Sea Level Rise and Coastal Flood Risk Assessment for Island County

27 September 2016

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

With Sascha Petersen and Matt Fougerat, Adapation International
And Dawn Pucci, Lori Clark and Brian Wood, Island County

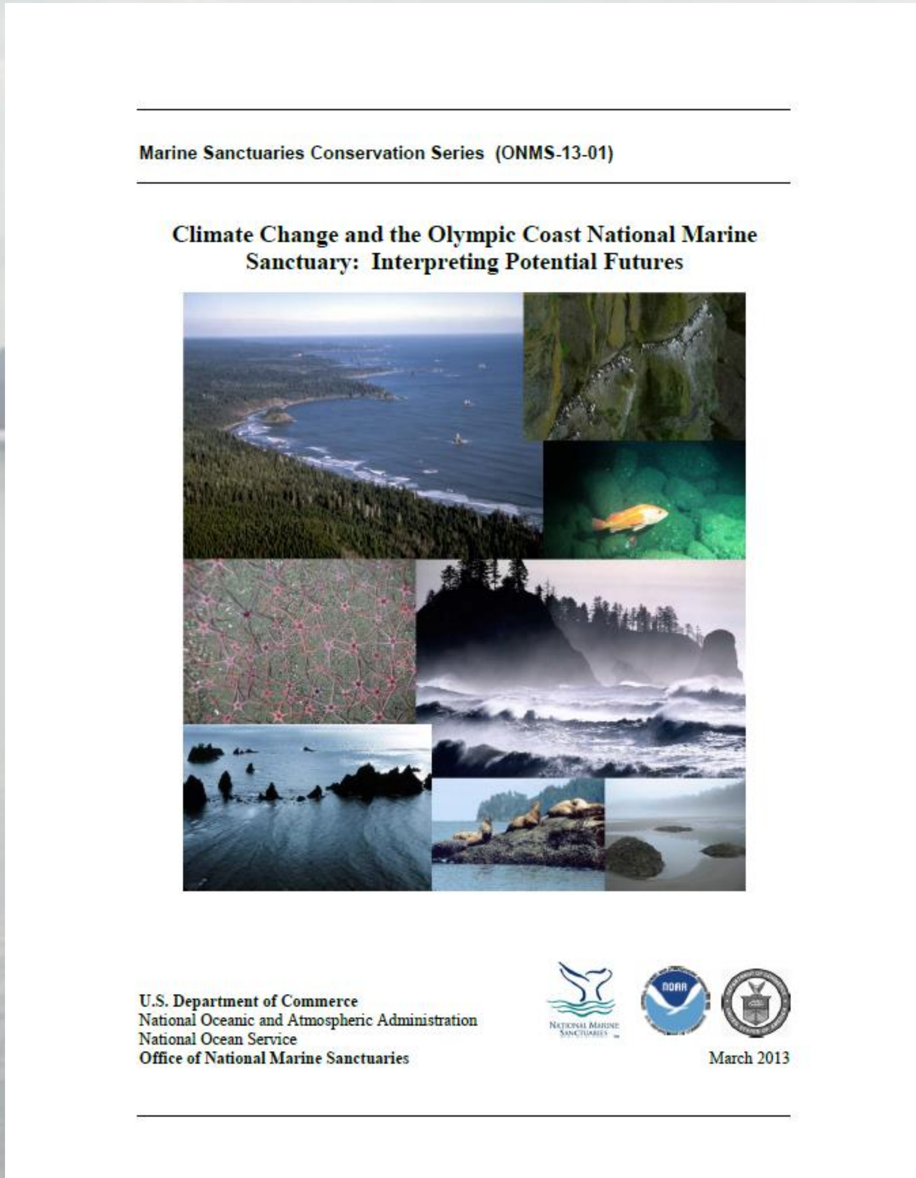
What you are in for:

- Who am I?
- The physical basis for SLR
- Our project work-flow
- Reading the projections and maps for Island County

Freeland Park, 10 March 16.
Unknown photographer, via Lori Clark

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

Coastal Impacts of Climate Change



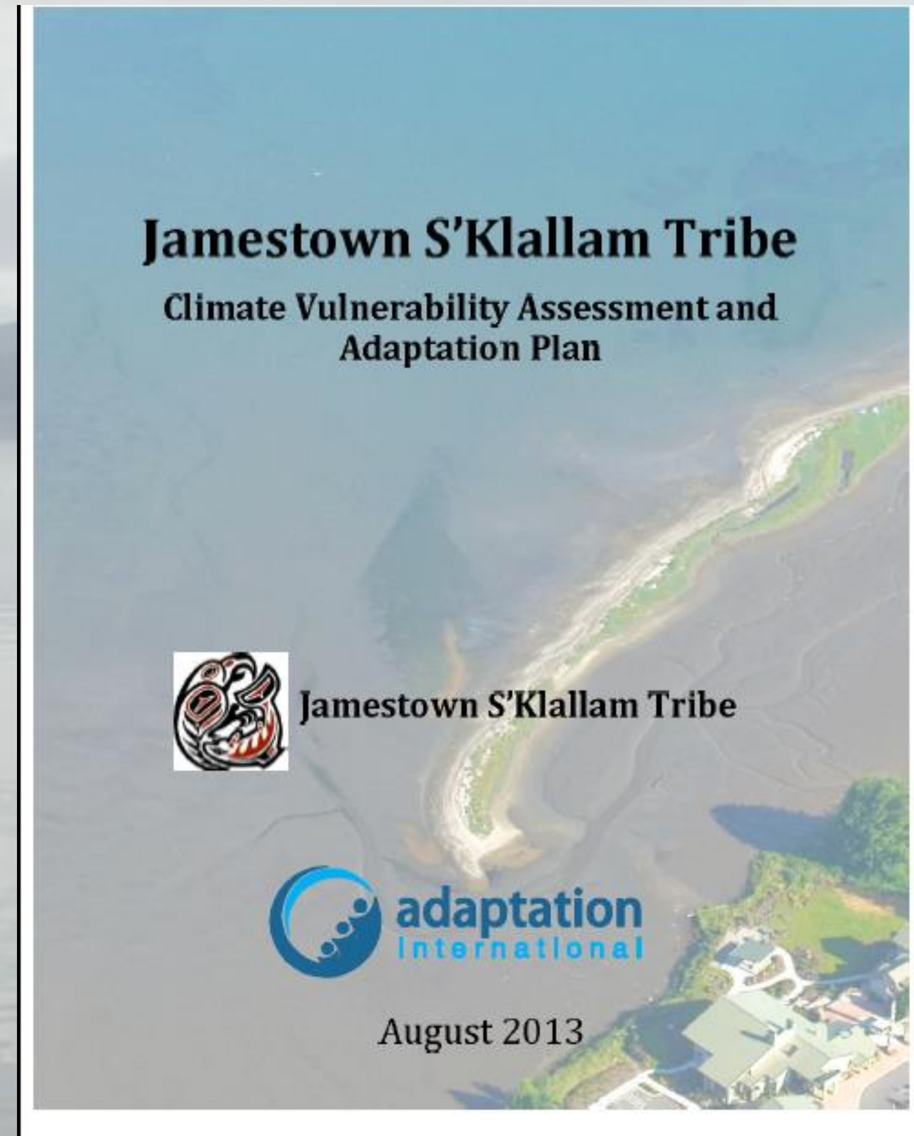
Marine Sanctuaries Conservation Series (ONMS-13-01)

Climate Change and the Olympic Coast National Marine Sanctuary: Interpreting Potential Futures

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of National Marine Sanctuaries

