ evaluation.

A LOOK AT STATEWIDE IMPACTS

	Total Miles Potentially Affected: RCI On & Off System Roads				
	USACE Low/ NOAA Low	USACE Int/ NOAA Int Low	NOAA Int High	USACE High	NOAA High
Decade	~ 8 inches (0.2m)	~ 1.6 feet (0.5 m)	~ 3.9 feet (1.2 m)	~ 5.0 feet (1.5 m)	~ 6.6 feet (2.0 m)
2040	3.2	4.0	16.5	19.5	34.2
2050	3.5	4.8	25.0	45.0	101.2
2060	3.7	15.6	60.3	108.1	274.1
2070	4.0	17.3	123.9	265.1	587.6
2080	4.4	24.8	274.1	521.0	1,102.3
2090	5.1	38.0	500.2	917.7	1,898.7
2100	5.3	62.6	843.5	1,487.9	2,860.2

GIS GEEK STUFF

For those interested in backend technology...

Data Processing

- Original models built in ArcGIS Model Builder
- Then converted to python for batch processing

User Interface:

- ArcGIS for Javascript API
- Dojo

Map Services:

- ArcGIS Server cluster running on Linux
- ArcPy map service automation/ customization

GIS Data

- Served from ArcSDE 10.4.1/ Oracle 12c instance

