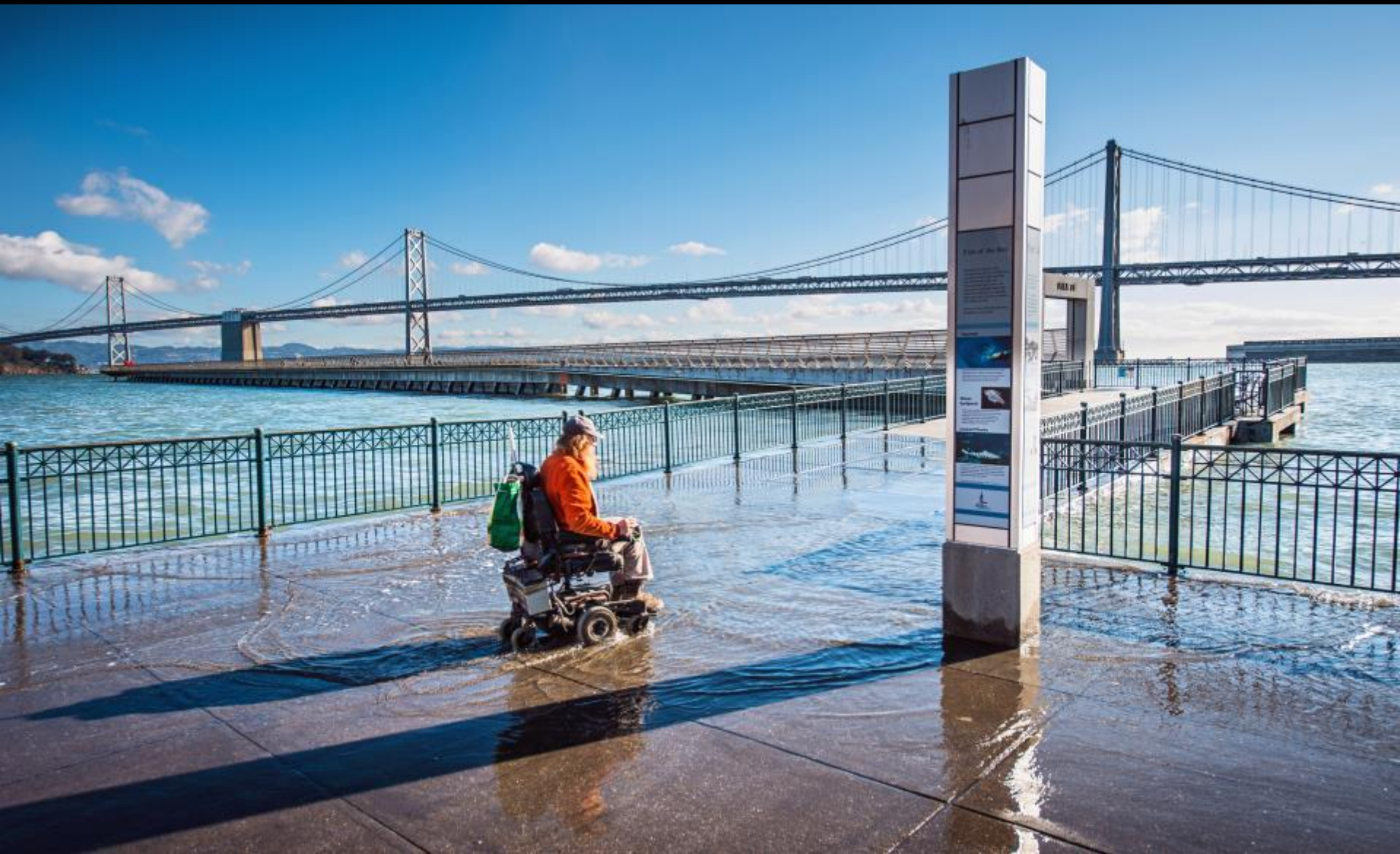
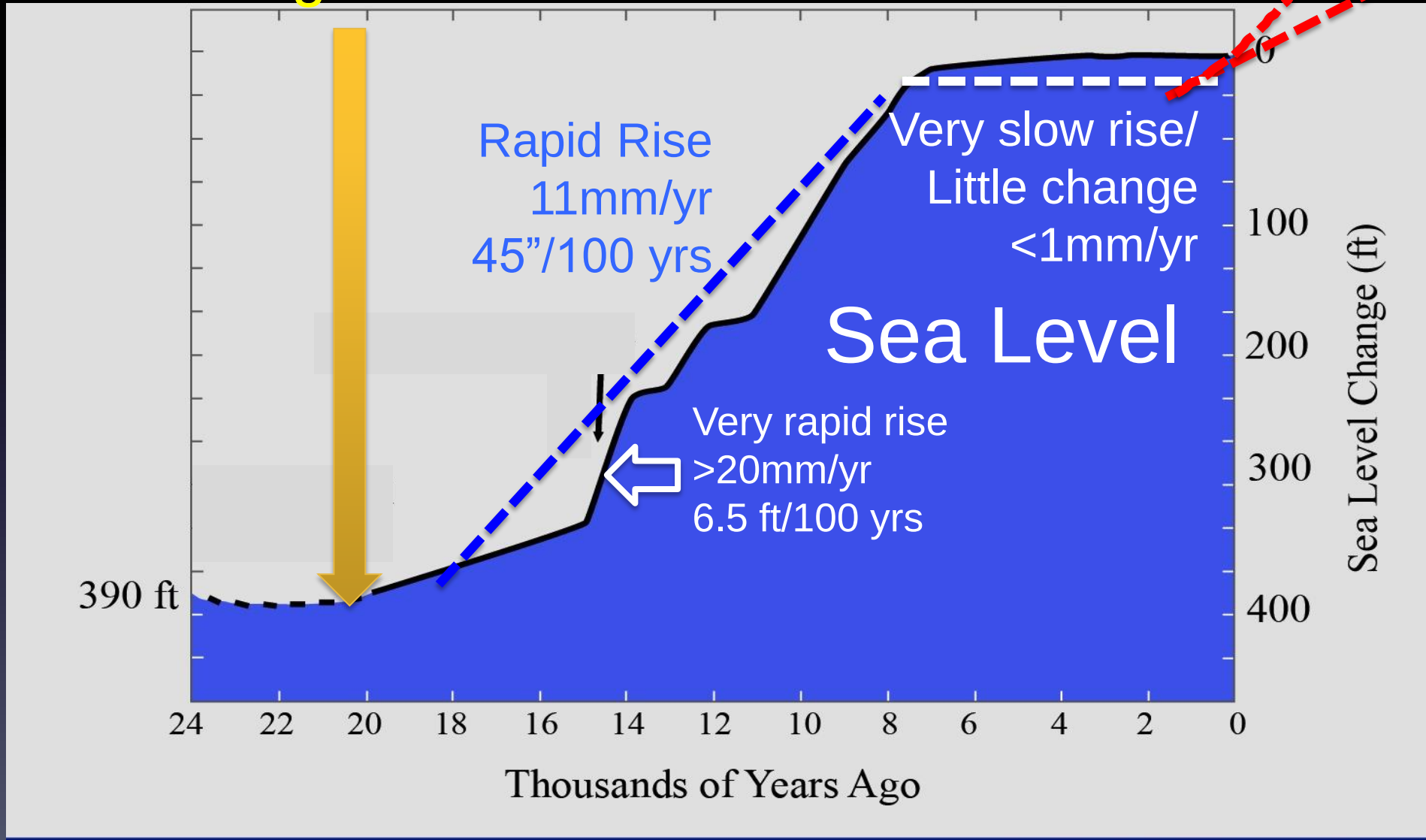
Sea-Level Rise as a Climate Change Indicator

Now, Certain and Everywhere



Present Rate
3.2mm/yr
(12”/100 yrs)

