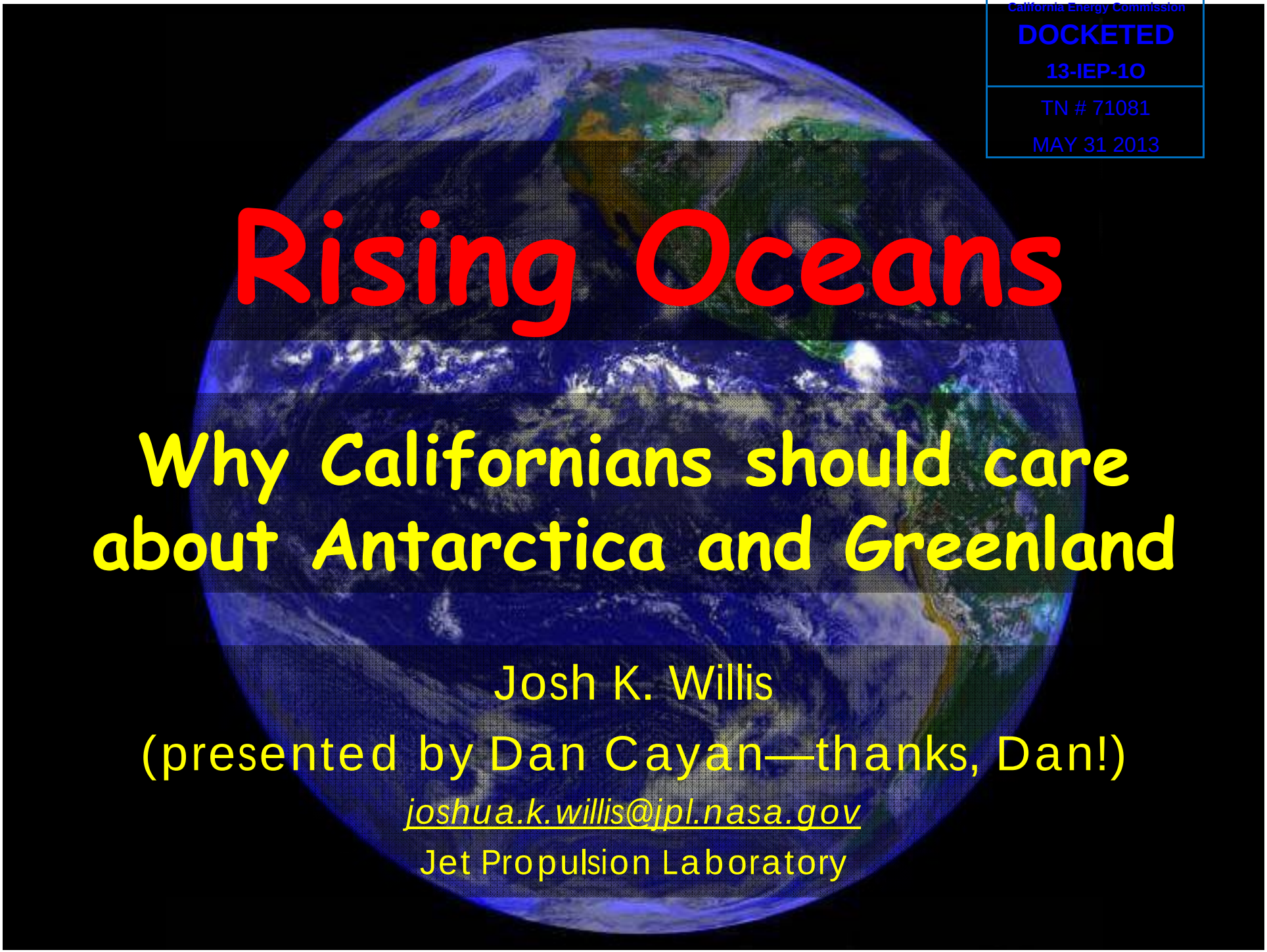


Rising Oceans

Why Californians should care about Antarctica and Greenland

Josh K. Willis

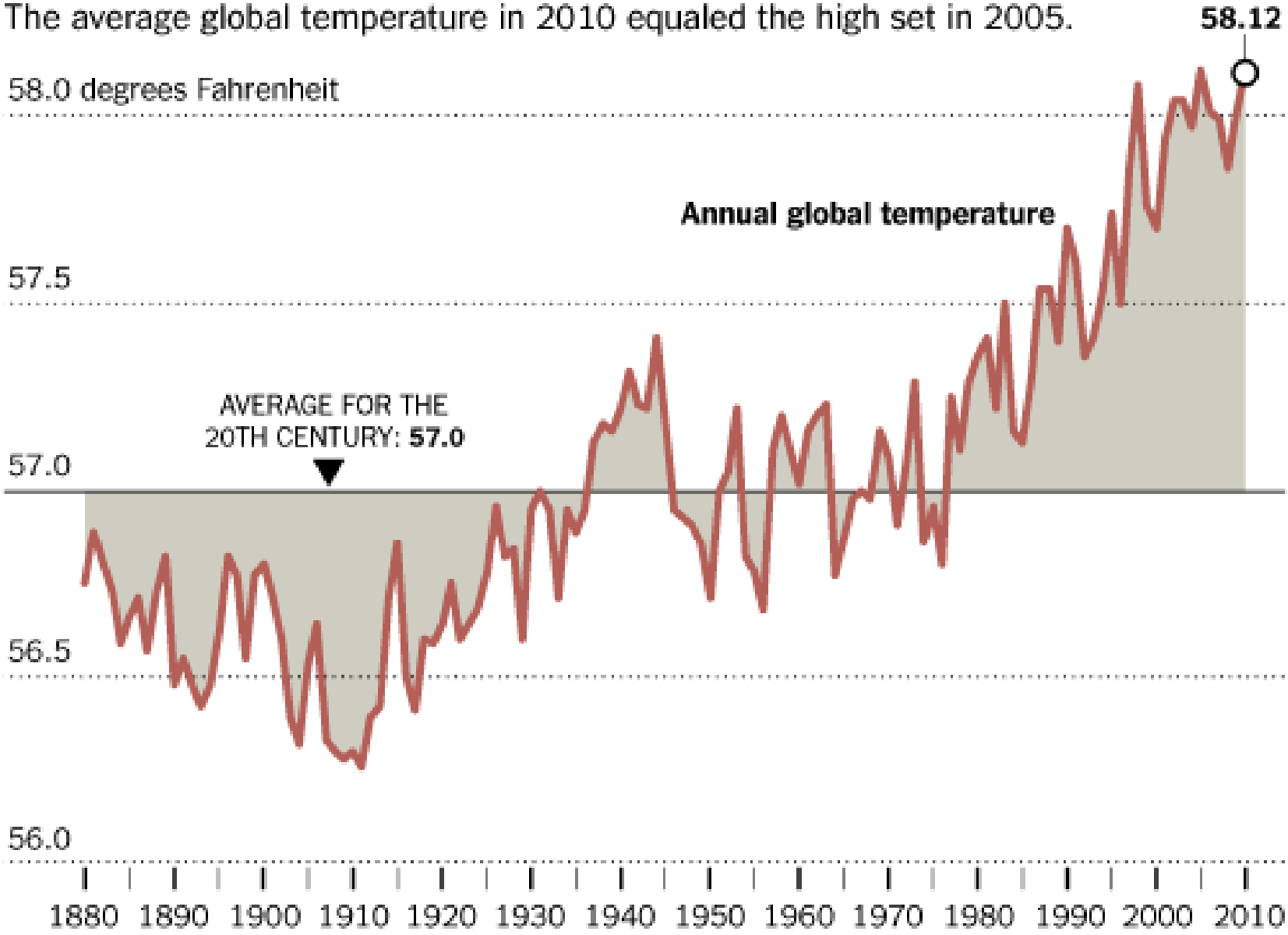
(presented by Dan Cayan—thanks, Dan!)

