COASTAL AREAS CLIMATE CHANGE EDUCATION PARTNERSHIP

CACCE

Preparing for a changing world.

Sea Level Rise

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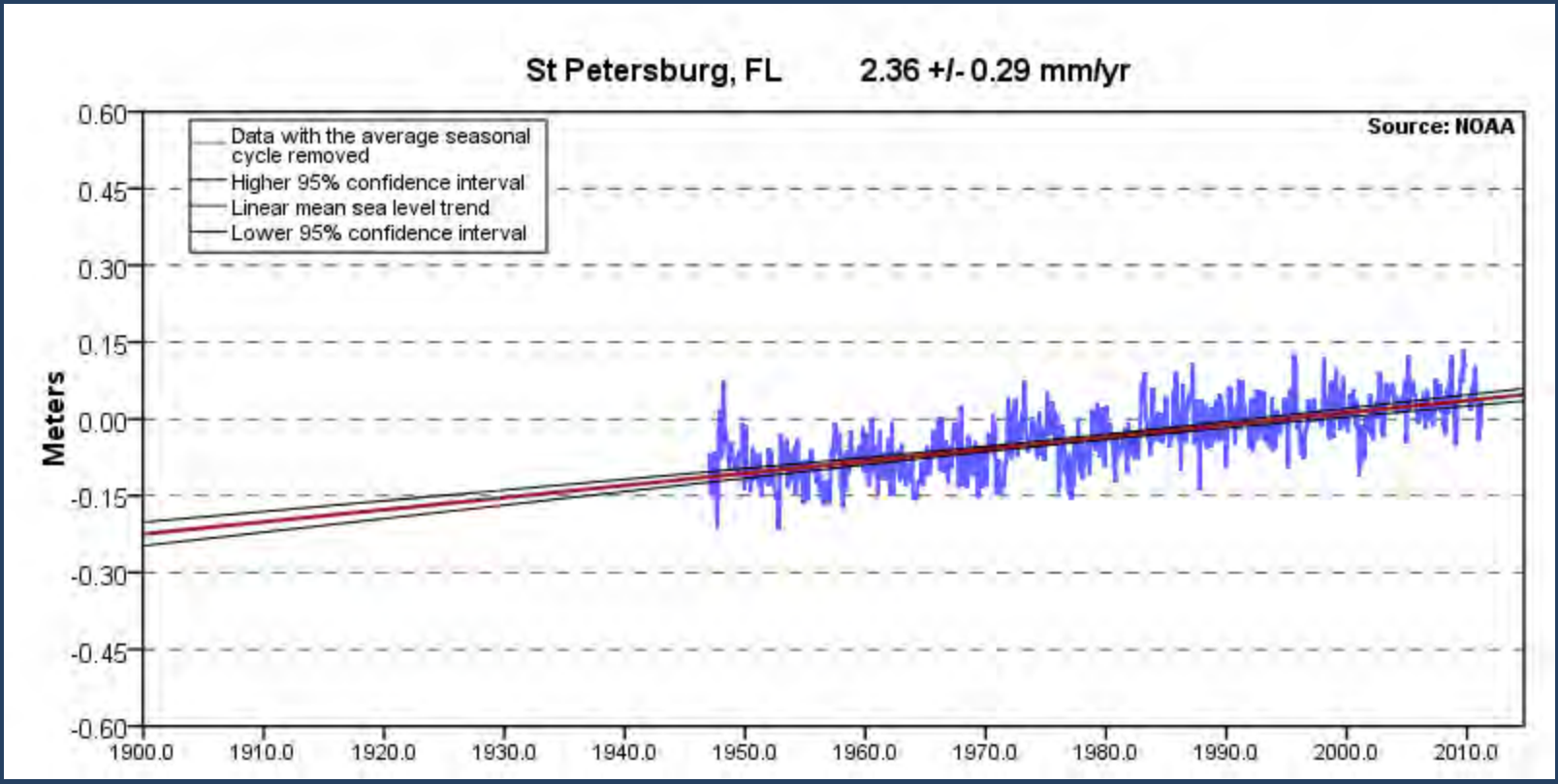
and the CACCE Team

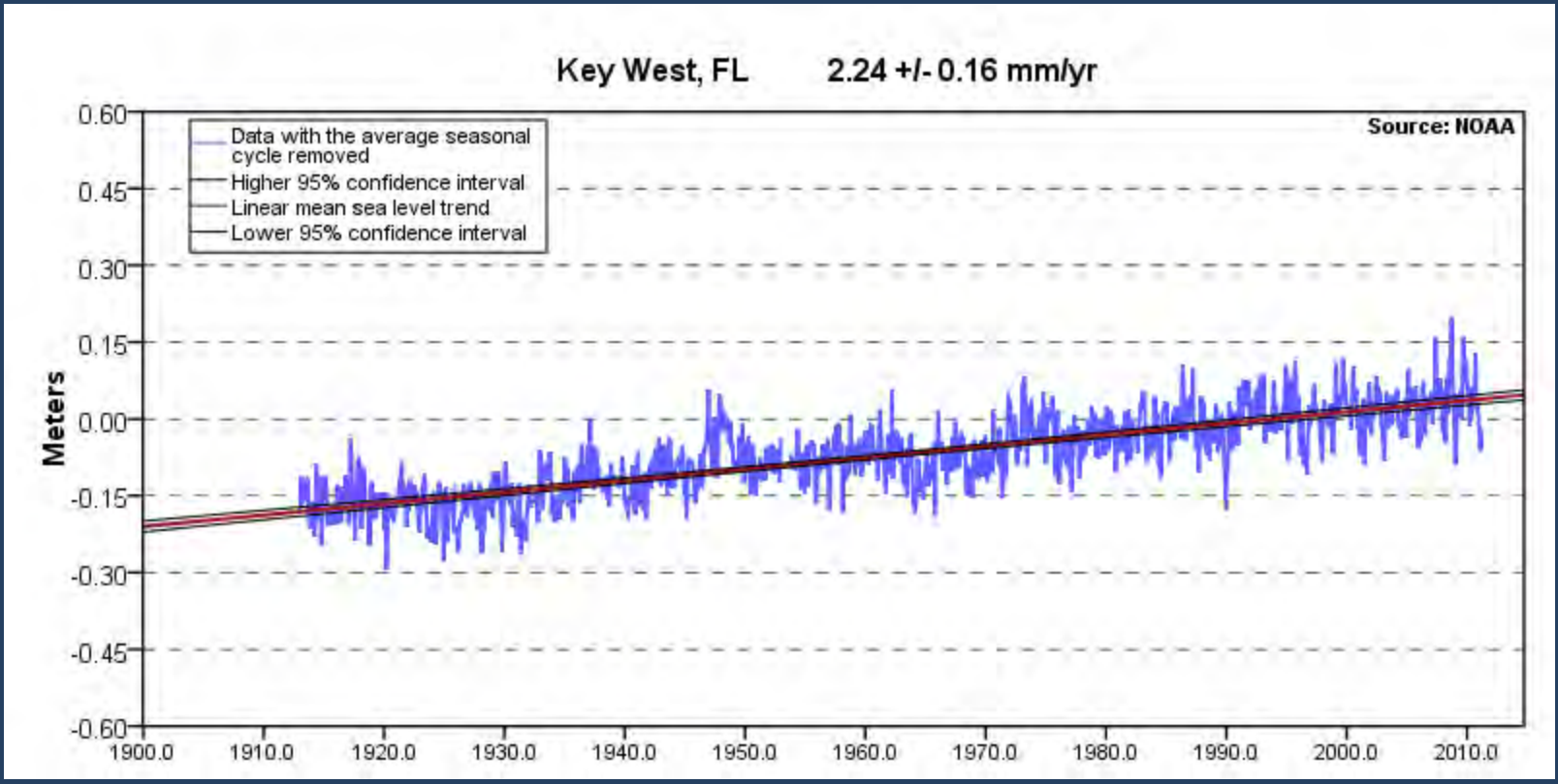
Regional and Global Sea Level

- Tide gauge record at St. Petersburg from about 1950 to 2010, and an older record at Key West from about 1910. San Juan records from NOAA are available since 1962
- For St. Petersburg, the trend over the past 60 years averaged ~2.4 mm/y (about 0.09 inches per year) or about 5.6 inches in 60 years since 1950.
- For Key West, we have an average trend since about 1910 of 2.2 mm/y (if we assume this is the same all along, this would be about 5.2 inches in the last 60 years or 8.7 inches in 100 y)
- In San Juan, Puerto Rico, the trend (1962-2010) is ~ 1.6 mm/yr
- Global average is ~1.7-2.5 mm/y for the last 100 y or so - the farther back you go the fewer tide gauges we have and we start depending on geological data).

