

Rising Oceans

Why Californians should care
about Antarctica and Greenland

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(presented by Dan Cayan—thanks, Dan!)

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It's Getting Hot Out There

The average global temperature in 2010 equaled the high set in 2005.

58.0 degrees Fahrenheit

57.5

Annual global temperature

AVERAGE FOR THE
20TH CENTURY: 57.0

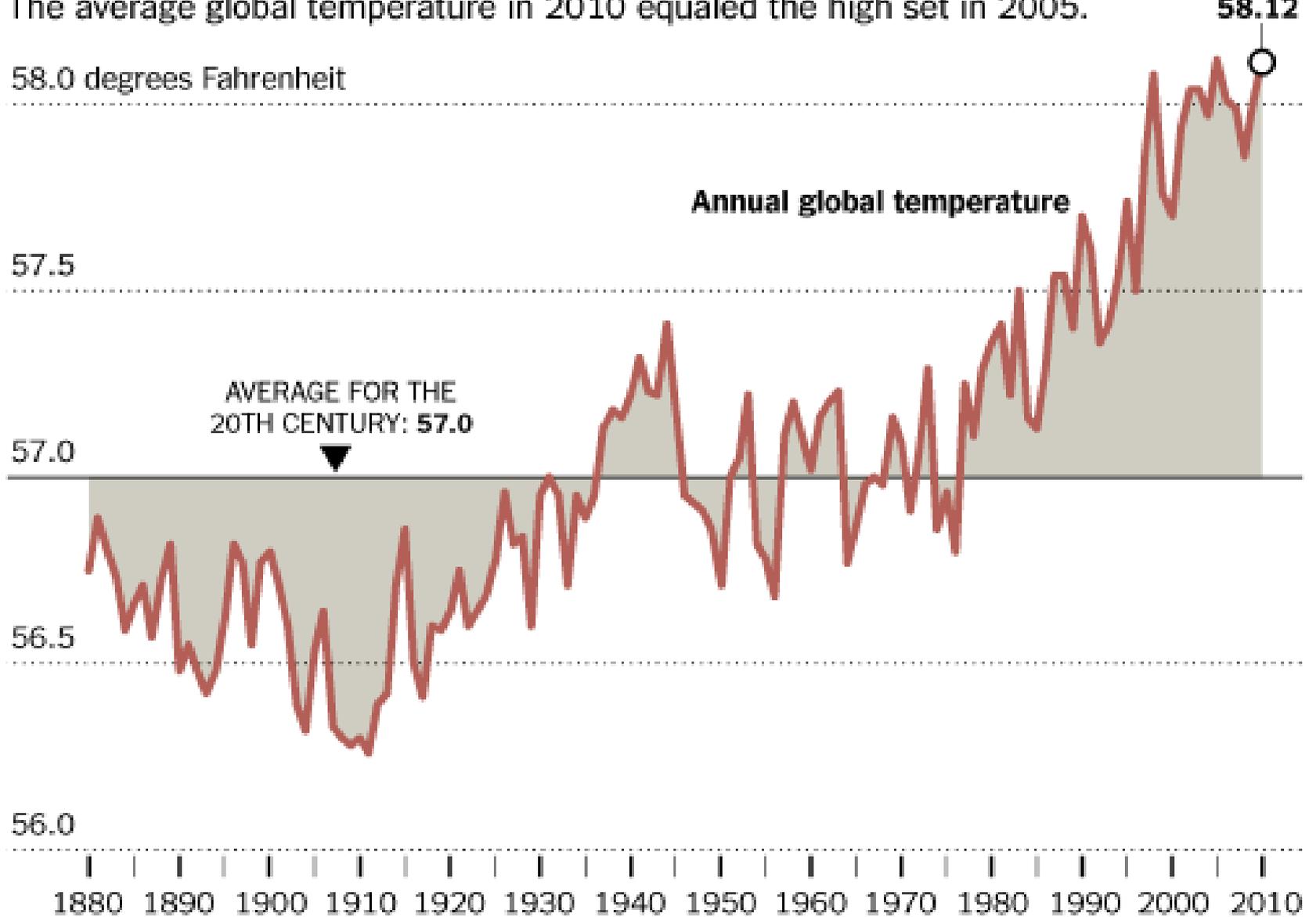
57.0

56.5

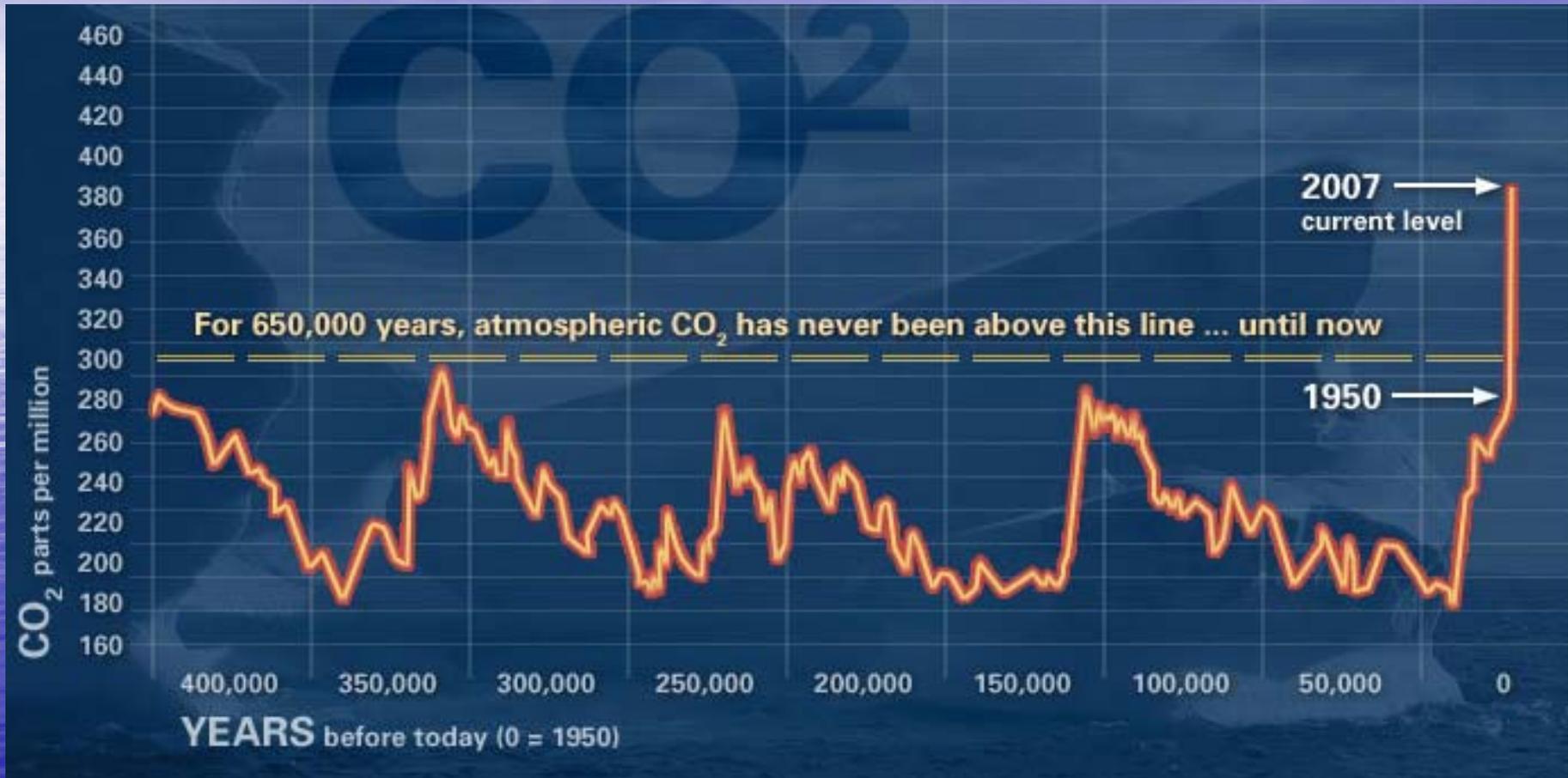
56.0

58.12

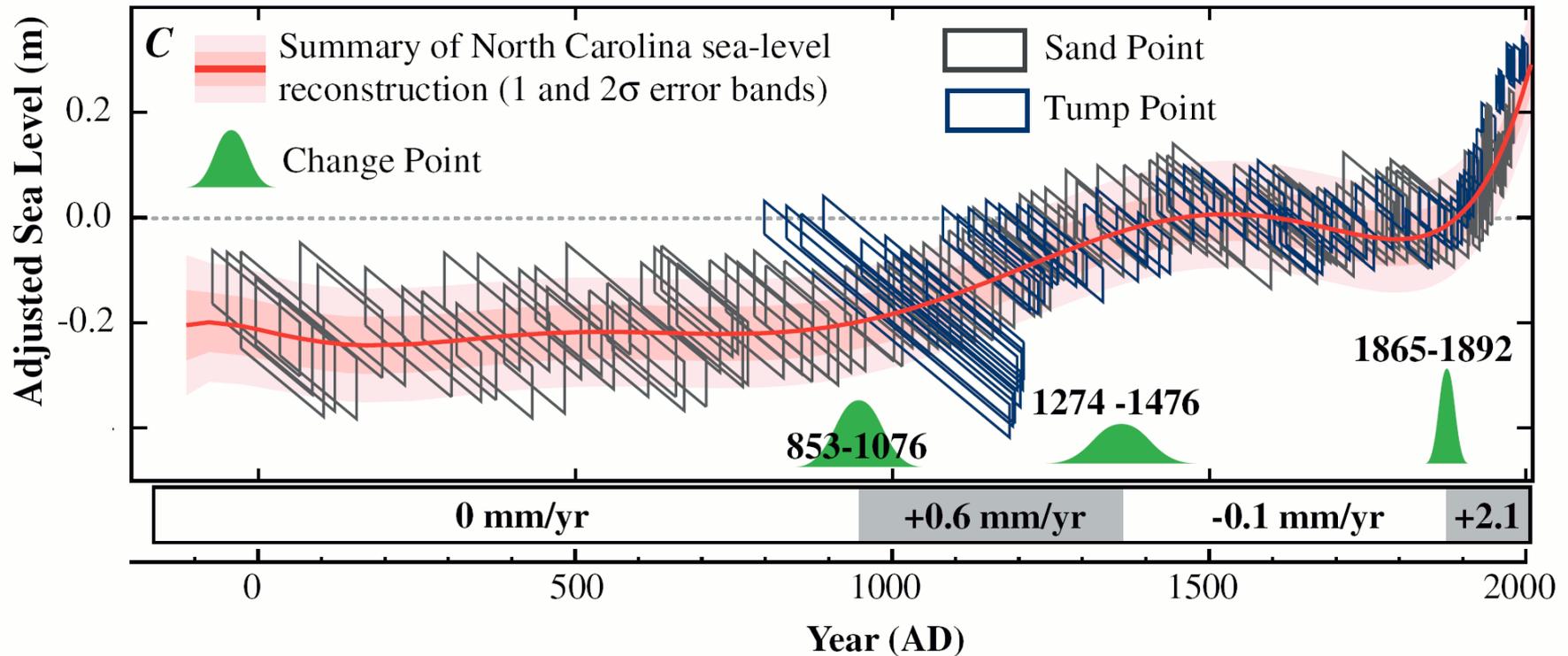
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010



What *really* causes global warming?

