



Sea Level Rise in Washington State and the San Juan Islands

29-30 June 2017

Lopez, Orcas and San Juan Island

Ian Miller, PhD
Coastal Hazards Specialist
Washington Sea Grant
Olympic Peninsula Field Office
immiller@uw.edu



With contributions from Sascha Petersen and Matt Fougerat, Adaption International
And Guillaume Mauger and Harriet Morgan, UW Climate Impacts Group



Washington Sea Grant funds marine research and provides science-based information and expertise to communities to strengthen understanding of the marine and coastal environment.

English Camp during a 2015 “King Tide”. Photo by Todd Owens



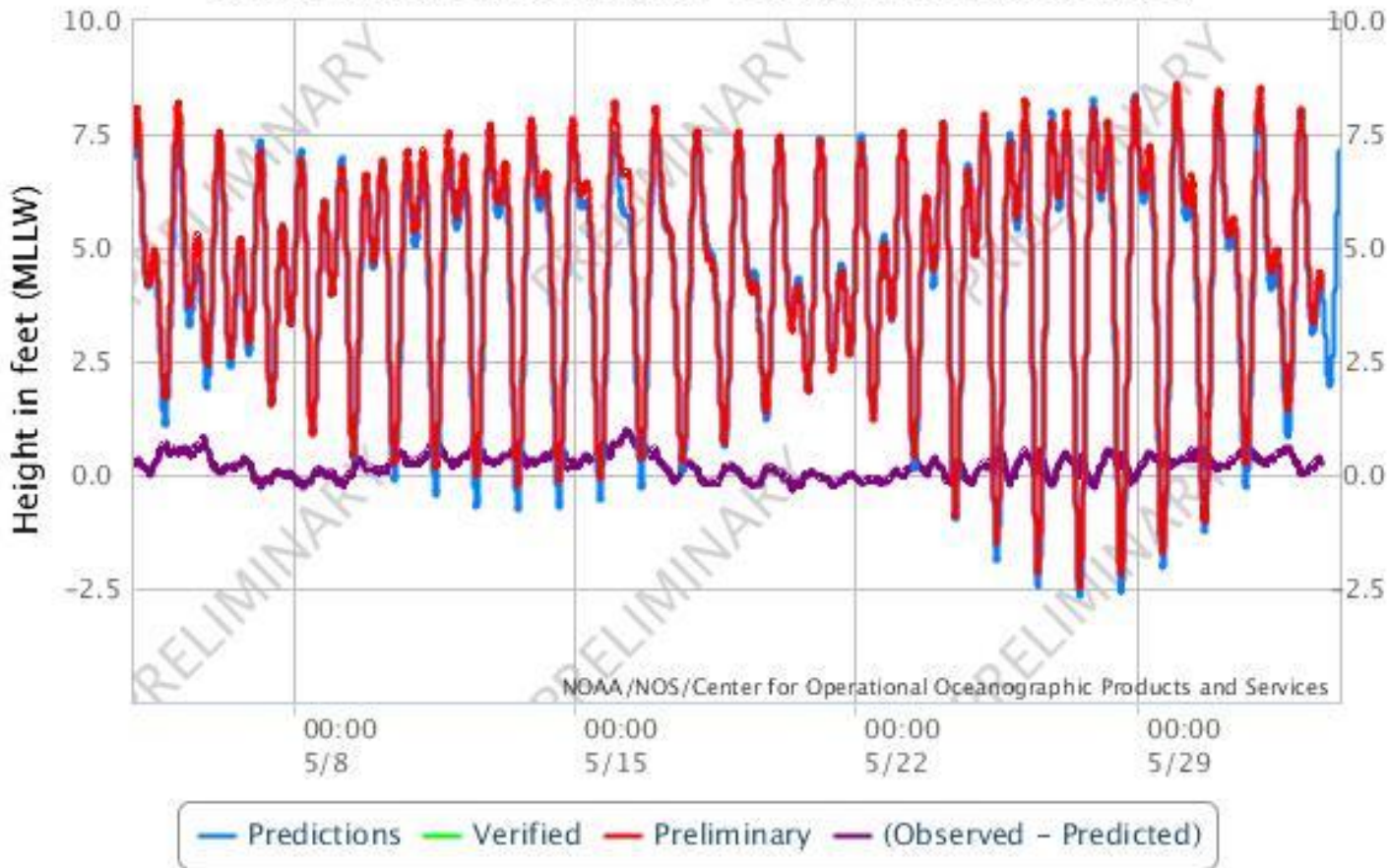
What you are in for:

- **What does sea level actually mean?**
- **Sea Level Rise and Climate Change: A quick primer**
- **What can we expect here?**



The sea is not level

NOAA/NOS/CO-OPS
Observed Water Levels at 9449880, Friday Harbor WA
From 2017/05/04 00:00 LST/LDT to 2017/06/02 23:59 LST/LDT

