Managing sea level rise to the year 2100 and beyond in the State of Florida, U.S.A.

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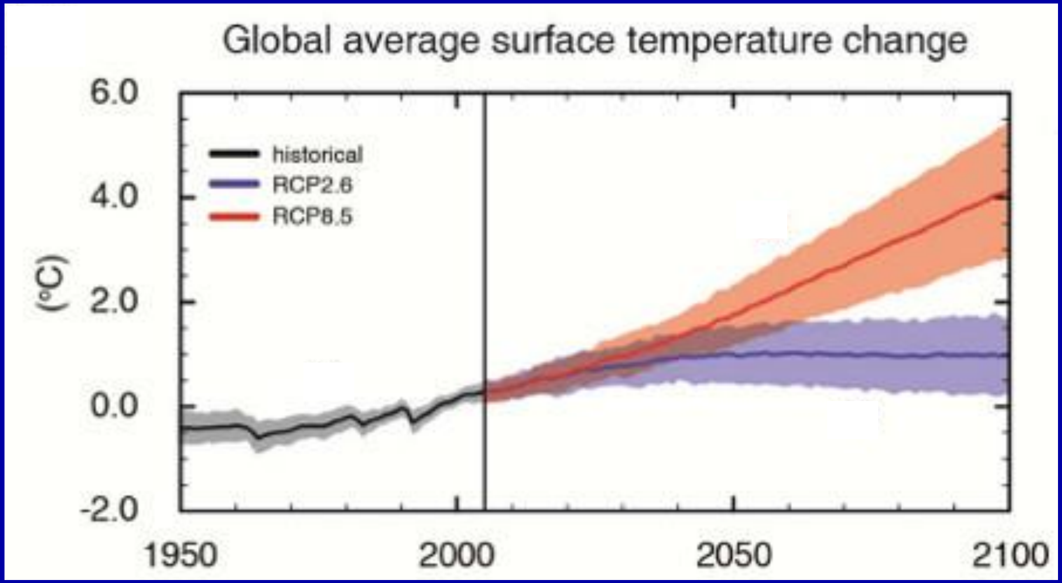
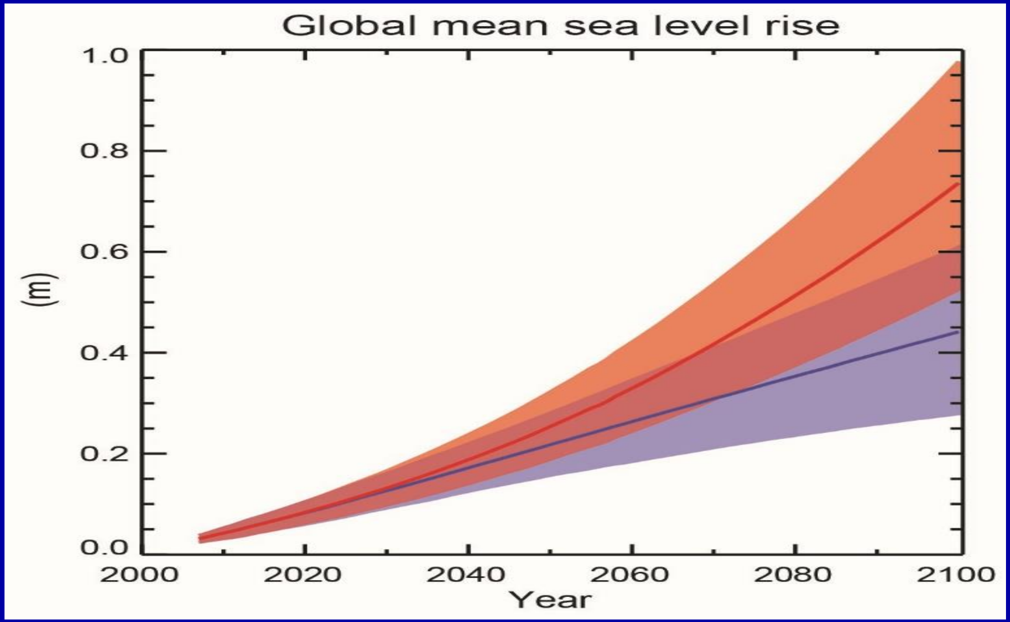
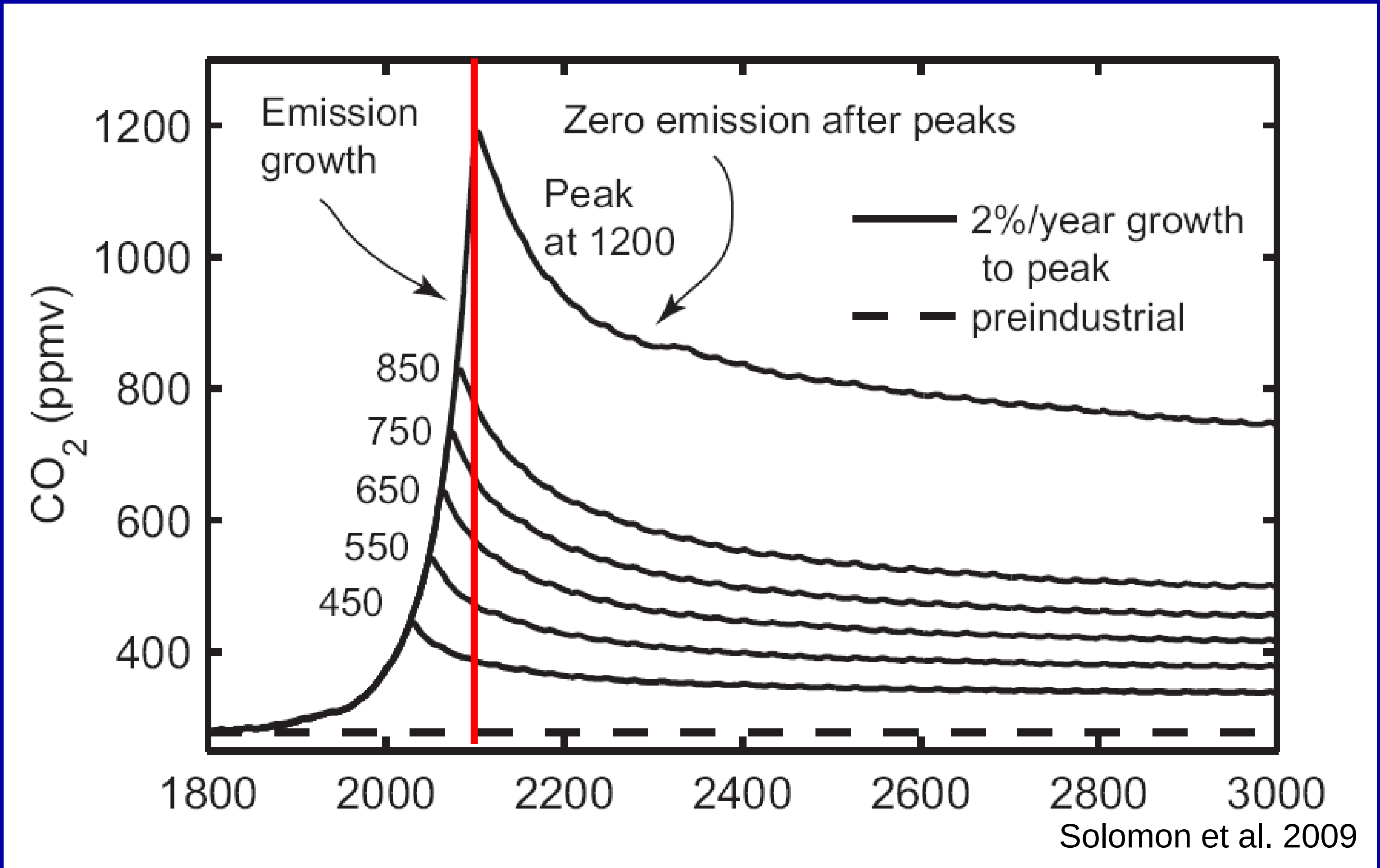
Miami Beach, Florida, September 29, 2015

(Photo by Joe Raedle/Getty Images)