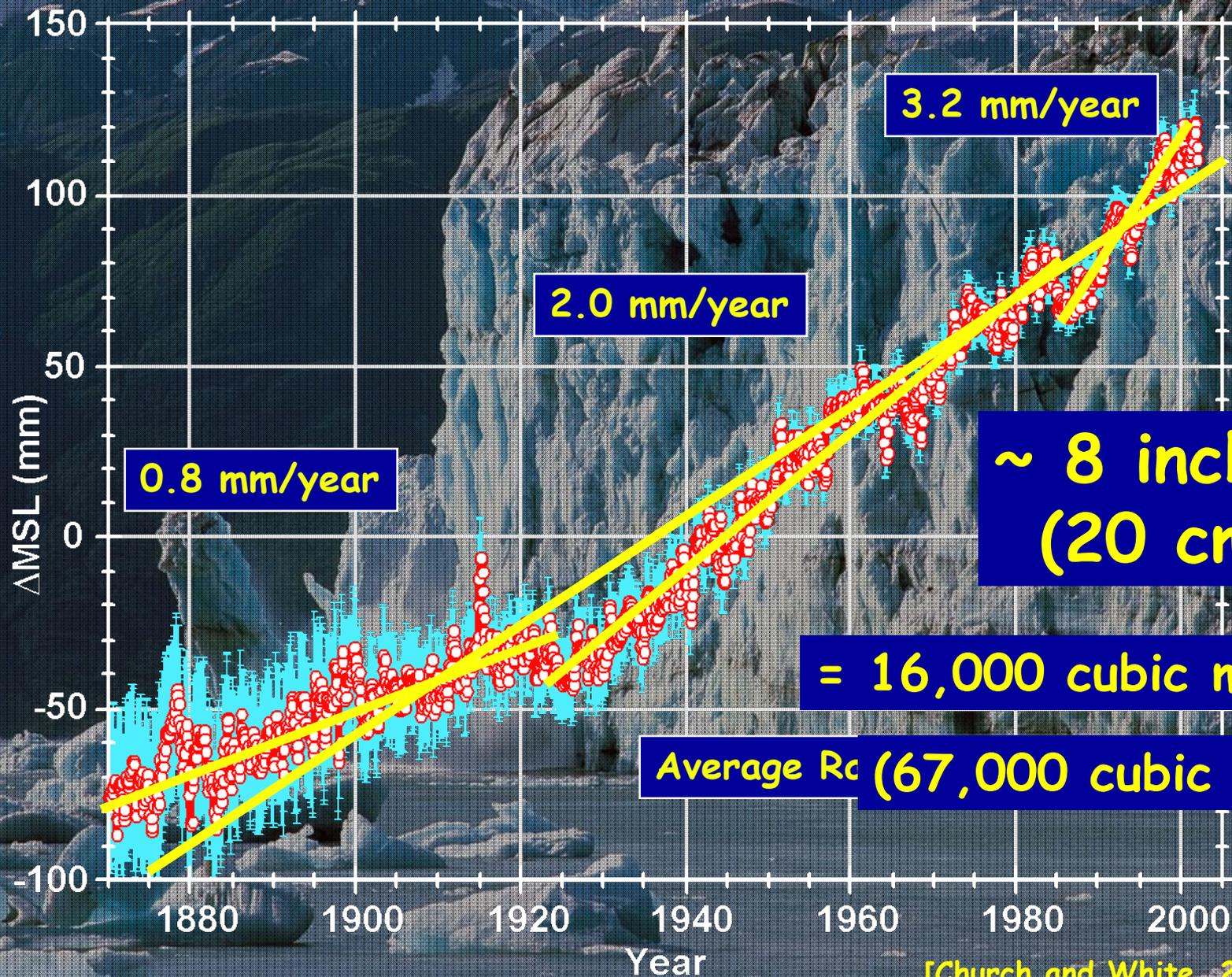


2000 Years of Sea Level



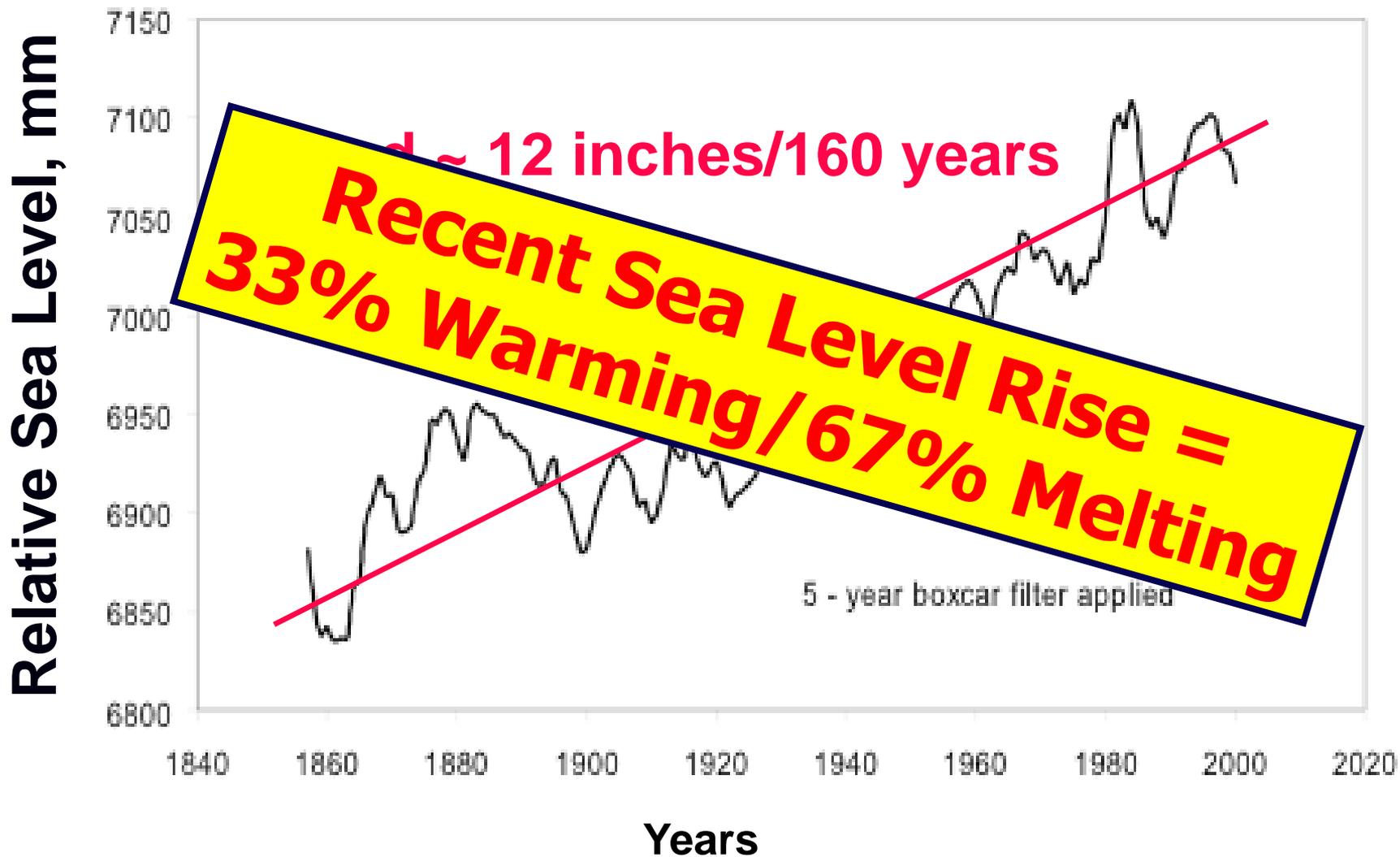
Sea Level Change in North Carolina

Tide Gauge Observations

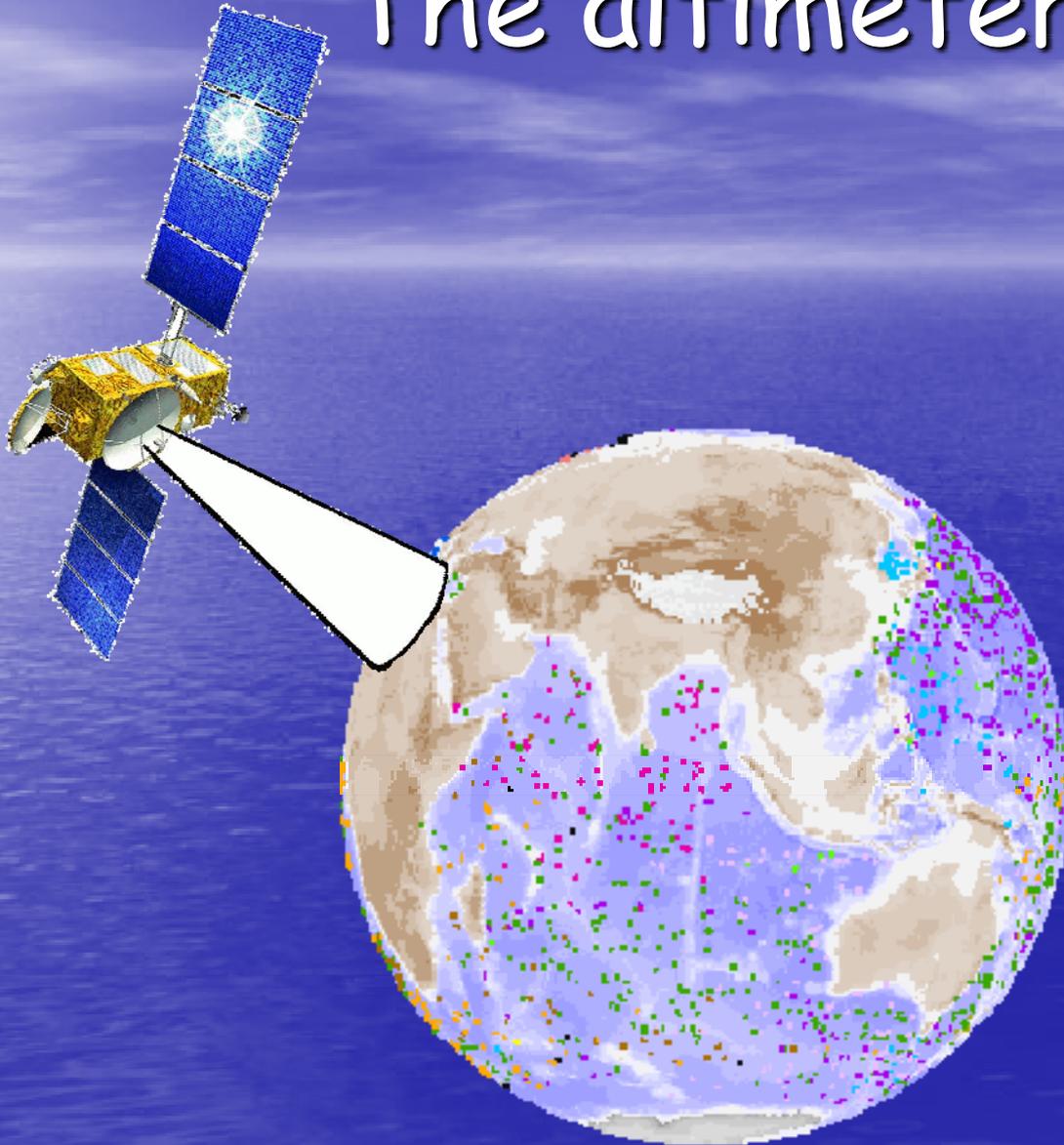


[Church and White, 2006]