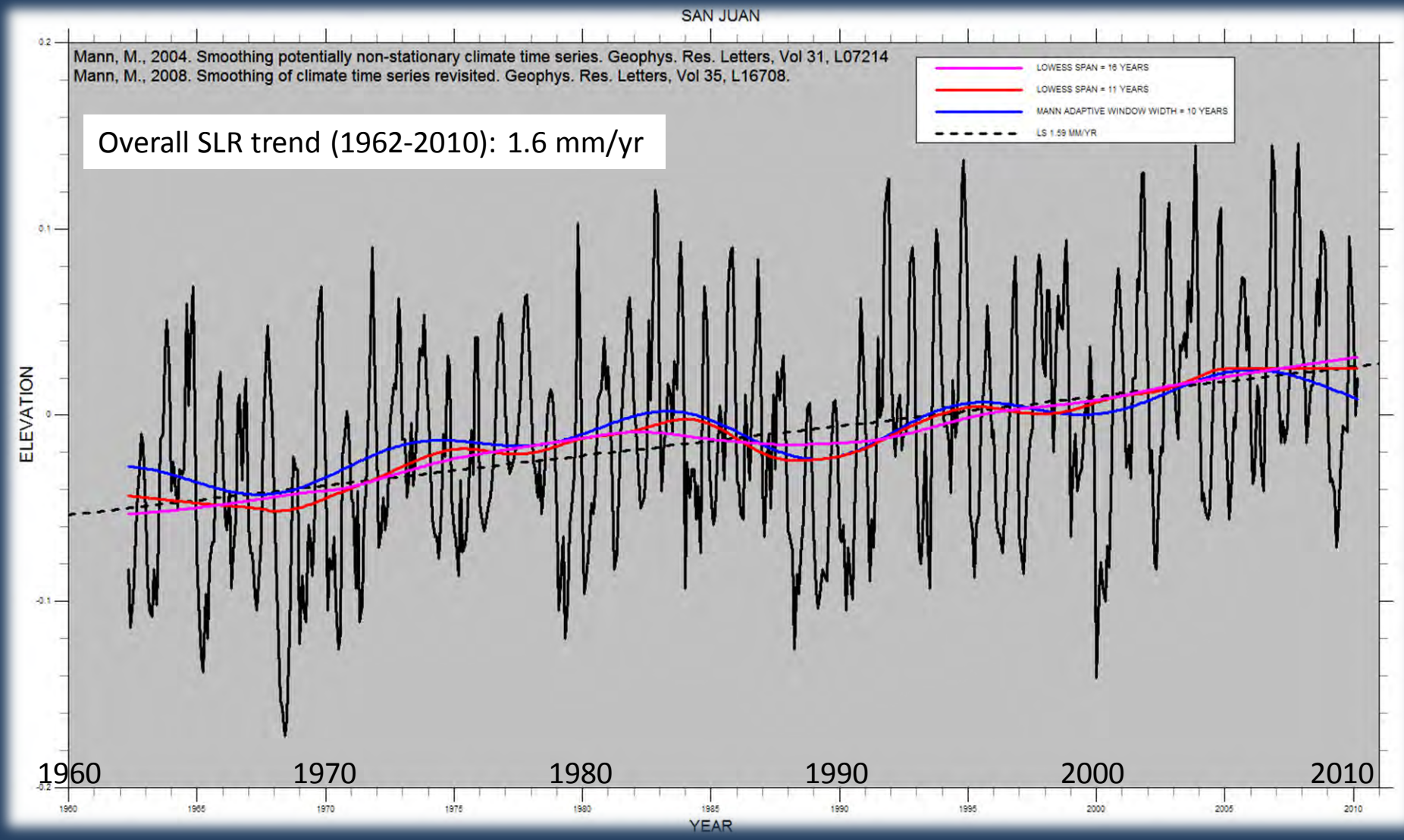
Sea Level at the Coast Guard Station: St Petersburg



Sea Level – Key west

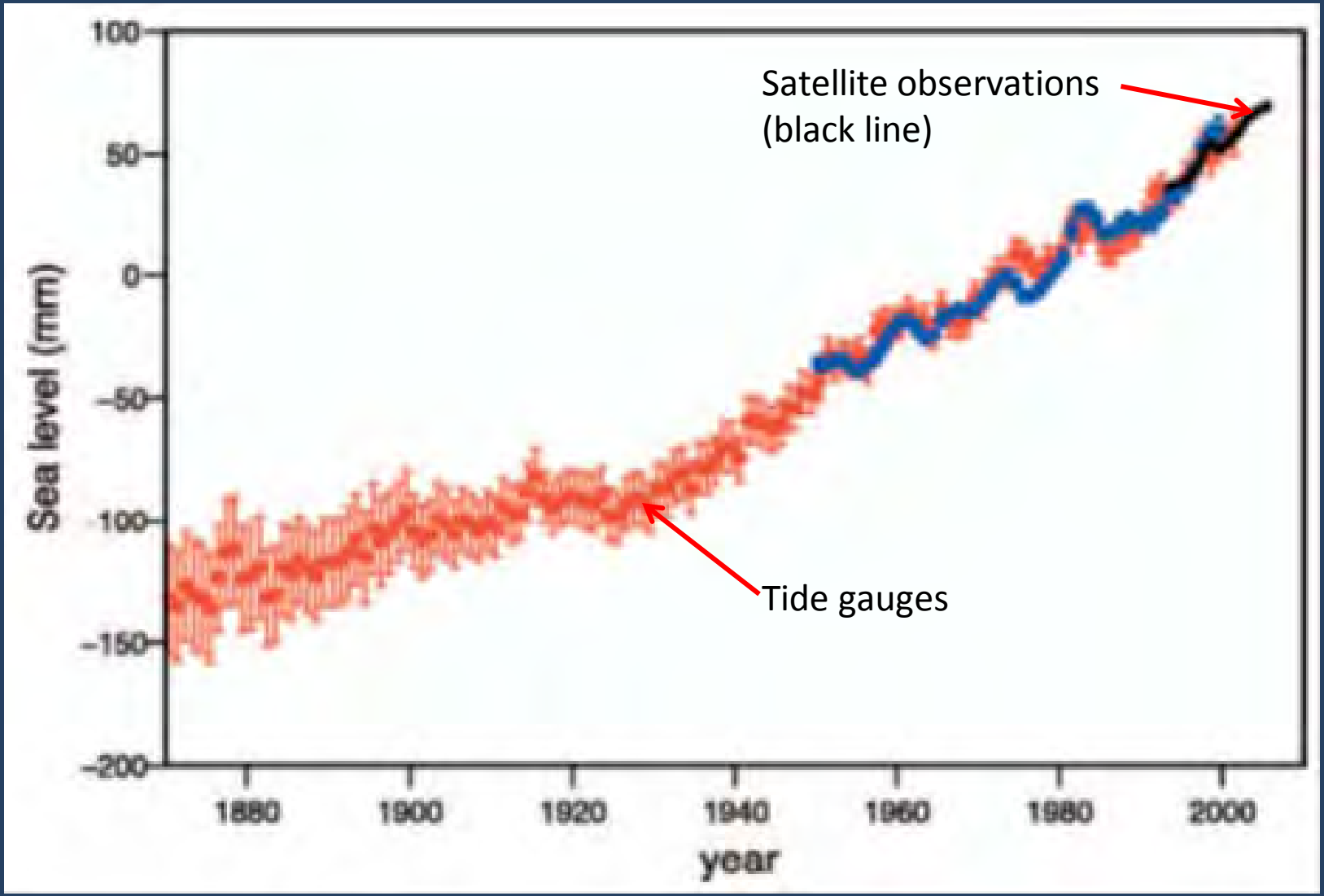


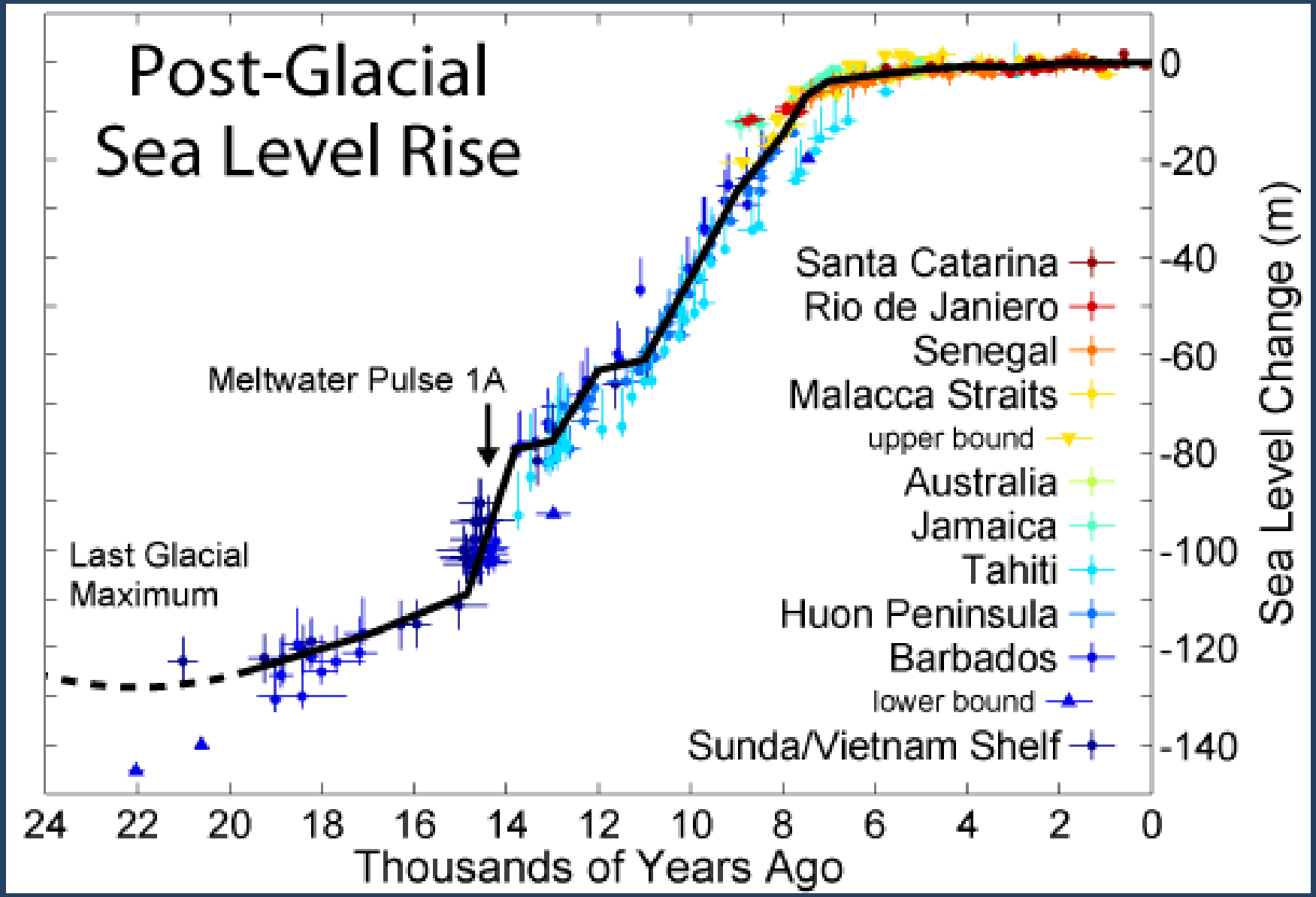
Puerto Rico Sea Level Rise Observations



Sea Level – Global Tide Gauges

Average rate: ~2mm/y over most of 20th century, increasing to >3 mm/y in the past 20-30 y