Ice Age ended



Temporal Differences in Sea Level Change

LONG-TERM:LOW RATE OF CHANGE

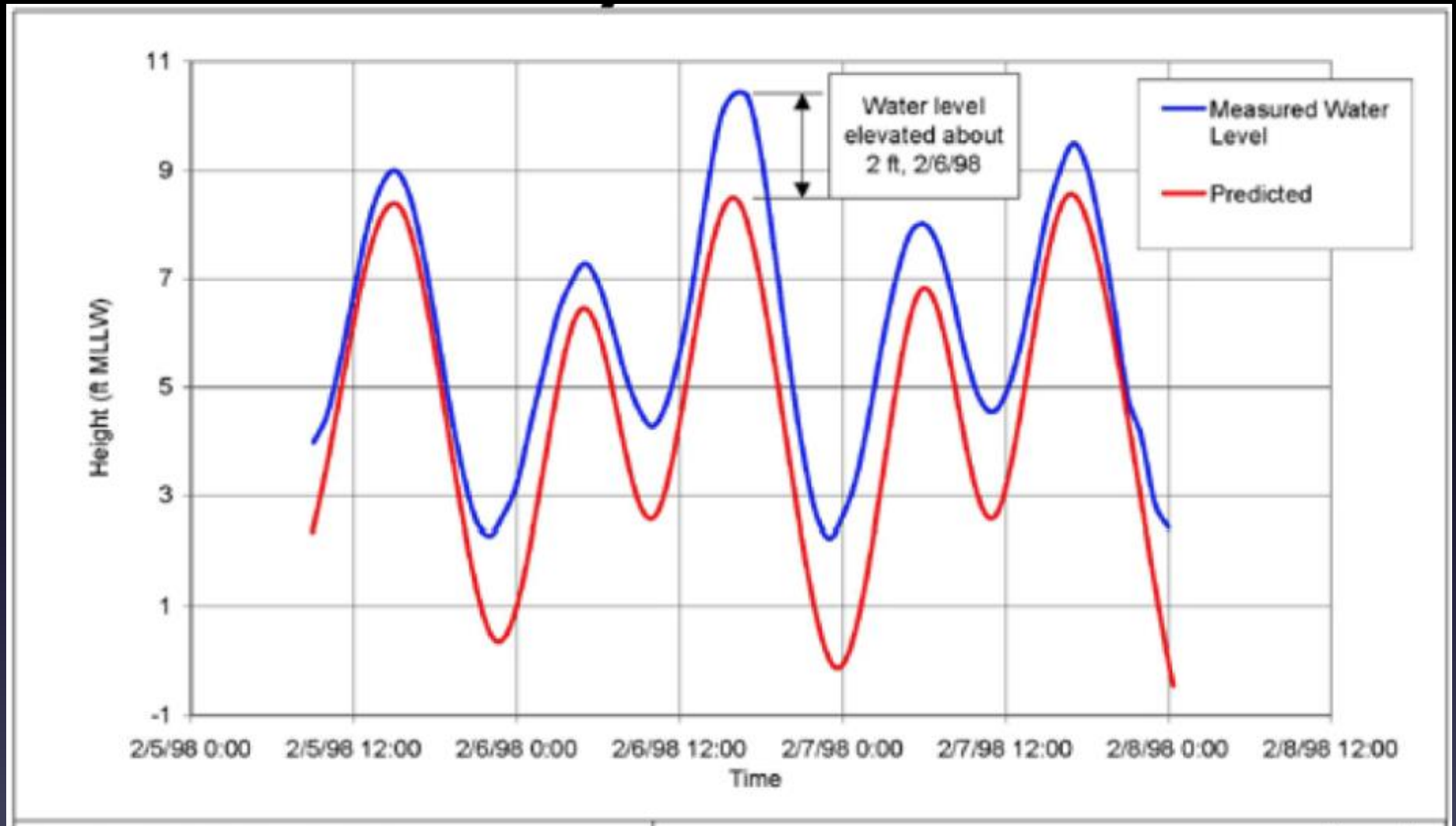
- Ice melt and thermal expansion of ocean: mm/year but hundreds of feet over thousands of years
- Plate tectonics and changing volume of ocean basins: hundreds of feet over millions of years

SHORT-TERM:HIGH RATE OF CHANGE (California)

- Tsunamis: up to 20 feet or more over minutes
- Storm Surges: up to 3 feet over hours
- El Niño: 1-2 feet over months
- Tides: 8-12 feet over hours, including King Tides

Short-Term Impacts of High Tides and Large Storm Waves Mission Beach, San Diego- 1988

