MOTE MARINE LABORATORY

Marine Policy Institute

'Sea Level Change' -- moving toward adaptation

Barbara Lausche, JD
Director, MPI
www.mote.org/mpi

Plymouth Harbor, Jan. 17, 2013

Some basics on Mote:

- Mission: marine science research, education, public outreach
- Total staff: 192
- Volunteers: 1,665 (contributing over 206,000 hours/year)
- Membership: 11,000 individual, 160 corp.
- 81 research staff (31 Doctoral level)
- Visitors to Aquarium: 360,000/yr.

(statistics 2012, www.mote.org)

Some basics about the Marine Policy Institute (MPI):

- Mission: support Mote science; strengthen the scientific basis of public policy and community decision making for economic development and sustainability of our oceans and coastal ecosystems
- In Mote Strategic Plan 2003-10, launched 2006, start up grant from GCCF
- Senior advisor, Dr. Michael Orbach (Duke U.); national advisory committee.

MOTE MARINE LABORATORY, INC.

Advancing the science of the sea since 1955!

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Policy work on Sea Level Rise -- Why?

- 95% scientific consensus: global climate is changing; global average sea levels are rising; impacts are site-specific

- Need local solutions and leadership.

- SLR is one of the most visible aspects of climate change for policy-makers, communities, businesses

- Florida particularly vulnerable: 78% of population resides in Florida's 35 coastal counties

- Implications for every area of Mote science research

- Many impacts can be addressed through early planning and adaptation: next 20-30 yrs. critical

Our discussion this evening:

- Context: Science and sea level rise (SLR)
- Emerging practice – many cities/states already doing SLR adaptation
- Sarasota region – opportunities for adaptation action
- Looking ahead

1. Context -- Some science basics:

Climate change and Global warming:

- The Earth is warming – about 1 degree last century.
- Climate defined as average weather over more than 30 years
- Impacts: extreme weather events, fires, drought
- Sea levels already rising in many places.
- Naturally-occurring gases, called greenhouse gases, critical to support life on Earth because they trap sunlight for heat. CO_2, water vapor, methane, nitrous oxide. Higher concentrations keep in more and more heat (greenhouse effect).

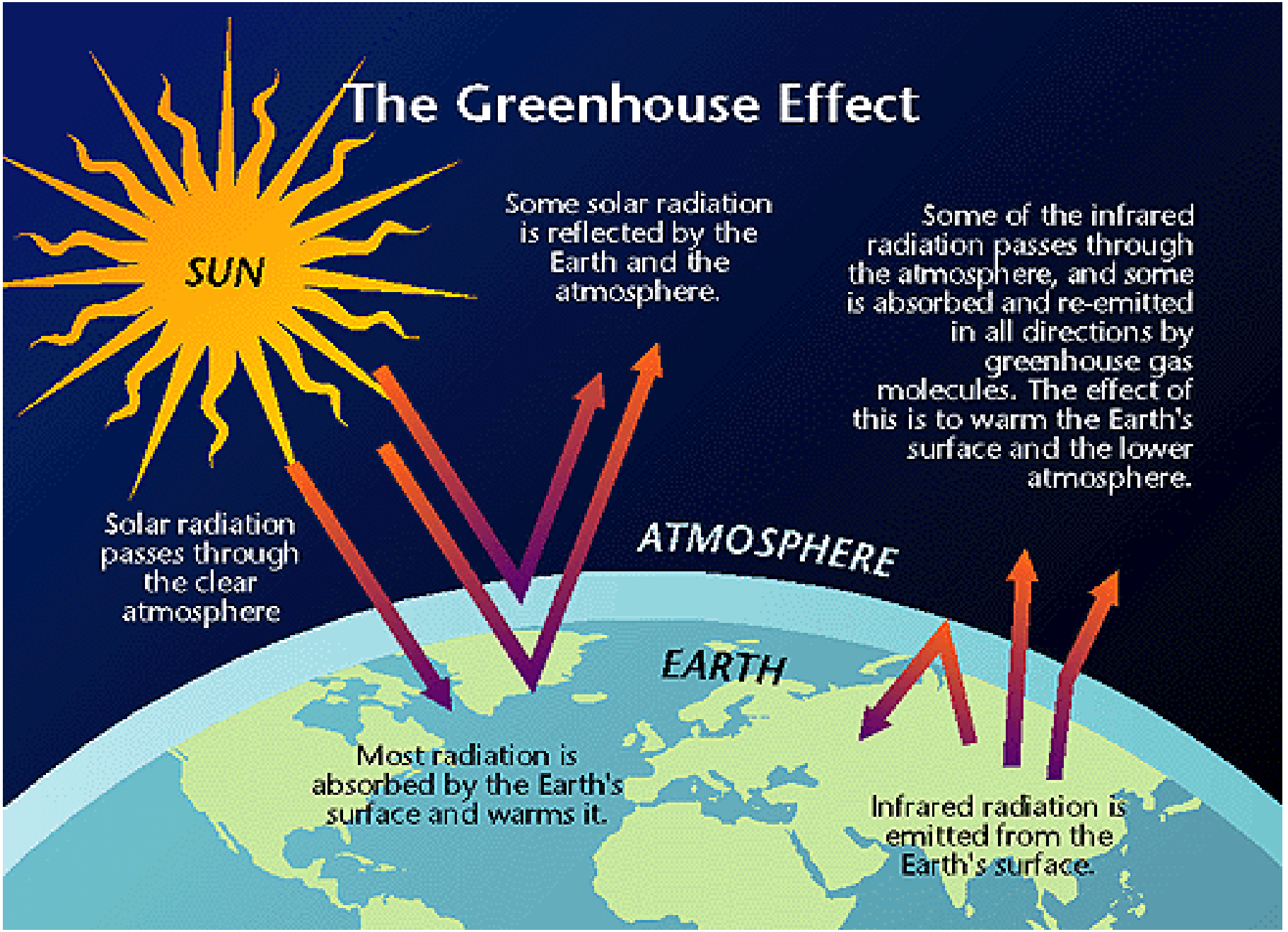
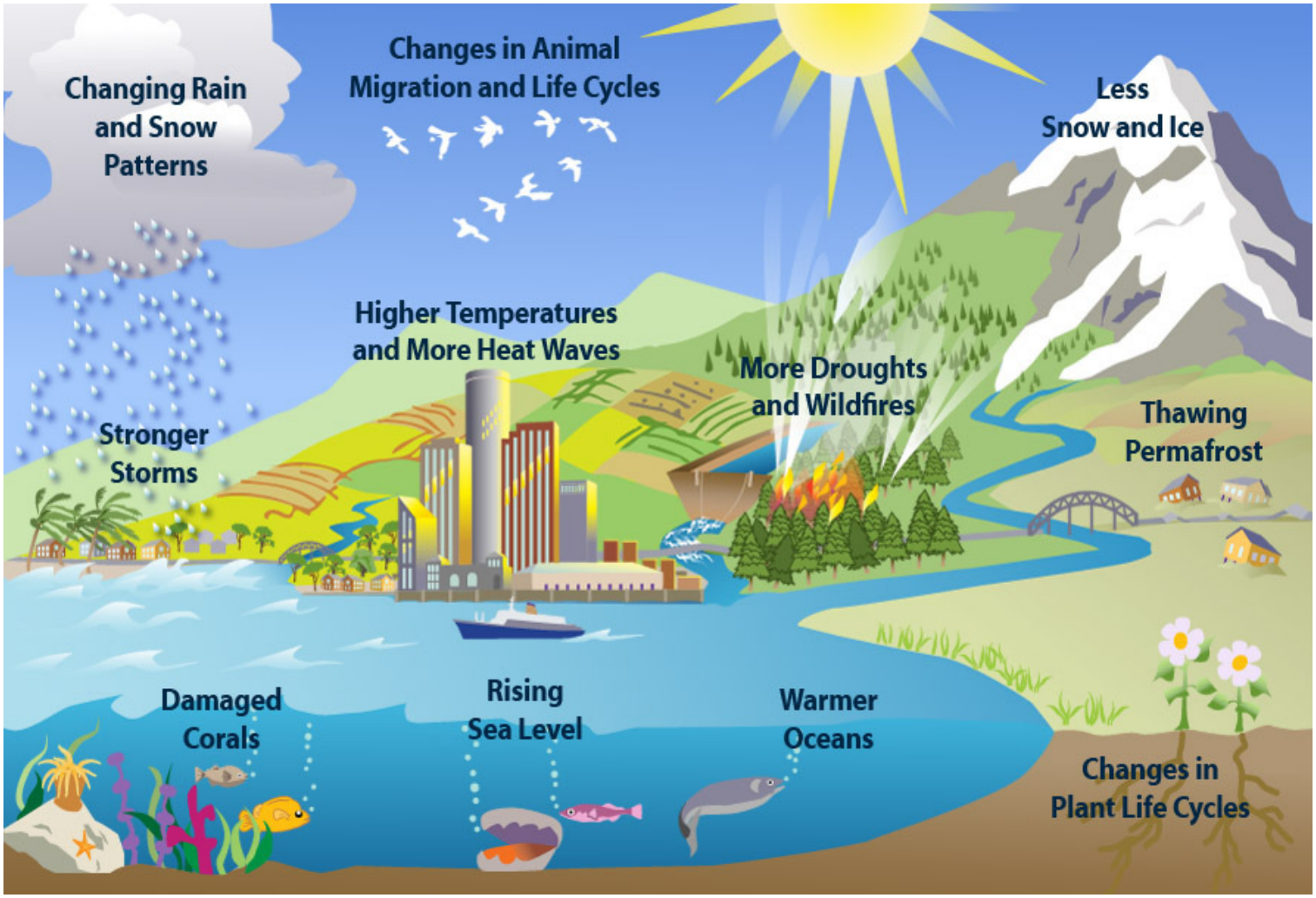


Chart from New England Aquarium web site.

Clues of Climate Change:



EPA

Science works with several key Indicators – increasingly there is data showing recent trends:

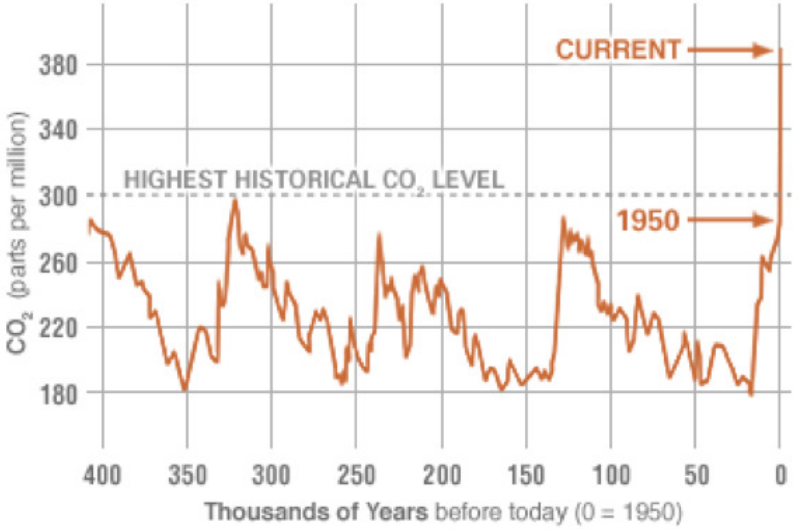
Carbon Dioxide Concentration

DOWNLOAD DATA

Data updated 11.08.12

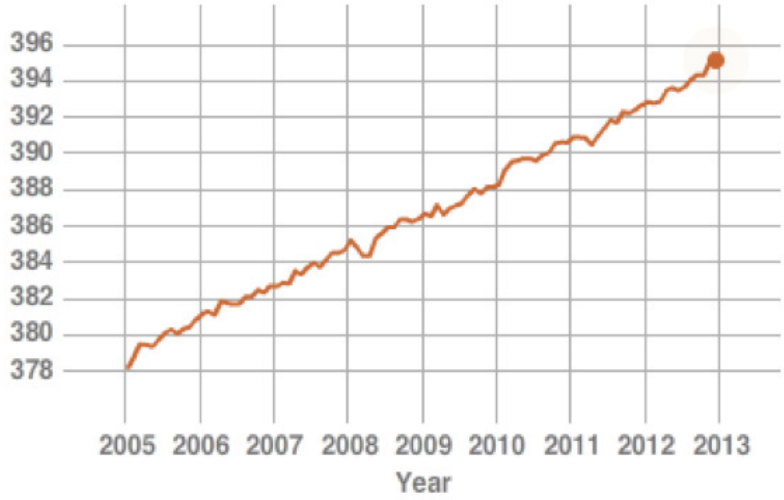
PROXY (INDIRECT) MEASUREMENTS

Data source: Reconstruction from ice cores.
Credit: NOAA



DIRECT MEASUREMENTS: 2005-PRESENT

Data source: Monthly measurements (corrected for average seasonal cycle). Credit: NOAA