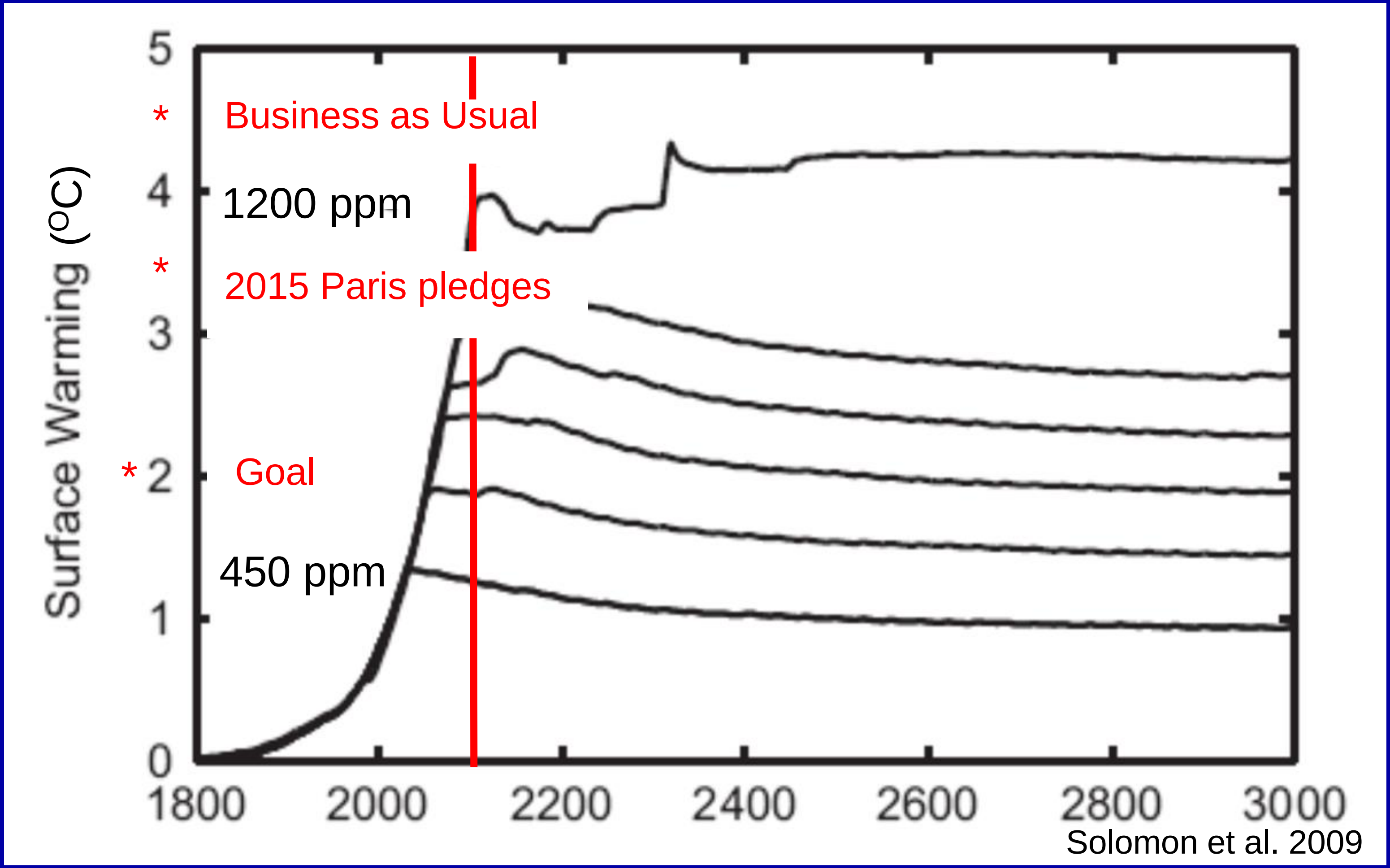

Global average surface temperature change
6.0
4.0
2.0
0.0
-2.0
(°C)
historical
RCP2.6
RCP8.5
1950
2000
2050
2100

IPCC 2014

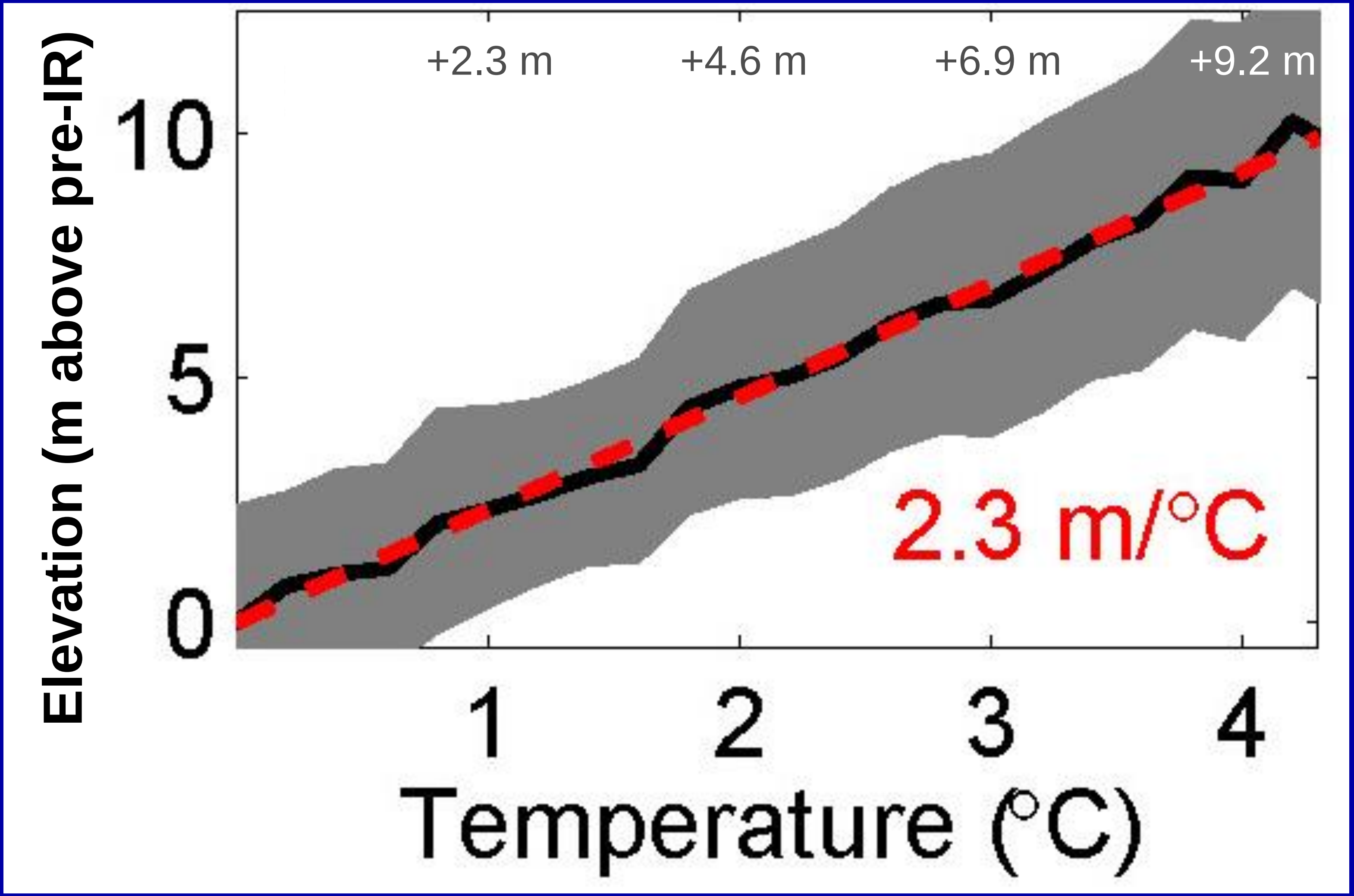

Global mean sea level rise
1.0
0.8
0.6
0.4
0.2
0.0
(m)
2000
2020
2040
2060
2080
2100
Year