El Niño 1997-98-Elevated Water Levels



Source: CO-OPS Verified Hourly Height Water Level

figure 3

South Bay Salt Ponds Restoration Project

Predicted and Measured Tidal Elevations at Redwood City, CA

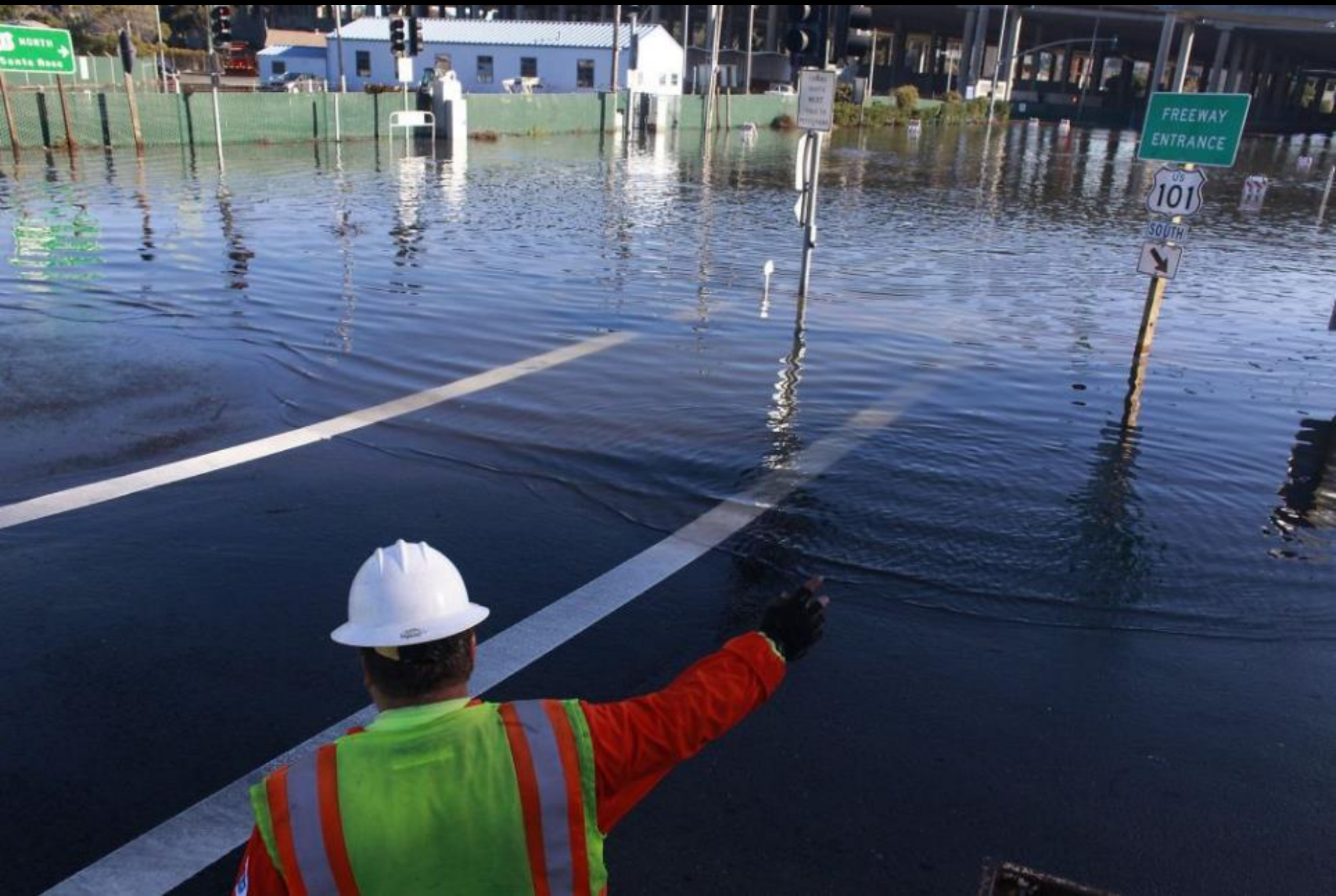
PWA Ref 1750.04

PWA

Seacliff State Beach- Santa Cruz County

Seacliff State Beach- El Niño Winter 1983

King Tide - Mill Valley, Marin County - December 12, 2012



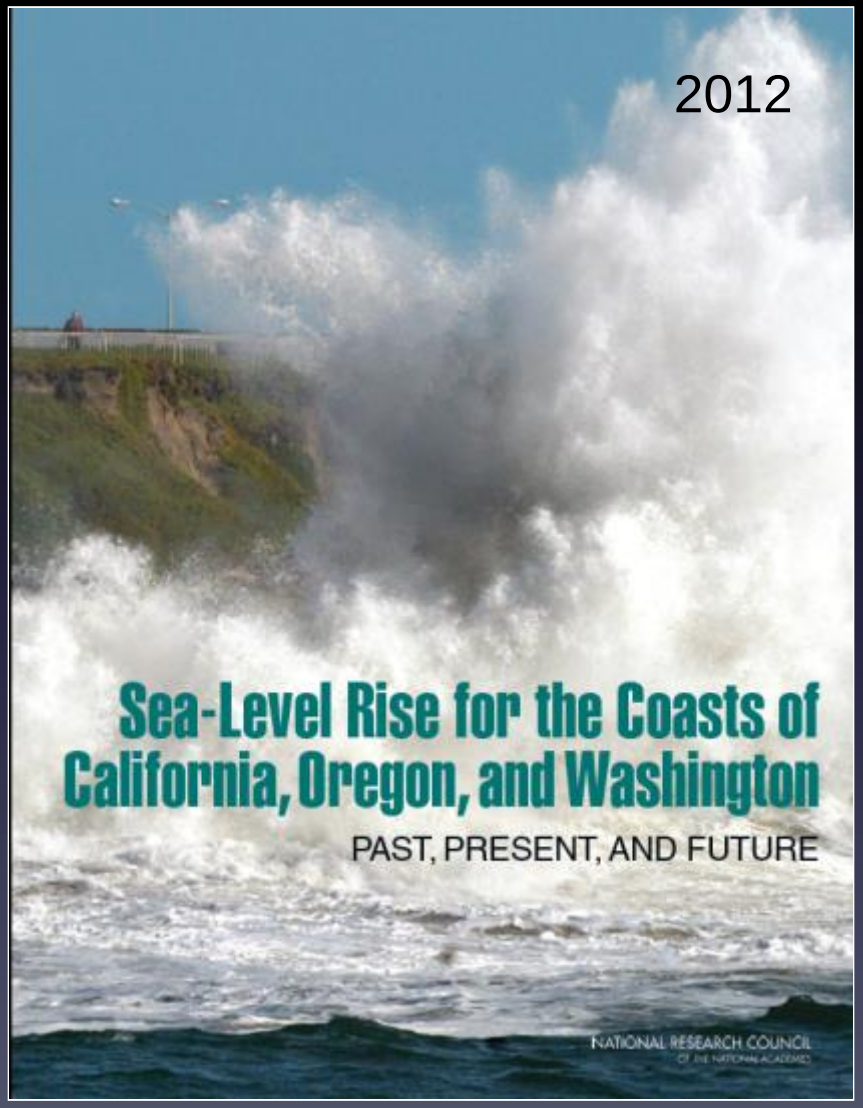
King Tide-The Embarcadero
San Francisco

Sea level is rising and the bathtub is slowly overflowing, but….

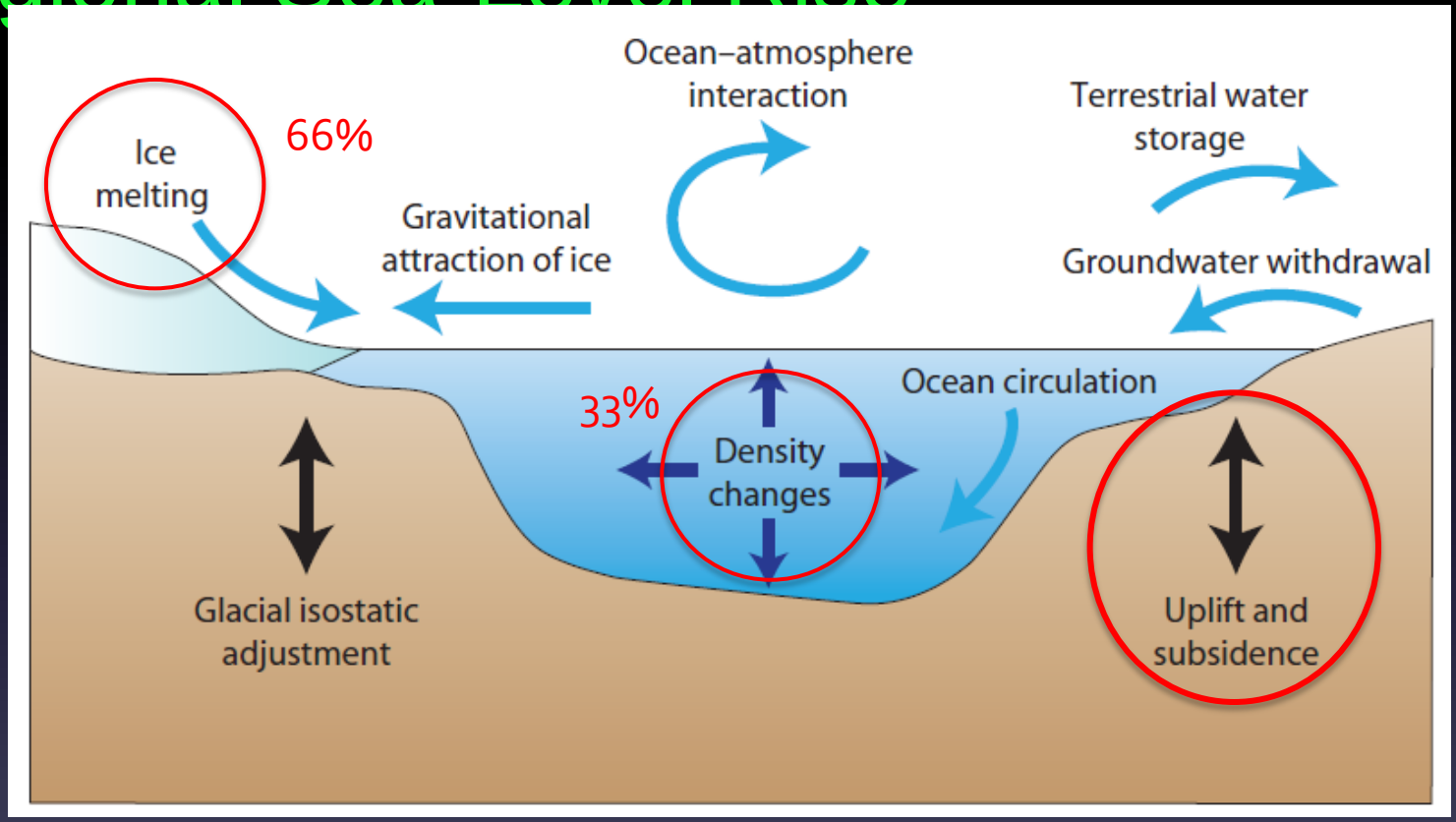
The extreme events are going to be of greater concern in the near term, however.

