SKAGIT CLIMATE SCIENCE CONSORTIUM

Sea-Level Rise Impact Pathways In the Skagit River-Delta

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Roger Fuller, The Nature Conservancy

November 28, 2012

WSU, Mt. Vernon

Outline

I. What we know about sea-level rise

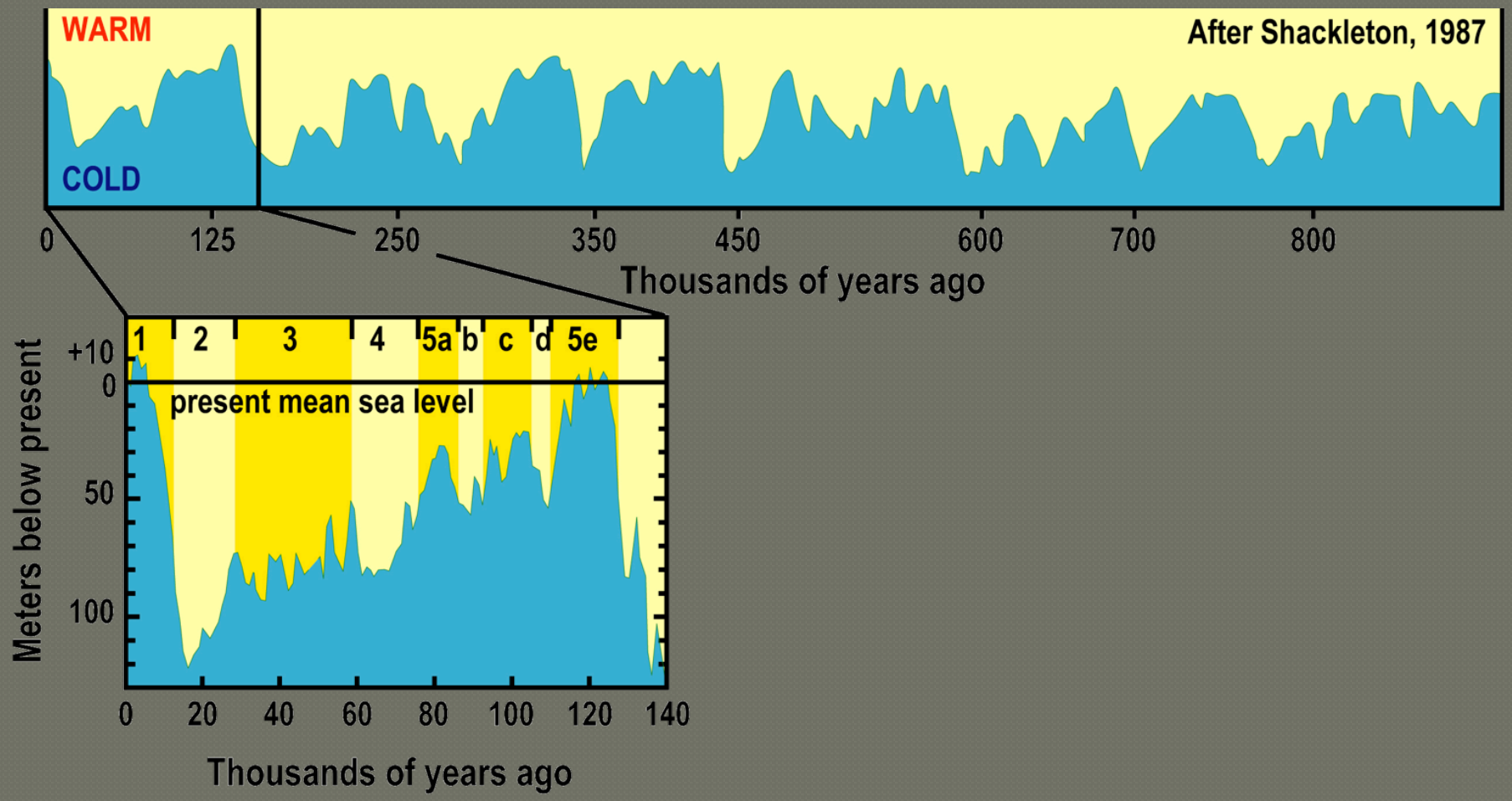
II. Components of coastal flooding and inundation

III. Impact pathways

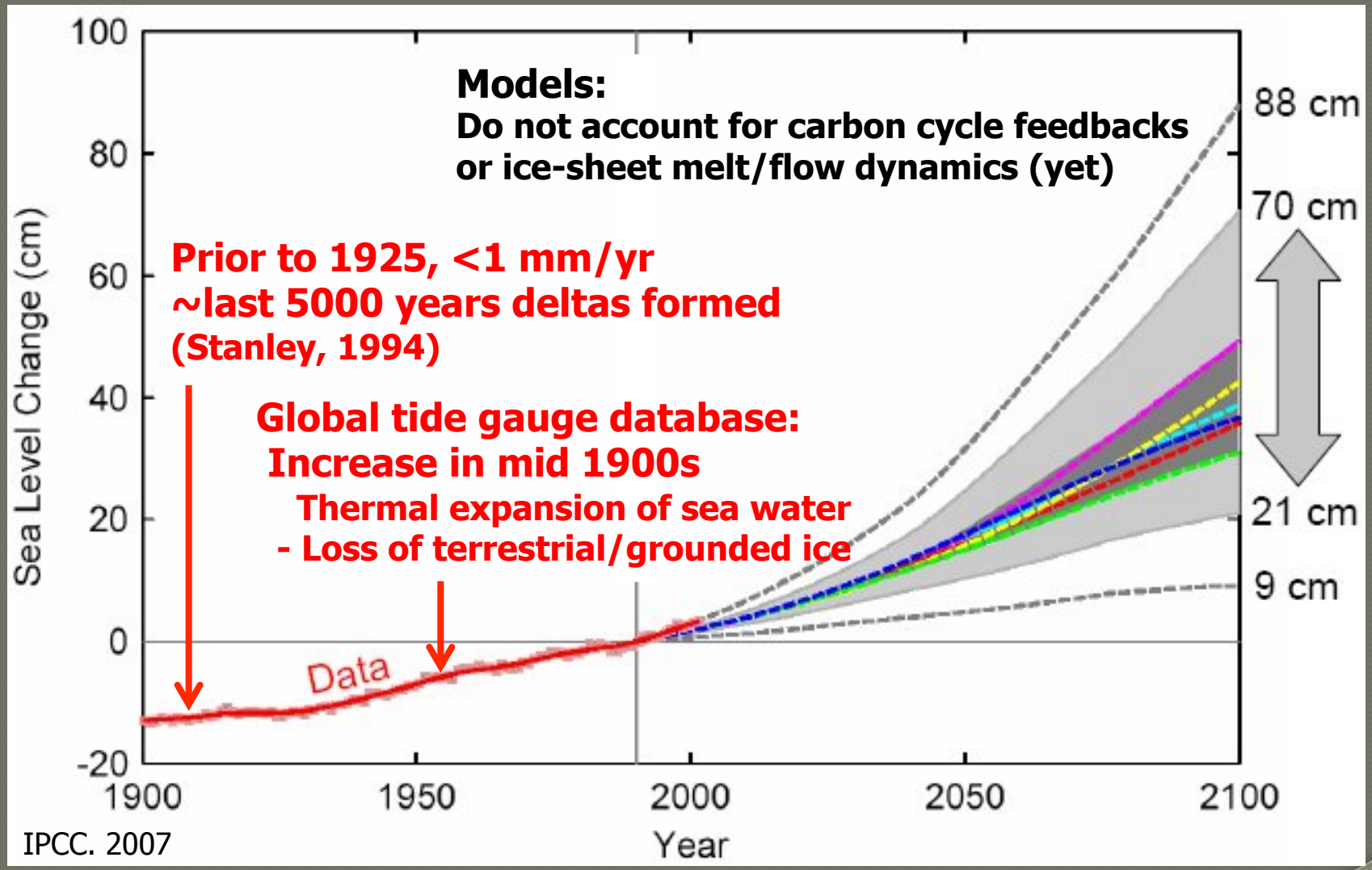
IV. Risk to infrastructure, ecosystems, communities