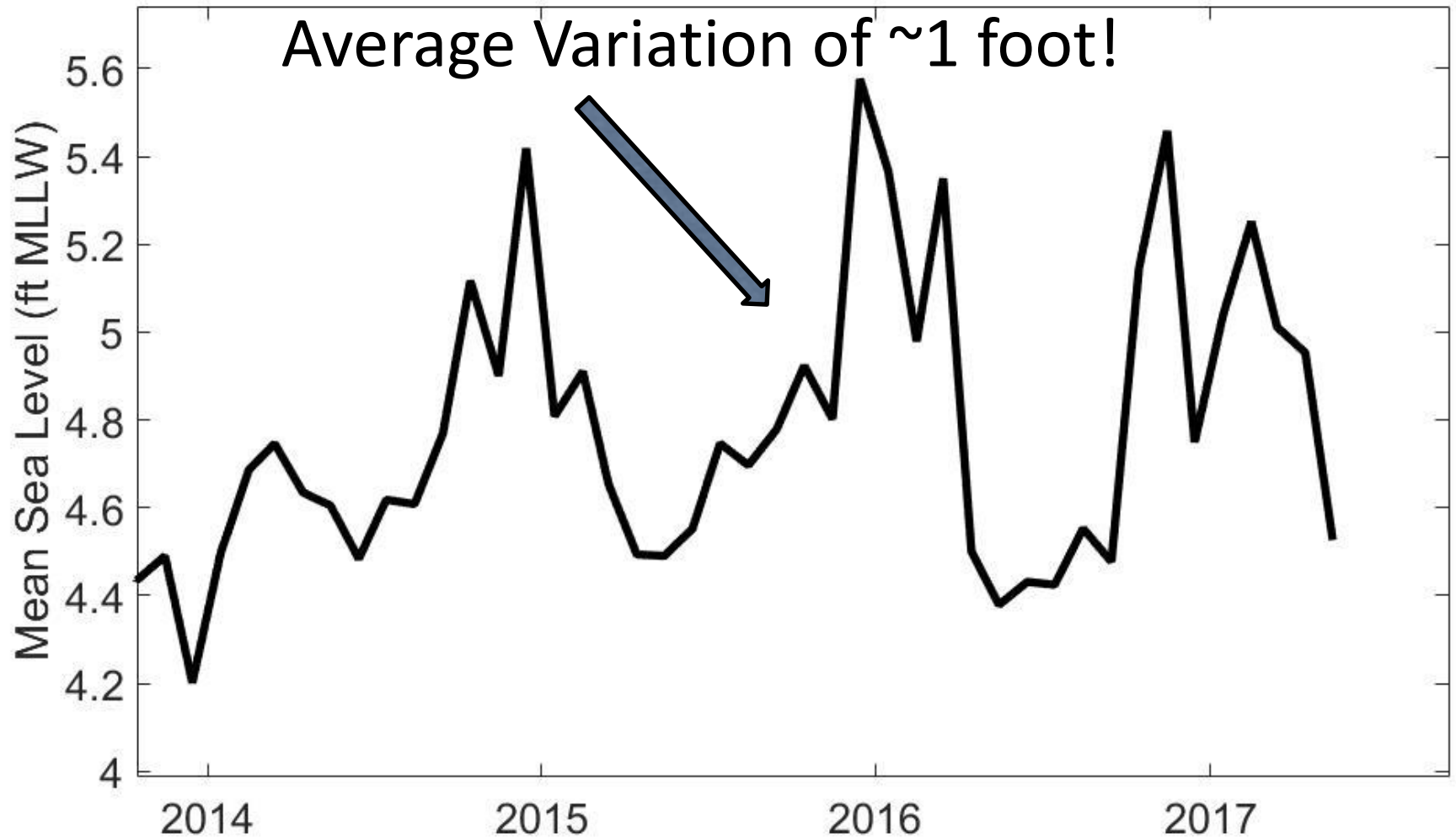


- HOWL
- MHHW
- MSL
- MLLW
- LOWL

Tides dominate water level variations in WA



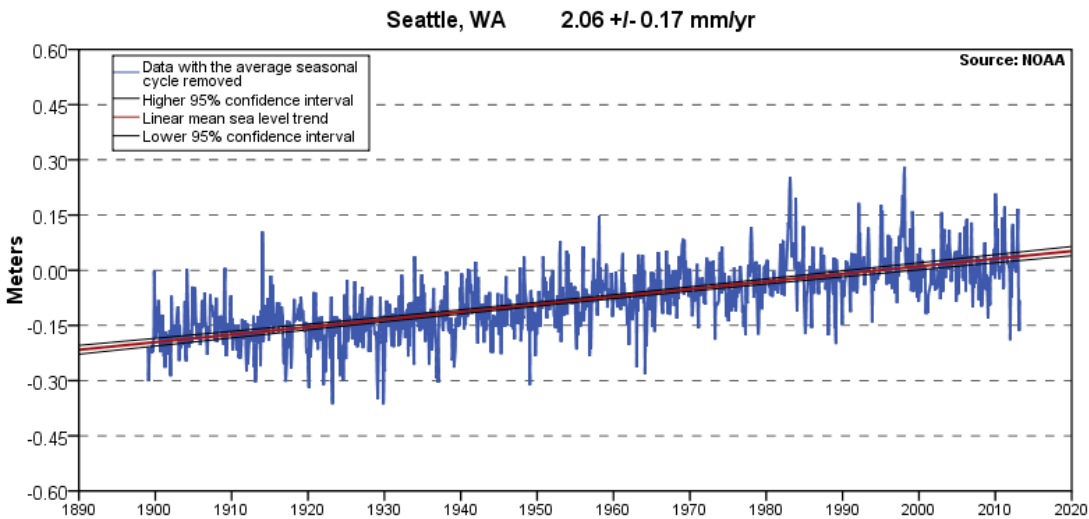
The sea is not level



...there is a *repeating* seasonal pattern

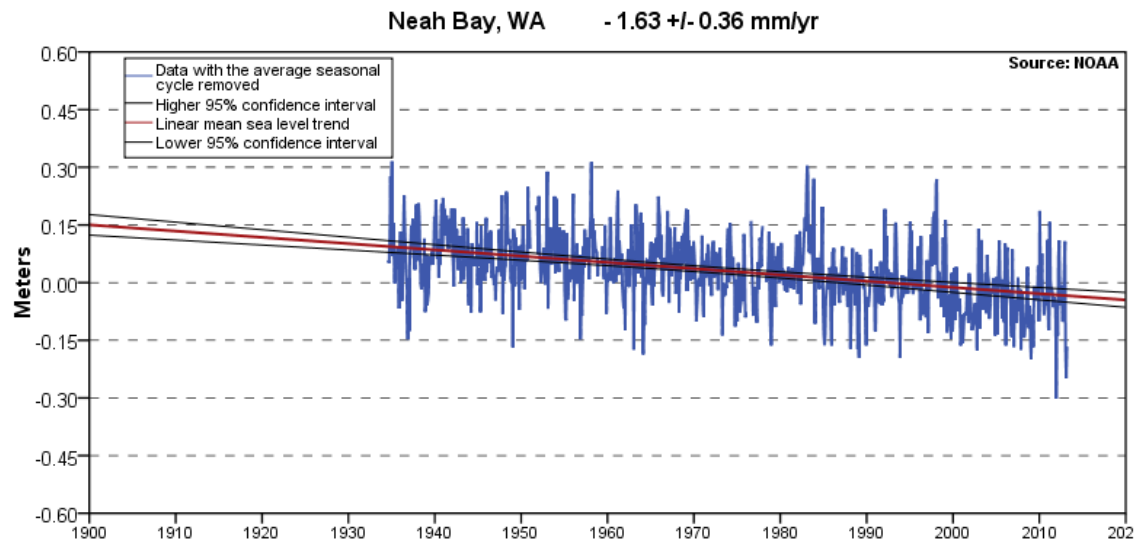


We also find land movement in tidal sea level records



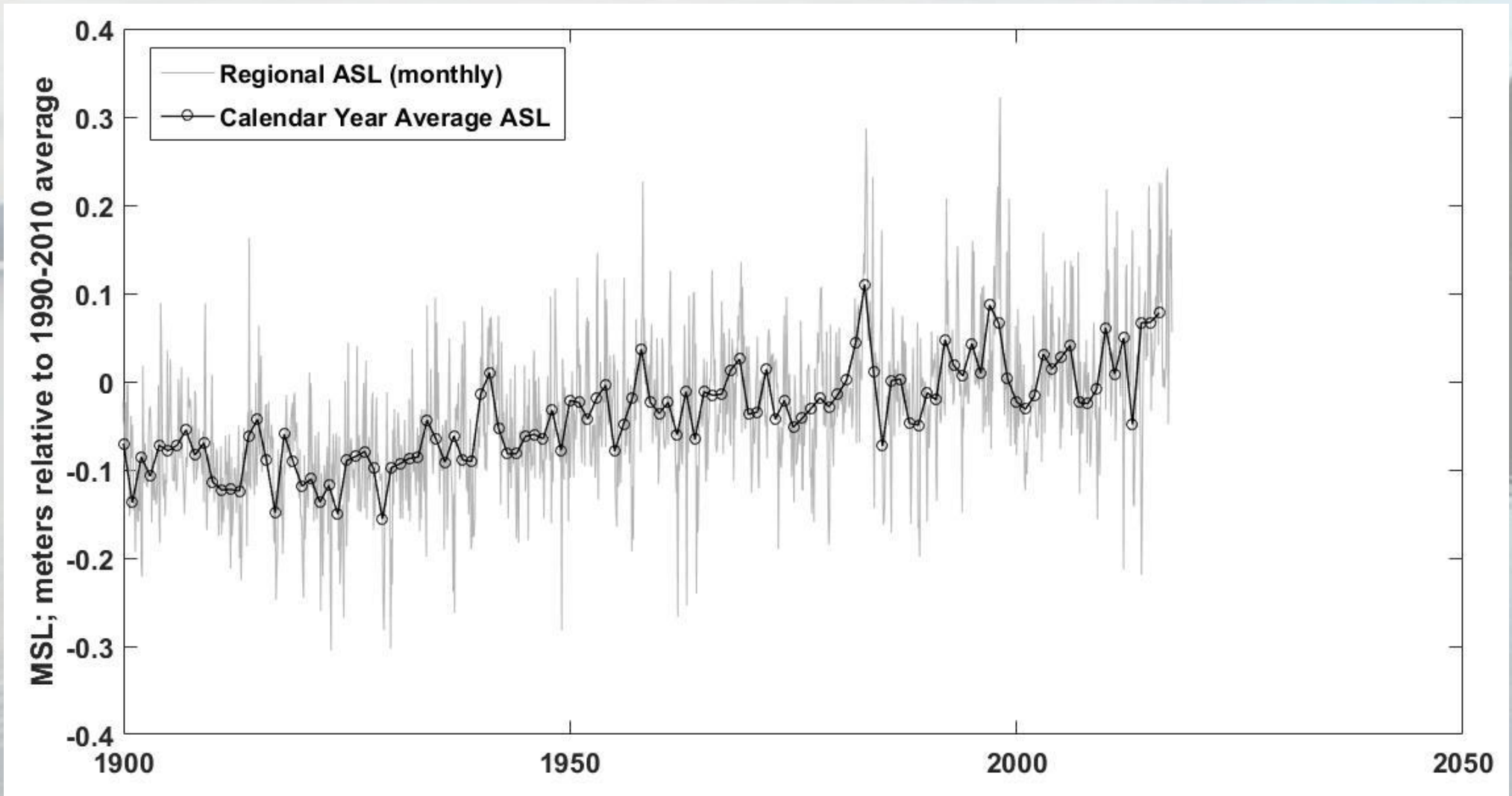
Seattle: Where subsidence exacerbates the regional SLR pattern

Neah Bay: where VLM is Outpacing historic sea level rise





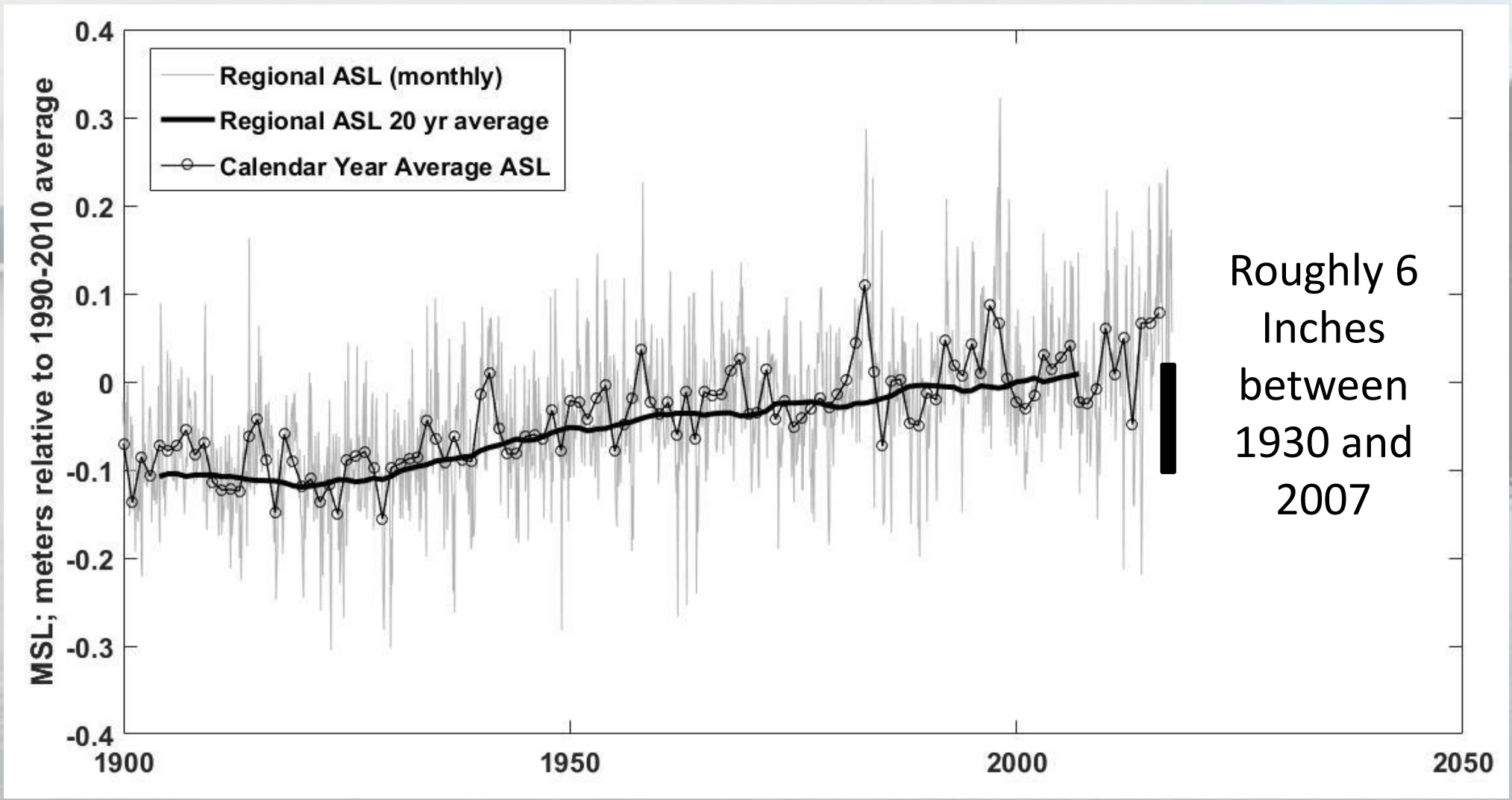
And if we pull out the seasons and the land...