IMPACTS OF SHORT (AND LONG) TERM SEA-LEVEL RISE

Sea-Level Rise for the Coast of California: Past, Present, and Future

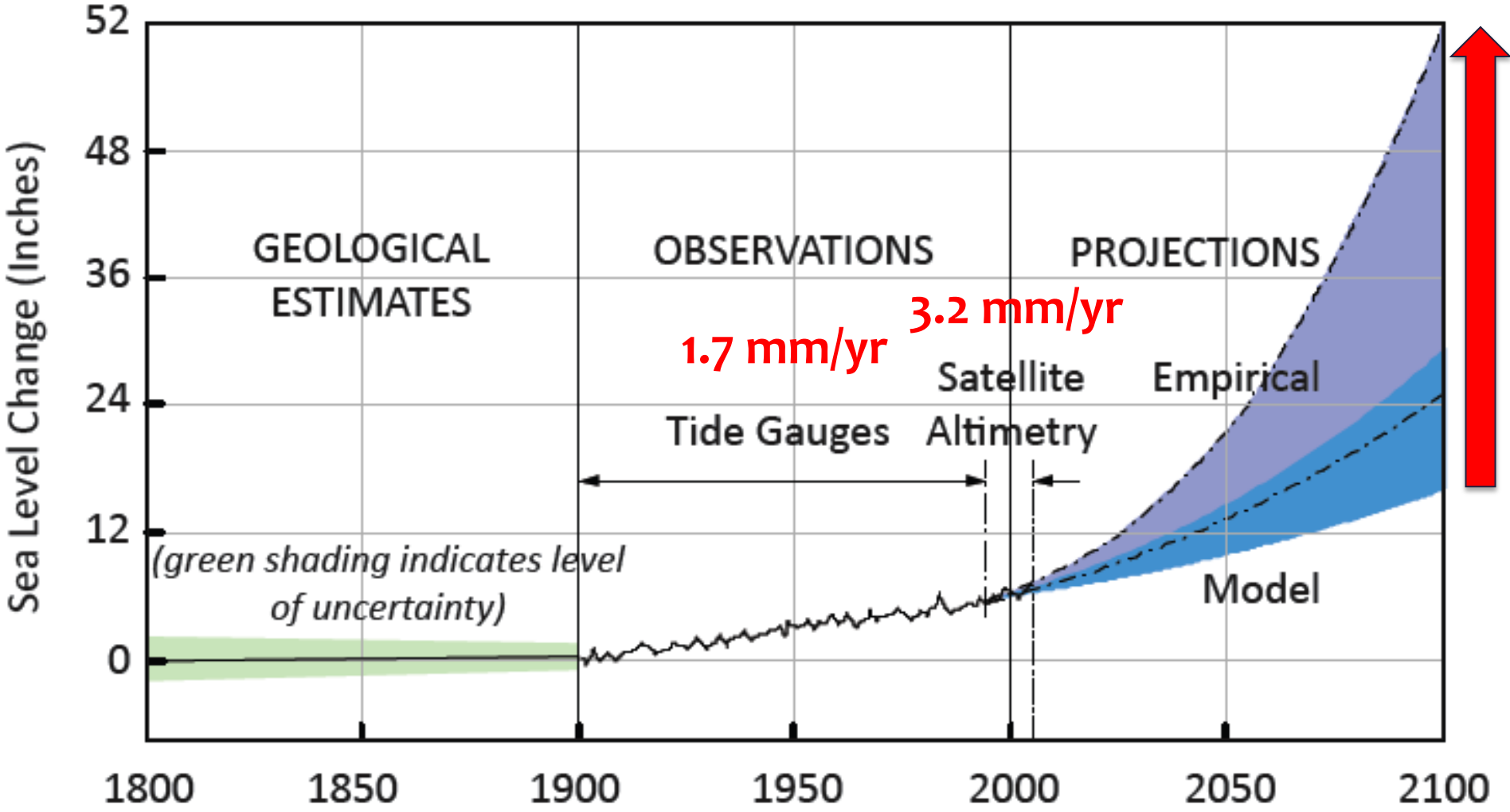


Components of Global and Regional Sea-Level Rise



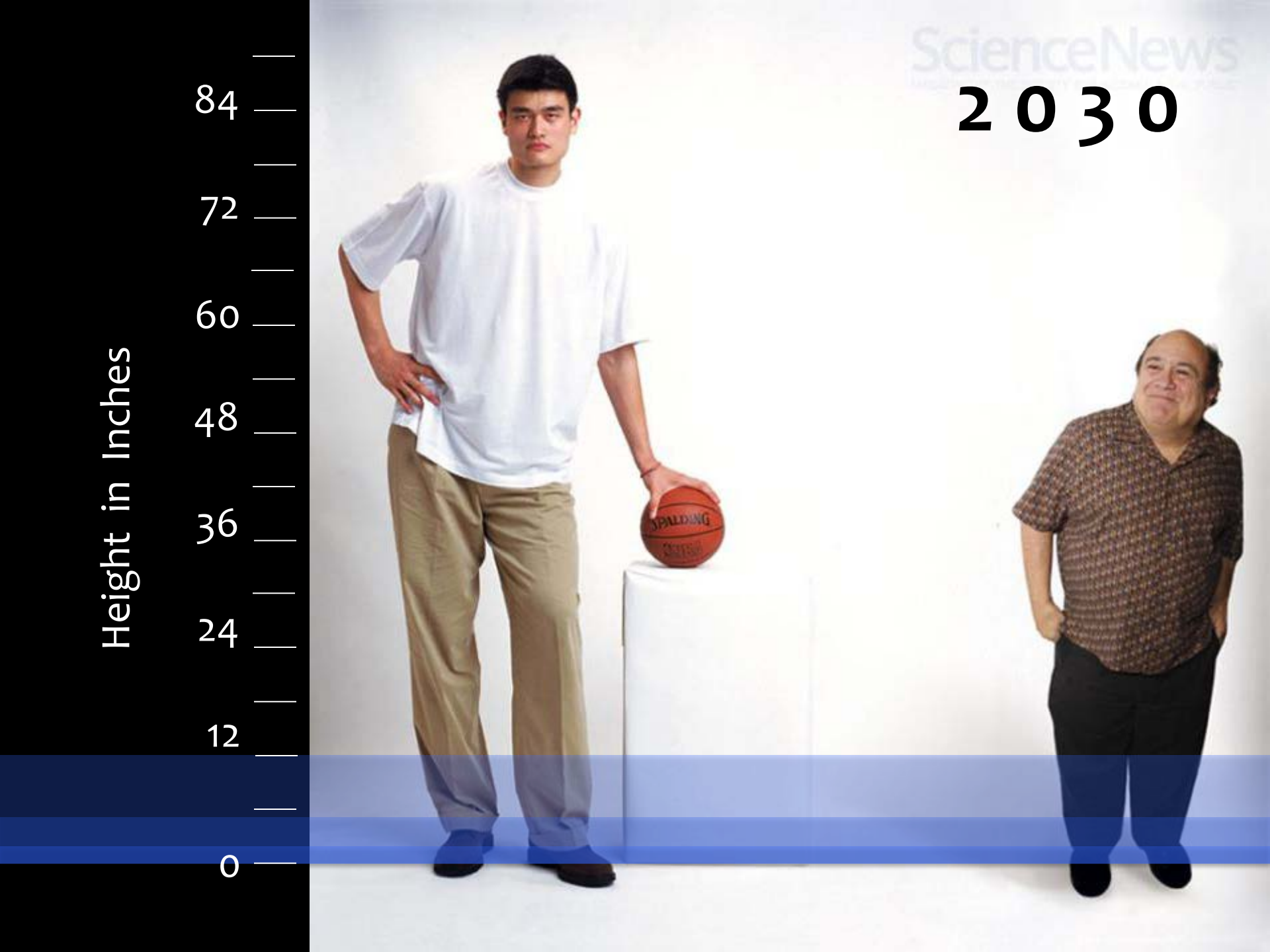
Sea-level rise at a particular place can be higher or lower than the global mean due to regional effects