Post-Glacial
Sea Level Rise
Meltwater Pulse 1A
Last Glacial
Maximum
Santa Catarina
Rio de Janiero
Senegal
Malacca Straits
upper bound
Australia
Jamaica
Tahiti
Huon Peninsula
Barbados
lower bound
Sunda/Vietnam Shelf
0
-20
-40
-60
-80
-100
-120
-140
Sea Level Change (m)
24
22
20
18
16
14
12
10
8
6
4
2
0
Thousands of Years Ago

Studies commissioned for Florida

Climate Scenarios: A Florida-Centric View
A White Paper on Climate Scenarios for Florida

November 2011

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Sea Level Changes in the Southeastern United States
Past, Present, and Future

By Gary T. Mitchum, University of South Florida

August 2011

Florida Climate Institute

Southeast Climate Consortium

IPCC 2007 projection:
+20-60 cm by 2100

There is concern, expressed by the IPCC that:

-Ocean water has warmed about 0.1C in the last century and it will continue to warm

(if upper 1,000 m of most of the ocean warm up by 1C, sea level will rise by ~50 cm)

-Glacial melt rates were not known and likely underestimated

-Antarctic ice loss rates are not well known but may be high

So, an estimate of SL rise including these "dynamic effects" is +40-80 cm by 2100

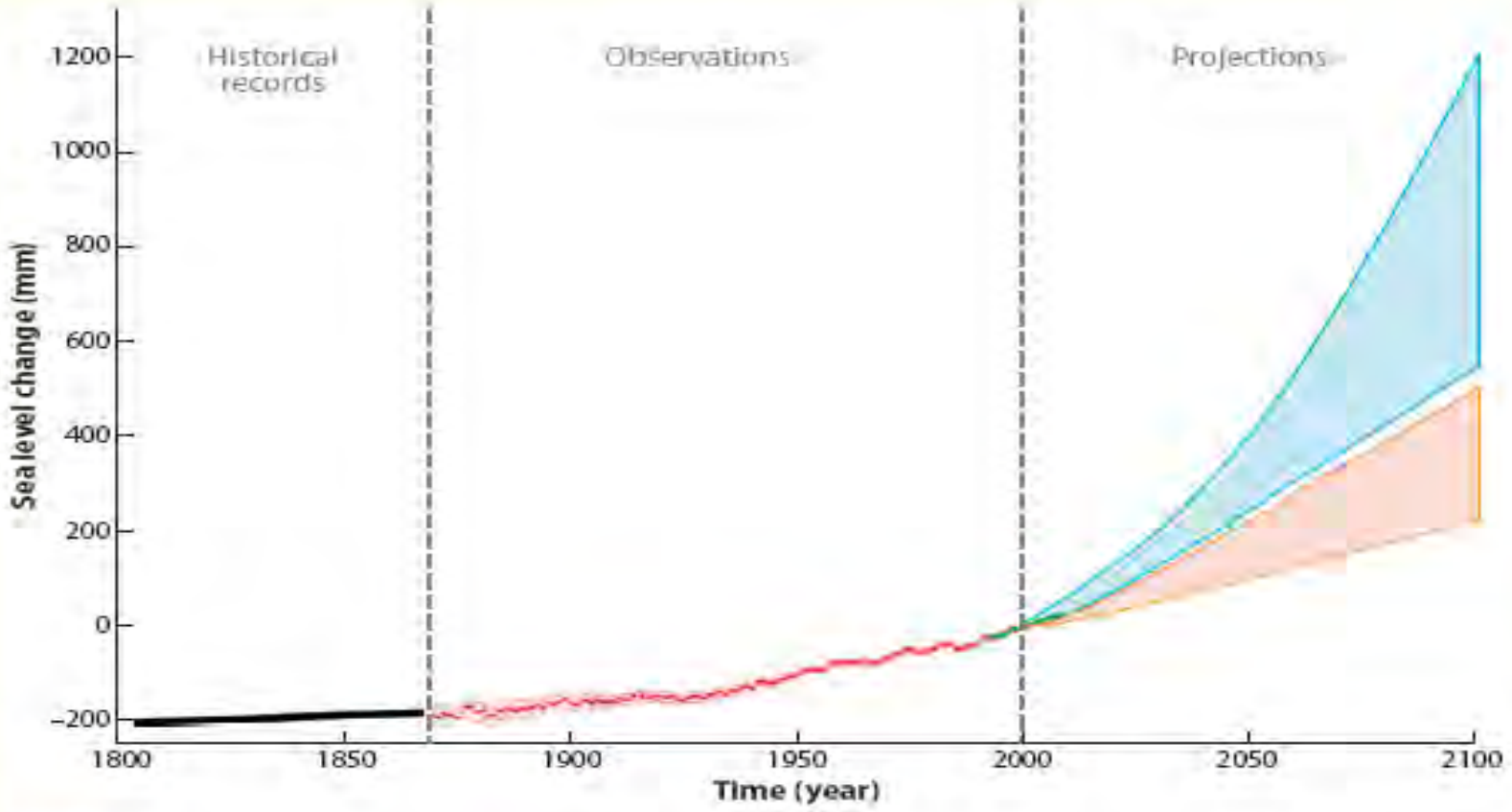
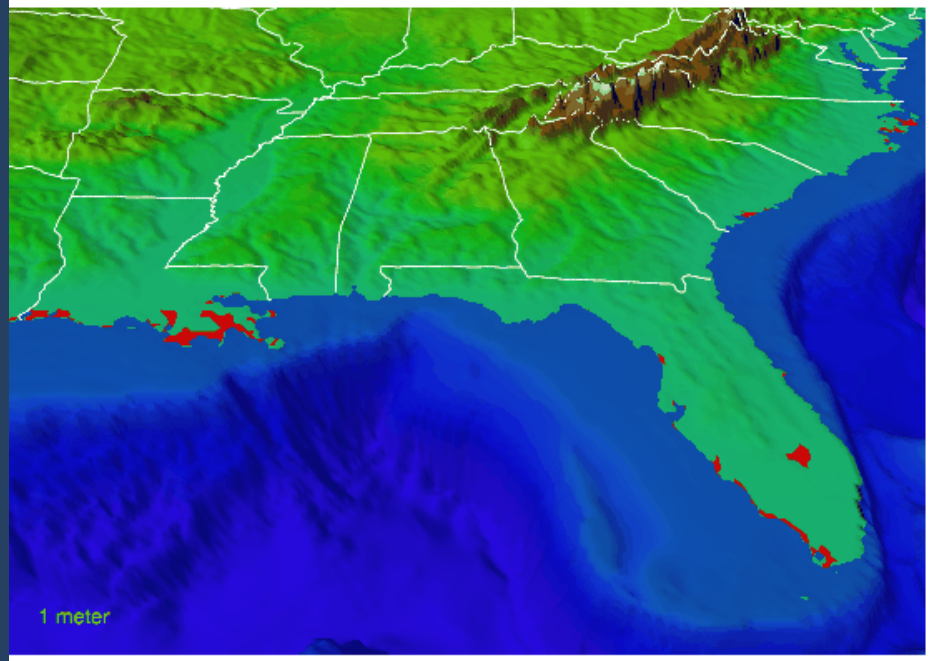


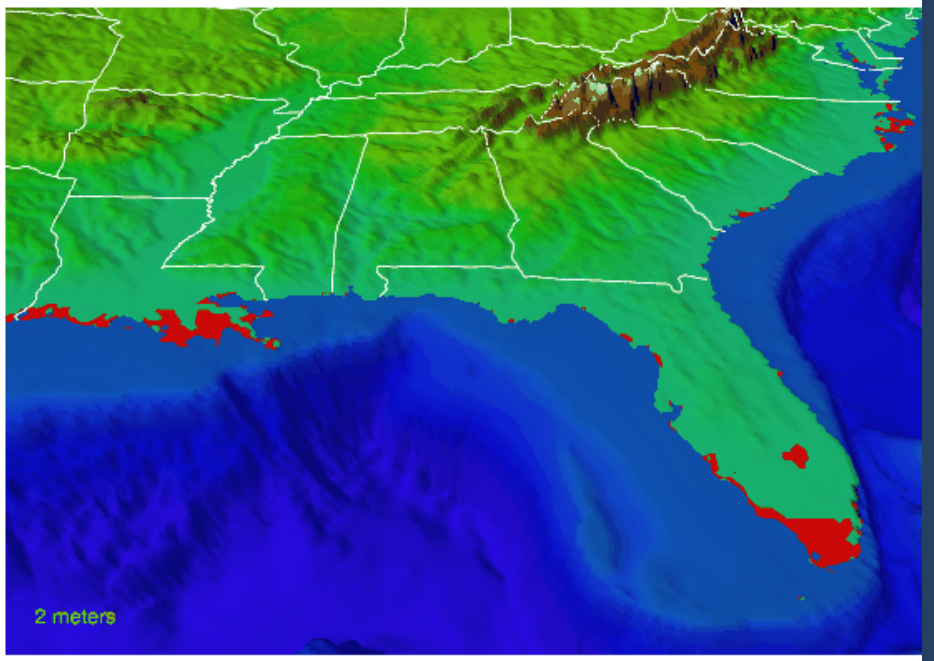
Figure 11

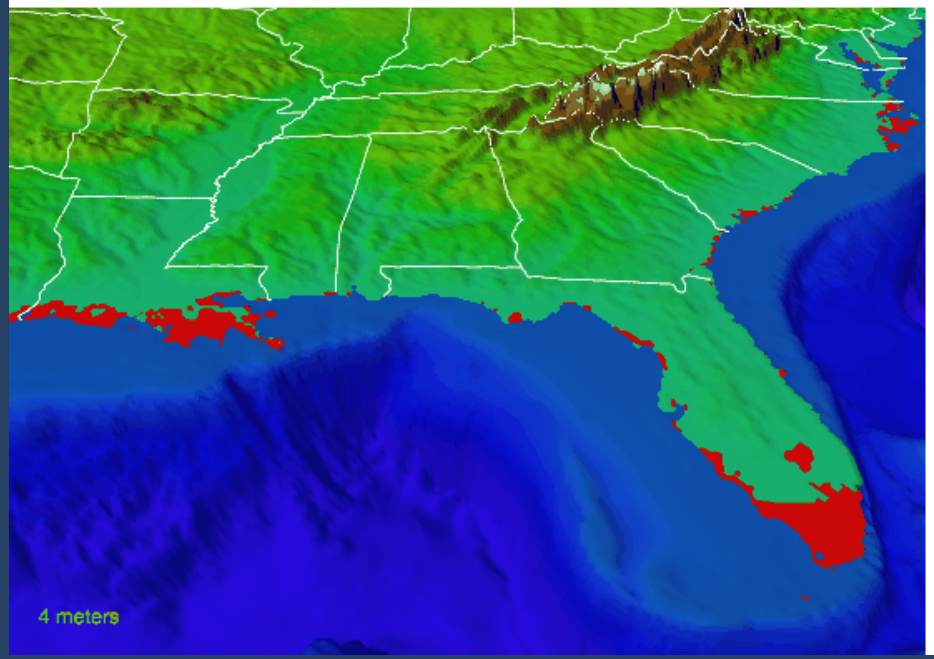
Evolution of the global mean sea level between 1800 and 2100 from observations (for the nineteenth and twentieth centuries) and model projections for the twenty-first century. The thick black line represents the long-term sea level based on various observations for the nineteenth century. The red line is based on tide gauge data (from Church et al. 2004). The green line is from satellite altimetry since 1993. The pink shaded region includes projections from coupled climate models [from IPCC (2007) AR4]. The light blue shaded region includes projections from Rahmstorf (2007).

