"Sea Level Acceleration Characteristics in the 20th Century and Extrapolation to 2100"

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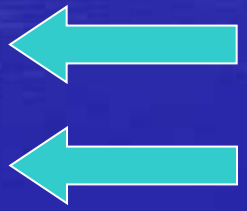
FSBPA Spring Conference

Two Related Papers

- Watson, P. (2011) "Is There Evidence Yet of Acceleration in Mean Sea Level Rise Around Mainland Australia?:, Journal of Coastal Research, Vol. 27, No. 2.
- Houston, J. R. and R. G. Dean "Sea-Level Acceleration Based on U. S. Tide Gages and extensions of Previous Global-Gauge Analyses", Accepted for Publication in Journal of Coastal Research

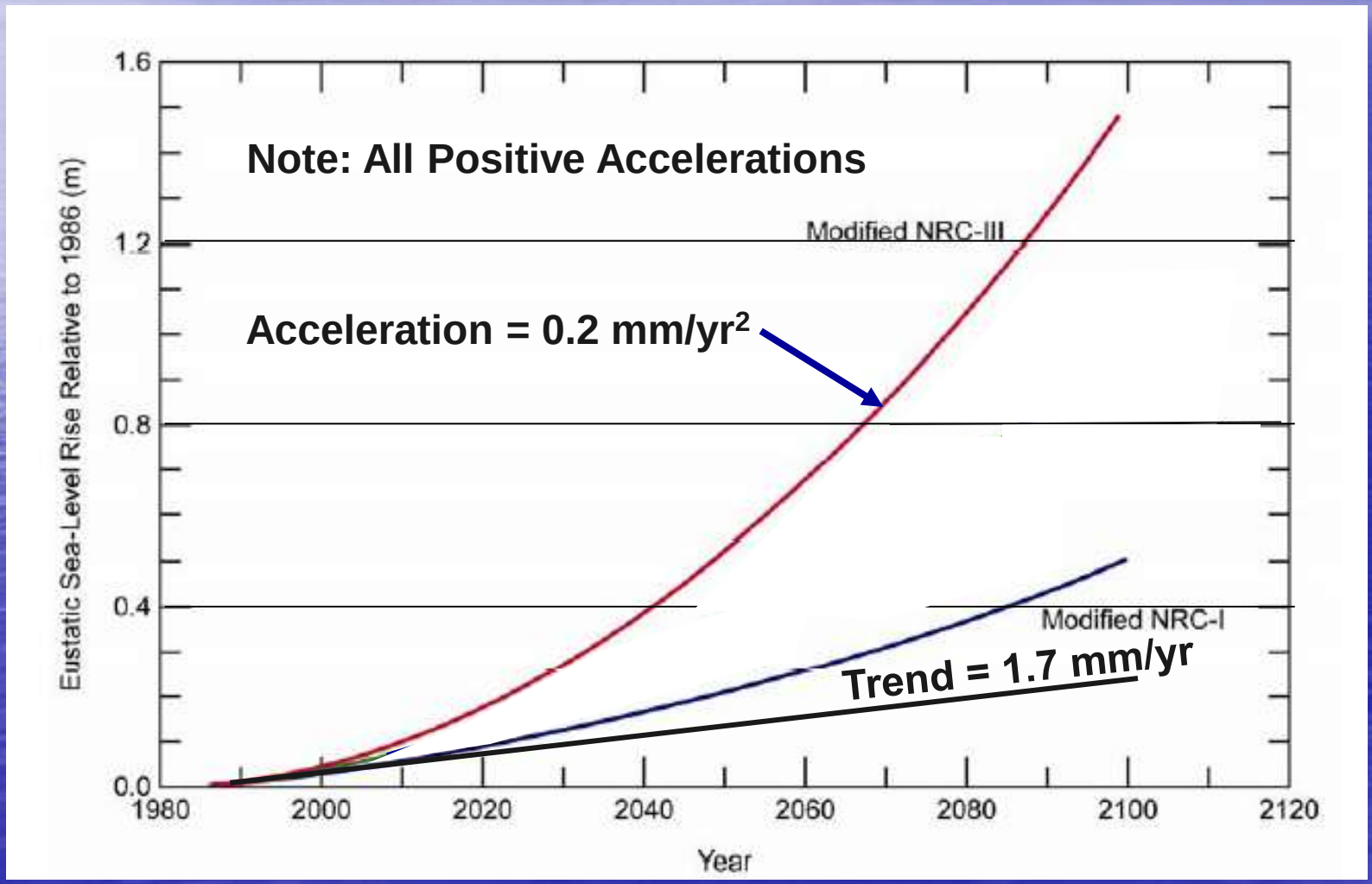
Outline

- Significance of Sea Level Acceleration
- Description of Tide Gage Records
- Analysis Issues
- Analysis of High-Quality U. S. Tide Gages
- Results Based on Florida Tide Gages
- US and Florida Rates of Increase Over 20th Century
- Extrapolation to 2100

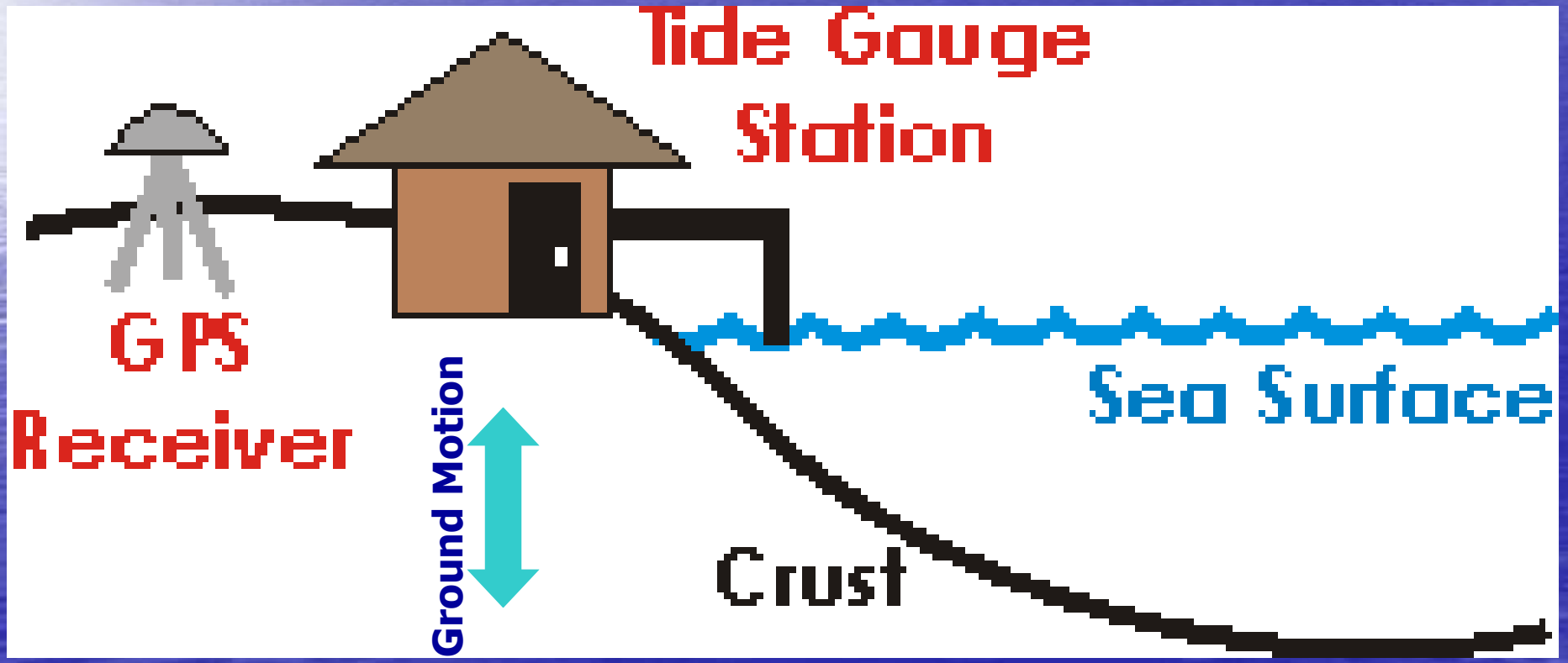


New

Corps of Engineers Guidance for Global (Eustatic) Sea Level Rise (2009)



Tide Gage


Tide Gouge
Station
GPS
Receiver
Ground Motion
Sea Surface
Crust

Sea Level Rise Components as Measured by a Tide Gage

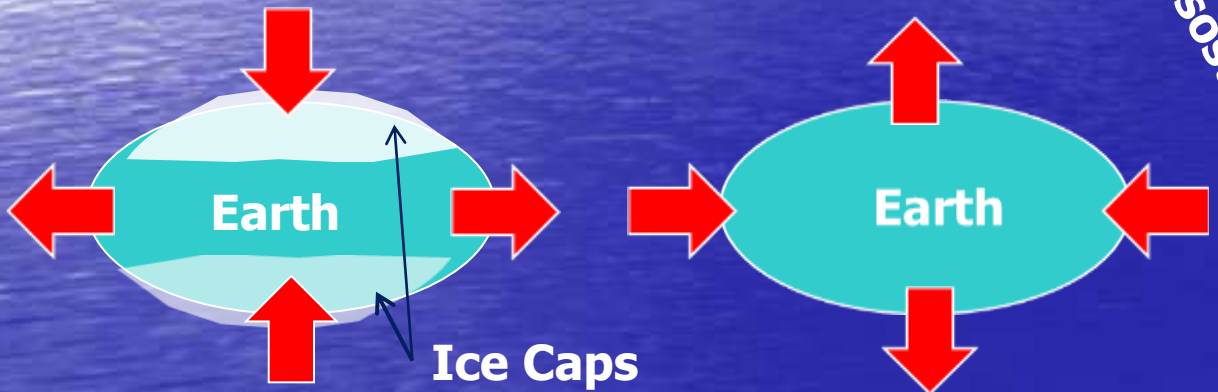
Sea Level Rise Components as Measured by a Tide Gage