http://climate.nasa.gov/key_indicators

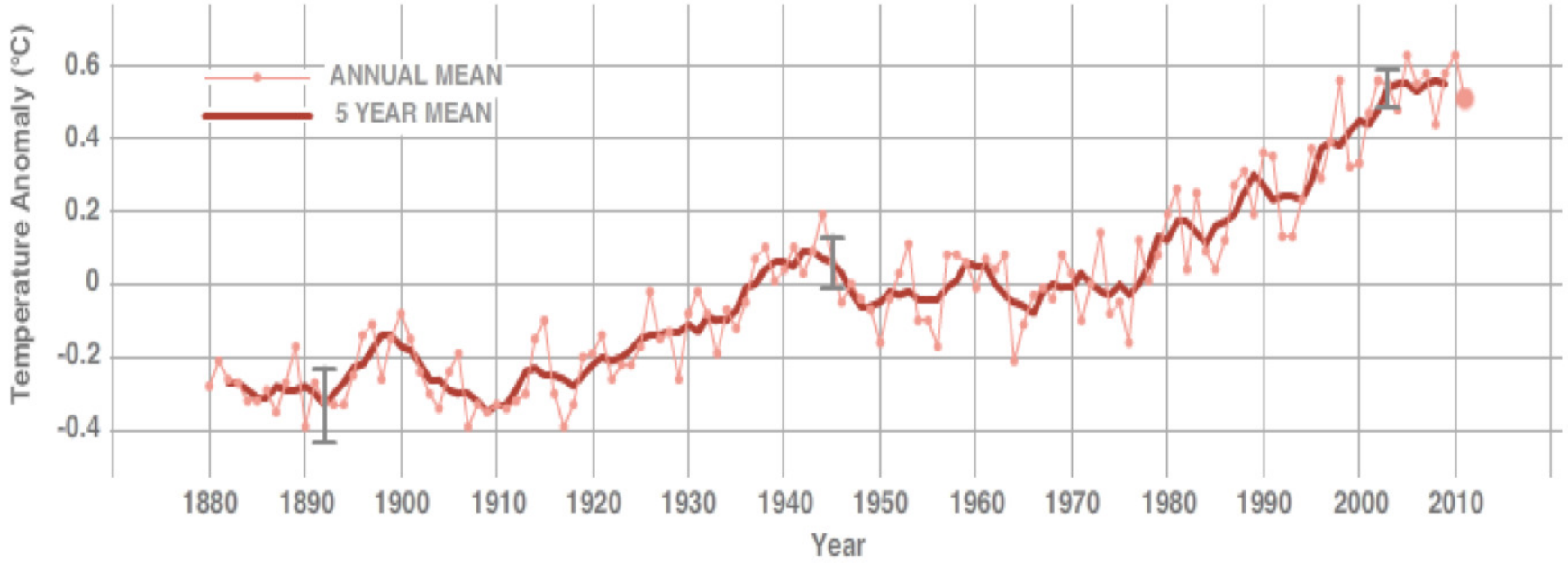
Global Surface Temperature

Data updated 4.18.11

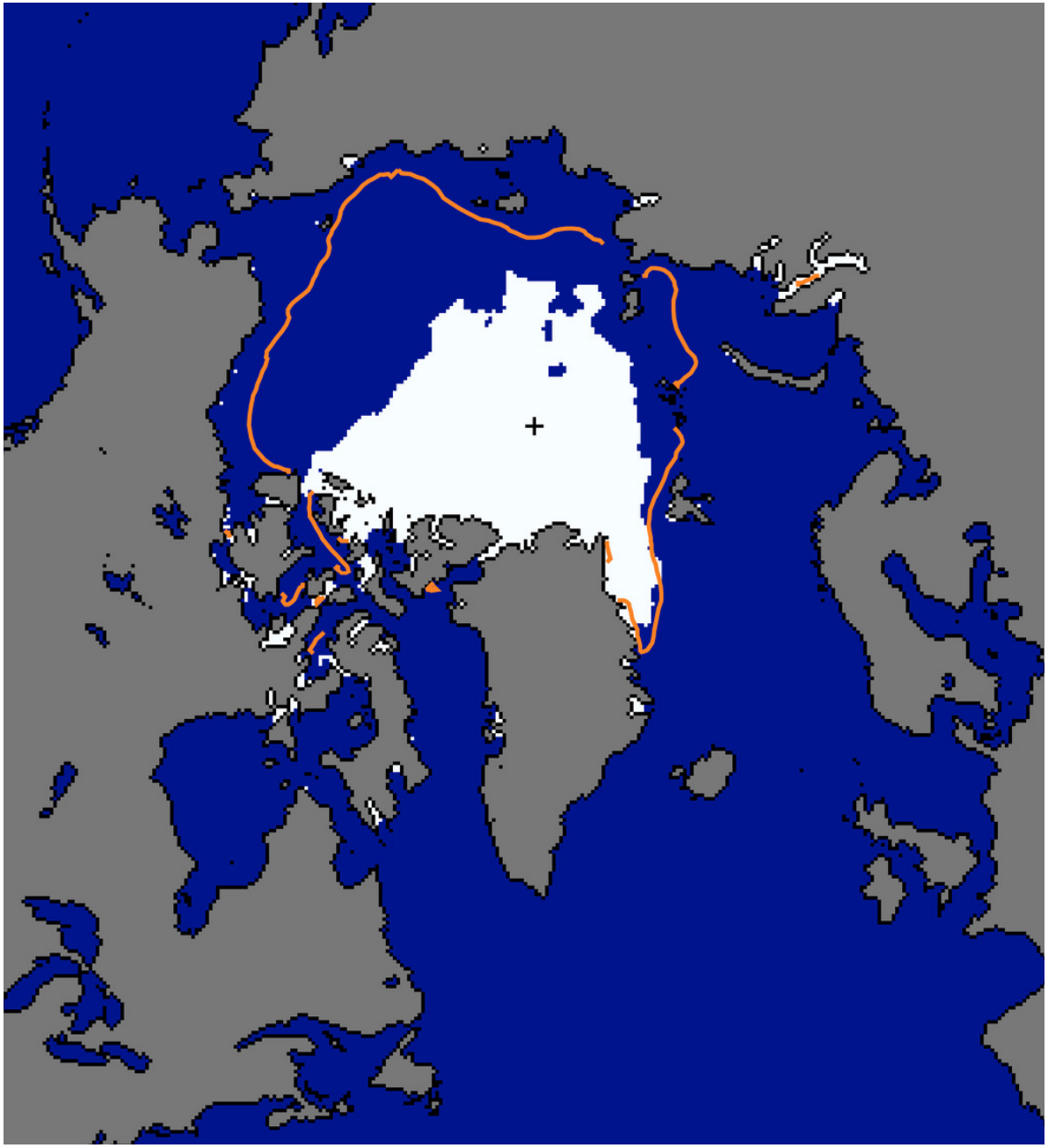
DOWNLOAD DATA

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Data source: NASA's Goddard Institute for Space Studies (GISS) This trend agrees with other global temperature records provided by the U.S. National Climatic Data Center, the Japanese Meteorological Agency and the Met Office Hadley Centre / Climatic Research Unit in the U.K. Credit: NASA/GISS



http://climate.nasa.gov/



Ex: Artic Sea Ice Melt

Satellite data show that Arctic sea ice has hit a new low. The white area shows the extent of Arctic sea ice as of September 3. The orange line shows how much sea ice usually covers the ocean around this time of year. Credit: National Snow and Ice Data Center [from *Science News For Kids*, Stephen Ornes, Sept. 10, 2012]

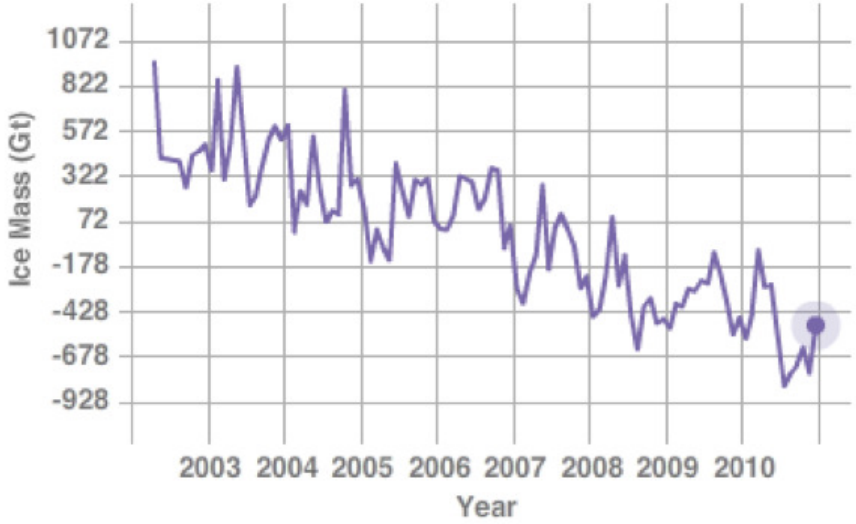
Land Ice

Data updated 11.4.11

DOWNLOAD DATA

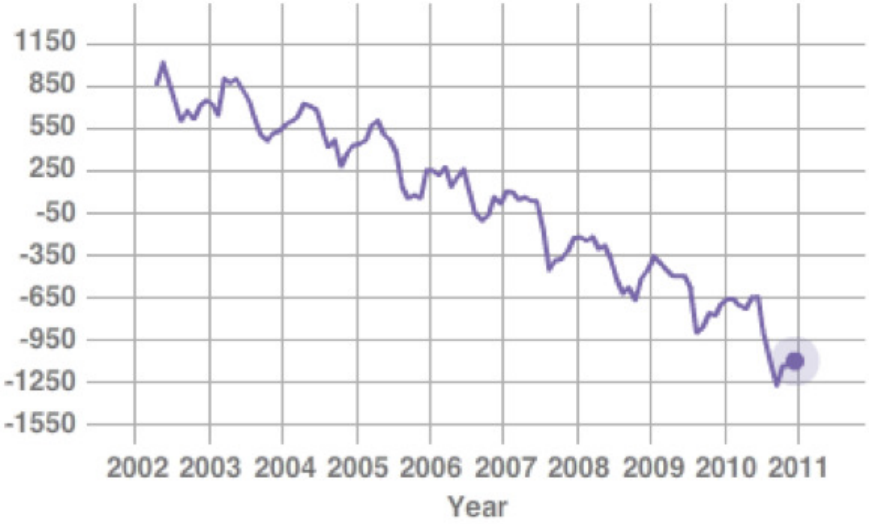
ANTARCTICA MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.
Credit: NASA/University of California, Irvine



GREENLAND MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.
Credit: NASA/University of California, Irvine

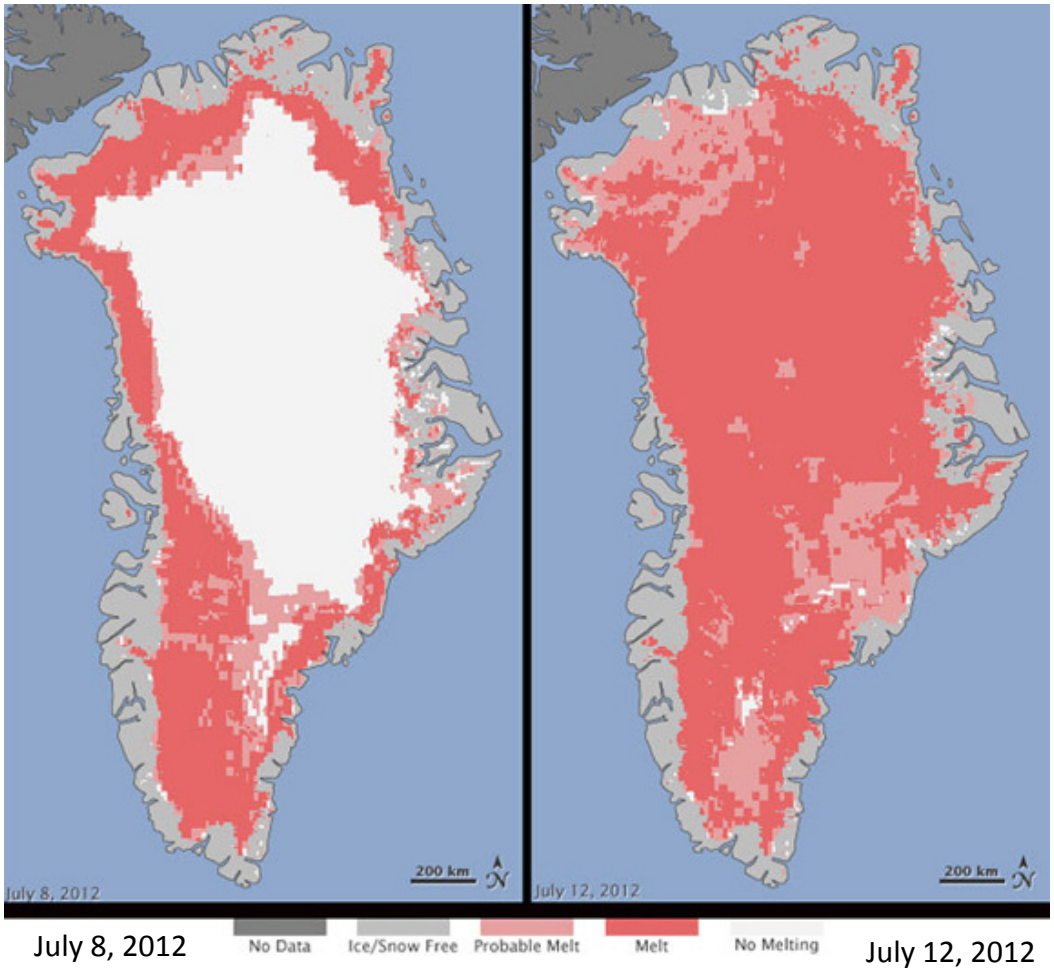


Note: In the above charts, mass change is relative to the average during the entire period. (Reference)

http://climate.nasa.gov/key_indicators

Ex: Accelerated Land Ice Melt in Greenland, July 2012

(fast melt happens every 150 yrs – upper level high pressure)