joshua.k.willis@jpl.nasa.gov

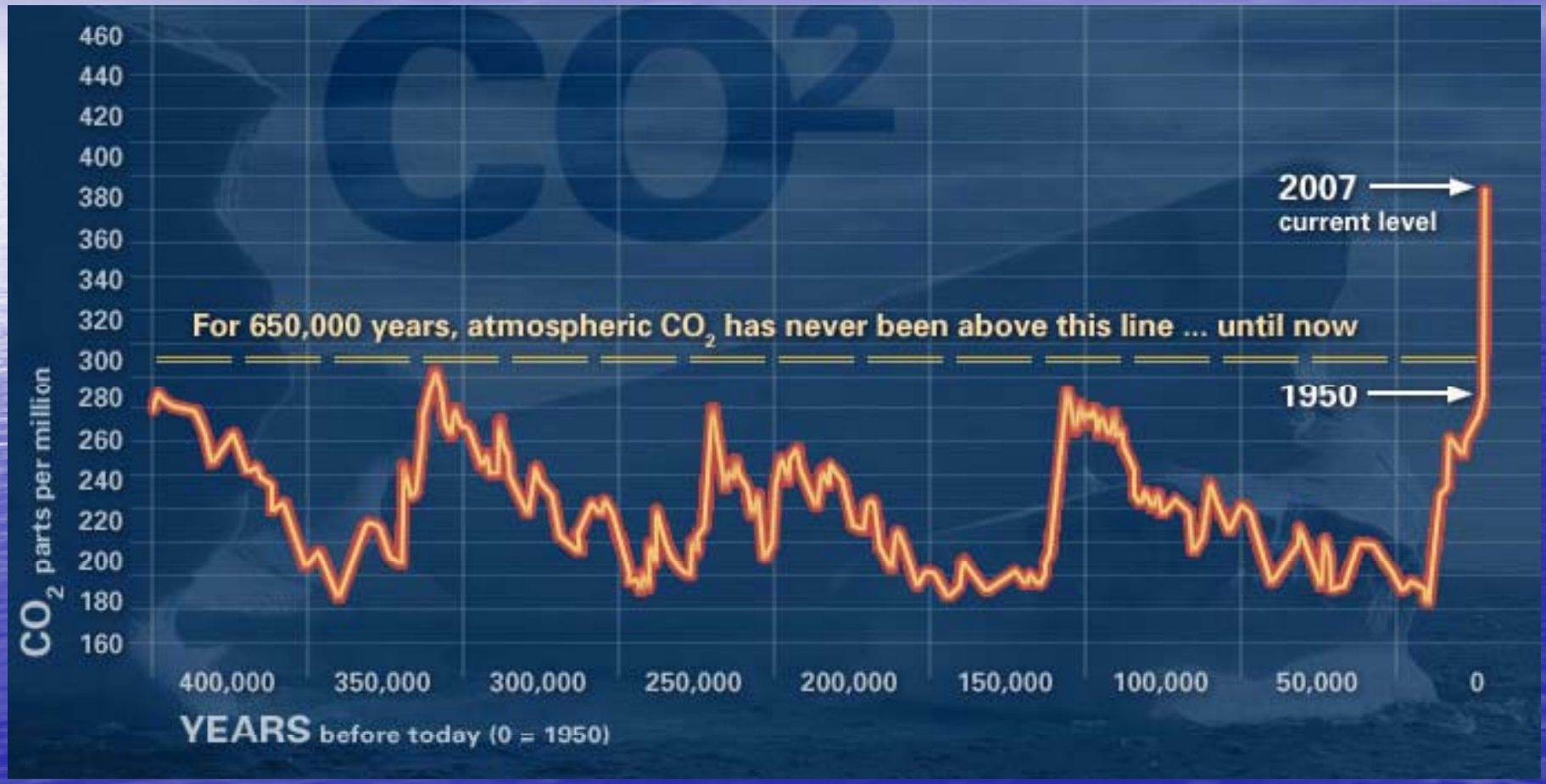
Jet Propulsion Laboratory

It's Getting Hot Out There

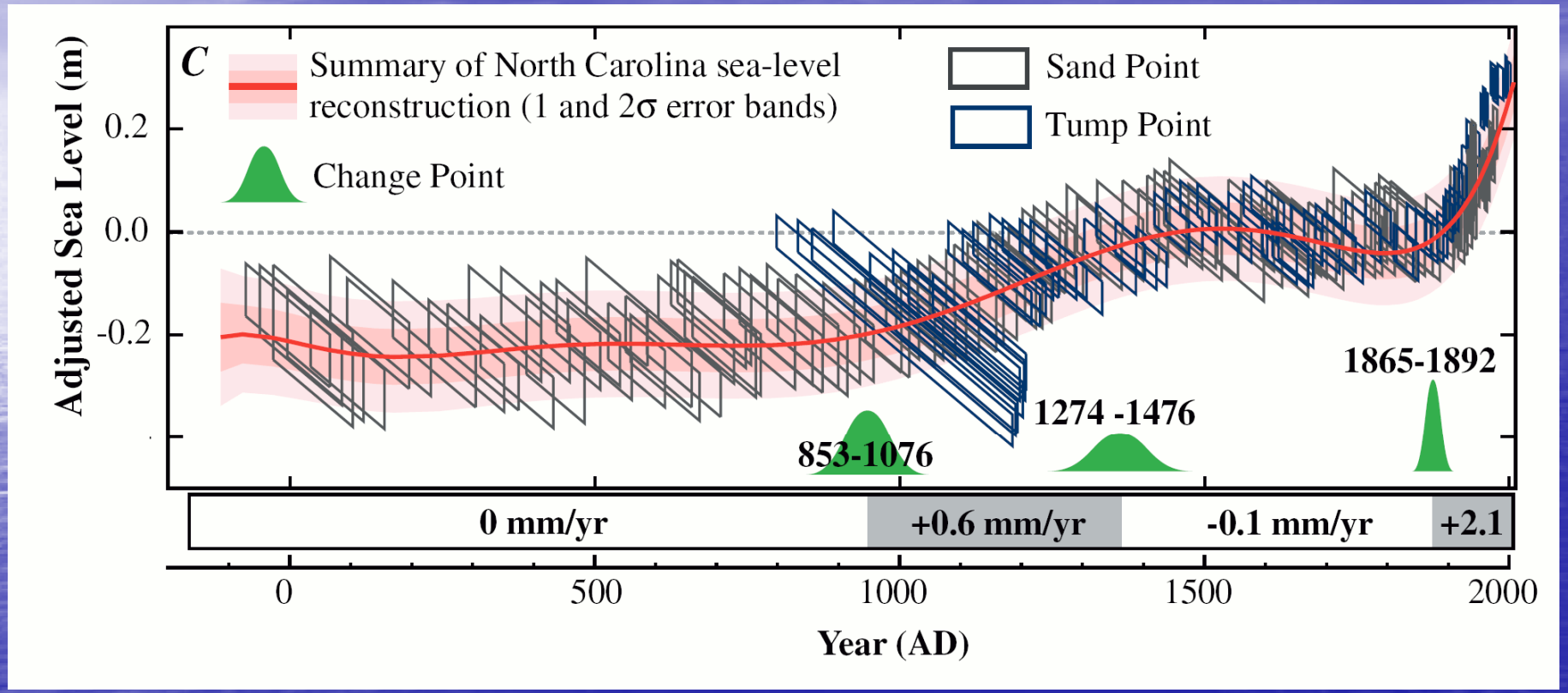
The average global temperature in 2010 equaled the high set in 2005.



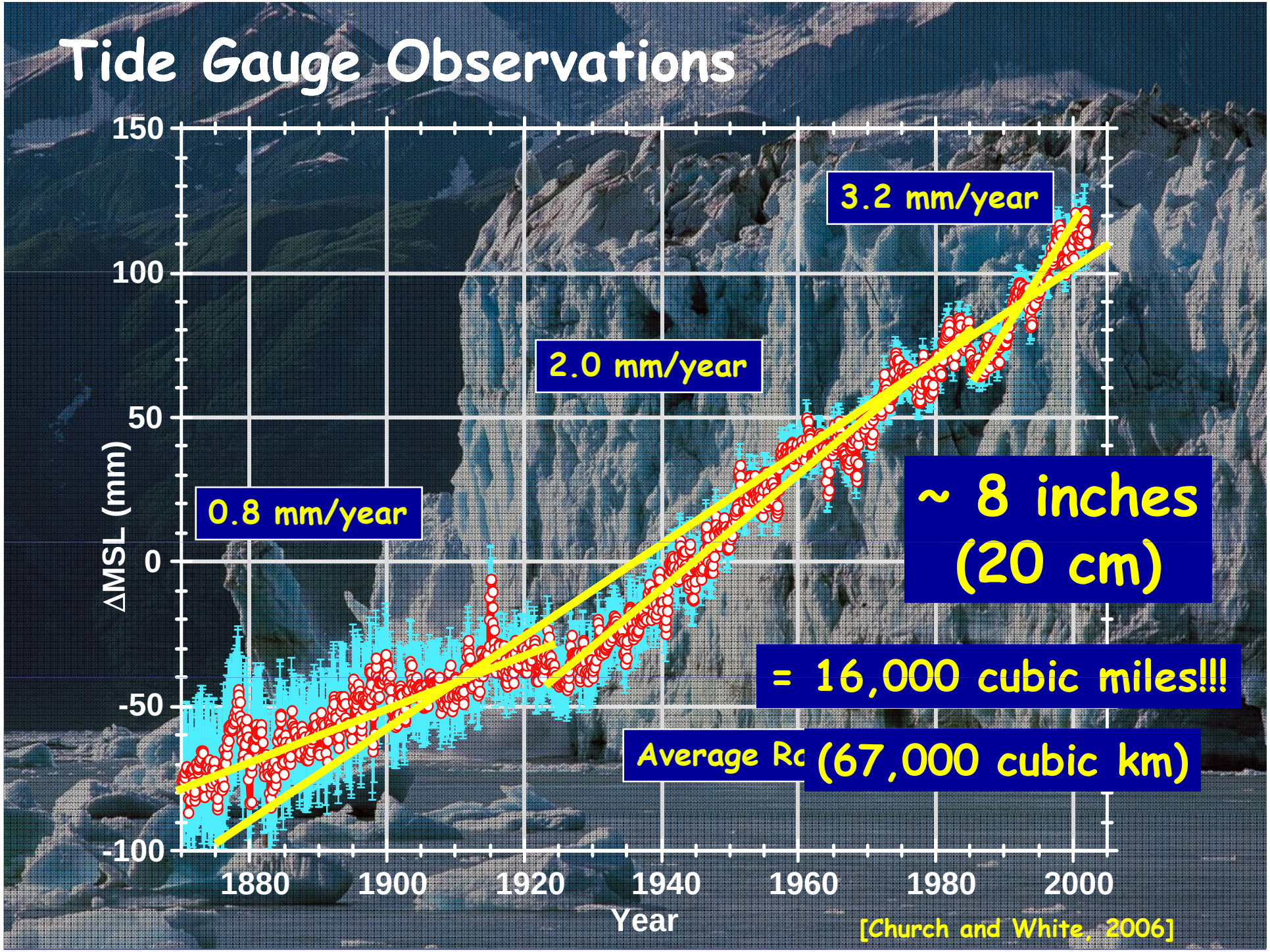
What *really* causes global warming?