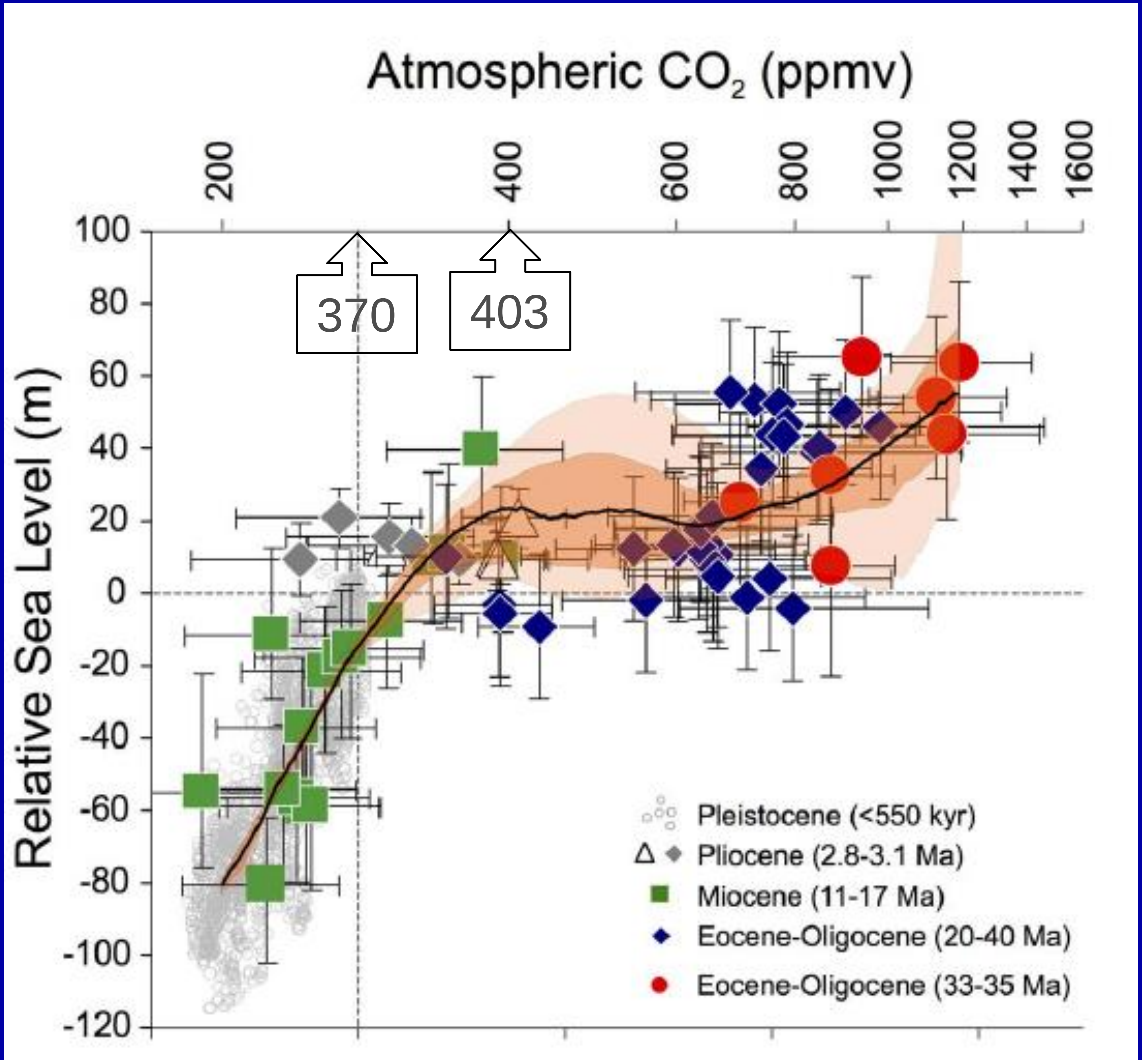
Carbon dioxide changes relative to preindustrial (280 ppm) conditions.



Warming associated with carbon dioxide changes.



Total sea level commitment per degree of warming. Includes ocean warming, mountain glaciers and ice caps, Greenland and Antarctic ice sheets (Levermann et al. 2013)



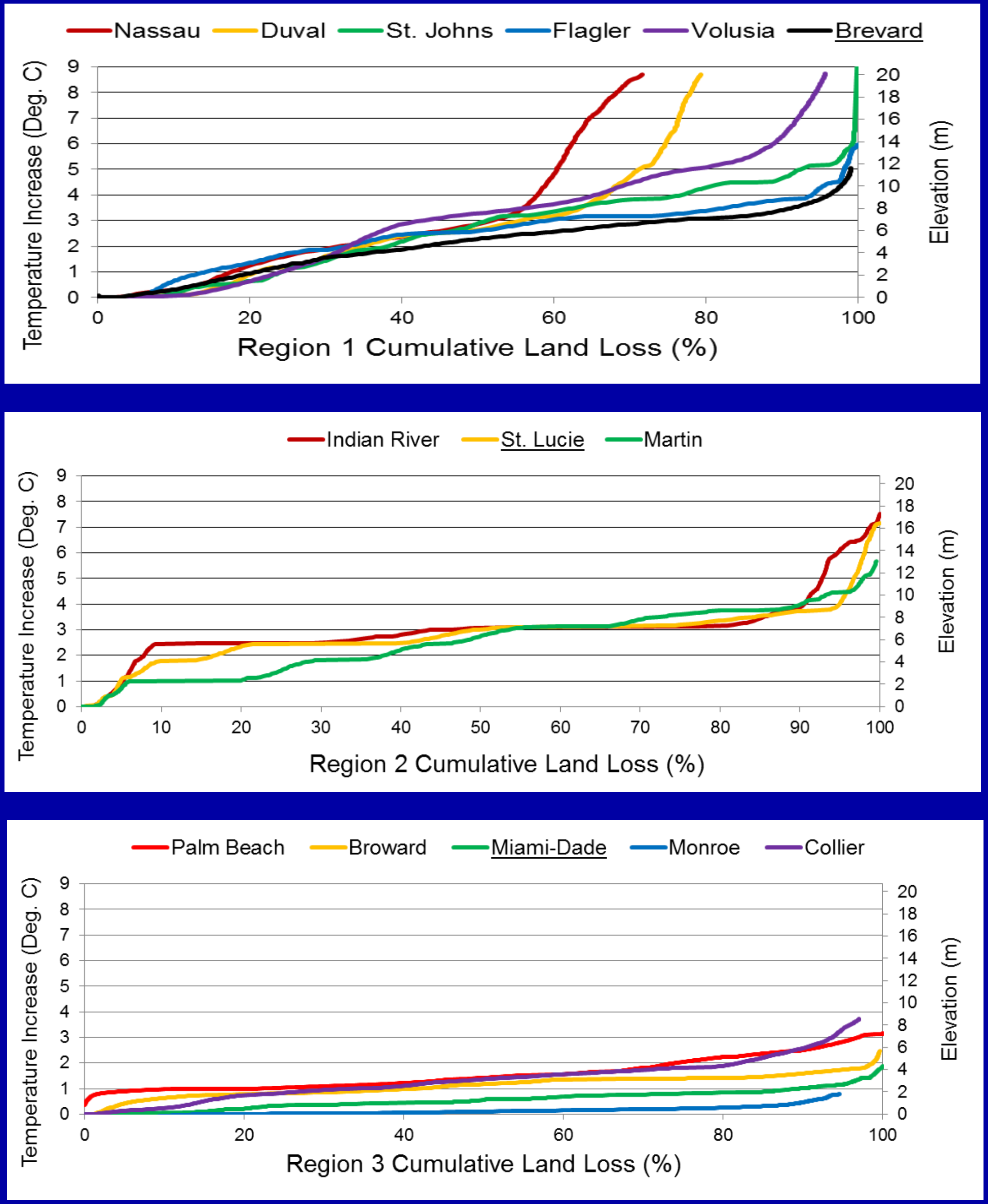
Sea level versus CO_2 concentrations over past 40 million years relative to year 2000. From Rohling et al. 2013.

Goal

Facilitate the implementation of effective adaptation activities in Florida to address the risks associated with sea level rise

Approach

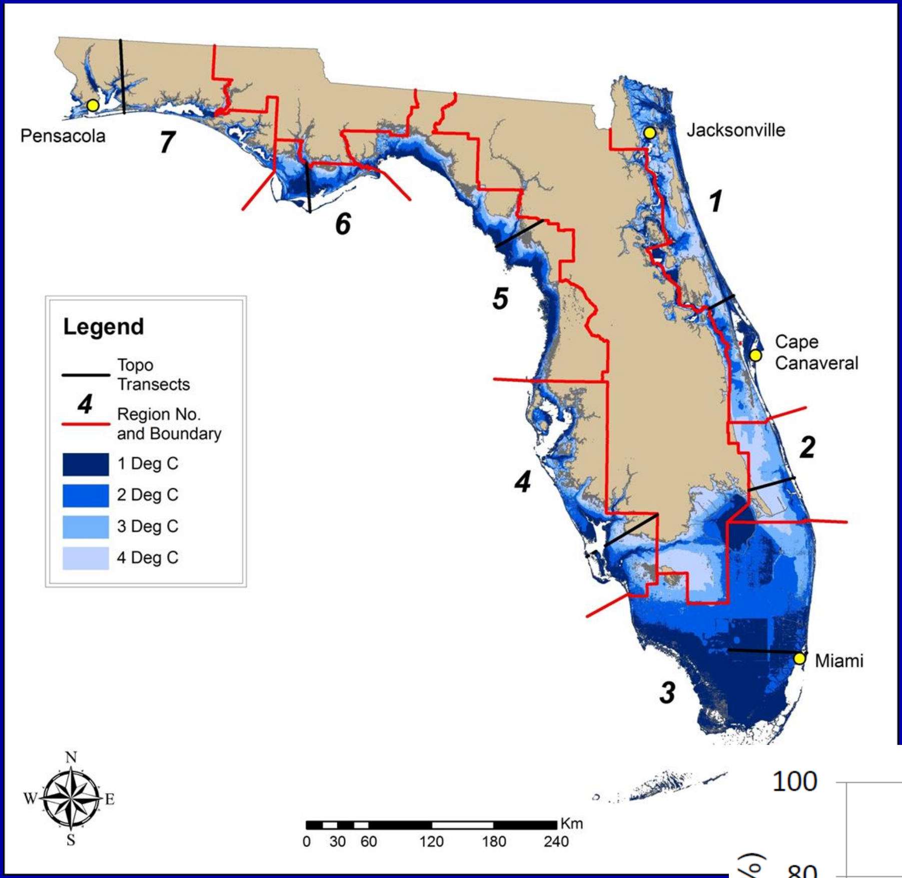
- Simulate the vulnerability of all 35 Florida coastal counties to rising sea level using a bathtub model unconstrained by the artificial end date of year 2100
- Vulnerability based upon the association between rising sea level and atmospheric temperature; a 2.3 m rise per each 1 ^{o}C increase
- Organize results into geographic regions of similar vulnerability based upon an assessment of hypsographic, geologic, and topographic attributes

