The Economic Impact of Climate Change in Coastal Areas in Florida

By

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FSU Center for Economic Forecasting and Analysis (CEFA)

- **The Florida State University Center for Economic Forecasting and Analysis (CEFA) specializes in applying advanced, computer-based economic models and techniques to examine and help resolve pressing public policy issues across a spectrum of research areas.**

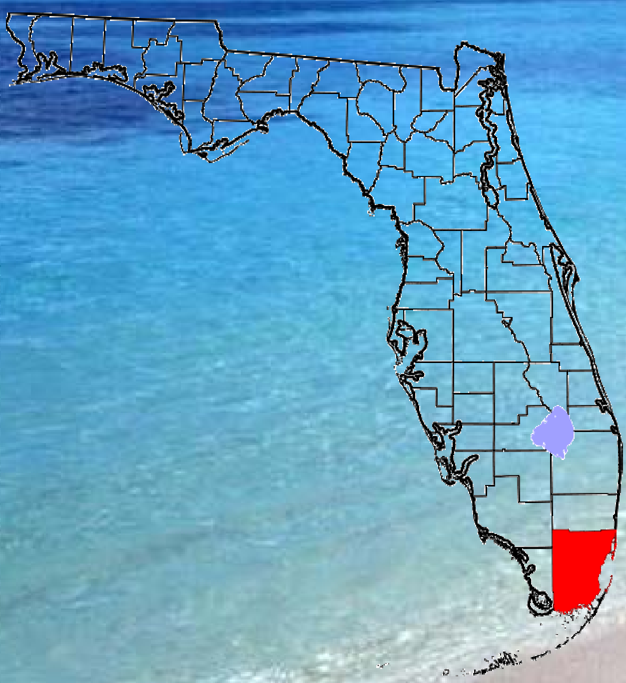
FSU Beaches and Shores Research Center

- The Florida State University Beaches and Shores Research Center was created in 1982 to assist the State of Florida in establishing a recommended Coastal Construction Control Line for each of Florida’s 24 coastal counties with sandy beaches. The Center actively seeks to understand how beaches can be better designed to protect upland property from coastal storms while protecting the native flora and fauna of this delicate ecosystem. Types of research include:
  - Analytical shoreline modeling
  - Bay/wetland response to tide
  - Impacts due to natural or man-made construction
  - Inlet stability
  - Water level extreme and distributional analysis
  - Short-term storm surge forecasting
  - Inlet modeling for improved storm surge estimates

General Framework

- Six County (Escambia, Duval, Dade, Wakulla, Dixie and Monroe - Demographics
- Sea Level Rise (SLR) – Eustatic Estimates (IPCC) and SLR Estimates and Methodology Performed by FSU Beaches and Shores Resources Center, Todd Walton for Years 2030, 2080.
- Property at Risk – Examples and Adaptation Measures in Florida
- Cost Damage Assessment Model Based on Flood Insurance Studies, and Hurricane Damage Assessments for Two Years in 2006 Dollars
- Economic Impact – Yohe Model

Demographics
Dade County



Area

Total 6,297 km^2 (2,431 mi^2)

Land 5,040 km^2 (1,946 mi^2)

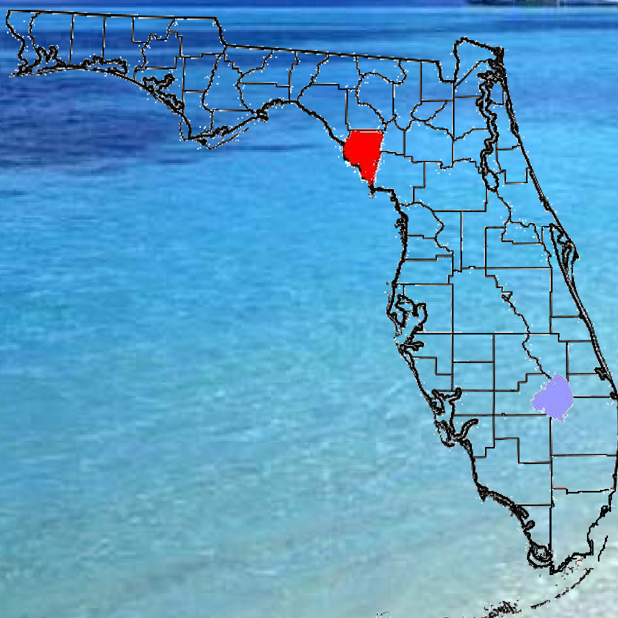
Water 1,257 km^2(485 mi^2) 19.96%

Population

Year 2000 2,253,362

Density 447/km^2

Demographics
Dixie County



Area

- *Total 2,237 km² (864 mi²)*
- *Land 1,824 km² (704 mi²),*
- *Water 413 km²(160 mi²) 18.49%*

Population

Year 2000 13827

Density 8/km²

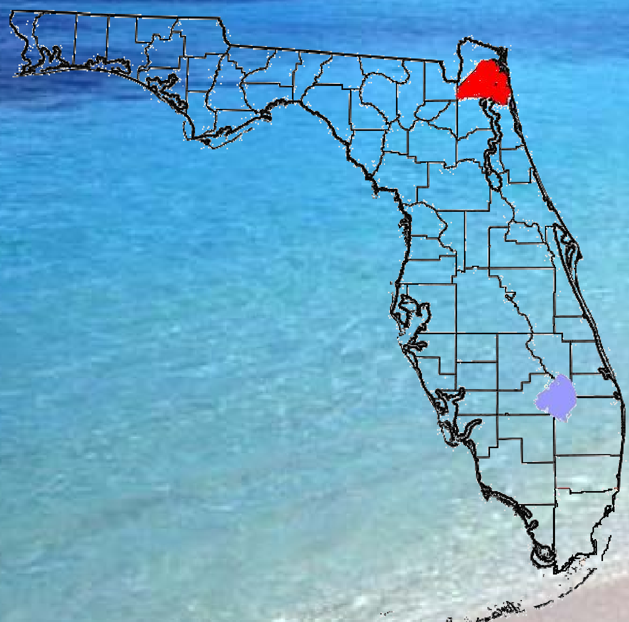
Demographics
Duval County

Area

Total 2,378 km^2 (918 mi^2)

Land2,004 km^2 (774 mi^2)

Water374 km^2 (145 mi^2), 15.74%

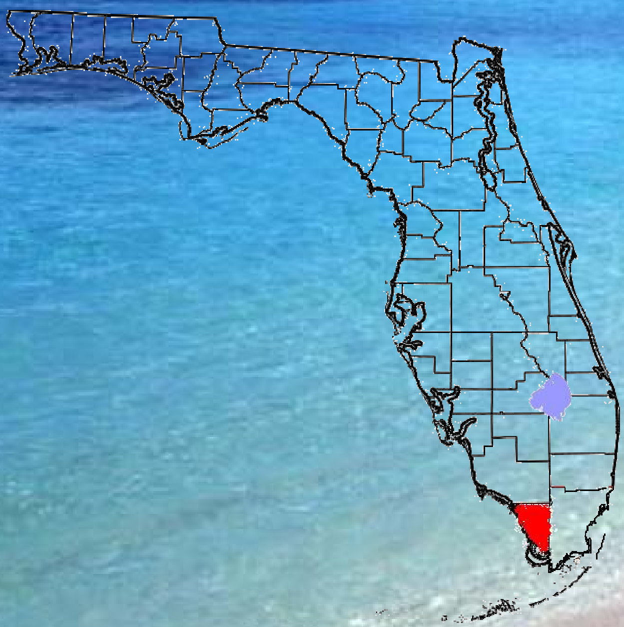


Population

Year 2000 778,879

Density 389/km^2

Demographics
Monroe County



Area

Total 9,679 km^2 (3,737 mi^2)

Land 2,582 km^2 (996.9 sq mi)

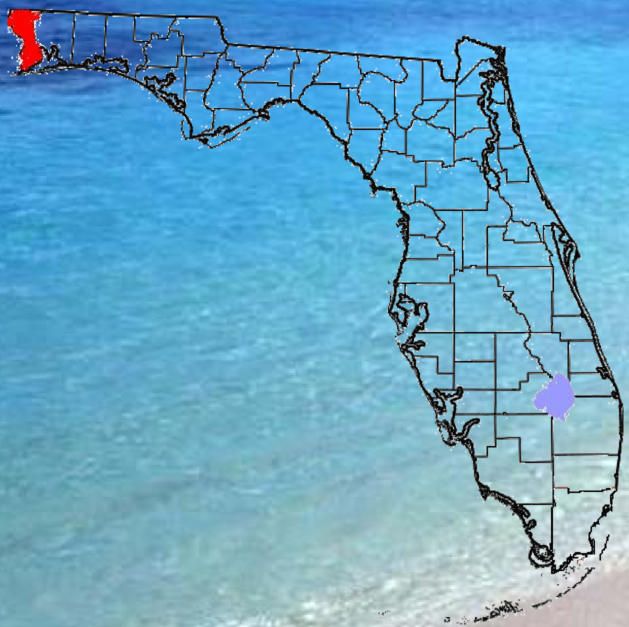
Water 7,097 km^2 (2,740 mi^2), 73.32%

Population

Year 2000   79,589

Density   30.8/km^2

Demographics
Escambia County



Area

Total 2,268 km^2 (876 mi^2)

Land 1,715 km^2 (662 mi^2)

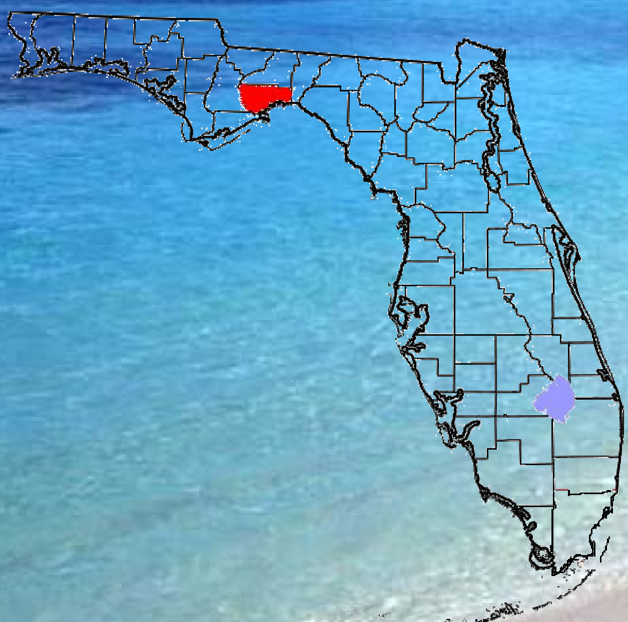
Water 552 km^2 (213 mi^2), 24.35%

Population

Year 2000 294,410

Density 172/km^2

Demographics
Wakulla County



Area

Total 1,906 km^2 (736 mi^2)

Land 1571 km^2 (607 mi^2)