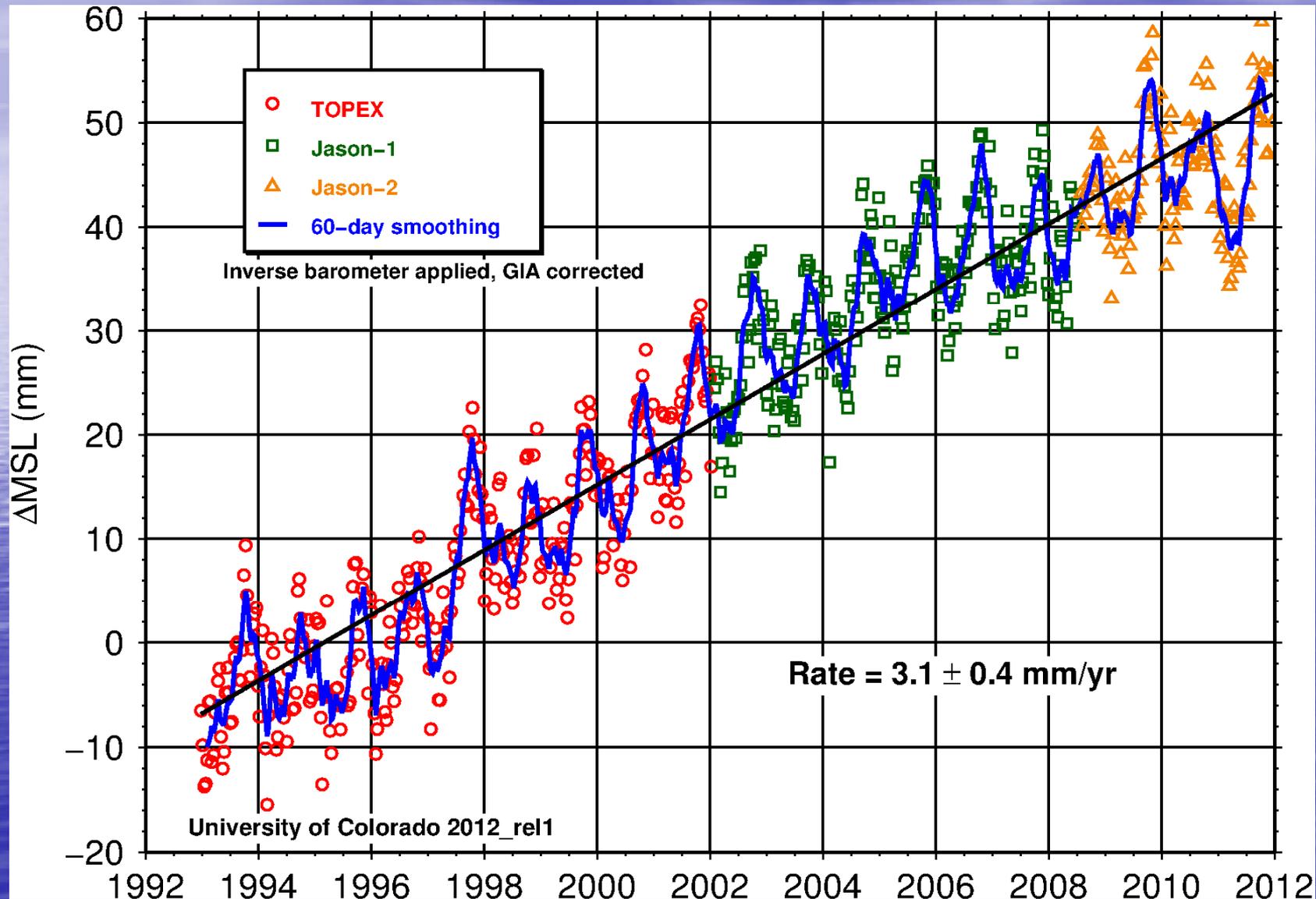
Sea Level at San Francisco, CA



The altimeter record

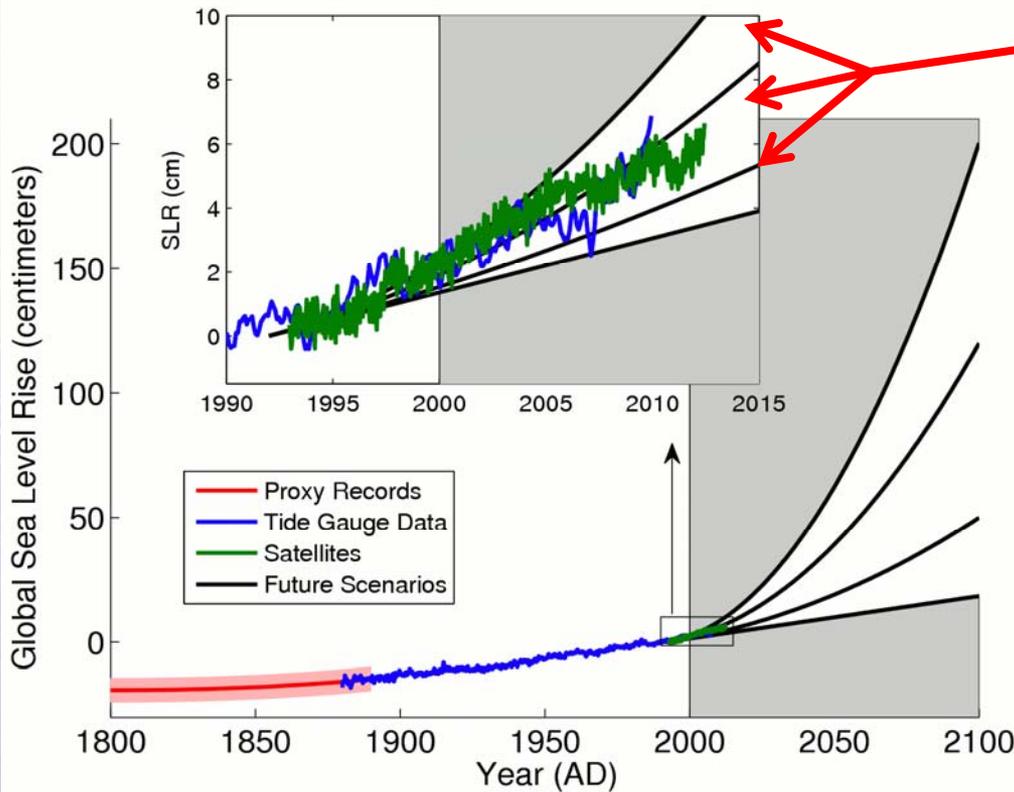


Sea Level Rise from Satellites



Jason-3 & Continuity

Projections of Future Rise



Which path
are we on?

Why so much
uncertainty?

How much/how fast?

Greenland and
Antarctic melting

Surfers Point, Ventura, CA



Projections of Dynamic Height (thermal expansion part of SLR)