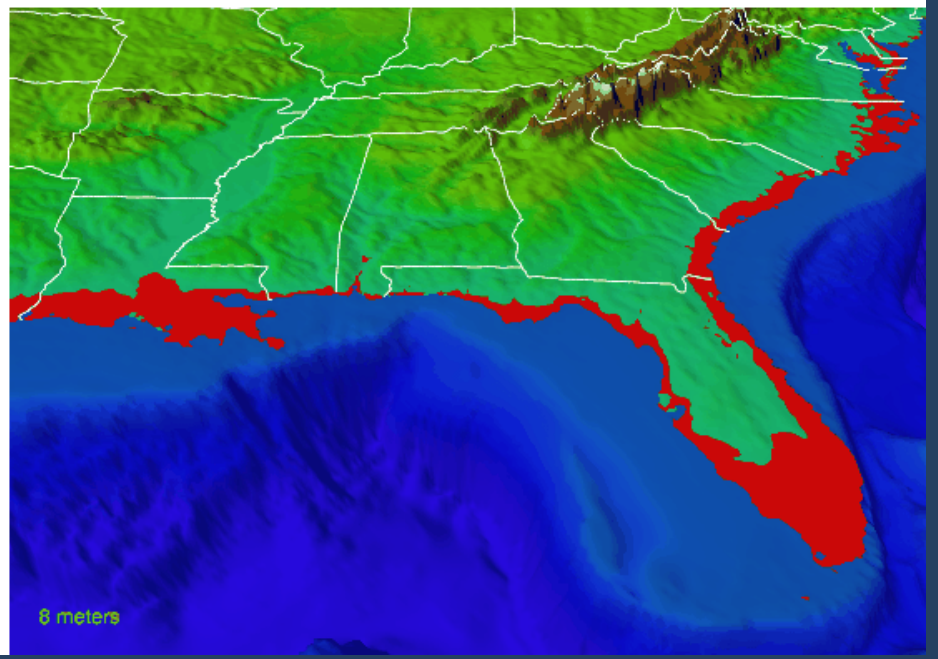
Contemporary Sea Level Rise. Anny Cazenave and William Llovel. Annu. Rev. Mar. Sci. 2010. 2:145–73

Sea Level Rise









Sea Level Rise Mapping

- Provides a 2D or 3D visualization of likely outcomes.
- Makes planning possible.
- Provides data for adaptation studies.
- Can be used as a foundation for detailed models.

Sea Level Rise Mapping Challenges

- Only as good as the elevation data.
  Bathtub type layering – not a true hydrological model.

- Does not show human responses.

- Requires careful mapping of land use, habitats, ecosystem services, valuation of these services

- Does not show natural changes resulting from coastal processes.

- Scares some people.

Example: Tampa Bay Area

- National Elevation Dataset
  - USGS
  - National Elevation Dataset 1/3 Arc-Second (NED 1/3)
  - 10m horizontal resolution
- Projection
  - GCS_North_American_1983
  - Datum: D_North_American_1983

San Juan, Puerto Rico Projections:

Metro Area Sea Level Rise 2 Meters Flood / Aumento de Nivel del Mar 2 Metros Área Metro

Important Notes:
Notas Importantes:

J E Hansen, 2007. Scientific reticence and sea level rise. Environmental Research Letters, Vol. 2: 1-6

J. Hansen y 47 co-autores mas, 2007. Dangerous human-made interference with climate: a GISSmodelE study. Atmos. Chem. Phys. Vol. 7: 2287-2312.

Mercado, A., 2008. Desarrollo costero en Puerto Rico Situación no sostenible.pdf, Capítulo II: Subida del nivel del mar: causa y evidencia. Disponible en ftp://136.145.125.20/Public/Aurelio_Mercado/Desarrollo%20costero%20en%20Puerto%20Rico-Situacion%20no%20sostenible.pdf

Church, J.A., E. N. J.White, T. Aarup, W. S. Wilson, P. L. Woodworth, C. M. Domingues, J. R. Hunter, and K. Lambeck, 2008. Understanding global sea levels: past, present and future. Sustainable Science, Vol. 3:9-22.

Pfeffer, W. T., J. T. Harper, and S. O. O'Neal, 2008. Kinematic constraints on glacier contributions to 21st-century sea-level rise. Science, Vol. 321:1340-1343.

Martin Redfern, 15 February 2008. Antarctic glaciers surge to ocean. Rothera Research Station, Antarctica. BBC News.

2008. U.S. Climate Change Science Program, Synthesis and Assessment Product 4.1: Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. U.S. Environmental Protection Agency, U.S. Geological Survey, NOAA.

Karin Strohecker, 15 April 2007. World Sea levels to rise 1.5m by 2100. European Geosciences Union conference. Reuters.

Topografía obtenida mediante tecnología LIDAR en el año 2006.
Topography obtained through LIDAR Technology in 2006.

Fecha foto aérea: diciembre 2006.
Date of aerial photo: December 2006 .

Proyección Cartográfica: North American Datum 1983.
Projection: North American Datum 1983.

Elevación esta referida al Nivel Promedio de la Marea Alta.
Elevation referred to the Mean High Water.

Límite Municipal obtenido de la Junta de Planificación de Puerto Rico.
Municipality Boundaries obtained from the Puerto Rico Planning Board.

Fuente de datos para inundación por aumento en el nivel del mar:
Sea Level Rise Flood Data Source by:

La penetración de la mar mostrada es un estimado conservador, ya que no incluye el efecto combinado del aumento en el nivel del mar junto a la erosión y la pérdida de terreno resultantes.
Depicted sea penetration is a conservative estimate, since it does not include the combined effect from sea level rise and the resulting erosion and loss of land.

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Legend / Leyenda

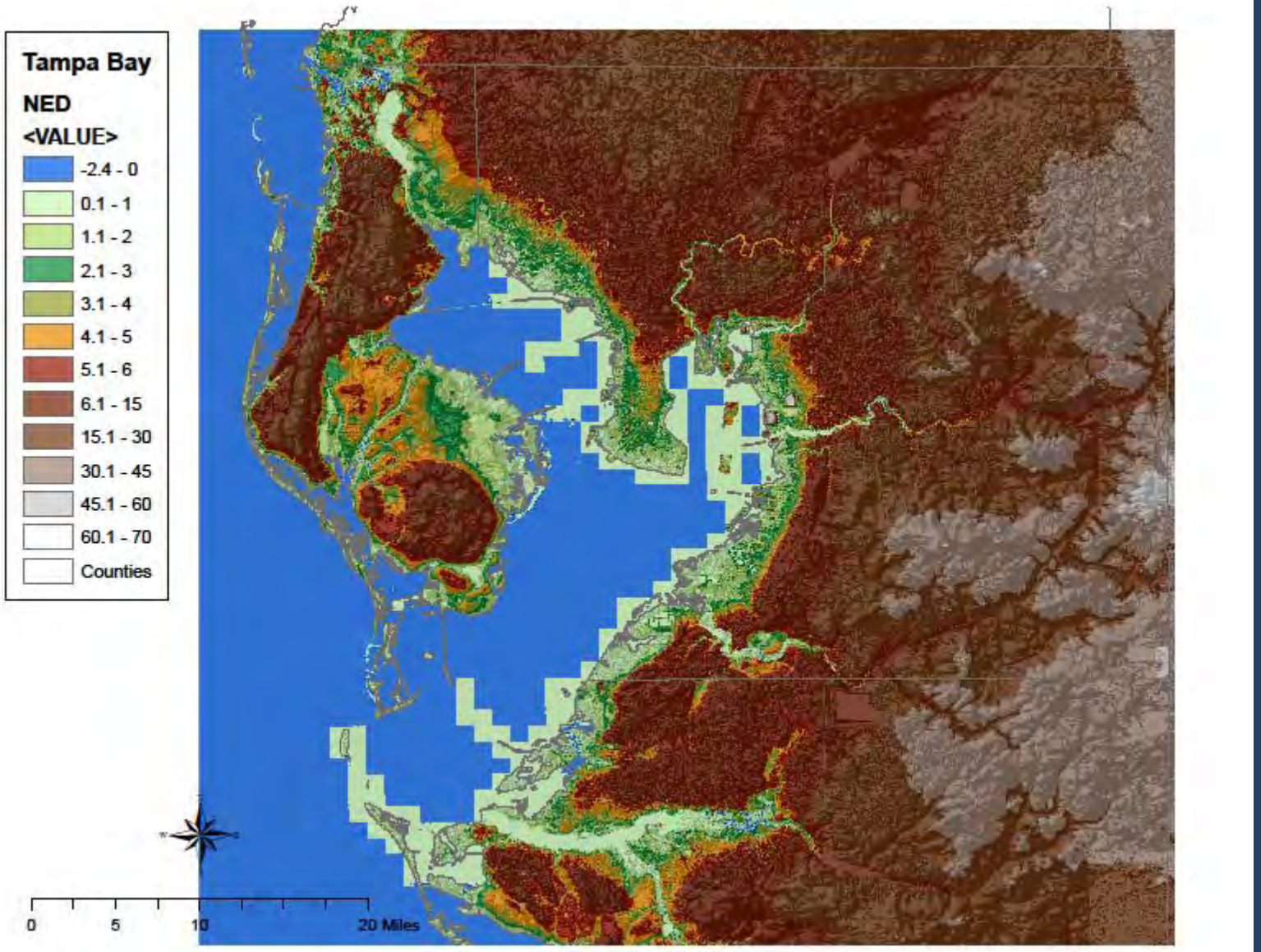
- Flood Zone / Inundación 2 MTS
- Airport / Aeropuerto
- Highway/Expreso
- Hotel / Hotel
- Marina / Marina
- State Road / Carretera Estatal
- Tourist Port / Muelle Turístico