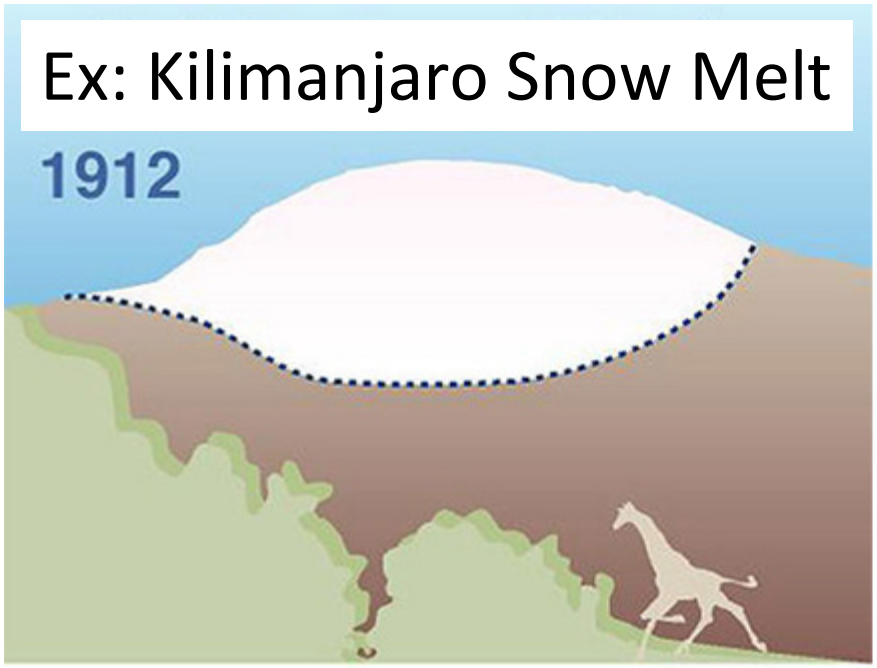


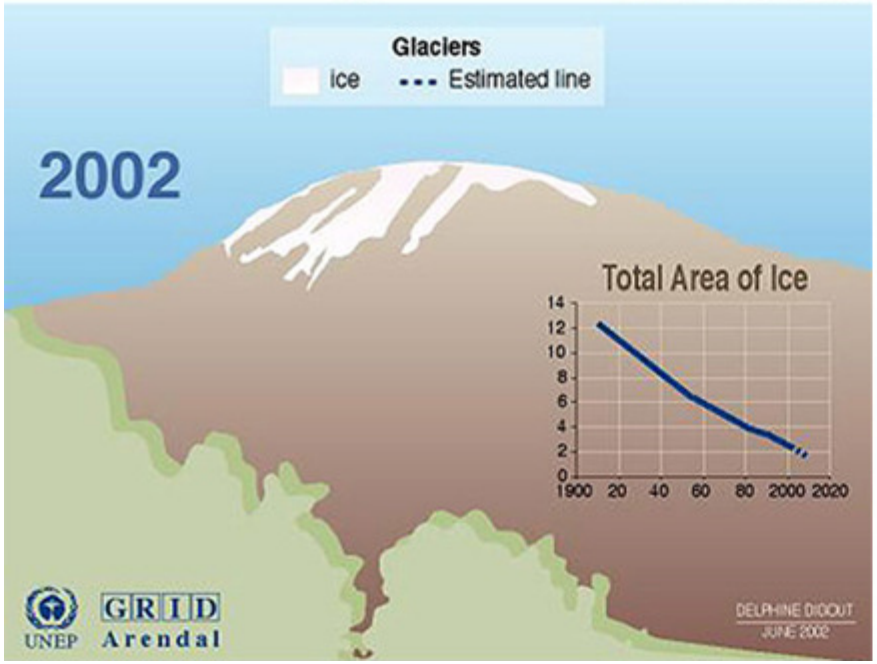
July 8, 2012

July 12, 2012

http://climate.nasa.gov/key_indicators

Ex: Kilimanjaro Snow Melt





Sea Level

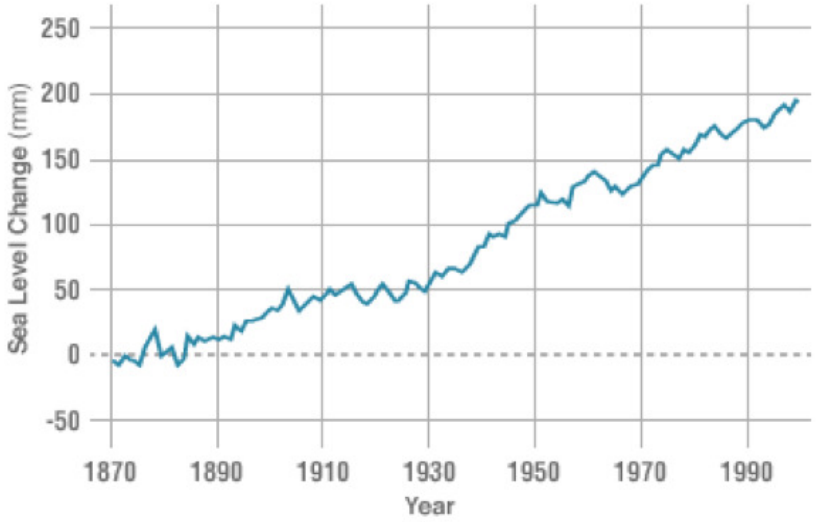
Data updated 3.30.12

DOWNLOAD DATA

GROUND DATA: 1870-2000

Data source: Coastal tide gauge records.
Credit: CSIRO

RATE OF CHANGE
↑1.70 mm*



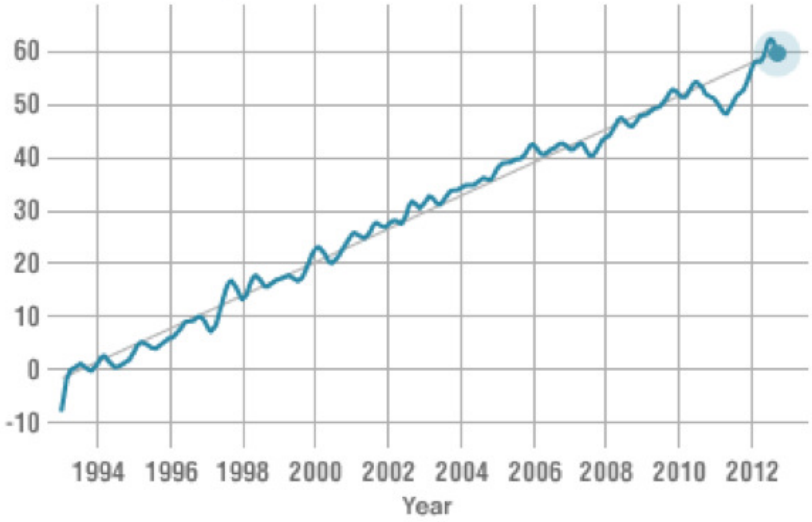
*estimate for 20th century

(.06in)

SATELLITE DATA: 1993-PRESENT

Data source: Satellite sea level observations.
Credit: CLS/Cnes/Legos

RATE OF CHANGE
↑3.16 mm



Inverse barometer applied and seasonal signals removed.

(.12in)

http://climate.nasa.gov/key_indicators

Understanding Sea Level Rise

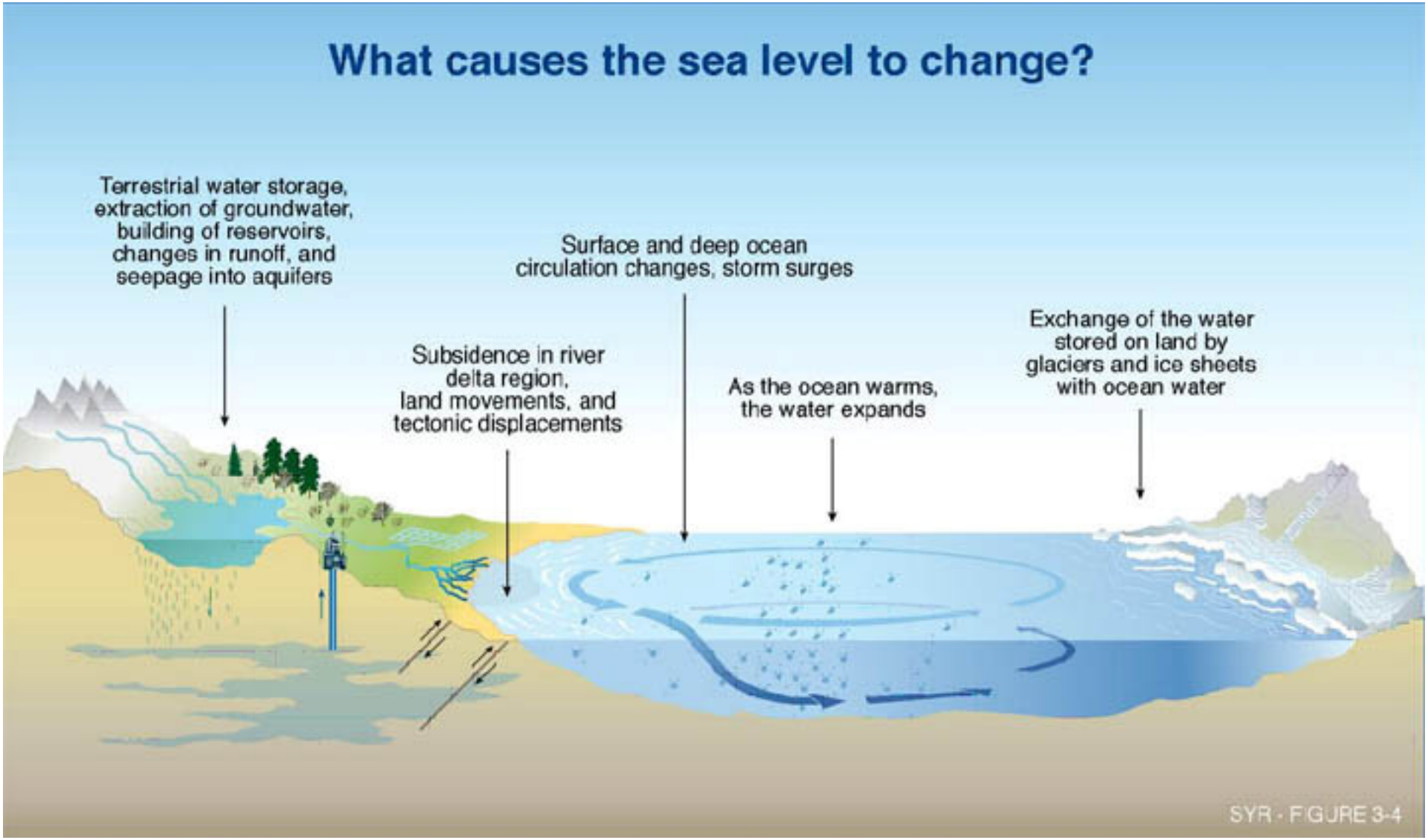
- Two natural processes increase ocean volume:

  1. Melting land ice (glaciers, ice caps, ice sheets), growing factor for SLR as more land ice melts

  2. Thermal expansion of sea water as it warms, estimated as roughly half of rise up to 2003, especially in tropics, because ocean temperatures are rising.

- Sea levels have varied throughout Earth's history (from 120 meters lower than present 18,000 years ago to 3-6 meters higher125,000 years ago).

What causes the sea level to change?