Sea Level = World Wide Sea Level + GIA + Local Effects + Noise

Eustatic Sea Level

Glacial Isostatic Adjustment

Can Be Natural or Anthropogenic



Last Ice Age
20,000 Years Ago

Presently

Glacial Isostatic Adjustment

Examples of Local Effects

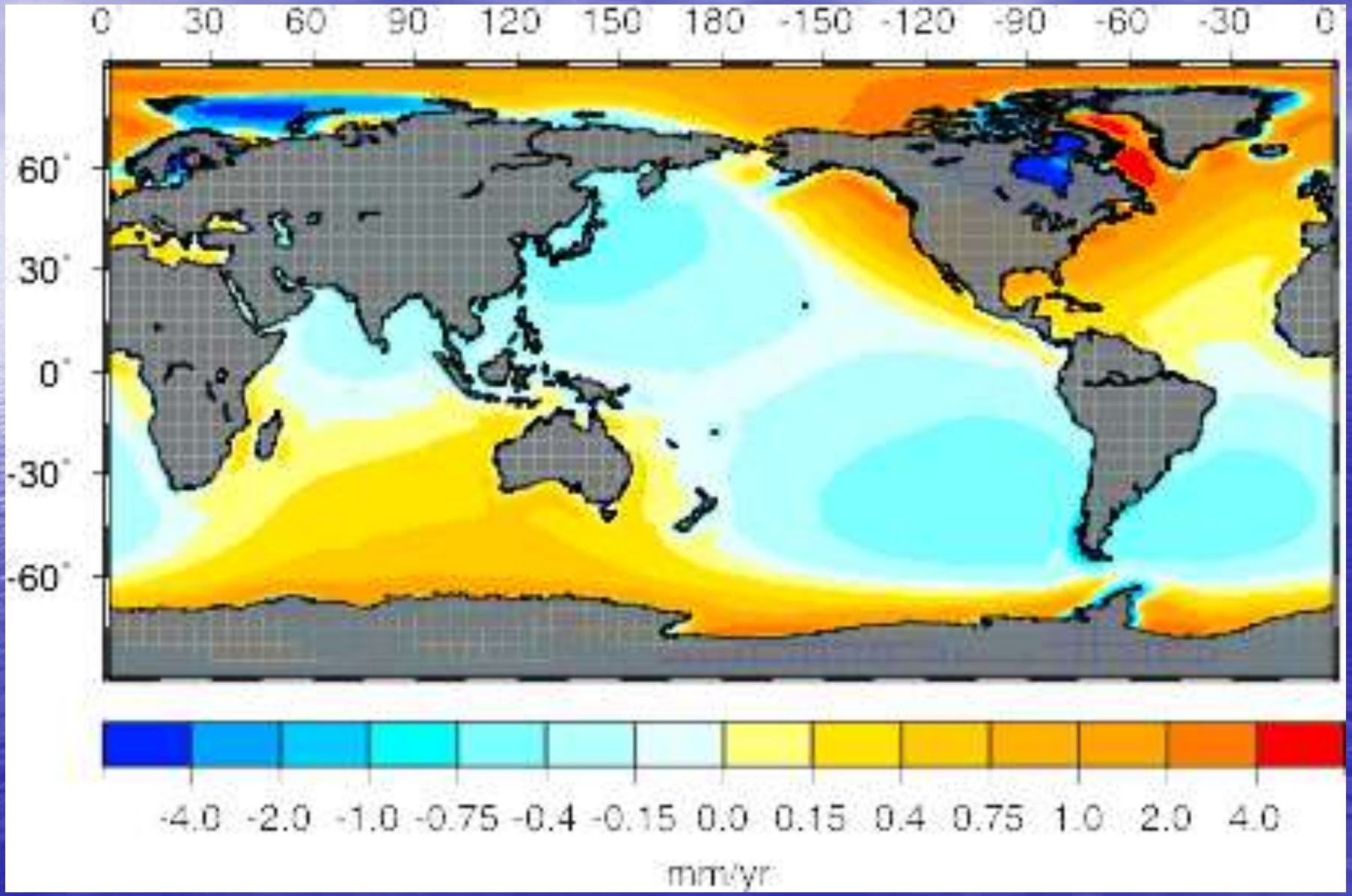
Natural

- Compaction of Underlying Sediments
- Earthquakes

Anthropogenically Induced

- Withdrawal of Ground Fluids (Gas, Oil, Water)
- Building Heavy Structures on Weak Sediments

Model Results for Glacial Isostatic Adjustment



The Algebraic Relationship

$$y = a_0 + a_1 t + \frac{1}{2} a_2 t^2$$

Sea Level

Constant

Initial Trend (mm/yr)

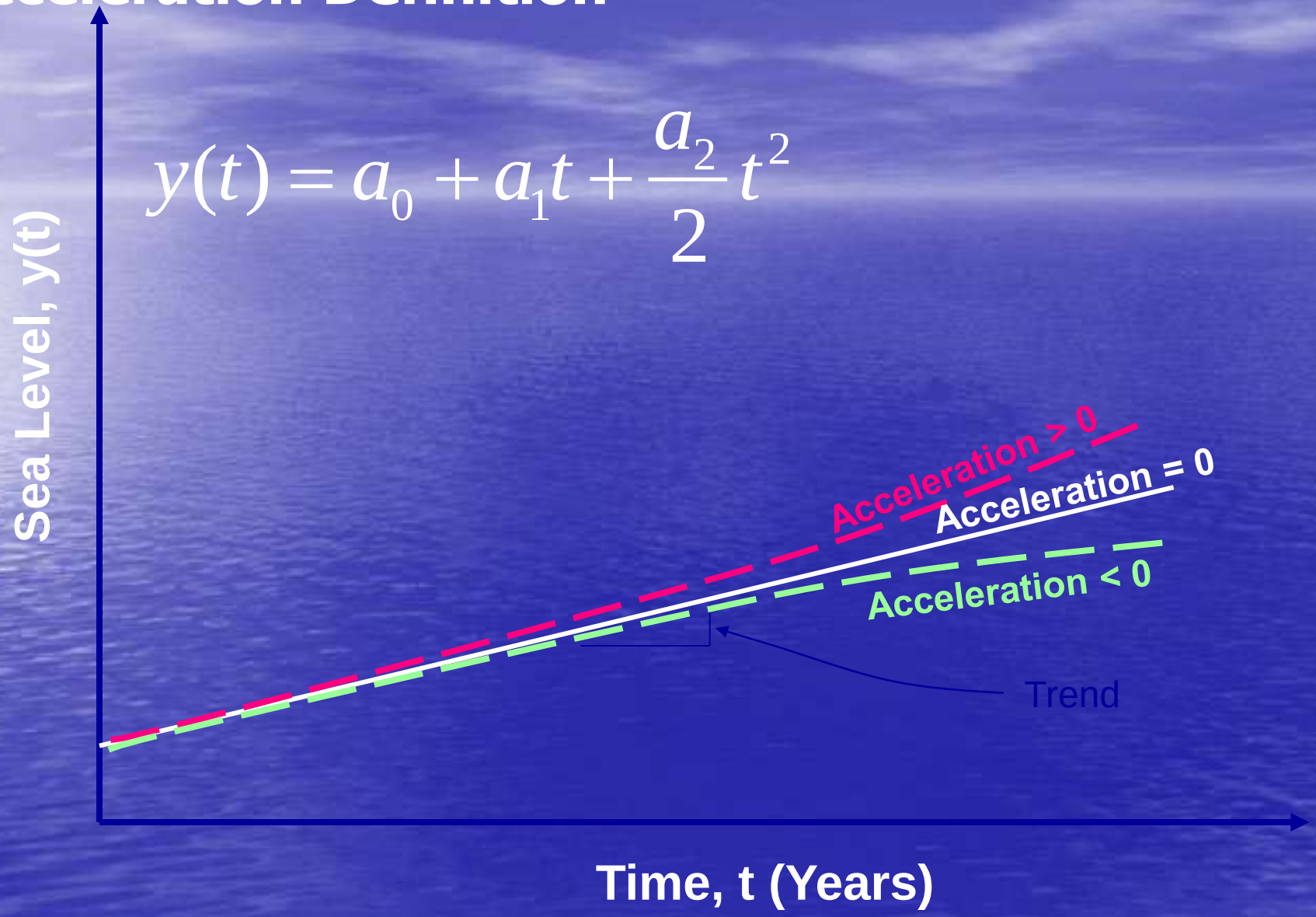
Time (Years)

Acceleration (mm/yr^2)

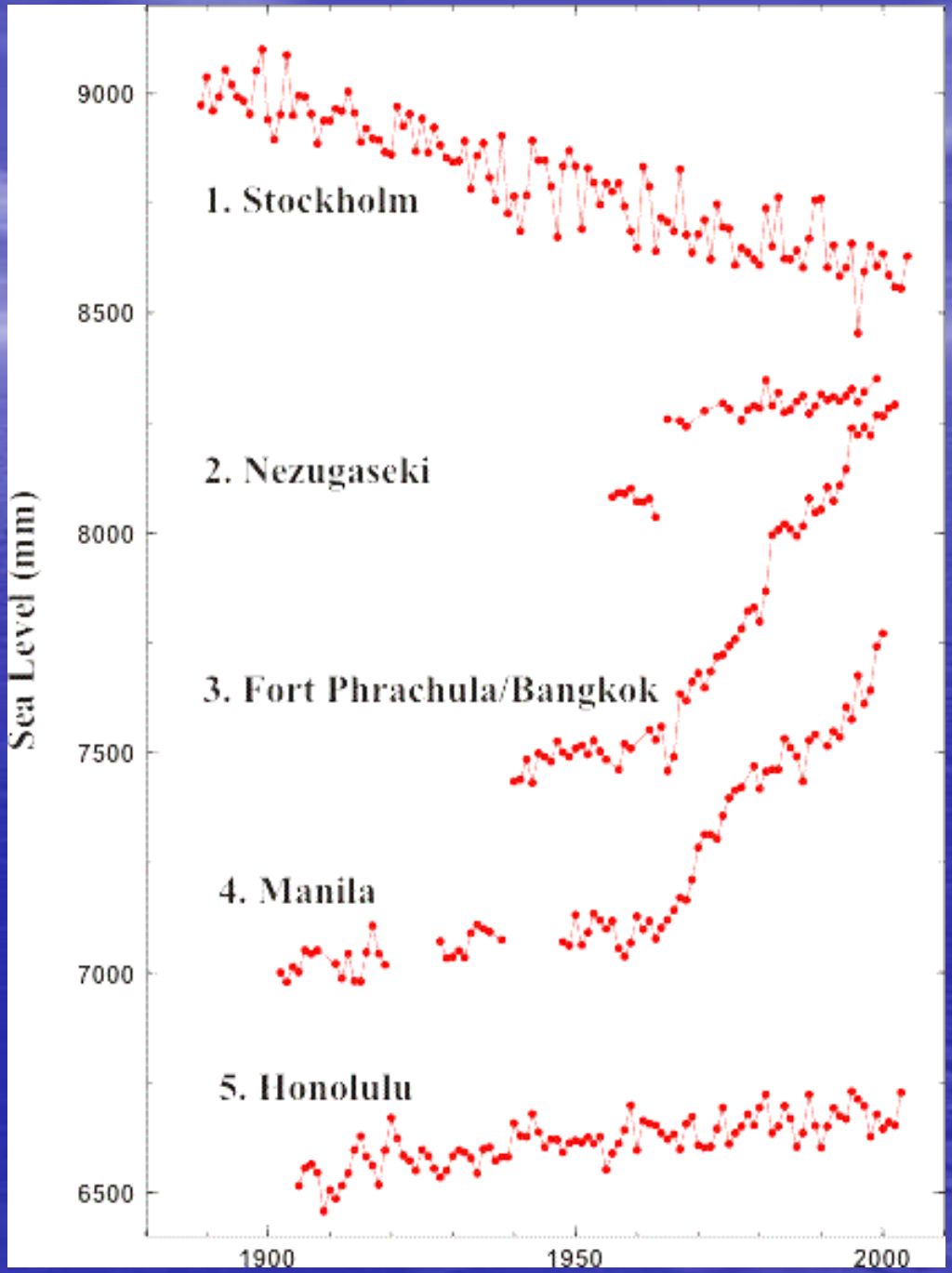
The accepted value of a_1 over the last century for the eustatic trend is approximately 1.7 mm/yr (6.7 inches per century)