0 0.25 0.5 1 1.5 2
Miles

0 0.5 1 2 3 4
Kilometers

Ponce, Puerto Rico, Projections:

Mayaguez Area Projections: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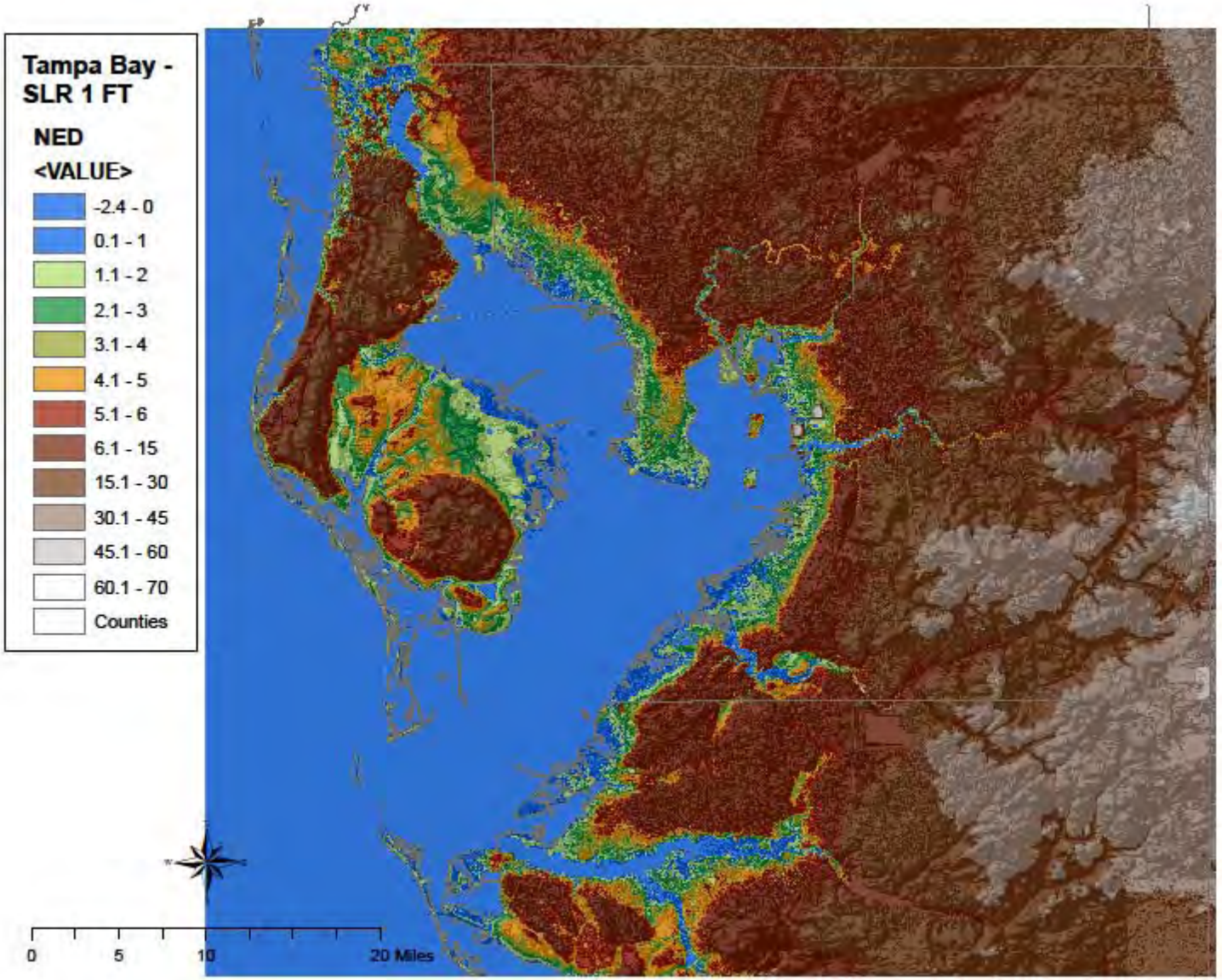
0.1 - 1
1.1 - 2
2.1 - 3
3.1 - 4
4.1 - 5
5.1 - 6
6.1 - 15
15.1 - 30
30.1 - 45
45.1 - 60
60.1 - 70
Counties
0
5
10
20 Miles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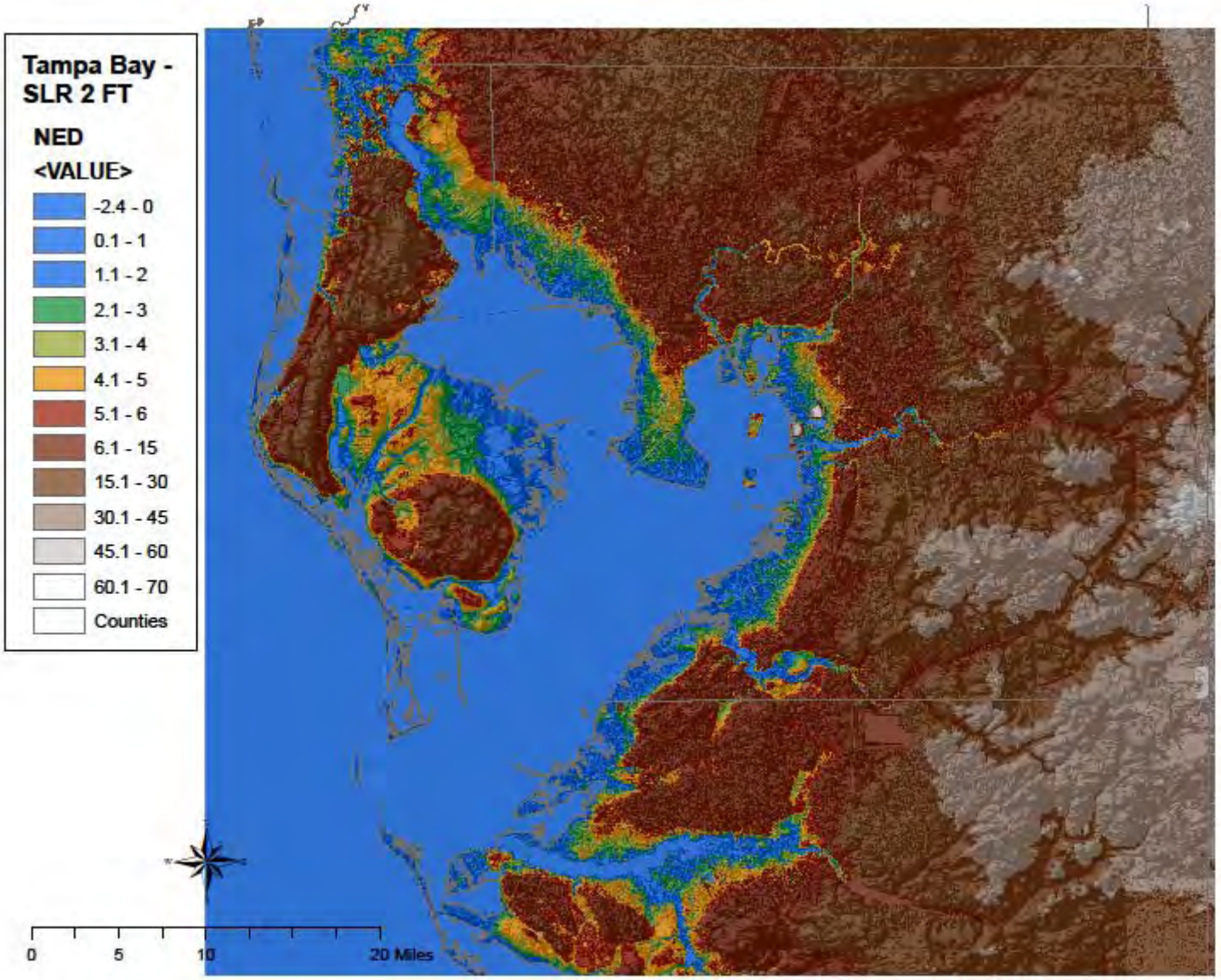
15.1 - 30
30.1 - 45
45.1 - 60
60.1 - 70
Counties
0
5
10
20 Miles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15.1 - 30
30.1 - 45
45.1 - 60
60.1 - 70
Counties
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5