Many user-friendly climate science web sites:

NOAA CLIMATE SERVICES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

→ http://www.noaa.gov/climate.html and
→ http://www.climate.gov/#climateWatch

Global Climate Change
Vital signs of the planet
→ http://climate.nasa.gov/

EPA

United States Environmental Protection Agency
→http://www.epa.gov/climatechange

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

USGS
science for a changing world

National Climate Change and Wildlife Science Center
→https://nccwsc.usgs.gov

StormSmart Coasts Network

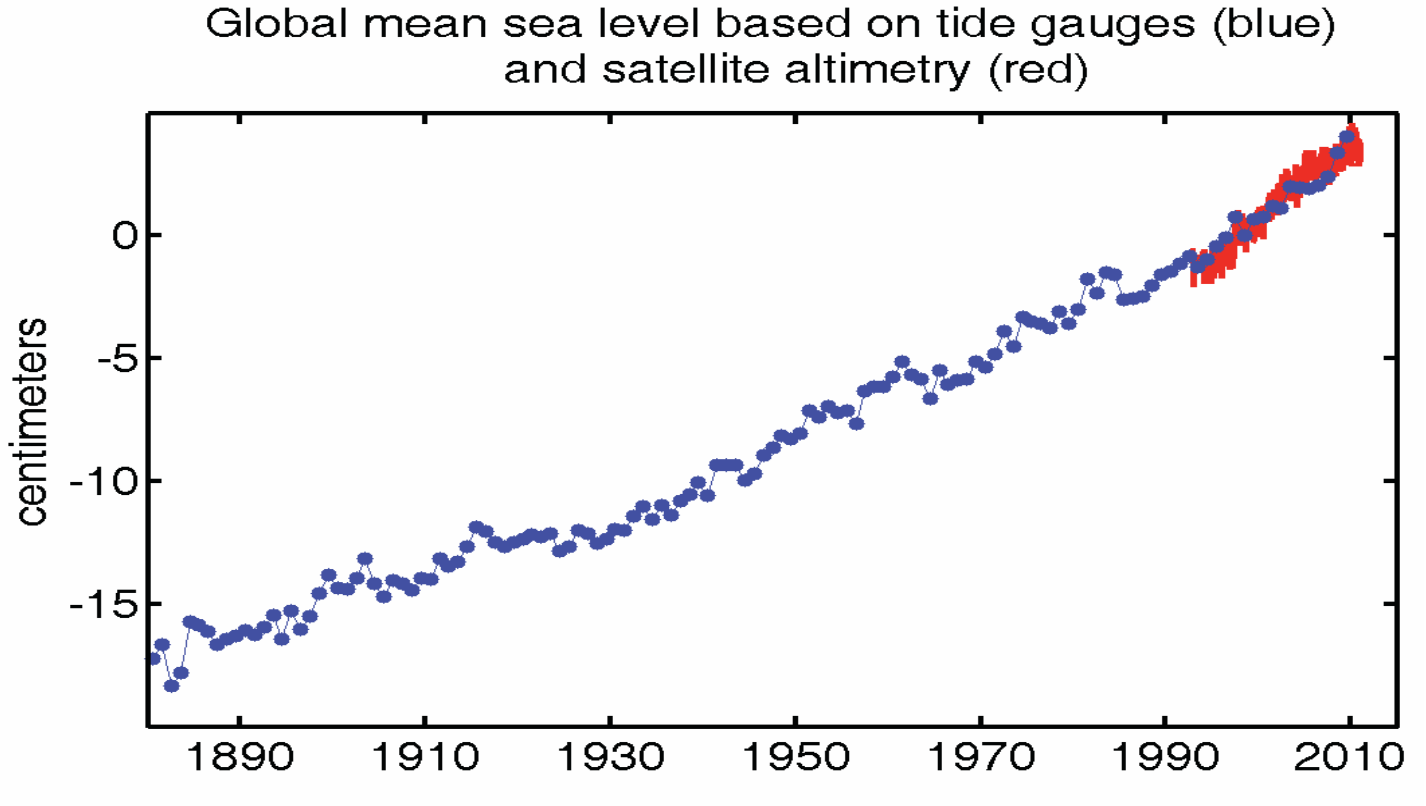
[Gulf of Mexico Alliance (GoMA)]
→http://stormsmart.org/

cake
Climate Adaptation Knowledge Exchange

→http://www.cakex.org/

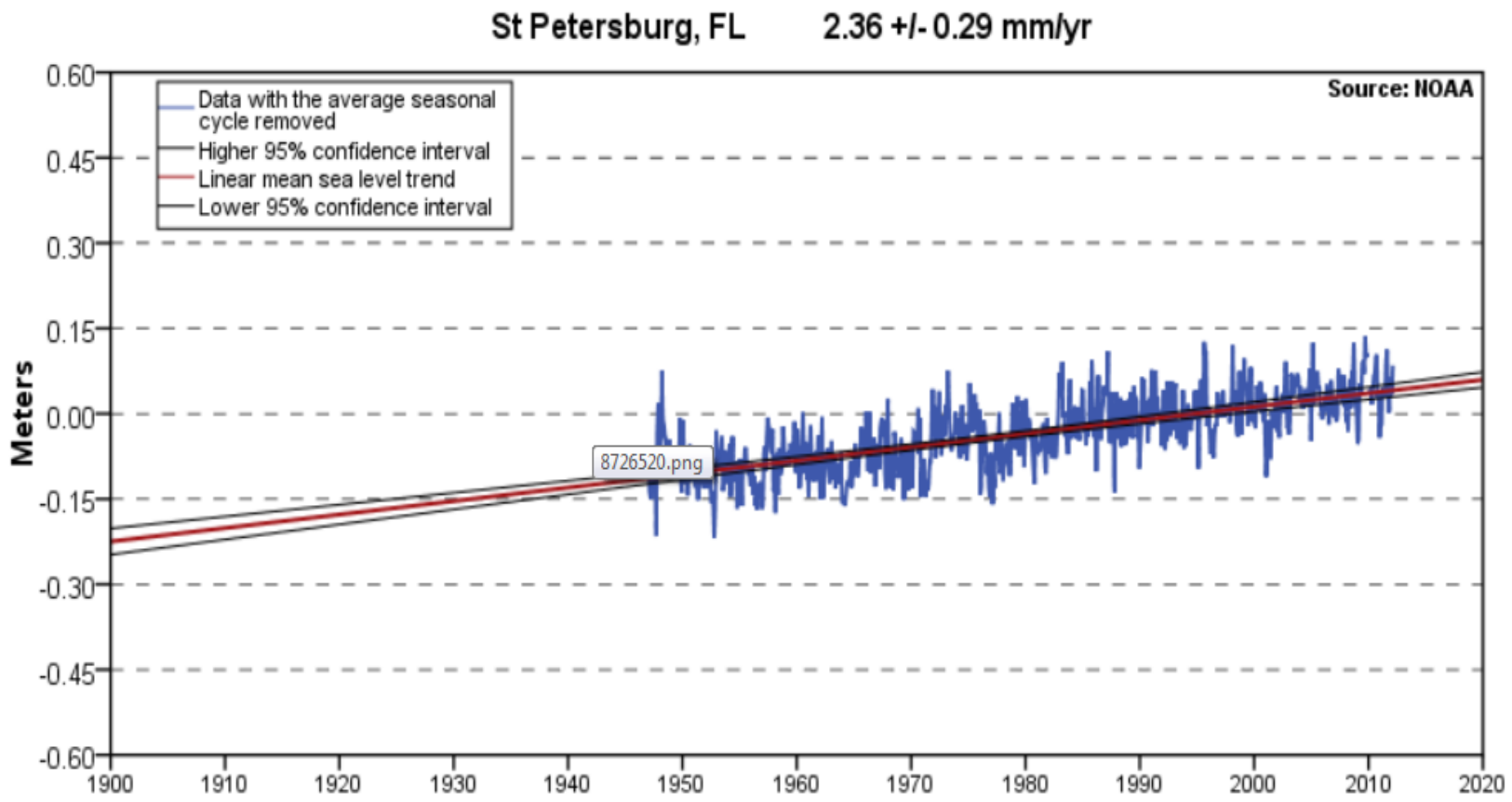
Data:

- Global average SLR: 6 -8 inches over the last 100 years (EPA).
- Florida sea-level rise similar to global sea-level rise (Merrifield et al., 2009).
- Rate of change increased since the 1990s, nearly doubling that of the last century (NASA)



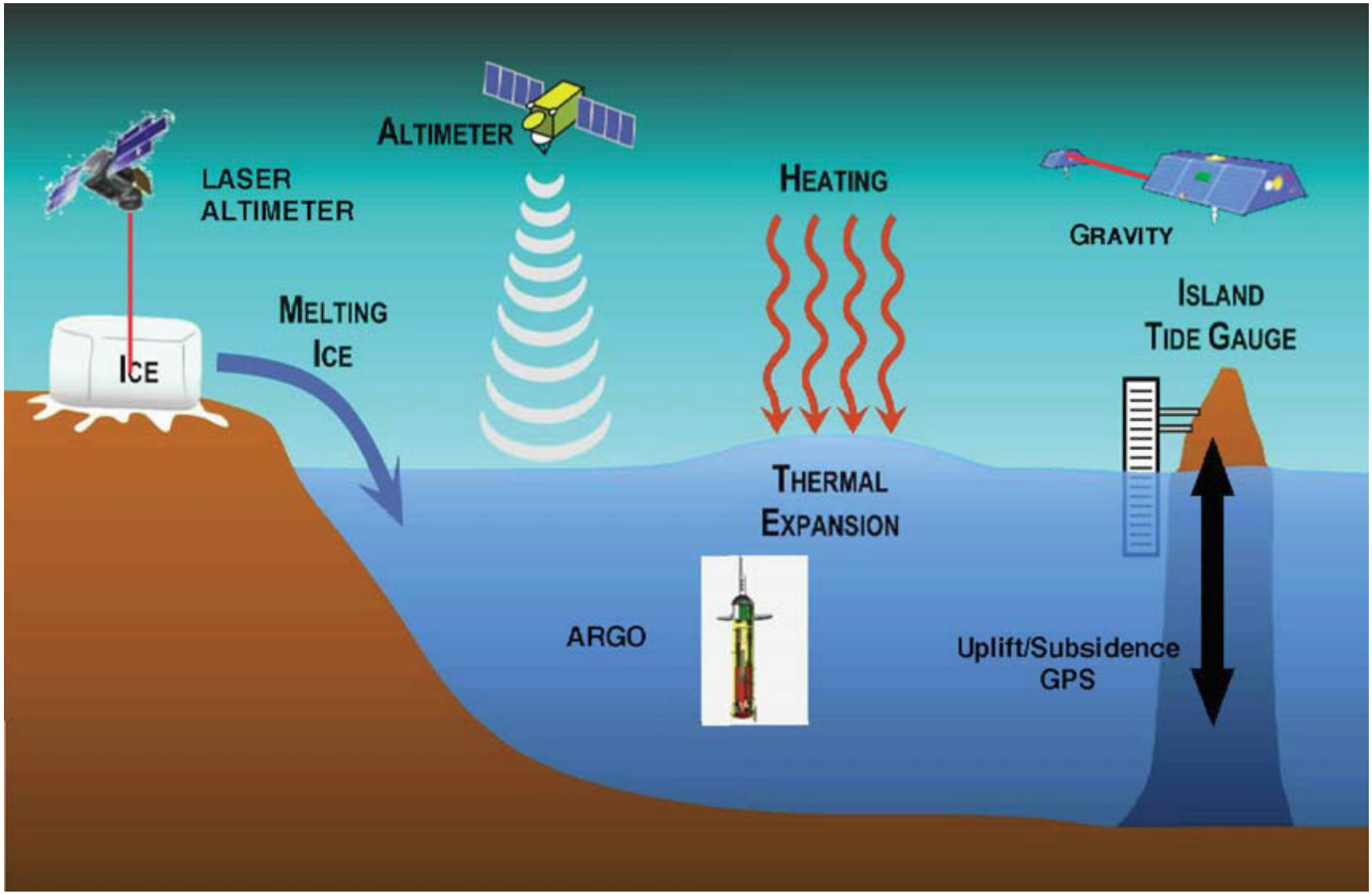
(G.T. Mitchum. 2011. "Sea Level Changes in the Southeastern United States: *Past, Present, and Future."* University of South Florida.)

Mean Sea Level Trend
8726520 St. Petersburg, Florida



The mean sea level trend is 2.36 millimeters/year with a 95% confidence interval of +/- 0.29 mm/yr based on monthly mean sea level data from 1947 to 2006 which is equivalent to a change of 0.77 feet in 100 years.