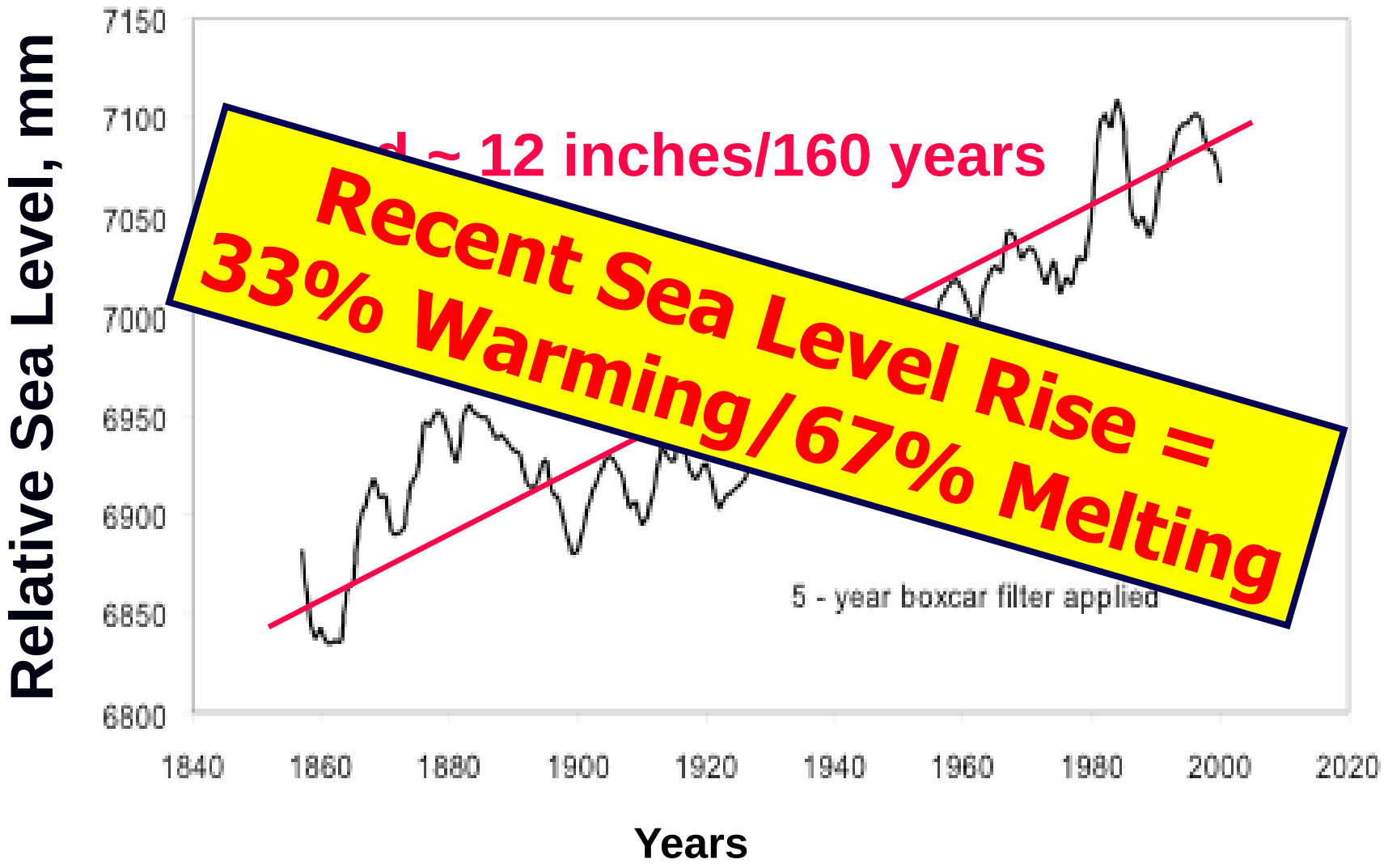
2000 Years of Sea Level



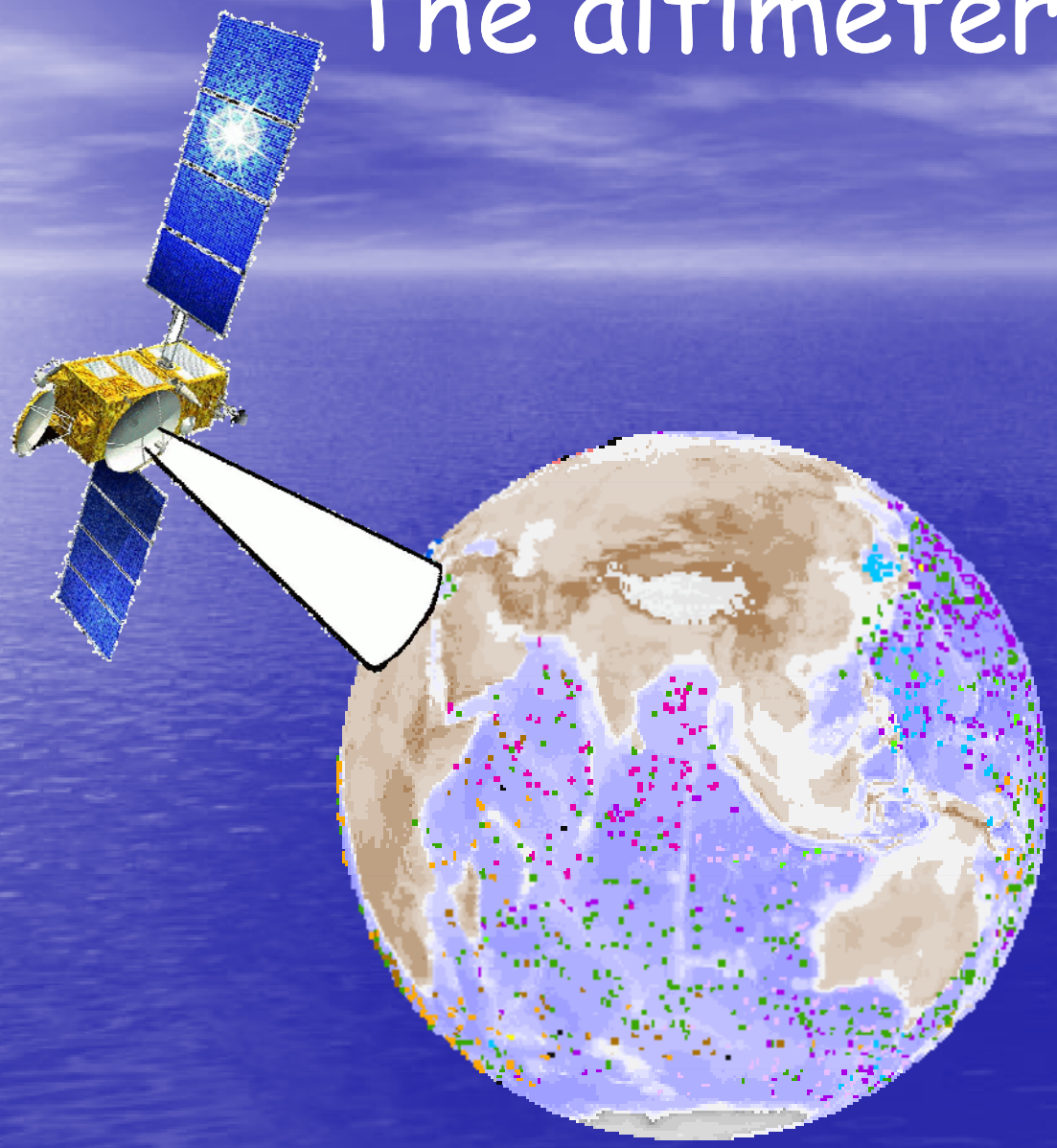
Sea Level Change in North Carolina


Tide Gauge Observations
150
100
50
0
-50
-100
ΔMSL (mm)
1880
1900
1920
1940
1960
1980
2000
Year
3.2 mm/year
2.0 mm/year
0.8 mm/year
~ 8 inches
(20 cm)
= 16,000 cubic miles!!!
Average Rc
(67,000 cubic km)
[Church and White, 2006]