V. Tools to evaluate vulnerability, predict impacts

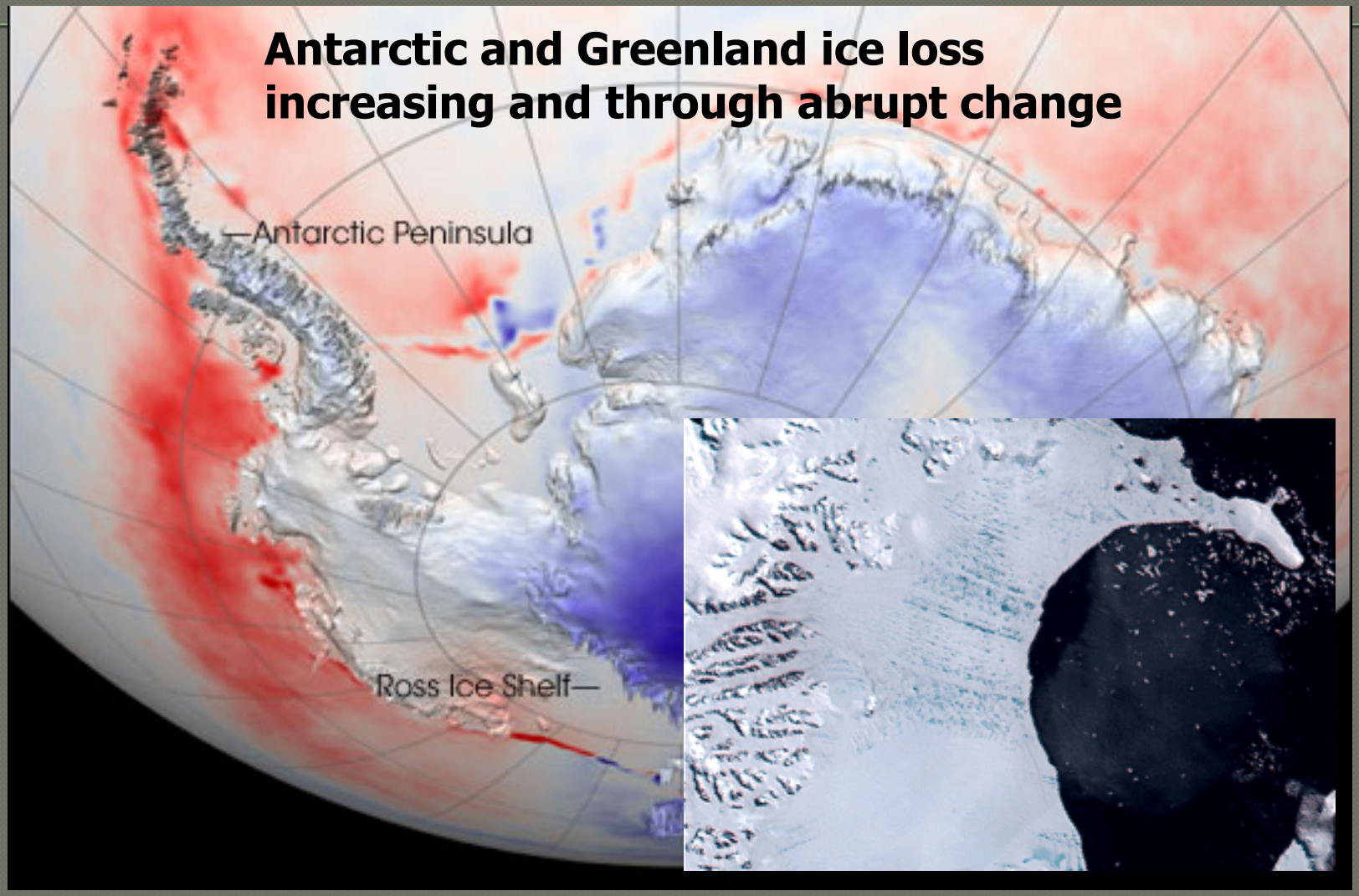
Sea Level Rise



Sea Level Rise

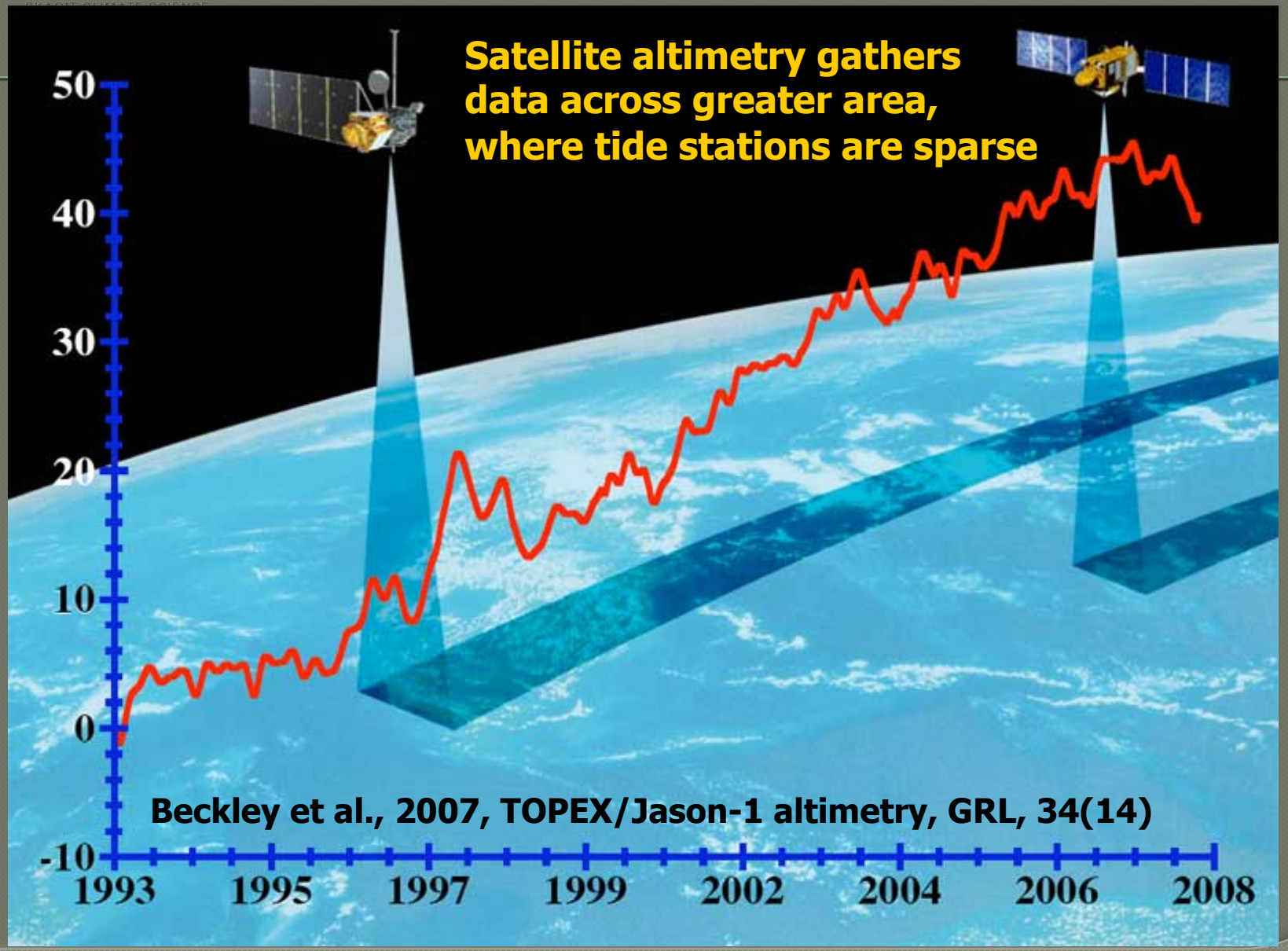


Sea Level Rise

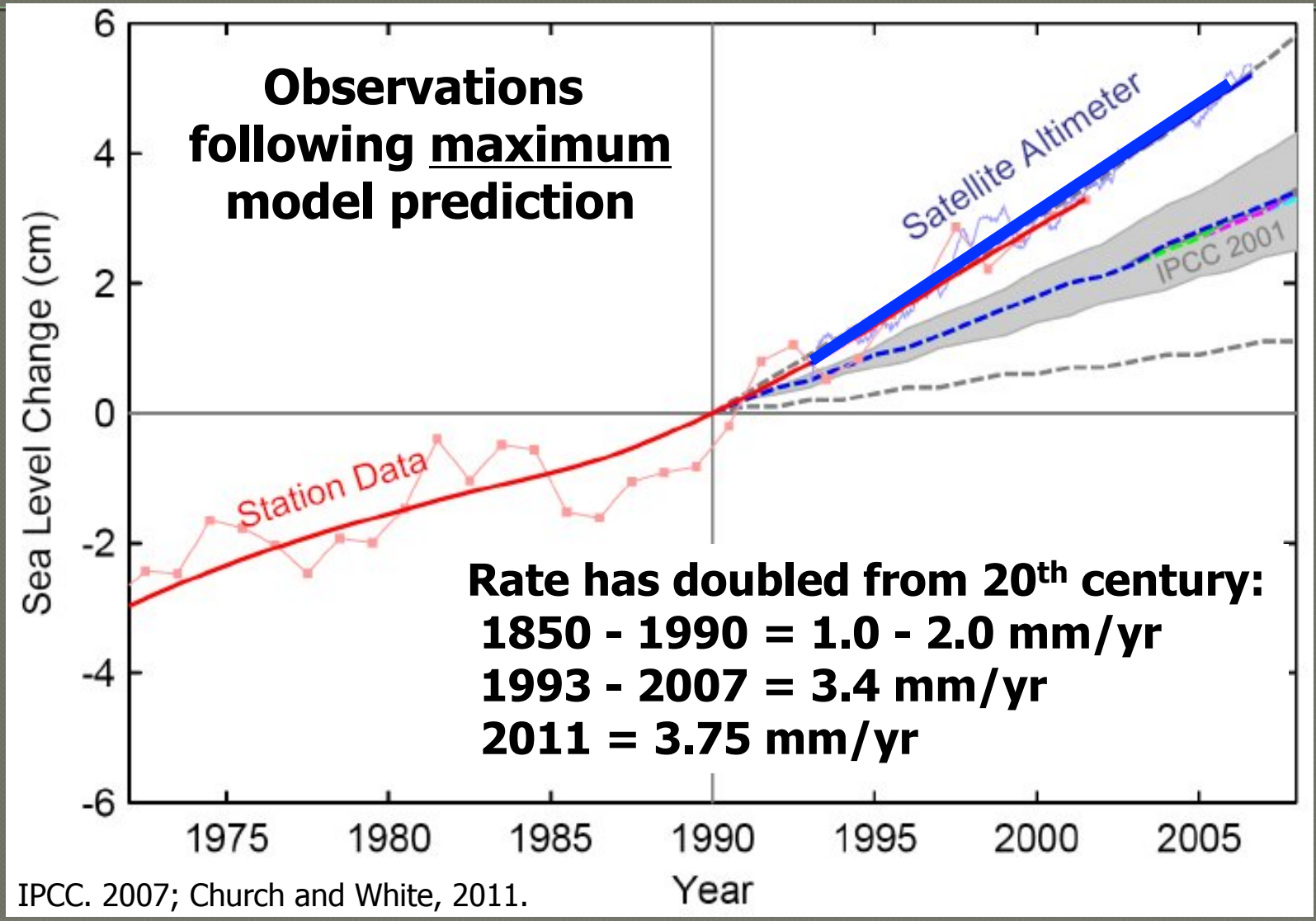


Rignot et al. (2008); NASA http://www.nasa.gov/topics/earth/features/antarctica

Sea Level Rise

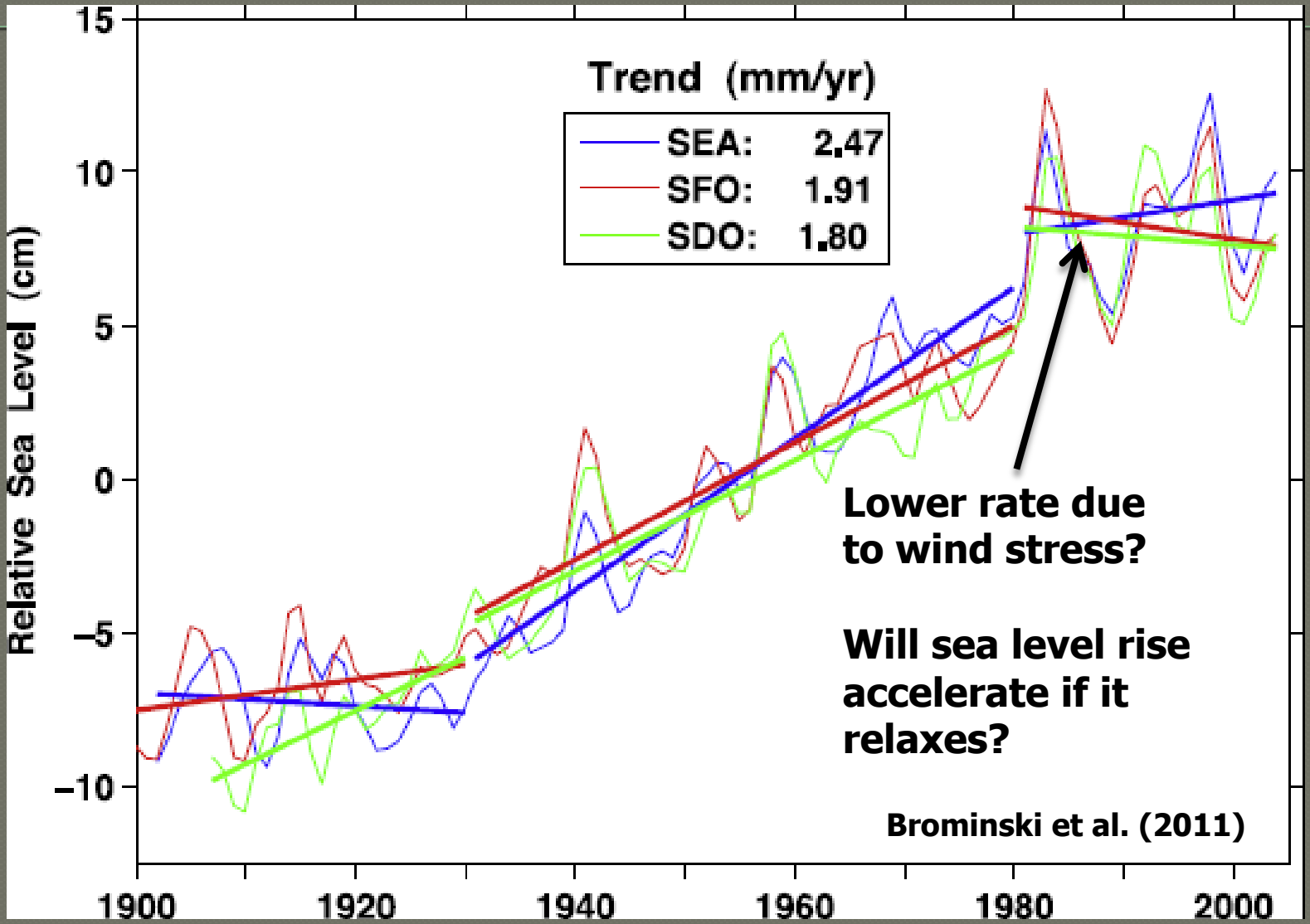


Sea Level Rise



IPCC. 2007; Church and White, 2011.

West Coast Anomaly



Vertical Land Motion

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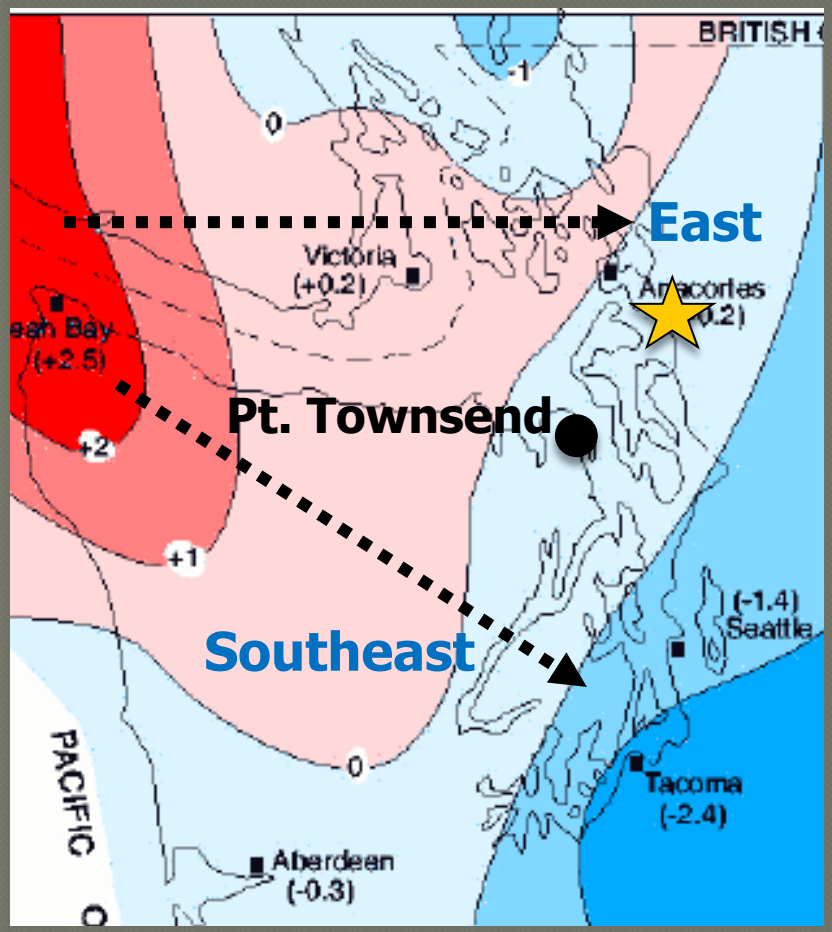
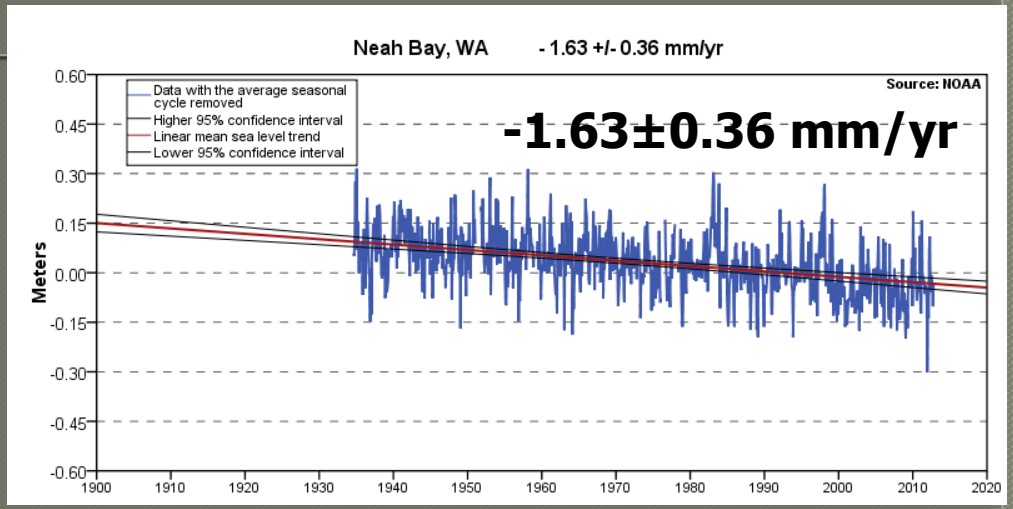
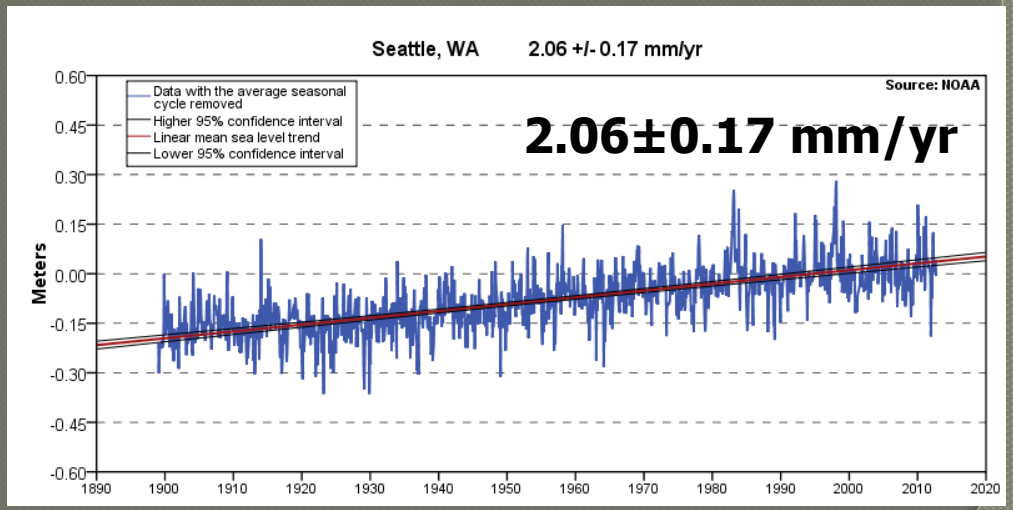
Uplift **Subsidence**