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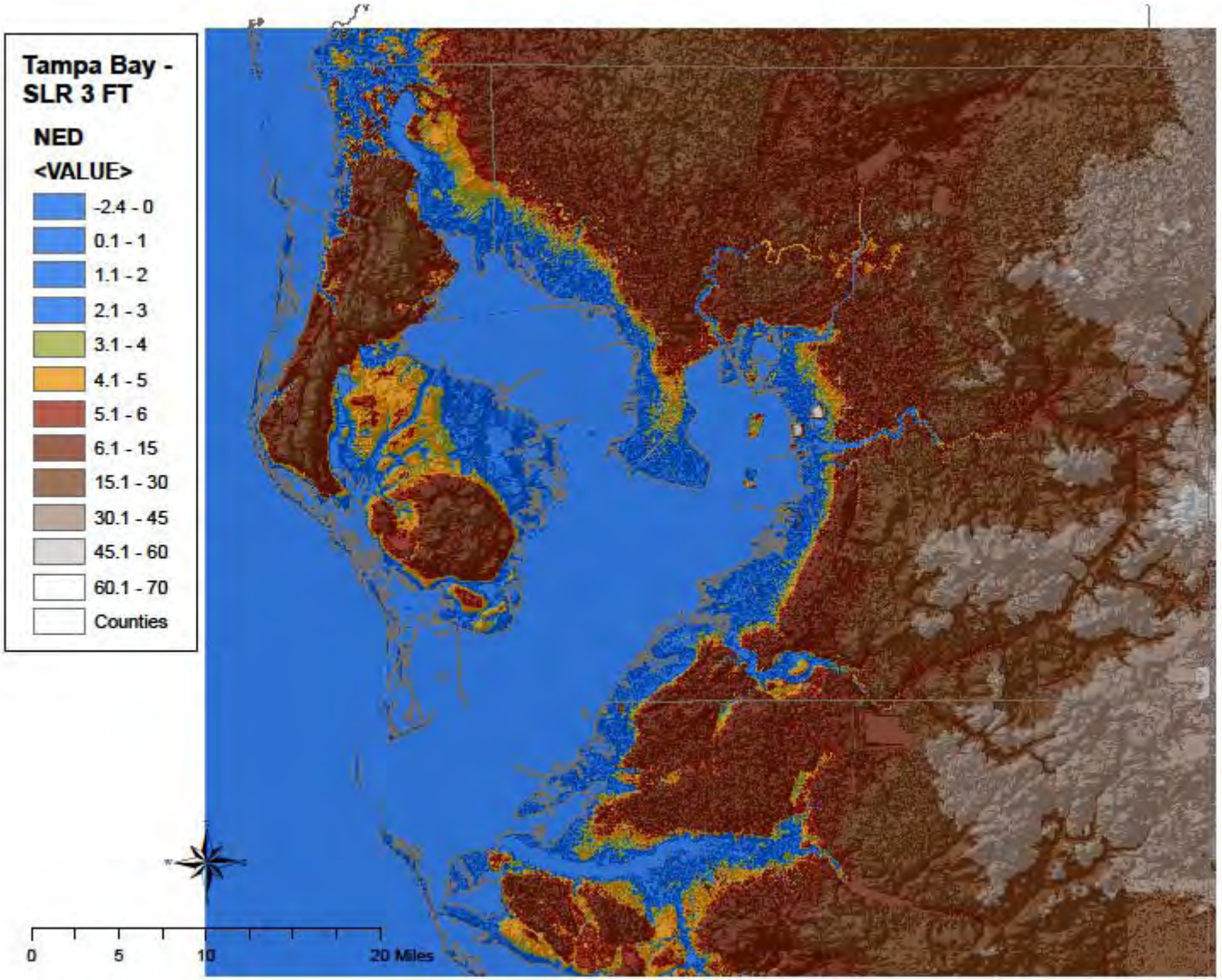
20 Miles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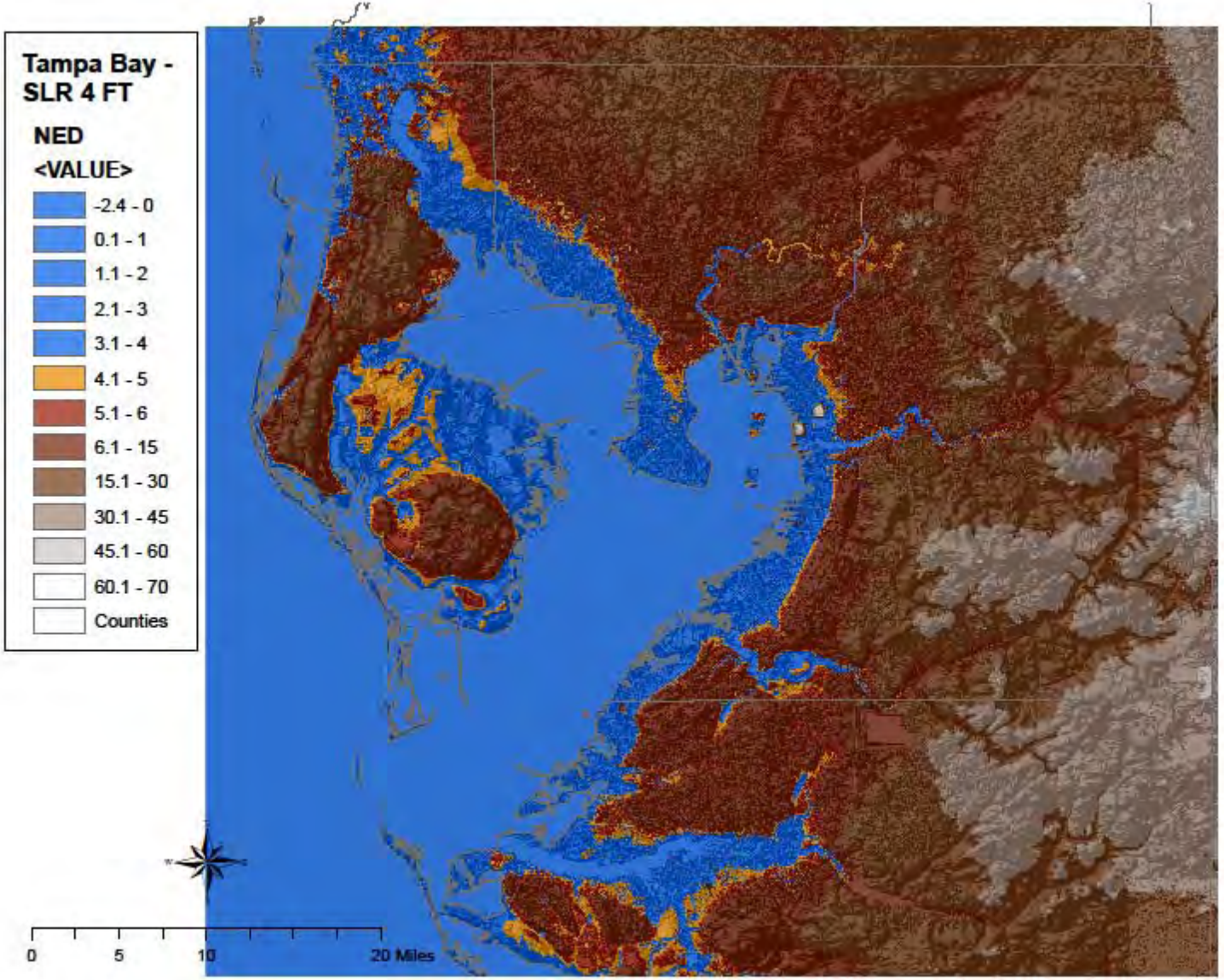
15.1 - 30
30.1 - 45
45.1 - 60
60.1 - 70
Counties
0
5
10
20 Miles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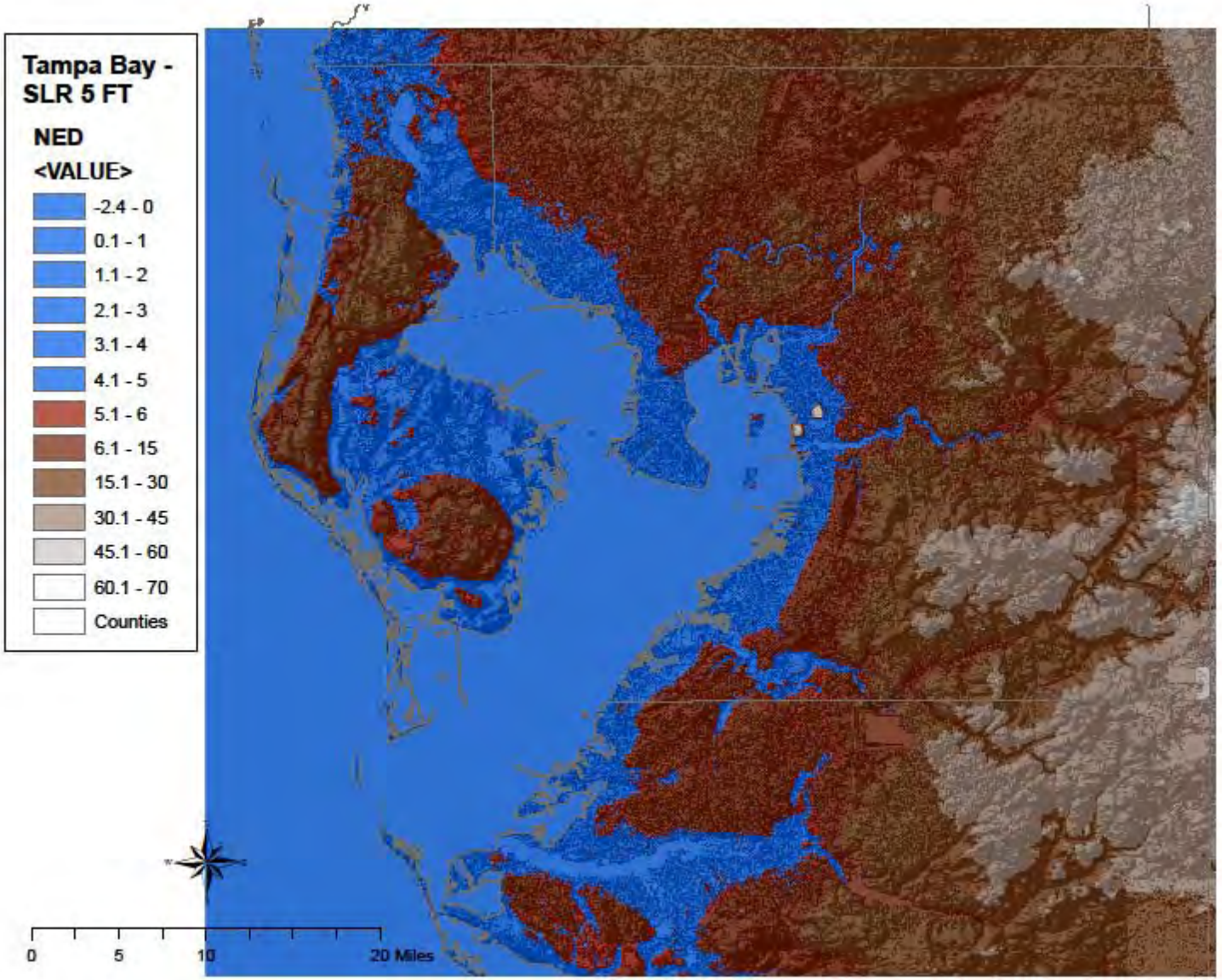
4.1 - 5
5.1 - 6
6.1 - 15
15.1 - 30
30.1 - 45
45.1 - 60
60.1 - 70
Counties
0
5
10
20 Miles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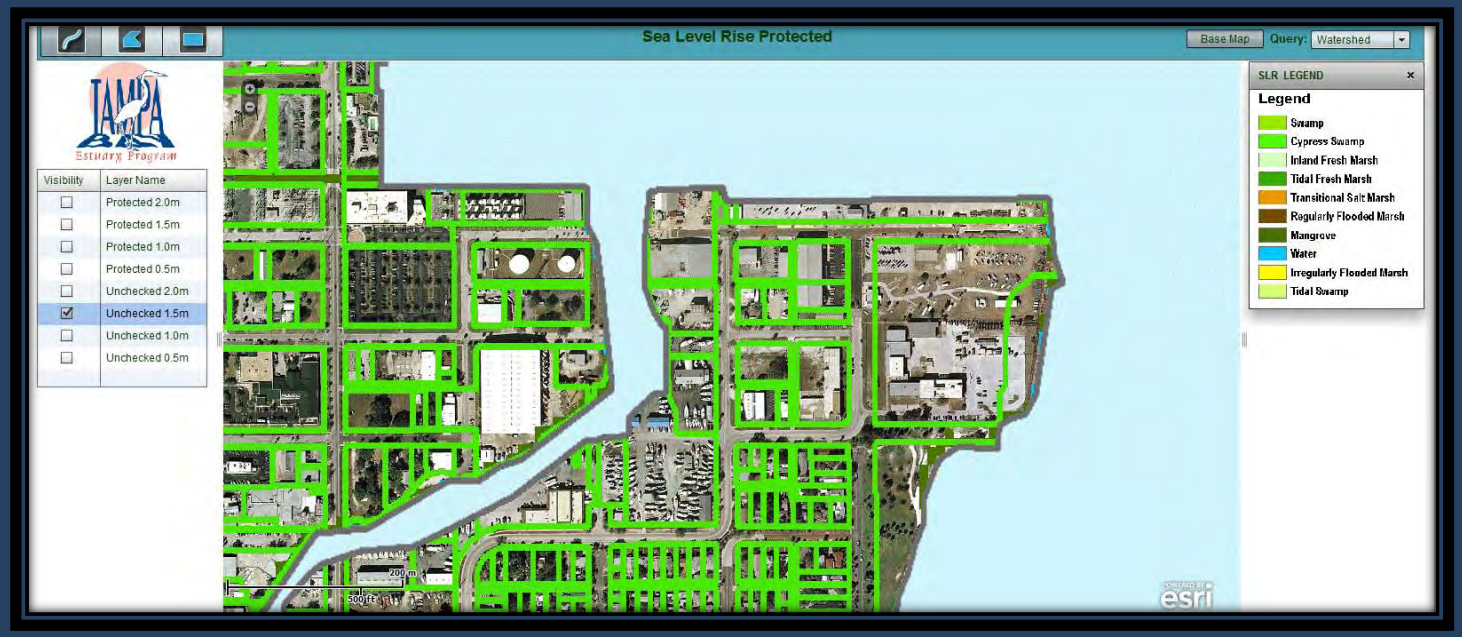
5.1 - 6
6.1 - 15
15.1 - 30
30.1 - 45
45.1 - 60
60.1 - 70
Counties
0
5
10
20 Miles