...we find all sorts of annual variability



Lets look at long-term averages...



Roughly 6
Inches
between
1930 and
2007

...to find a clear pattern of “real” sea level rise!

English Camp during a 2015 “King Tide”. Photo by Todd Owens



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Blame These Fine Looking Gentleman

Identified the role played by CO₂ in absorbing long-wave radiation



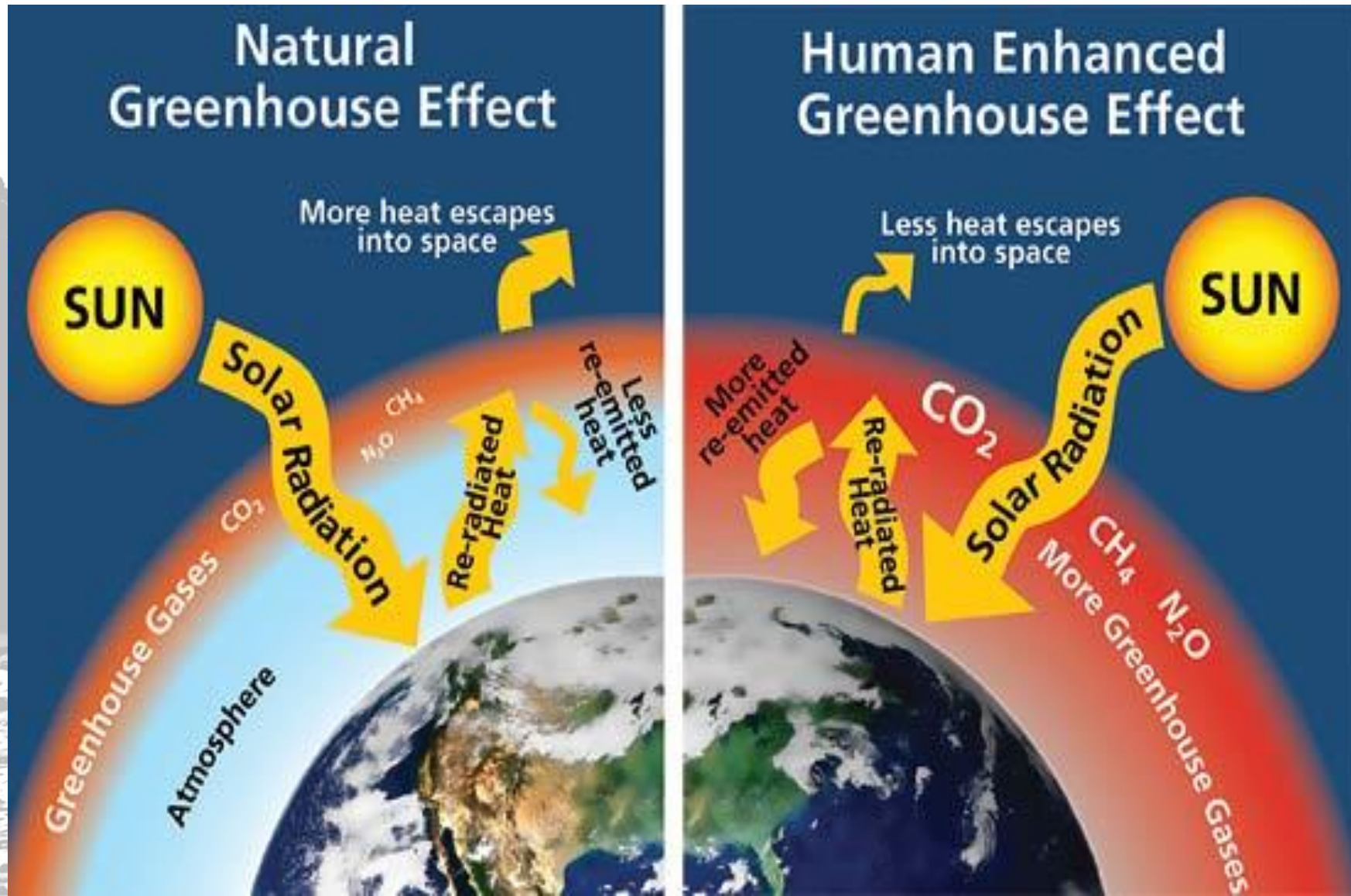
John Tyndall, 1864

Connected increasing anthropogenic CO₂ in the atmosphere to mean temperature



Svante Arrhenius, 1894

Fundamental Concept: Energy Imbalance



$$Q=mc\Delta T$$

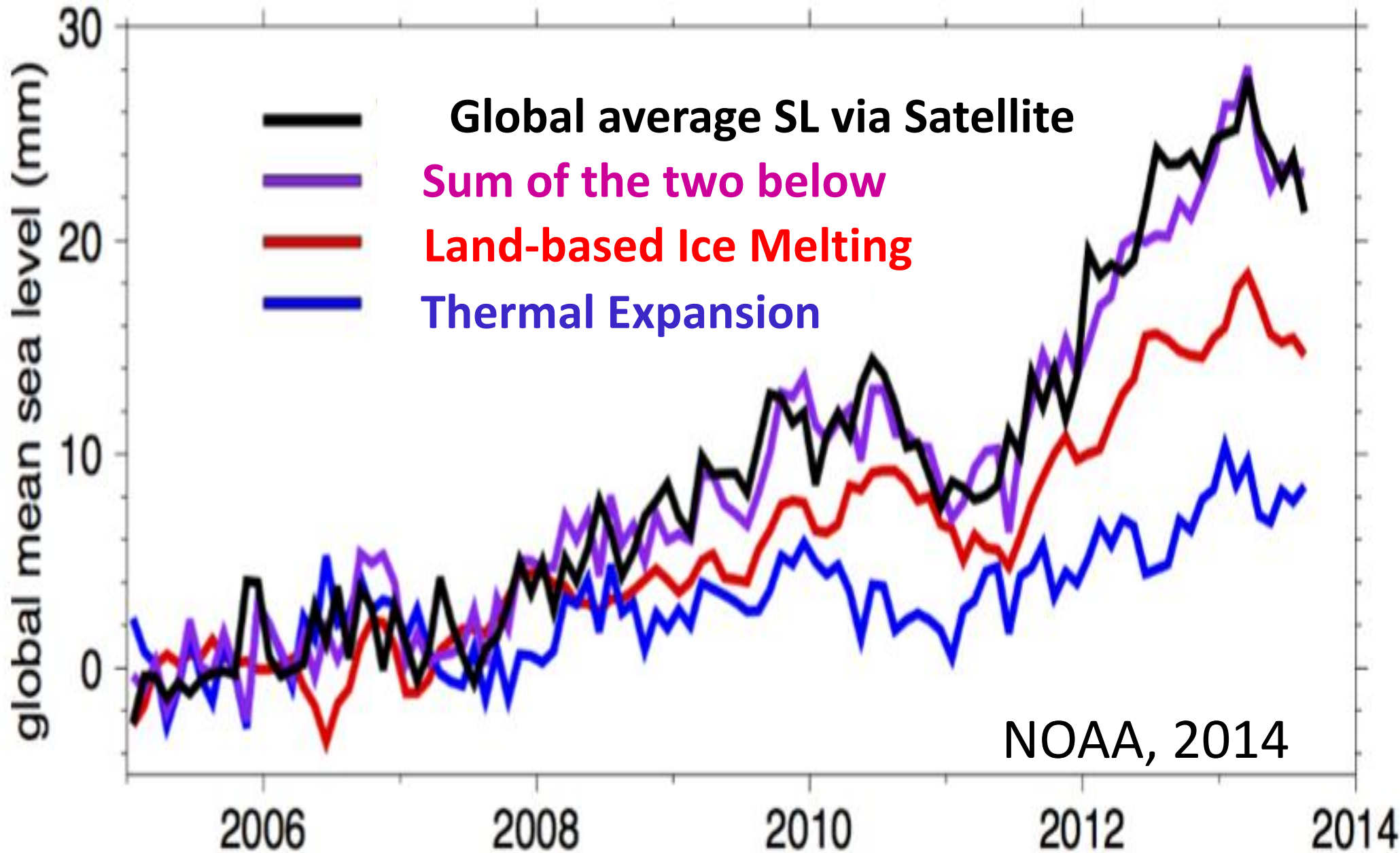


Yet another service brought to you by the ocean...