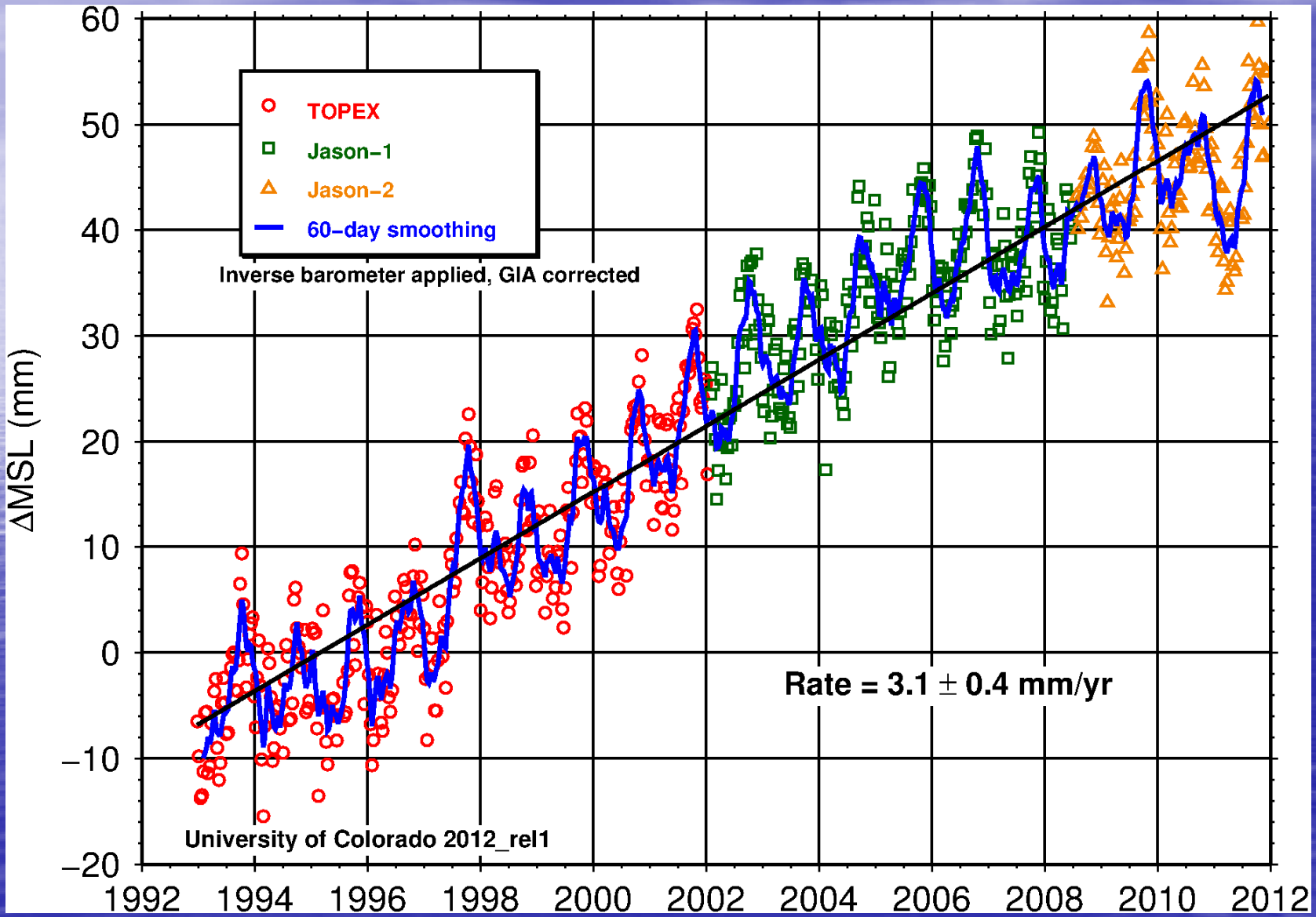
Sea Level at San Francisco, CA



The altimeter record

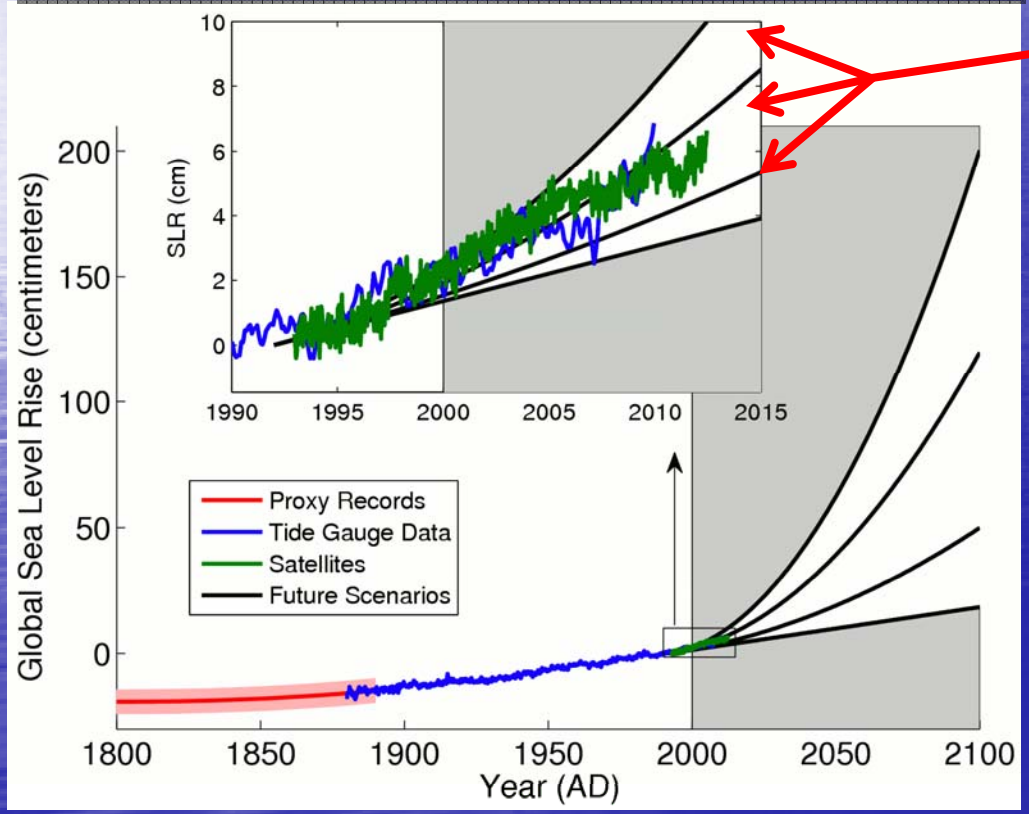


Sea Level Rise from Satellites



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)