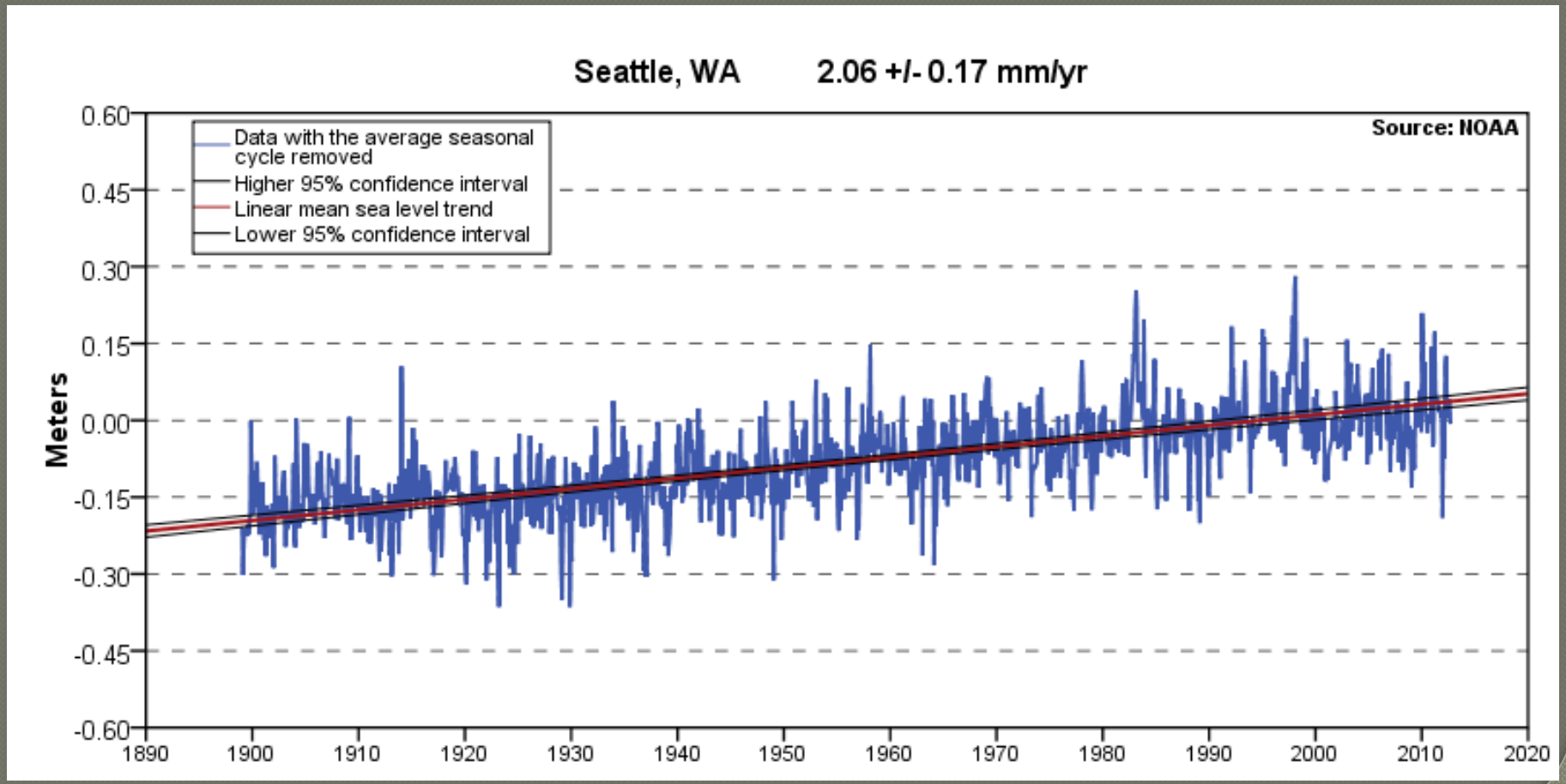




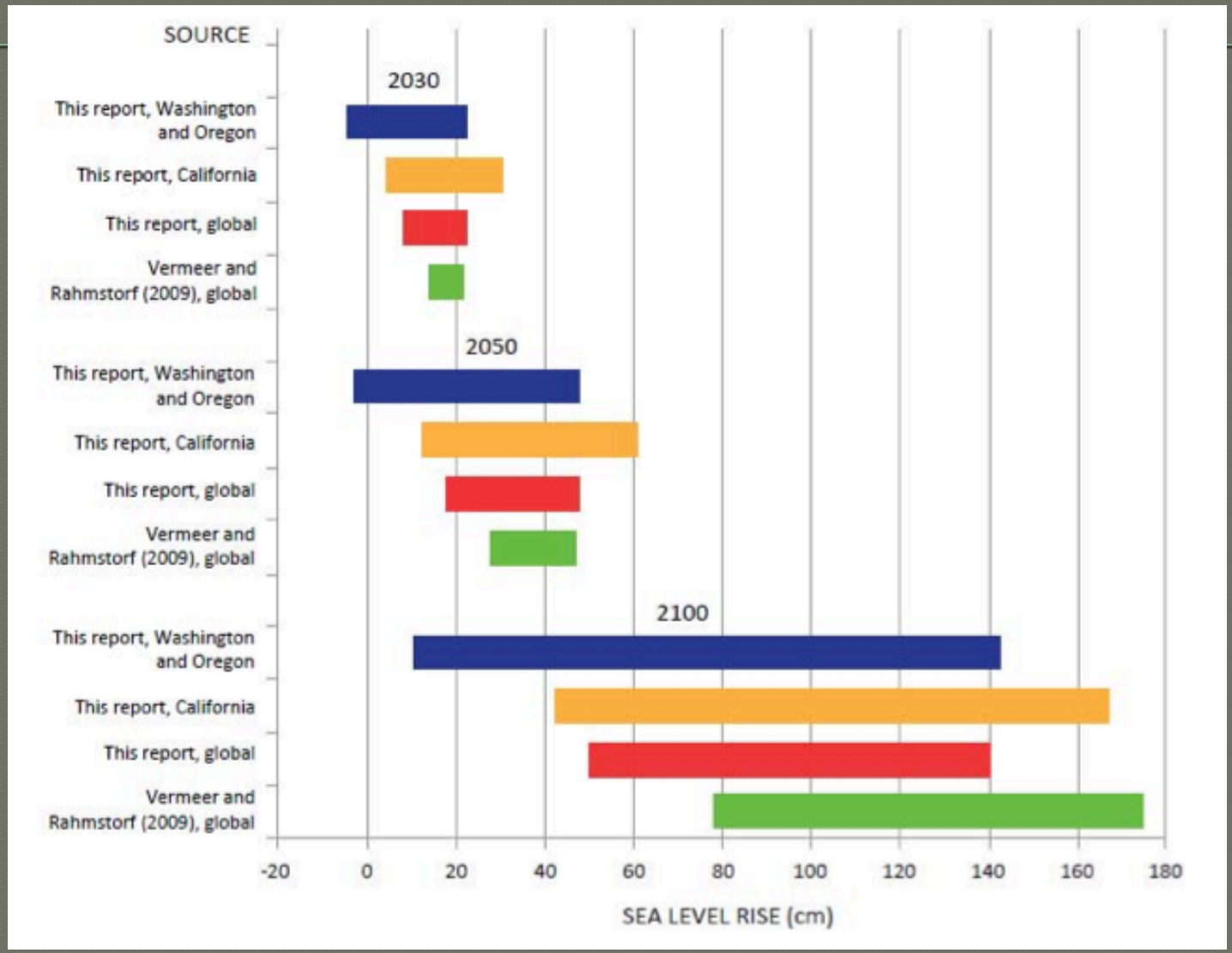
Verdonk (2006);Holdahl et al. (1989)

Seattle Sea Level Trend

Since 1950 ~ 5 inches



Sea Level Rise Forecasts



NAS. 2012. W. Coast Sea Level Rise Assessment

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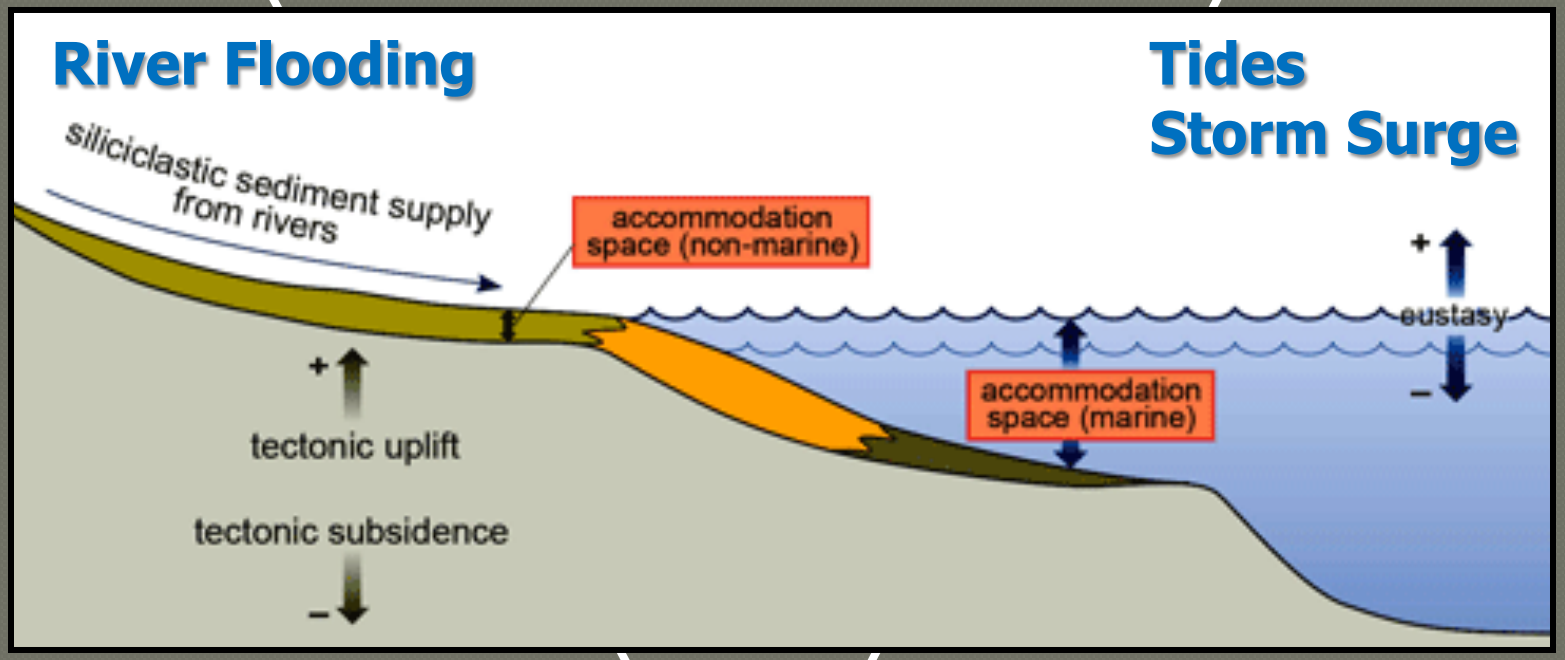
Components of Coastal Flooding and Inundation