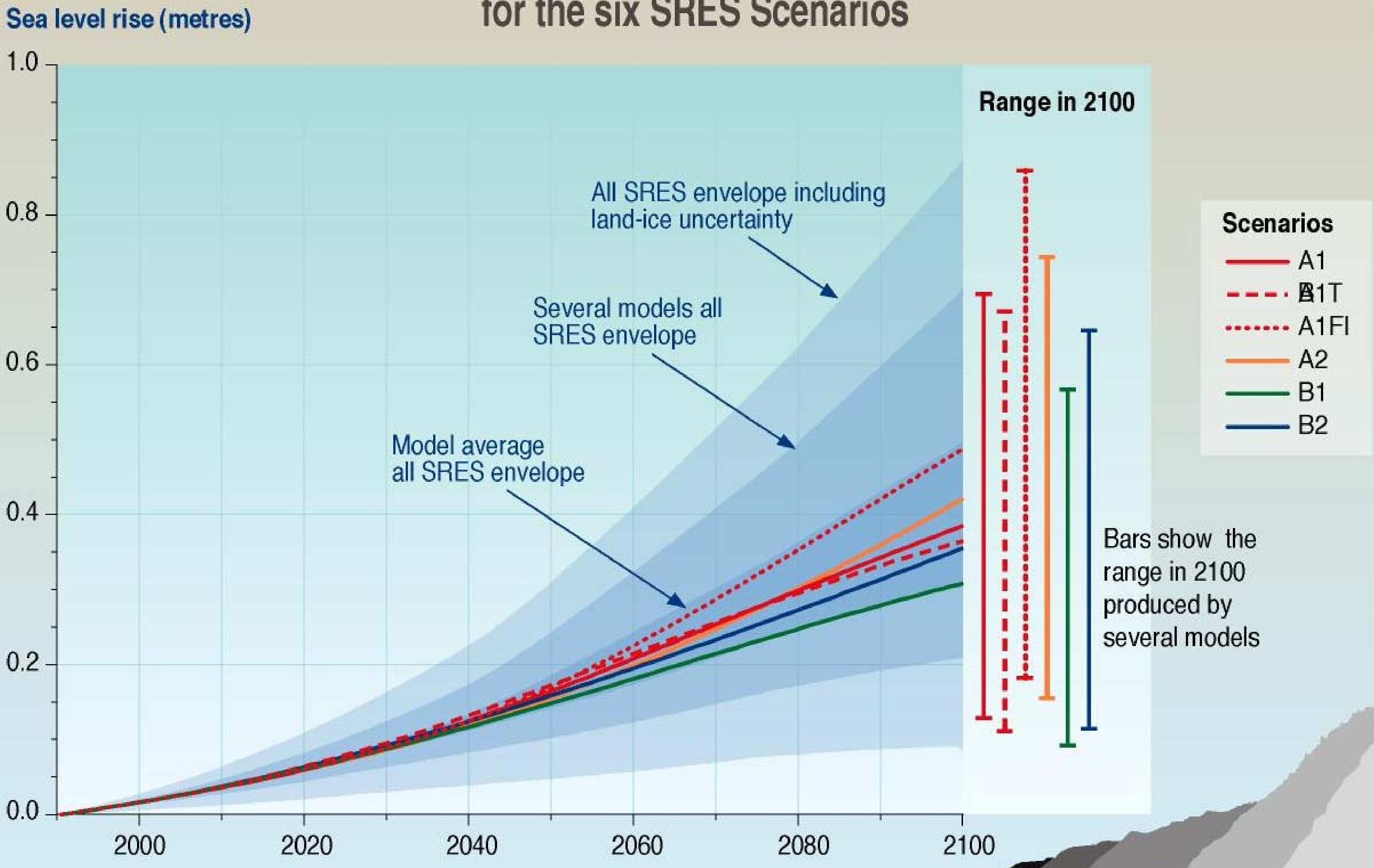
Water 334 km^2 (129 mi^2), 17.54%

Population

Year 2000 22,863

Density 15/km^2

Global average sea level rise (1990 - 2100)
for the six SRES Scenarios

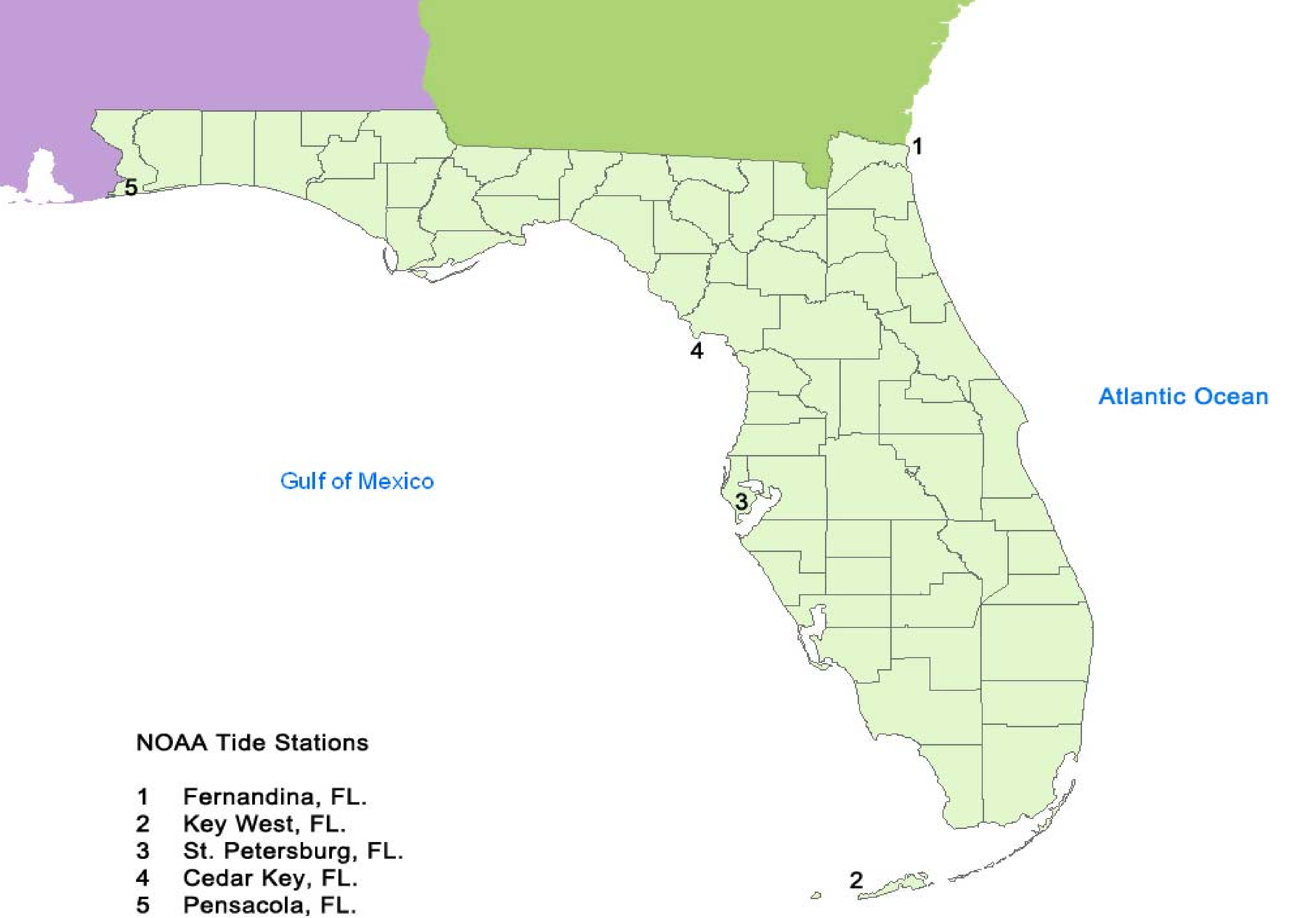


source: IPCC Climate Change 2001: The Scientific Basis

Reasons for Data Based Approach

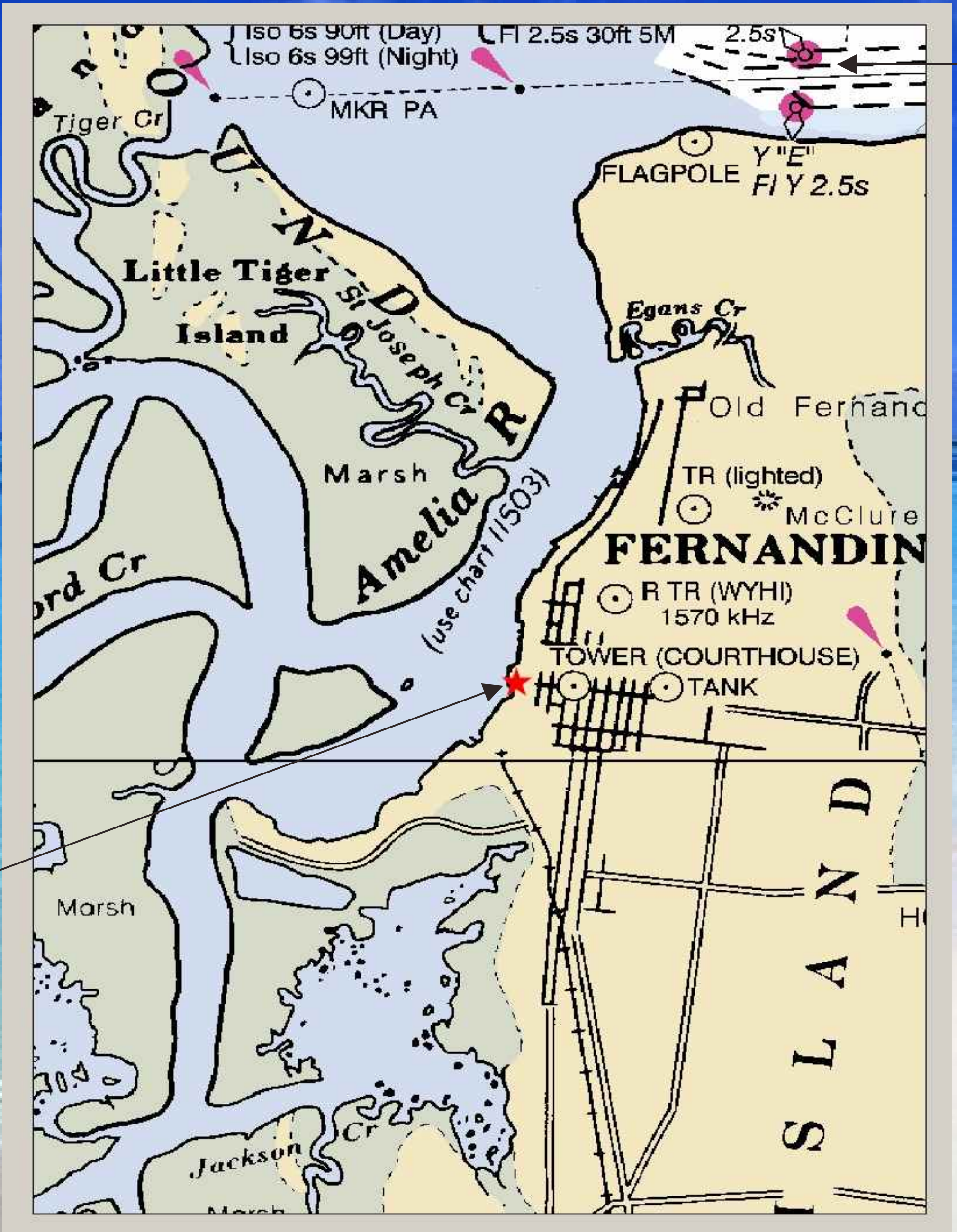
- **Based on Global Models of Climate Change (physics uncertain… i.e. can't predict El Nino's)**

- **Need Relative Sea Level Rise (for local damage estimates)**


1
5
4
3
2
Atlantic Ocean
Gulf of Mexico
NOAA Tide Stations
1 Fernandina, FL.
2 Key West, FL.
3 St. Petersburg, FL.
4 Cedar Key, FL.
5 Pensacola, FL.