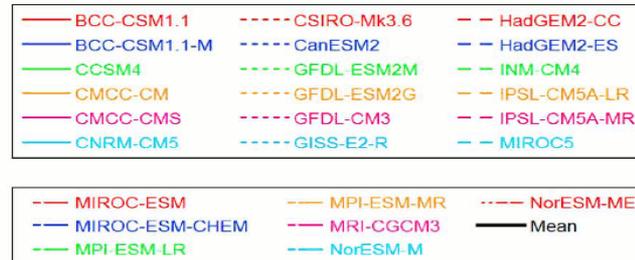
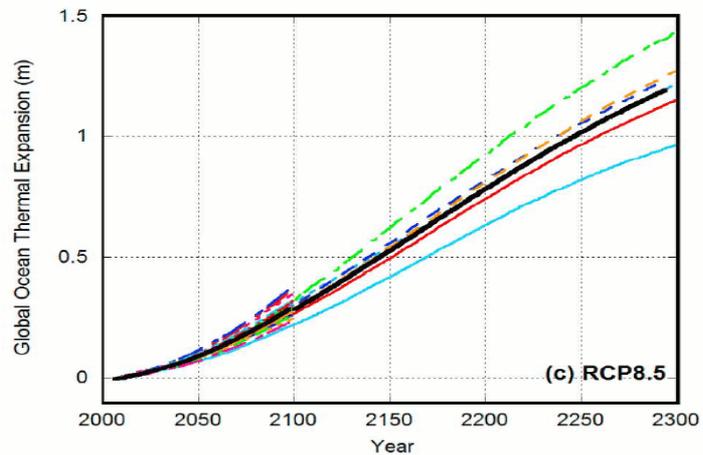
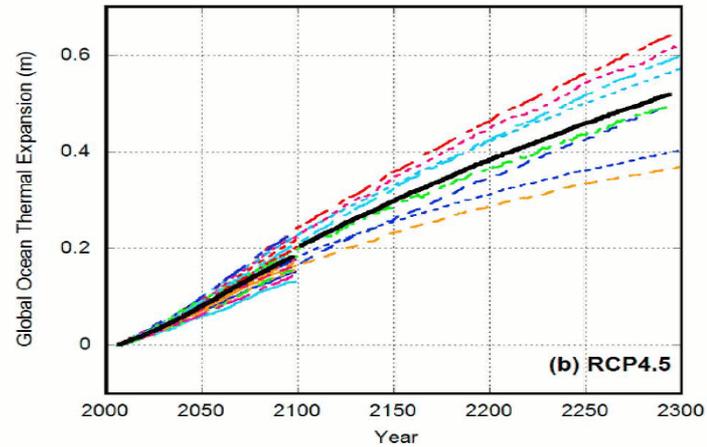
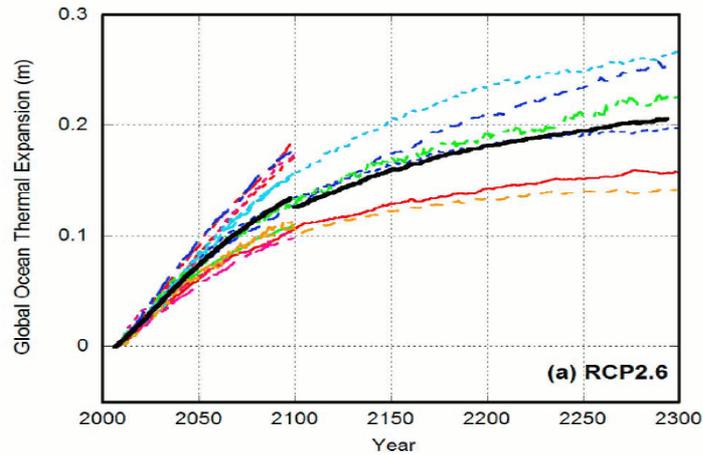


Figure 1. Individual and MEM projections of GTE (m) under (a) RCP2.6, (b) RCP4.5 and (c) RCP8.5. The curves show the GTE relative to 2006. Thick black lines indicate the MEM. The discontinuity at 2100 is due to the change of ensemble size.