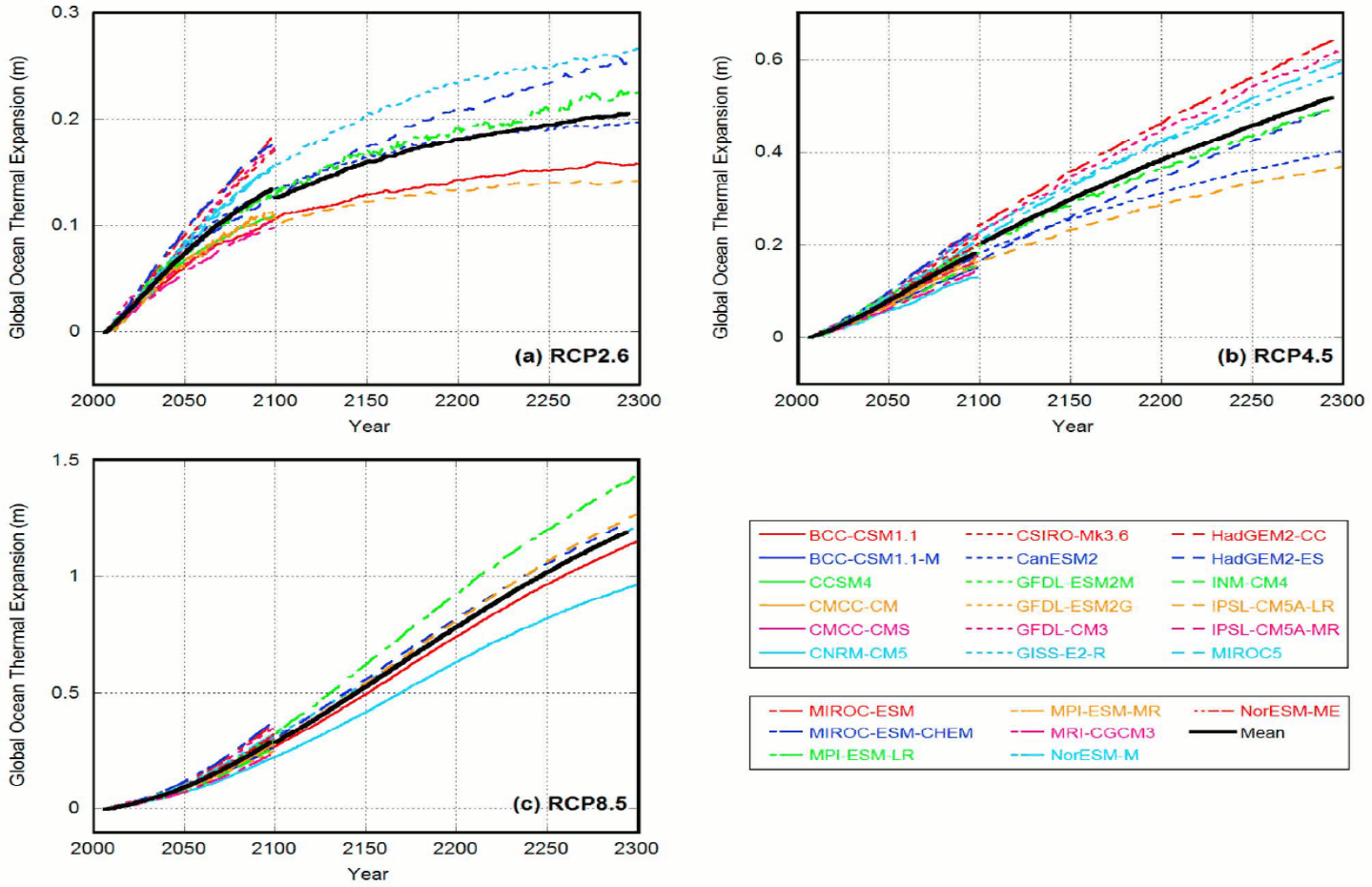


Figure 1. Individual and MEM projections of GTE (m) under (a) RCP2.6, (b) RCP4.5 and (c) RCP8.5. The curves show the GTE relative to 2006. Thick black lines indicate the MEM. The discontinuity at 2100 is due to the change of ensemble size.

Yin, GRL, 2012

California's Vulnerability to Sea Level Rise

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

January 1983 Monterey Bay, California

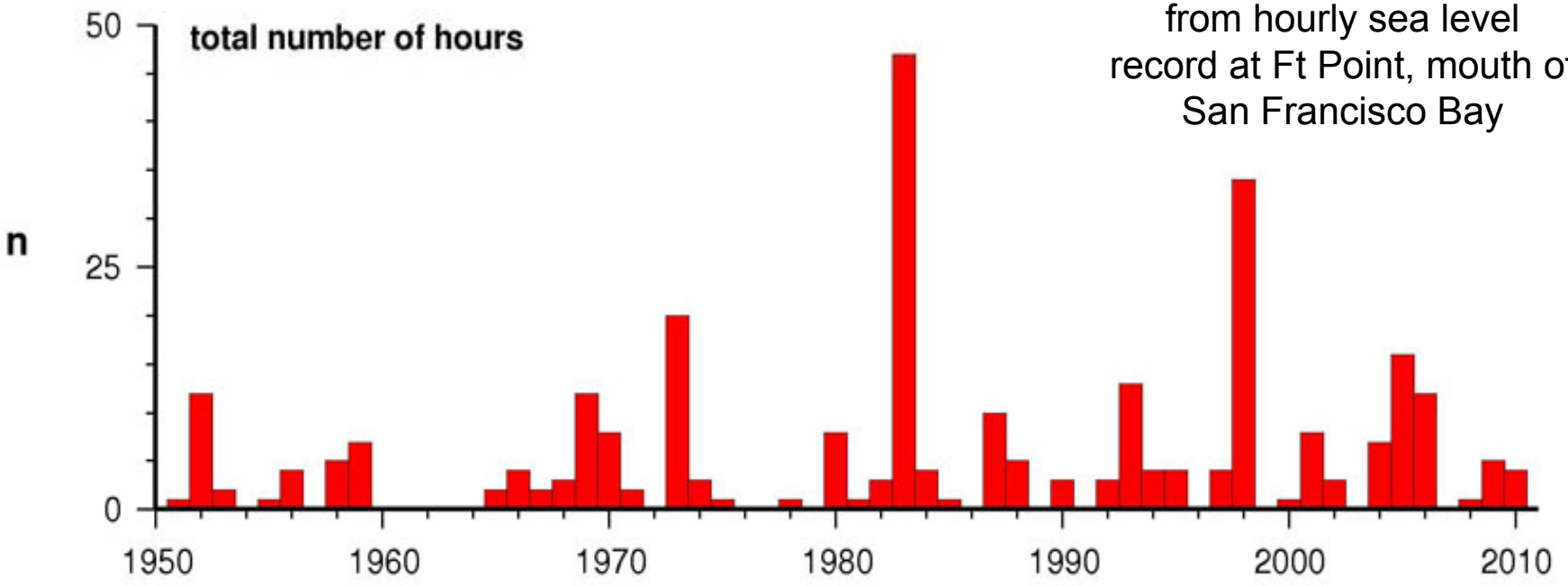
extreme sea level occurrences San Francisco

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

1983

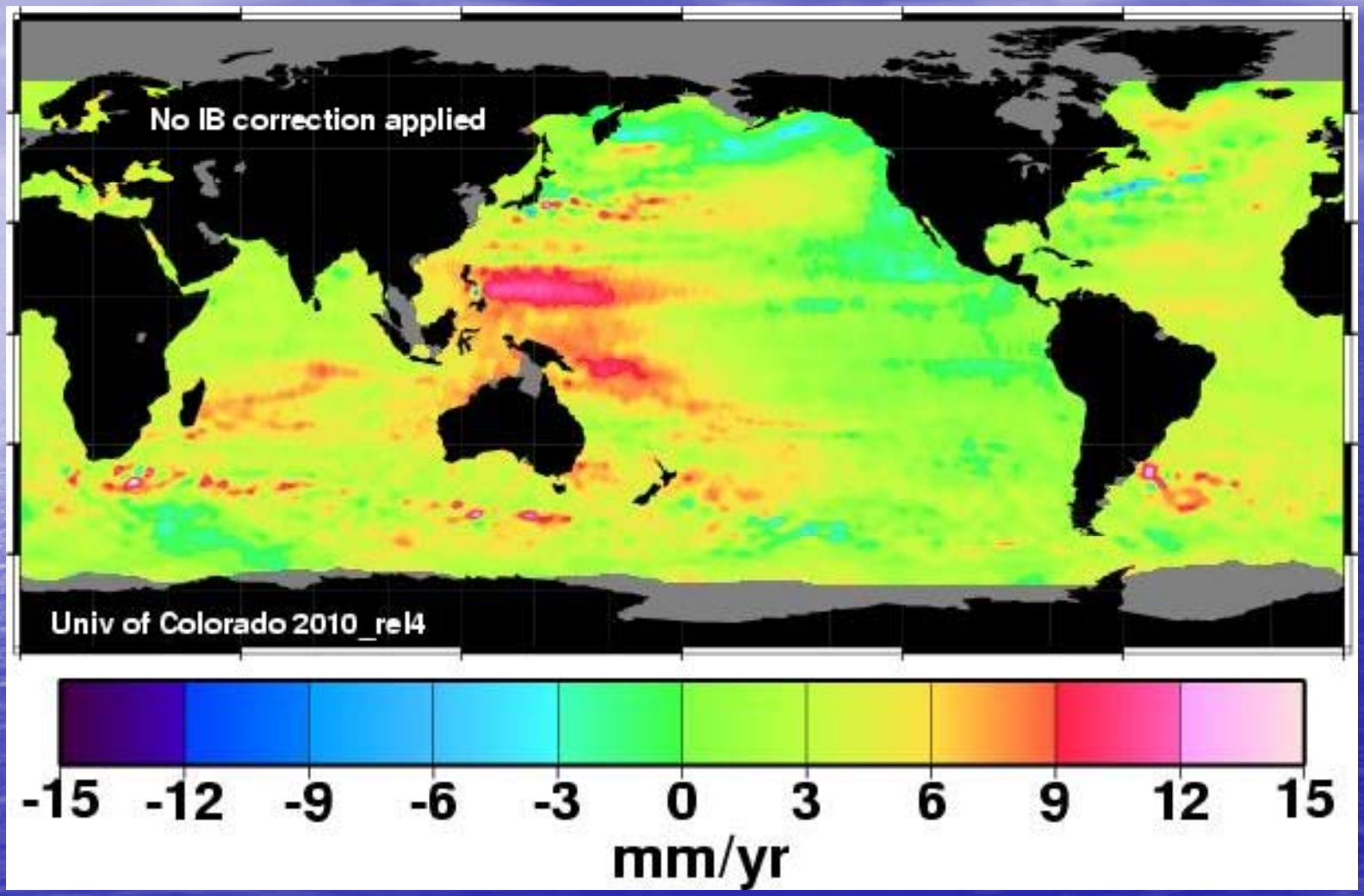
highest California sea levels have mainly occurred in just a few years, esp large El Ninos (1983 and 1998)