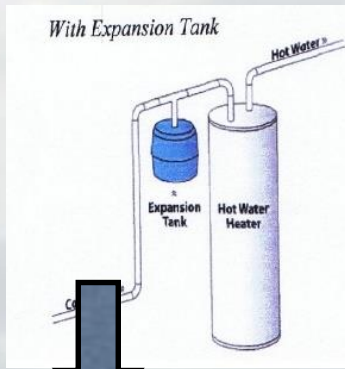


Observed Global SLR is due to heat

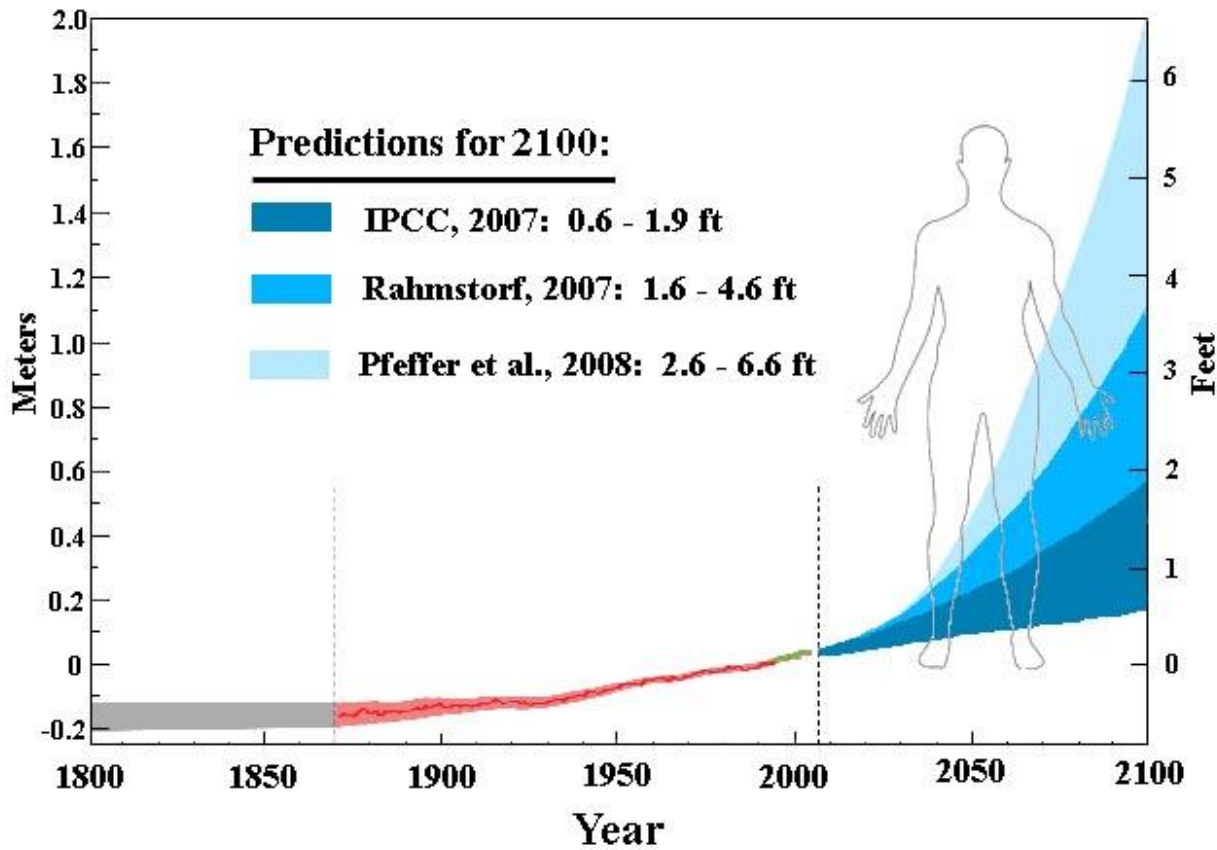




Building Projections



Sea Level Rise: Observed and Predicted



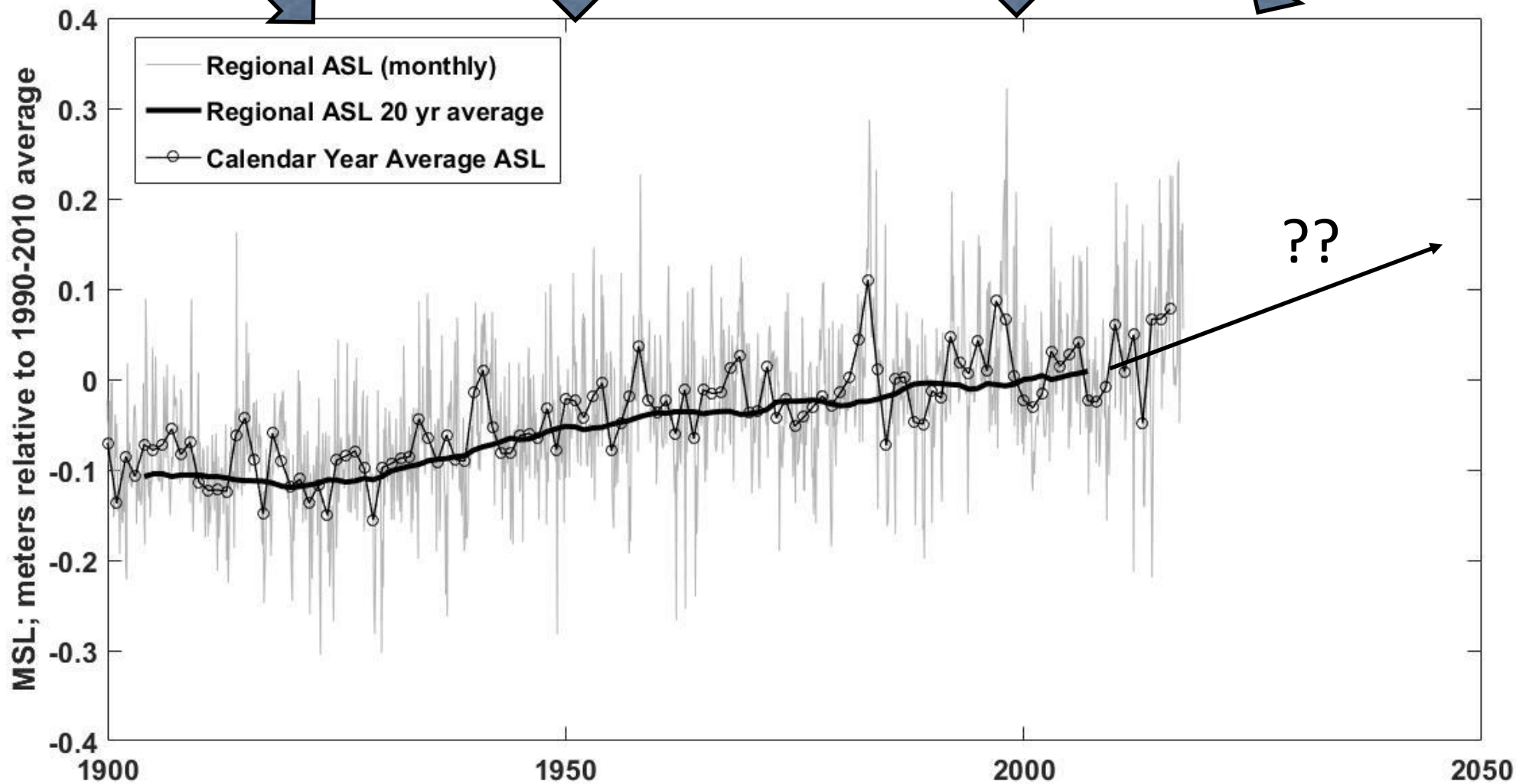
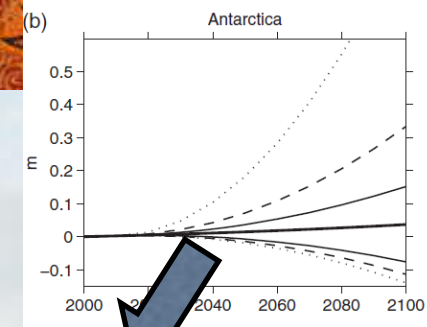
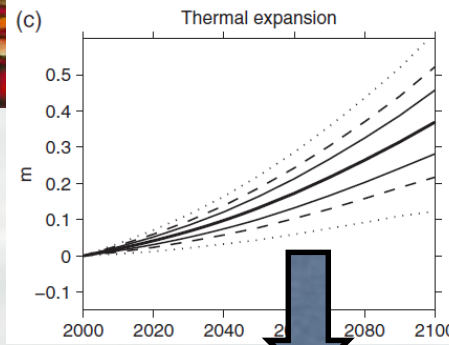
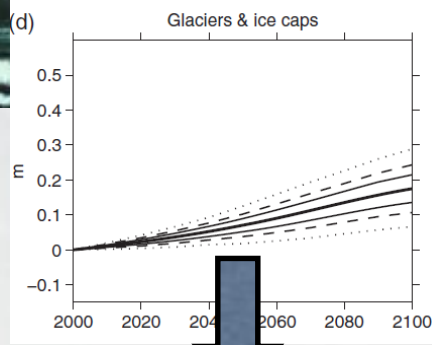
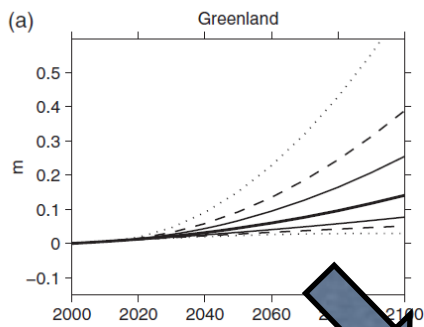
Note the
Uncertainty!