Acceleration Definition

$$y(t) = a_0 + a_1 t + \frac{a_2}{2} t^2$$



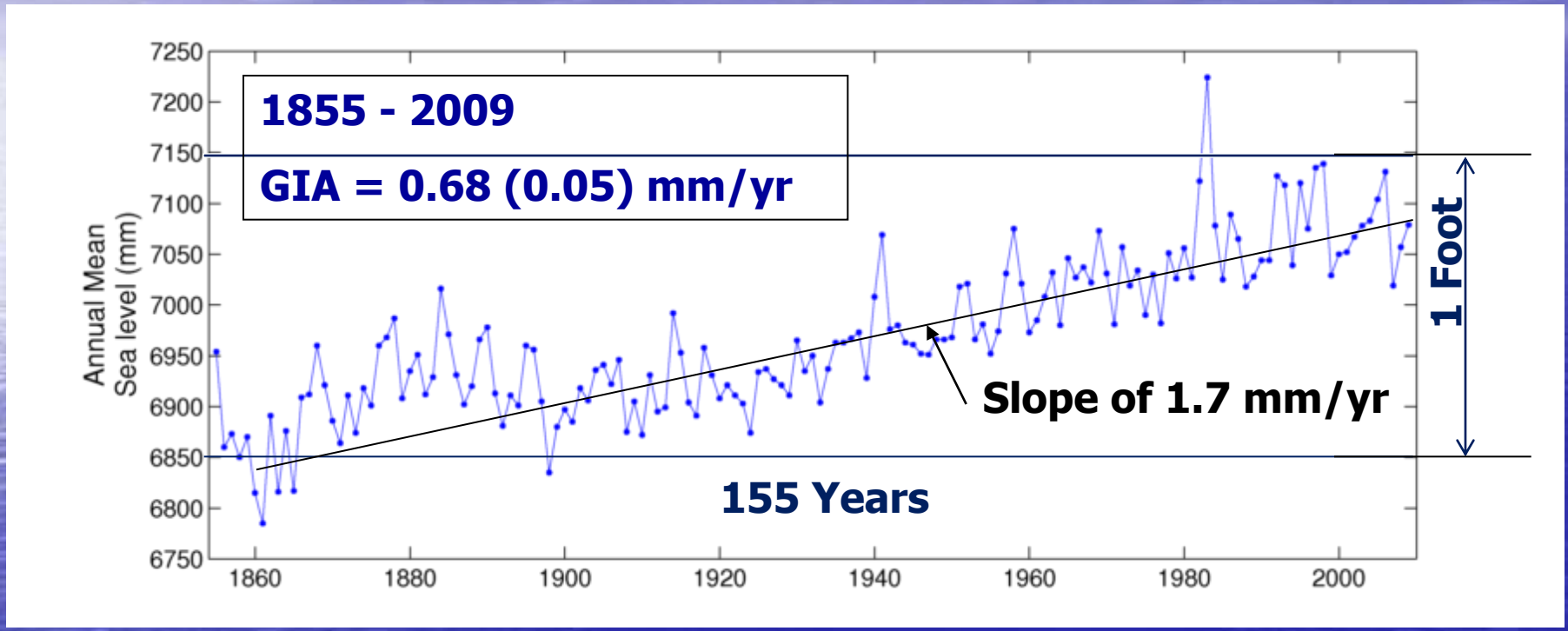
Tide Gage Data Are Not Always Consistent With the Model



Ideal Tide Gage Record

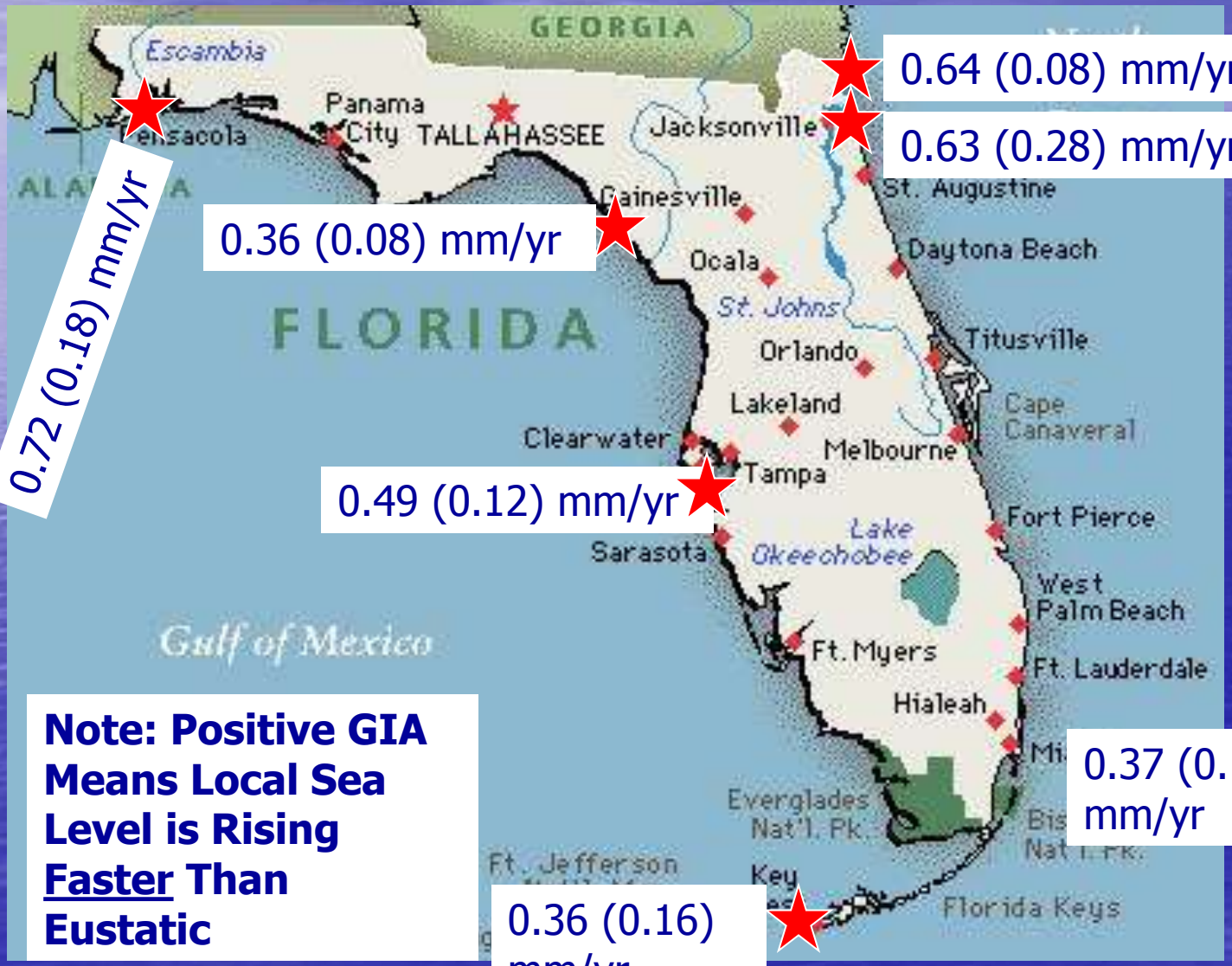
- Long Record (At least 50 to 60 years)
- Continuous (Minimal gaps)
- Location geologically stable
- Lots of gages of the above type

Example of Tide Gage Record (San Francisco: The Longest U.S. Gage)



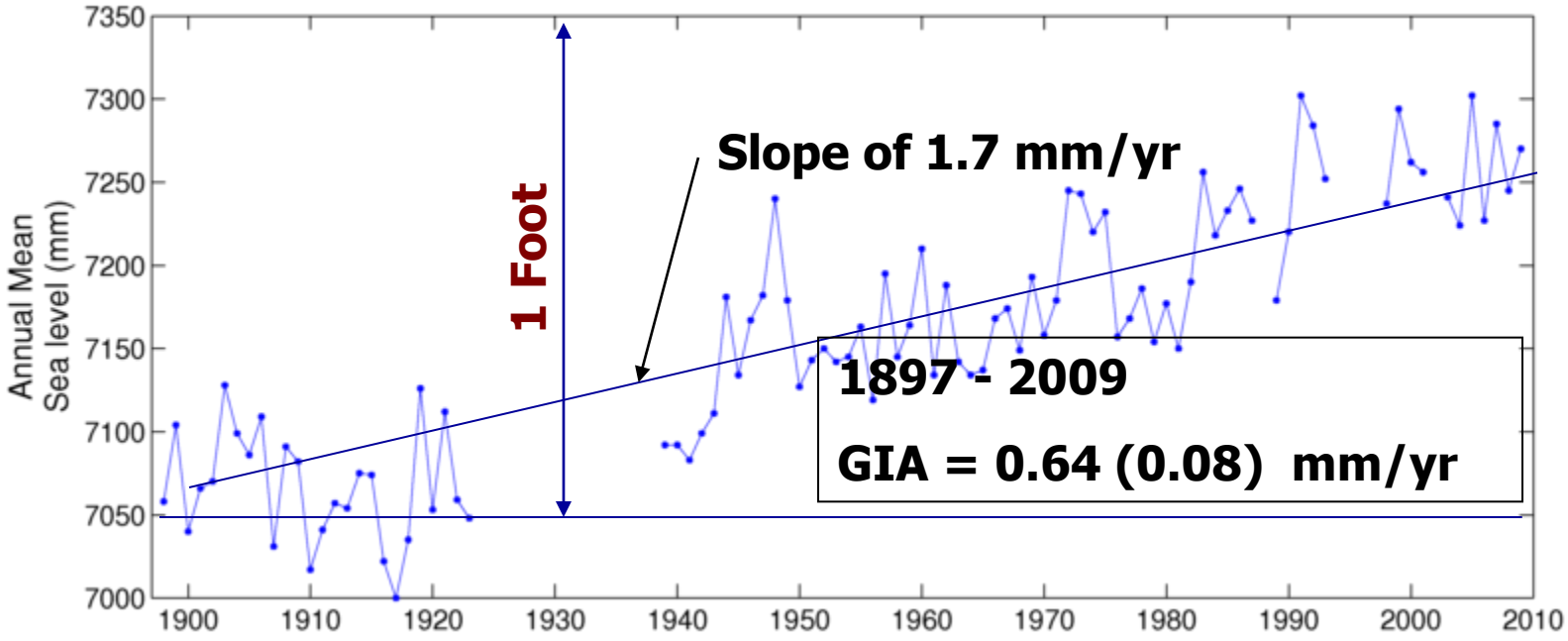
From PSMSL Web Site

Locations of Seven Florida Tide Gages and Two GIA Model Results (mm/yr)