March 2013

http://sanctuaries.noaa.gov/science/conservation/cc_ocnms.html



Jamestown S'Klallam Tribe

Climate Vulnerability Assessment and Adaptation Plan

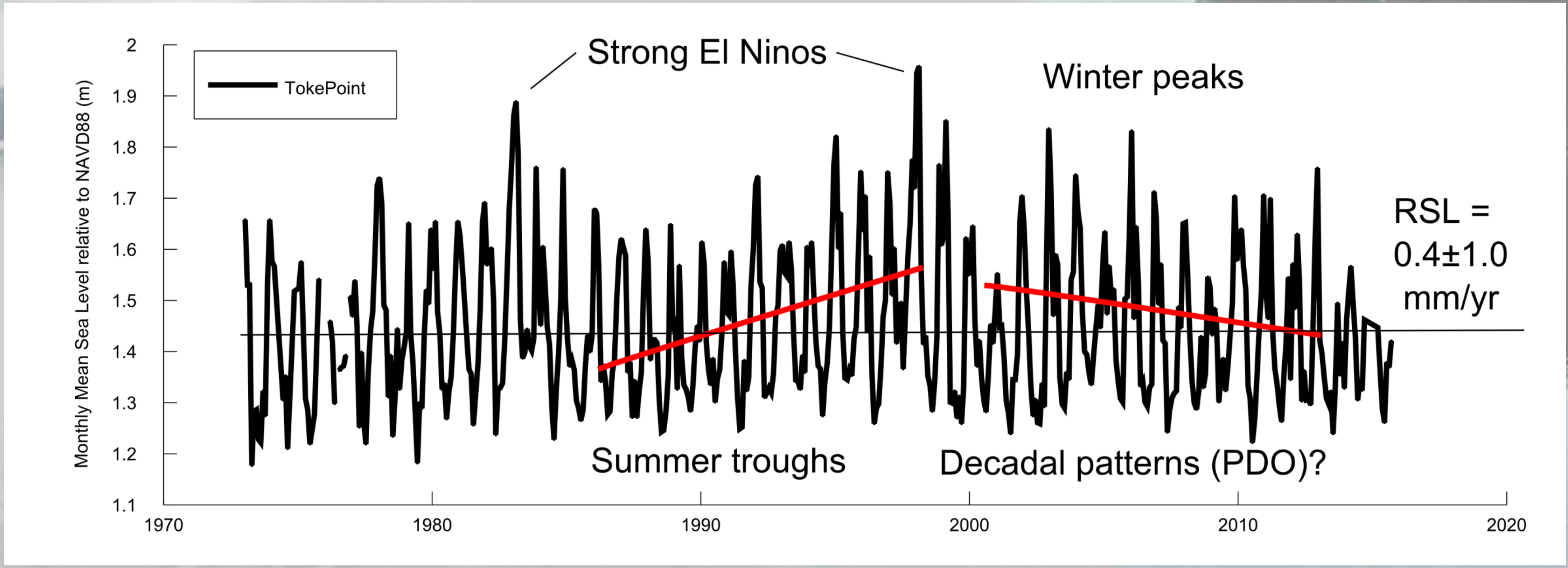
Jamestown S'Klallam Tribe

adaptation international

August 2013

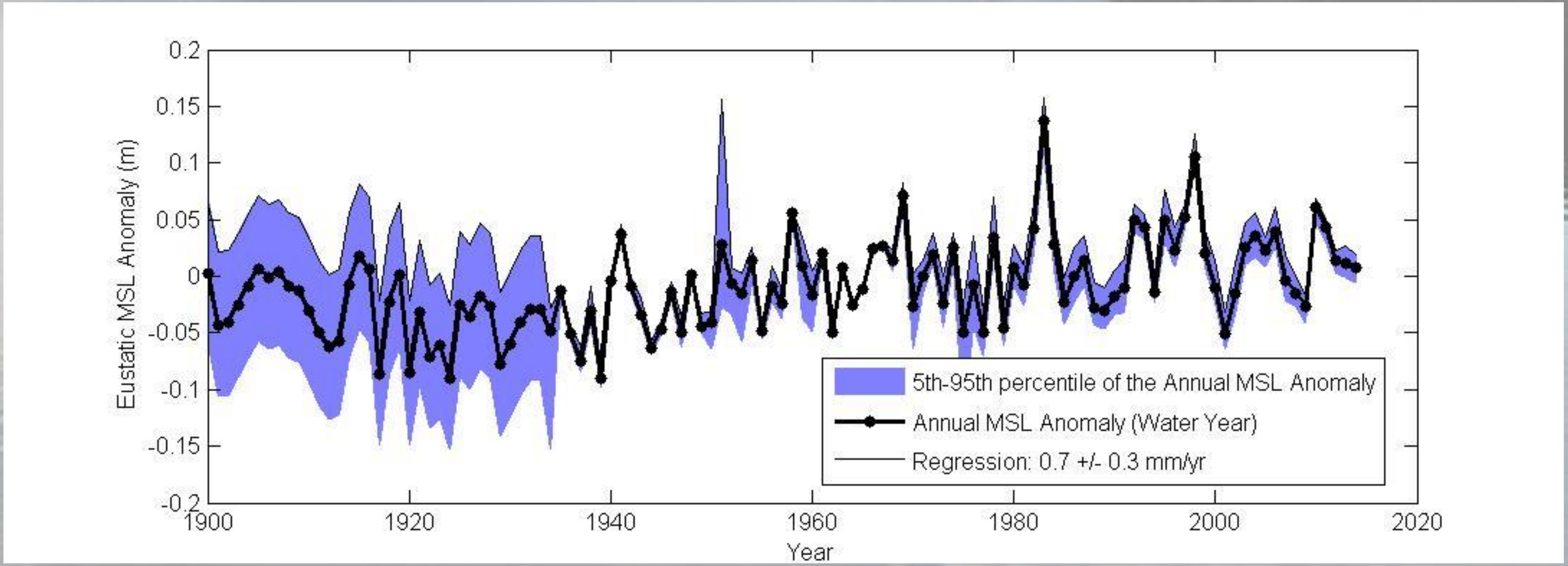
http://www.jamestowntribe.org/programs/nrs/nrs_climchg.htm

The sea is not level

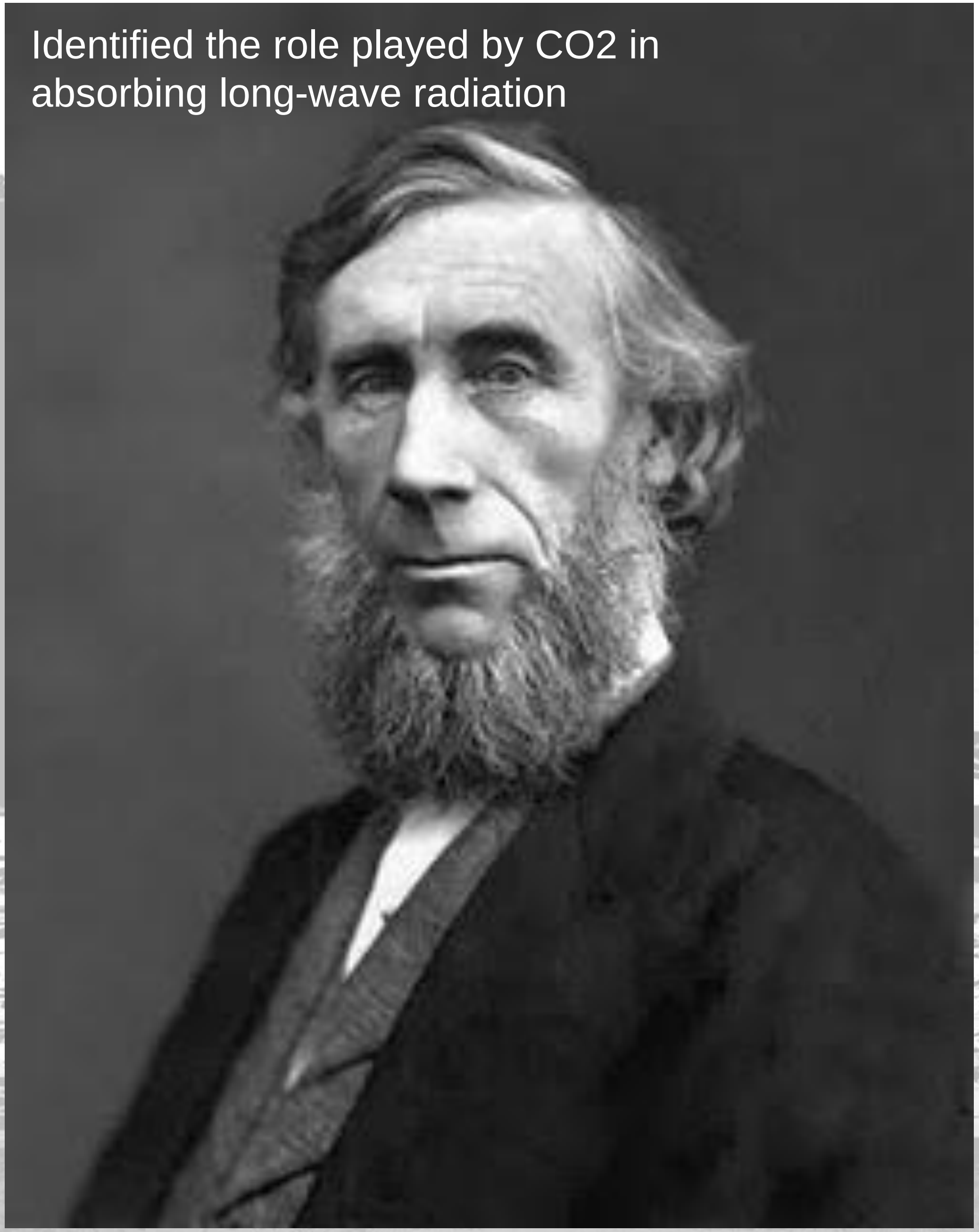


Primarily interested in multi-decadal averages

if you account for the movement of the land, average sea level is rising in our neighborhood…