English Camp during a 2015 “King Tide”. Photo by Todd Owens



What you are in for:

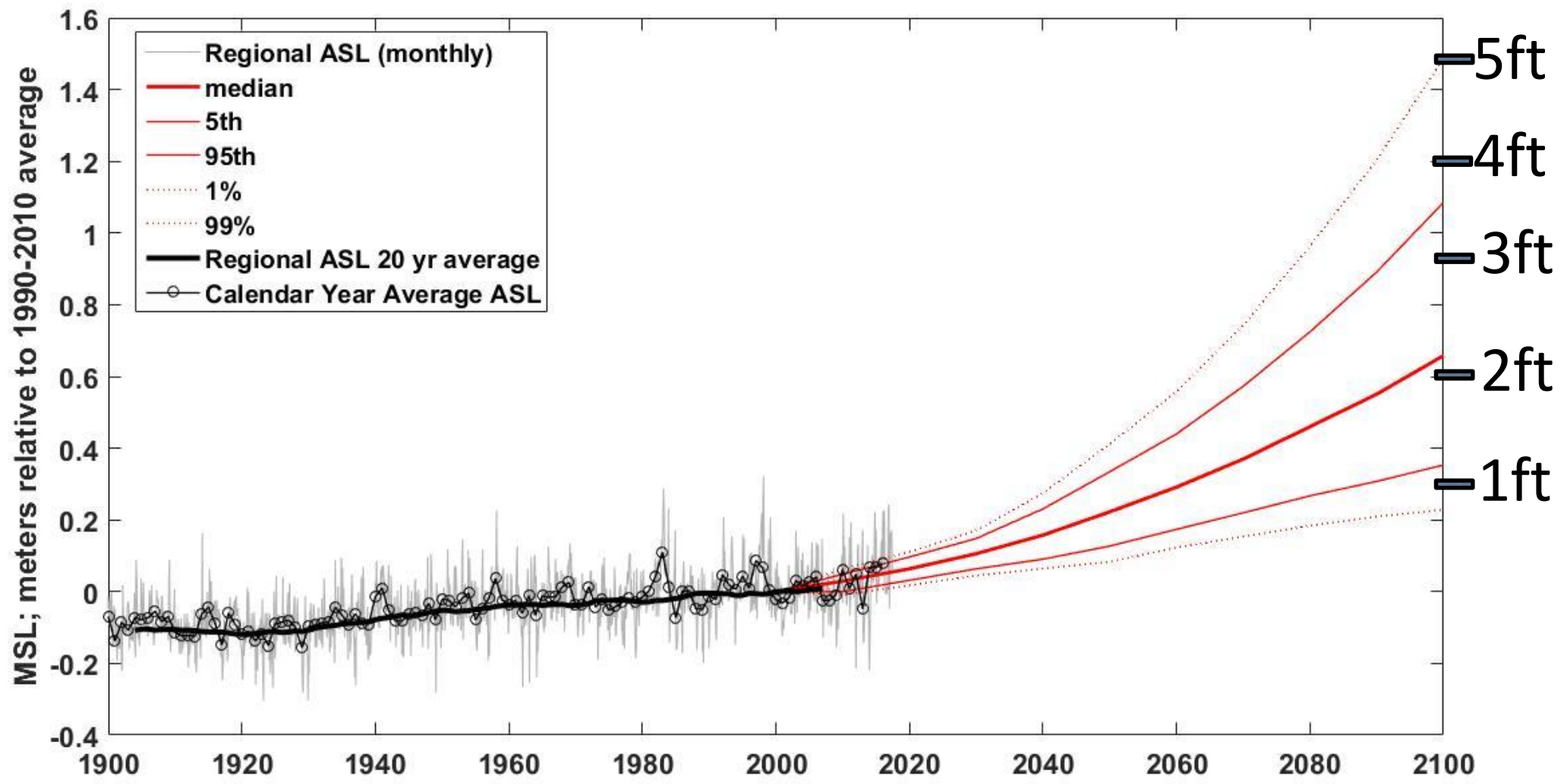
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Go back to here and add in sea level components



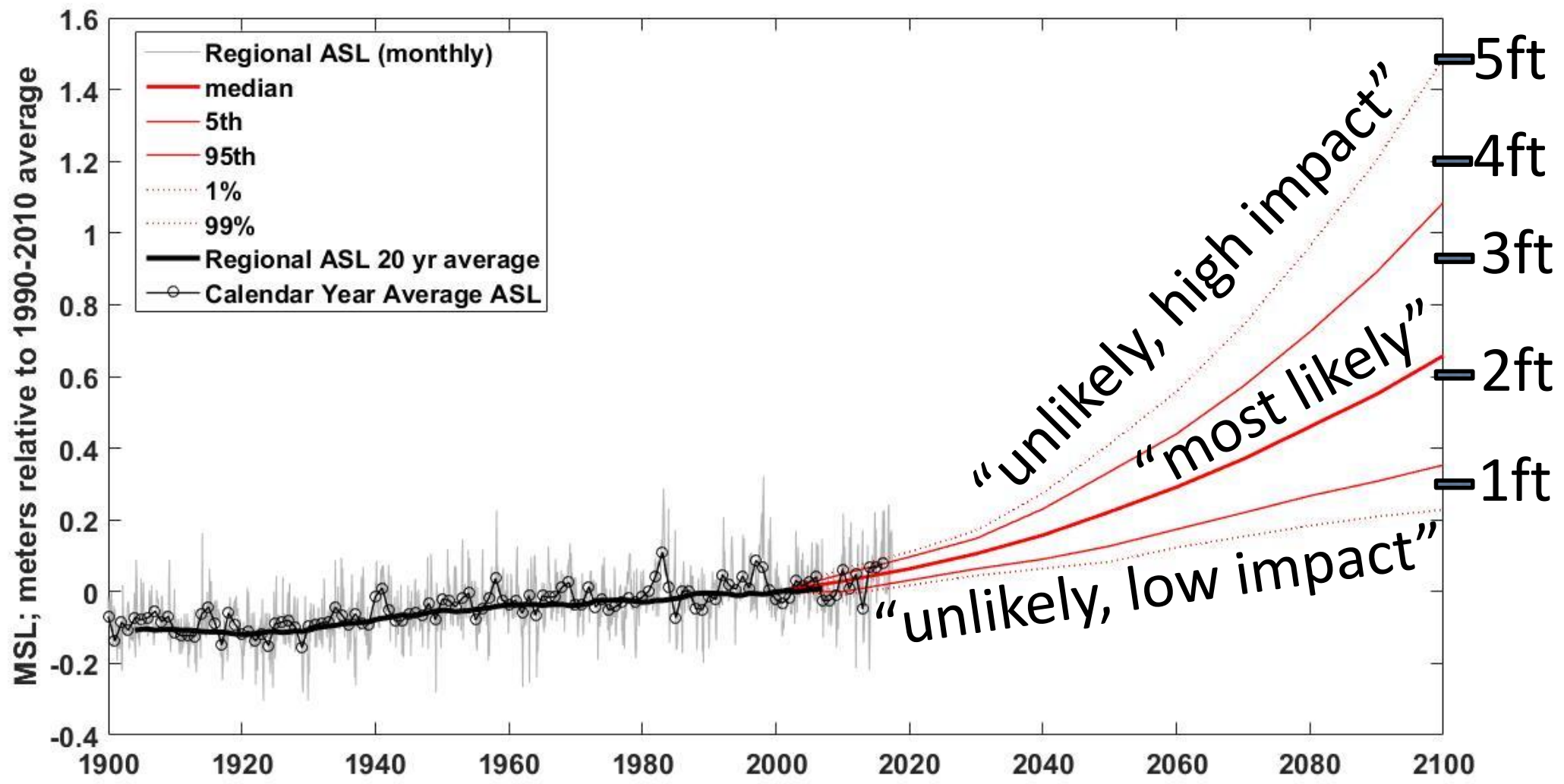
“Absolute Sea Level” Projections for WA



By 2100 (for RCP8.5)



“Absolute Sea Level” Projections for WA



By 2100 (for RCP8.5)



“Localized” Projections

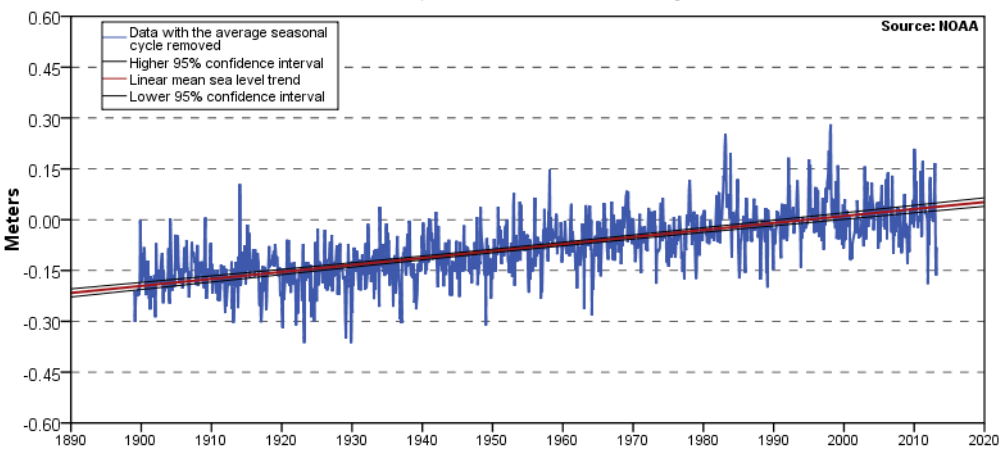
$$\text{Relative Sea Level} = \text{Sea Level} + \text{VLM}$$