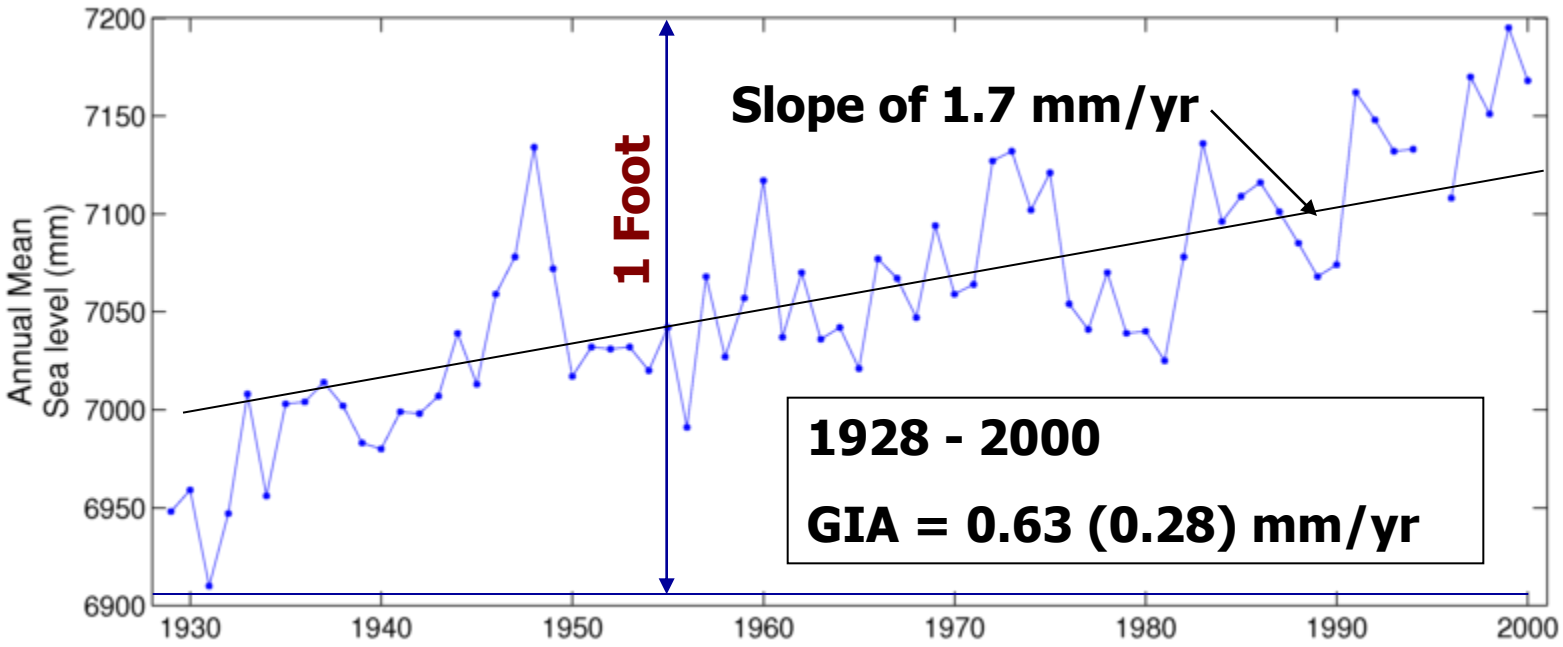
Note: Positive GIA Means Local Sea Level is Rising <u>Faster</u> Than Eustatic

Fernandina Beach, FL Tide Gage



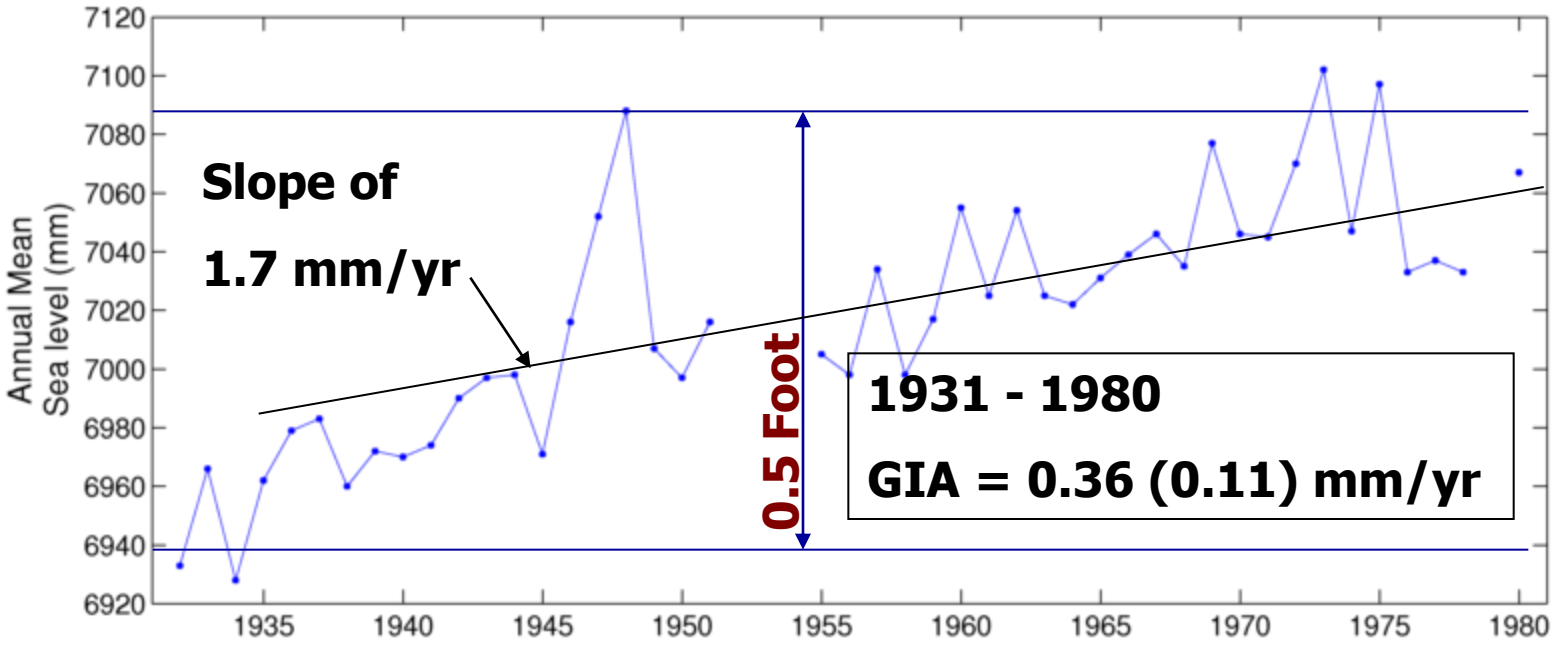
From PSMSL Web Site

Mayport, FL Tide Gage



From PSMSL Web Site

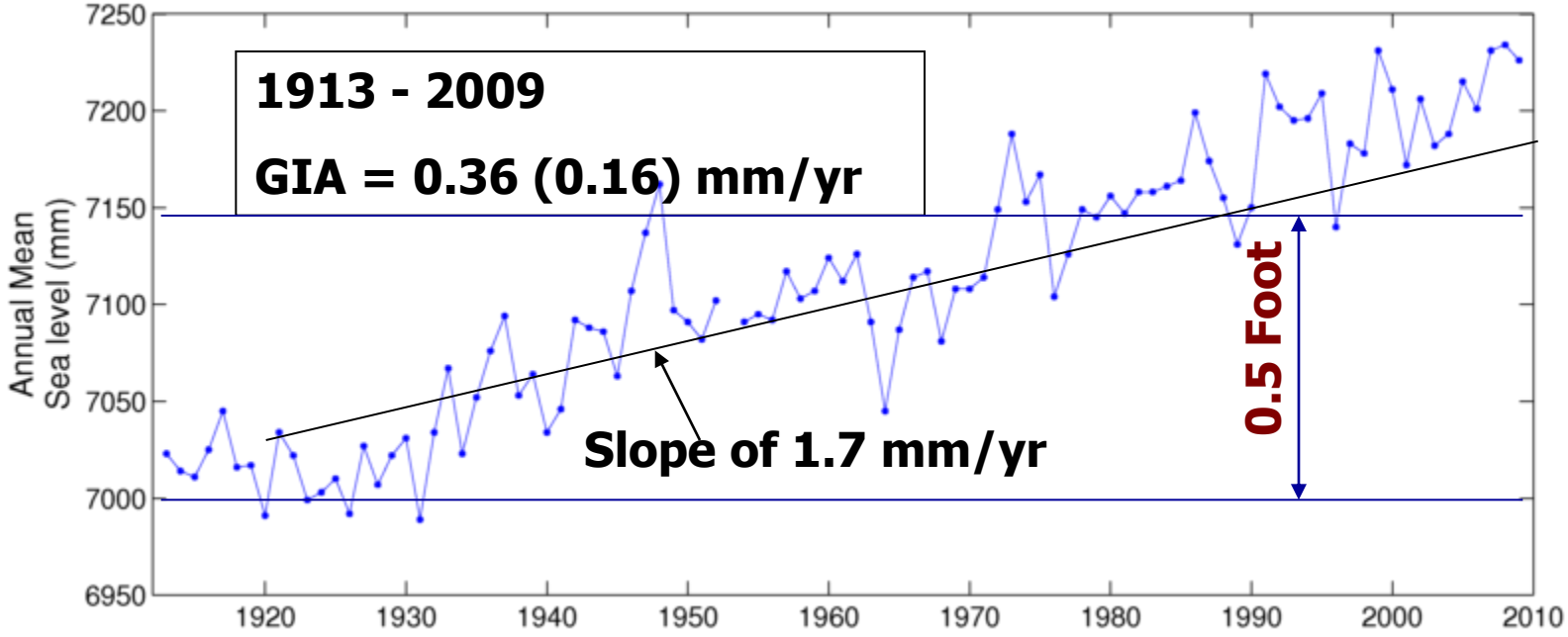
Miami Beach, FL Tide Gage



From PSMSL Web Site

Note: GPS located 4.8 km from this tide gage records 0.70 mm/yr.