Elevation, Elevation, Elevation

Sediment
Vegetation



Sea-Level Rise

Subsidence

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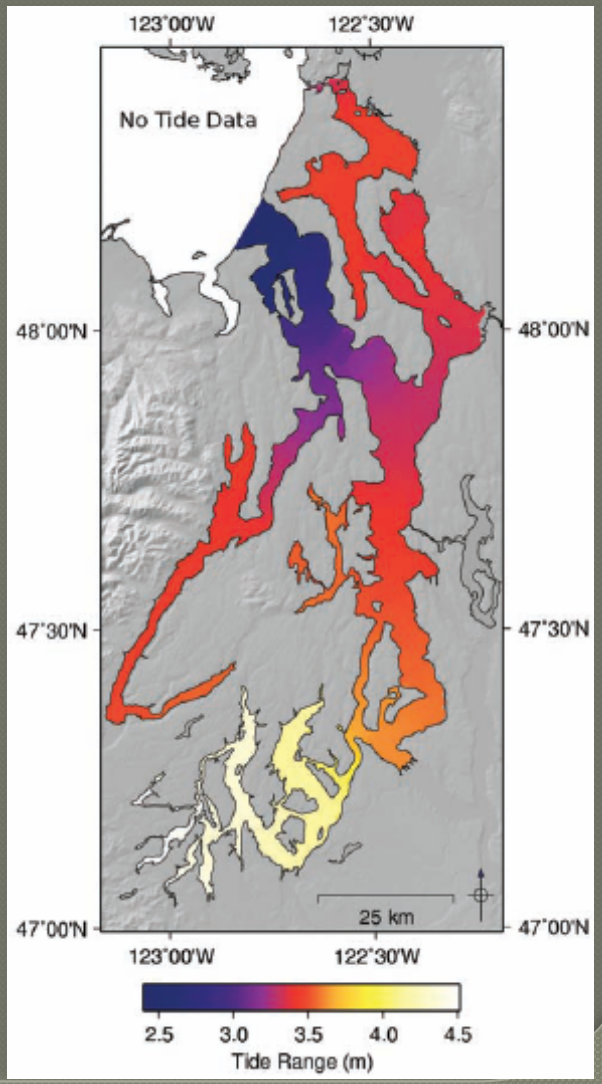
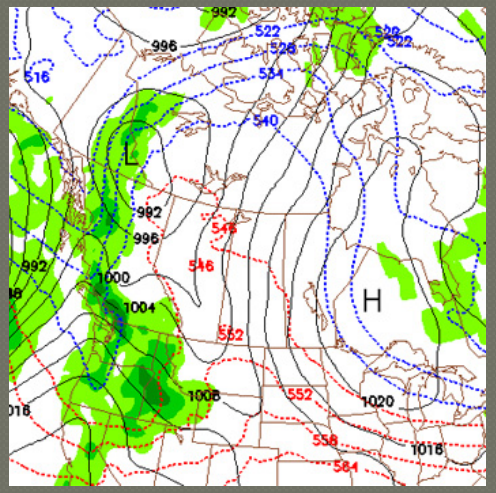
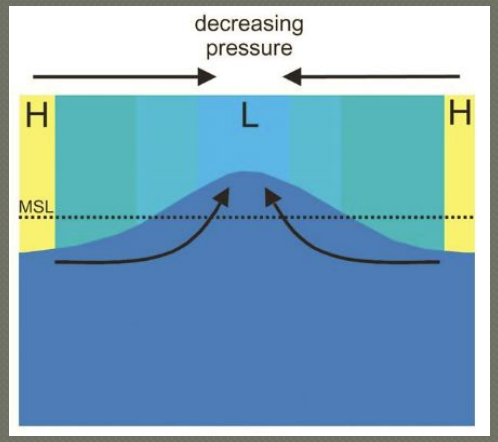
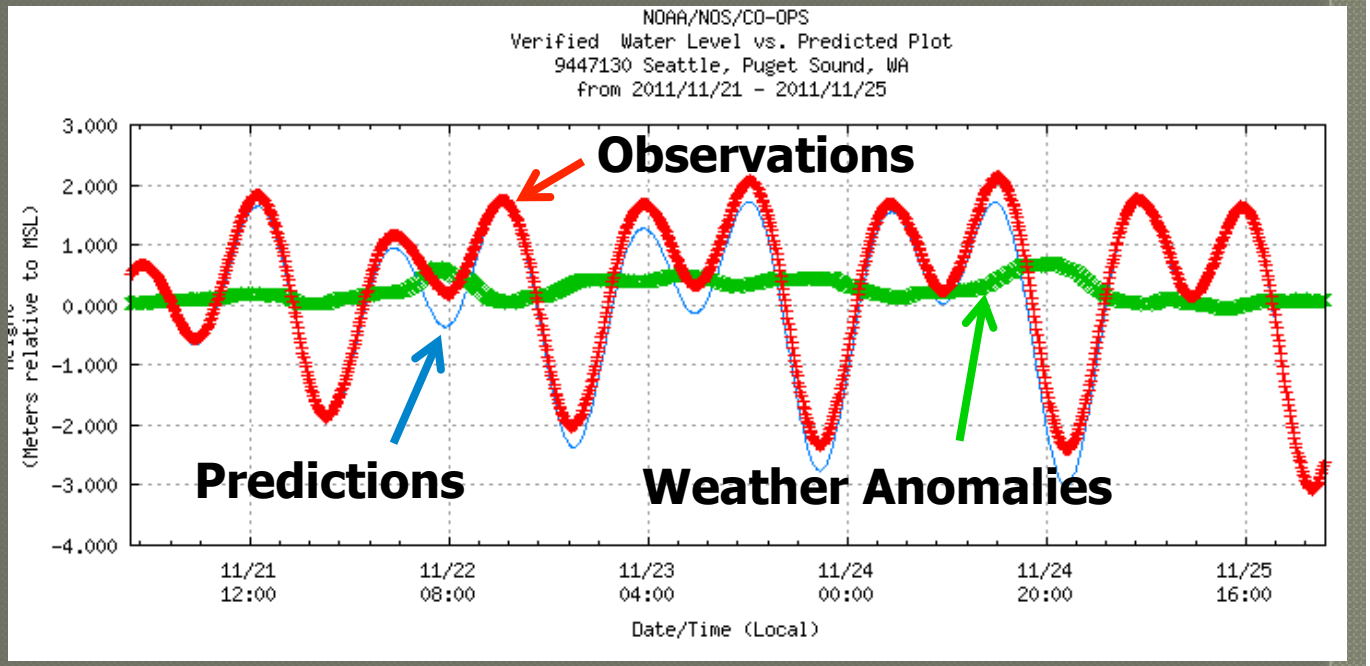
Tidal Variability



Storm Surge (Barometer Effect)

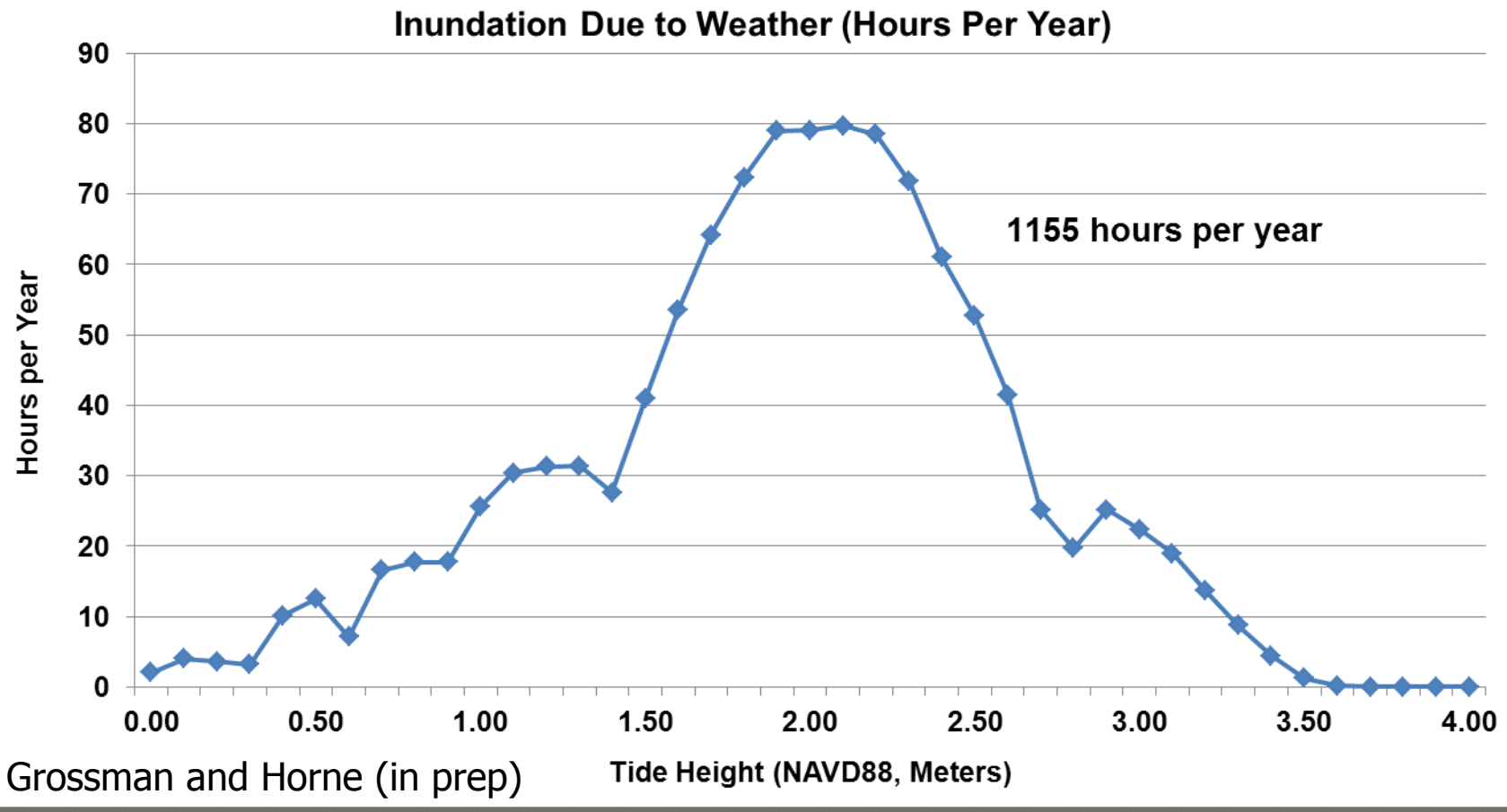






Inundation Frequency

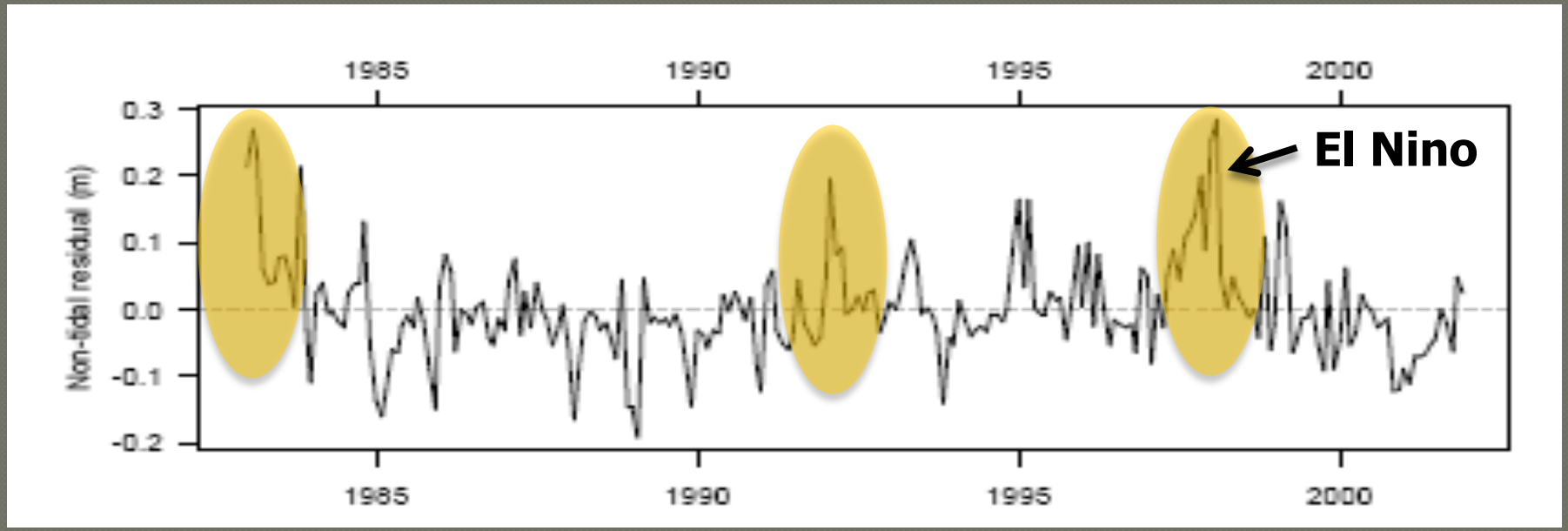
Storm Surge Today



Grossman and Horne (in prep)

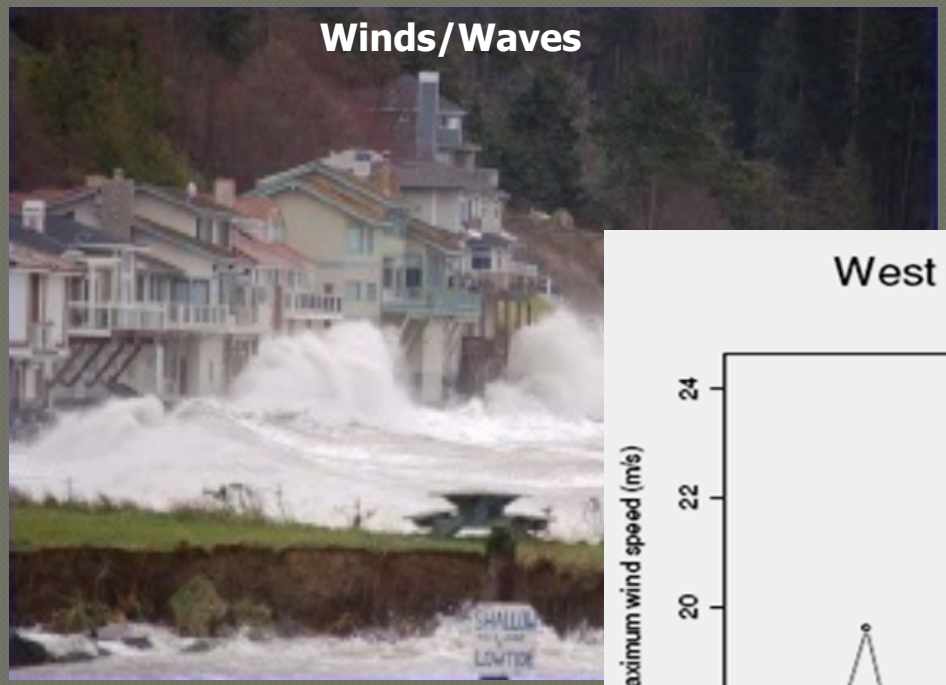
Storm Surge (Barometer Effect)