Seattle: Where subsidence exacerbates the regional SLR pattern

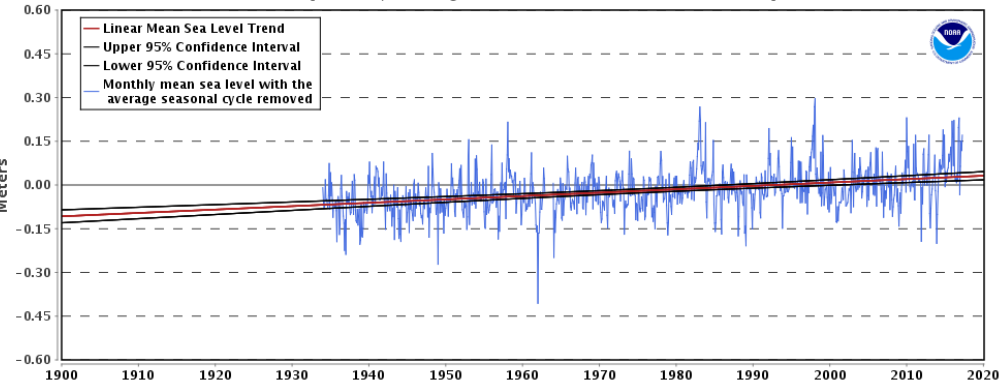
Friday Harbor: Where there appears to be little land movement

Neah Bay: where VLM is currently outpacing SLR

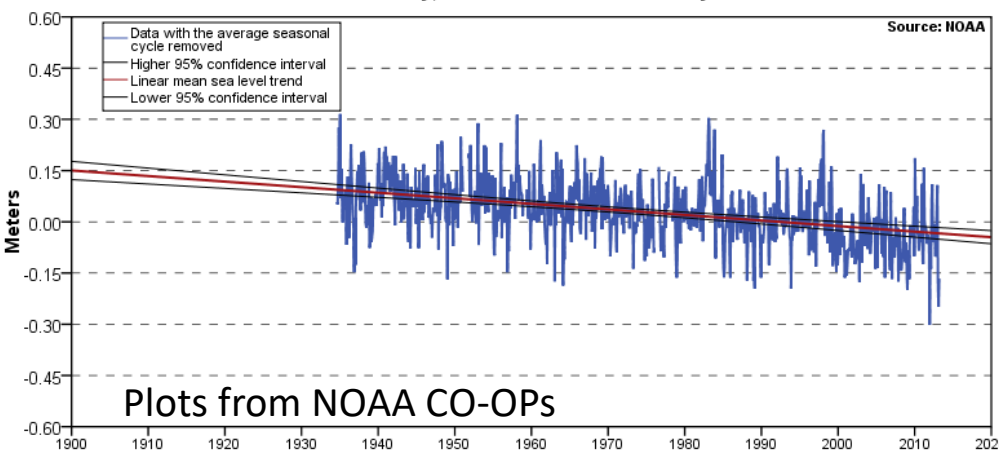
Seattle, WA 2.06 +/- 0.17 mm/yr



9449880 Friday Harbor, Washington 1.16 +/- 0.28 mm/yr

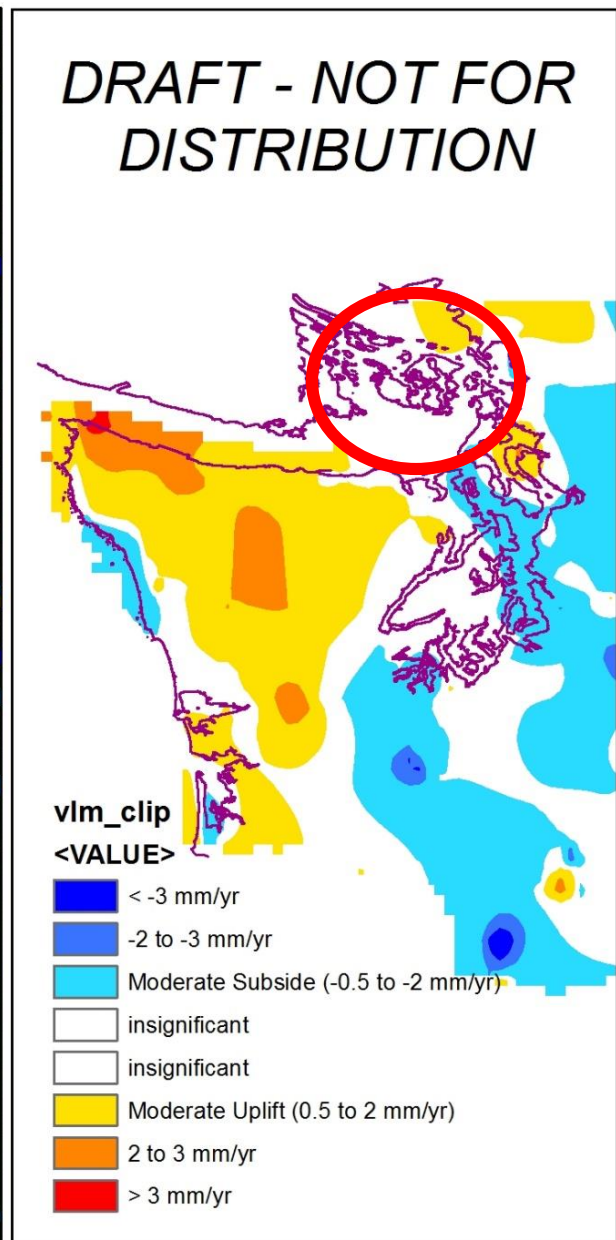
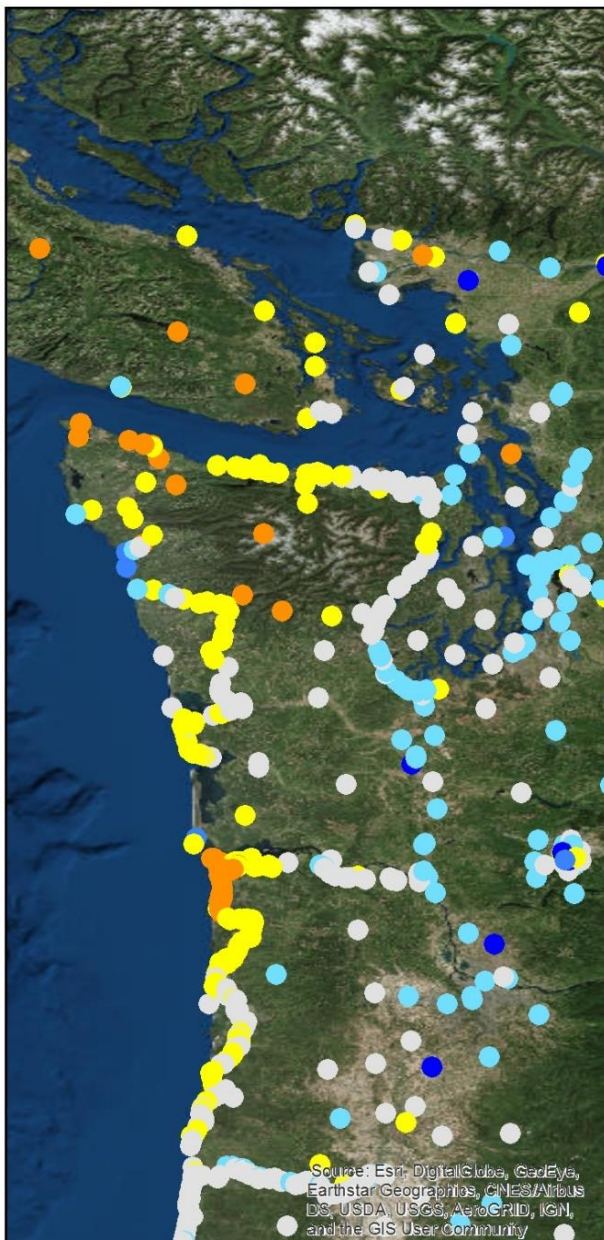
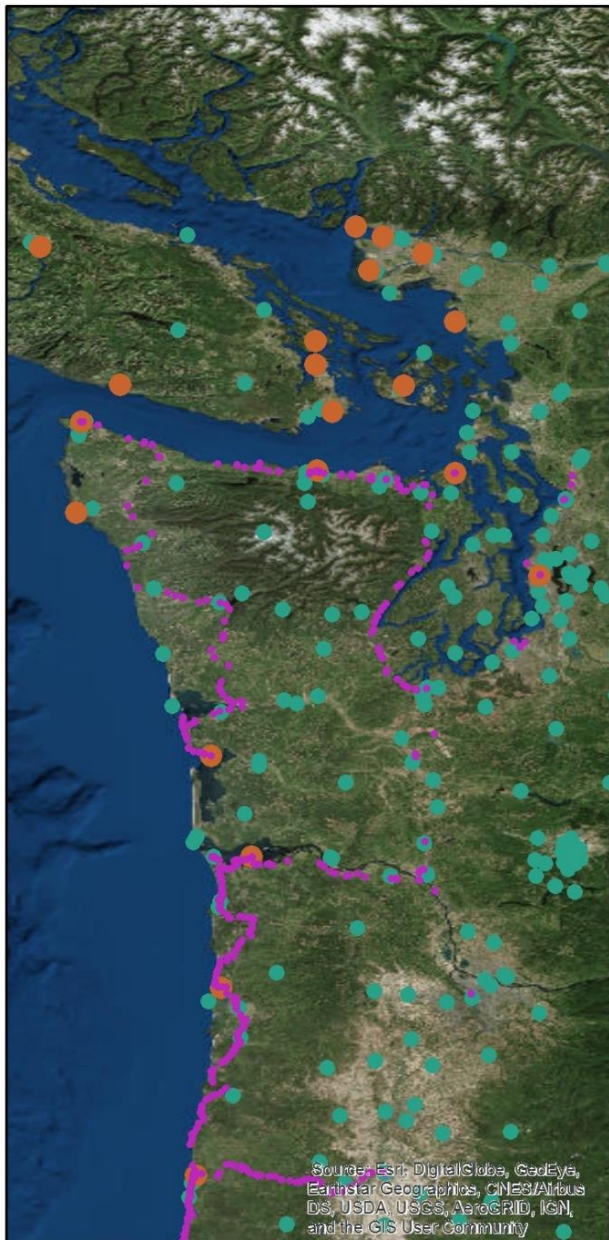