California's Vulnerability to Sea Level Rise

during high sea levels, the sea is often *not* quiescent



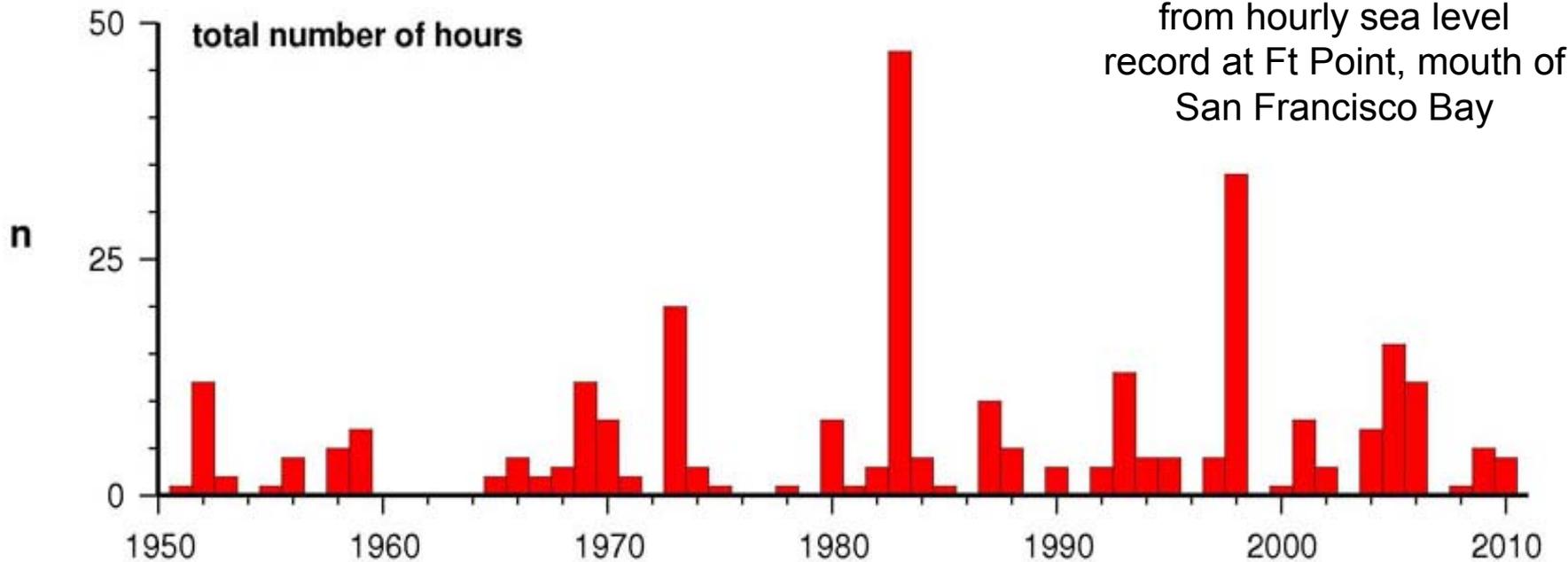
January 1983 - Monterey Bay, California

extreme sea level occurrences San Francisco

observed at or above 99.99% historical hourly threshold
1.41m above mean

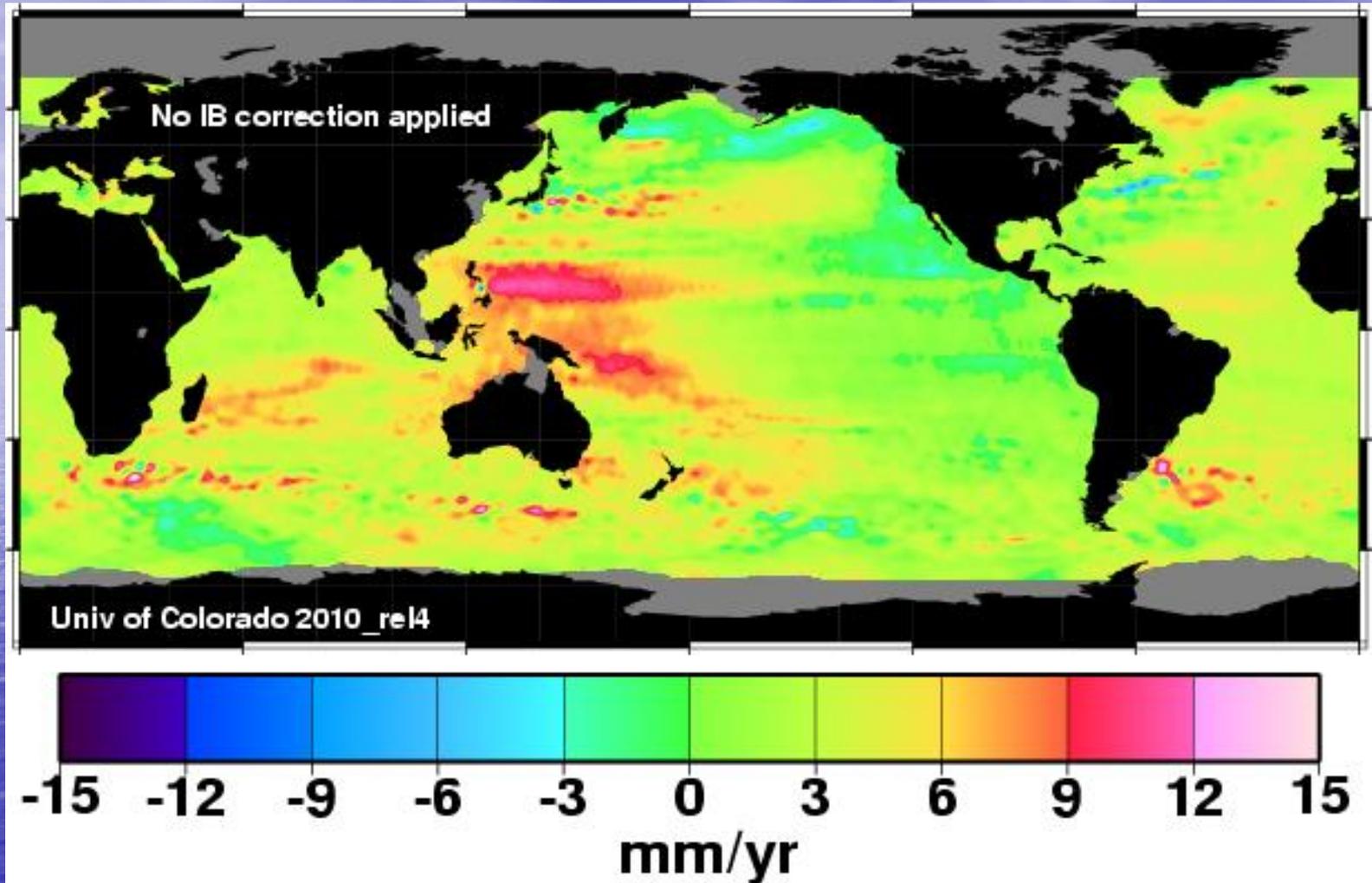
1983

highest California sea levels have mainly occurred in just a few years, esp large El Ninos (1983 and 1998)