Scientific tools to observe Sea Level Rise:



(G.T. Mitchum. 2011. "Sea Level Changes in the Southeastern United States: *Past, Present, and Future."* University of South Florida. p. 2)

Global Average SLR Projections to 2100:

- **High levels of uncertainty** depending on what happens with ocean warming and land ice melt. Projections evolving and use scenarios –
- **Intergovernmental Panel on Climate Change (IPCC)** 2007 projections estimated 1-2 ft SLR (without ice melt data);
- **Florida Ocean and Coastal Council, 2010:** 0.5–1.0 m (about 20–40 inches) and possibly more.
- **National Research Council 2011:** between 2ft. 2in. - 5ft. 3 in. depending on ice melt

National Climate Assessment 2012

(Latest official government statement)

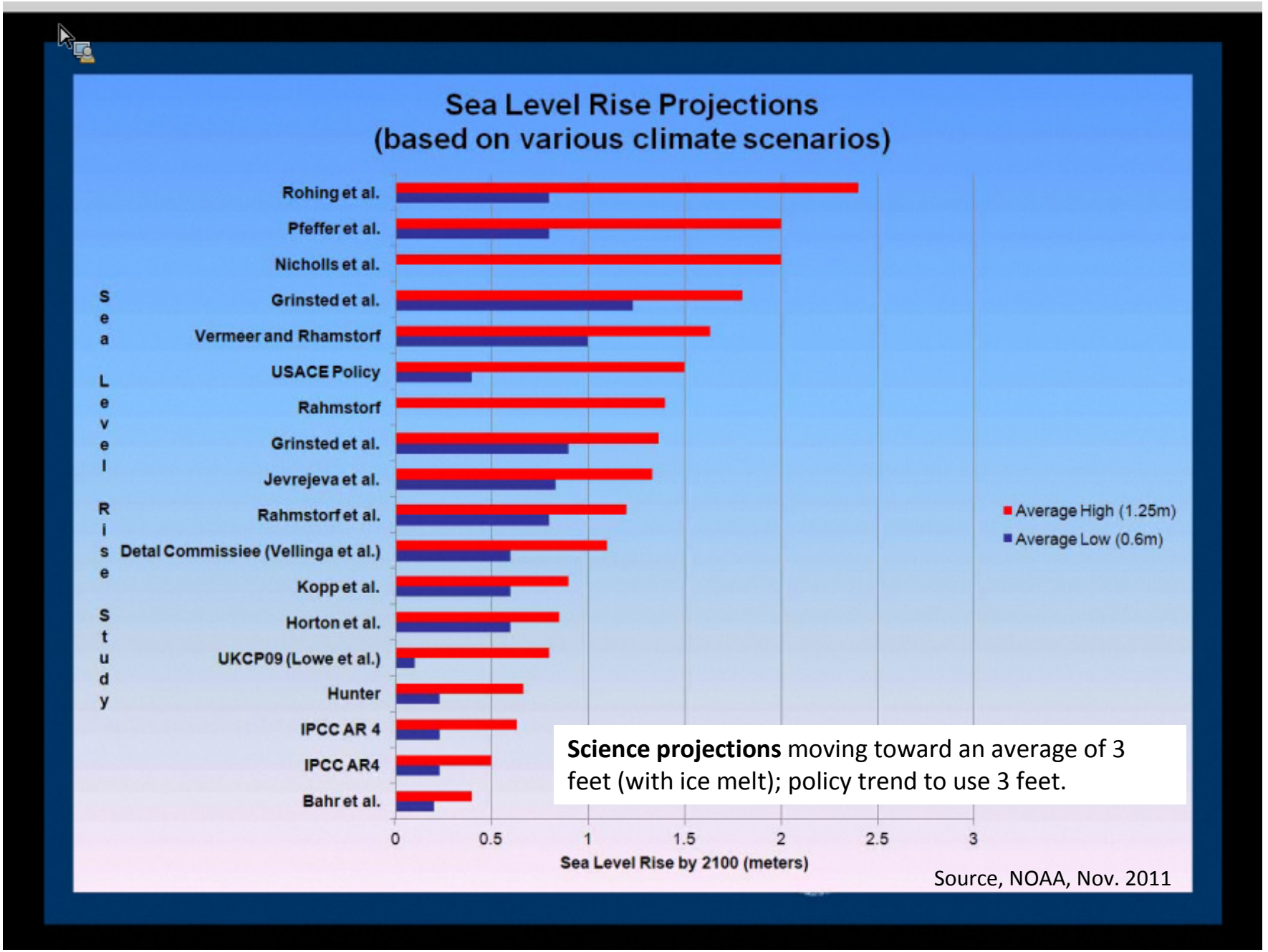
- New report prepared for 5th IPCC 2014:
- Scenarios for planners and policy makers:

  8 inches, historic rate, use only for high tolerance for risk

  3.9 feet based on projected ocean warming and recent ice sheet loss

  6.6 foot (highest sea level change scenario) maximum plausible contribution of land ice melting; to use where little tolerance for risk.

NOAA, Nov. 2012


Sea Level Rise Projections
(based on various climate scenarios)
Sea Level Rise Study
Rohing et al.
Pfeffer et al.
Nicholls et al.
Grinsted et al.
Vermeer and Rhamstorf
USACE Policy
Rahmstorf
Grinsted et al.
Jevrejeva et al.
Rahmstorf et al.
Detal Commissiee (Vellinga et al.)
Kopp et al.
Horton et al.
UKCP09 (Lowe et al.)
Hunter
IPCC AR 4
IPCC AR4
Bahr et al.
Average High (1.25m)
Average Low (0.6m)
0
0.5
1
1.5
2
2.5
3
Sea Level Rise by 2100 (meters)
Science projections moving toward an average of 3 feet (with ice melt); policy trend to use 3 feet.
Source, NOAA, Nov. 2011

2. Growing experience with SLR Adaptation – we are learning lessons and approaches

What is ‘Adaptation’ ?

- Many definitions – all relate to anticipating and monitoring climate change and undertaking actions to address their consequences.
- Actions taken to help communities and ecosystems cope with changing climate condition. (UNFCCC)
- Options for natural systems – permit migration inland, preserve/restore wetlands and coastal vegetation, remove hard protections, etc.
- Options for human systems – protect, accommodate, gradual move and rebuild inland, etc.
- All actions need science, policy, community support, resources.

Planning for Sea Level Rise

Lessons – common steps:

1) recognize SLR as long term risk,

2) assess risk,

3) develop adaptation plan,

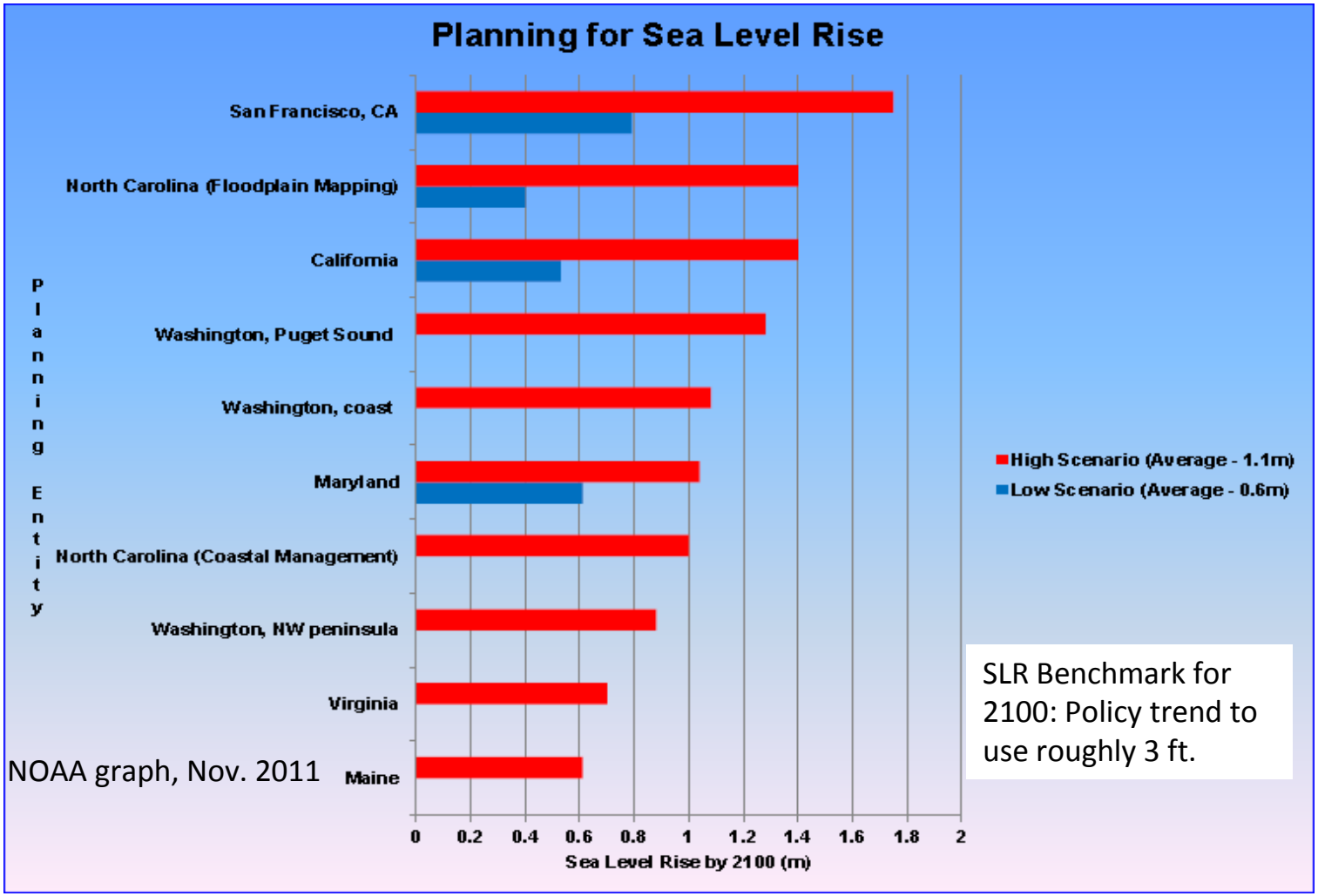
4) create mechanisms,

5) adopt explicit policies,

6) incorporate adaptation in planning and projects.

- Start with SLR benchmarks for planning.

Many jurisdictions are already taking action



Above: Illustrates various levels of SLR planning benchmarks (x-axis) adopted by various local communities (y-axis).

Three examples of Sea Level Rise Adaptation: 1) San Francisco Bay

Current Sea Level in San Francisco Bay Sea Level Rise Projected Rise by 2050

In 2012, National Research Council (NRC) projected SLR for <u>California</u> --

- **6 inches by 2030**
- **12 inches by 2050**
- **36 inches by 2100**

San Francisco Bay authorities projected --

17 inches by 2050
55 inches by 2100

San Francisco Bay – key adaptation elements:

- "**Climate Change adaptation** " in Bay Plan in 2011 (Resolution 11-08)

- **Implementation mechanism**: designated SF Bay Conservation and Development Commission with regulatory and enforcement authority, to 100ft inland from Mean High Tide

- **Highlights of new rules**:
  - Existing shoreline buildings must be resilient to mid-century sea level rises
  - SLR risk assessment for new shoreline projects
  - Buffers for wildlife and infill projects for flood protection

- **Dozens of partners** (Federal, state, local, business, universities, community organizations, NGOs)

- **Current budget +$2billion** (multi-funding sources)

Current Sea Level

Sea Level Rise 1 meter

2) New York City and Sea Level Rise

- Over the past century, 12 in SLR in NYC area
- Sea level rise projections of up to 55 in by 2080
- More than 60% of all New Yorkers live on or near coastal areas

New York Sea Level Rise Adaptation Plans

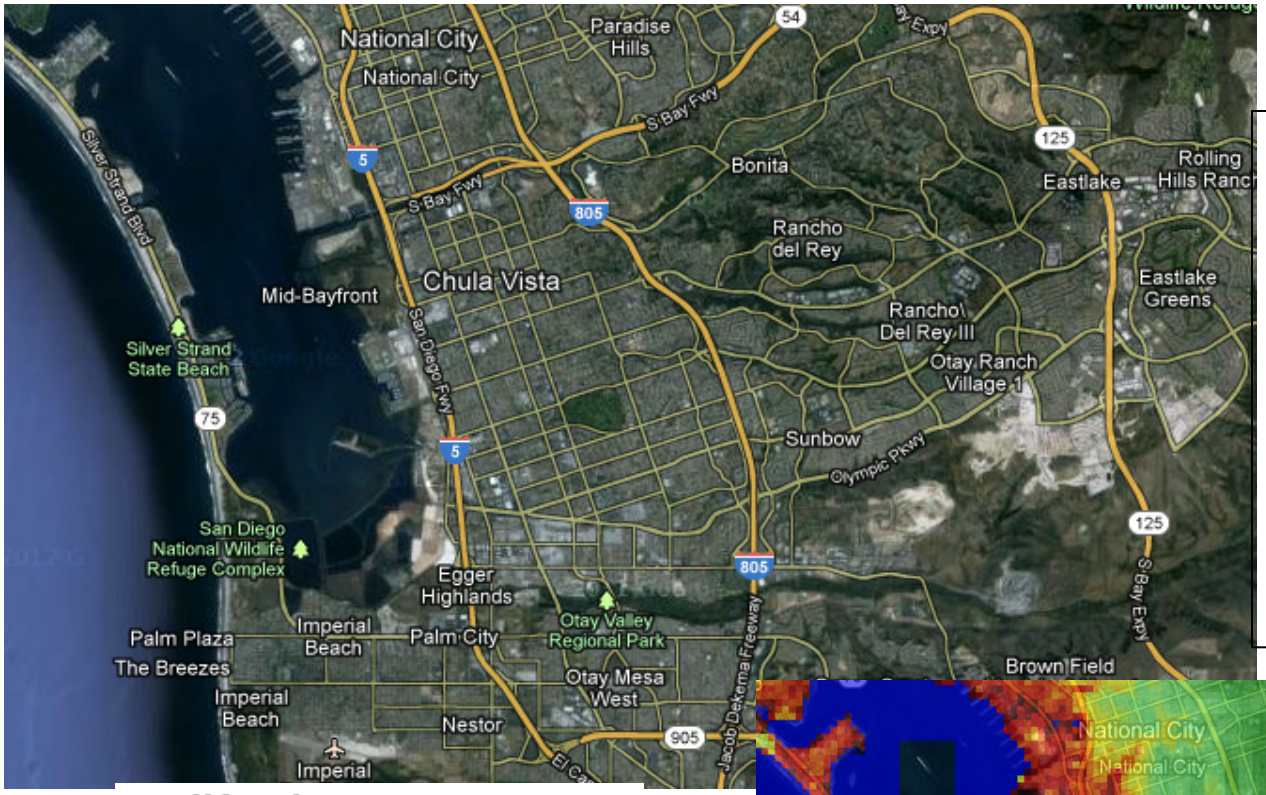
- **SLR Task Force Report 2010**: implement adaptive measures and amend local/state law to respond to climate change
- **Stony Brook University engineers 2009** offer designs for seawalls and gateways
- **NYC Waterfront Revitalization Program Amendments 2012** SLR vulnerability assessment of new projects and resiliency design features for existing buildings
- **New York City Panel on Climate Change**: current co-chairs from NASA and CUNY.