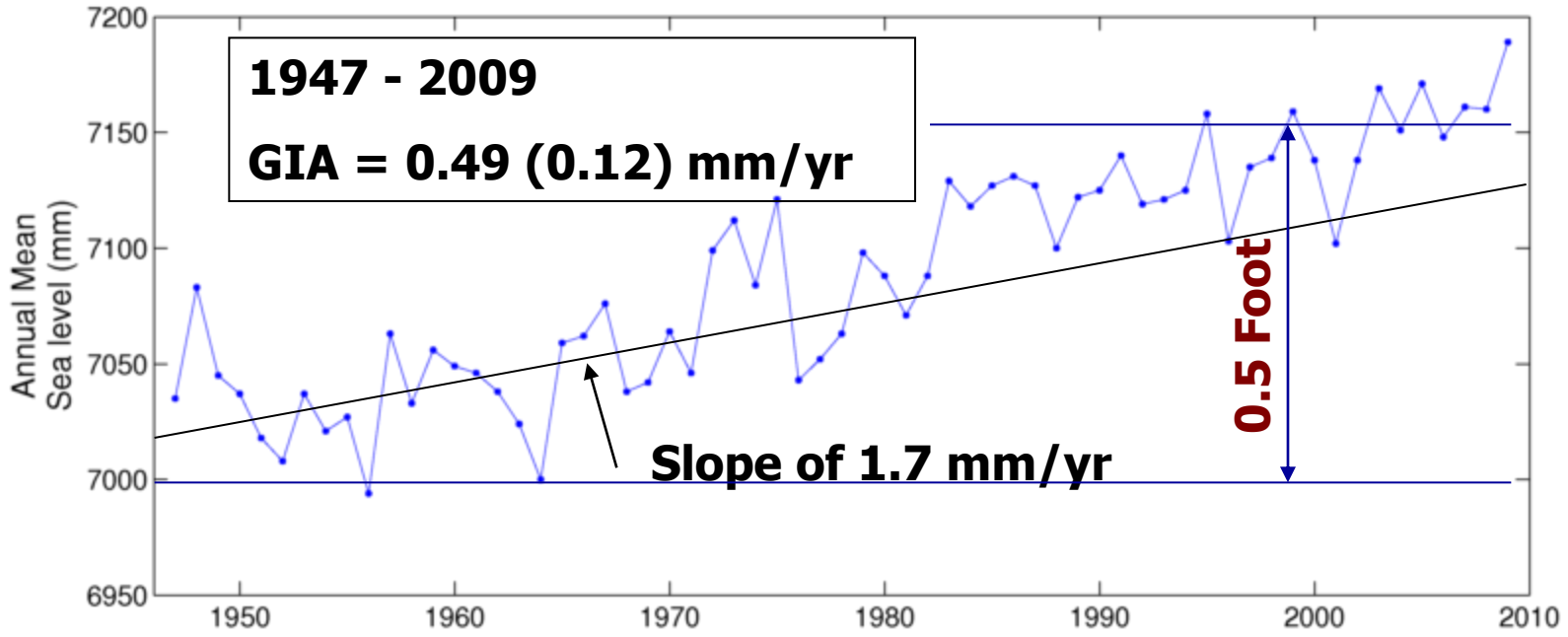
Key West, FL Tide Gage



From PSMSL Web Site

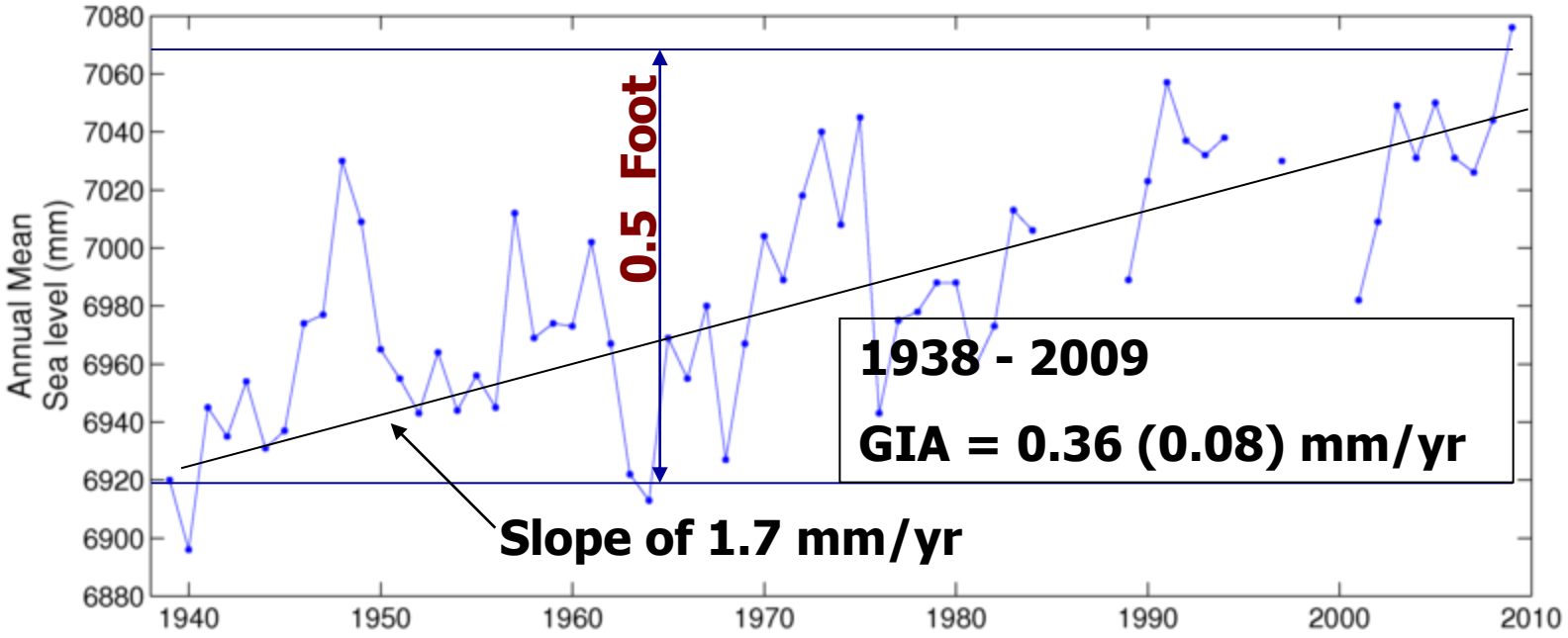
Note: GPS located 16 km from this tide gage records 0.30 mm/yr.

St. Petersburg Tide Gage



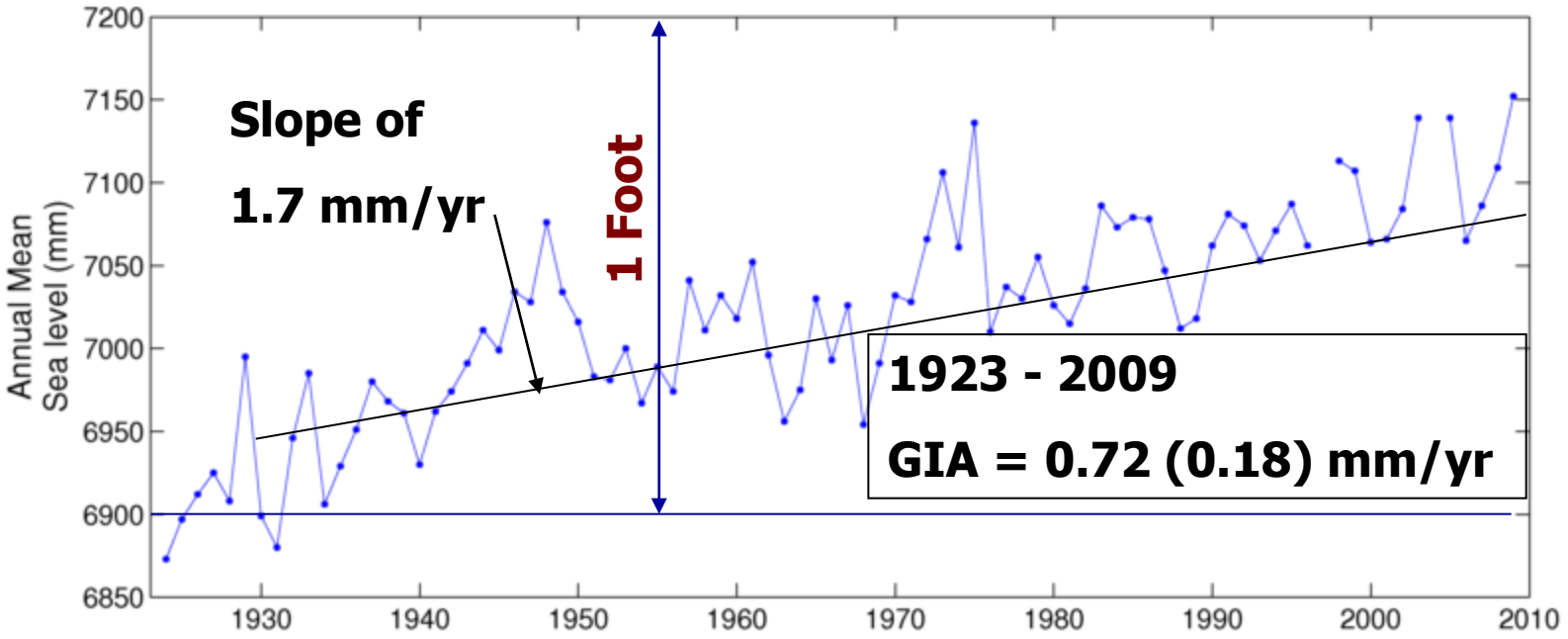
From PSMSL Web Site

Cedar Key II, FL Tide Gage



From PSMSL Web Site

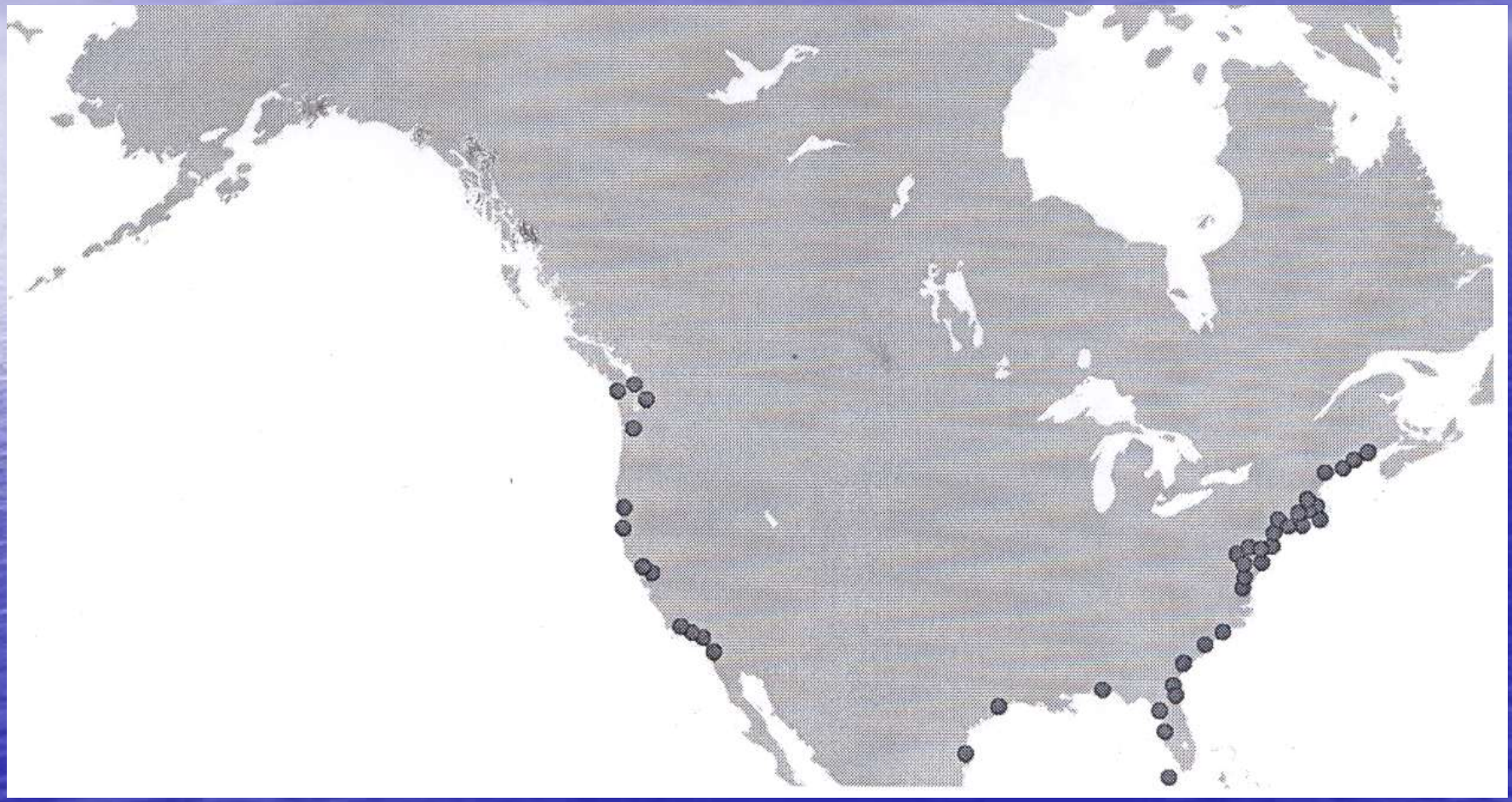
Pensacola, FL Tide Gage



From PSMSL Web Site

Note: GPS located 7.5 km from this tide gage records 0.20 mm/yr.