Key West Tide Station

Fernandina Beach Tide Station



St. Mary's Sound

Atlantic Ocean

Gage Location

NOAA Water Level Recording Stations

Station Name	Station Number	Record Span
Fernandina, FL	*8720030*	*1941-2005*
Key West, FL	*8724580*	*1941-2005*
St. Petersburg, FL	*8726520*	*1947-2005*
Cedar Key, FL	*8727520*	*1941-2005*
Pensacola, FL	*8729840*	*1941-2005*

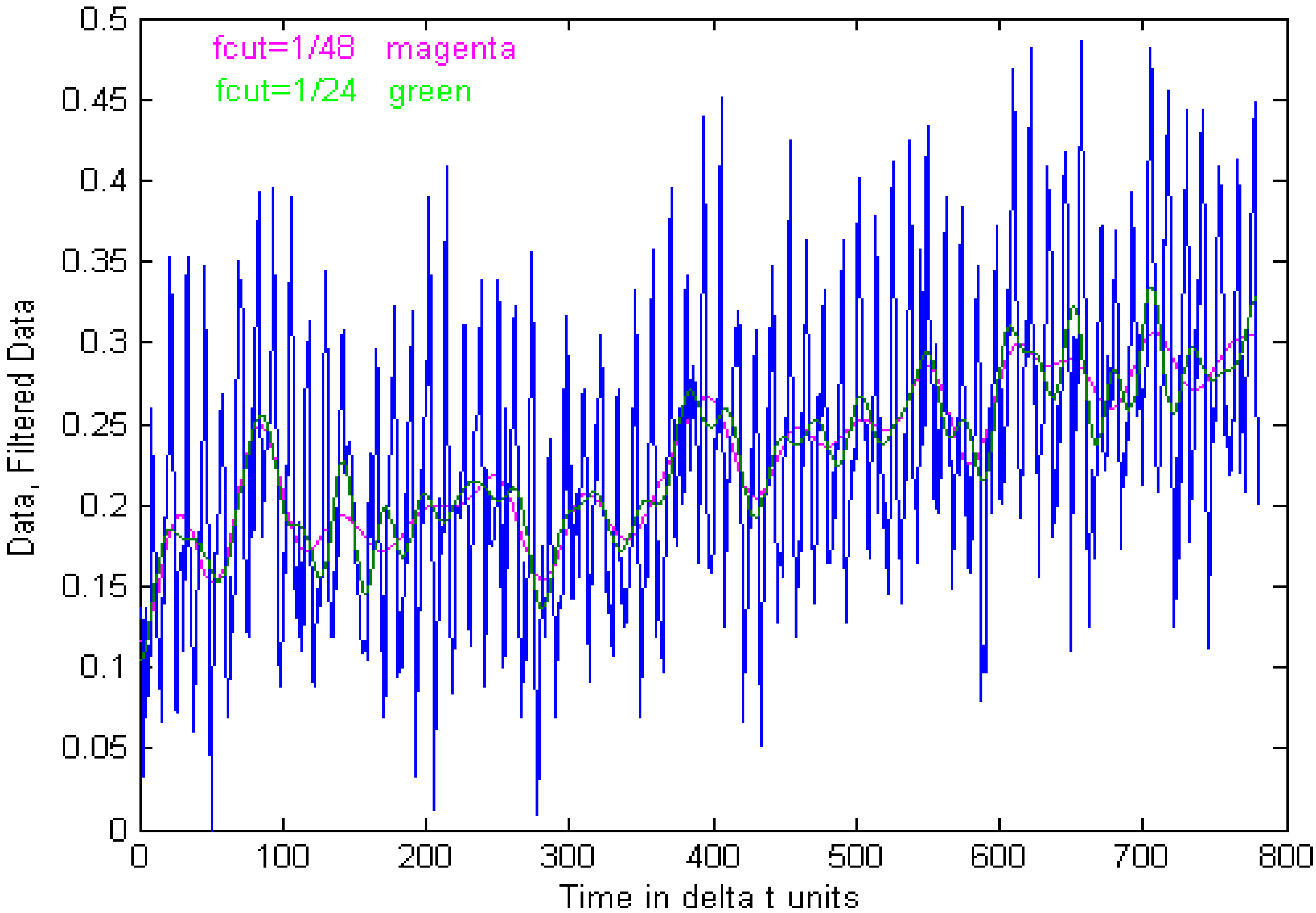
Data Based Methods of Forecasting

- ***Noise in data***
- ***Missing observations***

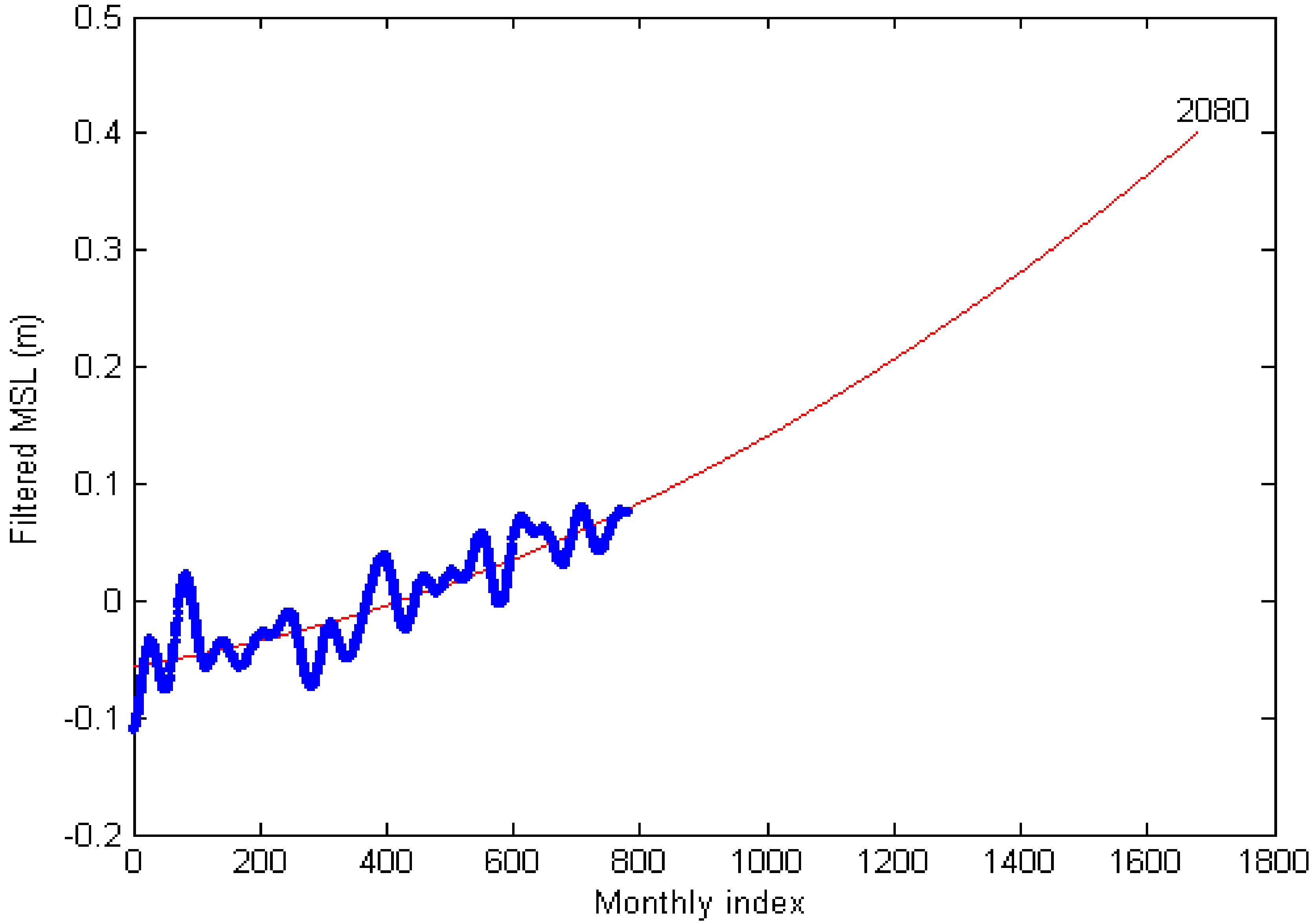
Filtering Approaches

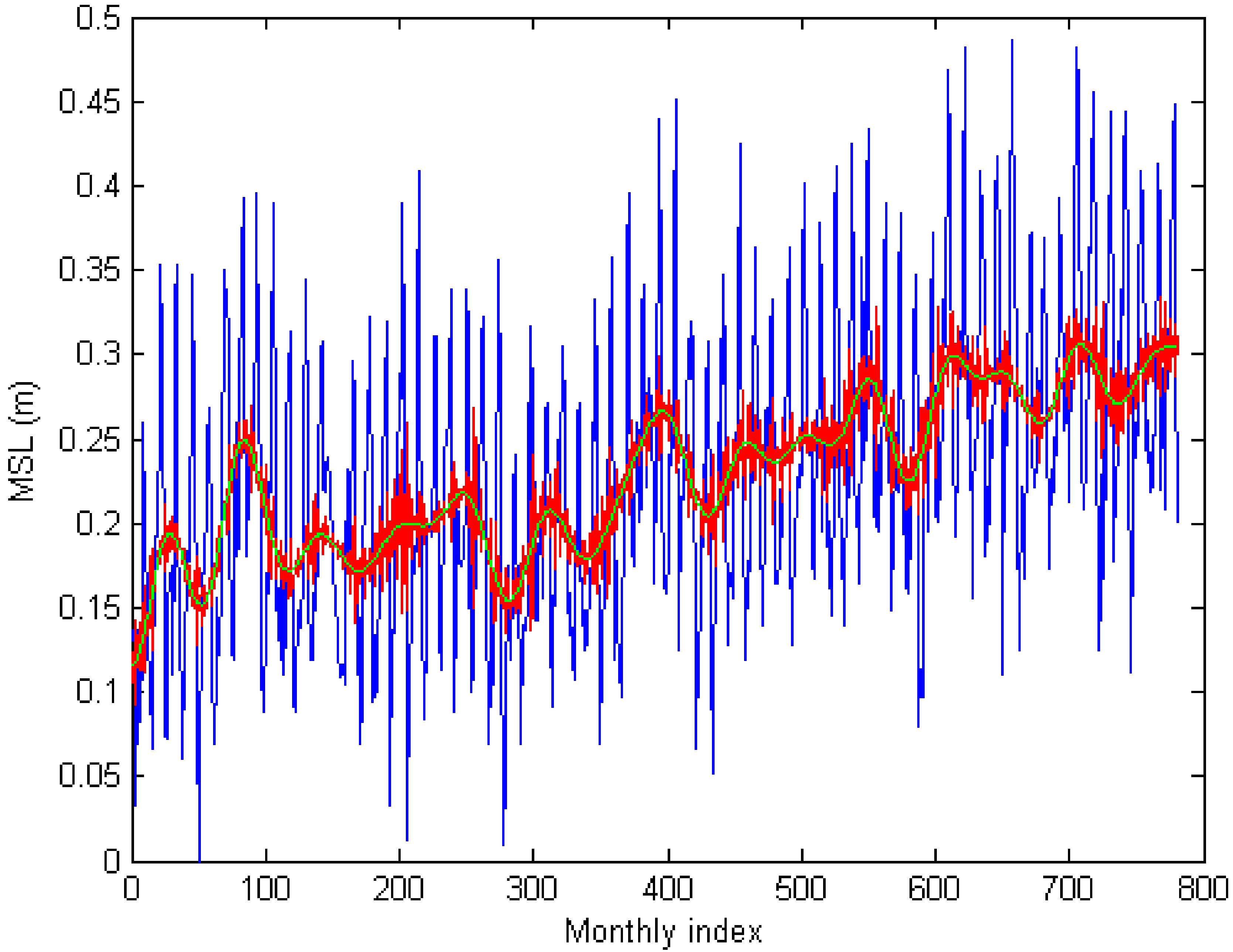
- ***Monthly Means***
- ***Low Pass***
- ***Band Pass***
- ***Singular Spectral Analysis (SSA)***