Projected Sea Level Rise in Two Regions of New York (ClimAID Integrated Assessment, 2010)

Lower Hudson Valley & Long Island	2020s	2050s	2080s
Sea level rise	2 to 5 in	7 to 12 in	12 to 23 in
Sea level rise with rapid ice-melt scenario	5 to 10 in	19 - 29 in	41 to 55 in

Mid-Hudson Valley & Capital Region	2020s	2050s	2080s
Sea level rise	1 to 4 in	5 to 9 in	8 to 18 in
Sea level rise with rapid ice-melt scenario	4 to 9 in	17 to 26 in	37 to 50 in

After Sandy, Red Hook, NY saw a record 13 ft storm surge



Smaller jurisdiction:

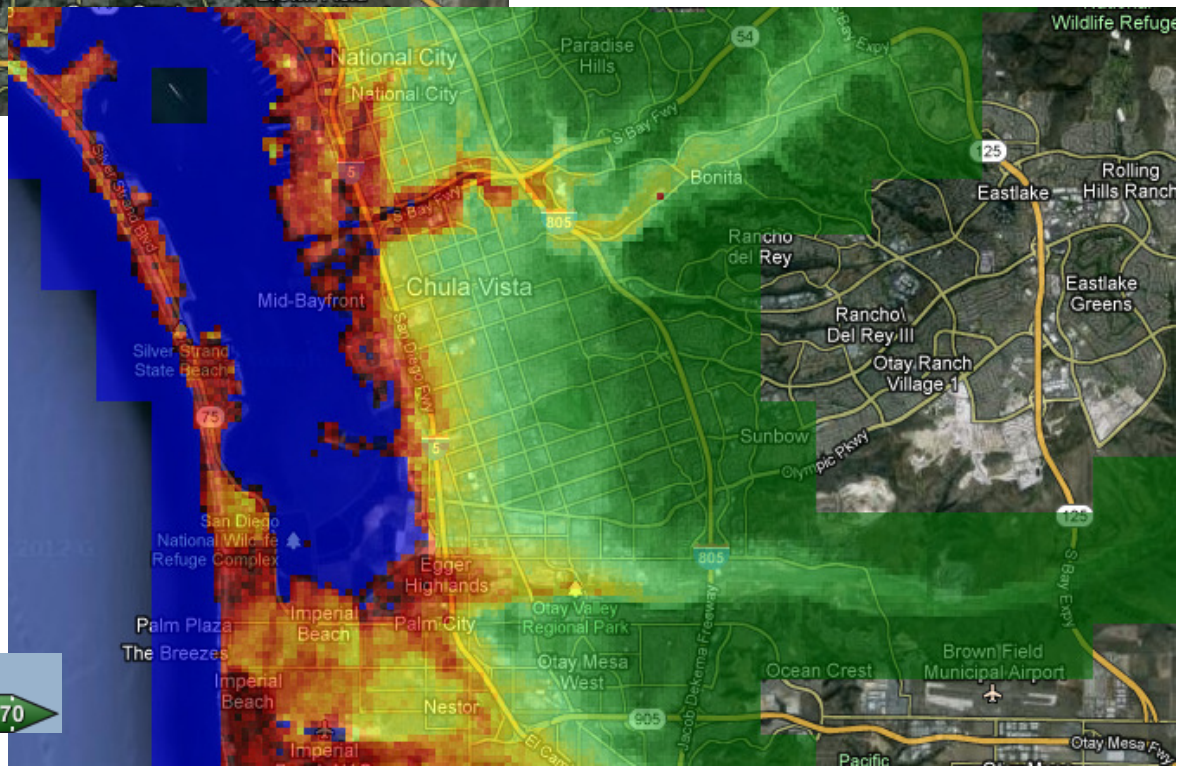
3) Chula Vista, California

Coastal city: 6 in. SLR recorded 1990-2000

Projections: 12-18 in by 2050

Population: 247,535

Second largest city in San Diego Metropolitan area



Chula Vista: Fast track action in 2011

- Climate Change Working Group (created in 2000), Climate Change Action Plan (2008)
- 2011: added 11 adaptation strategies to Plan
- For example, strategy 10 –
  - add SLR to grading ordinance (approved by City Council in July 2011)
  - Modify subdivision manual to ensure proper drainage with higher SLR (approved Dec. 2011)
  - Working to incorporate SLR into state environmental quality guidelines

3. Sarasota Bay region – opportunities for action

We know we have SLR risks:

Our coastal low-lying areas and barrier islands face more --

- Coastal/beach erosion, flooding
- Disturbance to fish, shellfish, wildlife species
- Loss of tidal wetlands and coral reefs as buffers
- Sedimentation changes
- Salt water intrusion, threats to fresh water ecosystems and ground water

Long-range impacts extend to our economy and way of life, social systems, human health, culture.

Florida's 2006 Coastal Economy

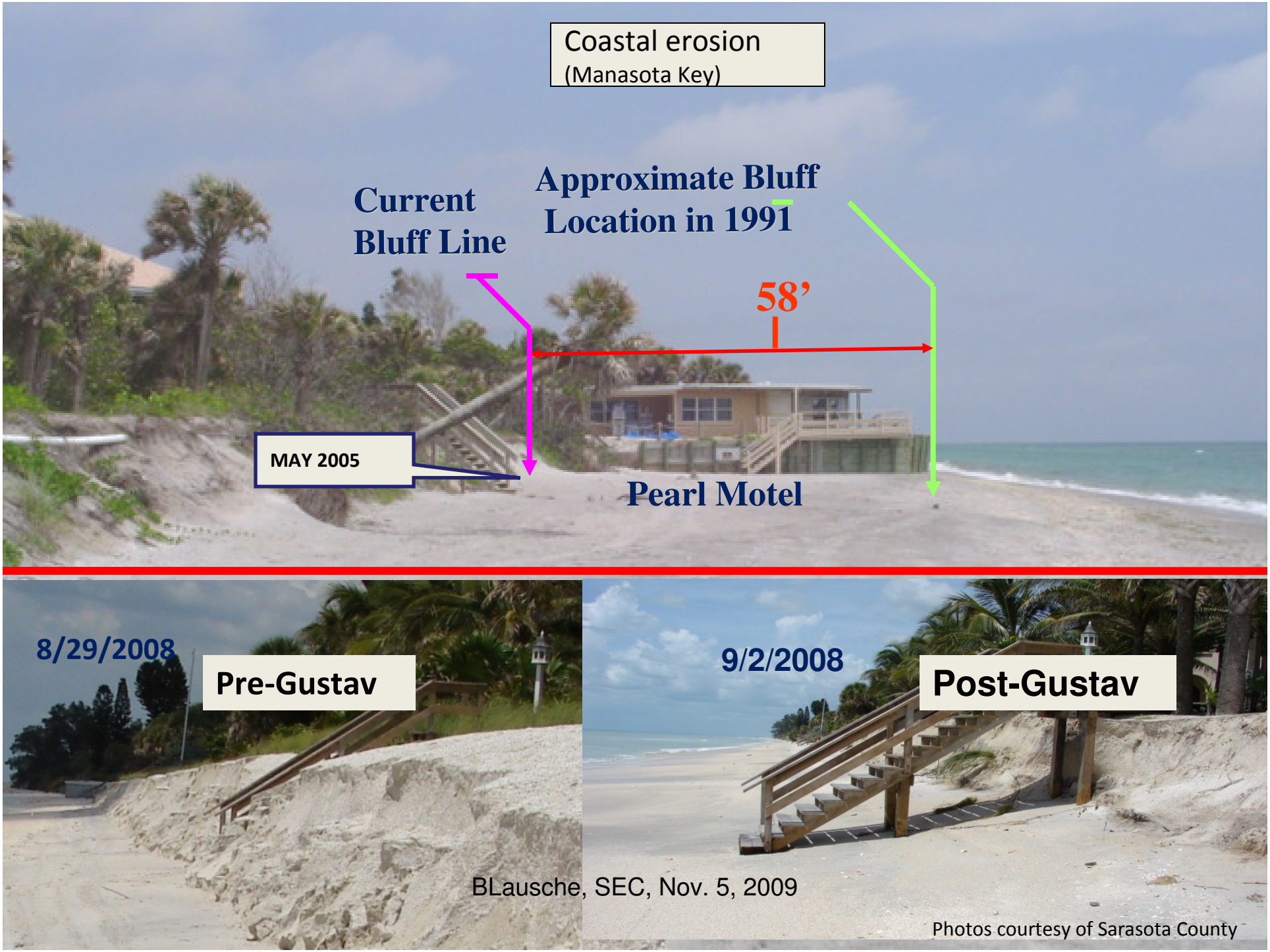
- **$562 billion in GSP**
- **$226 billion in wages**
- **5.8 million jobs**

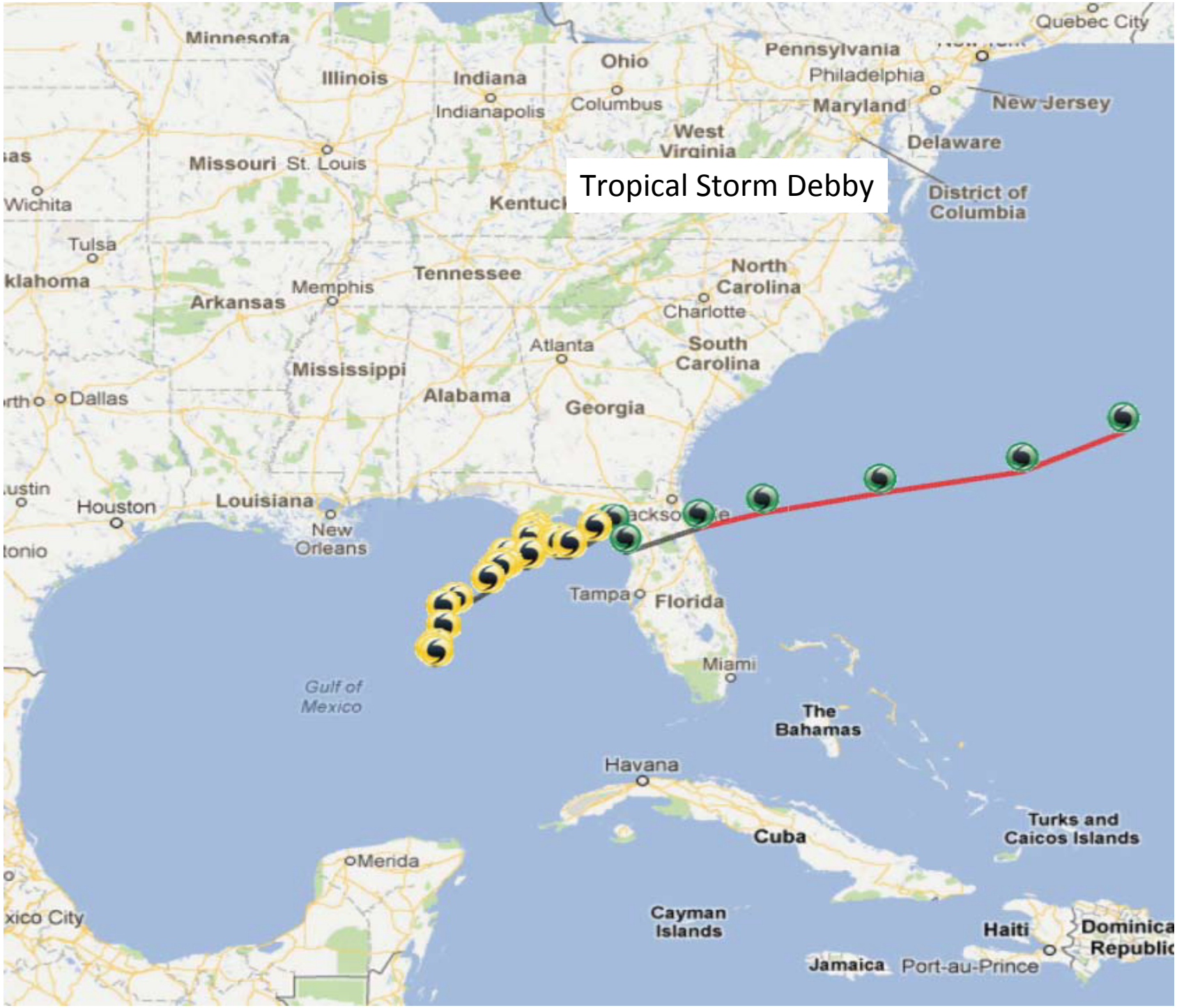
FLORIDA OCEANS AND COASTAL COUNCIL

Based on two studies conducted by the National Ocean Economics Program for FOCC

The PDRP tells us: Our future vulnerability to coastal storms and hurricanes is even greater as sea level rise increases impacts of beach erosion and storm surge. (PDRP Guide, 2010, p. 6)

Photos courtesy of Sarasota County


Coastal erosion
(Manasota Key)
Current
Bluff Line
Approximate Bluff
Location in 1991
58’
MAY 2005
Pearl Motel
8/29/2008
Pre-Gustav
9/2/2008
Post-Gustav
BLausche, SEC, Nov. 5, 2009
Photos courtesy of Sarasota County


Tropical Storm Debby
Minnesota
Illinois
Indiana
Ohio
Pennsylvania
Quebec City
Philadelphia
Indianapolis
Columbus
Maryland
New Jersey
West Virginia
Delaware
Missouri
St. Louis
District of Columbia
Wichita
Kentucky
Tulsa
Tennessee
North Carolina
Memphis
Arkansas
Charlotte
Atlanta
South Carolina
Mississippi
Alabama
Georgia
Dallas
Houston
Louisiana
New Orleans
Tampa
Florida
Miami
Gulf of Mexico
The Bahamas
Havana
Cuba
Turks and Caicos Islands
Merida
Cayman Islands
Haiti
Jamaica
Port-au-Prince

Tropical Storm Debby

More than 30 ft. of dune eroded in front of 7100 Manasota Key. Dune walk over structure damaged and steps washed away.