Blame These Fine Looking Gentleman



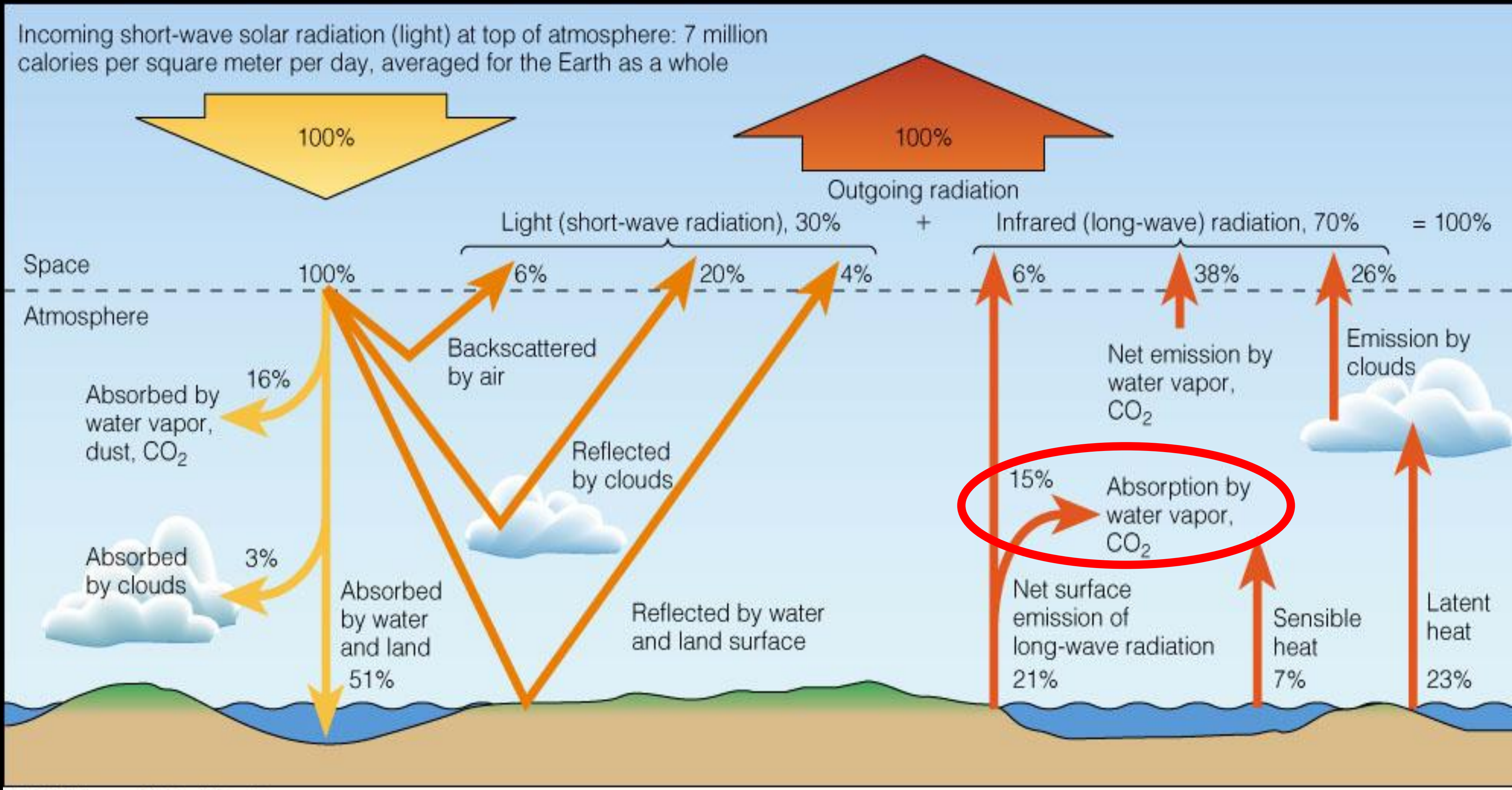
John Tyndall, 1864

Svante Arrhenius, 1894

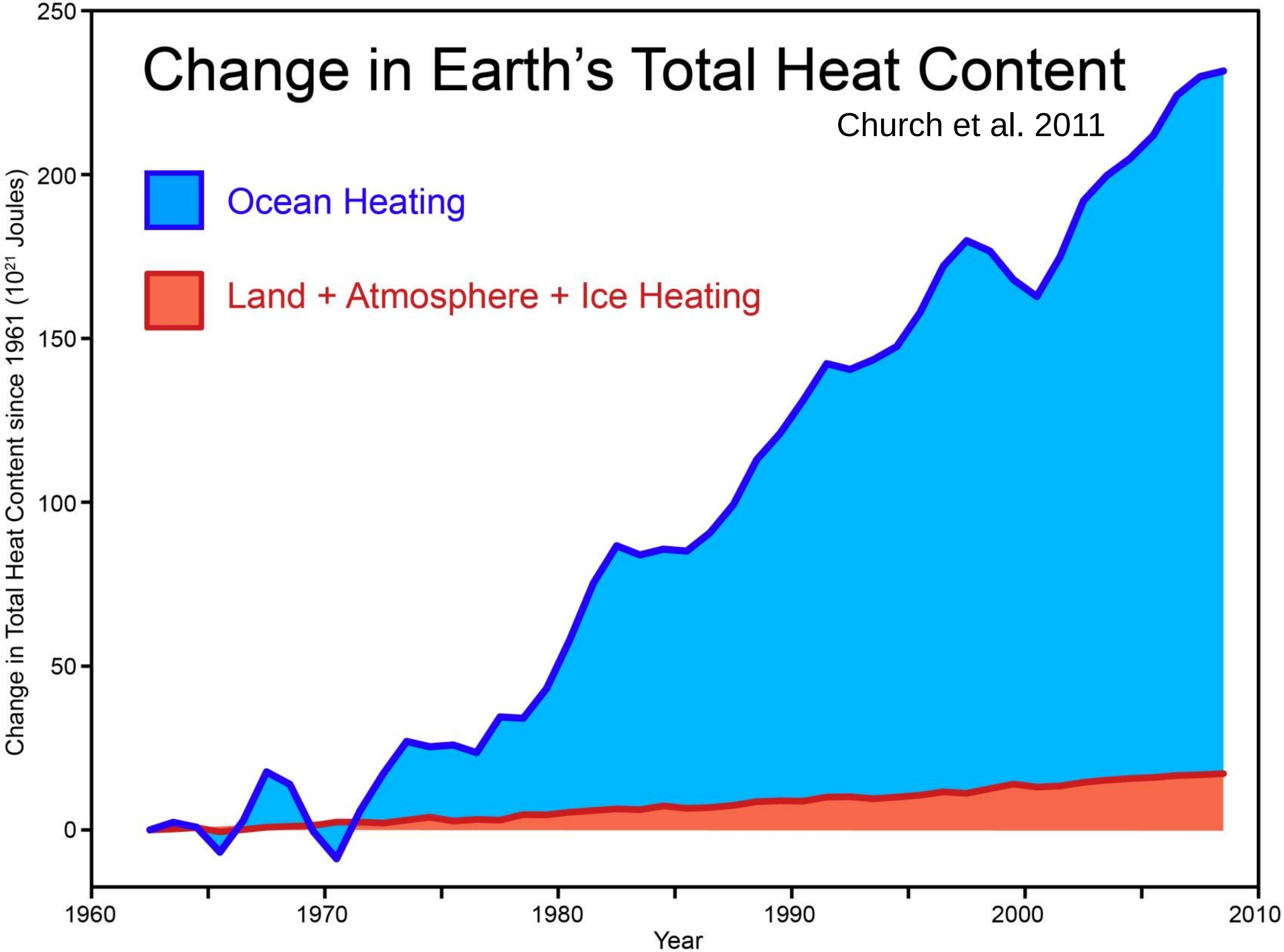
Fundamental Concept: Energy Imbalance

greenhouse gases in the atmosphere trap heat by absorbing infrared radiation (heat) emitted from the Earth:

Water vapor, carbon dioxide, methane, nitrous oxide and ozone

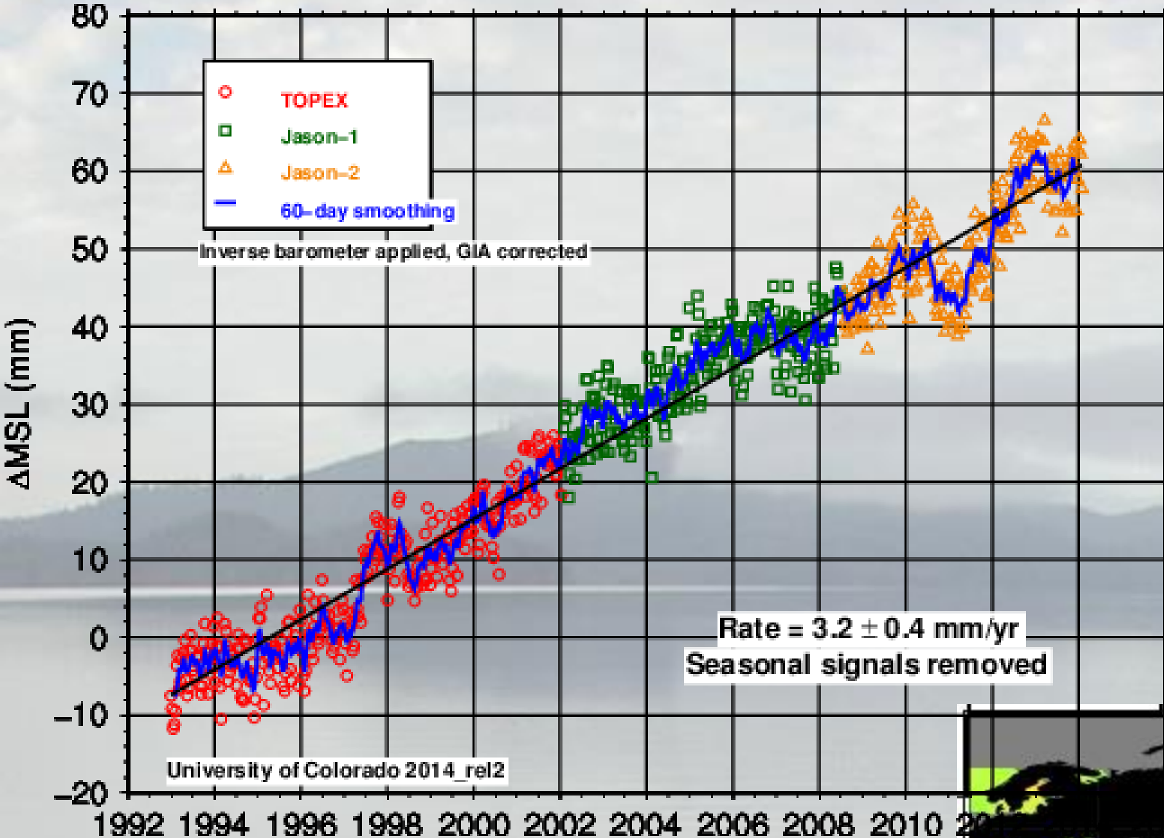


Where is the excess heat?