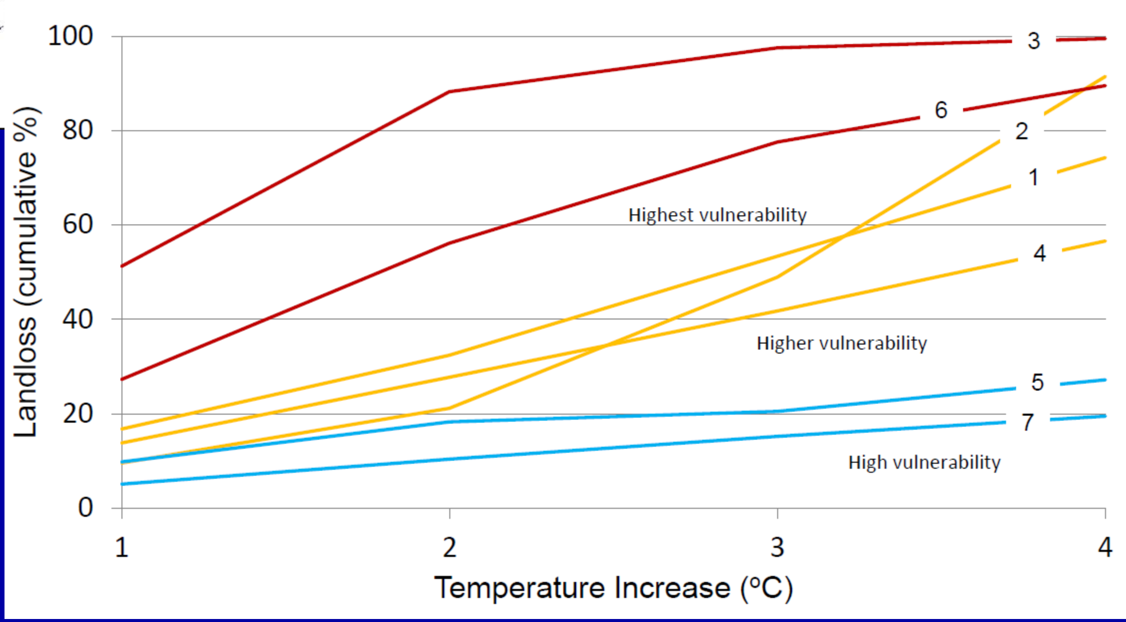


Coastal county clusters for east coast and southern peninsula

Region	Counties	Geologic Features					
		Holocene			Relict		
		1 Barrier Island	2 Coastal Wetland	3 Estuarine Embayment	4 Ridge	5 Interior Lowland	6 Exposed Limestone
Region 1 North Atlantic Coast	Nassau	•			•	•	
	Duval	•			•	•	
	St Johns	•			•	•	
	Flagler	•			•	•	
	Volusia	•			•	•	
	Brevard	•			•	•	
Region 2 Central Atlantic Coast	Indian River	•			•		
	St Lucie	•			•		
	Martin	•			•		
Region 3 South Florida	Palm Beach	•			•	•	
	Broward	•			•	•	
	Dade	•			•	•	•
	Monroe		•			•	•
	Collier	•	•			•	•
Region 4 South Gulf Coast	Lee	•		•			
	Charlotte	•		•			
	Sarasota	•					
	Manatee	•		•	•		
	Hillsboro			•	•		
	Pinellas	•		•	•		
Region 5 Big Bend	Pasco		•		•		•
	Hernando		•		•		•
	Citrus		•		•		•
	Levy		•		•		•
	Dixie		•		•		•
	Taylor		•		•		•
	Jefferson		•		•		•
	Wakulla		•		•		•
Region 6 East Panhandle	Franklin	•				•	
	Gulf	•				•	
Region 7 West Panhandle	Bay	•		•	•		
	Walton	•		•	•		
	Okaloosa	•		•	•		
	Santa Rosa	•		•	•		
	Escambia	•		•	•		

Relative Vulnerability of Seven Regions





1. North Atlantic Coast
2. Central Atlantic Coast
3. South Florida
4. South Gulf Coast
5. Big Bend
6. East Panhandle
7. West Panhandle

Utility of submergence simulations using the bathtub model

- The model assumes the shoreline migrates across a static landscape in response to sea level rise with minimal change in the physical and biological materials being transgressed.
- All features at or below the selected sea level elevation are submerged.
- The literature and internet are now replete with bathtub model simulations

FIU (0.6 m)

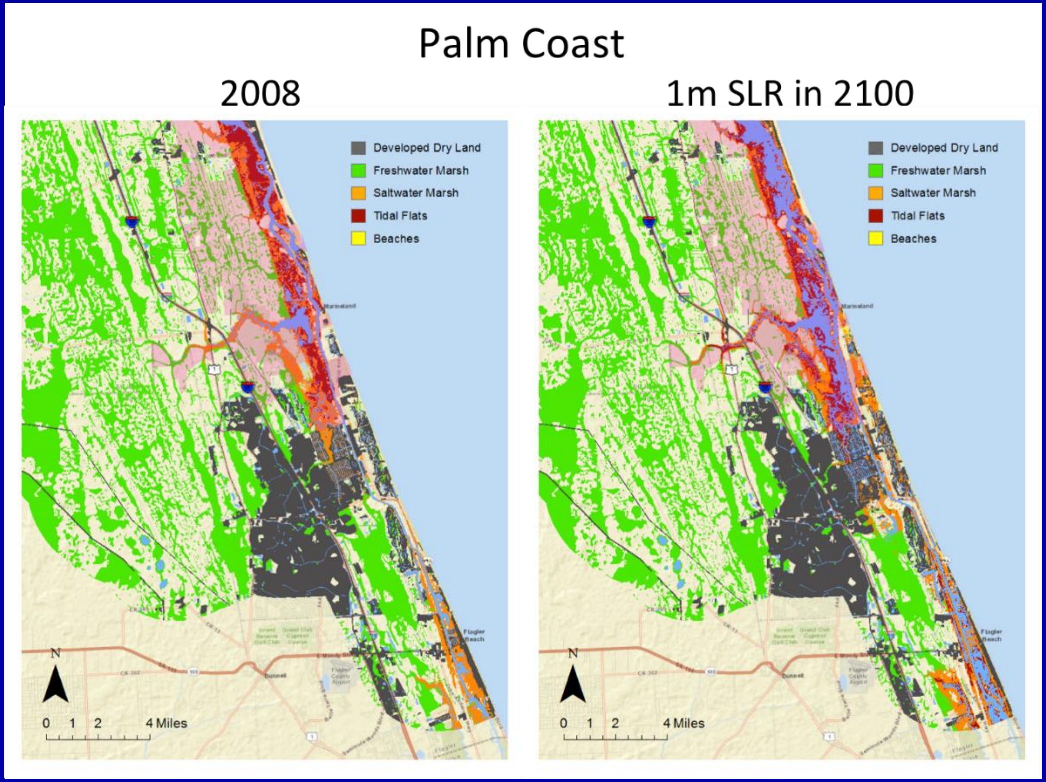
Weiss and Overpeck (1 m)

Tropical Audubon Society (6m)