Low Pass Filtering

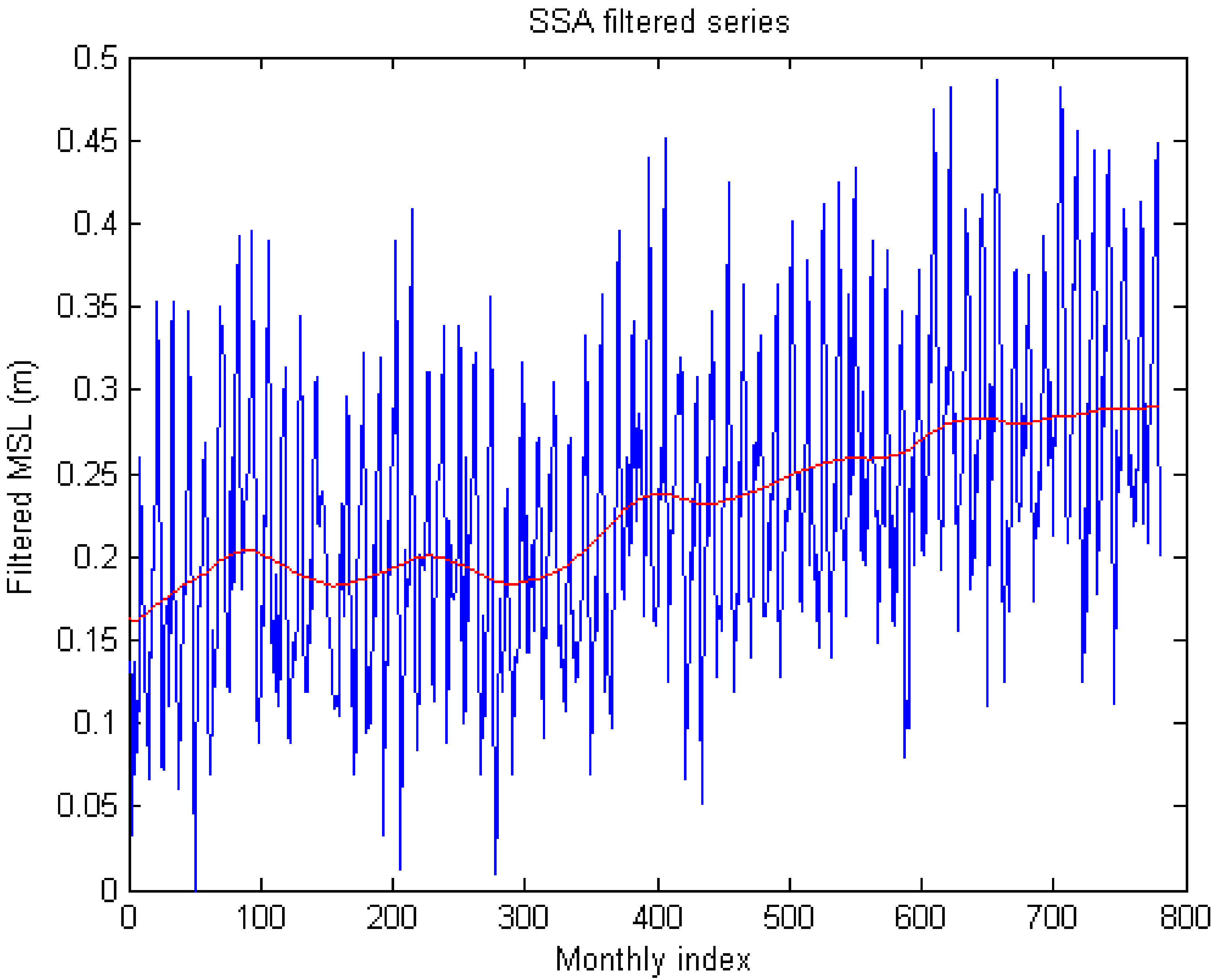


Low Pass Filtering Forecast to 2080





0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
MSL (m)
0
100
200
300
400
500
600
700
800
Monthly index


SSA filtered series
Filtered MSL (m)
Monthly index
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
600
700
800

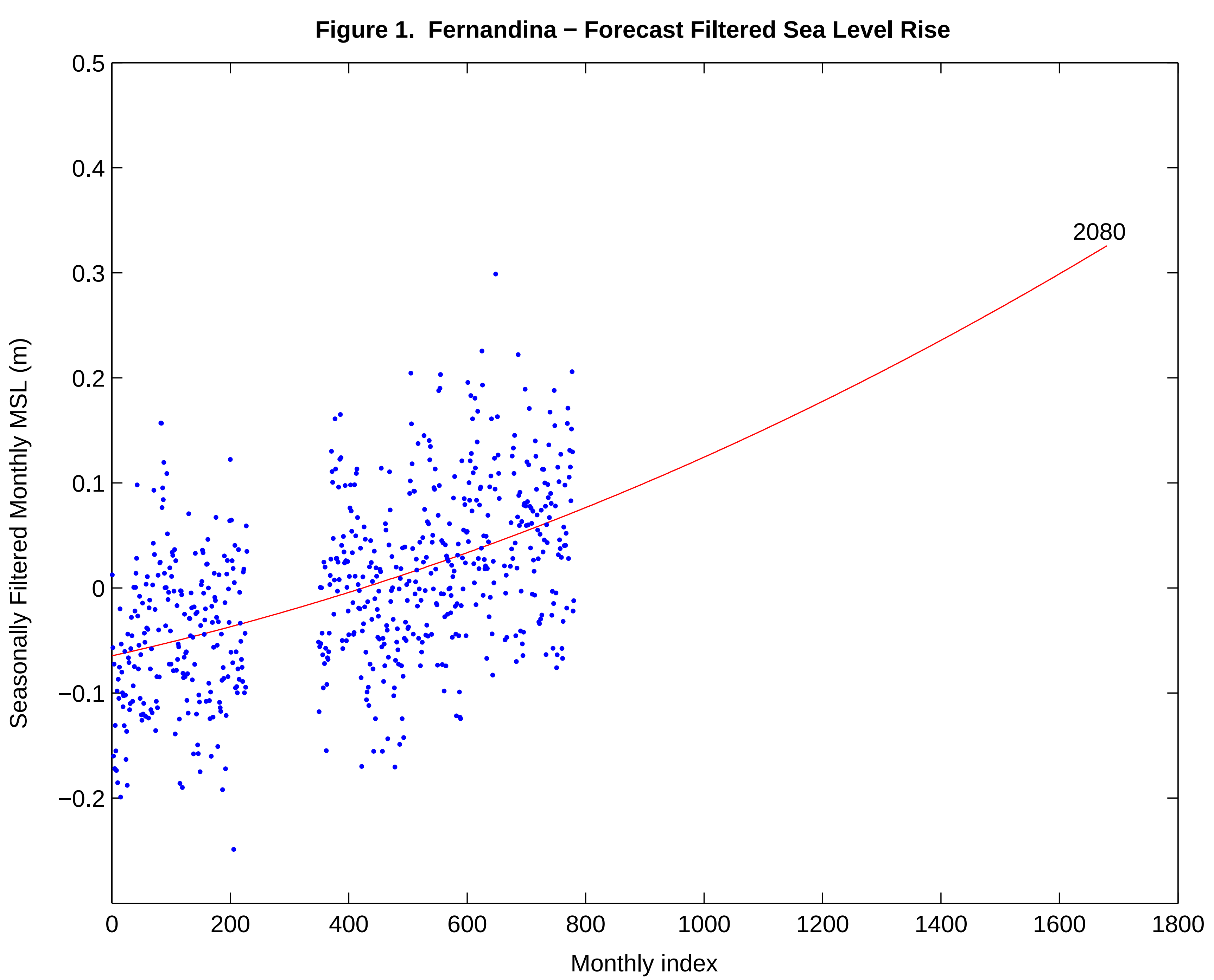
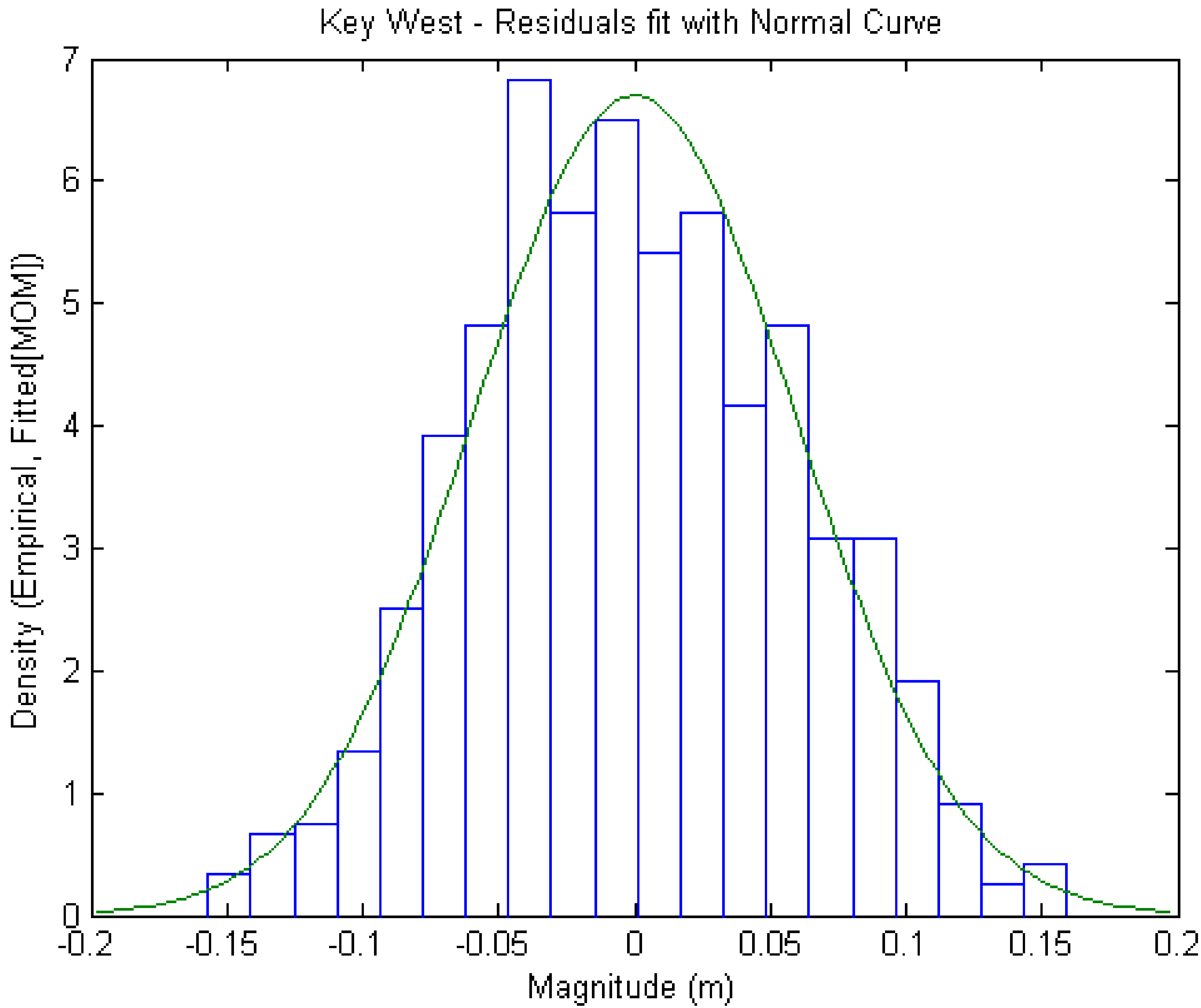