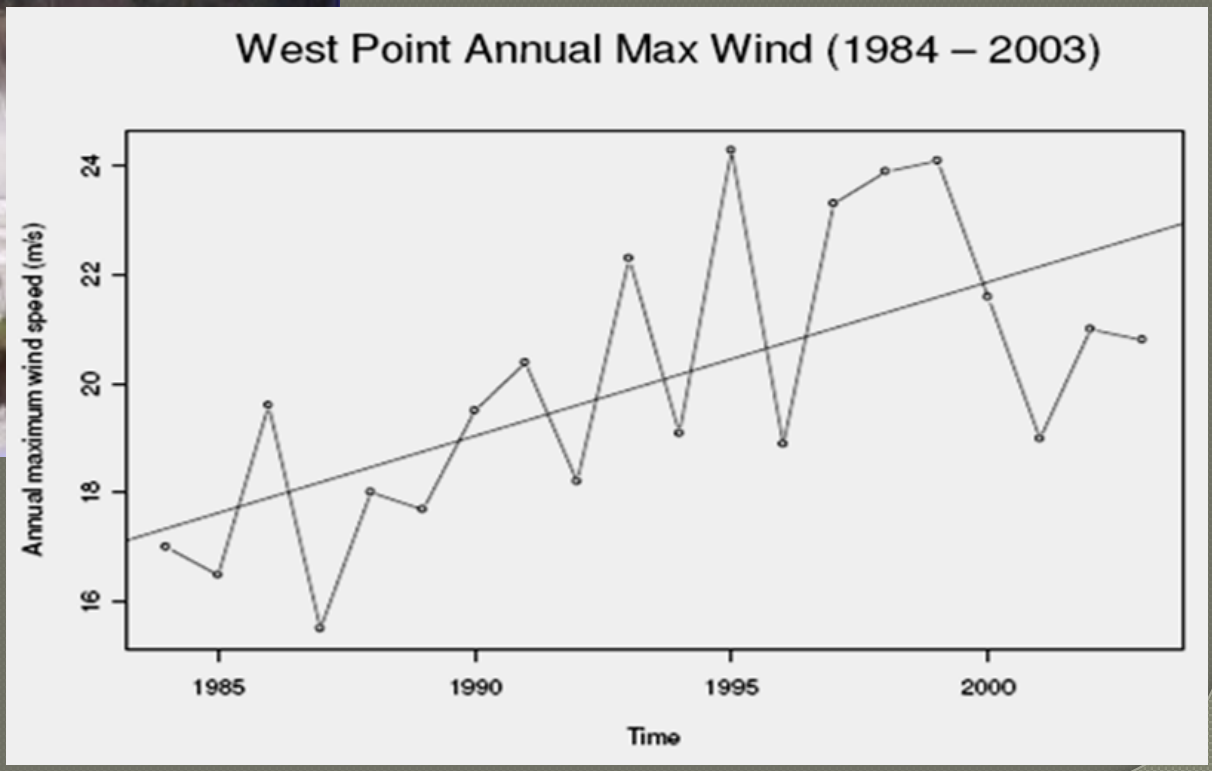
During El Nino Conditions, anomalies may last weeks to months



Finlayson (2006)

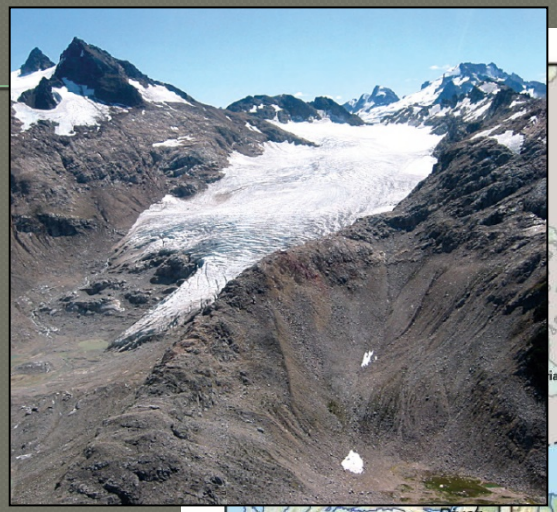
Storm Surge (Winds/Waves)





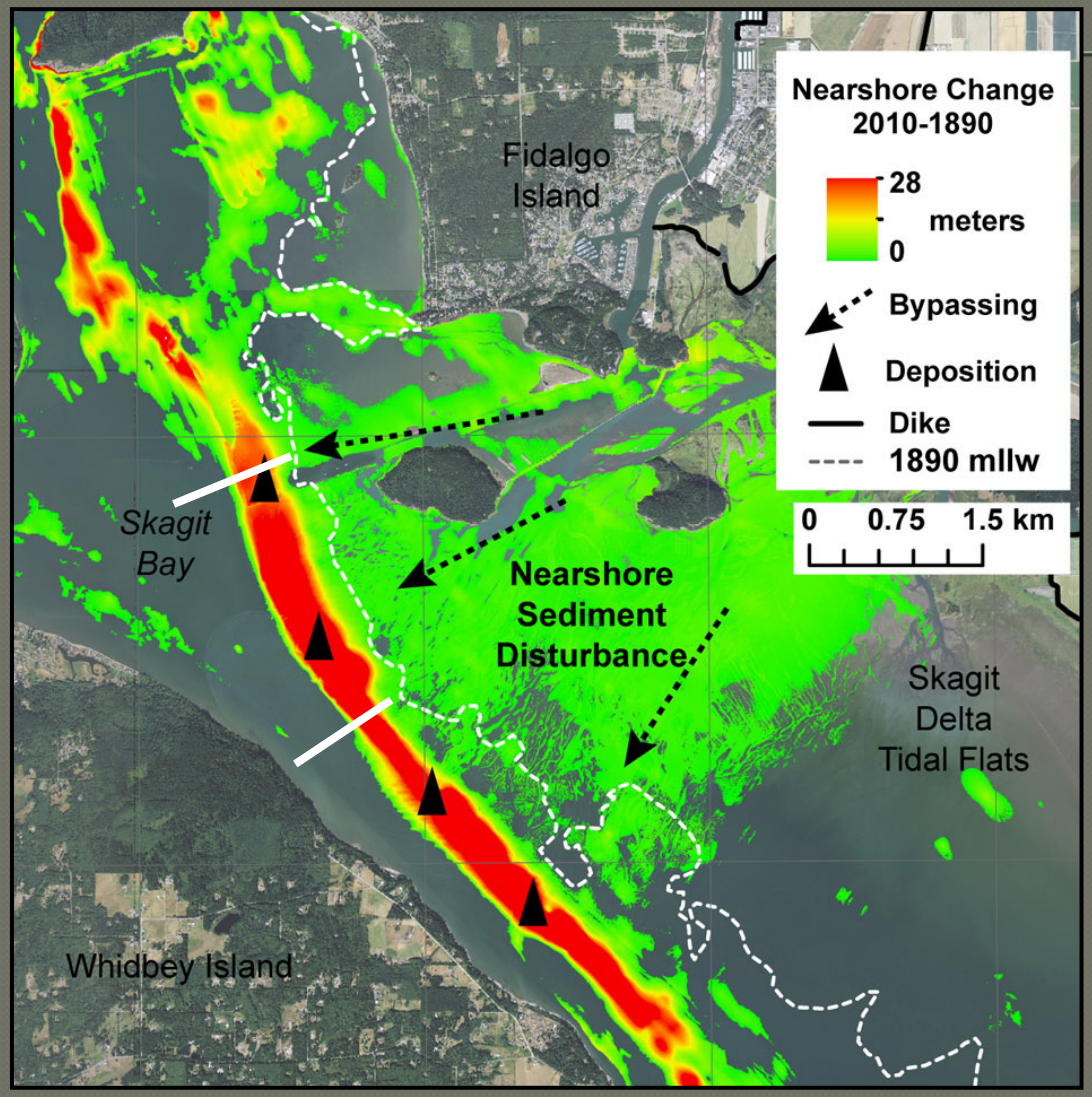
Sedimentation

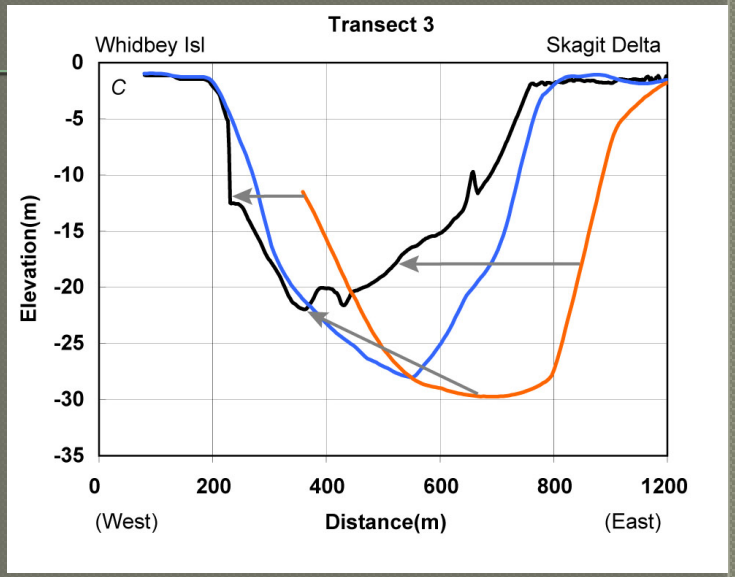
Elevation
Roughness
Erodibility



Curran and Grossman (2011); Czuba et al. (2011); Grossman et al. (2011)

Skagit Sediment Dynamics





Volume: 60 Mm³

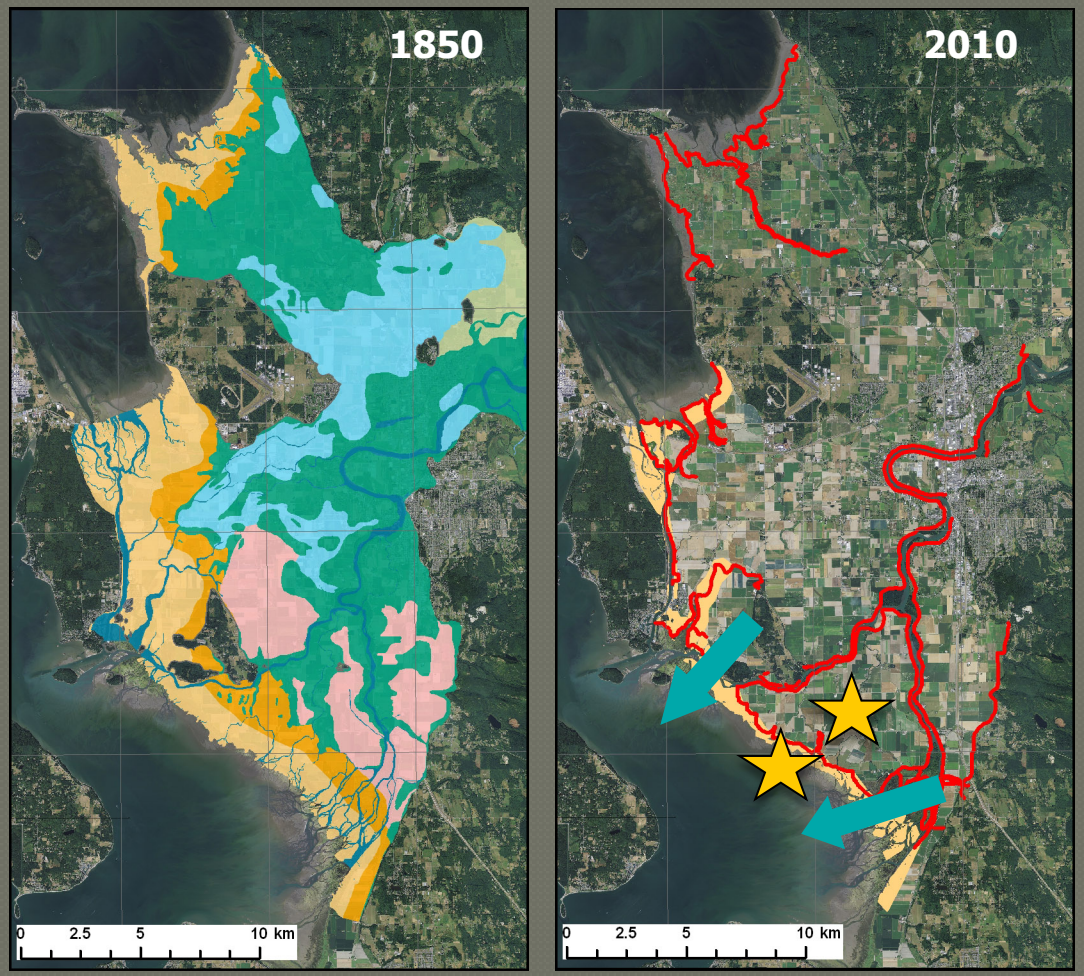
<50% of Total Load

Bypassing nearshore, lost resource for delta

5-10x the rate of the last 1000-3000 yrs

Grossman et al. (2011); Grossman et al. (in Review)

Skagit Sediment Dynamics



After Collins 2000

Lost sediment:

- Erosion bayfront marsh (Hood, 2012)
- 1m subsidence Fir Isl. (Haugerud, 2006)

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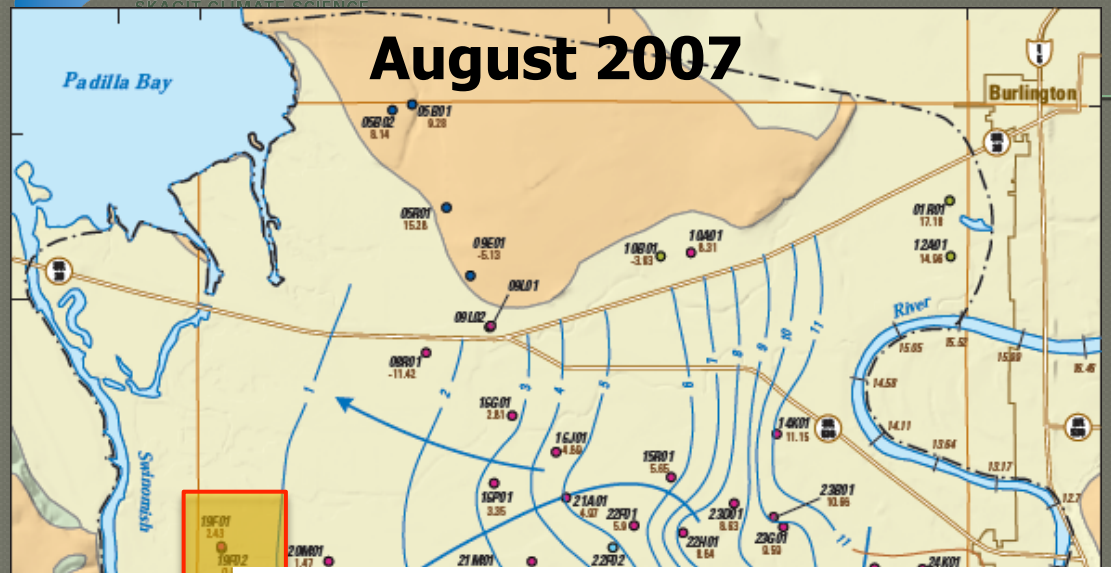
Impact Pathways

Overwash

Breach
Water
Salinity
Sediment
Erosion
Drainage

12” SLR, turns a 100-yr storm surge today into a 10-yr event by 2050
24” SLR, turns a 100-yr storm surge today into a 1-yr event by 2100