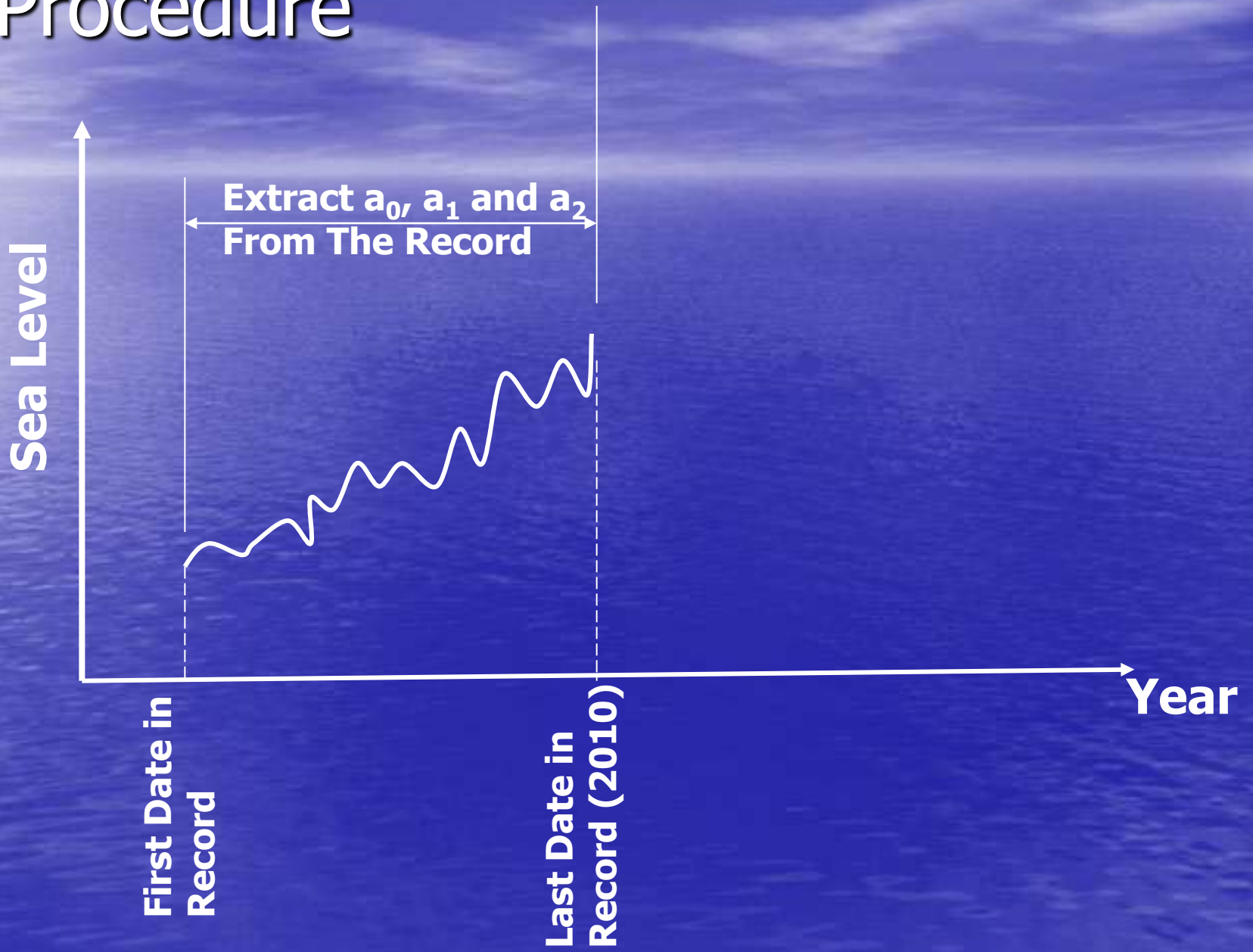
The 44 Continental US Gages Analyzed Here



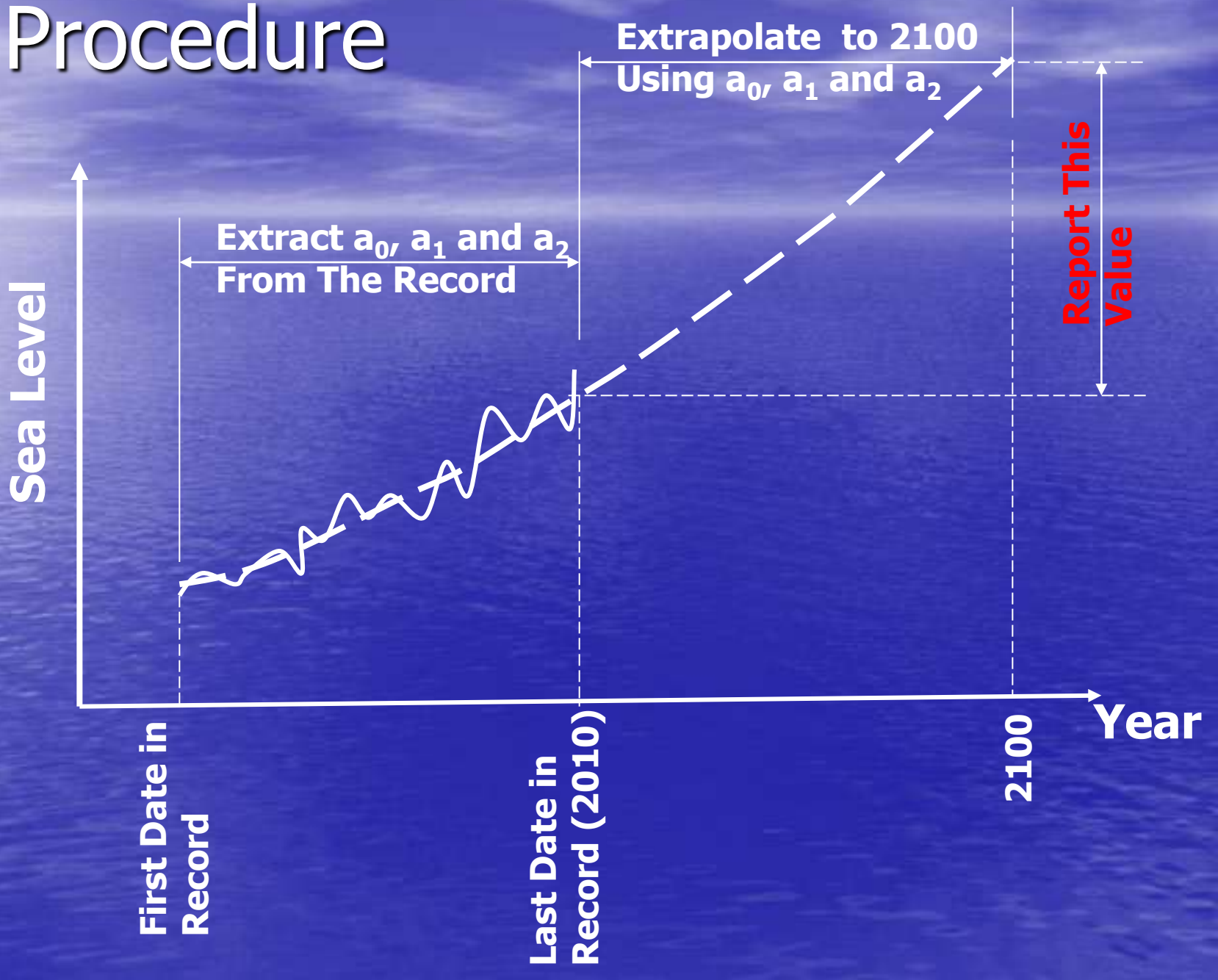
Analysis for Each of 44 US Gages and Each of 7 Longer-Term Florida Gages

- Determine a_0, a_1 and a_2
- Calculate sea level rise from earliest record date to 2010
- Calculate sea level rise from earliest date to 2100
- Subtract results to determine additional rise from 2010 to 2100

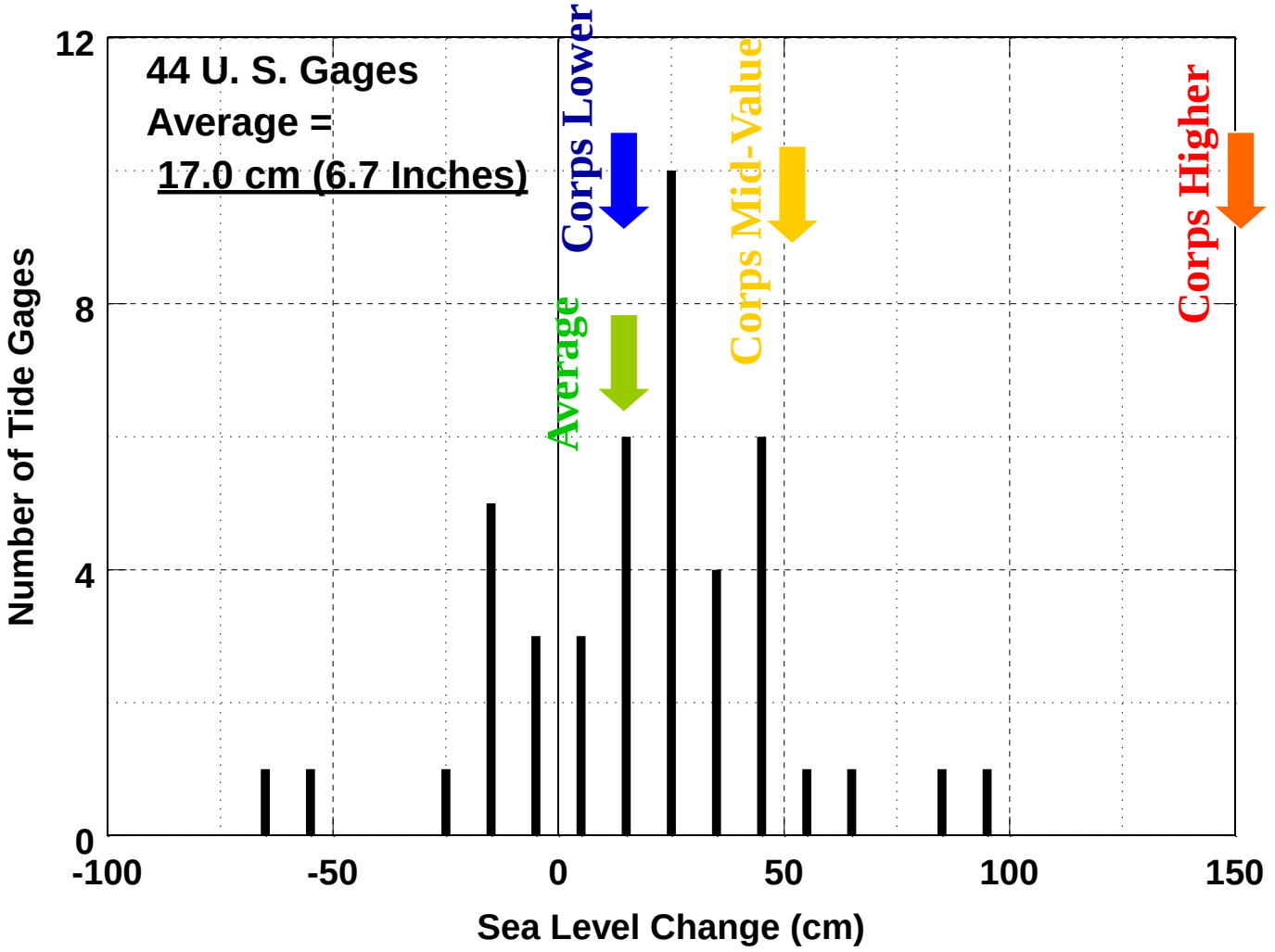
Procedure


Extract a_0, a_1 and a_2
From The Record
Sea Level
Year
First Date in Record
Last Date in Record (2010)