Figure 1. Fernandina – Forecast Filtered Sea Level Rise
Seasonally Filtered Monthly MSL (m)
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
0
200
400
600
800
1000
1200
1400
1600
1800
Monthly index
2080


Key West - Residuals fit with Normal Curve
Density (Empirical, Fitted[MOM])
Magnitude (m)
0
1
2
3
4
5
6
7
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2

Forecasting Approaches

- *Linear*
- *Linear with Second Order Acceleration Term*
- *Non-Linear*
- *Autoregressive Series (Unstable)*

Linear

$$y(time) = a + b \cdot time + \varepsilon$$

Linear with Second Order Term

(for acceleration/deceleration of slr)

$$y(time) = a + b \cdot time + c \cdot time^2 + \varepsilon$$

Non-Linear Exponential

$$y(t) = p_1 + p_2 \cdot e^{(p_3 \cdot t)} + error$$

$$y(t) = p_1 + p_2 \cdot (1 + p_3 \cdot t + \frac{p_3 \cdot t^2}{2} + \ldots hot) + error$$

Forecast Relative Sea Level Rise from 2006 to 2080

Station	Relative SLR (meters)
Fernandina, FL	*0.25*
Key West, FL	*0.31*
St. Petersburg, FL	*0.35*
Cedar Key, FL	*0.27*
Pensacola, FL	*0.34*

Forecast Relative Sea Level Rise from 2006 to 2080

Station	Relative Sea Level Rise (in Meters)		
	1st Order	*2nd Order*	*Exponential*
Fernandina, FL	*0.16*	*0.25*	*0.27*
Key West, FL	*0.15*	*0.31*	*0.28*
St. Petersburg, FL	*0.18*	*0.35*	*0.36*
Cedar Key, FL	*0.11*	*0.27*	*
Pensacola, FL	*0.13*	*0.34*	**

*parameter estimation convergence problems

SLR Estimation Conclusions

"Predictions are risky, especially when they're about the future." ---Yogi Berra

- **Linear (straight line) Trend Forecasts do not allow for sea level acceleration.**
- **A small sea level rise acceleration is noted in the Florida data.**
- **Sea level rise trends using (straight line) linear trends underestimate the sea level rise to be realized (for Florida and the time span considered).**
- **Sea level rise trends found using data are within the band of IPCC findings using global climate models.**

"The future ain't what it used to be." ---Yogi Berra

Property at Risk

- **How will your Coastal Property be Effected in the Year 2080?**

According to the IPCC estimate of a 65cm scenario SLR, and with respect to the six counties, it appears that although a number of properties along the coast will be considered to not be inundated, it doesn't assure that these coastal properties are safe from the effects of SLR. Numerous coastal parcels are predicted to be affected due to hurricane damage up to the year 2080.

Data Limitations and Benefits

Limitations

1. Lidar data was only available for 3 counties; Duval, Escambia, and Dade. Flyover only included the coastal areas.
2. Lidar data did not include "Bare Earth" estimation, i.e., structures were "not" removed.
3. Lidar data has a 0.5 foot accuracy, so if we use the 34 cm estimate, it's similar to the range of error.
4. Northern Duval County has no private parcels, and Southern Duval County has parcels but the coast is controlled by an Erosion Control Line (ECL)
5. Approximately 90% of Escambia County is publicly owned coast. Most of the private parcels are behind the ECL.

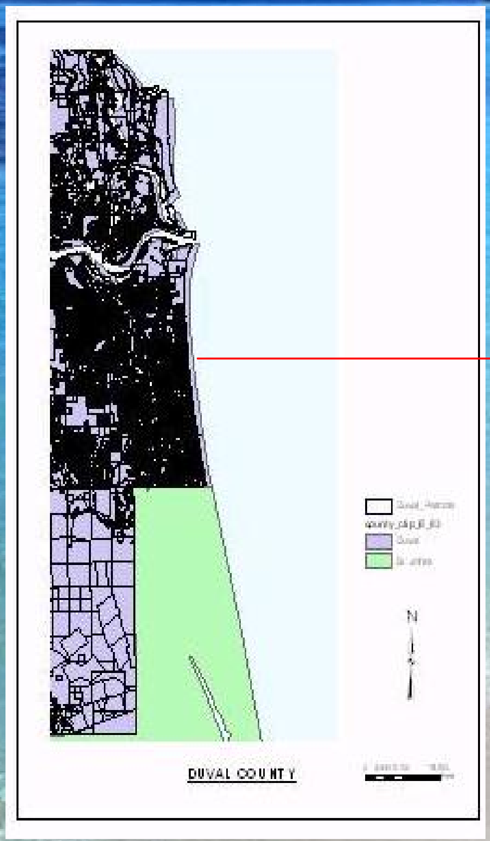
Benefits

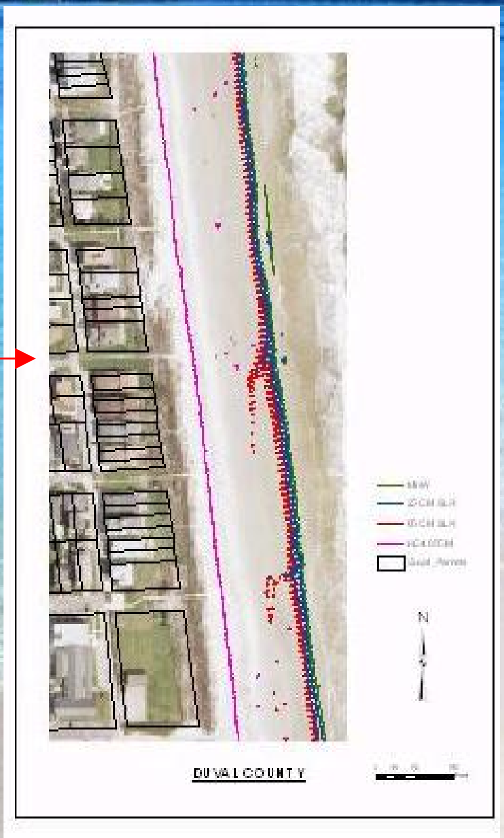
1. Parcel ID (property value) database has distinct variables for land value and for structure value.
2. Parcel ID data was available for all six counties.

Dade County

- Parcels are close to mean high water (MHW)
- Storm surge in a Category 4 (20.132ft) hurricane would likely hit structures and inundate those adjacent properties by the year 2080.

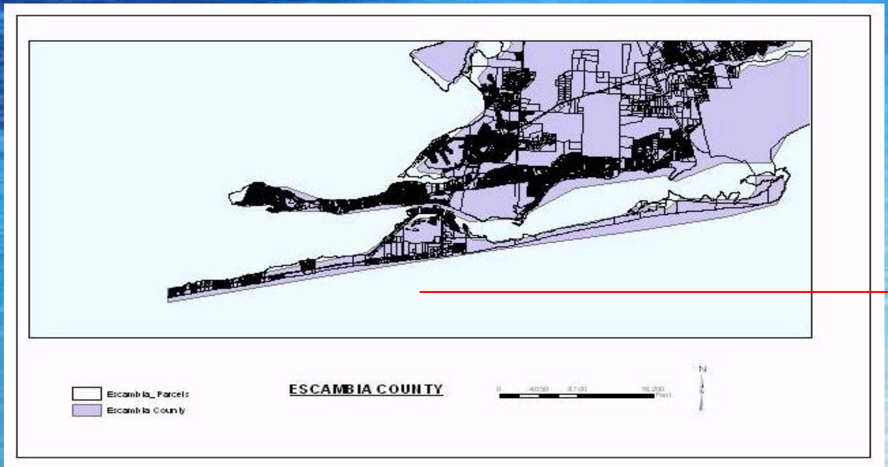
Duval County

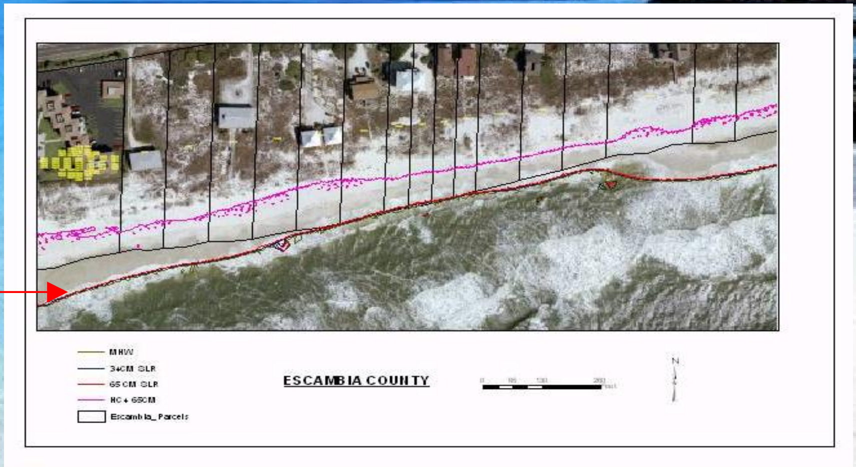




- **Properties located behind the possible line of the Hurricane Category 4 (HC4) contour will likely experience reduced damage costs in 2080.**

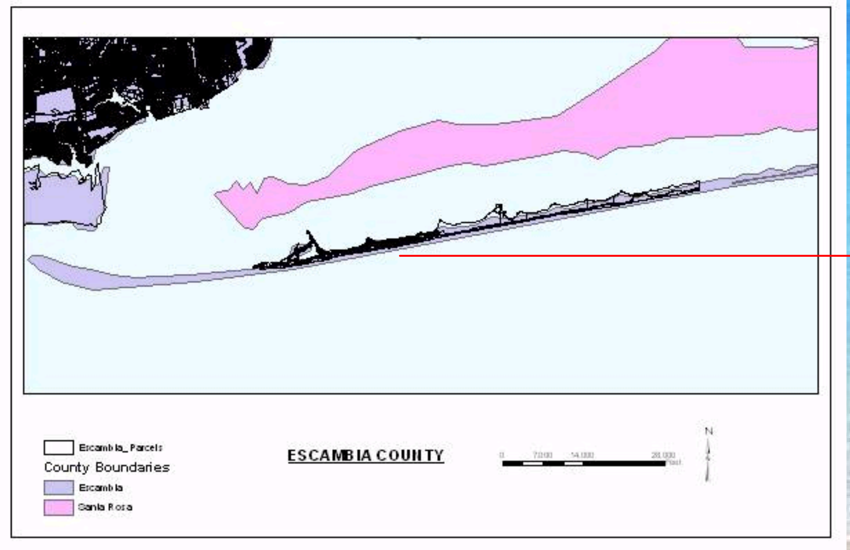
Escambia County (West Side)