National Estuary Program/NEP-Tampa Bay Estuary Program and Tampa Bay Regional Planning Council

(Courtesy of Holly Greening and Lindsay Cross)

Tool to depict local effects of sea level rise scenarios on Tampa Bay coastline and habitats

Overlays of the built environment, wetlands, utilities, remote sensing images, and various future sea level scenarios

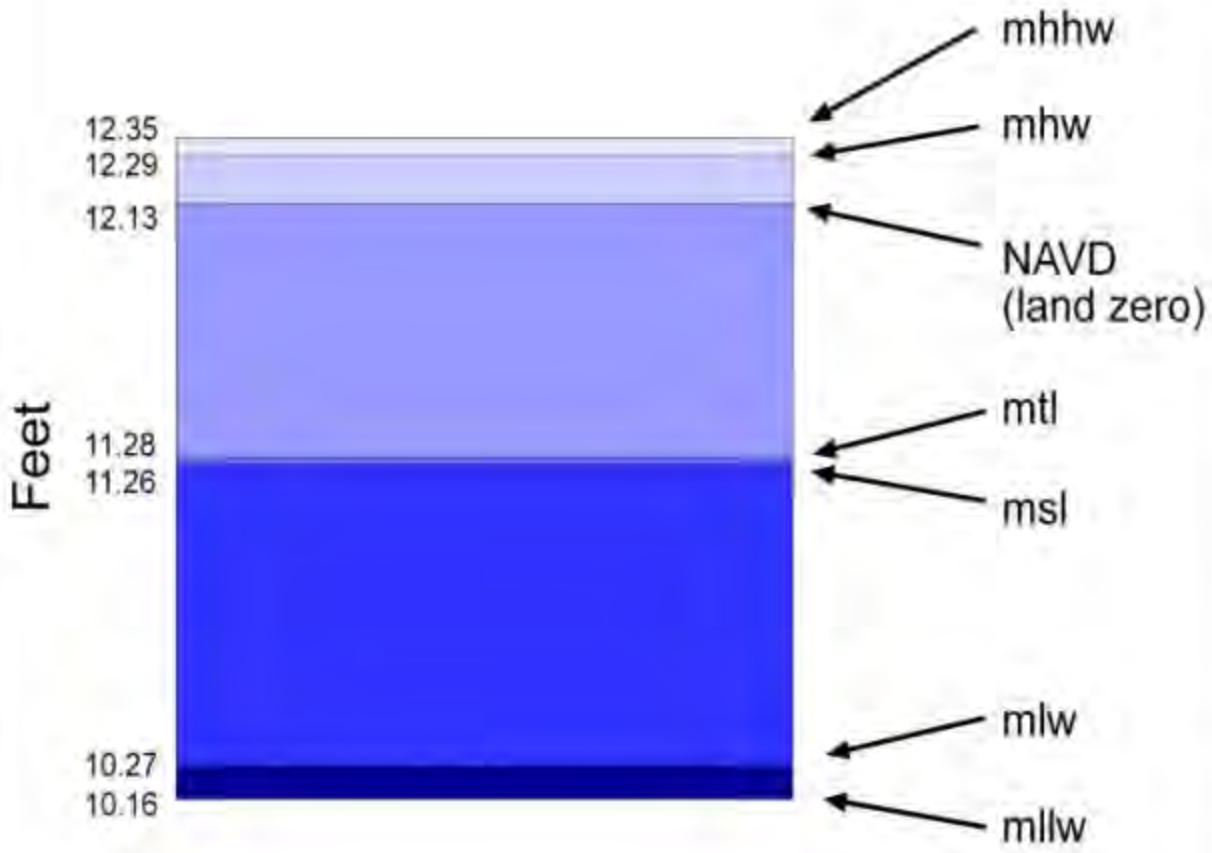


In order to make maps like you have just seen we must understand both the tidal prism

and

the elevation of the ocean versus the land.

Ocean Height



NOAA tidal prism

Data for a tide gauge station.

mhhw= mean higher high water.

mhw = mean high water.

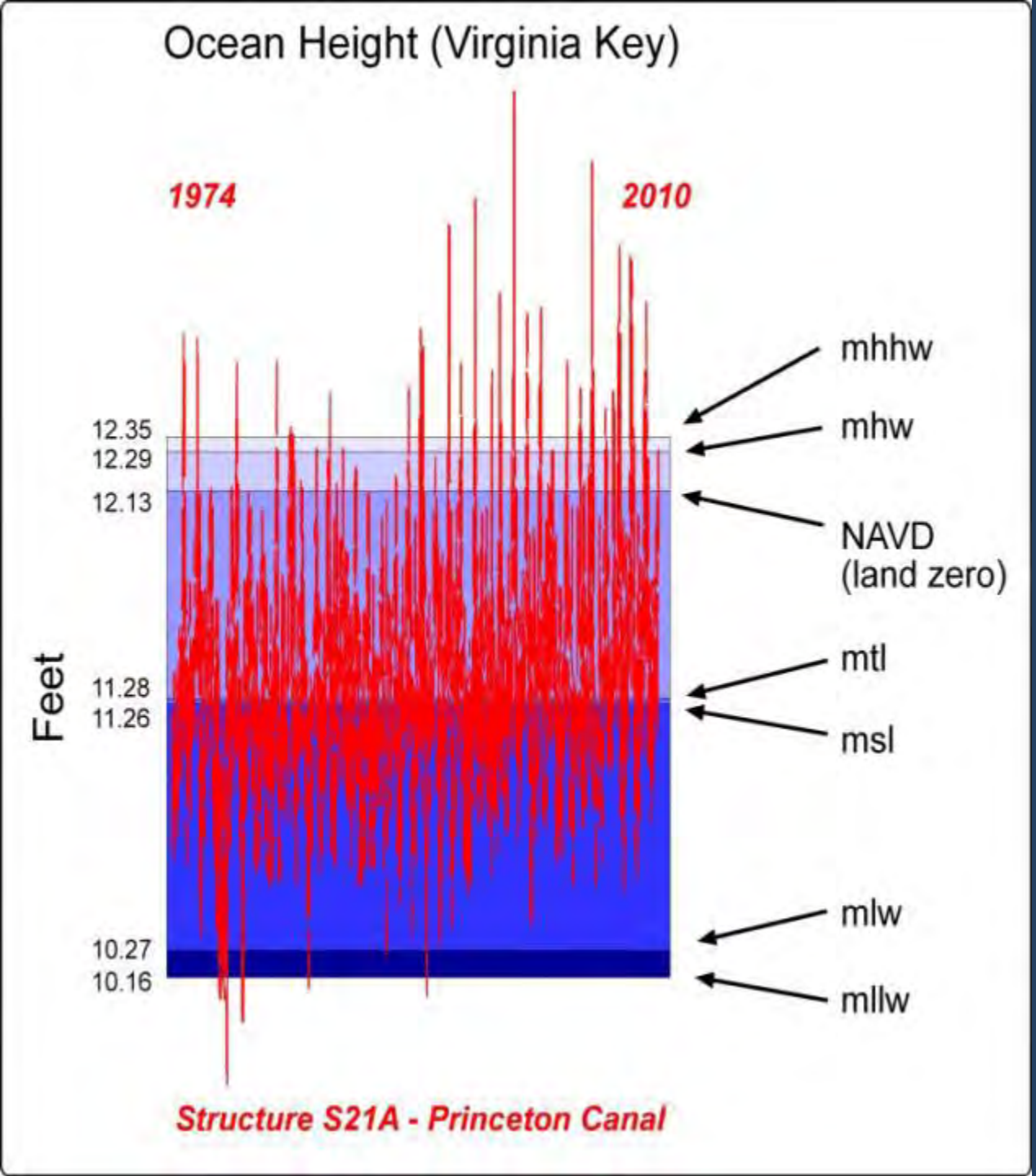
NAVD = the 1988 geoid datum ‘s zero elevation.

mtl = mean tide level.

msl = mean sea level.

mlw = mean low water.