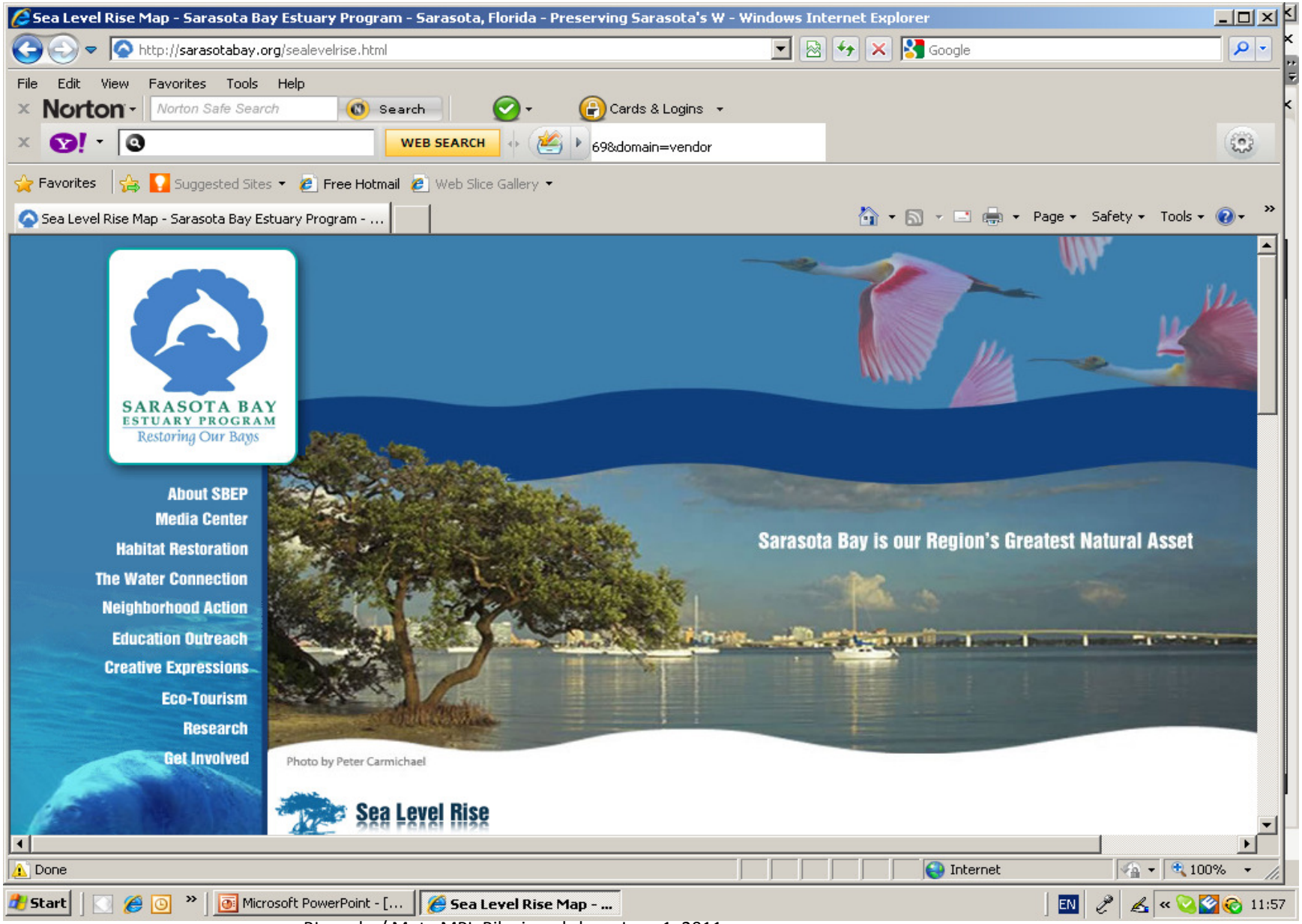
Fisherman's Cove and Condos, restored beach and native dune vegetation washed away.

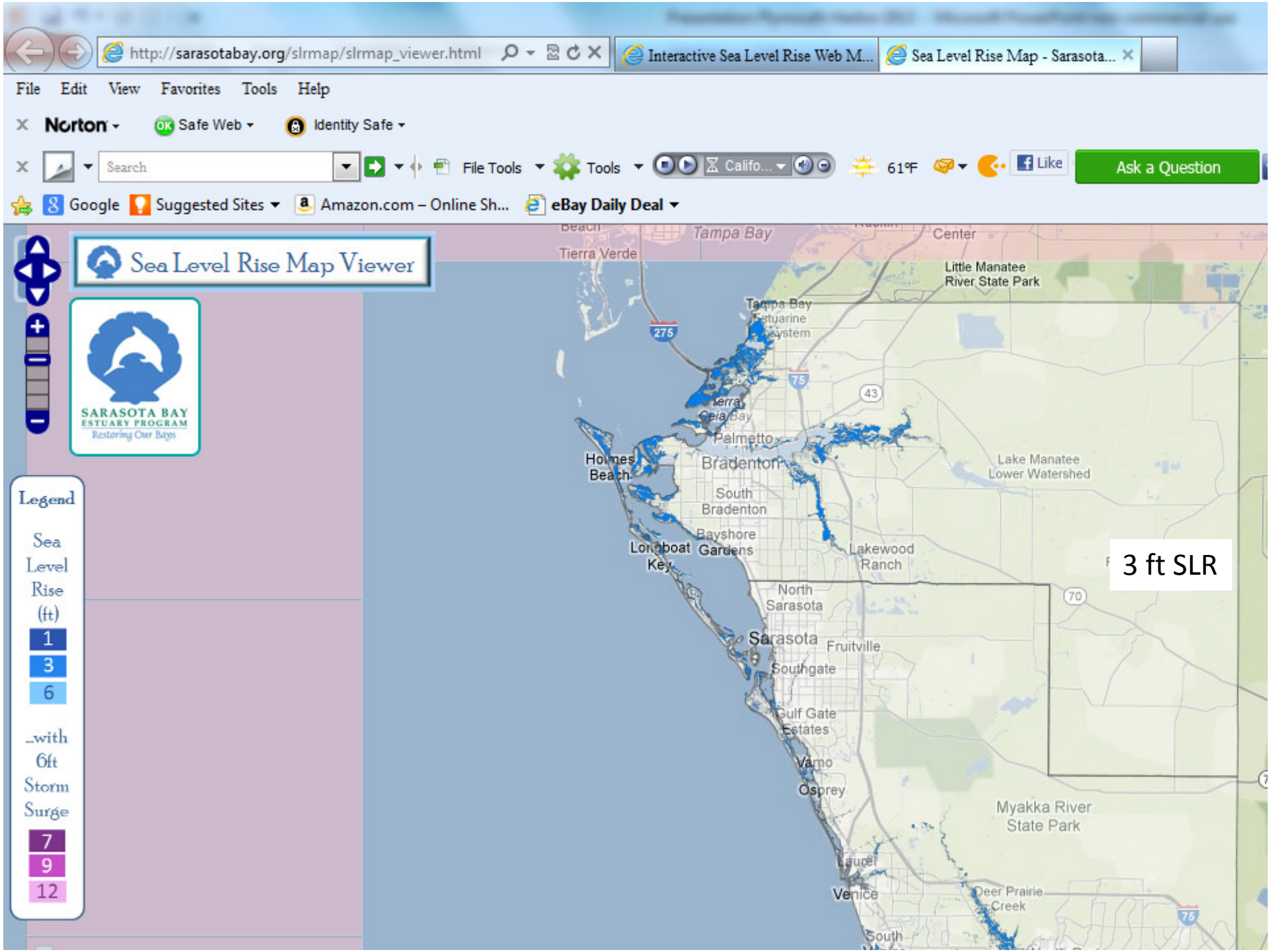
Beach Road

Photos from: Weiqi Lin P.E., Ph.D.
Coastal Resources/Community Services
"**Tropical Storm Debby** -- Post-Debby Beach/Dune Damage Assessment Report, Sarasota Florida".
June 29, 2012