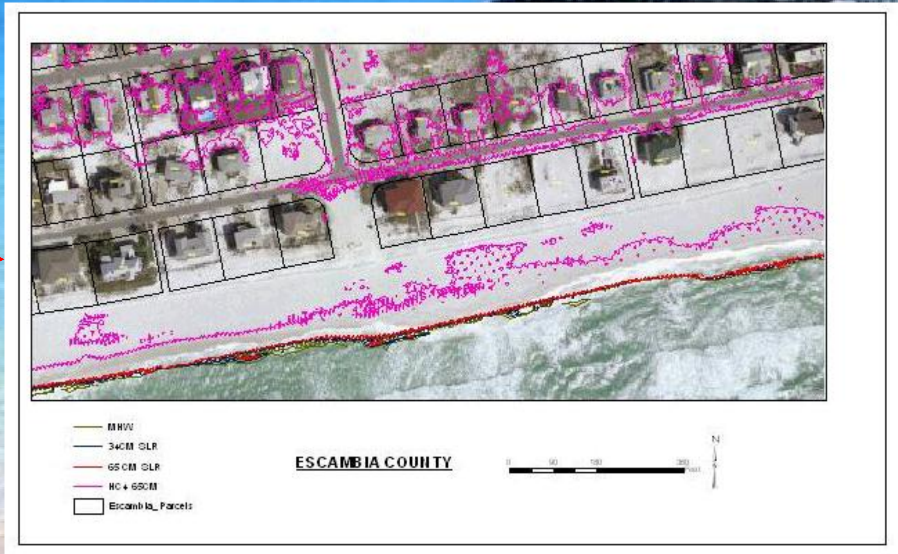




- Land parcels susceptible to SLR and highly likely that properties will be inundated by a HC4

Escambia County (East Side)

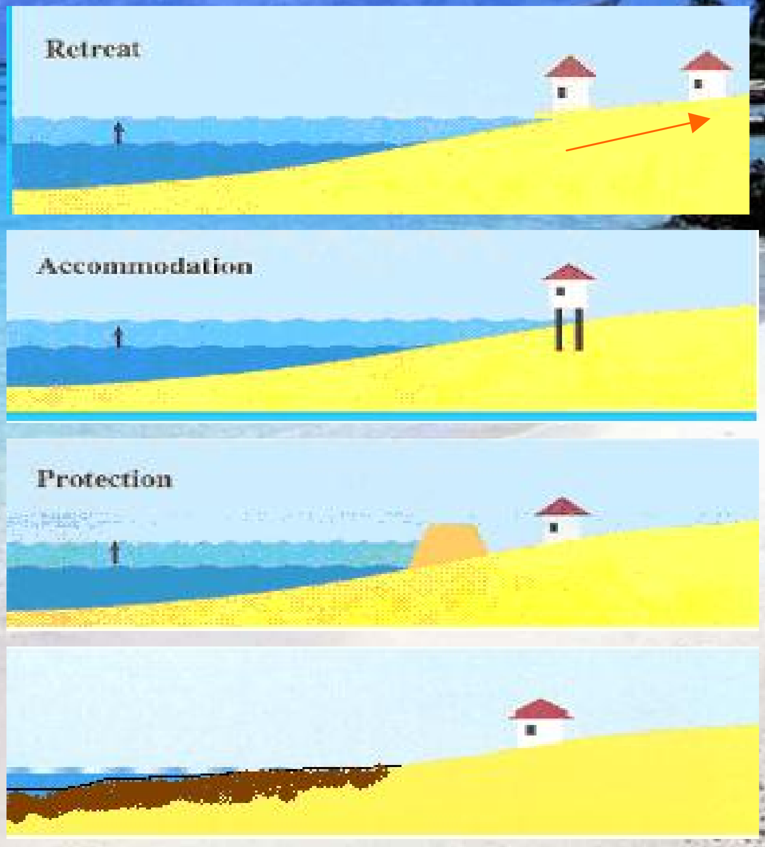




- Properties do not immediately face inundation; however, there is a risk that the lower areas (pink contours) could flood if surge crosses the summit of the frontier of the property

Adaptation Measures in Florida

- ***Retreat*** *: no effect to protect the land from the sea*
- ***Accommodation****: continue to use land at risk*
- ***Protection****: involves hard structure such as sea walls and dikes*
- ***Nourishment****: consists of the placement of good quality sediment along the water's edge to advance the shoreline seaward.*



Comparisons of Alternative Measures

	Retreat	Accommodation	Protection	Beach Nourishment
Pros:	• The most appropriate option in areas of high erosion and in the presence of small economic revenue base	• Provides the opportunities for inundated land to be used for new purposes	Effective Defense	• Reduces Water Power Slowly
Cons:	• Can be costly	• Requires hefty insurance premiums • Frequent maintenance • Property is at risk	• Erosion • Costly Solution • Visually Unattractive	• Necessary to regularly nourish a beach • Dredging may cause short-term direct mortality to sessile organisms, modifies seafloor habitats and sedimentary character

Resource: Report Of The Coast Management Subgroup

Cost Damage Assessment Model

Regression Model

- **Elevation_Return Years** [1] — $Y = a + b \log X$
  Y=surge (ft) , X=year

- **Damage Cost[2]_Storm Surge[3]** — $Y = c + d\,M$ [4]
  Y=surge (ft) , M=damage cost ($ in 2006)

Damage cost and return years of the storm event associated with storm surge are simulated by linear interpolation and regression.

This approach was developed by CEFA, FSU to project damage cost and return year period.

1 *Flood Insurance Study, FEMA, 2000*
2 *Hurricane Summary Data, Florida Office of Insurance Regulation, 2006 ; 2006 Dollars*
3 *Tropical Cyclone Report 2005*
4 *Regression with 95% confidence*

Cost Damage Assessment

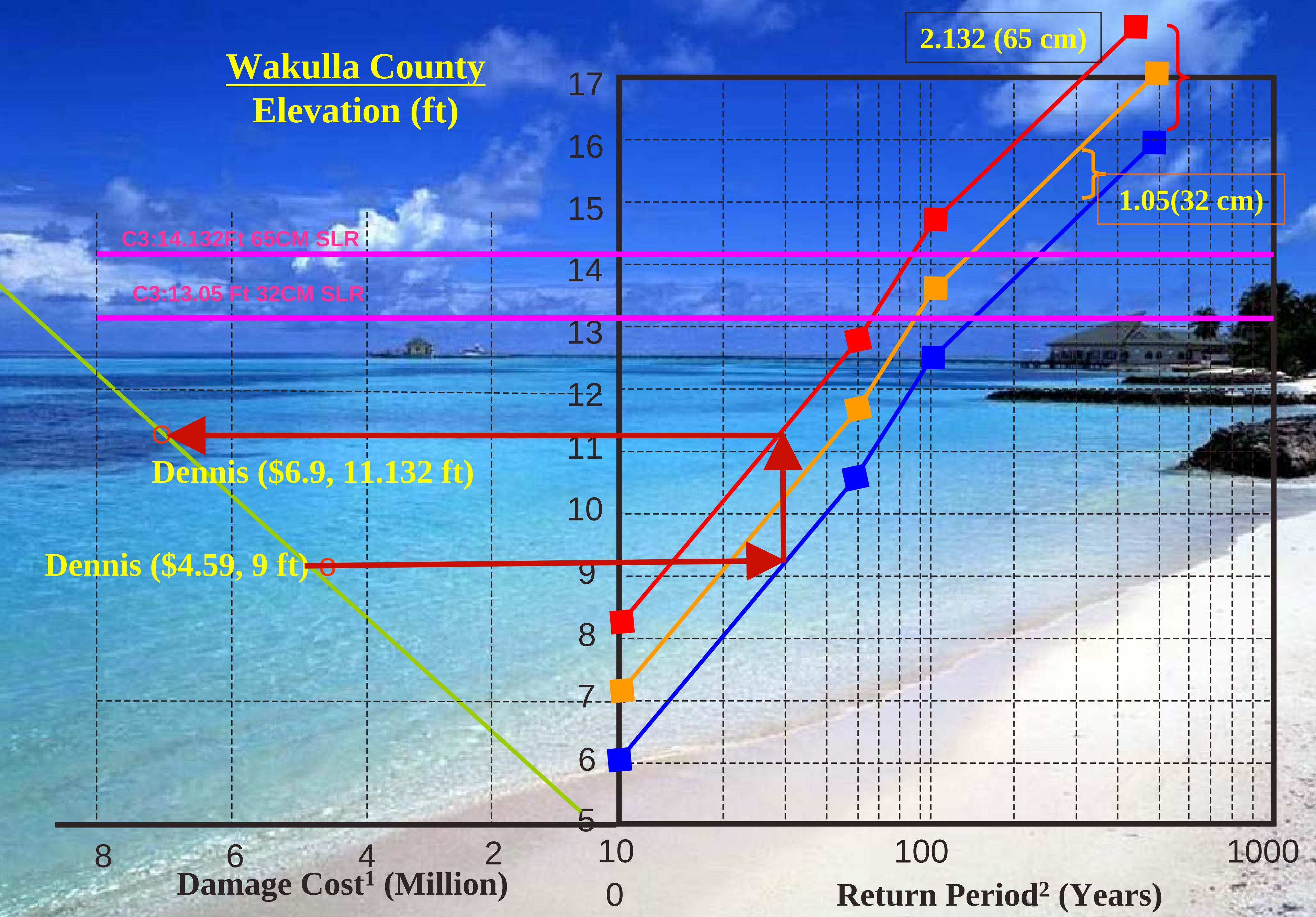
There are Two Approaches[1] to Measure the Damage Associated with SLR.

- **Increase of the Damage Cost**
- **Reduction of Hurricane Return Years**

In Dade County, the return year for a Category 2 hurricane with a storm surge of 8 feet will be reduced from 412 years to 12 years for a 65 cm SLR scenario.

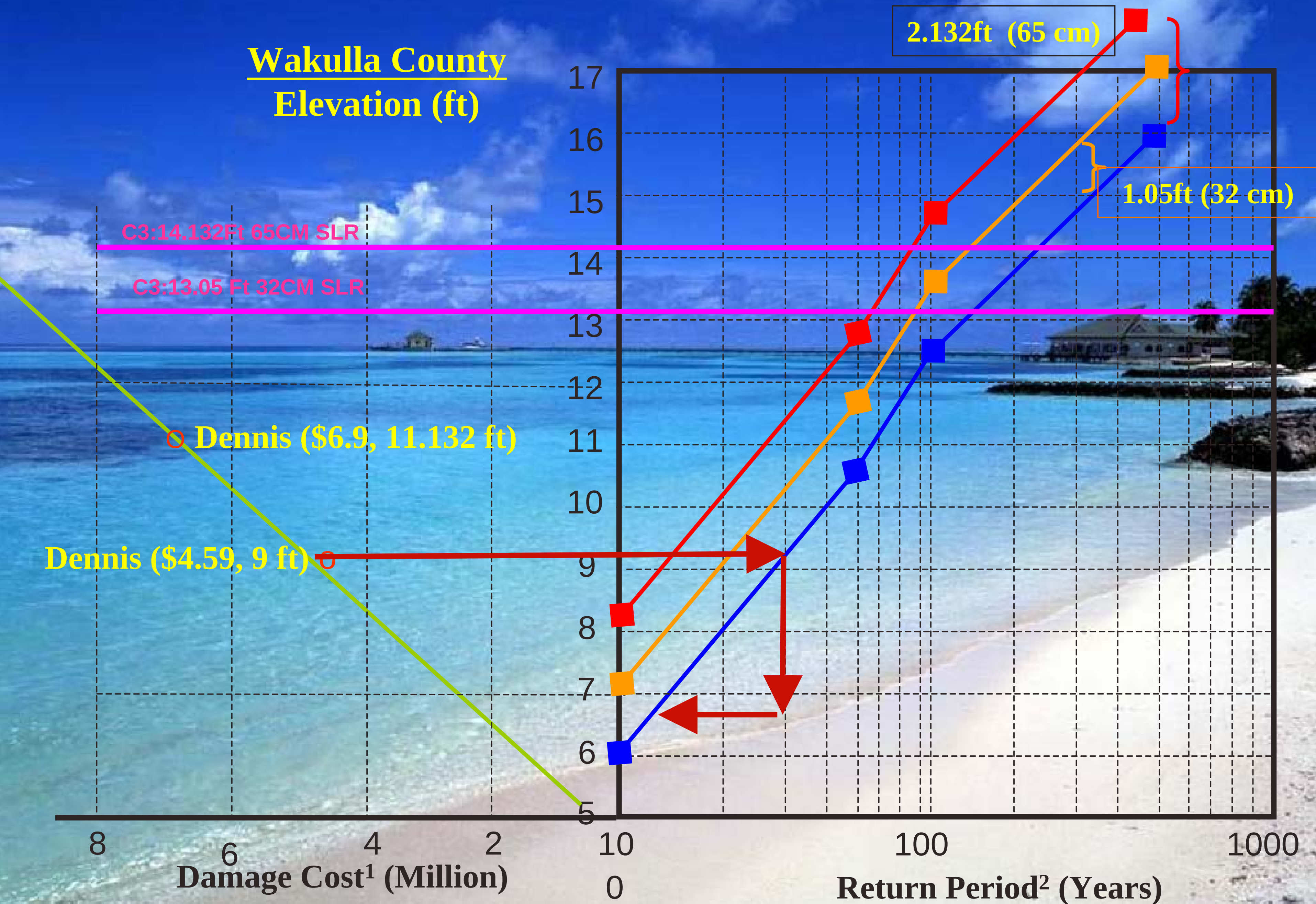
The associated damage cost will increase from \$2.4 Billion to \$3.3 billion.[2]