Neah Bay, WA -1.63 +/- 0.36 mm/yr



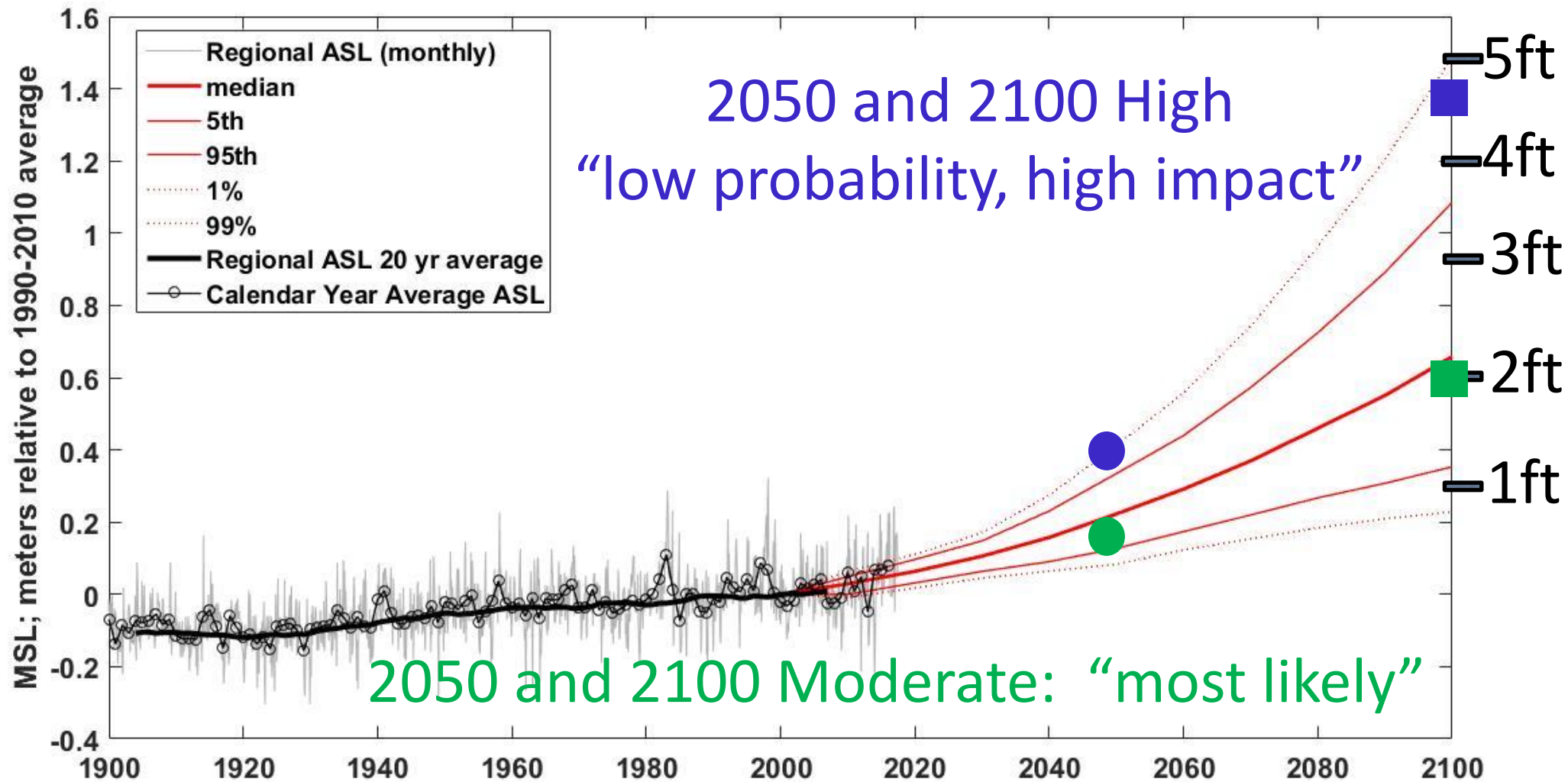
Plots from NOAA CO-OPs

Vertical Land Movement





4 Map Scenarios used for San Juans





Thank you!

Key Points:

1. Sea level has risen historically in Washington State - ~6 inches since 1930 or so
2. Climate change, due to thermal expansion AND new water contributions to the oceans basin, is very likely to accelerate sea level rise in the coming decades.
3. There is little evidence that the San Juans are either moving up or down
4. As a result “likely” sea level rise for the San Juans based on our current assessment suggest another ~6 inches by 2050, and >2 ft by 2100.
5. But higher magnitudes of SLR are possible. >5 ft by 2100

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Olympic Peninsula Field Office
immiller@uw.edu
360 417 6460





Additional Resources

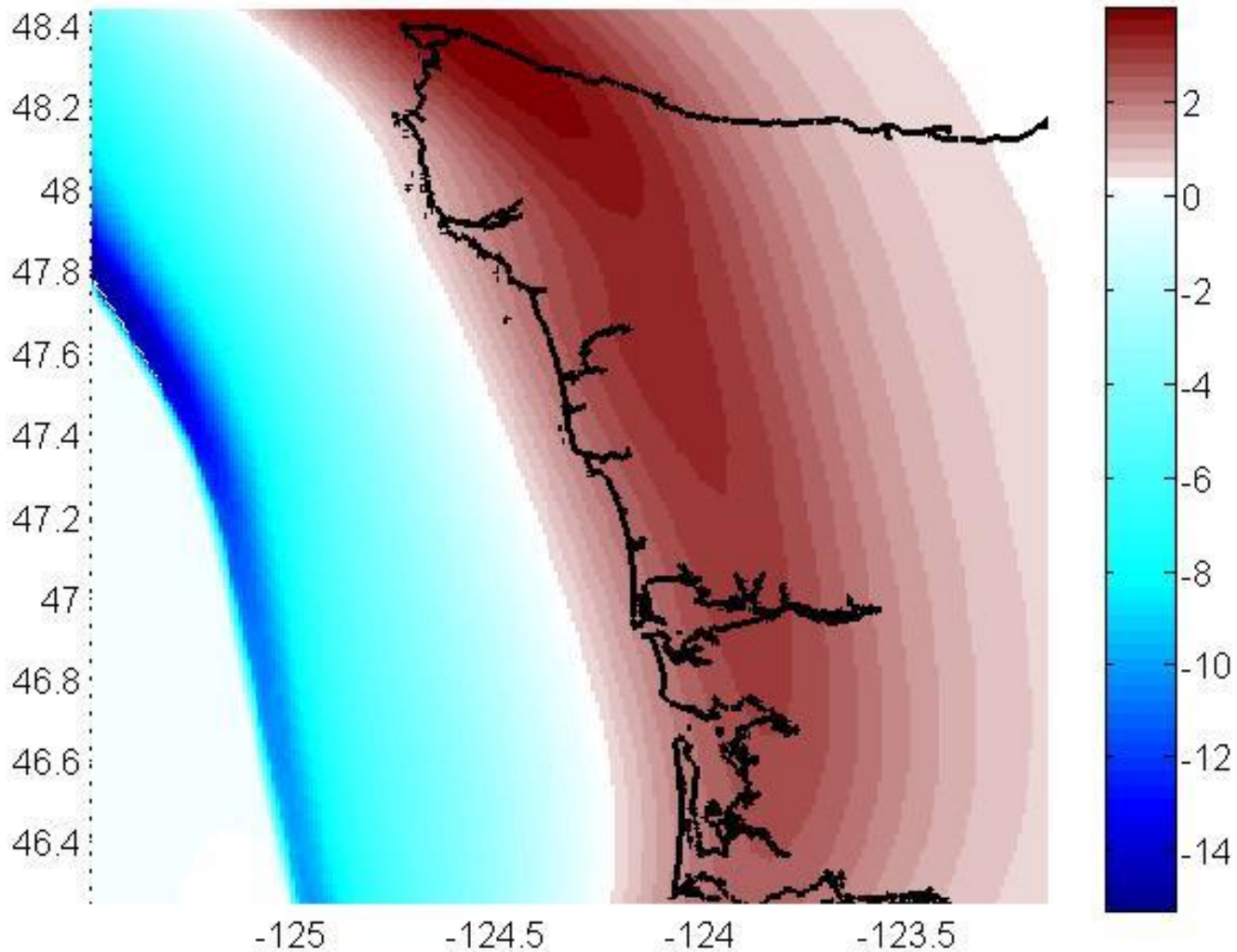
- State of Knowledge: Climate Change in Puget Sound (http://ces.washington.edu/picea/mauger/ps-sok/PS-SoK_2015.pdf)
- Recent blog on probabilistic projections (<http://www.wacoastalnetwork.com/blog/communicating-probabilities-for-more-informed-decisions-about-sea-level-rise>)
- Clallam/Jefferson Climate Change Assessment (<http://www.nopr.cd.org/about2>)

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360 417 6460





Note: VLM may change



Modelled coseismic land surface deformation, L1 scenario.