from hourly sea level record at Ft Point, mouth of San Francisco Bay



Sea Level Trends 1992-2010

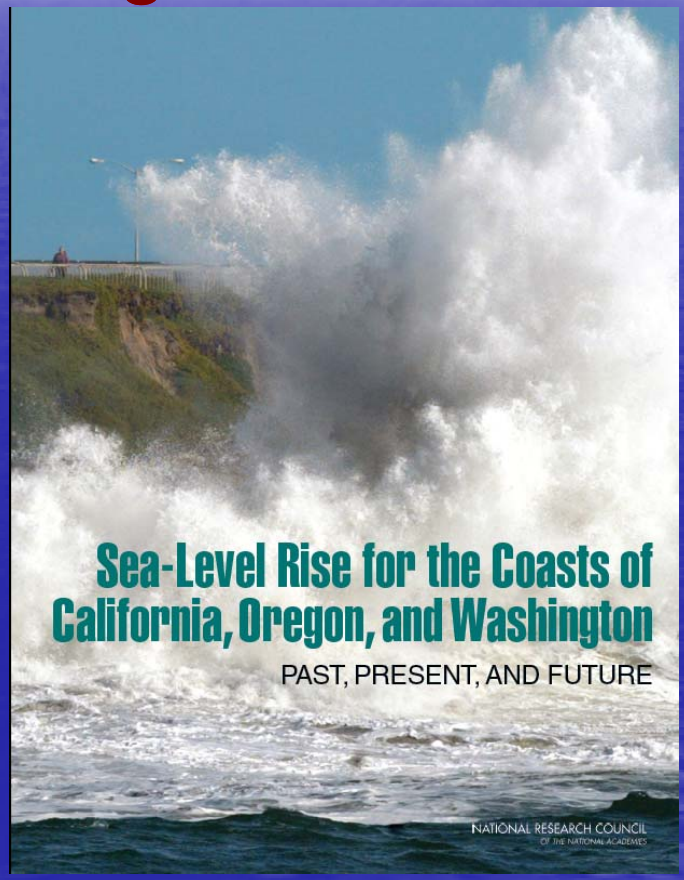
How much/how fast will be future sea level rise along the California Coast?



Steve Nerem et al. U. Colorado

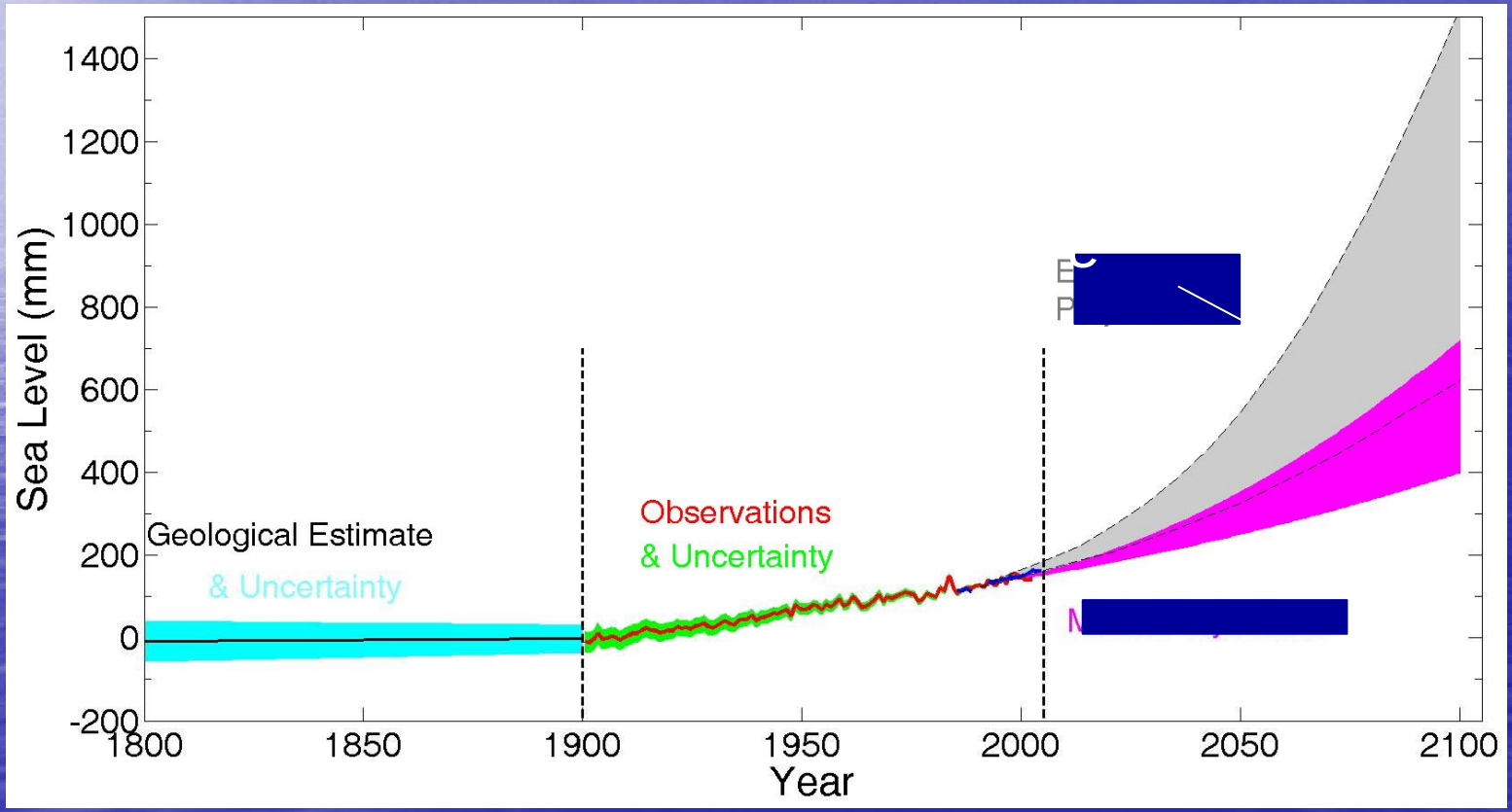
Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future—NRC Committee findings