1 CEFA, Florida State University
2 Linear Regression with 95% confidence



1 *Hurricane summary data, Florida Office of Insurance Regulation, 2006*

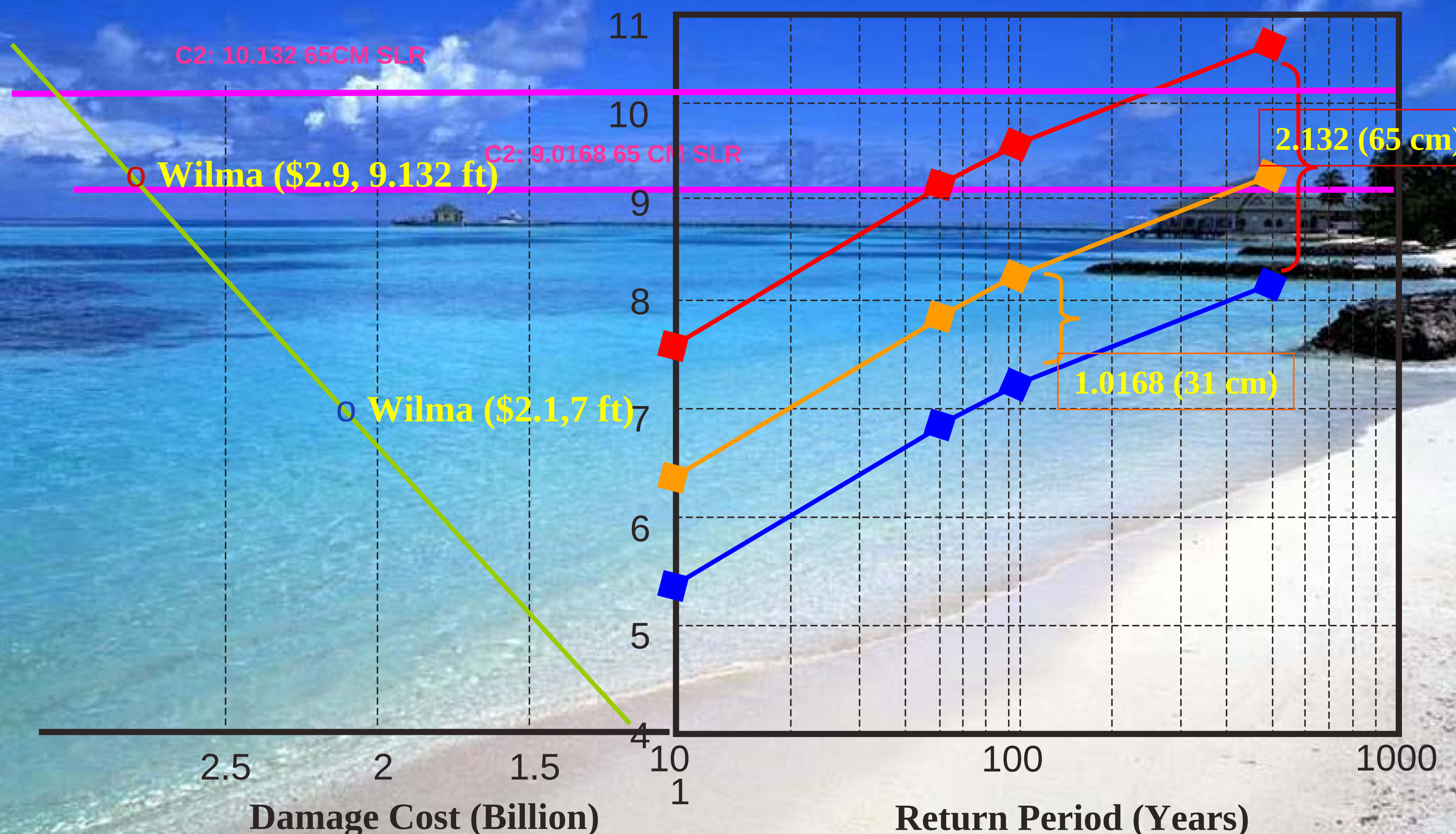
2 *Flood Insurance study, FEMA, 2000*



[1] *Hurricane summary data, Florida Office of Insurance Regulation, 2006*

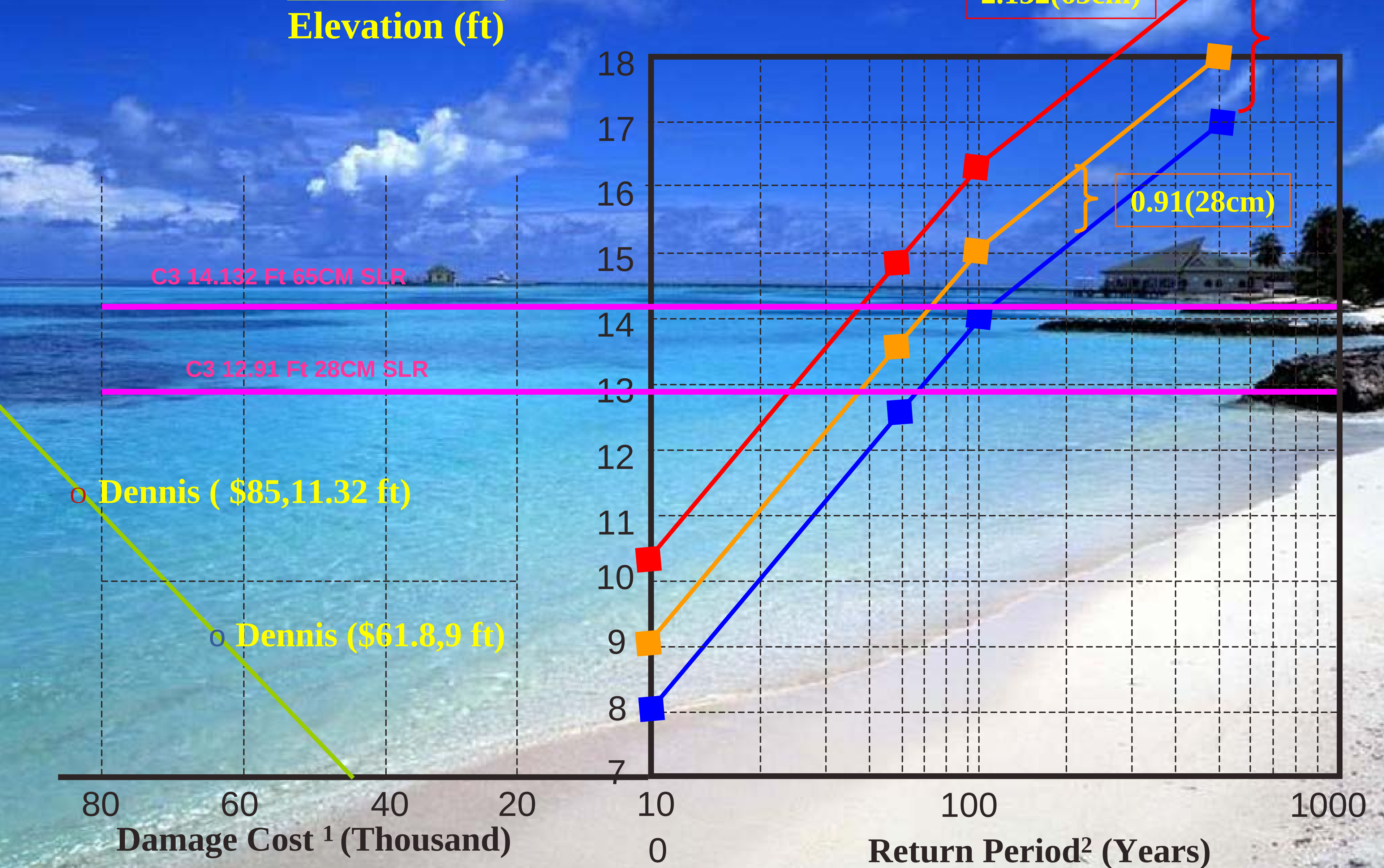
[2] *Flood Insurance study, FEMA, 2000*

Dade County
Elevation (ft)