Heat Capacity of sea water = ~4000 J/Kg/C, 4x that of air
Mass of the ocean = 1.4 x 10^{21} kg, 280x that of the atmosphere…so ΔT is very small

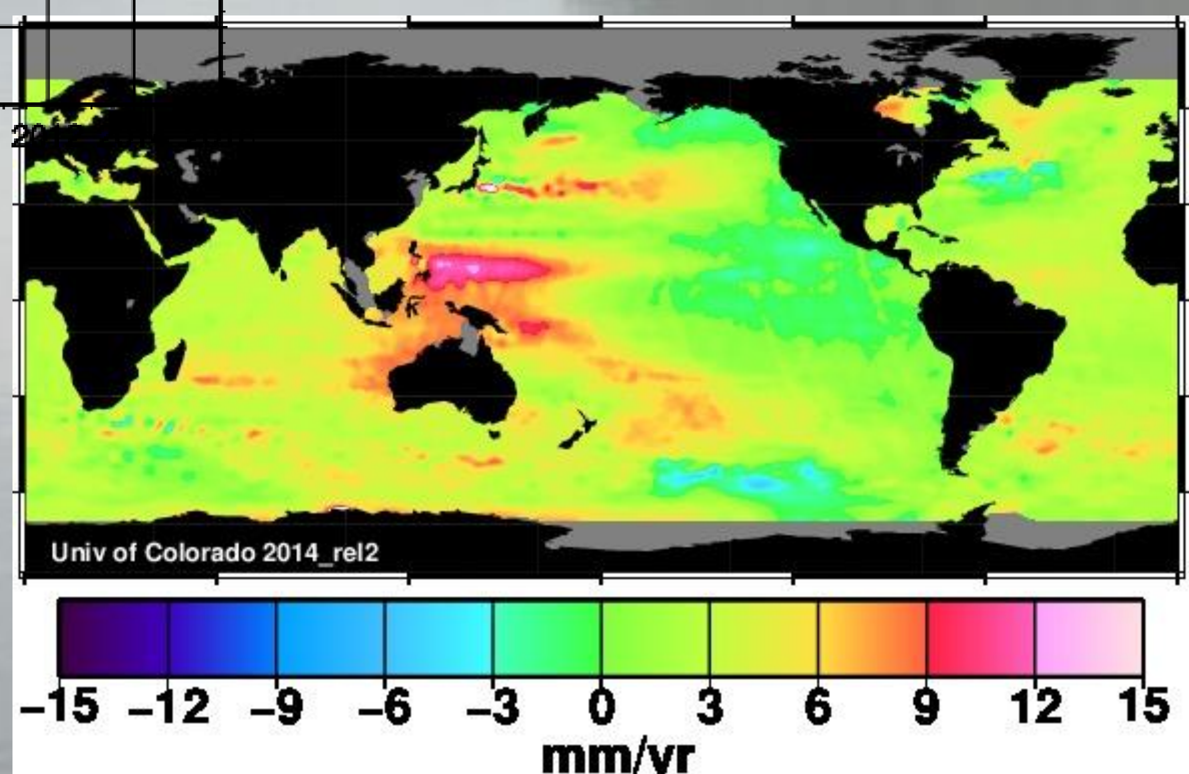
SLR is due to heat



Mean Global Sea Level (1993-present) suggests a global pattern of rising seas…

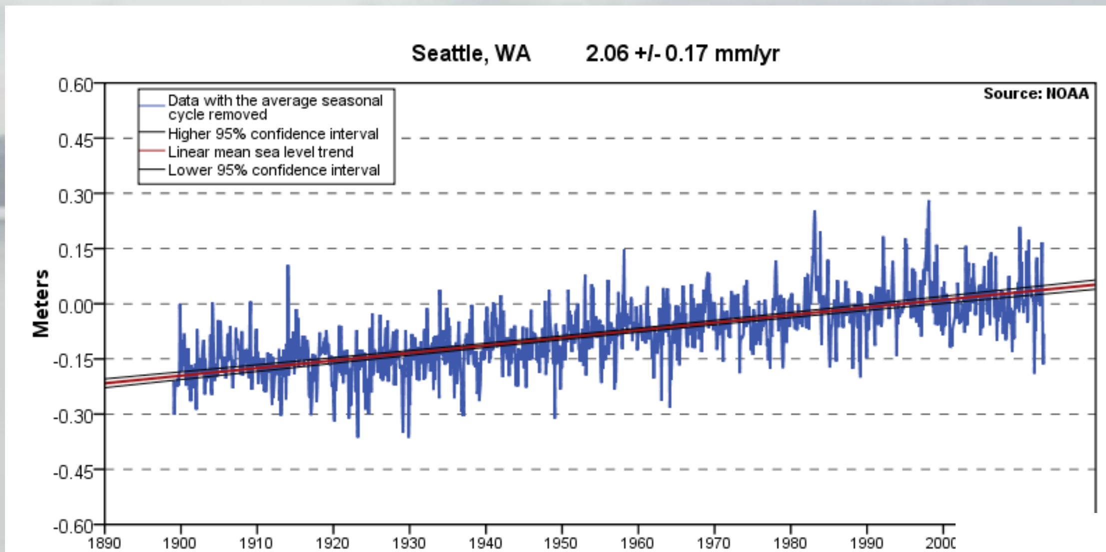
Nerem et al. 2010

…but the global distribution of this pattern of SLR is complex…and in the PNW eustatic sea level has not risen rapidly since the early 90’s (though that is changing)

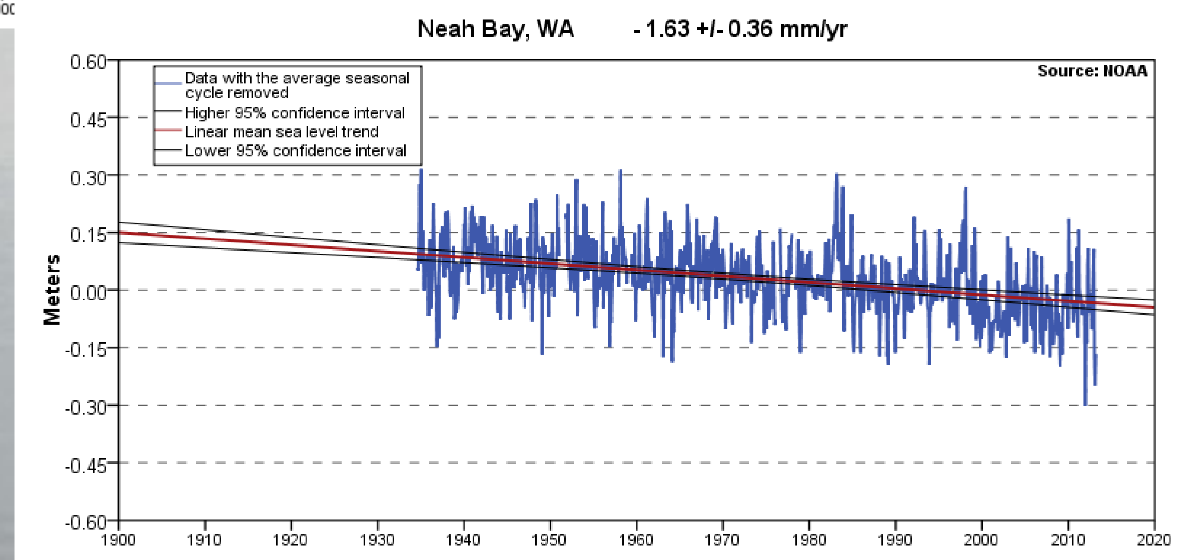


“Localized” Projections

<u>Relative Sea Level = Regional Absolute Sea Level + VLM</u>



Seattle: Where subsidence exacerbates the regional SLR pattern



Neah Bay: where VLM is likely to outpace SLR for at least the next few decades

Plots from NOAA CO-OPs

Hasn't this been done?