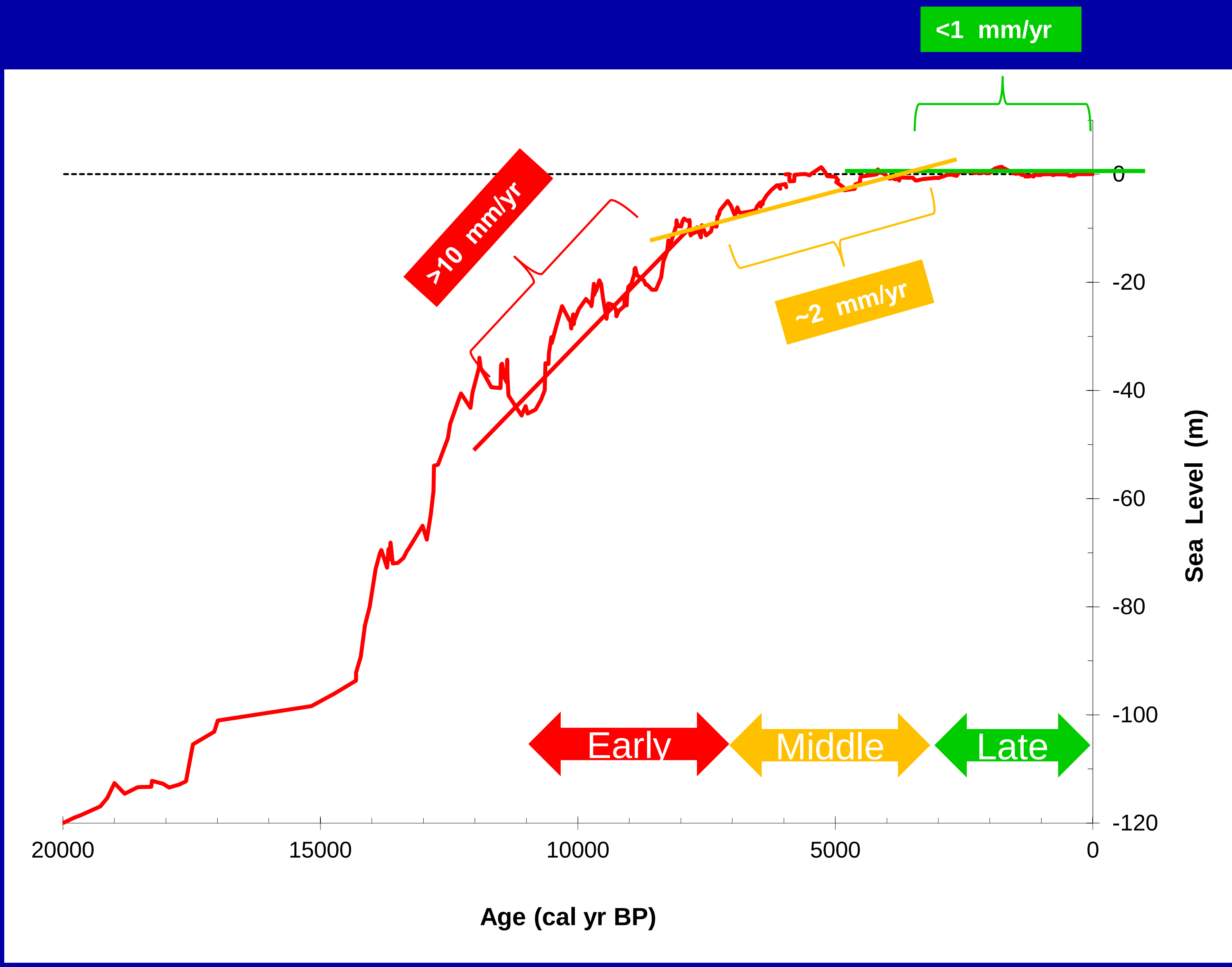
Utility of submergence simulations using the bathtub model

- Others have utilized dynamic models to forecast changes to the natural landscape

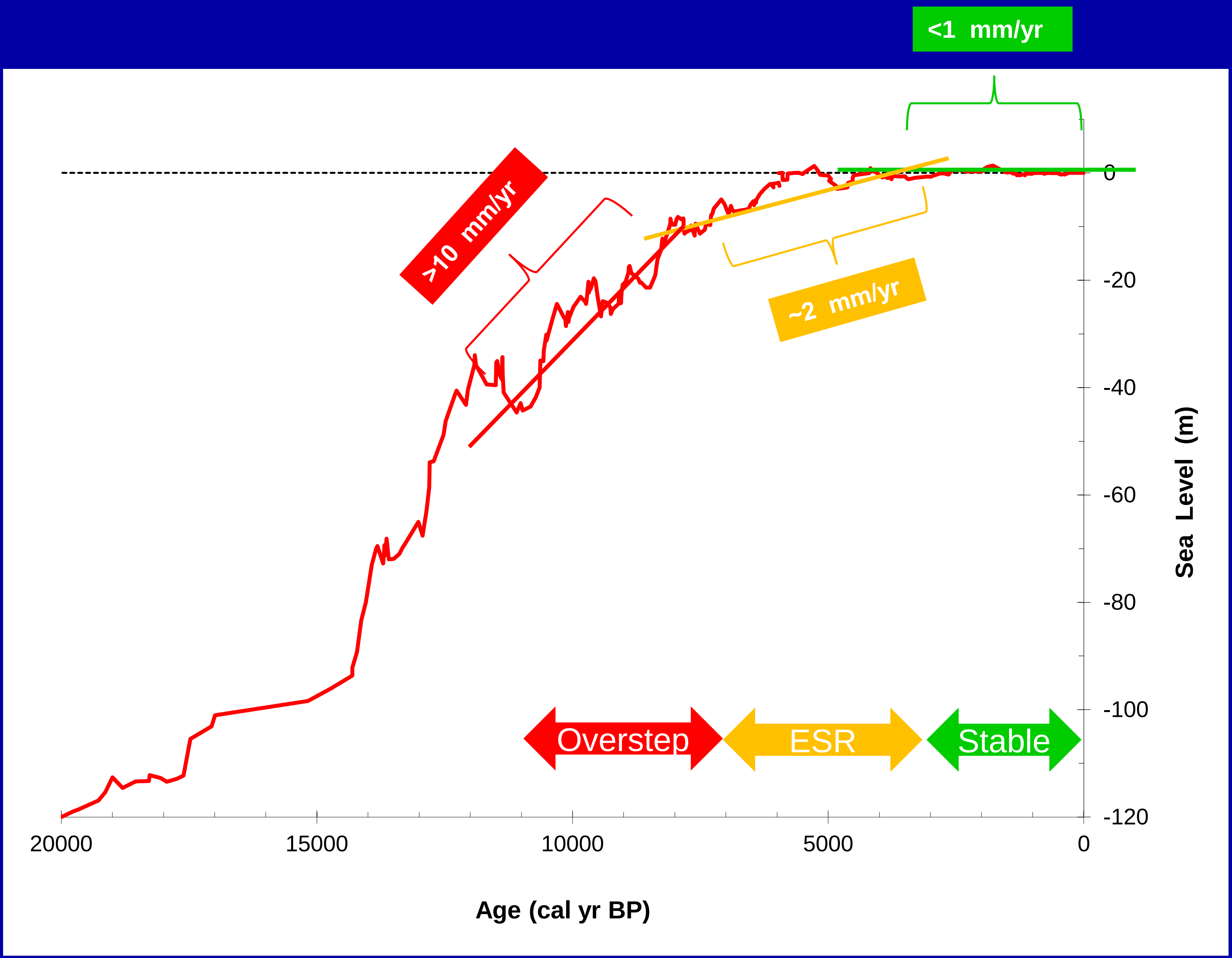
- The most common is SLAMM – Sea Level Affecting Marshes Model – used to simulate impacts of sea level rise on wetlands and shorelines



UF/NERR



Sea-level history for the northern Gulf of Mexico since the last glacial maximum. Samples from the coast and shelf of Florida, Louisiana, Texas, and Mexico. Figure adapted from Balsillie and Donoghue (2004).