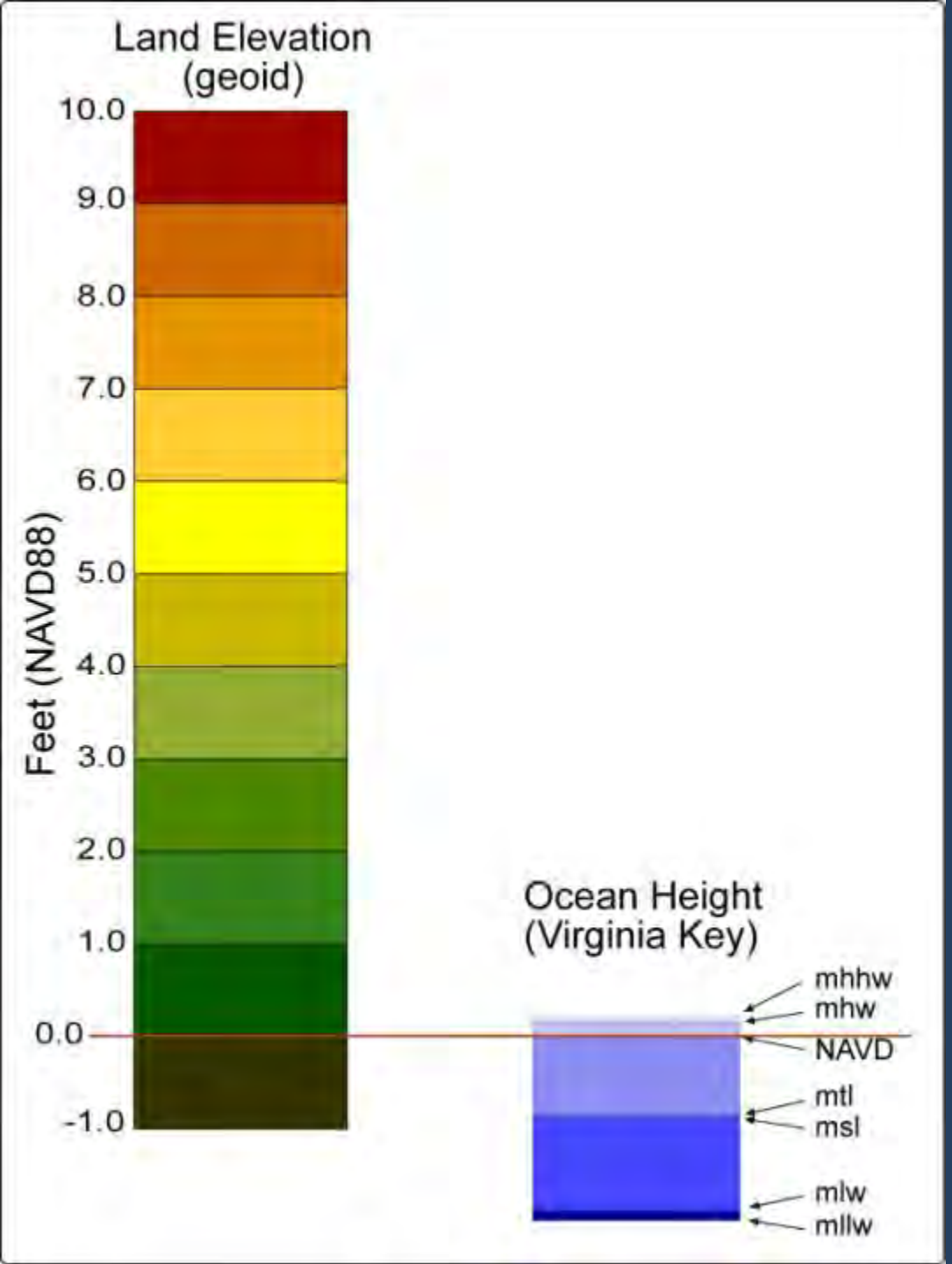
mllw = mean lower low water.



SFWMD data for the ocean side (tidewater) of canal structure S21A, the salt barrier located at the mouth of Princeton Canal.

Data shown are daily average water levels from 1974 to 2010.

Note that the ocean sometimes exceeds the calculated tidal prism values!

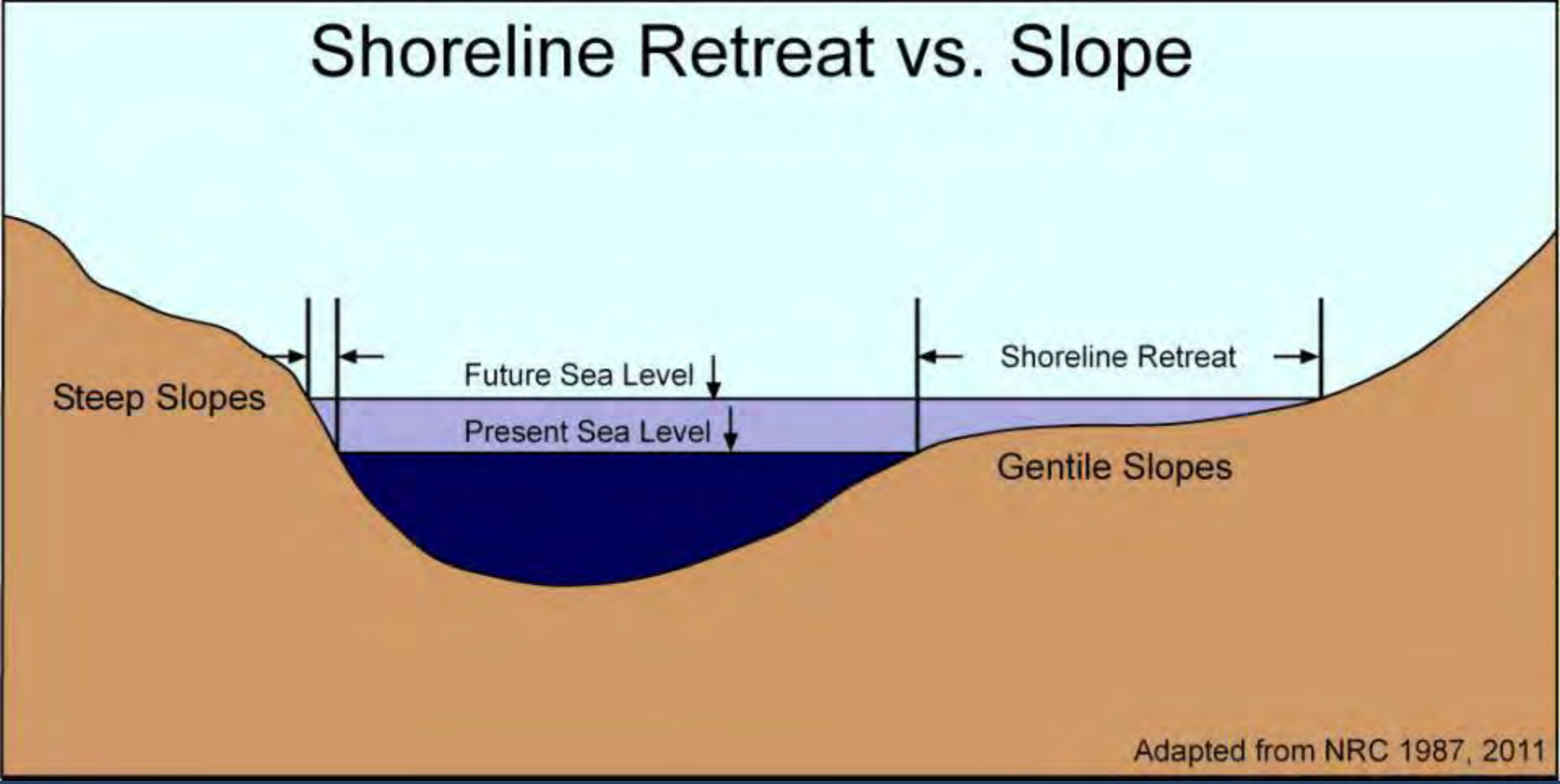


Fitting the ocean to the land.

The NAVD elevation of the tidal prism lines up with the zero elevation on the land elevation (the earth's geoid)

Note that the tidal prism is local. That means the tidal prism for Virginia Key is not the same size or elevation as the ones at Key West or Cape Cod!

As sea level rises, the tidal prism will rise a corresponding amount. However we must be aware that the tidal prism will probably change too as the depth of the ocean and bays increases.



The land slope determines how much land we will lose with each increment of sea level rise.

We can examine our local slope by means of a hypsographic curve made from the LiDAR DEM data.

Please Remember – these maps do not show the effects of severe storms acting in conjunction with elevated sea levels.

Recommendations

- Maintain a robust regional network of accurate tide gauge stations
- Develop regional coastal ecosystem valuation programs
- Integrate with accurate digital elevation models and maps of land use
- Work with communities, planners and engineers to develop plans for the ‘built environment’

Thank You

http://cacce.net