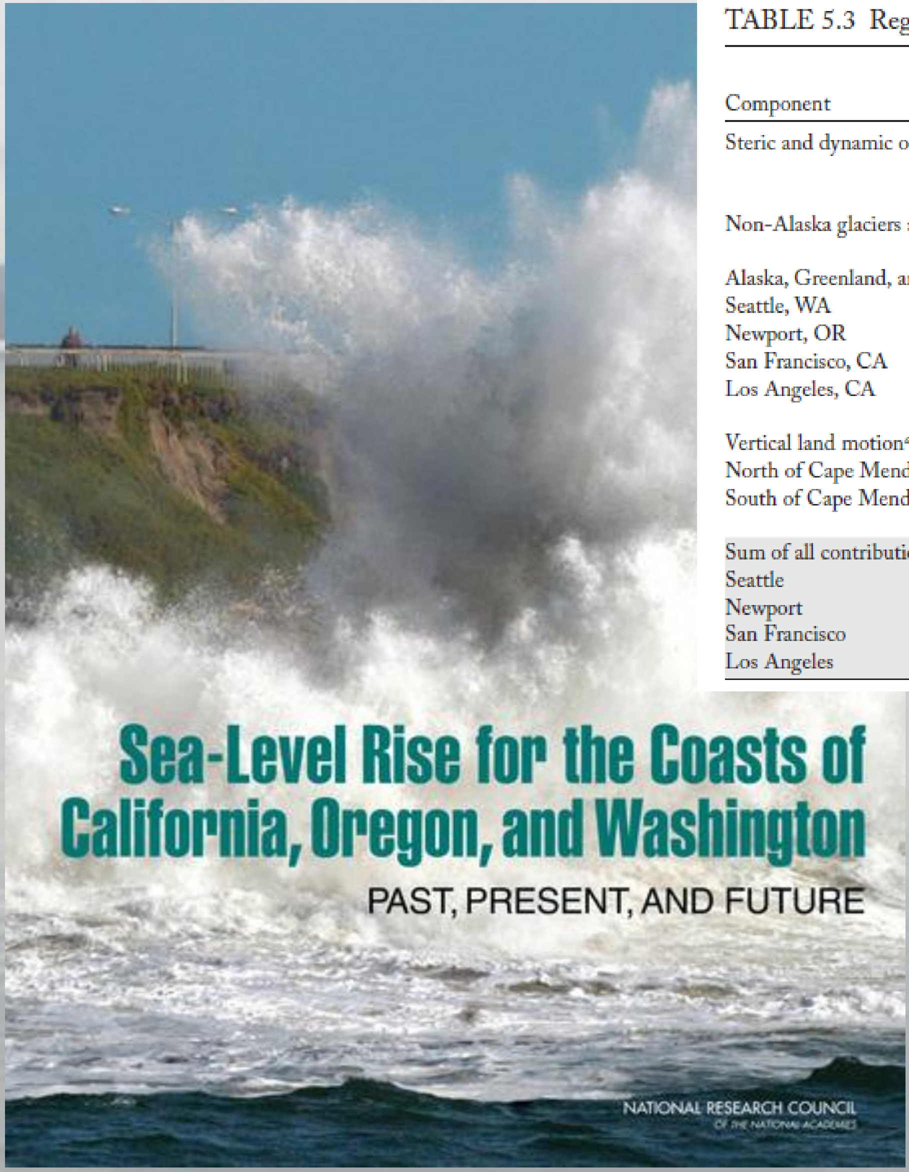


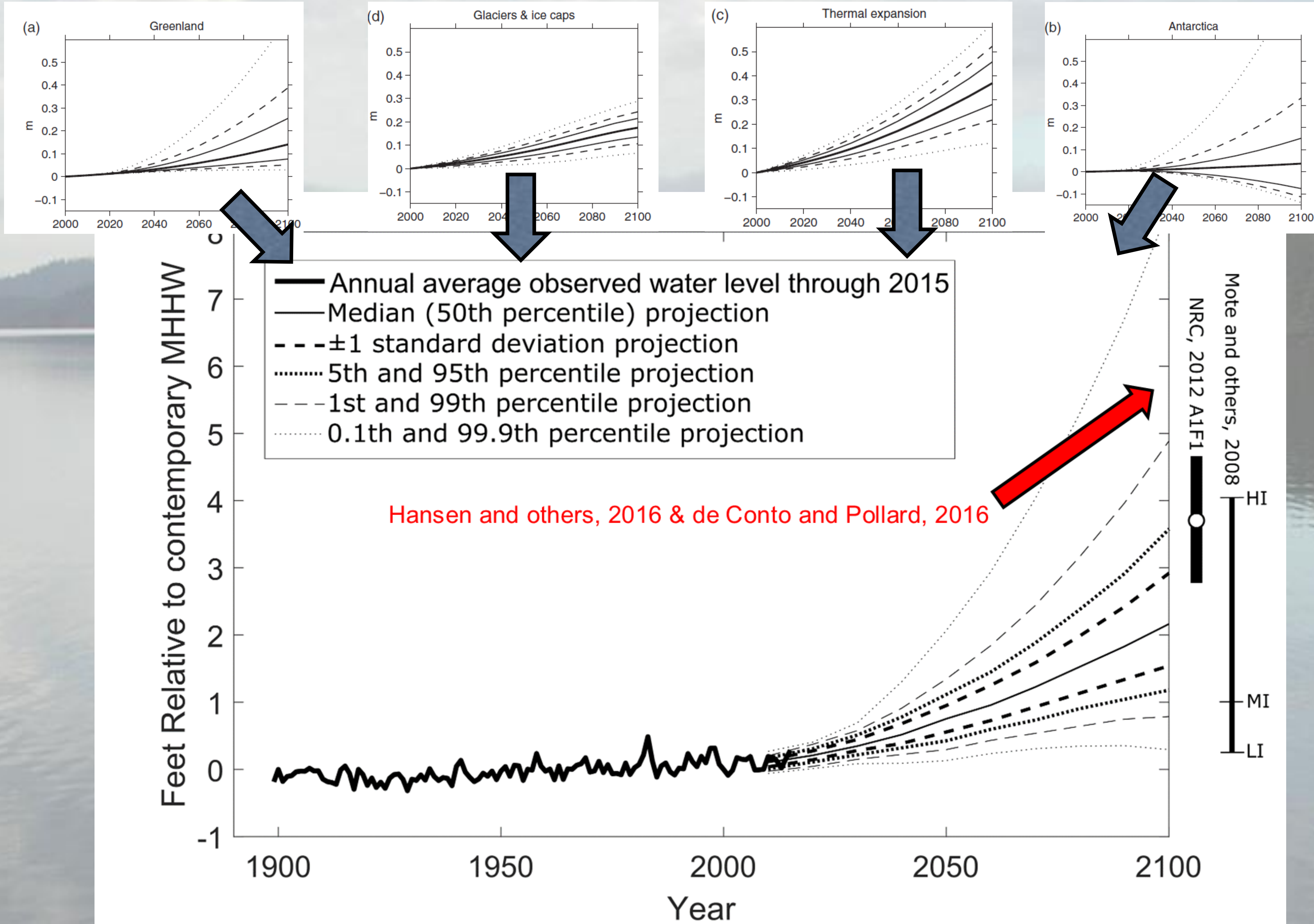
TABLE 5.3 Regional Sea-Level Rise Projections (in cm) Relative to Year 2000

	2030		2050		2100	
Component	Projection	Range	Projection	Range	Projection	Range
Steric and dynamic ocean[a]	3.6 ± 2.5	0.0–9.3 (B1–A1FI)	7.8 ± 3.7	2.2–16.1 (B1–A1FI)	20.9 ± 7.7	9.9–37.1 (B1–A1FI)
Non-Alaska glaciers and ice caps[b]	2.4 ± 0.2		4.4 ± 0.3		11.4 ± 1.0	
Alaska, Greenland, and Antarctica with sea-level fingerprint effect[c]						
Seattle, WA	7.1	5.4–9.5	16.0	11.1–22.1	52.7	32.7–74.9
Newport, OR	7.4	5.6–9.5	16.6	11.7–22.2	54.5	34.1–75.3
San Francisco, CA	7.8	6.1–9.6	17.6	12.7–22.3	57.6	37.3–76.1
Los Angeles, CA	8.0	6.3–9.6	17.9	13.0–22.3	58.5	38.6–76.4
Vertical land motion[d]						
North of Cape Mendocino	-3.0	-7.5–1.5	-5.0	-12.5–2.5	-10.0	-25.0–5.0
South of Cape Mendocino	4.5	0.6–8.4	7.5	1.0–14.0	15.0	2.0–28.0
Sum of all contributions						
Seattle	6.6 ± 5.6	-3.7–22.5	16.6 ± 10.5	-2.5–47.8	61.8 ± 29.3	10.0–143.0
Newport	6.8 ± 5.6	-3.5–22.7	17.2 ± 10.3	-2.1–48.1	63.3 ± 28.3	11.7–142.4
San Francisco	14.4 ± 5.0	4.3–29.7	28.0 ± 9.2	12.3–60.8	91.9 ± 25.5	42.4–166.4
Los Angeles	14.7 ± 5.0	4.6–30.0	28.4 ± 9.0	12.7–60.8	93.1 ± 24.9	44.2–166.5