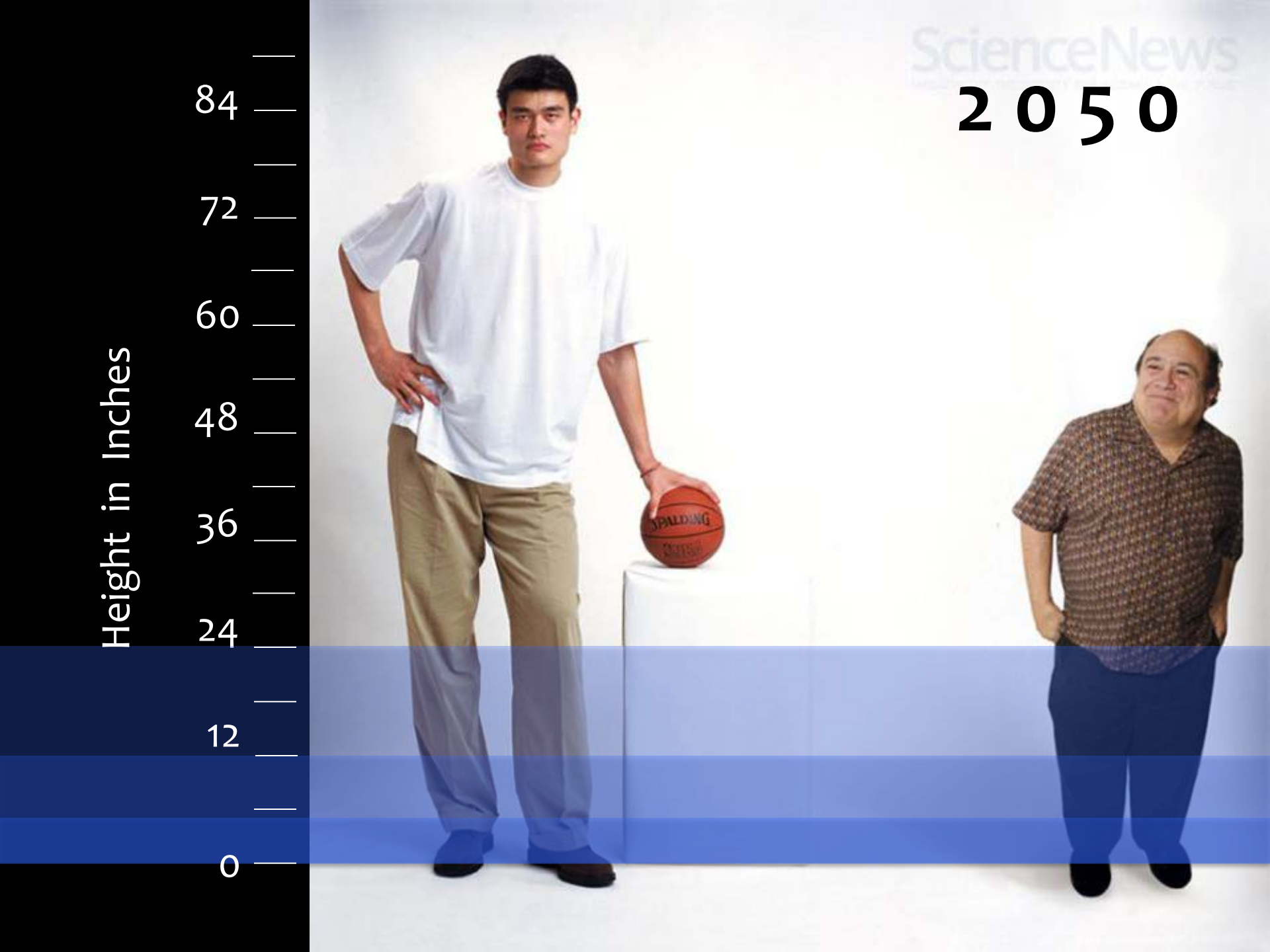
The rate of global sea-level rise was measured from tide gages historically and satellites since 1993.



Uncertainty

"*There are the known knowns, there are the known unknowns, and there are the unknown unknowns".*


Height in Inches
84
72
60
48
36
24
12
0
ScienceNews
2030
SPALDING


Height in Inches
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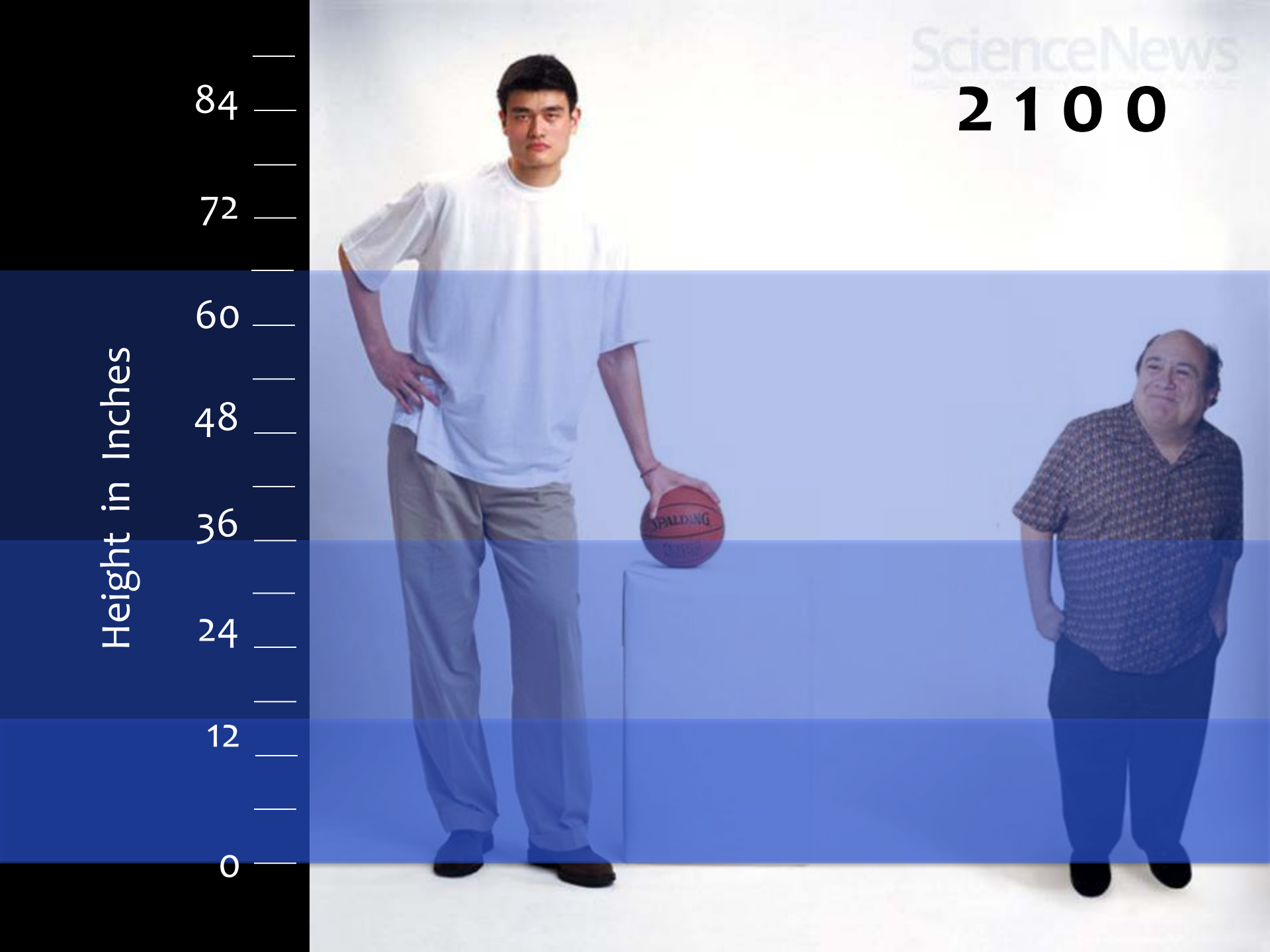

Height in Inches
84
72
60
48
36
24
12
0
ScienceNews
2100

Which of these future projections should we be using?