Groundwater



- Higher, Persistent Water Level
- Moisture/Saturation
- Salinity
- Drainage
- Pumping

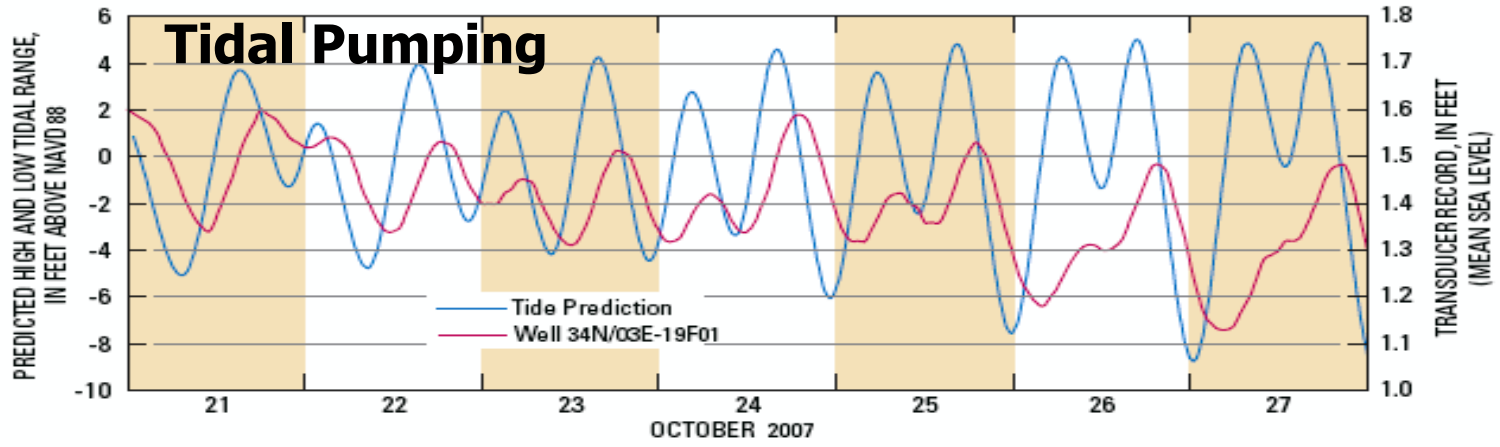
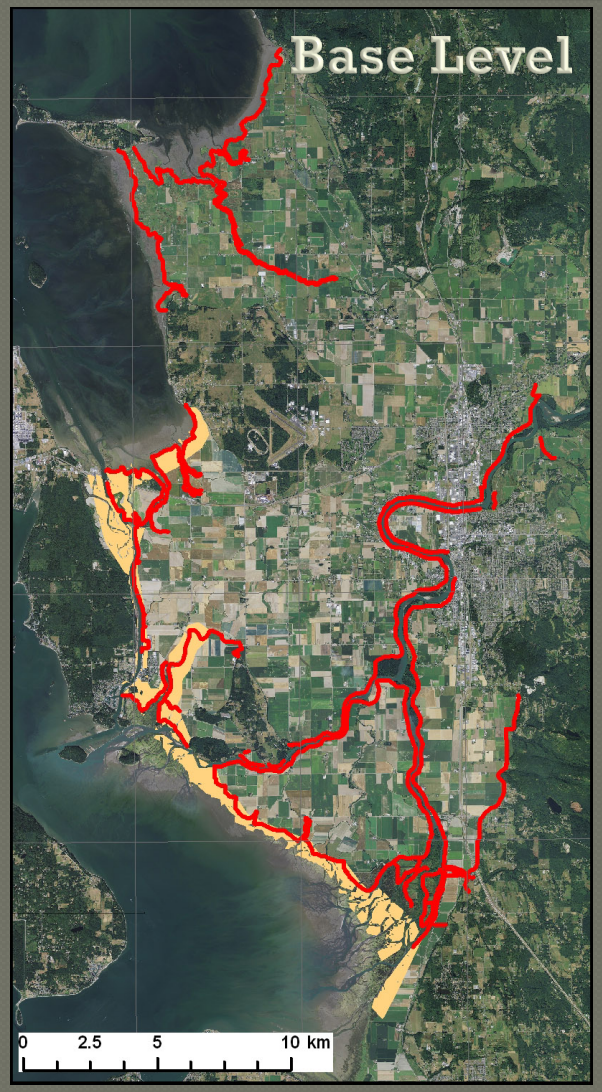


Figure 13. Water levels in well 34N/03E-19F01 and nearby tidal fluctuations near La Conner, Washington, October 2007.

Savoca et al., 2009

Joint Occurrence of Sea Level Rise and River Flooding "Backwater"



FEMA Historical 100-yr Flood

Storm Surge, ft

1.5

Inundation, acres

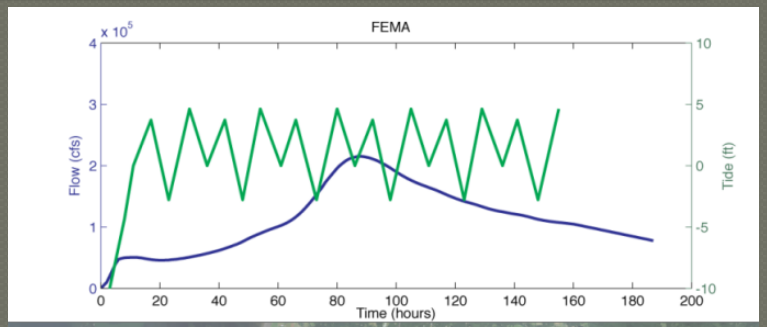
42,266

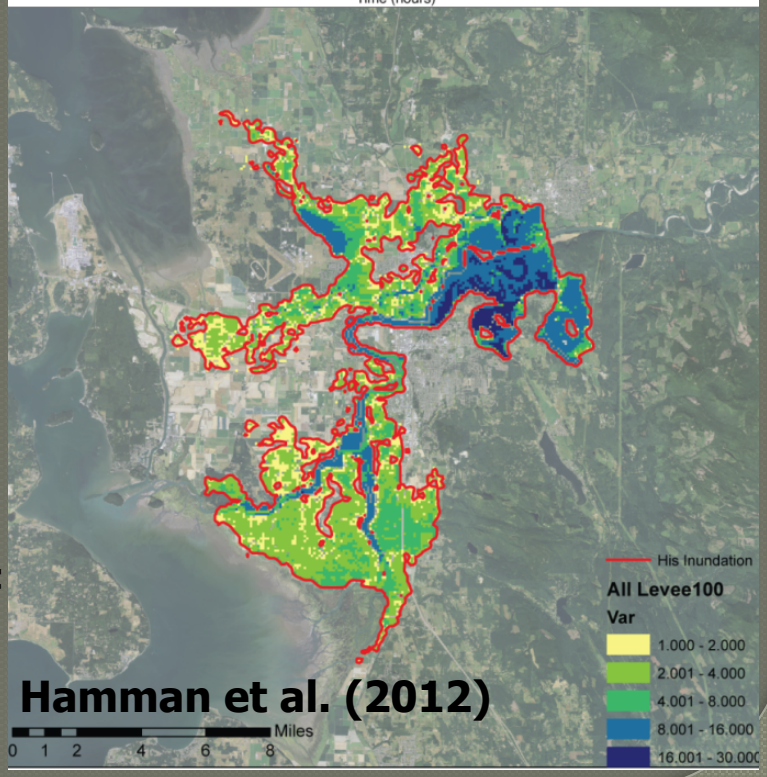
Mt. Vernon Depth, ft

0.00

Burlington Depth, ft

0.77





Hamman et al. (2012)

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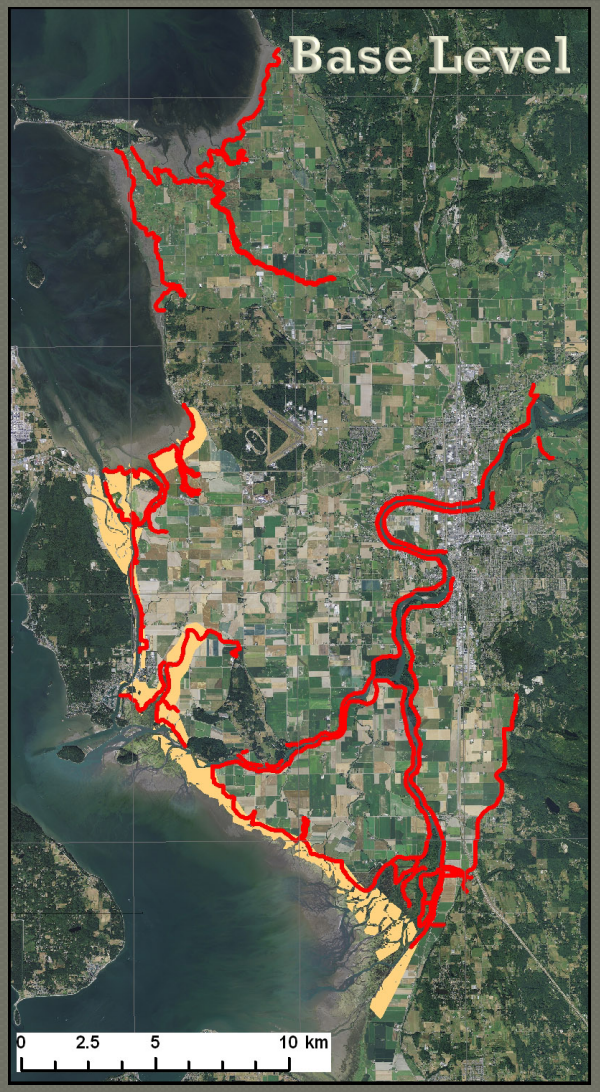


2020 100-yr Flood

Sea Level Rise, ft

0.93

Storm Surge, ft

1.5

Inundation, acres

64,878

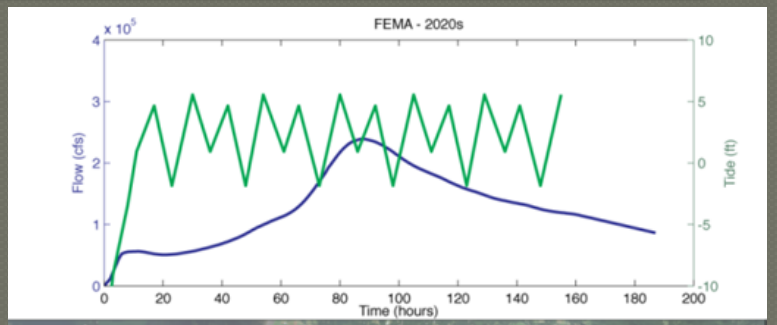
(1.53x)