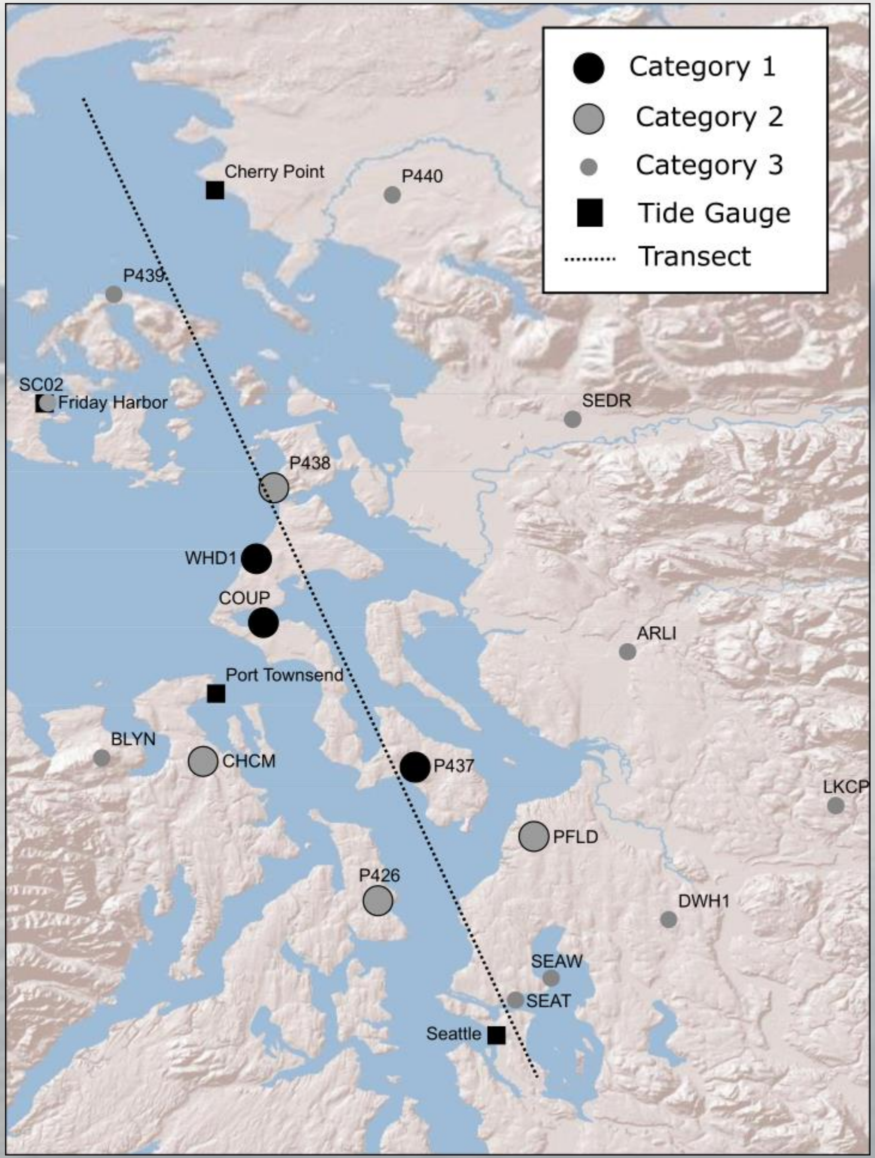
Incredibly detailed, but perhaps hard to digest?

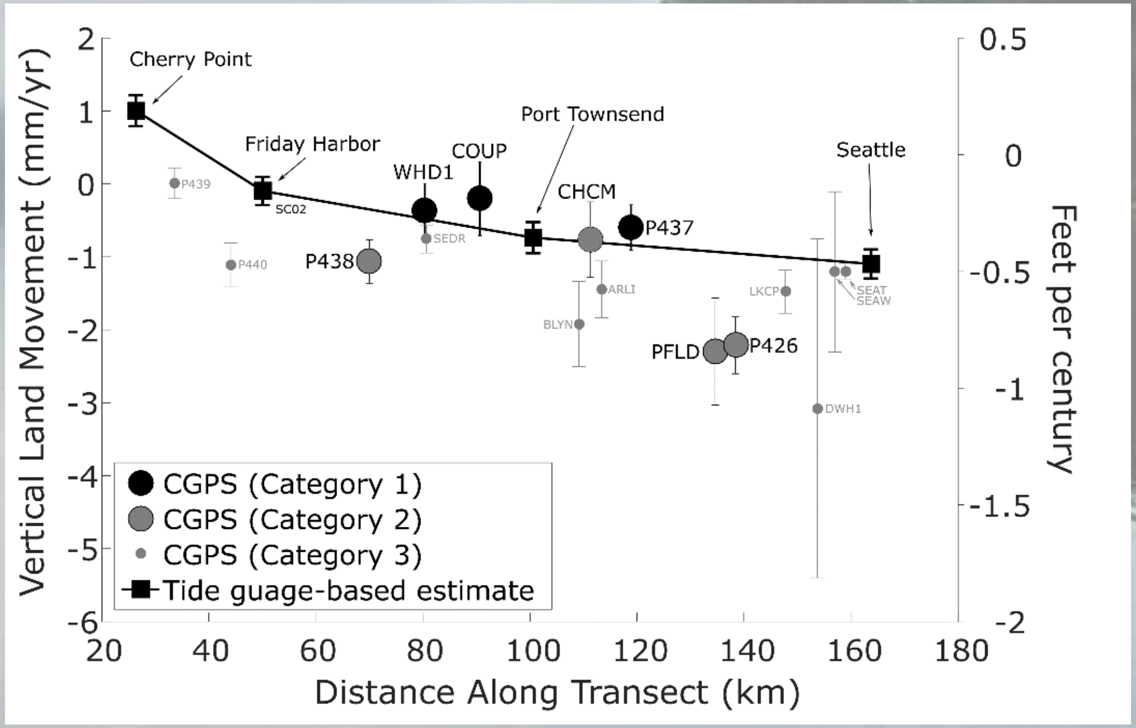
"Regionalized" VLM, so sort of glossed over variability in Washington

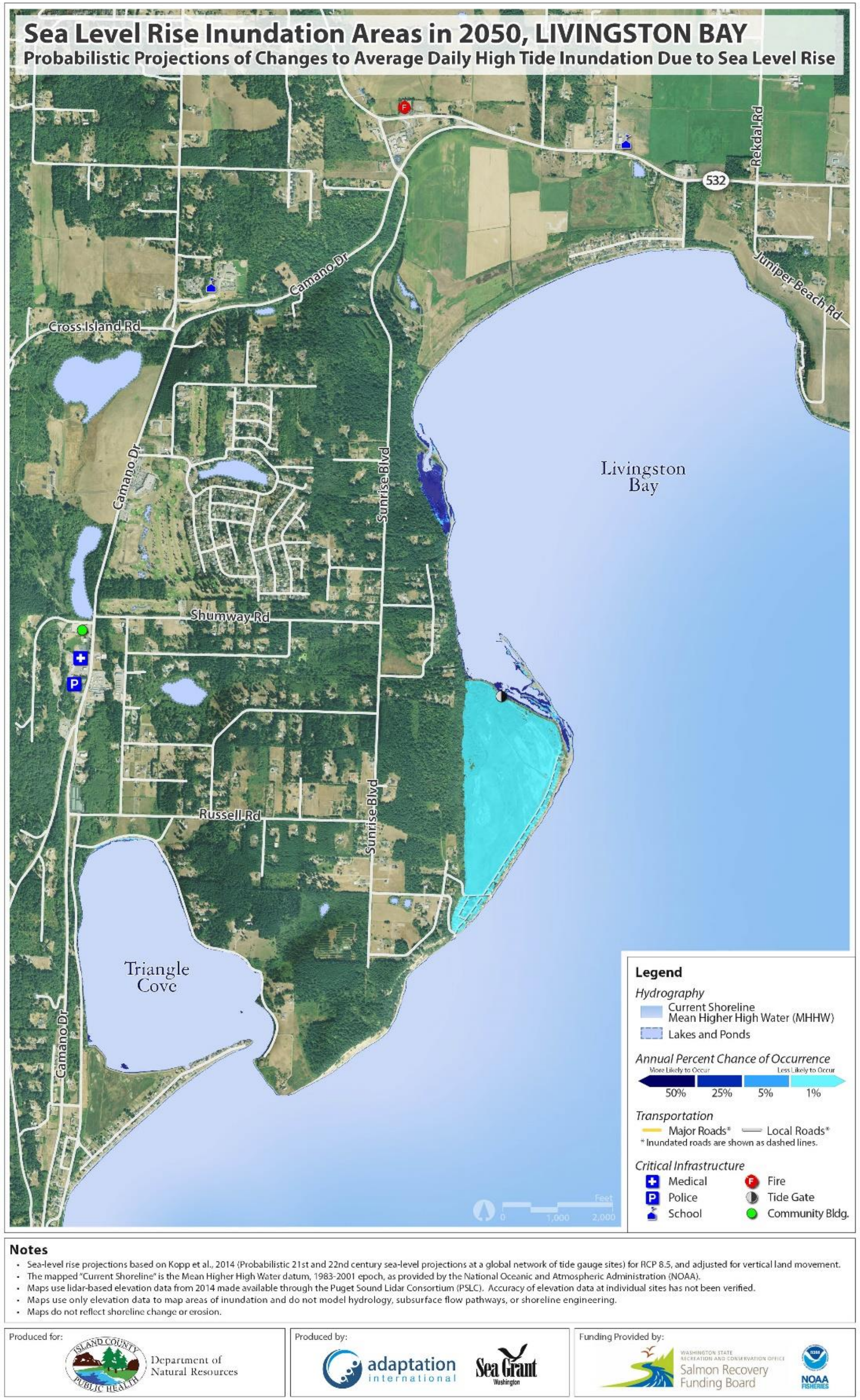
For Island County: Start with "regionalized" probabilistic projections