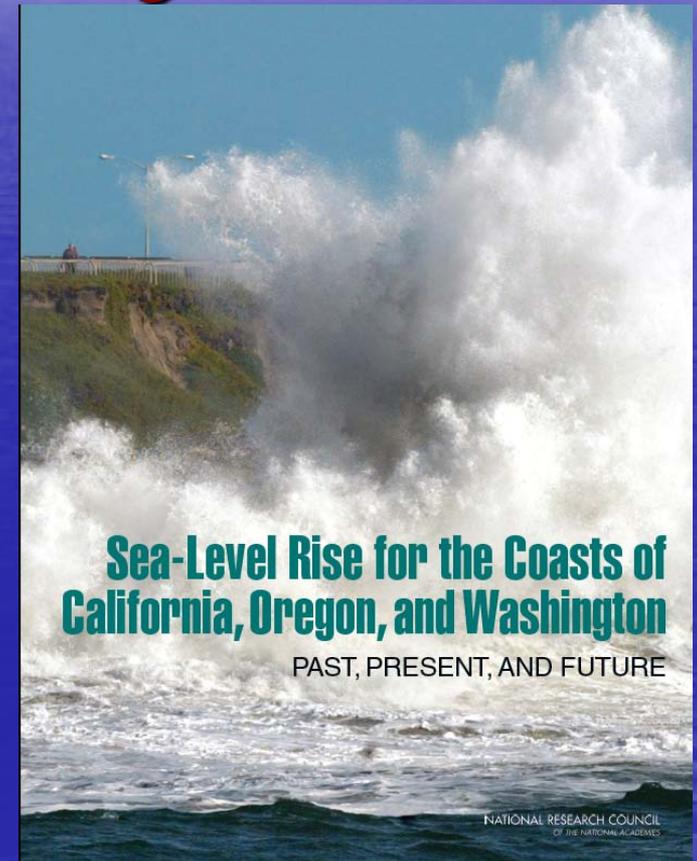
Sea Level Trends 1992-2010

How much/how fast will be future sea level rise along the California Coast?



Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future—NRC Committee findings

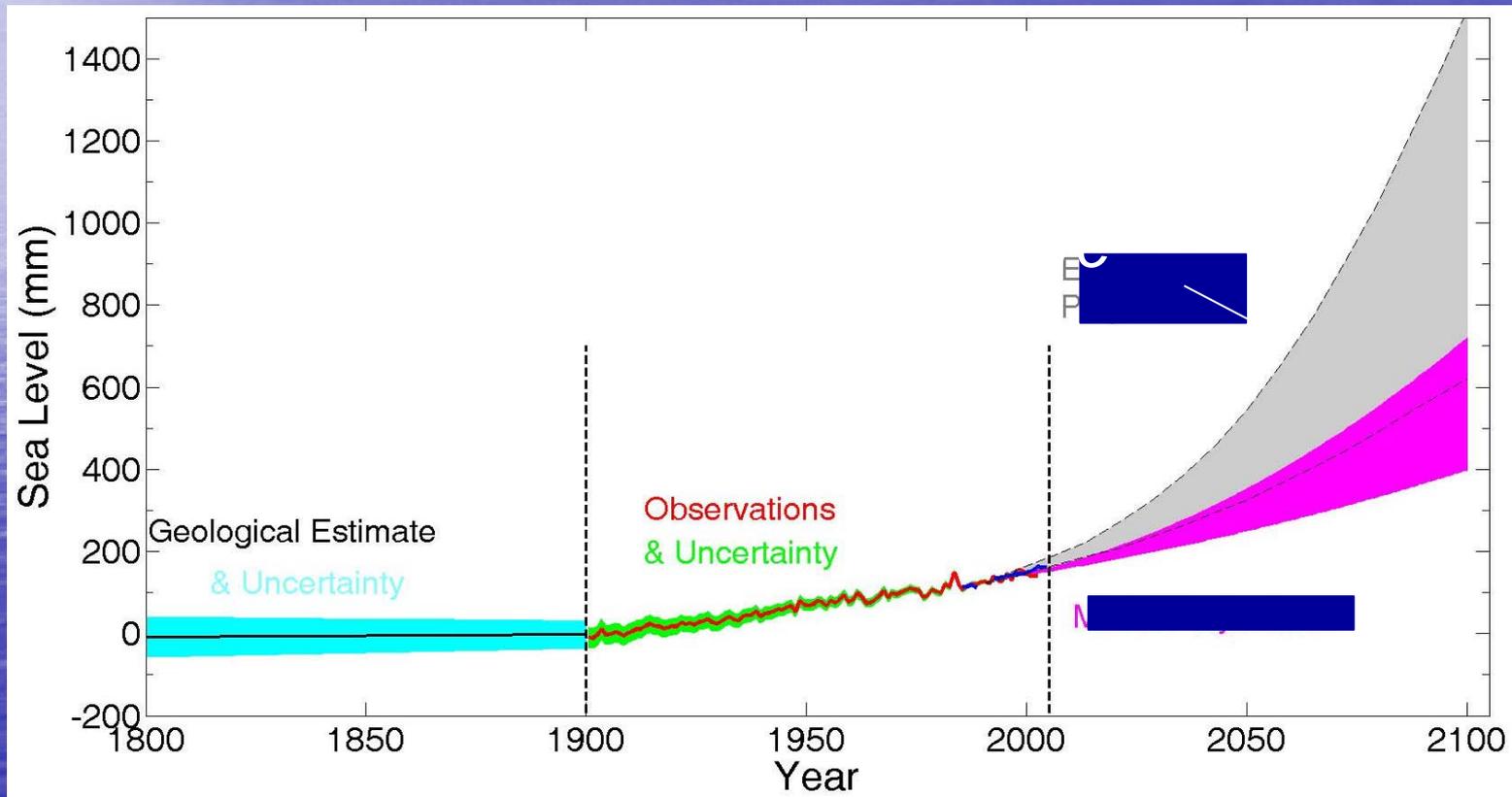
from a presentation by
Dr. Robert A. Dalrymple,
Chair, NRC West Coast SLR Committee
Johns Hopkins University