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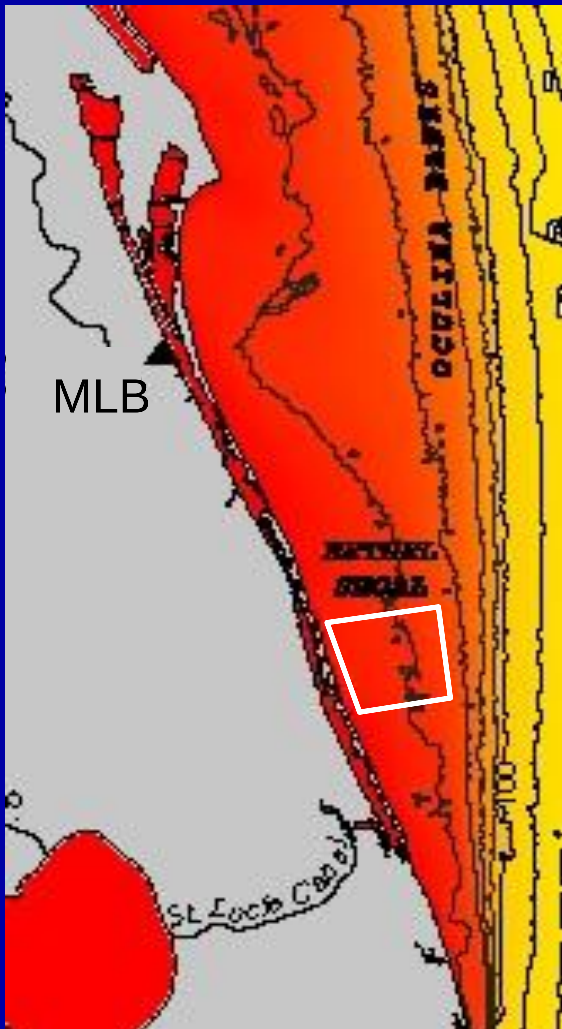
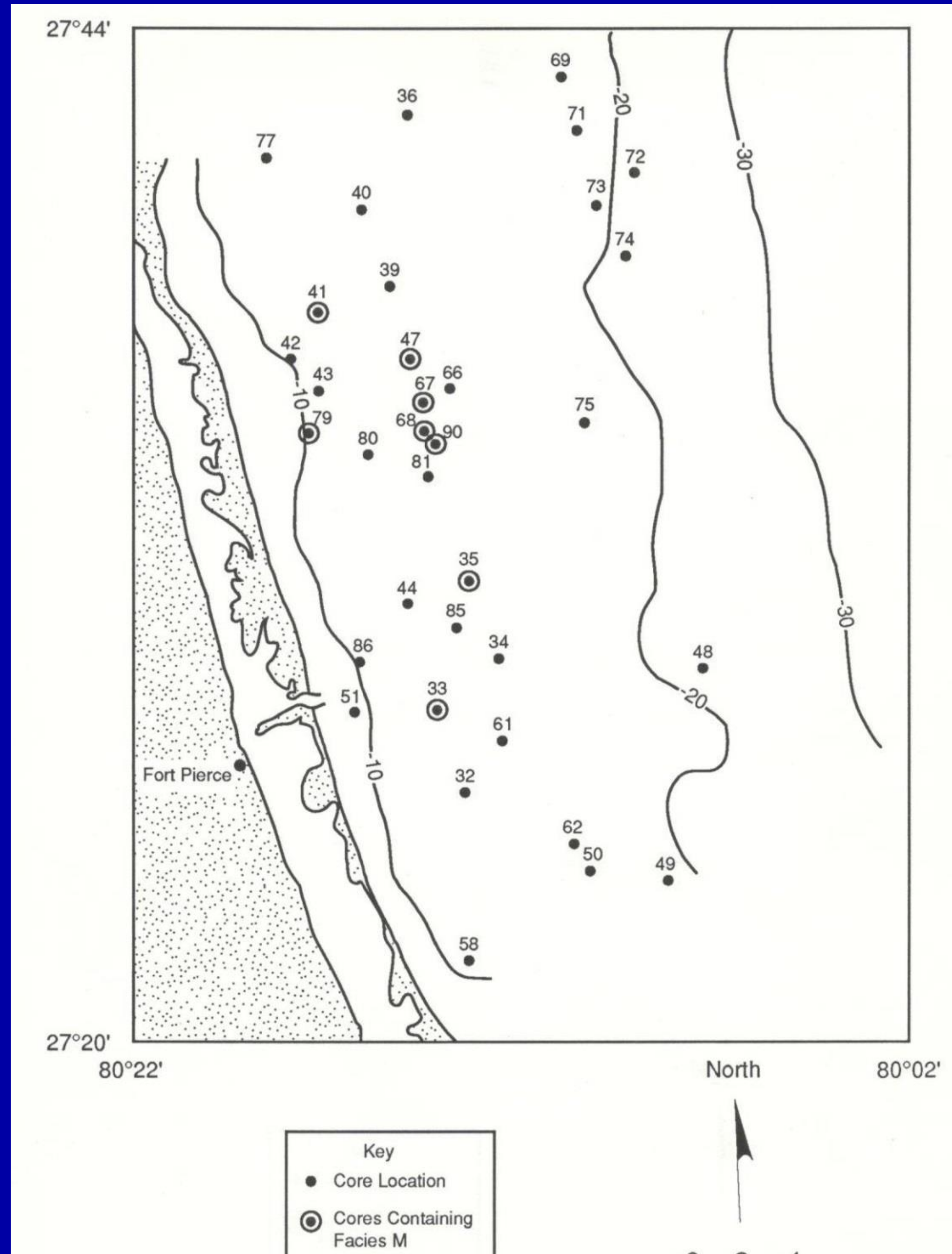
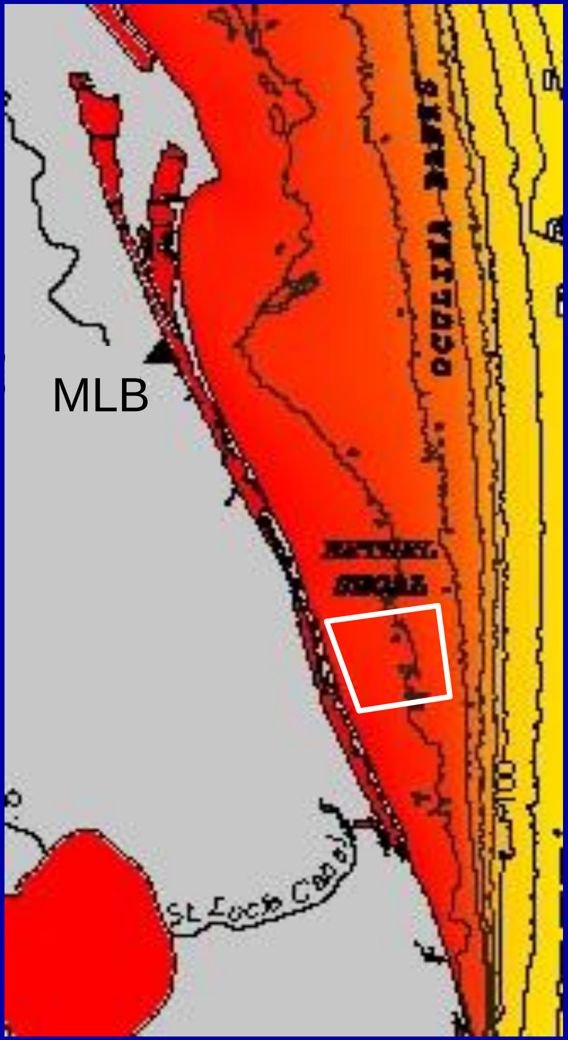
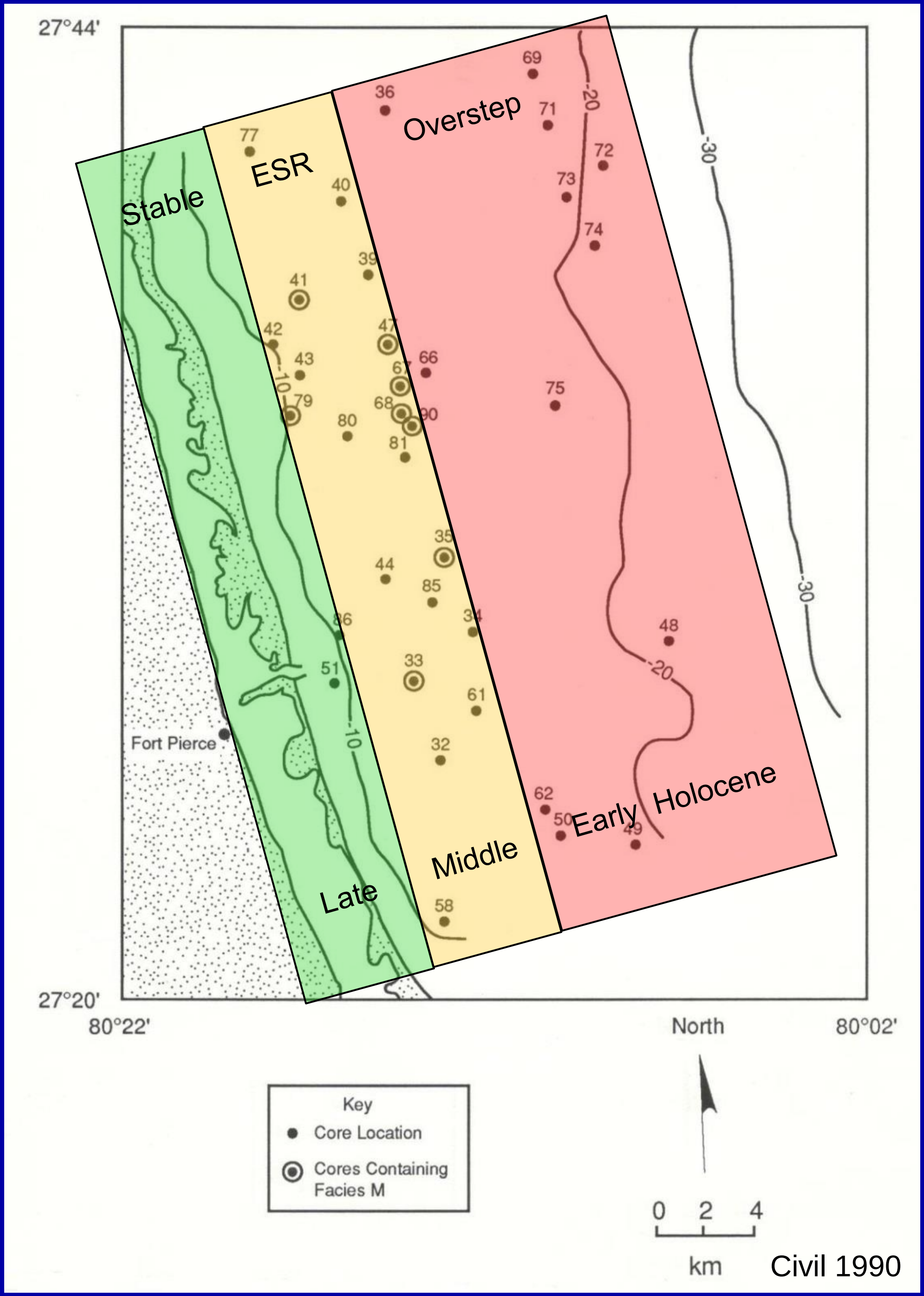