Island County VLM





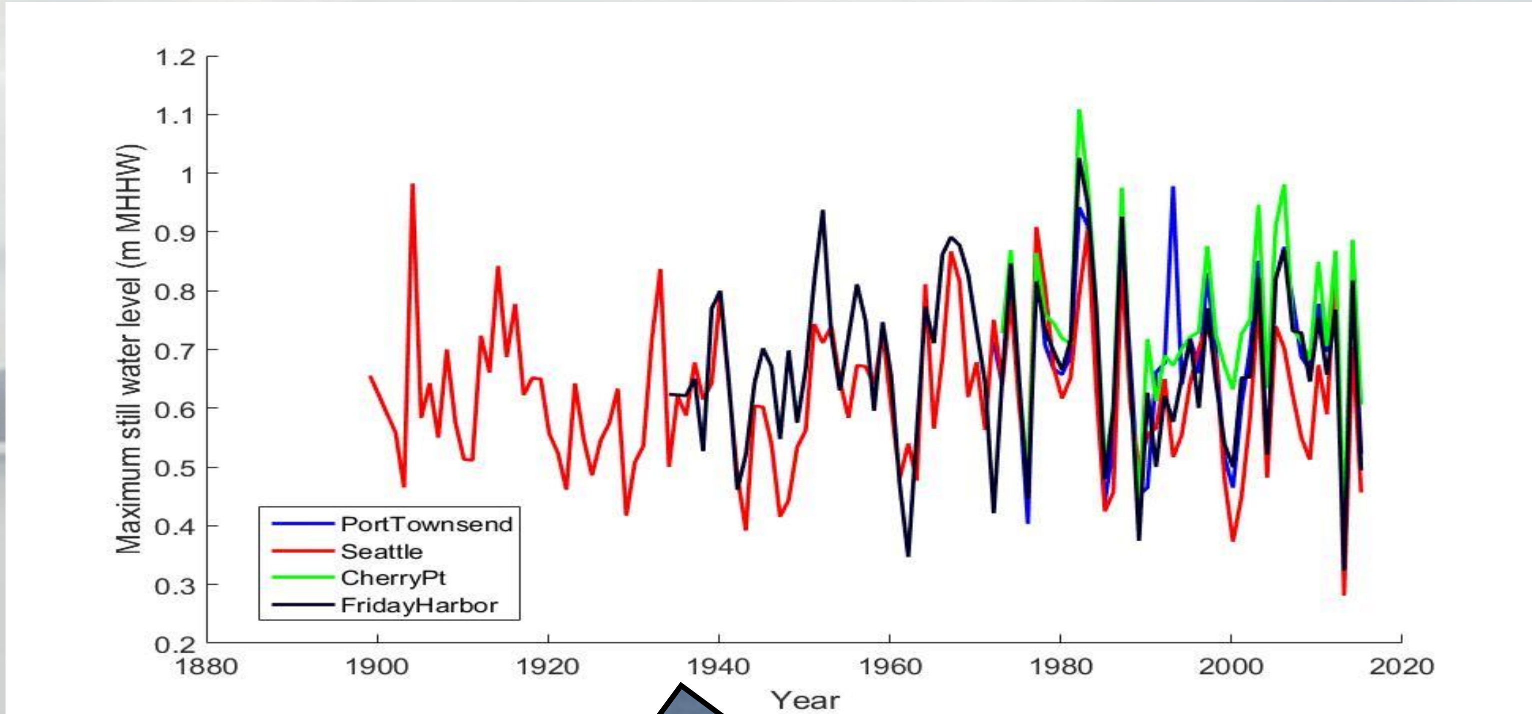


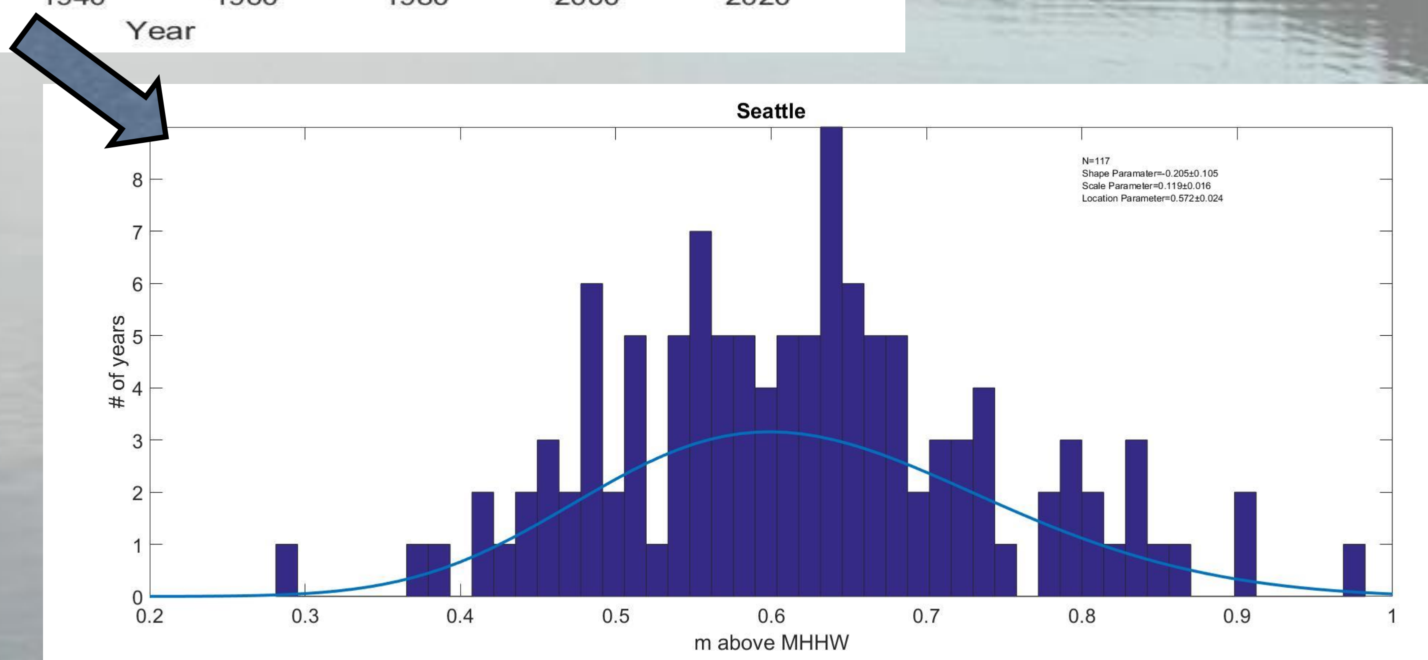
Projections and Mapping

	Probability of Exceedance									
YEAR	99.9	99	95	75	50	25	5	1	0.2	0.1
2010	-0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3
2020	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4
2030	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.6	0.7
2040	0.1	0.2	0.3	0.5	0.6	0.6	0.8	0.9	1.1	1.3
2050	0.1	0.3	0.5	0.6	0.8	0.9	1.1	1.4	1.7	2.1
2060	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.9	2.5	3.0
2070	0.3	0.6	0.8	1.1	1.3	1.5	1.9	2.5	3.4	4.1
2080	0.4	0.7	0.9	1.3	1.6	1.9	2.4	3.2	4.5	5.3
2090	0.4	0.7	1.1	1.5	1.9	2.2	3.0	4.0	5.8	6.8
2100	0.3	0.8	1.2	1.8	2.2	2.7	3.6	4.9	7.1	8.4
2110	0.8	1.1	1.4	1.9	2.4	2.9	3.9	5.6	8.4	9.8
2120	0.9	1.2	1.6	2.2	2.7	3.3	4.6	6.7	10.1	11.8
2130	0.9	1.3	1.7	2.4	3.0	3.7	5.3	7.8	11.8	13.8
2140	0.9	1.4	1.9	2.7	3.3	4.2	6.0	8.9	13.6	16.1
2150	0.9	1.4	2.0	2.9	3.7	4.6	6.8	10.1	15.7	18.5