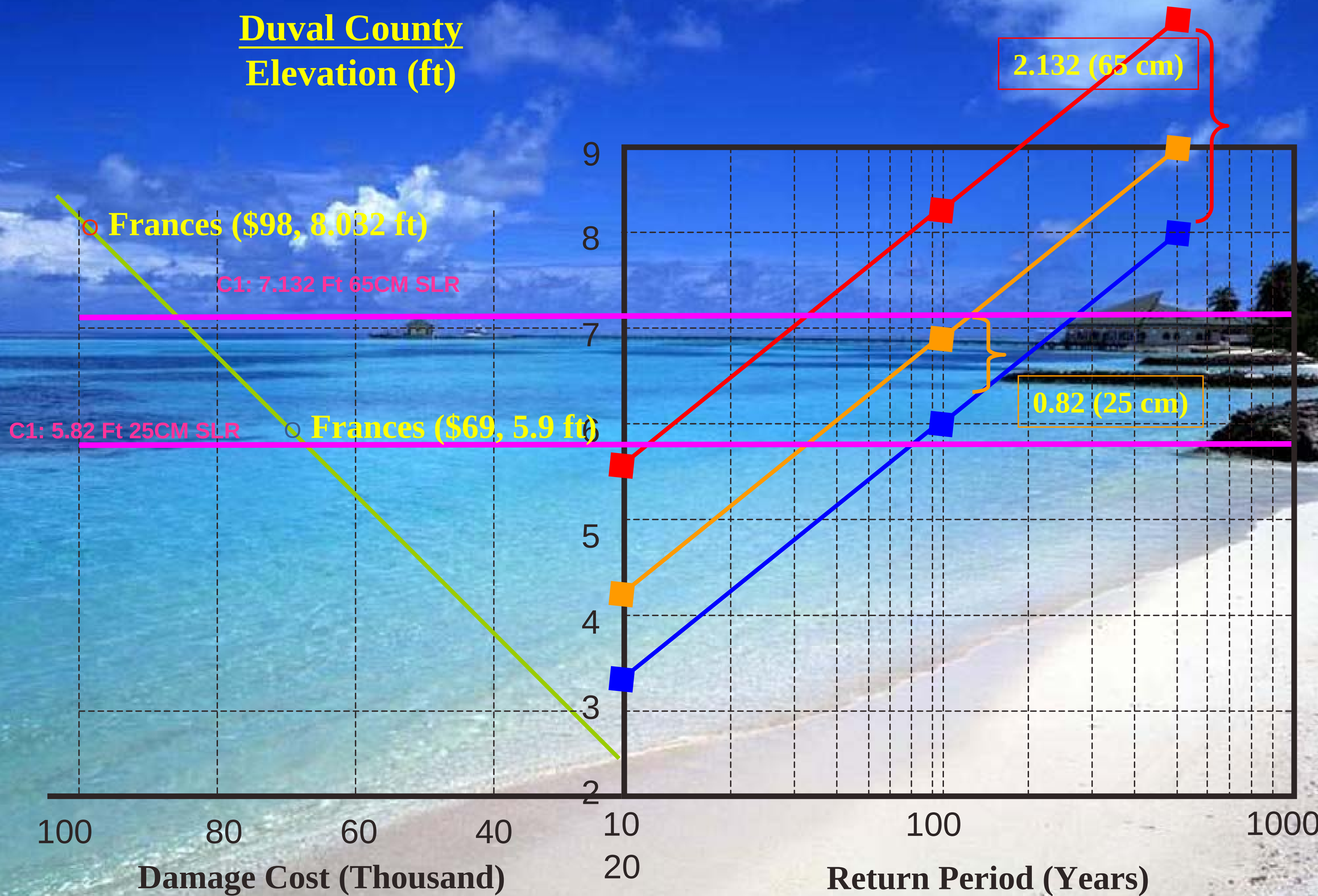
1 *Hurricane summary data, Florida Office of Insurance Regulation, 2006*
2 *Flood Insurance study, FEMA, 2000*

Dixie County



[1]*Hurricane summary data, Florida Office of Insurance Regulation, 2006*

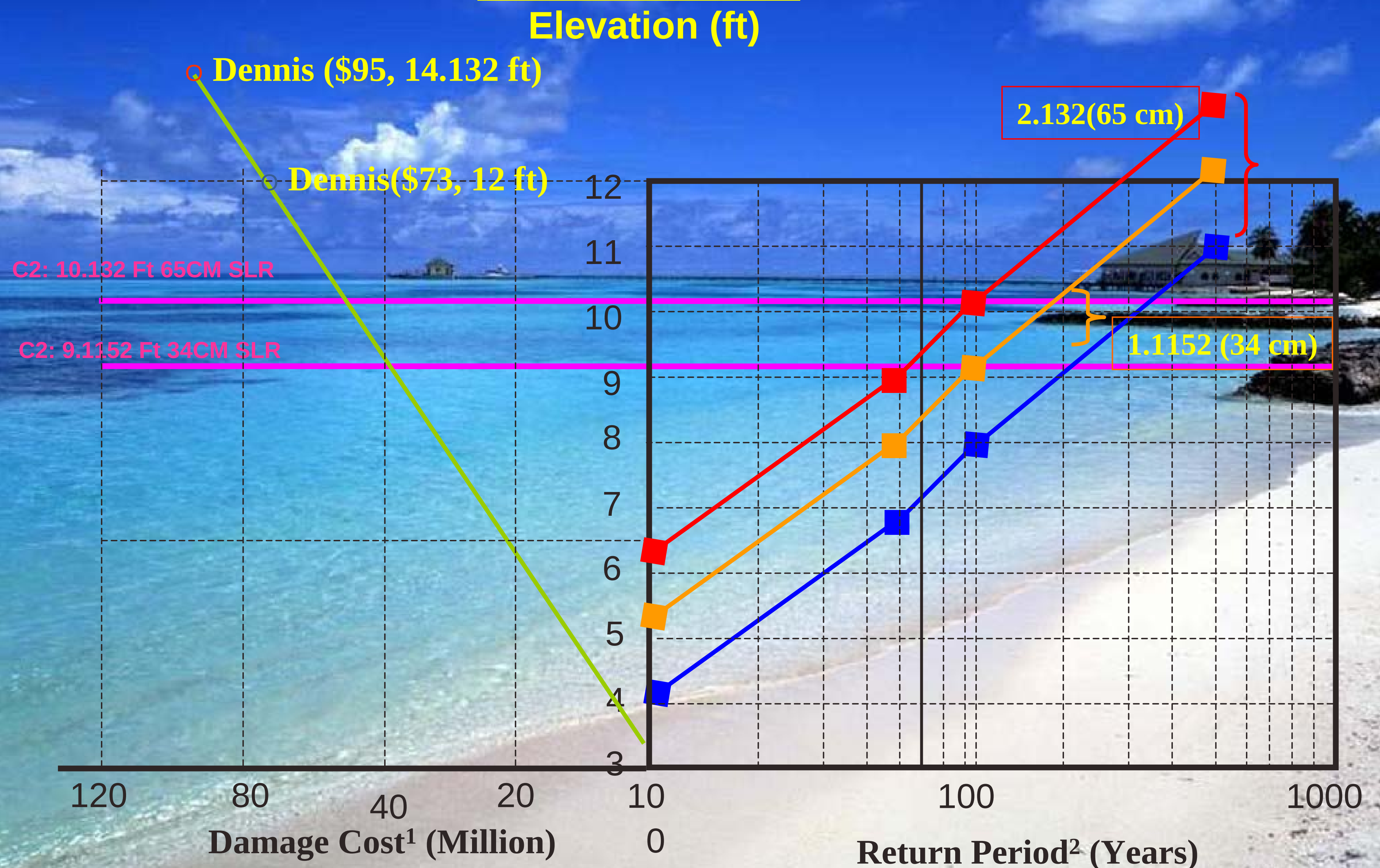
[2] *Flood Insurance study, FEMA, 2000*



1 *Hurricane summary data, Florida Office of Insurance Regulation, 2006*

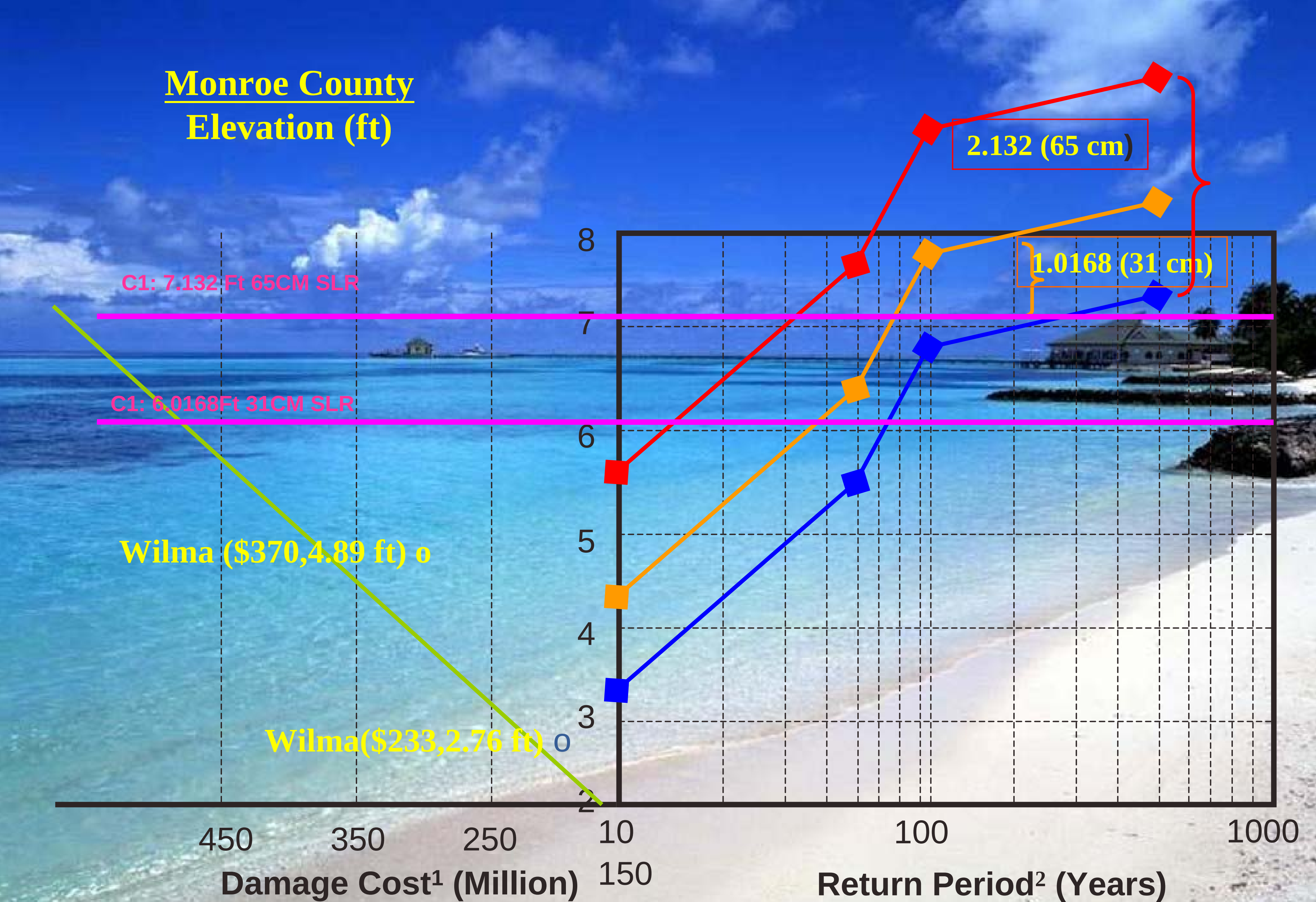
2 *Flood Insurance study, FEMA, 2000*

Escambia County



1 *Hurricane summary data, Florida Office of Insurance Regulation, 2006*
2 *Flood Insurance study, FEMA, 2000*

Monroe County
Elevation (ft)



1 *Hurricane summary data, Florida Office of Insurance Regulation, 2006*
2 *Flood Insurance study, FEMA, 2000*

Event Totals by County of Loss Occurrence - CY 2004 in 2006 Dollars

	Charley	Frances	Ivan	Jean
Dade	$3,008,721	$70,468,075	$2,865,950	$16,170,268
Dixie	$36,408	$4,945,128	$63,237	$971,682
Duval	$5,906,950	$72,322,498	$1,649,646	$22,404,237
Escambia	$1,001,182	$12,980,961	$2,010,001,983	$19,105,056
Monroe	$663,804	$4,945,128	$363,295	$133,665
Wakulla	$14,047	$1,854,422	$214,588	$193,451

Resource: Hurricane summary data, Florida Office of Insurance Regulation, 2006

Event Totals by County of Loss Occurrence- CY 2005 in 2006 Dollars

	Dennis	Katrina	Rita	Wilma
Dade	$5,976,177	$585,157,998	$4,396,620	$2,152,438
Dixie	$59,559	$1,742	$661	$33,104
Duval	$361,426	$831,764	$151,072	$1,055,752
Escambia	$70,706,486	$11,341,048	$150,867	$283,996
Monroe	$4,400,998	$27,907,960	$11,329,370	$215,335,831
Wakulla	$4,418,483	$588,457	$1,274	$28,279

Resource: Hurricane Summary Data, Florida Office of Insurance Regulation, 2006