What is the sea-level rise rate from closest tide gauge?

What is the cost or value of the proposed project or infrastructure?

What is the lifespan of the proposed project or infrastructure?

What is the impact of damage to or loss of facility or infrastructure?

San Francisco International Airport and Oracle with a 16-inch rise in sea level.

San Francisco Bay Conservation and Development Commission

Vulnerable areas

0 1.5 3 MILES

NORTH

16-Inch Sea Level Rise By Mid-Century Central Bay West Shore

What are the best indicators of future risks from sea-level rise?

LONG-TERM: *Sea-level rise trends from NOAA tide gauges combined with most recent future projections*

SHORT-TERM:

- *Episodic events (ENSO) from historic tide gauge records, or from local surveys if no nearby tide gauge.*
- *Documentation of frequency and extent of flooding (nuisance flooding) from King Tides (tide gauges and local surveys or measurements)*

Both long and short-term risks are closely tied to elevations and topography of shoreline areas, and to type and intensity of development.

Crescent City

Humboldt Bay

Point Reyes
San Francisco
Alameda
Redwood City
Monterey

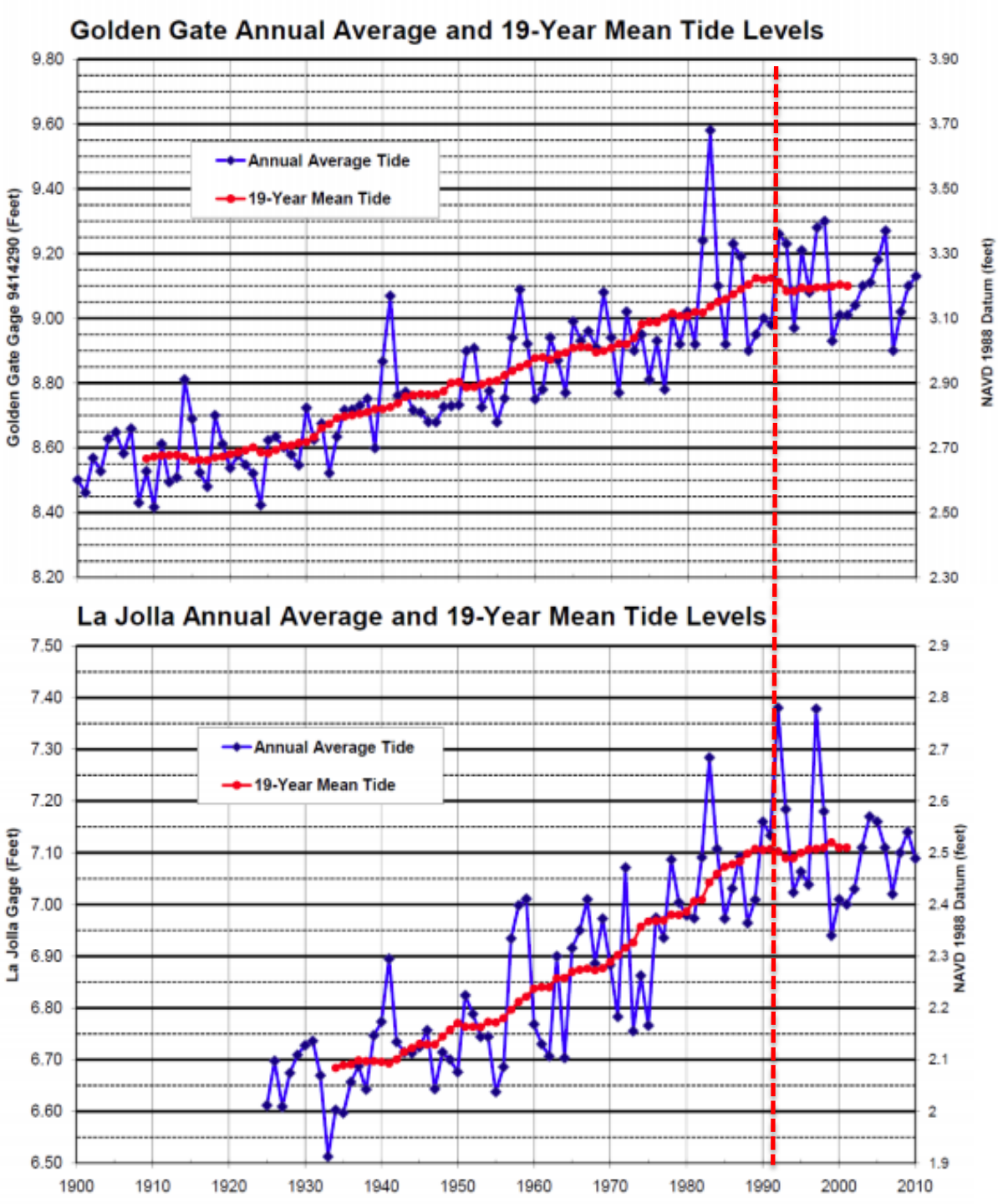
Port San Luis

Santa Barbara
Santa Monica
Los Angeles

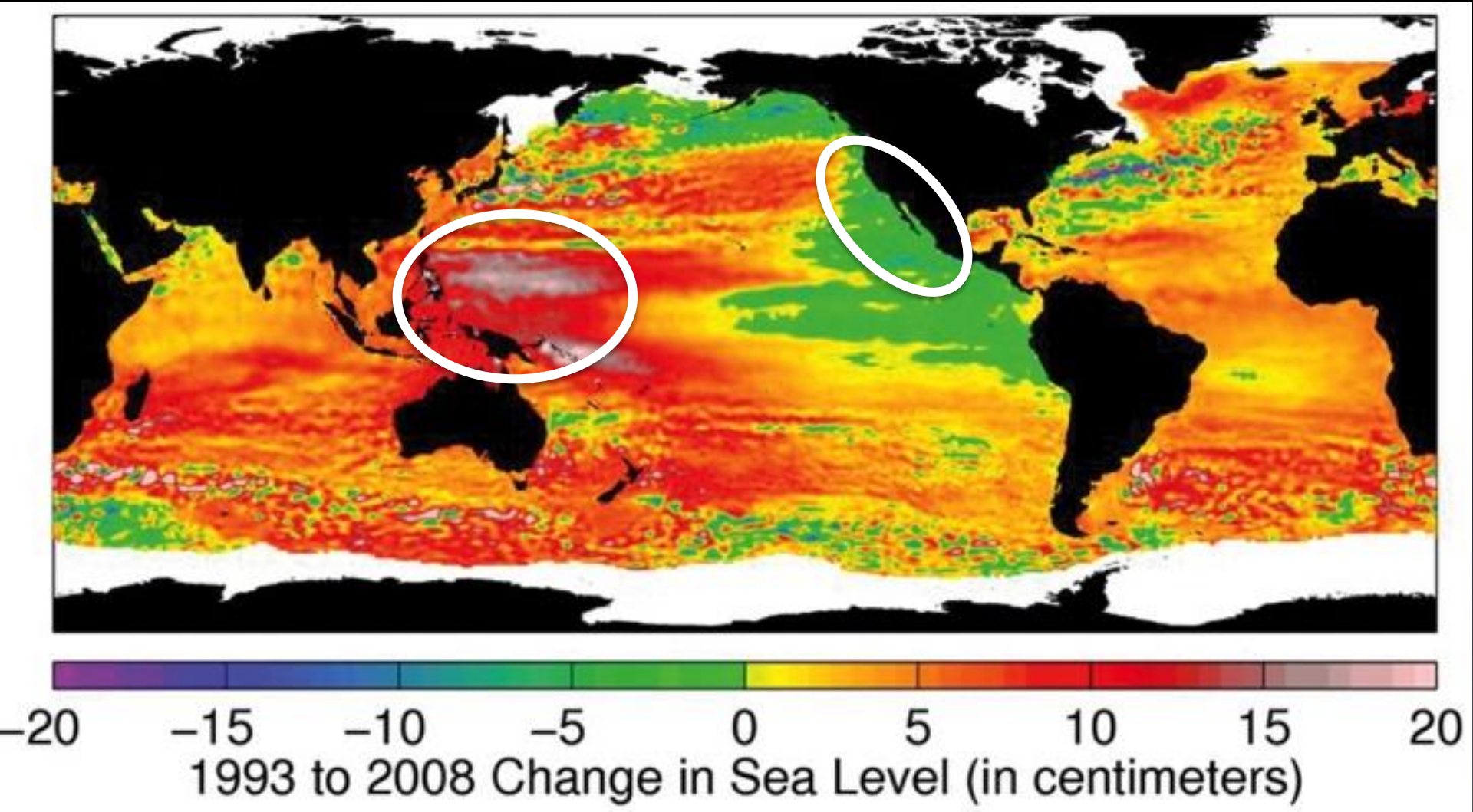
La Jolla
San Diego

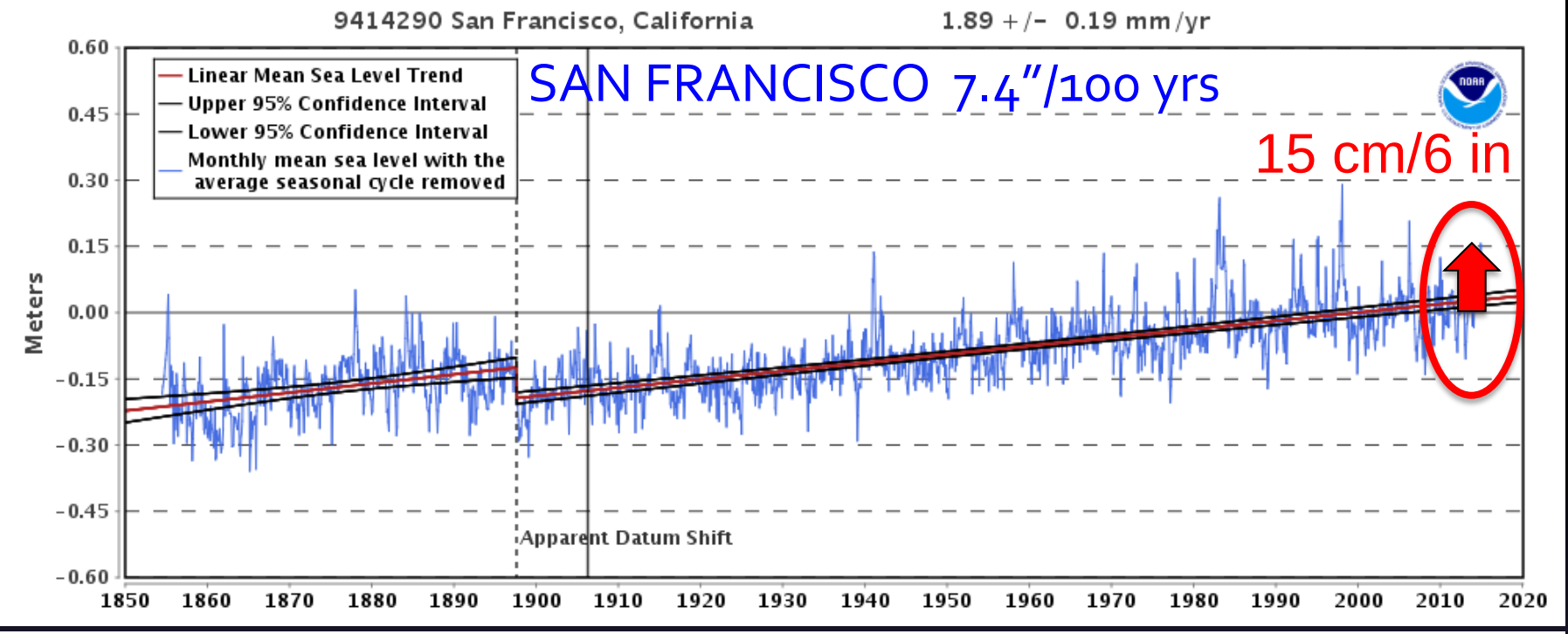
Sea-level rise from NOAA tide gauges at the Golden Gate and La Jolla

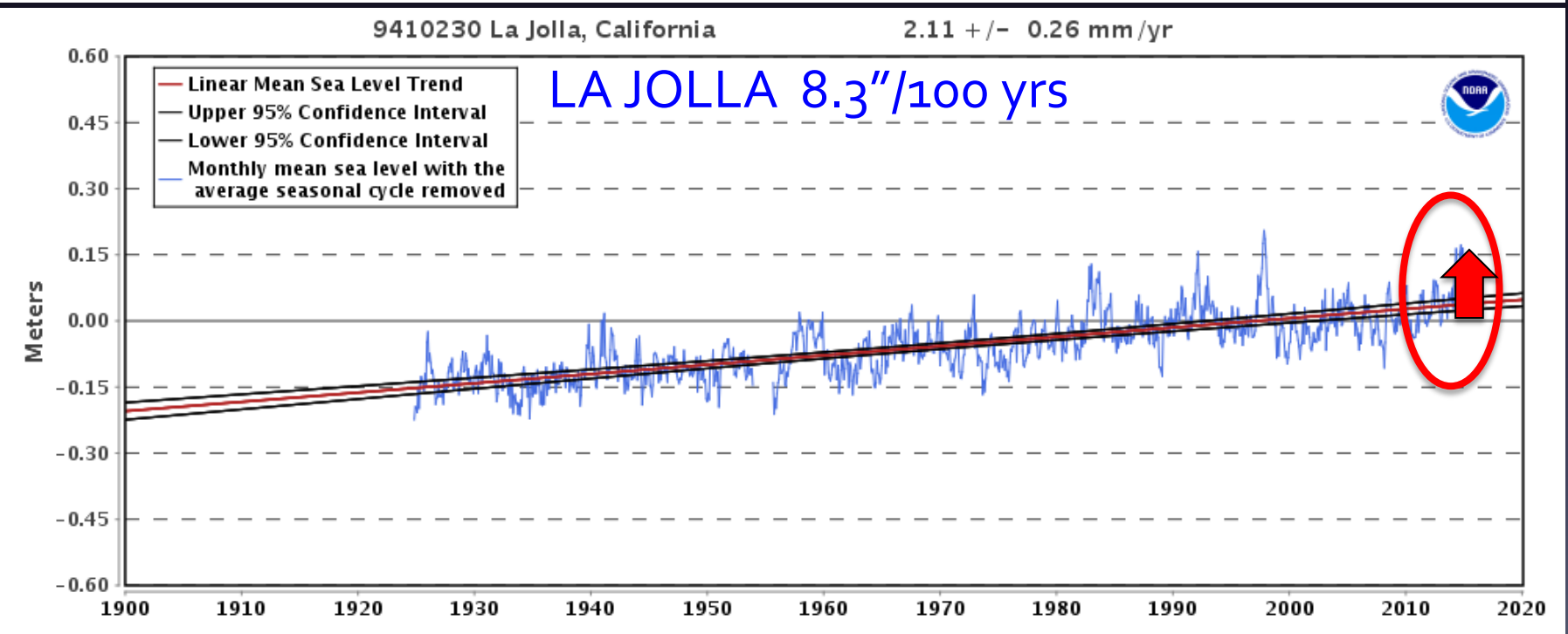
(from *2013 Indicators of Climate Change in California)*