Its not just about average sea level

Annual extreme water level projections





Extreme "Still" Water Level Projections

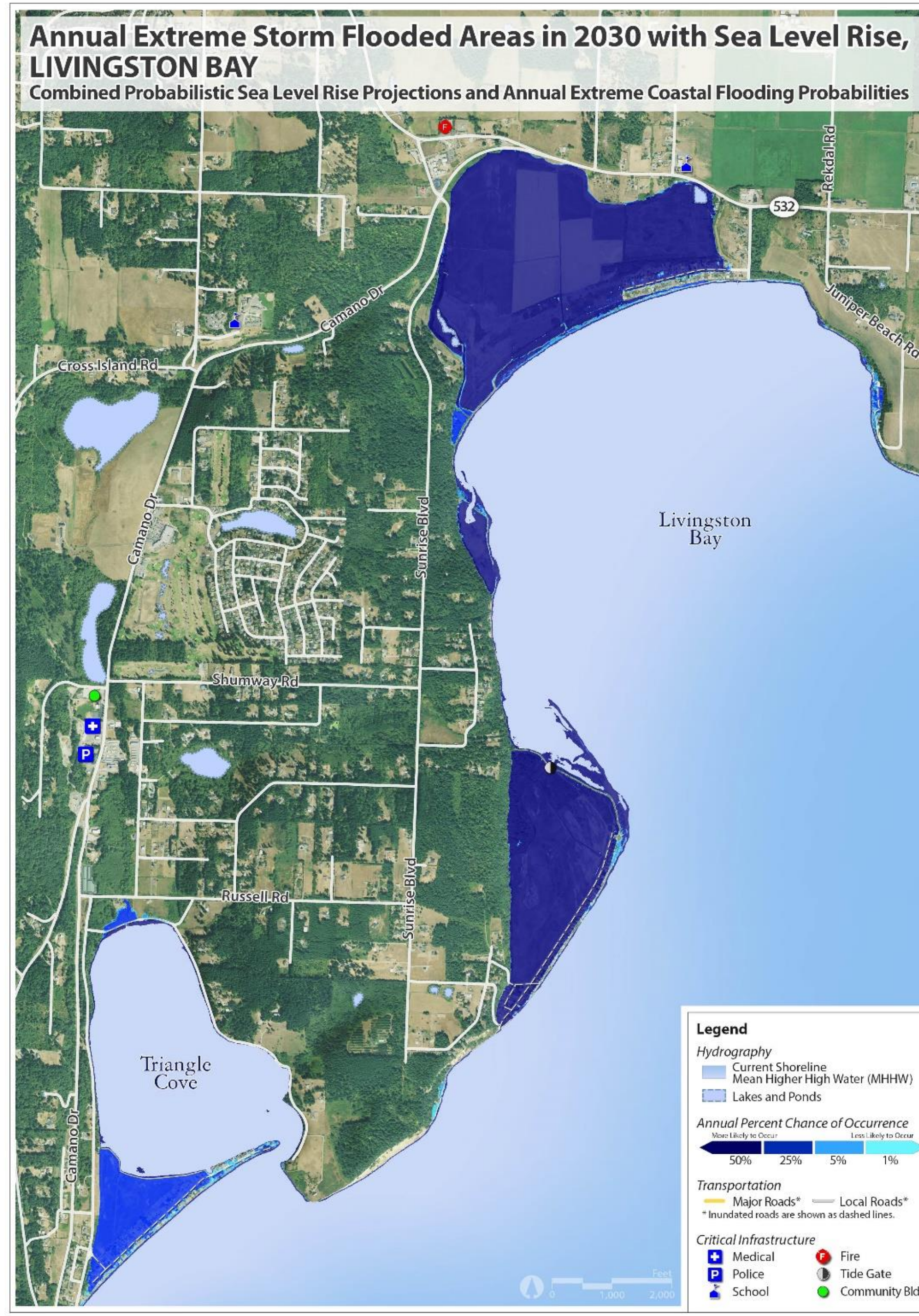
*Table 2. **Annual extreme still water level projections for Island County, Washington for RCP 8.5** relative to the current MHHW tidal datum (1983-2001 epoch), accounting for the climatically-controlled components of sea level change, coupled with vertical land movement, and GIA-driven sea level change, and the modelled distribution of annual extreme water level based on historic records from four tide gauges. Numbers are in feet above the current MHHW level.*

	Probability of Exceedance (RCP8.5)									
YEAR	**99.9**	**99**	**95**	**75**	**50**	**25**	**5**	**1**	**0.2**	**0.1**
Current	0.9	1.2	1.5	1.9	2.2	2.6	3.0	3.2	3.4	3.4
2010	1.0	1.3	1.6	2.0	2.3	2.6	3.1	3.3	3.5	3.5
2020	1.1	1.4	1.7	2.1	2.4	2.8	3.2	3.5	3.6	3.7
2030	1.2	1.5	1.8	2.3	2.6	2.9	3.4	3.6	3.8	3.8
2040	1.3	1.7	2.0	2.4	2.8	3.1	3.6	3.8	4.0	4.1
2050	1.5	1.8	2.2	2.6	3.0	3.3	3.8	4.2	4.5	4.7
2060	1.7	2.0	2.4	2.9	3.2	3.6	4.1	4.5	5.0	5.3
2070	1.8	2.2	2.6	3.1	3.5	3.9	4.5	5.0	5.8	6.4
2080	2.0	2.4	2.8	3.4	3.8	4.2	4.9	5.7	6.9	7.7
2090	2.1	2.5	3.0	3.6	4.1	4.6	5.4	6.4	8.0	9.2
2100	2.2	2.7	3.2	3.9	4.4	5.0	6.0	7.3	9.3	10.9
2110	2.4	2.9	3.3	4.1	4.6	5.2	6.3	7.9	10.6	12.0
2120	2.6	3.1	3.6	4.3	4.9	5.6	7.0	9.0	12.1	14.3
2130	2.7	3.2	3.7	4.6	5.2	6.0	7.6	10.0	14.0	15.9
2140	2.6	3.3	3.9	4.8	5.6	6.4	8.4	11.1	15.8	18.0
2150	2.7	3.3	4.0	5.1	5.9	6.9	9.1	12.4	17.8	20.5

Notes

- The mapped "Current Shoreline" is the Mean Higher High Water datum, 1983-2001 epoch, as provided by the National Oceanic and Atmospheric Administration (NOAA).
- Maps use lidar-based elevation data from 2014 made available through the Puget Sound Lidar Consortium (PSLC). Accuracy of elevation data at individual sites has not been verified.
- Maps use only elevation data to map areas of inundation and do not model hydrology, subsurface flow pathways, or shoreline engineering.
- Maps do not reflect shoreline change or erosion.

Produced for: Island County Public Health Department of Natural Resources
Produced by: adaptation international, Sea Grant Washington
Funding Provided by: Washington State Recreation and Conservation Office Salmon Recovery Funding Board, NOAA Fisheries



Notes

- Sea-level rise projections based on Kopp et al., 2014 (Probabilistic 21st and 22nd century sea-level projections at a global network of tide gauge sites) for RCP 8.5, and adjusted for vertical land movement.
- The mapped "Current Shoreline" is the Mean Higher High Water datum, 1983-2001 epoch, as provided by the National Oceanic and Atmospheric Administration (NOAA).
- Maps use lidar-based elevation data from 2014 made available through the Puget Sound Lidar Consortium (PSLC). Accuracy of elevation data at individual sites has not been verified.
- Maps use only elevation data to map areas of inundation and do not model hydrology, subsurface flow pathways, or shoreline engineering.
- Maps do not reflect shoreline change or erosion.
- Maps do not reflect the additional flood risk associated with waves in elevating water level during storms (applies to the *Annual Extreme Storm Flooded Areas with Sea Level Rise* map only).
- Annual extreme flooding probabilities derived from historical data collected at nearby NOAA tide stations and do not take into account possible climate-related changes to storminess patterns.

Produced for: Island County Public Health Department of Natural Resources
Produced by: adaptation international, Sea Grant Washington
Funding Provided by: Washington State Recreation and Conservation Office Salmon Recovery Funding Board, NOAA Fisheries

Gaps and Needs

Impacts Assessment

- Waves
- Erosion
- Groundwater Interactions (i.e. intrusion)
- Bluff Failure
- Critical Habitat

Ian Miller, PhD
Coastal Hazards Specialist
Olympic Peninsula Field Office
immiller@u.washington.edu
360 417 6460

Sea Grant Washington

New "Regional Resilience" Project

CLIMATE IMPACTS GROUP
Sea Grant Washington
DEPARTMENT OF ECOLOGY State of Washington
USGS science for a changing world
ISLAND COUNTY
UNIVERSITY of WASHINGTON
The Nature Conservancy
City of Tacoma WASHINGTON
WESTERN WASHINGTON UNIVERSITY

Will:

- Support an updated sea level rise and storm surge assessment for coastal Washington
- Develop better information on the contribution of waves and shoreline change to the changing community hazard profile
- Build climate resilience principles into state agency processes and plans
- Look for resilience benefit from ecological restoration investments in Puget Sound
- Create outreach tools, including "Resilience Ambassadors", to facilitate implementation of resilience projects and plans

Thank you!

Ian Miller, PhD
Coastal Hazards Specialist
Olympic Peninsula Field Office
immiller@u.washington.edu
360 417 6460