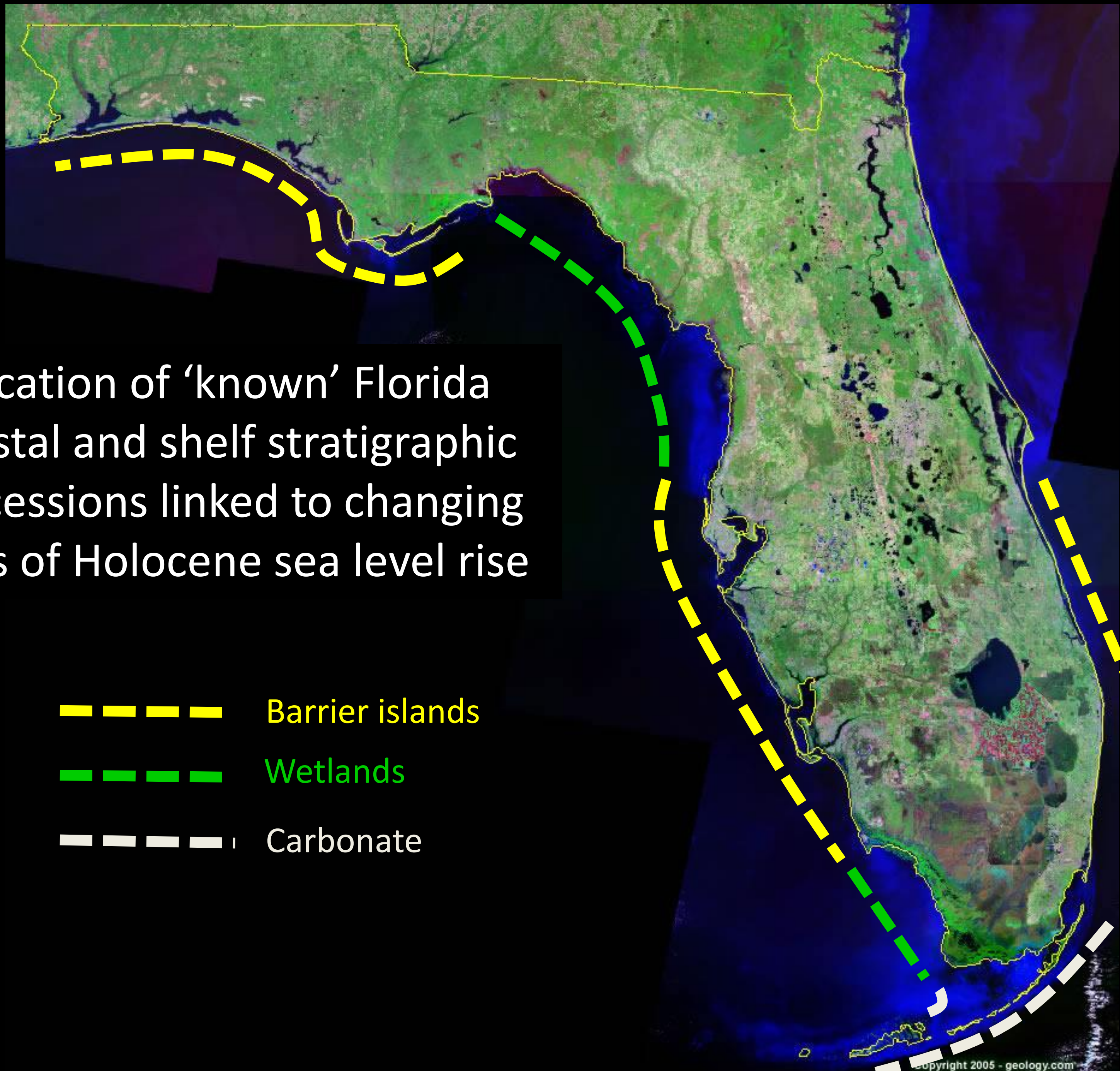


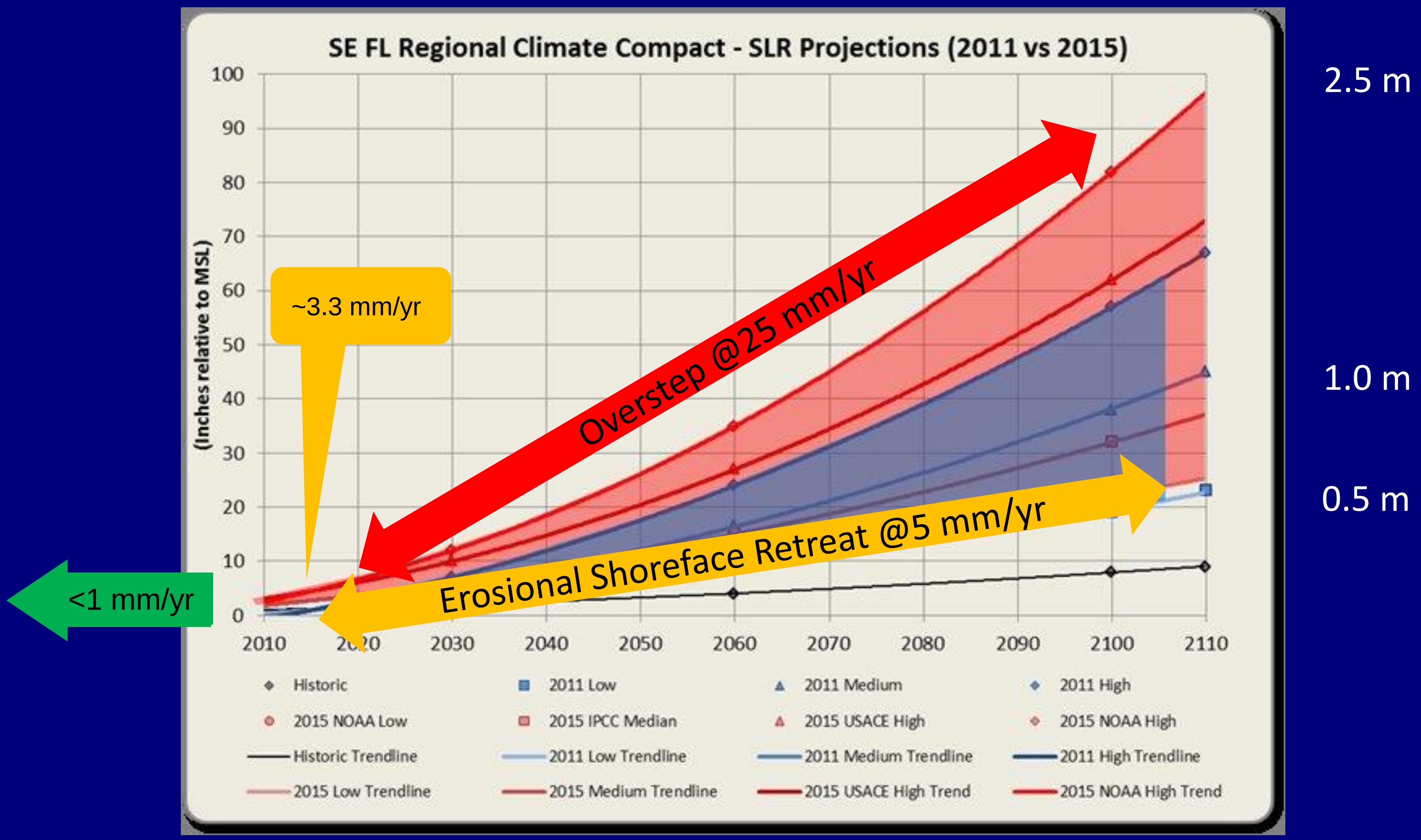
Civil 1990 using raw data from Meisburger and Duane 1971