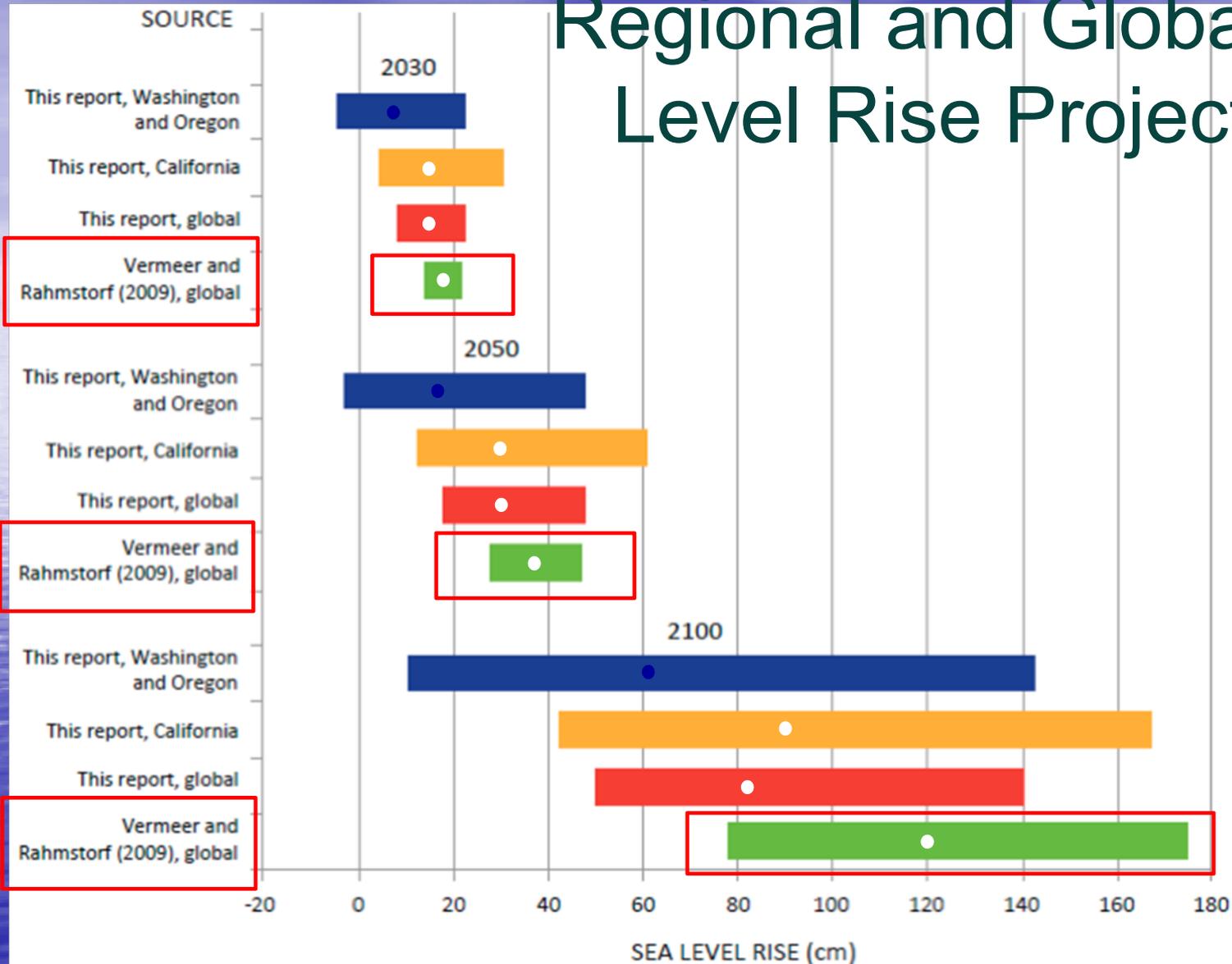
Global sea-level is rising primarily because land ice is melting and ocean water expands as it warms.

1.7 mm per year over 20th century (from tide gages)

3.1 mm per year since 1993 (from satellites & tide gages)



Regional and Global Sea-Level Rise Projections



Being used by California for interim planning



Rising seas increase coastal erosion, shoreline retreat, and wetland loss; increases the risk of coastal flooding, and increases coastal damage from storms.

The *pace* of climate change is projected to be rapid

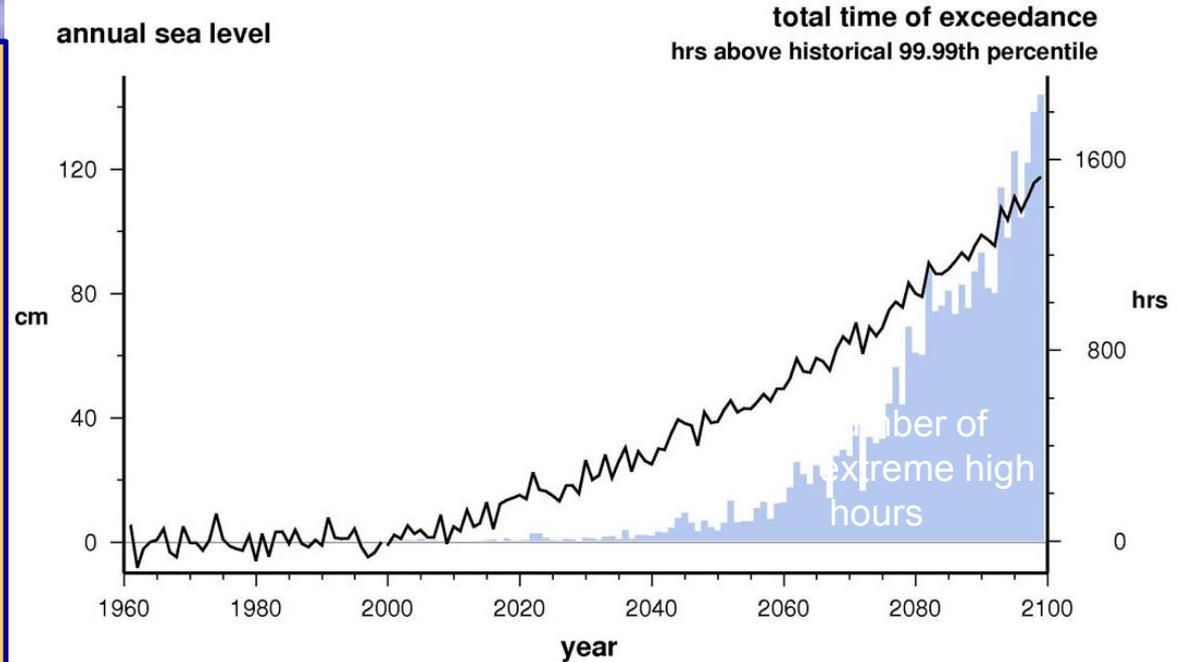
INCREASING SEA LEVEL EXTREMES

As mean sea level rises the frequency and magnitude of extremes would increase markedly. Under plausible rates of sea level rise, an event which in present day occurs less than once per year occurs scores of times per year by mid 21st Century and becomes commonplace by end of 21st Century.

Importantly the duration of extremes becomes longer, so exposure to waves is considerably greater.

San Francisco near Golden Gate

NOAA observations and
NCAR PCM1 SRES B1 using Vermeer and Rahmstorf global SLR scheme (2009)



historical 1970–2000 avg annual sea level (cm): -0.54
historical 1970–2000 avg hrs above 99.99th percentile: 0.71

historical 1961–1990 99.99th percentile: 1.394m
NCAR PCM1 1961–1990 99.99th percentile: 1.413m

Key Issues

Global Climate Projection Uncertainty

- GHG/Land Use Response over multi-decades

- Natural Variation, including multi-decadal and event scale processes

- Disposition of winter storms (track and intensity) is problematic

Downscaling

- Observational data to validate, train, monitor is crucial but sparse

- Projections in high gradient climate regions are very fuzzy.