…and we have tools to begin to assess risks and act --

SLR Web Viewer for Sarasota Bay Estuary

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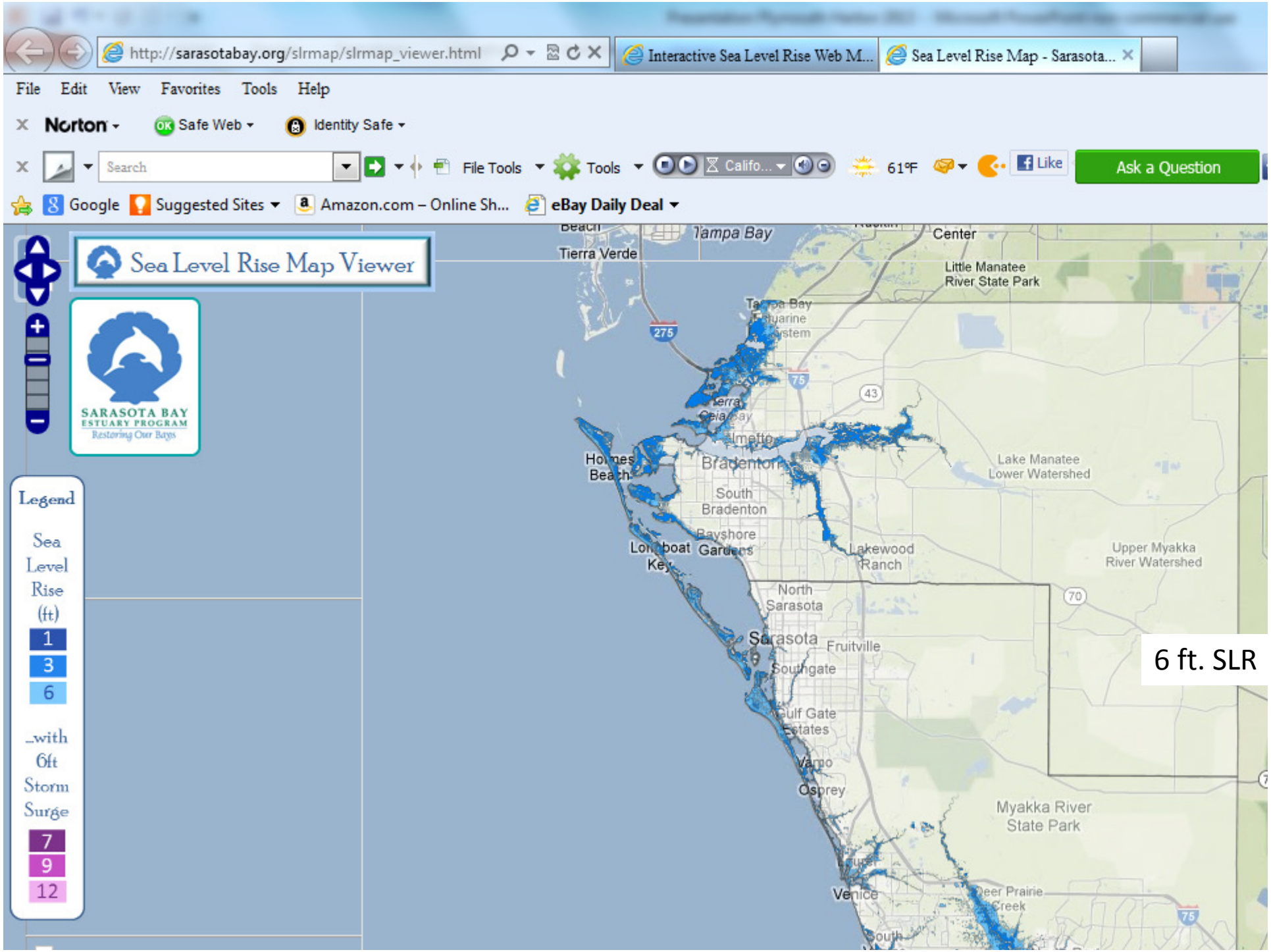
Suggested Sites
Amazon.com – Online Sh...
eBay Daily Deal
Sea Level Rise Map Viewer
SARASOTA BAY ESTUARY PROGRAM
Restoring Our Bays
Legend
Sea Level Rise (ft)
1
3
6
with 6ft Storm Surge
7
9
12
3 ft SLR
Tampa Bay
Tierra Verde
Little Manatee River State Park
Tampa Bay Estuarine System
Terra Ceia Bay
Palmetto
Bradenton
Holmes Beach
South Bradenton
Bayshore Gardens
Longboat Key
Lake Manatee Lower Watershed
Lakewood Ranch
North Sarasota
Sarasota
Fruitville
Southgate
Gulf Gate Estates
Vamo
Osprey
Myakka River State Park
Laurel
Venice
Deer Prairie Creek
South
275
75
43
70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Lake Manatee Lower Watershed
Upper Myakka River Watershed
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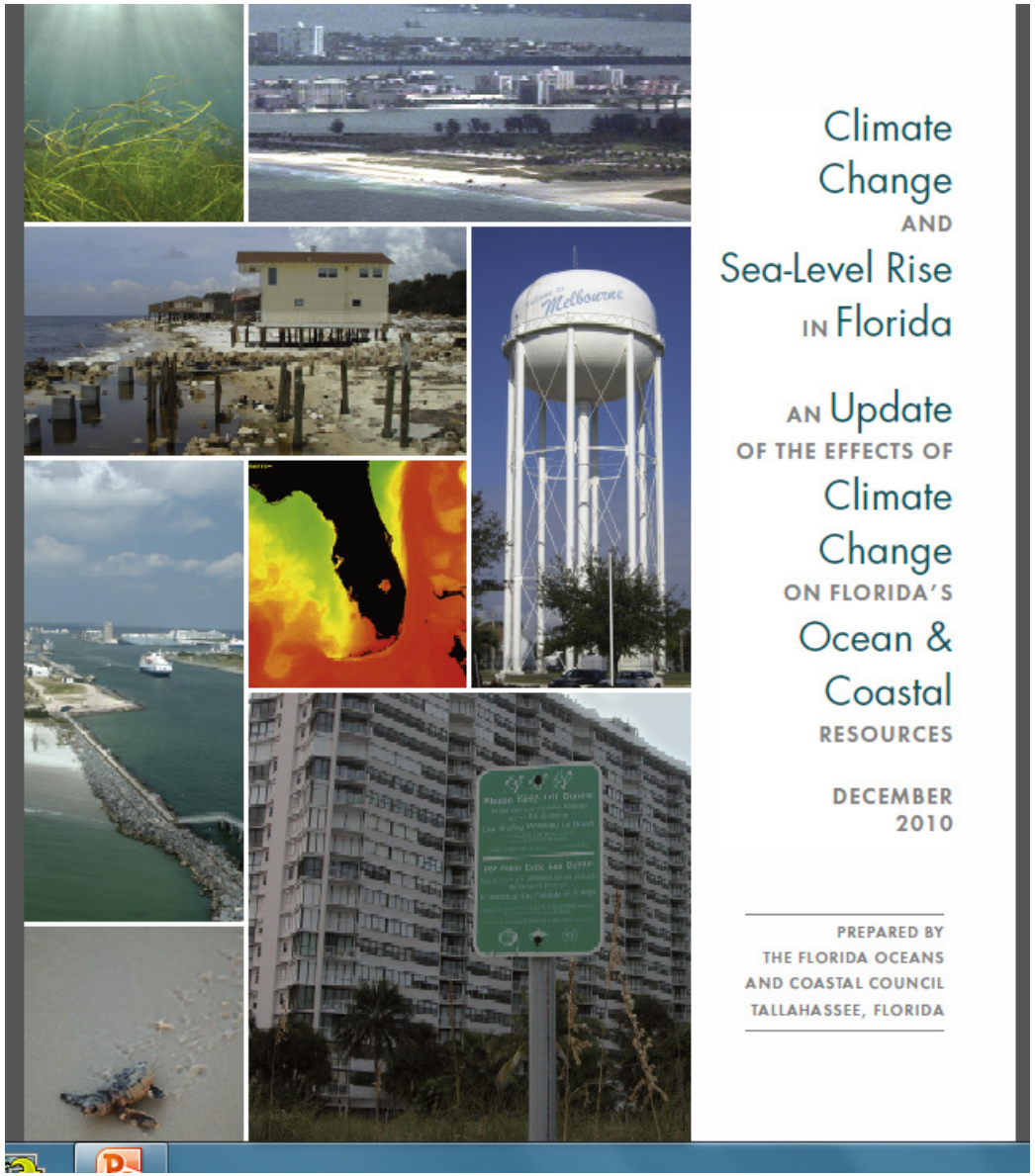
Sarasota
Fruitville
Southgate
Gulf Gate Estates
Venice
Osprey
Myakka River State Park
6 ft. SLR



Science reports - Florida Oceans and Coastal Council

http://www.floridaoceanscouncil.org/reports/Climate_Change_and_Sea_Level_Rise.pdf


State Plan: October 2010
POST-DISASTER REDEVELOPMENT PLANNING
A Guide for Florida Communities
FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS | FLORIDA DIVISION OF EMERGENCY MANAGEMENT

Closer to home: Some Florida local/regional actions:

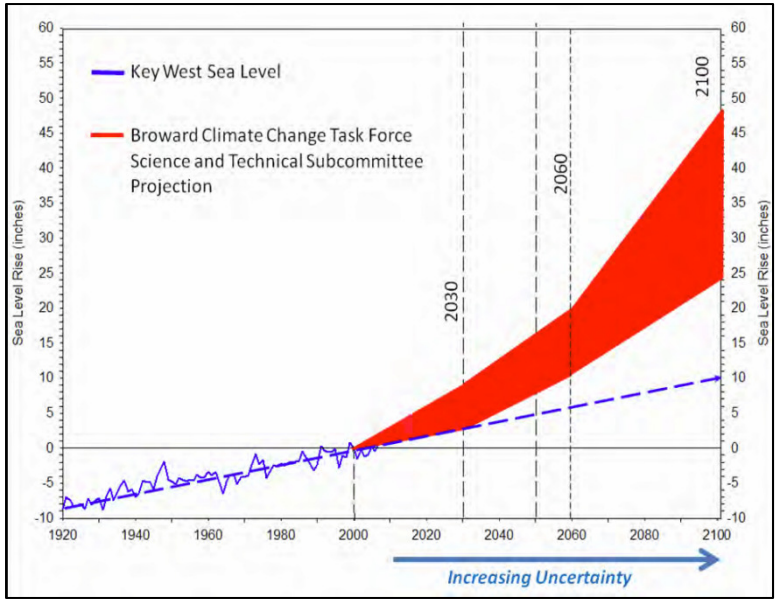
Southeast Florida Regional Compact Climate Change Action Plan:

- by 2030, SLR is projected to be 3-7 inches,
- by 2060, 9-24 inches.
- SLR continuing to rise, roughly 1 foot
- Review every four years.

Broward County Climate Change Action Plan:

- 3-to-9 inches increase by 2030
- 10-20 inches by 2060
- 24-48 inches of sea level rise by 2100

(as of May 2012)



Building Awareness:

King Tide Contest Sarasota, June 2012: Low and High Tide

1) Bayou Louise, Siesta Key

2) Clambar Bayou and Champlain Bayou, Snead Island

3) Fort DeSoto Beach

Why relate tides to SLR?

- A rise in sea level of 23 inches is easy to visualize around the edges of our coasts and barrier islands. The natural range between our highest tide and lowest tide is about 25 inches. When sea level is two feet higher than today, the lowest tides will be approximately where the highest tides are now. (from Dr. Ernie Estevez, Scientist Emeritus, Mote)

Building Awareness:

Sarasota Water Festival 2012

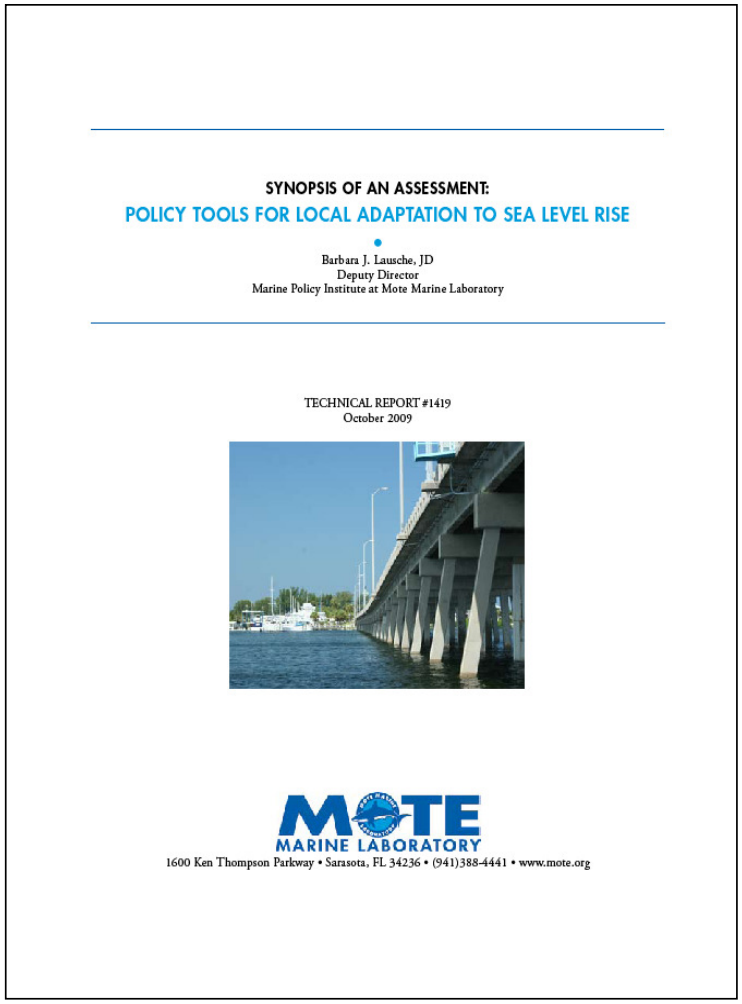
- Iceberg sculpture designed by Rick Herzog and New College students
- Connecting icebergs to sea level rise
- Opportunity for survey on climate change and sea level rise

Survey: Views on Sea Level Rise and Climate Change

- Believe Climate Change is occurring
  - 96% of the general public vs. 100% of the students
- Concerned local community will be affected by SLR
  - 70% of the general public vs. 90% of the students
- Believe local SLR will pose a serious threat in their lifetimes
  - 48% of the general public vs. 60% of the students

!YOU ARE INVITED TO TAKE THE SURVEY HERE OR ONLINE!

Local existing policy tools for SLR adaptation --



SYNOPSIS OF AN ASSESSMENT:

POLICY TOOLS FOR LOCAL ADAPTATION TO SEA LEVEL RISE

Barbara J. Lausche, JD
Deputy Director
Marine Policy Institute at Mote Marine Laboratory

TECHNICAL REPORT #1419
October 2009

MOTE MARINE LABORATORY
1600 Ken Thompson Parkway • Sarasota, FL 34236 • (941)388-4441 • www.mote.org

1. Comprehensive plans
2. Coastal management and development rules
3. Conserving sensitive coastal land; purchase, conservation easements
4. Add SLR to infrastructure planning
5. Post-disaster redevelopment planning.

Looking ahead – How do we begin locally to plan for Sea Level Rise

- **We already adapt to SLR in many ways:**
  - Seawalls, Docks and Piers
  - Bridges and Causeways
  - Stormwater Systems
  - Beach Policies and Practices
  - Wetland Creation
  - Environmentally sensitive land purchases
  - Building Heights
  - Disaster Preparedness
  - New elevation maps (LIDAR)

Some key starting points:

- Build community and business support – need serious science-based conversations**
- Begin with existing planning tools – there are many
- Broaden local planning horizons (e.g., 50-75 years)
- Create institutional focus – e.g., SLR task force, work group/advisory panel
- Learn about and understand market factors – e.g., insurance and reinsurance, bank lending rules.
- Stay flexible for changes in global projections
- Remember SLR is a slow process; early planning works.

Thank you for coming

Marine Policy Institute

Thanks also to Plymouth Harbor,

and to --

- Elspeth Boynton
- Leonard Giarrano
- Luke Maier

(young MPI professionals who helped research and prepare for this presentation)

blausche@mote.org

www.mote.org/mpi