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

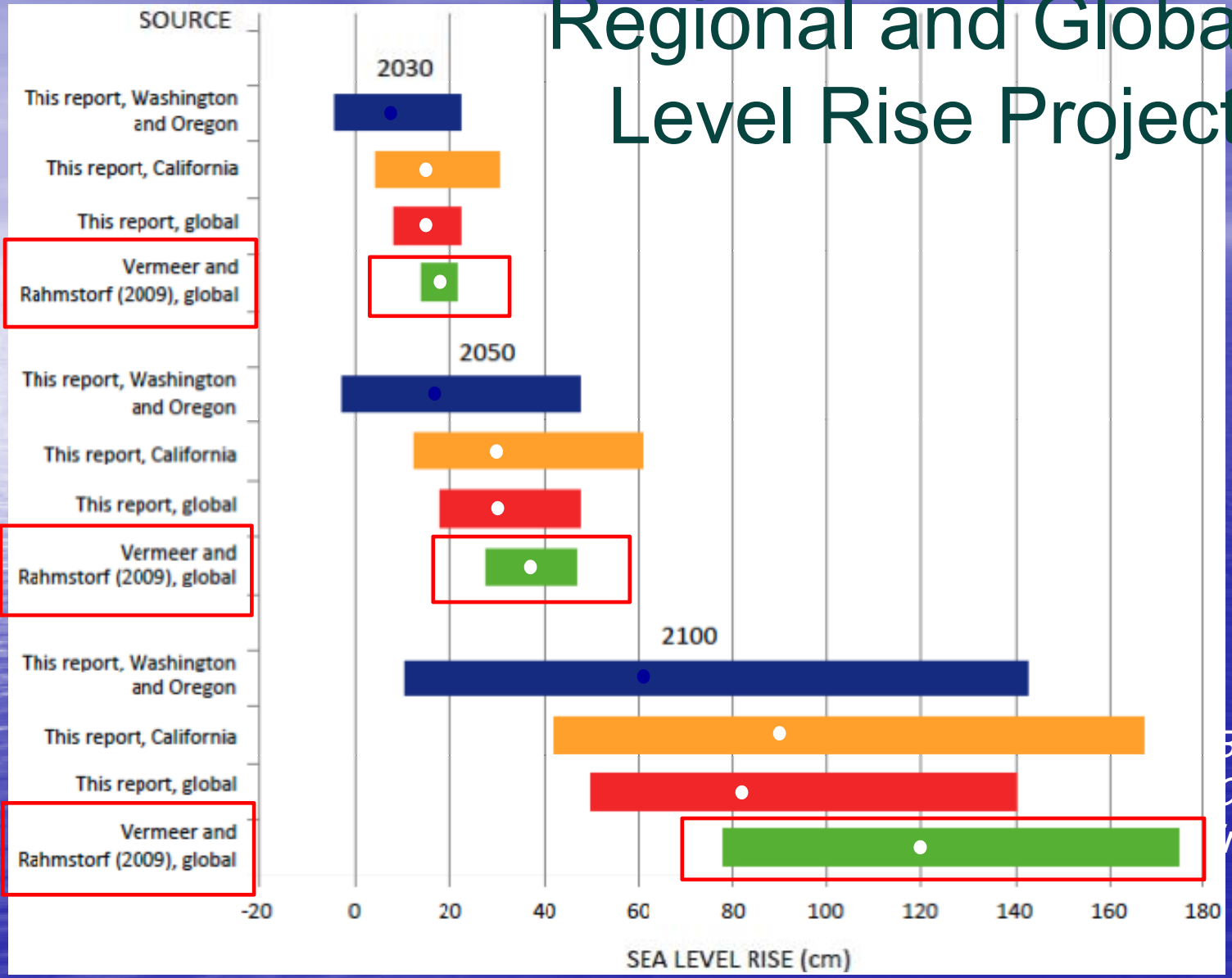


Global sea-level is rising primarily because land ice is melting and ocean water expands as it warms.

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

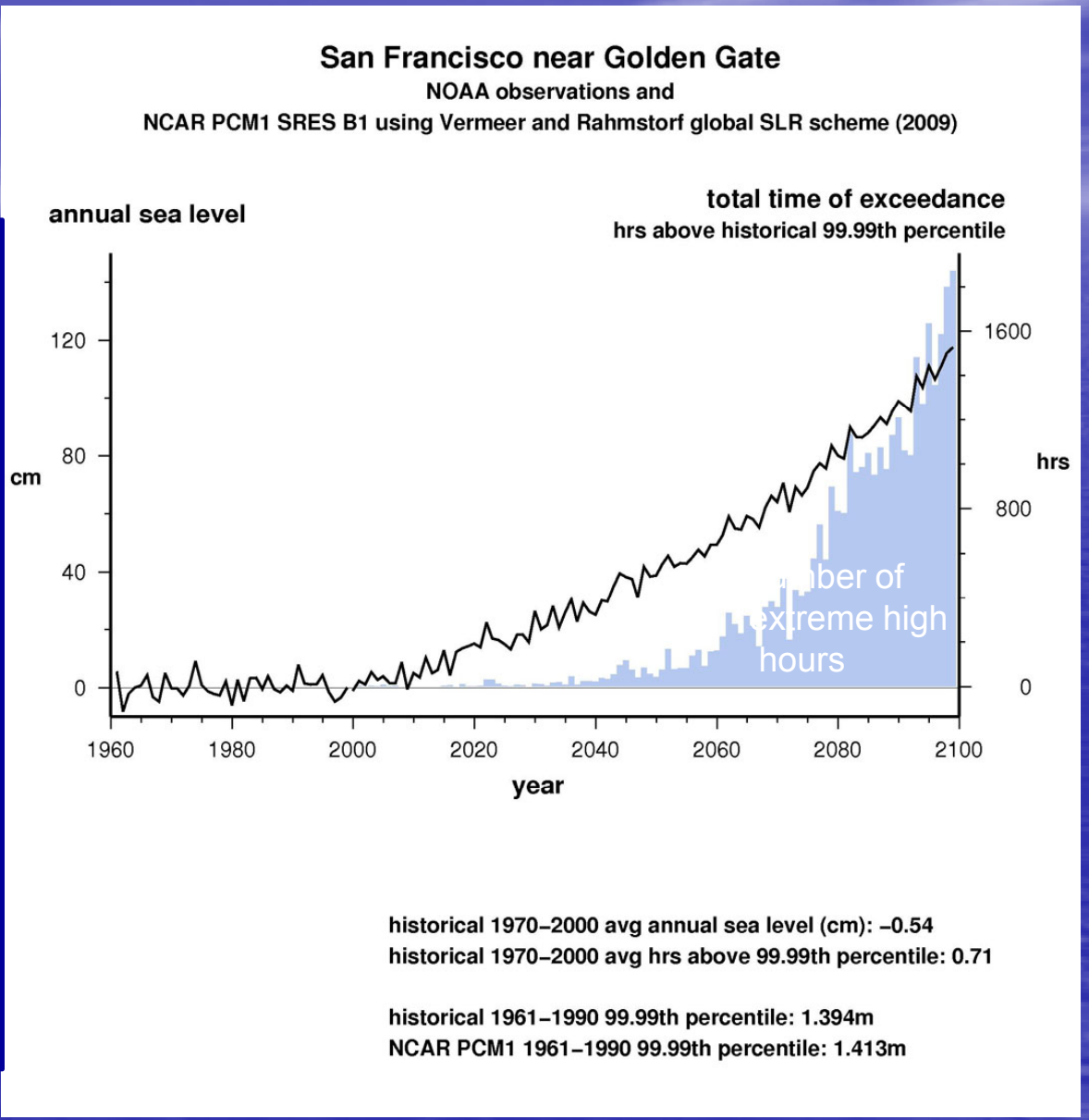
Rising seas increase coastal erosion, shoreline retreat, and wetland loss; increases the risk of coastal flooding, and increases coastal damage from storms.

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.