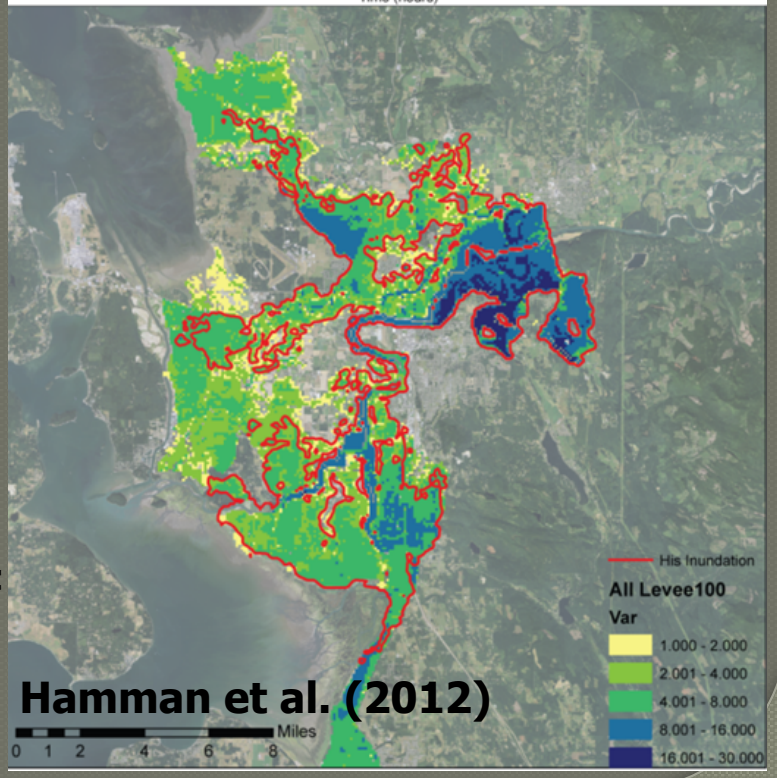
Mt. Vernon Depth, ft

0.00

Burlington Depth, ft

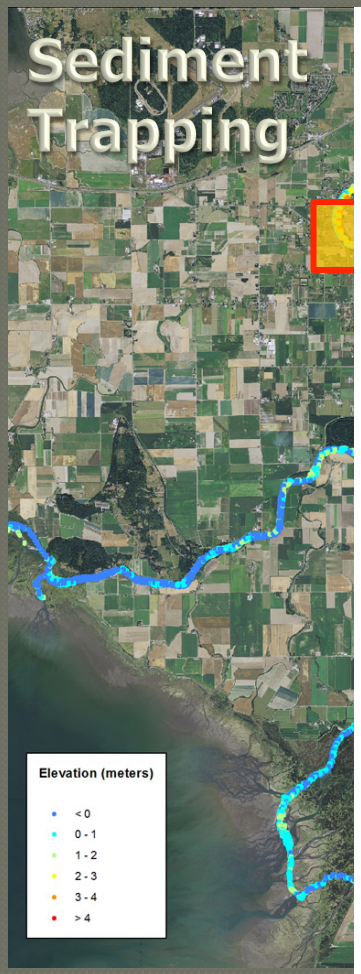
1.89

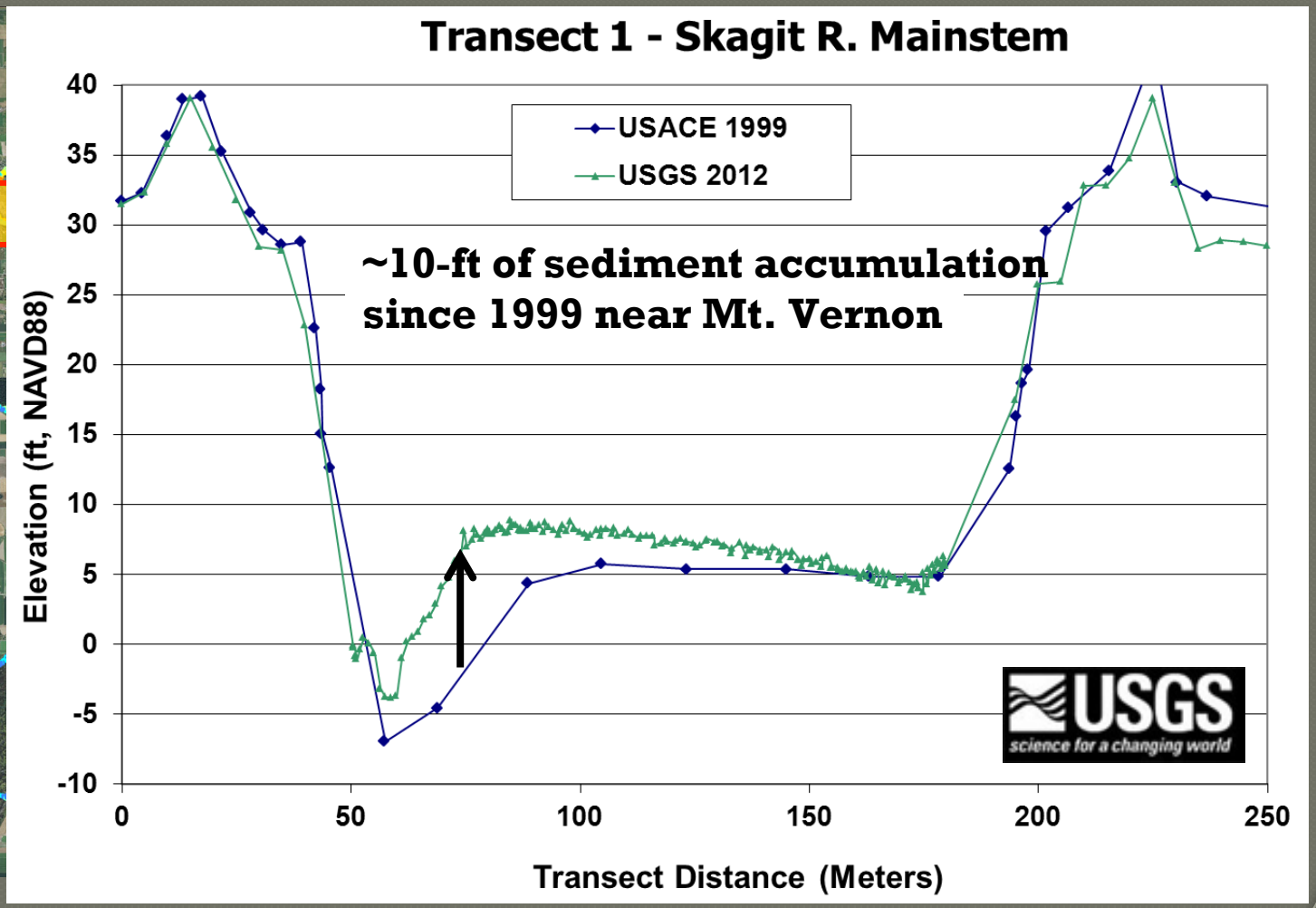




Hamman et al. (2012)

Joint Occurrence of Sea Level Rise and River Flooding "Backwater"





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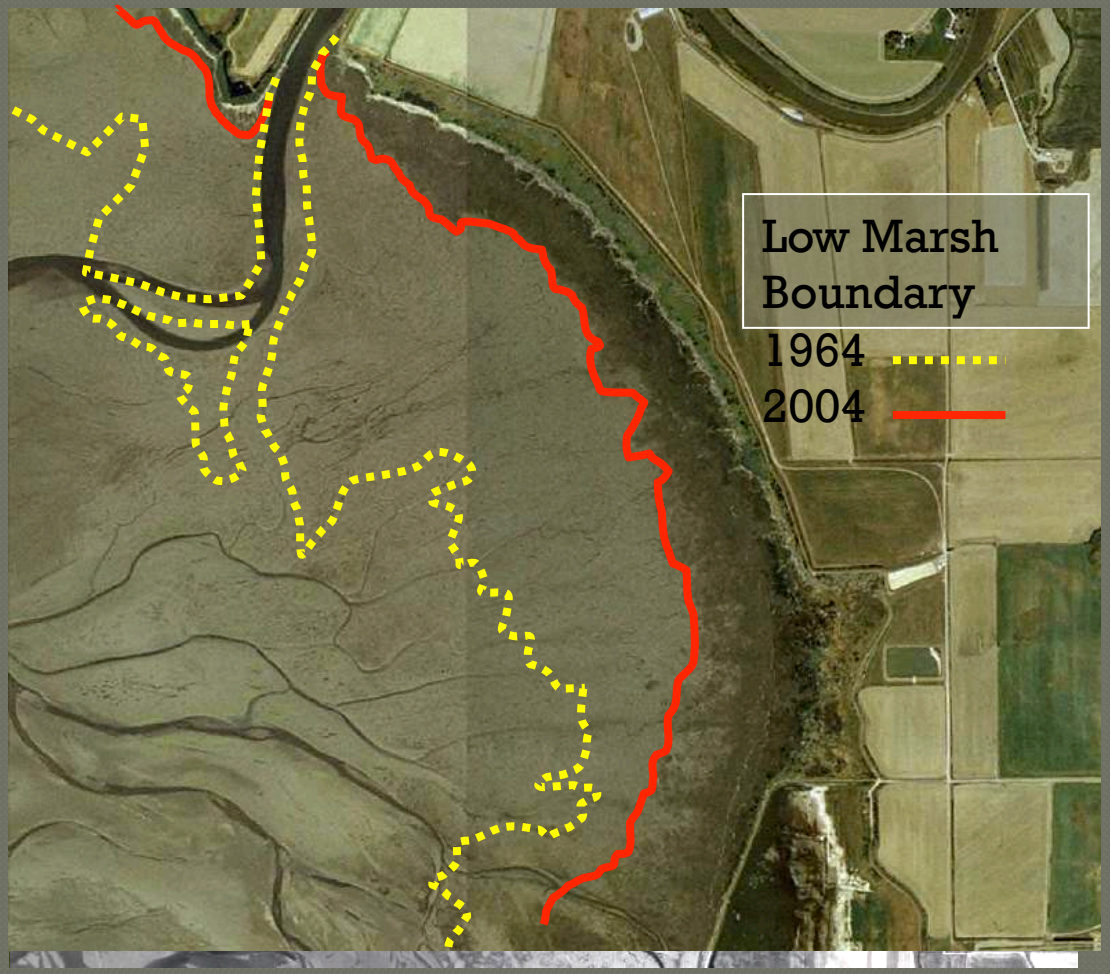
Risk to infrastructure, ecosystems and communities

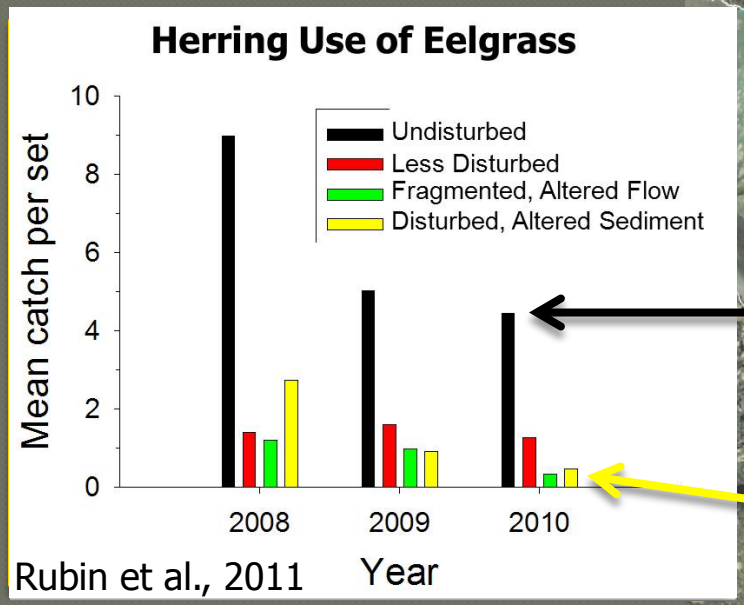
Risk – People/Infrastructure

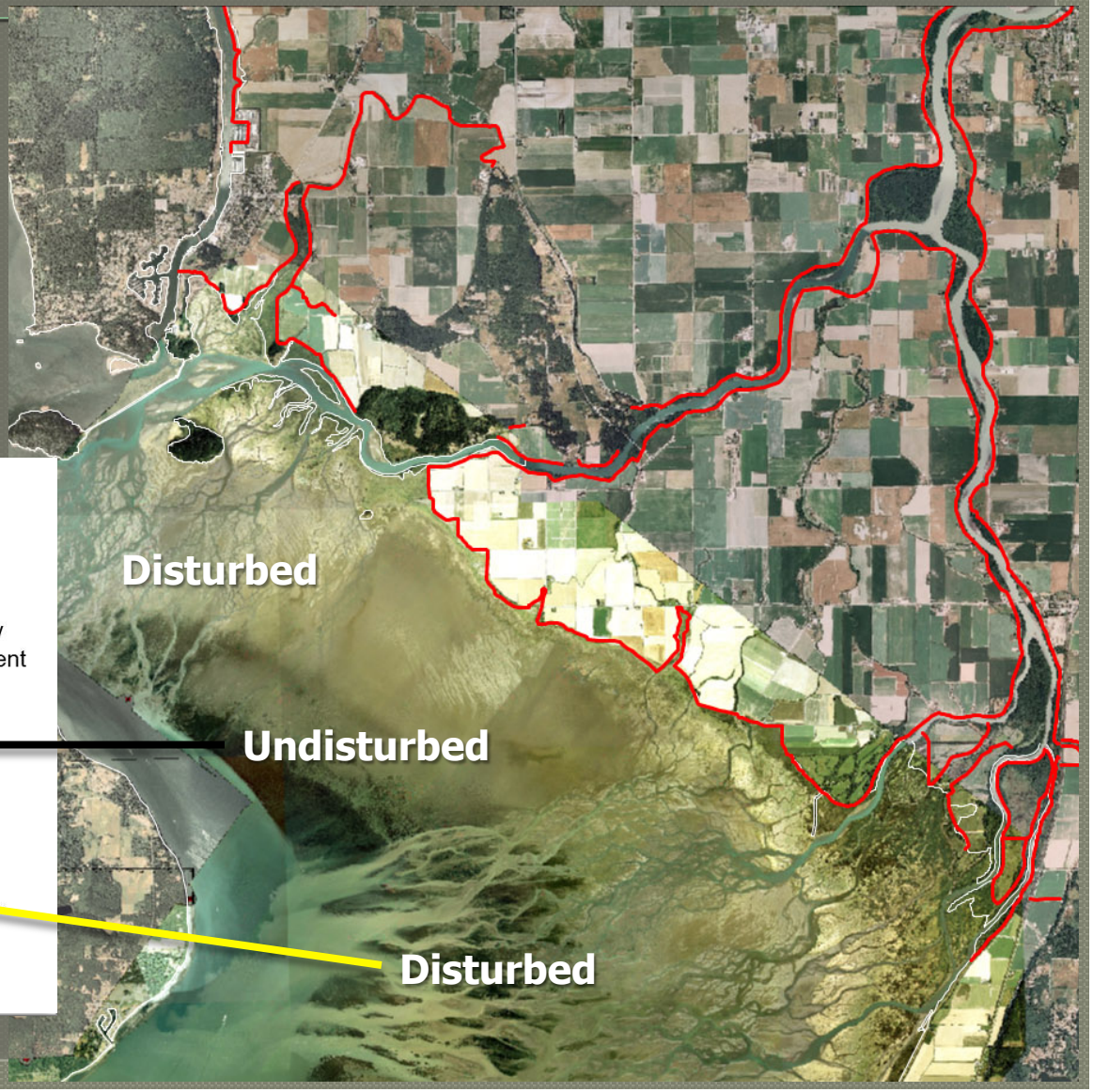
- Lives, property
- Livelihoods
- Culture/Tradition
- Roads, Rail
- Dikes, levees
- Tide Gates
- Pumps
- Drainage Channels
- Water Intakes, Treatment Plants



Risk – Ecosystems/Functions

Habitat Squeeze/Loss
Food, Recreation
Nutrient Cycling
Water Filtration
Wave/Sediment
Attenuation/Erosion





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Tools for managers

Coastal Resilience Network

USGS science for a changing world | The Nature Conservancy Protecting nature. Preserving life. | The University of Southern Mississippi

Map Layers | Legend | Change to Split View | Geographies | Flood Scenarios | Background | Help | Bookmark Link

Map Layers

Left Map | Right Map

Clear All | Sync Maps | Set Transp

- Global
- Mesoamerican Reef
- US Virgin Islands
- Ventura County
- Florida Keys
- Savannah River
- Puget Sound
  - Infrastructure
    - [x] Dikes
    - [x] Public Facilities
    - [x] Rail Roads
    - [x] Roads
    - [ ] Water Wells

Skagit SLR

Impacts | Methods

Land Use
Roads
Habitat

MHHW Depths 2100

Legend

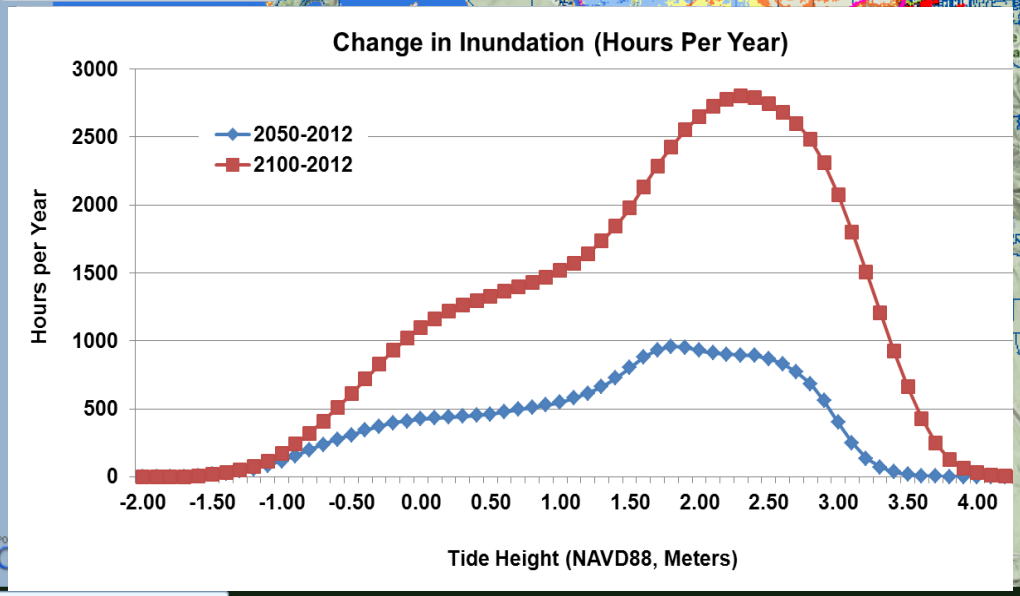
Flood_Scenarios
MHHW Depths_2100
- 0-1 Meter
- 1-2 Meters
- 2-3 Meters
- >3 Meters