A nearly 20 year hiatus in sea-level rise along the west coast…




9414290 San Francisco, California
1.89 +/- 0.19 mm/yr
SAN FRANCISCO 7.4"/100 yrs
15 cm/6 in
Linear Mean Sea Level Trend
Upper 95% Confidence Interval
Lower 95% Confidence Interval
Monthly mean sea level with the average seasonal cycle removed
Meters
Apparent Datum Shift


9410230 La Jolla, California
2.11 +/- 0.26 mm/yr
LA JOLLA 8.3"/100 yrs
Linear Mean Sea Level Trend
Upper 95% Confidence Interval
Lower 95% Confidence Interval
Monthly mean sea level with the average seasonal cycle removed
Meters

ENCROAC

FIGURE 7. Tidal Flooding Today, in 2030, and in 2045

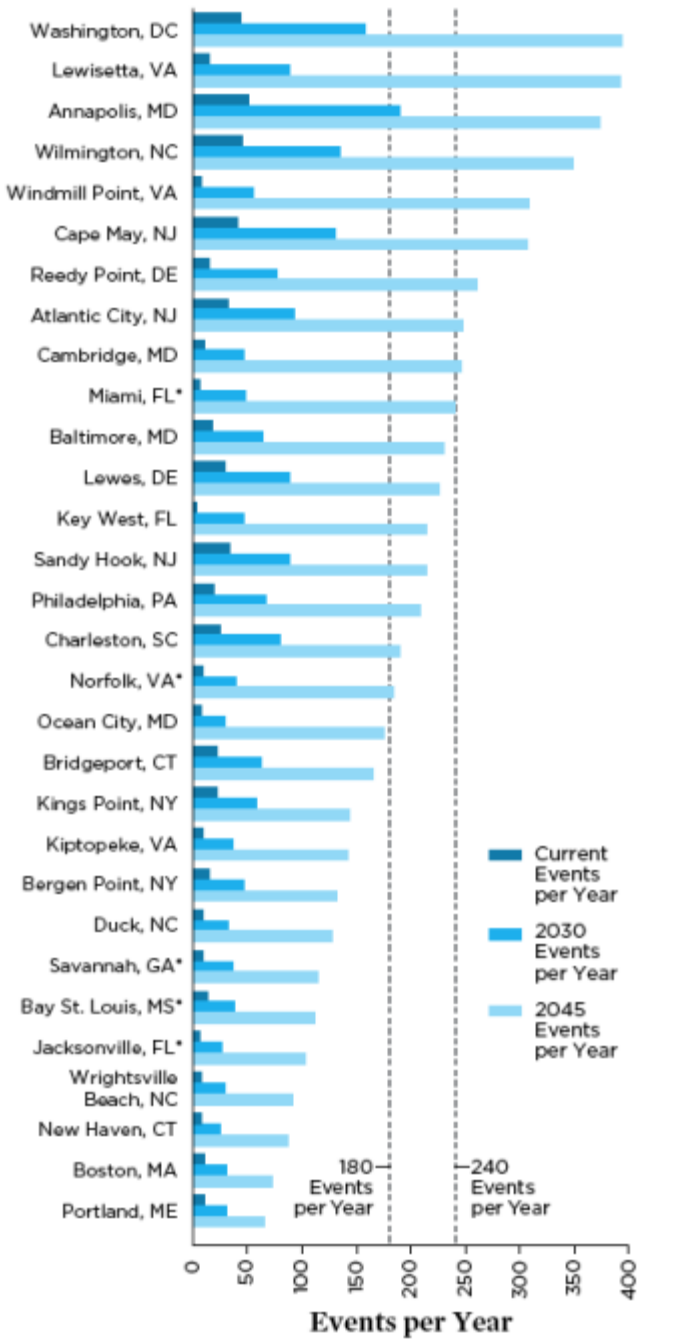
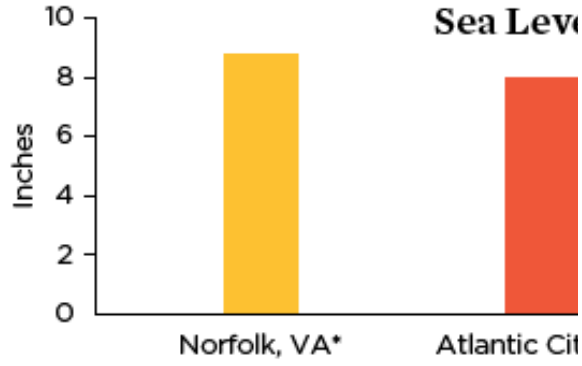
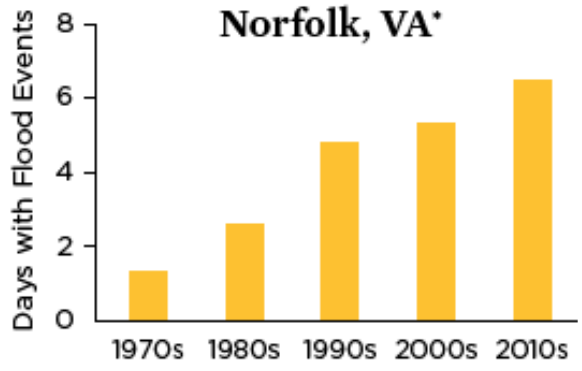
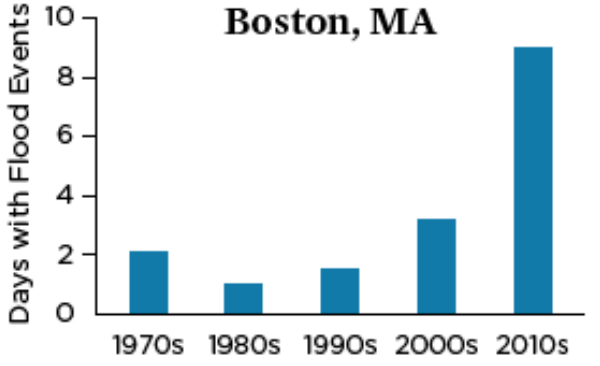
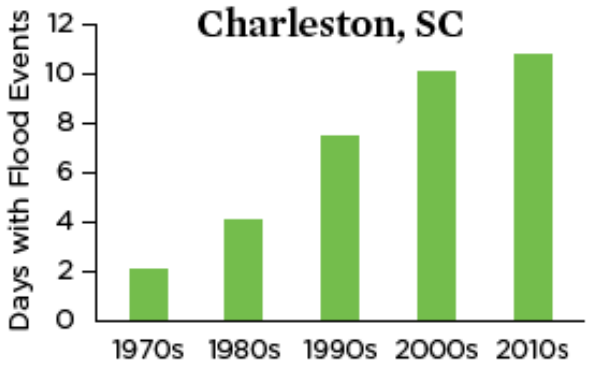


FIGURE 4. Local Sea Level Rise and









[Union of Concerned

napolis, Maryland

Nuisance Flooding at High Tide

Huntington Beach

SEA-LEVEL RISE VULNERABILITY ASSESSMENT FOR CITY OF SANTA BARBARA

PRESENT HIGH WATER

HIGH WATER + 24" SLR (2050) + 100 YEAR FLOOD

HIGH WATER + 66" SLR (2100) + 100 YEAR FLOOD

We need to inventory those coastal areas that are subject to short and long-term sea-level rise, assess vulnerabilities and risks, and develop responses.