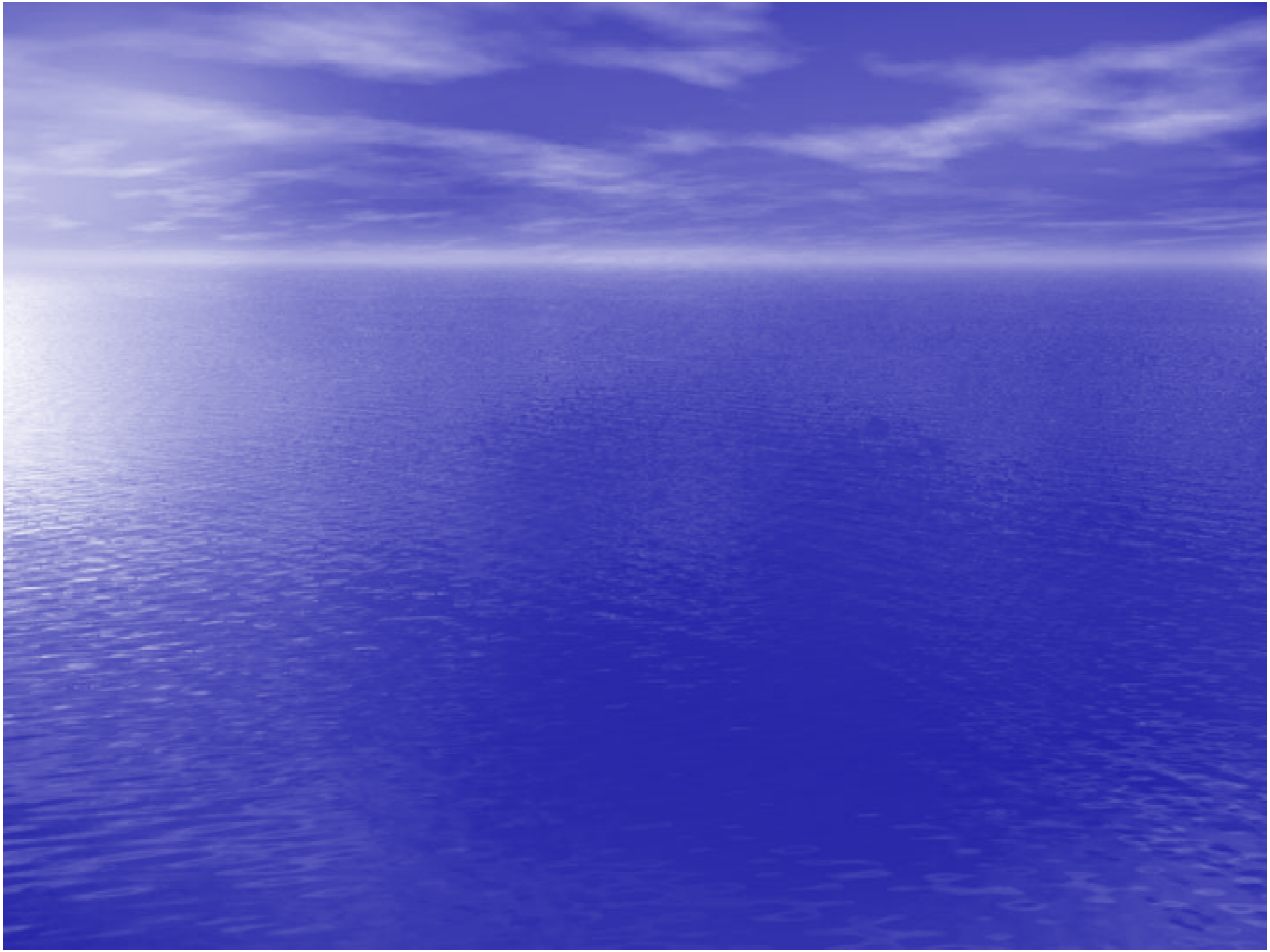
Key Issues

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

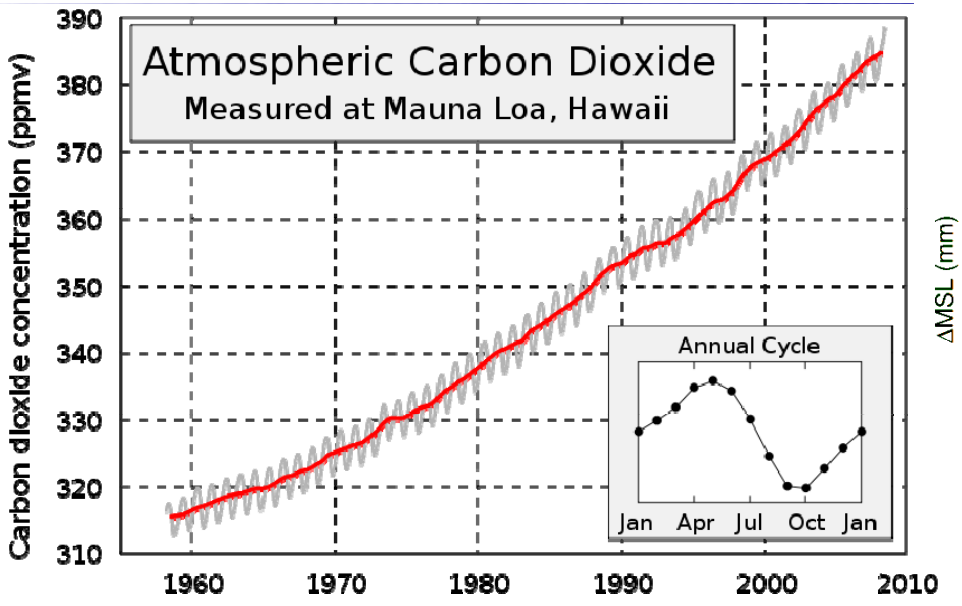
Sea Level Rise
- Global sea level rise projections are greatly uncertain
- Pacific basin change has strong affect of natural interannual-interdecada variation
- Regional influences also play a role

Extreme Events
- Prolonged drought not well represented in GCMs
- Large floods only grossly replicated by GMCs and downscaling

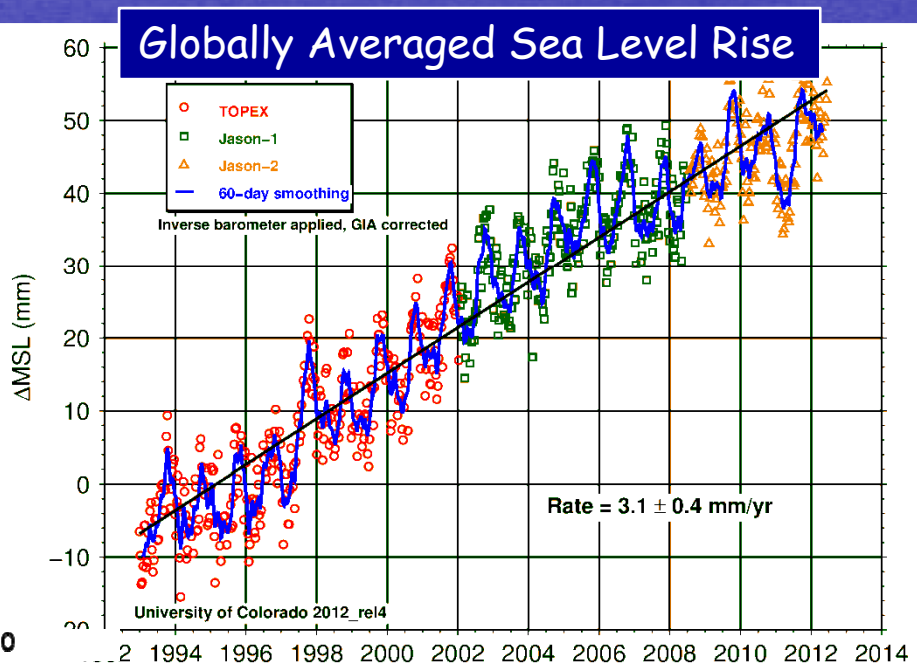


Satellite Altimeters Measure Sea Level Rise

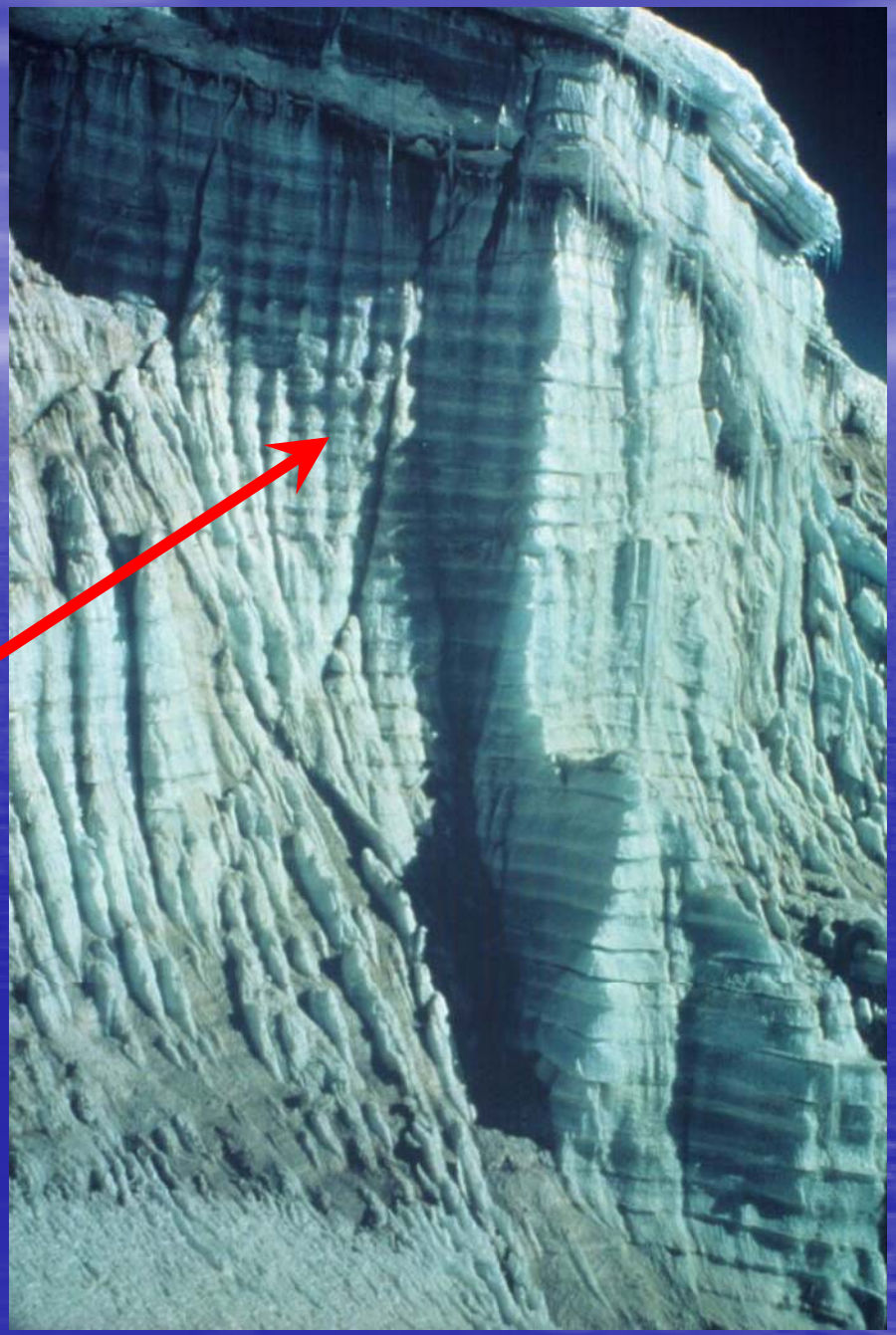
Cause



Effect



How do we know?



Annual layers

Side of Quelccaya ice cap, Peru

Lonnie Thompson

Greatest problems: large storm + high tide