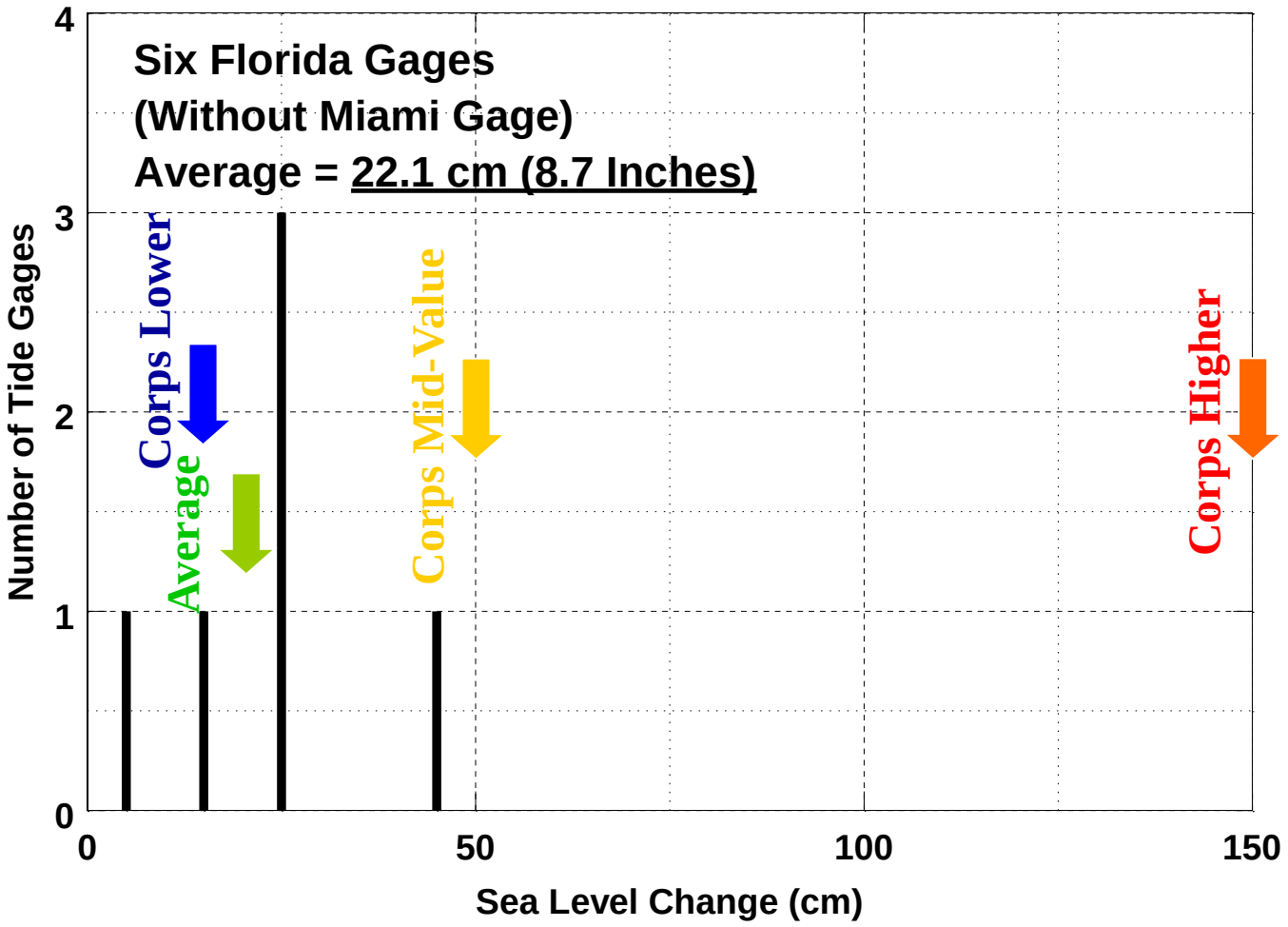
Procedure


Extrapolate to 2100
Using a_0, a_1 and a_2
Extract a_0, a_1 and a_2
From The Record
Report This Value
Sea Level
Year
First Date in Record
Last Date in Record (2010)
2100

Extrapolated Sea Level Change: 44 US Gages, 2010 to 2100



Extrapolated Sea Level Change: Florida Gages, 2010 to 2100



Summary of Extrapolations (Note: These Results Include GIA)

Averages of Extrapolated Sea Level Rise 2010 to 2100

- **44 U. S. Gages**
  - **17 cm (6.7 Inches)**
- **7 Florida Gages**
  - **All 7 Gages: 11.1 cm (4.4 Inches)**
  - **Without Miami Beach (Six Gages): 22.1 cm (8.7 Inches)**

Summary of Determination of Eustatic Sea Level Rise From 1910 to 2010. (GIA Accounted For)

- **44 U. S. Gages**
  - **1.25 mm/yr to 1.90 mm/yr, Depending on GIA Model**
- **7 Florida Gages**
  - **All 7 Gages: 1.51 mm/yr to 1.87 mm/yr, Depending on GIA Model**
  - **Without Miami Beach (6 Gages): 1.50 mm/yr to 1.88 mm/yr, Depending on GIA Model**

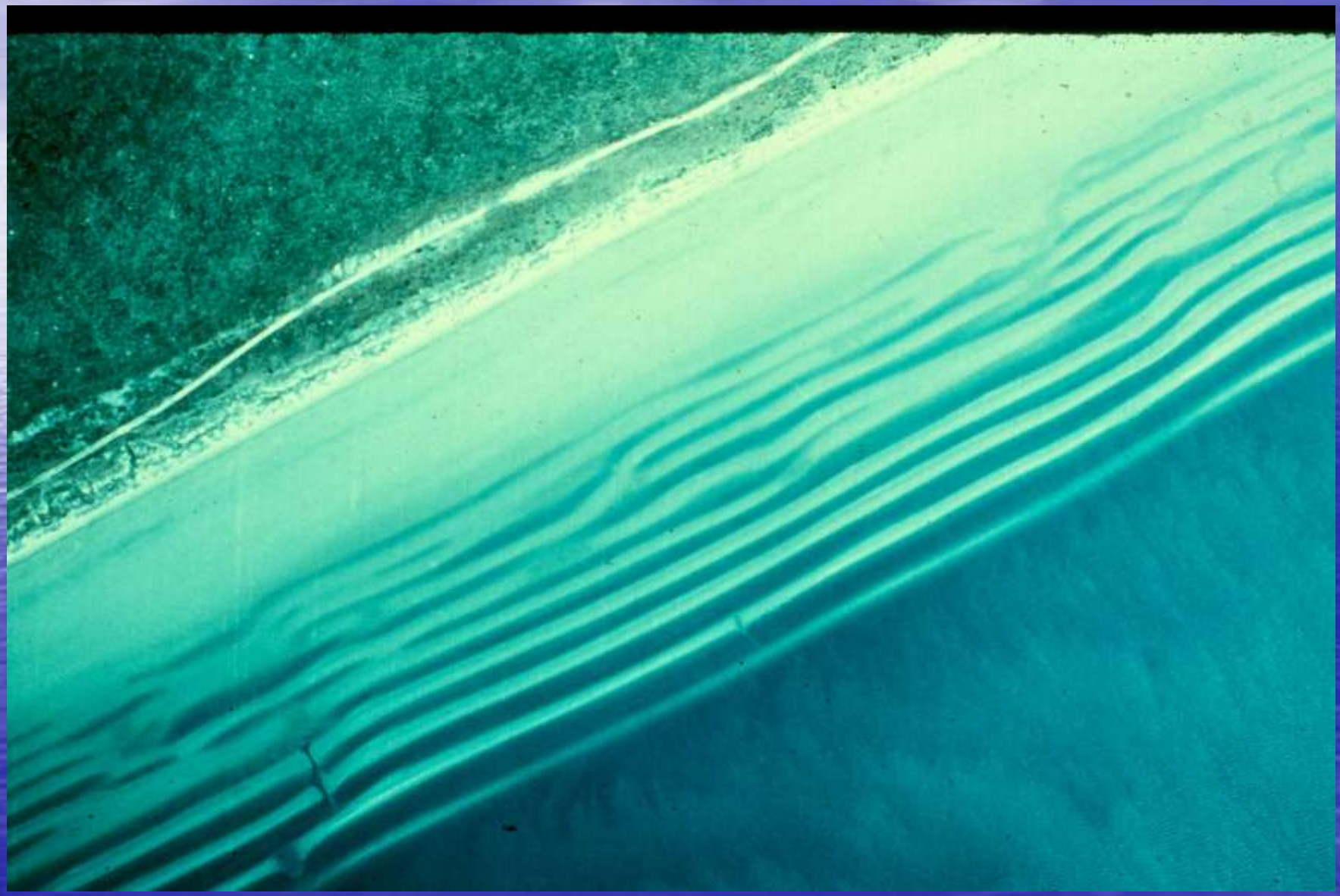
Summary

1. Over the last year, we have conducted extensive analyses of quality tide gage data including world wide and U. S. gages.
2. Tide gage data are "noisy" requiring analysis of many long-term records from areas of geological stability.
3. The results of all of our analyses are consistent - There is no indication of an overall world-wide sea level acceleration in the 20th Century data. Rather, it appears that a weak deceleration is present.
4. Florida tide gage data are limited but appear to be quite consistent with U. S. and world-wide data.
5. While issues exist with extrapolating analysis results forward over the next century, it is one approach (based on data) in the attempt to establish bounds of future sea level rise.
6. Extrapolated 2100 sea levels are considerably less that Corps and other agency guidance, but are in reasonable accord with IPCC of 18 to 59 cm by 2100.

Recommendations

1. Continue collecting tide gage data in Florida. In particular, reactivate the Miami Beach gage.
2. In view of the significant differences in the model-produced GIA values, install GPS units adjacent to longer term tide gages.

Questions?