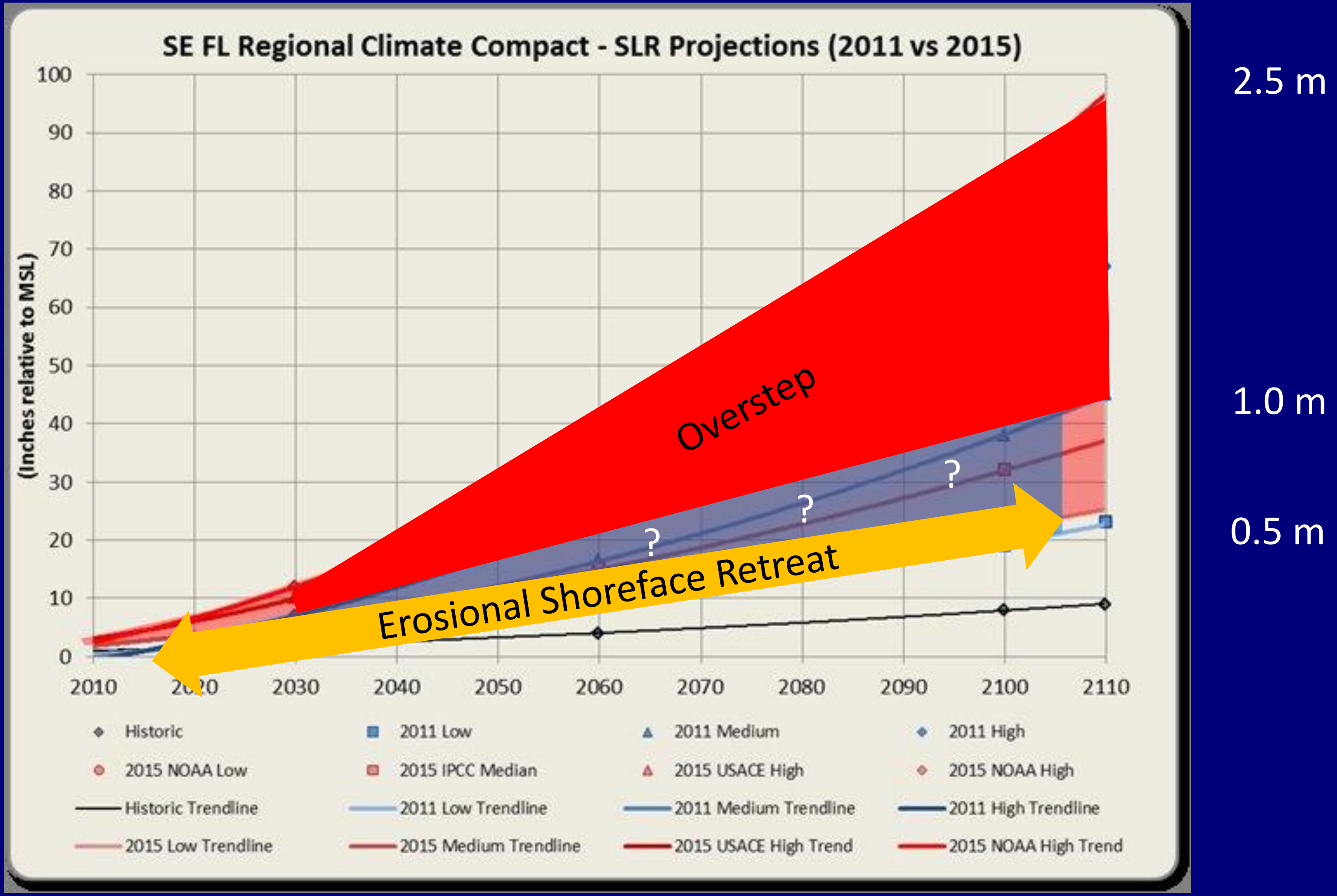

MLB
St Lucie Canal


27°44'
27°20'
80°22'
80°02'
Stable
ESR
Overstep
Late
Middle
Early Holocene
Fort Pierce
North
Key
Core Location
Cores Containing Facies M
0 2 4
km
Civil 1990

Location of ‘known’ Florida coastal and shelf stratigraphic successions linked to changing rates of Holocene sea level rise




SE FL Regional Climate Compact - SLR Projections (2011 vs 2015)
(Inches relative to MSL)
100
90
80
70
60
50
40
30
20
10
0
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
~3.3 mm/yr
Overstep @25 mm/yr
Erosional Shoreface Retreat @5 mm/yr
<1 mm/yr
2.5 m
1.0 m
0.5 m
Historic
2011 Low
2011 Medium
2011 High
2015 NOAA Low
2015 IPCC Median
2015 USACE High
2015 NOAA High
Historic Trendline
2011 Low Trendline
2011 Medium Trendline
2011 High Trendline
2015 Low Trendline
2015 Medium Trendline
2015 USACE High Trend
2015 NOAA High Trend



SE FL Regional Climate Compact - SLR Projections (2011 vs 2015)
(Inches relative to MSL)
100
90
80
70
60
50
40
30
20
10
0
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
Overstep
Erosional Shoreface Retreat
?
?
?
Historic
2011 Low
2011 Medium
2011 High
2015 NOAA Low
2015 IPCC Median
2015 USACE High
2015 NOAA High
Historic Trendline
2011 Low Trendline
2011 Medium Trendline
2011 High Trendline
2015 Low Trendline
2015 Medium Trendline
2015 USACE High Trend
2015 NOAA High Trend
2.5 m
1.0 m
0.5 m

Adapting to Rising Sea Level

Current options include:

- do nothing
- protect and defend
- accommodate
- strategic withdrawal or managed retreat

Couldn’t find any Florida examples

Adapting to Rising Sea Level

To date the preferred active management option has been *protect and defend*

In the natural environment this has included the protection, restoration, and management of *extant* habitat (i.e. dune vegetation, coastal wetlands)

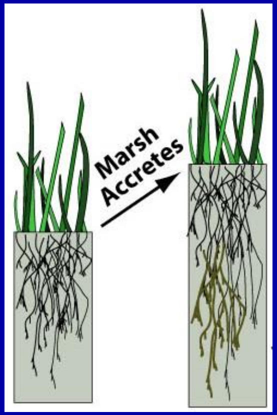
In the built environment this has included:

- dune restoration
- beach nourishment
- construction of seawalls, wavebreaks, groins

Adapting to Rising Sea Level

These *protect and defend* strategies will not be effective in the long term:

- Rate of sea level rise will become too fast for extant wetland habitats to keep pace through soil accretion

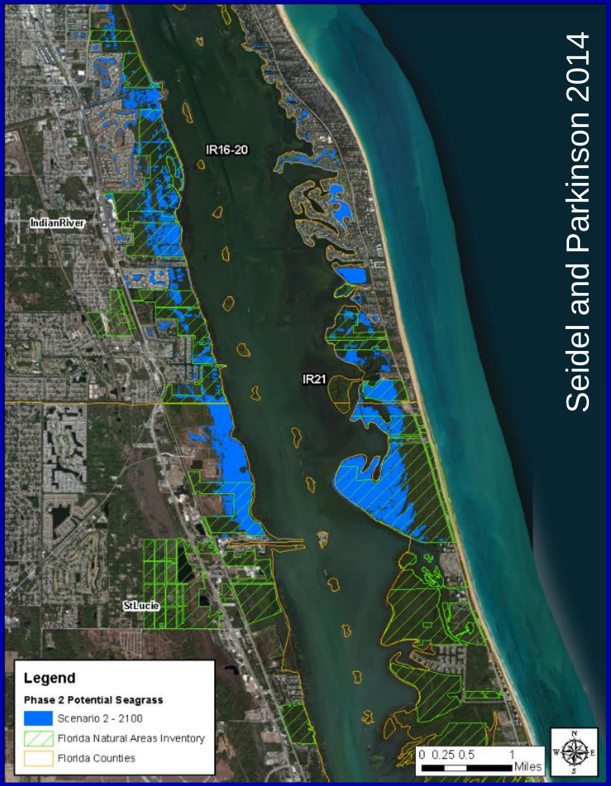


- Both frequency and scale of shore protection projects will increase commensurate with accelerating sea level rise and eventually exceed the tipping point between ‘cost effective strategies’ and irreversible geomorphic change

- Furthermore, these activities do not address the increasing frequency and magnitude of flooding in low lying *inland* areas

Recommended Actions/Concluding Remarks

- In the *natural* environment, the focus should shift from the protection, restoration, and management of *extant* habitat to acquisition of undeveloped buffer zones in adjacent upland areas



Potential seagrass habitat after 4 ft slr (blue) and existing Florida Natural Lands (green cross-hatch).

- In the *built* environment, we must transition away from shore protection projects and towards long term adaptation activities like accommodation and ultimately strategic withdrawal

Miami Beach 2013

For more info:
Parkinson, R., Harlem, P., and Meeder, J. 2015. Managing the Anthropocene Marine Transgression to the Year 2100 and Beyond in the State of Florida U.S.A. Climatic Change, v128:85-98.