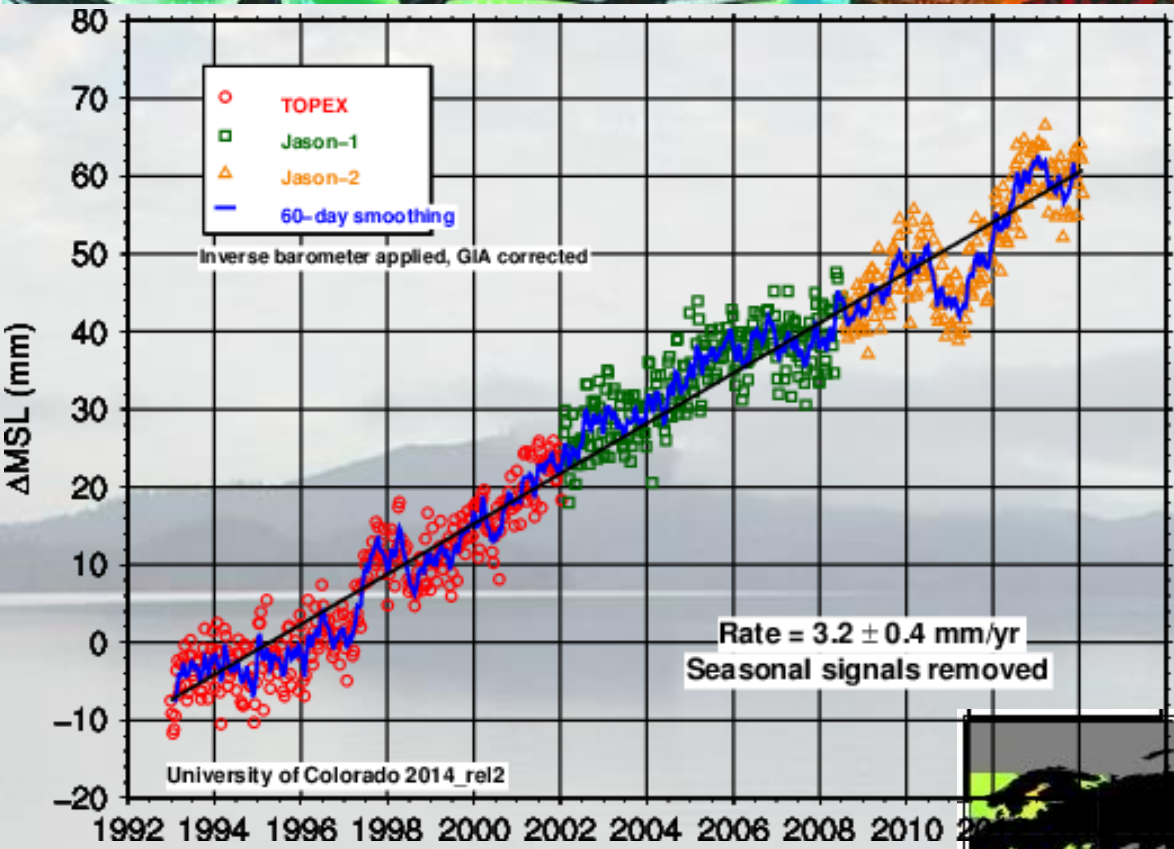
Courtesy of Diego Arcas and Edison Gica, NOAA PMEL



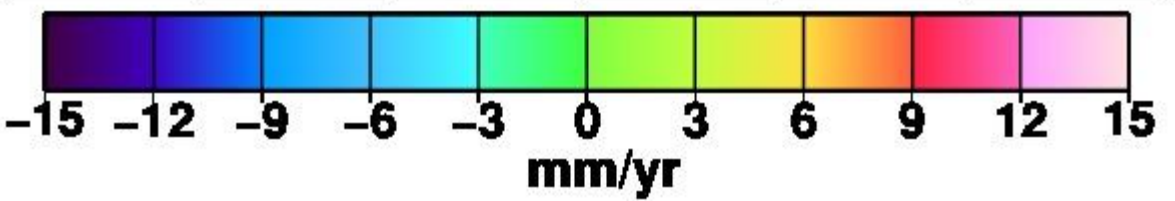
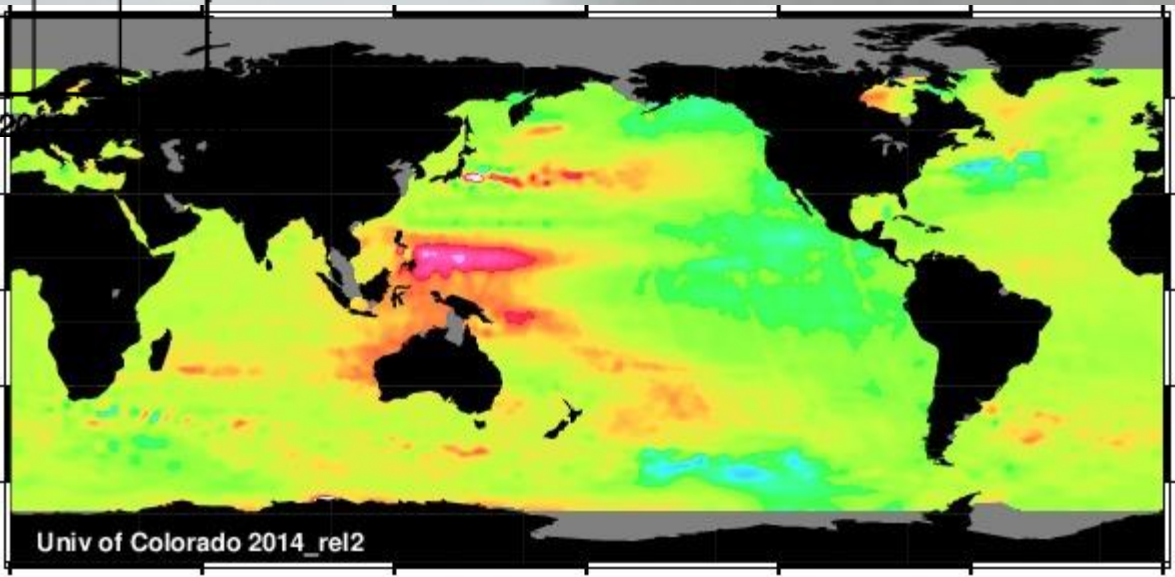
Getting Regional

Mean Global Sea Level (1993-present) is rising....

Nerem et al. 2010

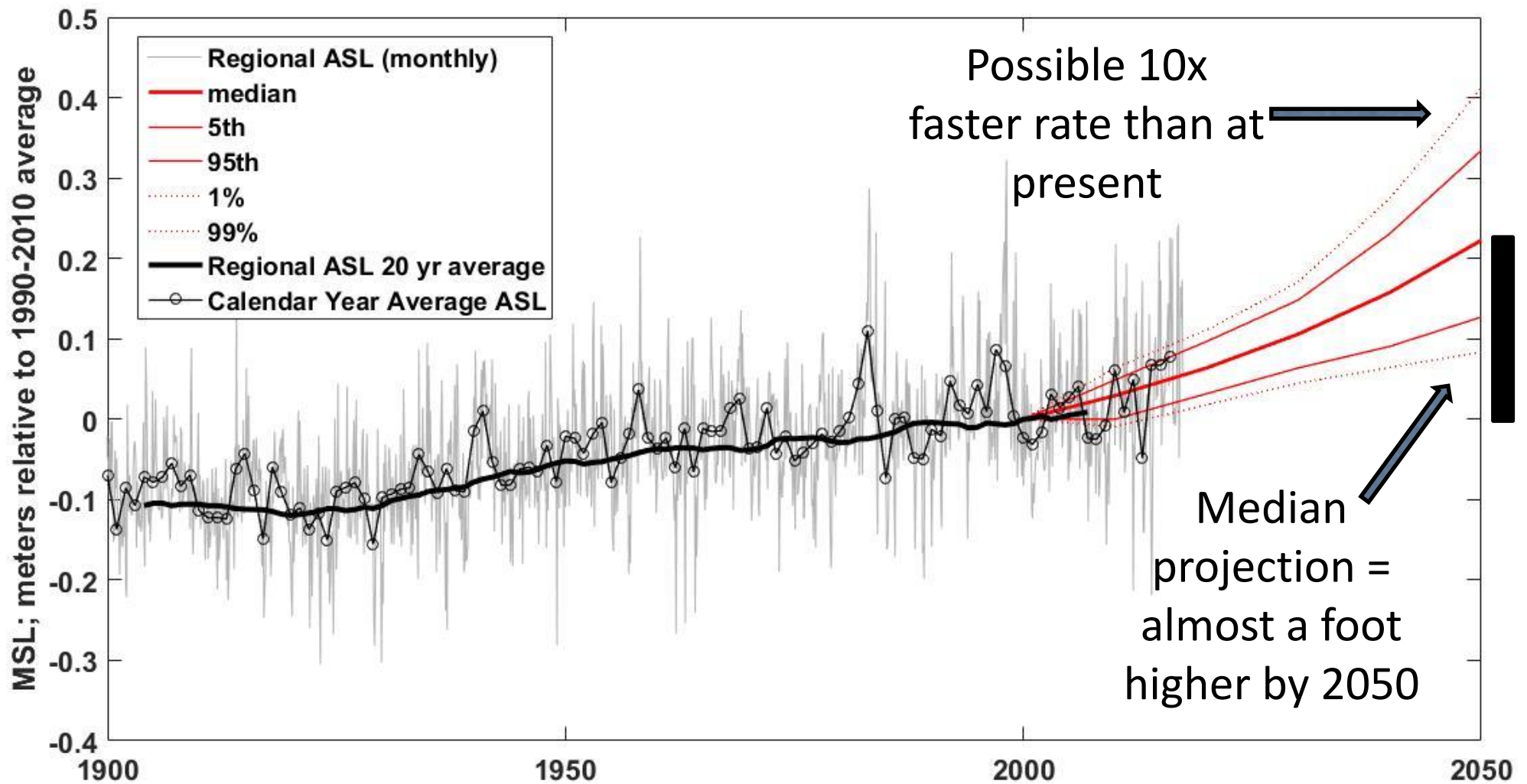


...but the global distribution of this pattern of SLR is complex, and in the PNW the rate of sea level rise has been SLOWER than the global average





“Probabilistic” Sea Level Projections



By 2050