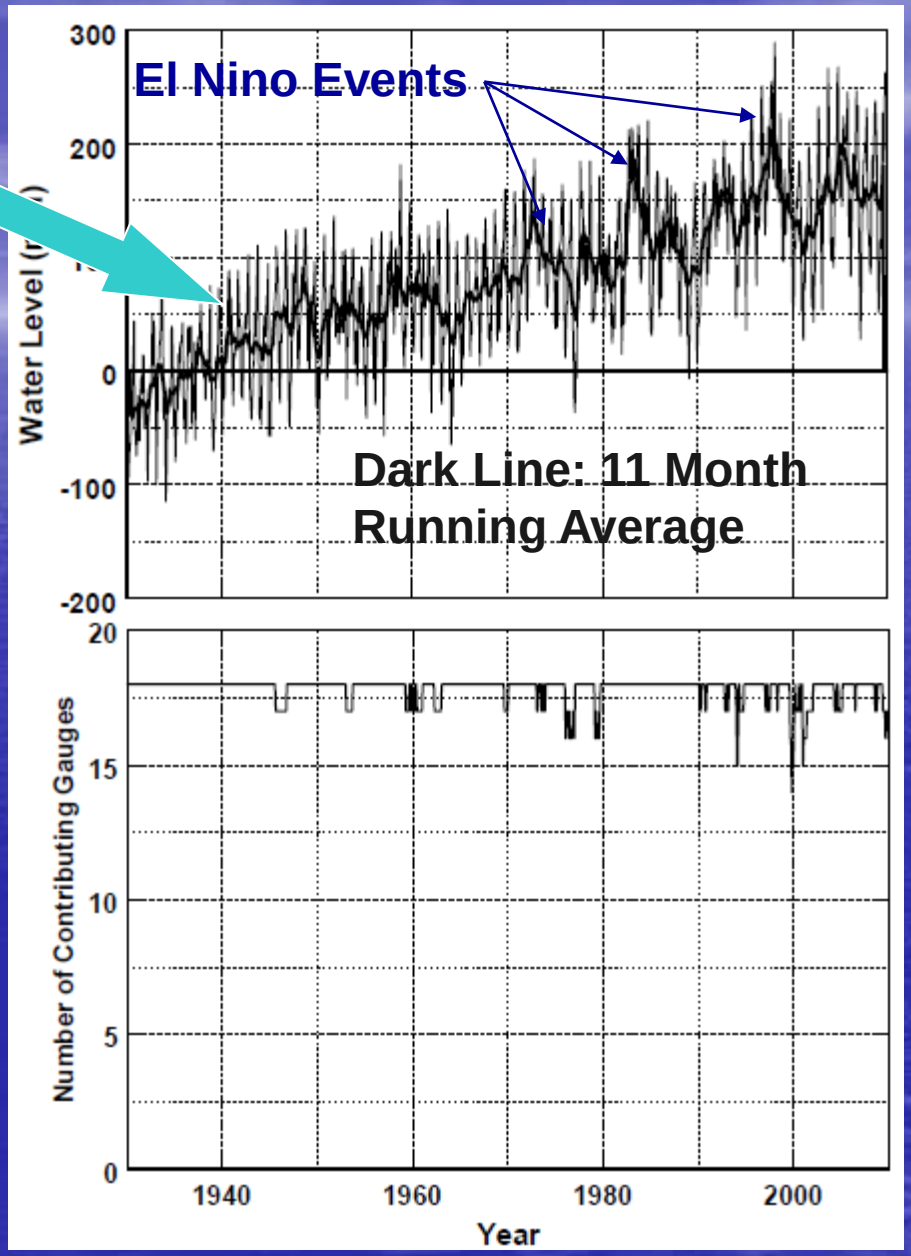


Backup Slides

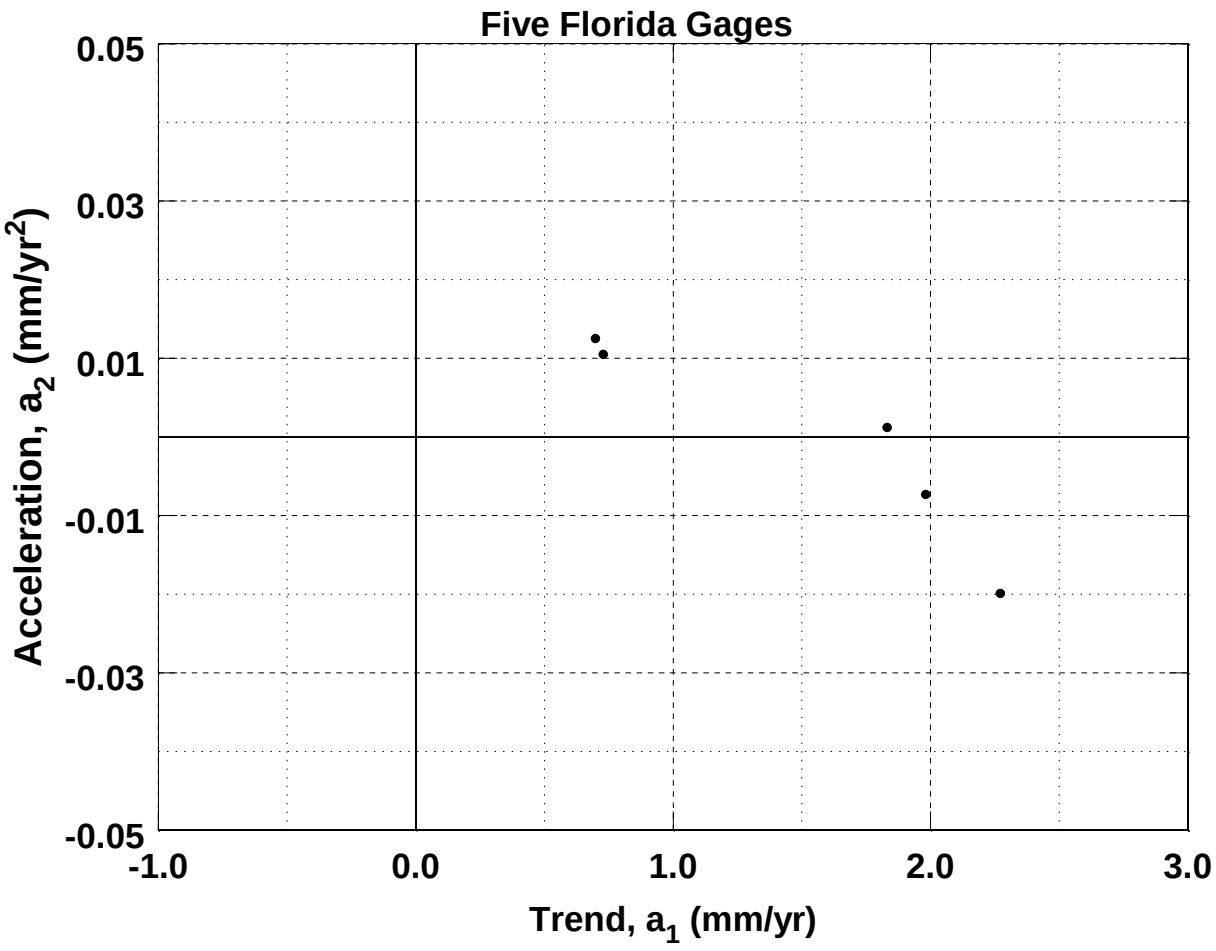
Our Study of 18 U. S. Gages With Record Lengths > 80 Years and Less Than 5% Missing Data

Average of 18 Long-Term U. S. Gages

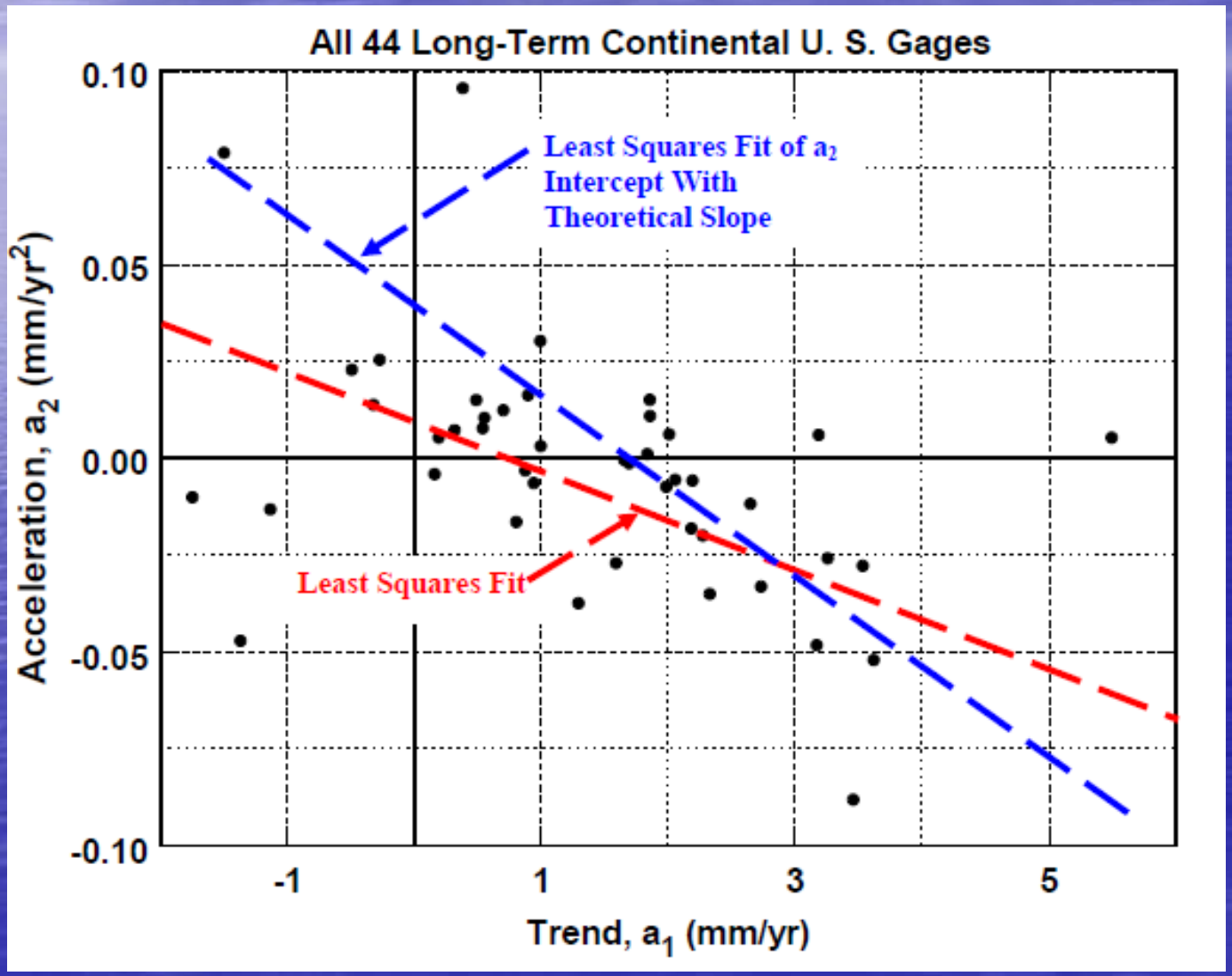
Our Study of 18 U. S. Gages With Record Lengths > 80 Years and Less Than 5% Missing Data



Results of Analyzing 5 Long-Term Florida Tide Gages



Results of Analyzing 44 Long-Term U. S. Tide Gages



Correlation of a1 and a2 For San Francisco Gage Data