Infrastructure
Dikes

Public Facilities
- School
- Library
- Hospital
- Police Station
- Fire Station
- City Hall
- Post Office
- Airport

Rail Roads

Roads



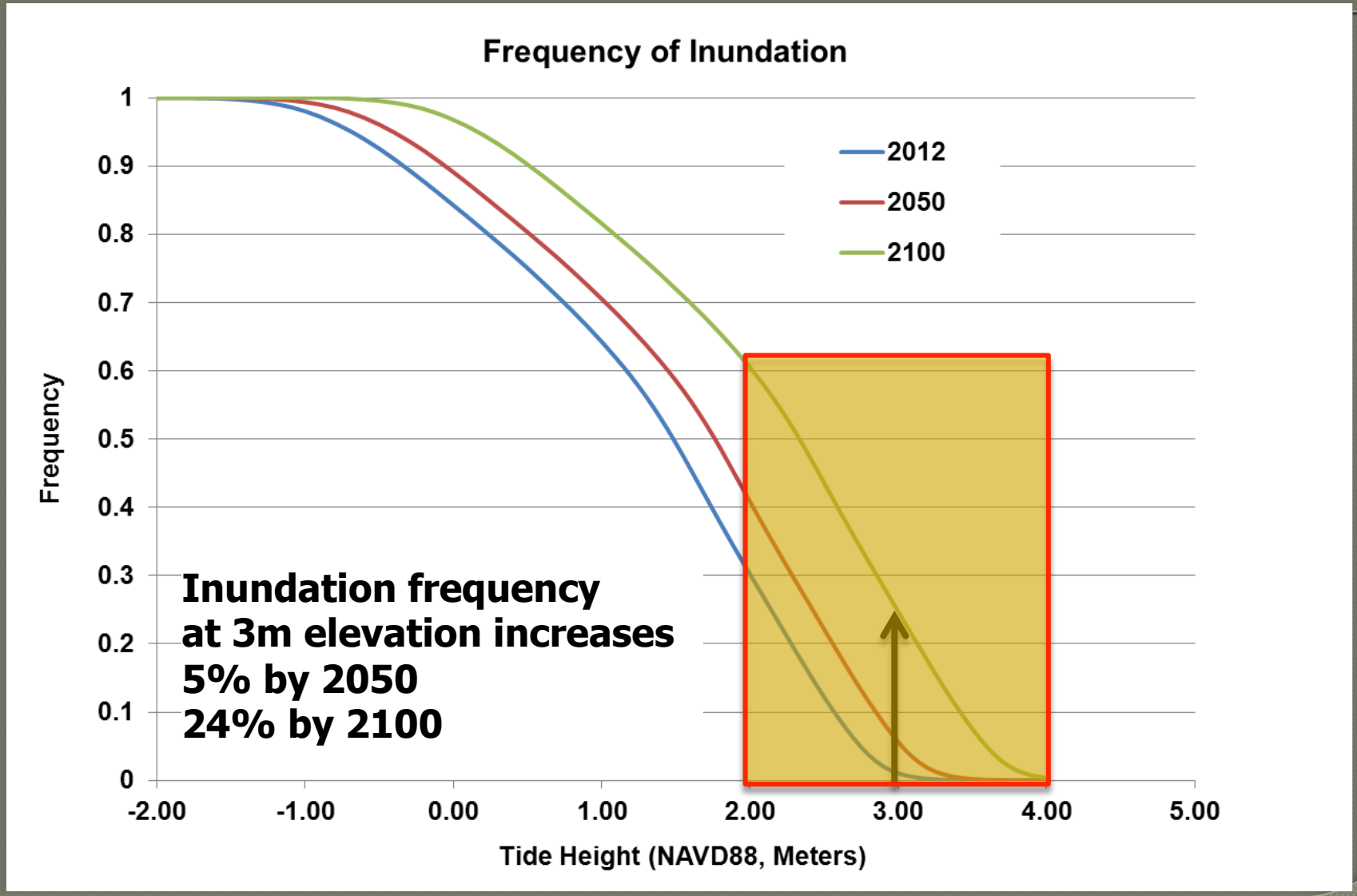
Samish Bay | Padilla Bay | Lyman Hill | Sterling Hill | Skagit River | Skagit Regional Airport | Haystack Mountain | Devils Mountain | Mt Washington | Ebey Hill | 268th St NE

Map data ©2012 Google - Terms of Use

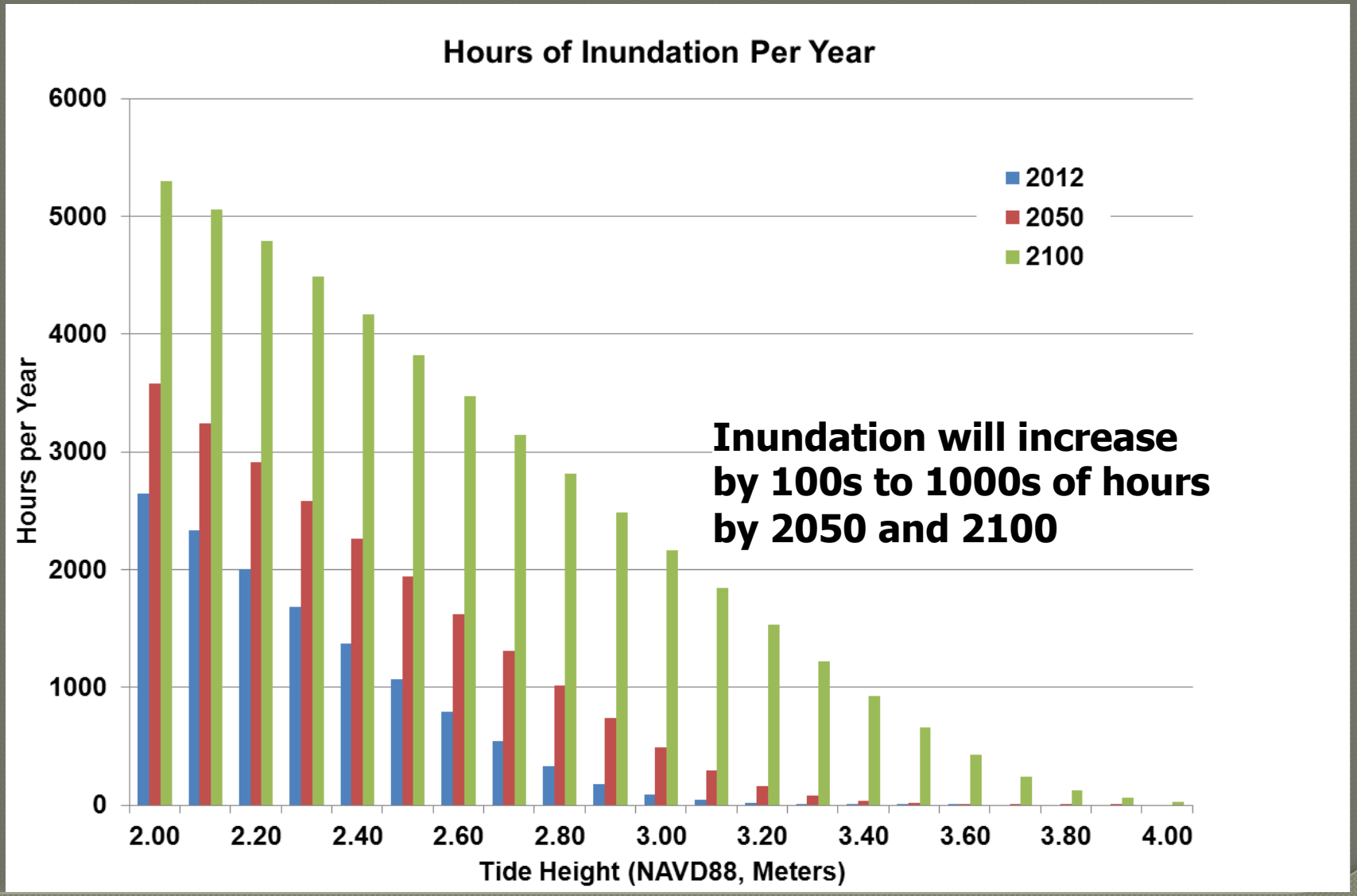
LAT: 48.313 N LON: 121.994 W

The Nature Conservancy | Coastal Resilience | Legal Disclosure

Inundation Frequency

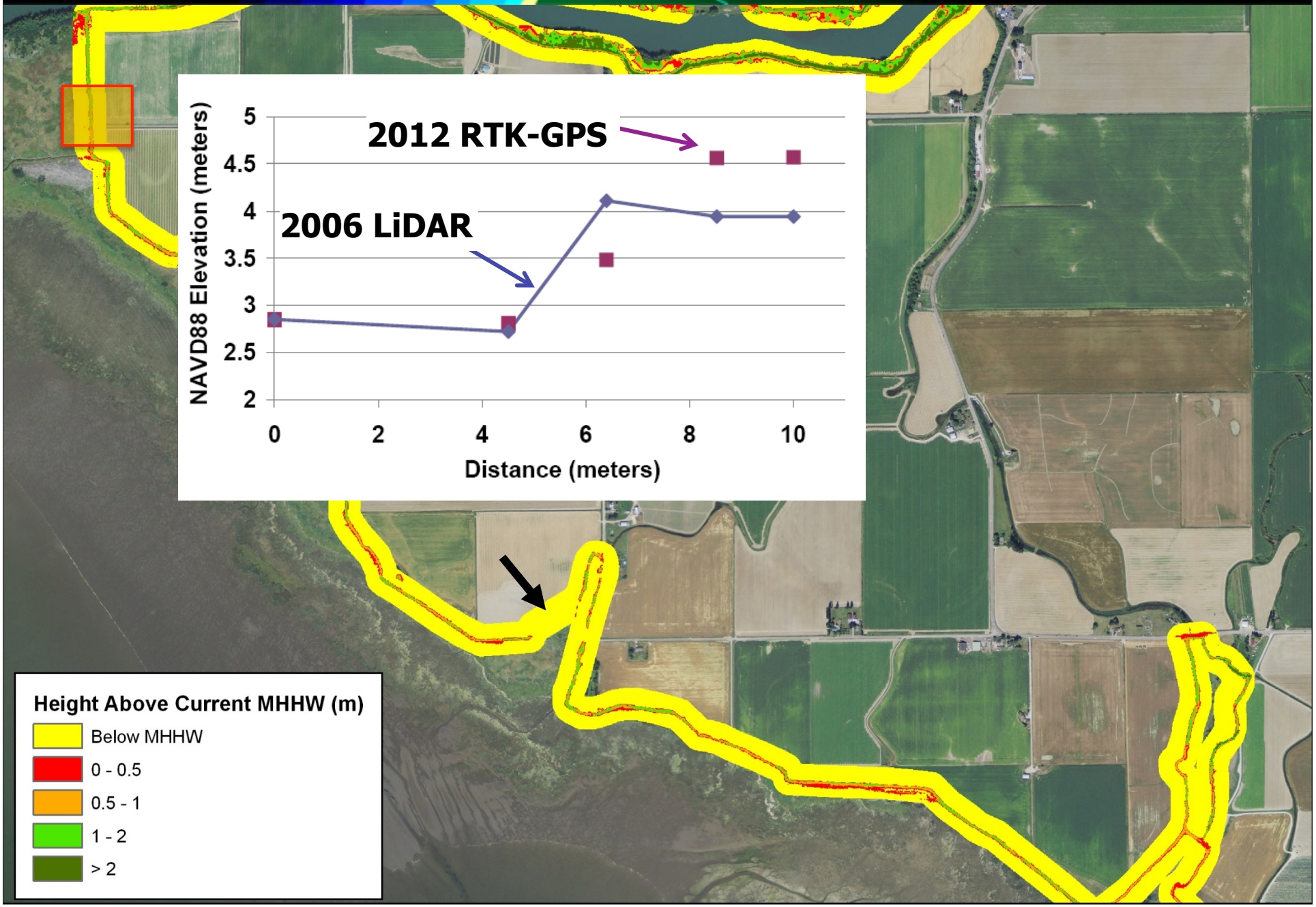


Inundation Frequency



USGS
science for a changing world

Vulnerability Assessment



Conclusions:Take Home Messages

1. Sea level rise has happened, is happening now, and will continue to increase the magnitude and frequency of coastal flooding.

2. The delta, where people are concentrated, faces the greatest increase in flood risk due to the interaction of sea-level rise, storm surge, river flooding, and sediment transport processes, all of which are changing.

3. Sea-level rise increases the potential for flooding by reducing the ability to efficiently evacuate river floodwater downstream of Sedro-Woolley and by increasing the power of wind-driven coastal storms.

4. Sea-level rise will turn a 100-yr storm surge today into a 10-yr overwash event by 2050 and into a 1-yr overwash event by 2100.

5. Sediment affects flood risk in different ways. Channel aggradation increases flood risk by reducing flood conveyance. Estuary accretion reduces water depths, wave energy, storm surge erosion and overtopping of sea dikes.

Final Thoughts

Addressing coastal hazards, ecosystem restoration, and climate change in an integrated way may help find solutions for the complex challenges facing Skagit communities.

Modifications to sediment transport processes and fate are likely to have long-standing impacts to flood hazards and ecosystem services that are important to people.

Need for coastal research to fill information gaps (elevations, geology/ erodibility, nearshore hydrodynamics, groundwater processes.

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