- Dynamical downscaling methods are computationally expensive, still developing

Sea Level Rise

- Global sea level rise projections are greatly uncertain

- Pacific basin change has strong affect of natural interannual-interdecadal variation

- Regional influences also play a role

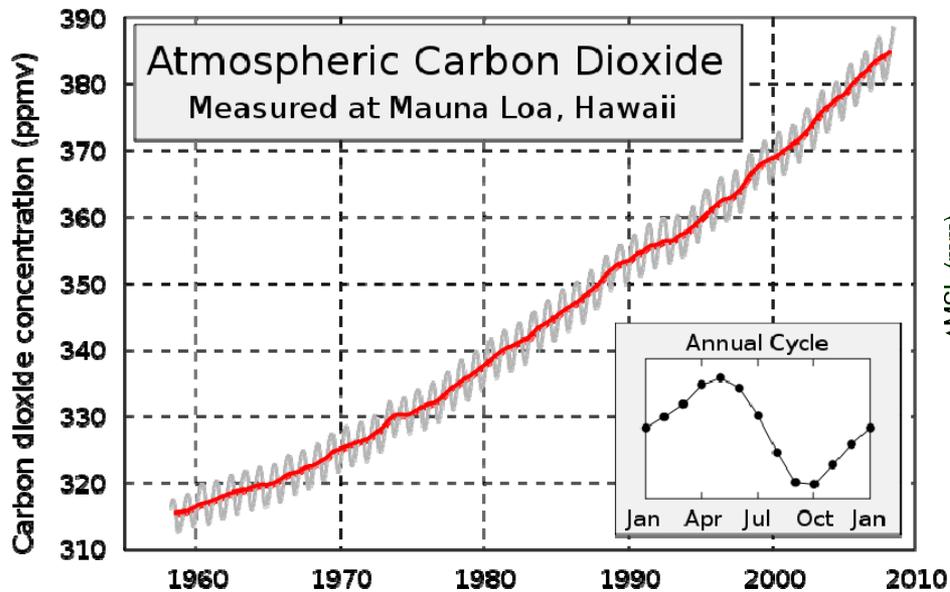
Extreme Events

- Prolonged drought not well represented in GCMs

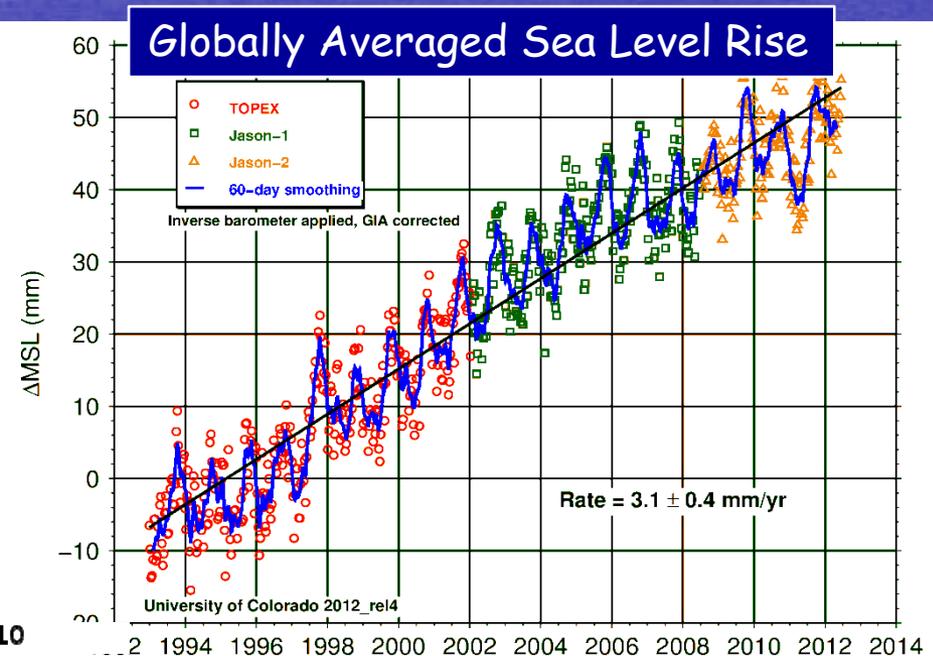
- Large floods only grossly replicated by GMCs and downscaling

Satellite Altimeters Measure Sea Level Rise

Cause

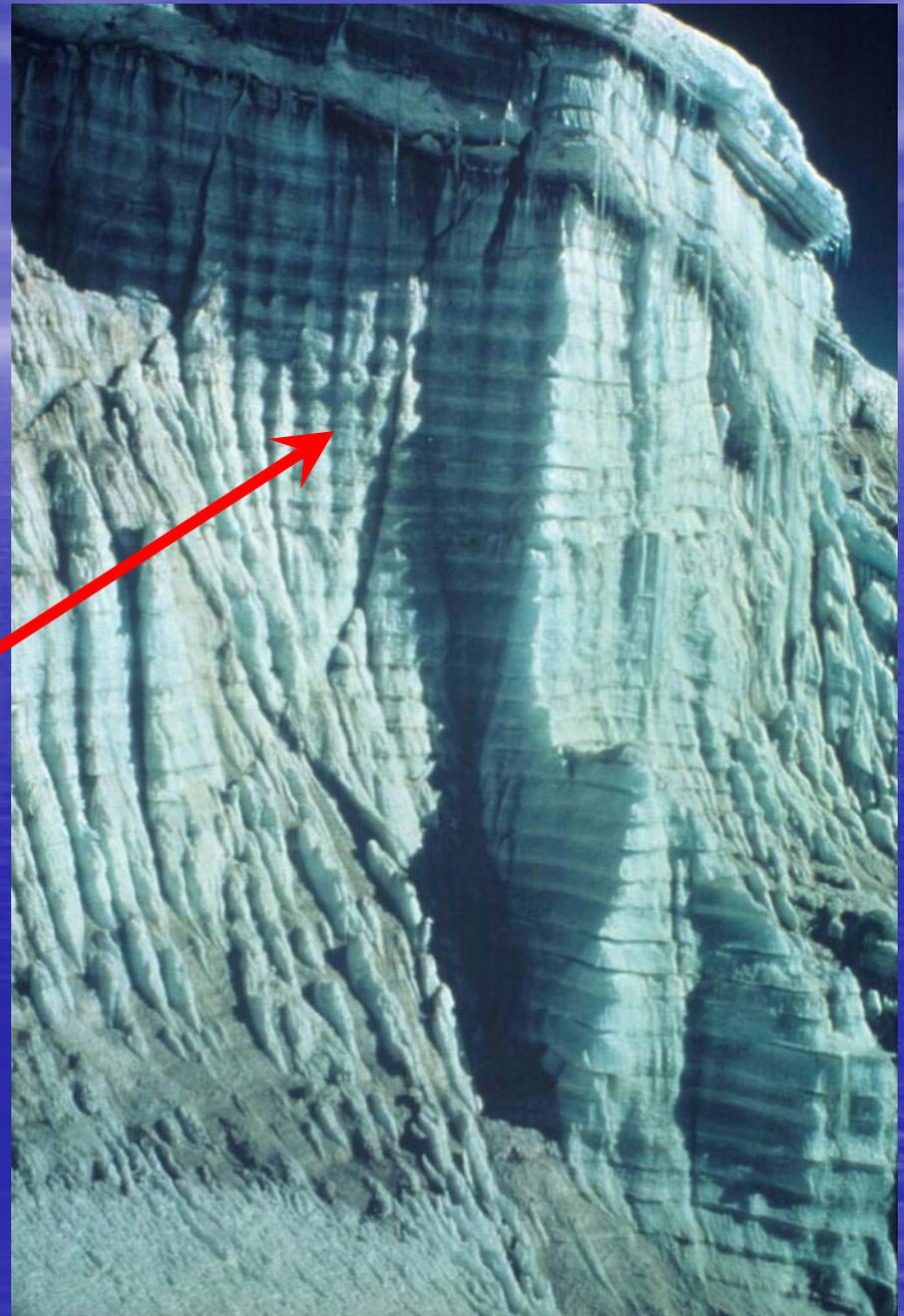


Effect



How do we know?

Annual layers



Side of Quelccaya
ice cap, Peru

Lonnie Thompson

Greatest problems: large storm + high tide

NOAA/NOS/CO-OPS
Verified Water Level vs. Predicted Plot
9414290 San Francisco, CA
from 1983/01/25 - 1983/01/31

