Climate Central's Public Sea Level Rise & Coastal Flood Risk Web Tools

APA Sustainability & Resilience Series:
Technology Tools for Sustainability
May 13th, 2022

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CLIMATE
CENTRAL

About Climate Central

- A climate science research and communications NGO, founded in 2008 and based in Princeton, NJ

- Non-partisan, <u>non-advocacy</u>

- Localized, evidence-based information on climate science, impacts, & solutions

Tools in Use

At-Risk Populations

Those residing in close proximity to Warren's extensive coastline in the Special Flood Hazard Area (SFHA) comprised of the V and A Flood Zones are more at risk to coastal flooding.

Social vulnerability (e.g., from low income) can further compound coastal risks. As depicted in **Figure 4-17**, of the roughly 970 people who reside on land below an elevation of 5-feet, the vast majority fall into the high social vulnerability category.

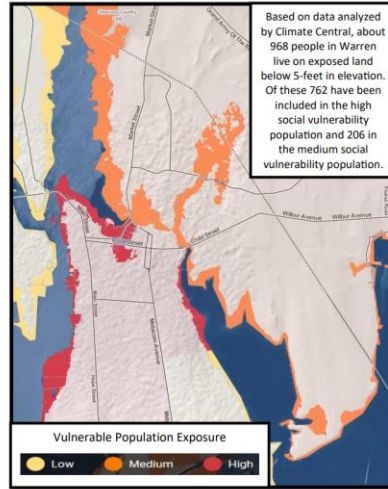**Figure 4-17   Vulnerable Population Residing on Land below 5-Feet Elevation**

Based on data analyzed by Climate Central, about 968 people in Warren live on exposed land below 5-feet in elevation. Of these 762 have been included in the high social vulnerability population and 206 in the medium social vulnerability population.

Vulnerable Population Exposure
Low   Medium   High

Image Credit: adapted from Climate Central. *Surging Seas Risk Zone Map*

DRAFT
Hazard Mitigation & Flood Management Plan

TAKE A LOOK AT THIS!

Vulnerability Exposure Web Map: This is an excellent **PLANNING TOOL** created in conjunction with the **HM&FMP** to provide a visual representation of the potential threat to Warren from extreme storm events and sea level rise. TO VIEW CLICK BELOW:

WARREN WEB MAP

Want to Learn More?

Following are some links that will provide additional information related to the HM&FM Plan Project

- Warren Hazard Mitigation Plan 2015
- FEMA Flood Zone Interactive Map for Warren
- RI BeachSAMP and STORMTOOLS

TOWN GOVERNMENT

RESIDENTS

BUSINESSES

GET TO KNOW WARREN

I WANT TO...

Search

Figure 4-18   Coastal Flood Analysis – Providence RI

"According to the National Climate Assessment, coastal flooding in the northeast has increased due to a rise in sea level of around one foot since 1900. And in the future, if we continue to emit greenhouse gases, global sea levels are expected to rise one to four feet by 2100. Specifically in the coastal Northeast, due to the natural sinking of land, sea levels are likely to rise even *higher* than the global average. A sea level rise of two feet would more than triple the frequency of coastal flooding across the Northeast, without any change in storms" (Di Liberto).

Image Credit: Climate Central. *Surging Seas Risk Zone Map*

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More Use Cases

Organization	Climate Central Resource	How They Intend to Use
County officials in Dept. of Planning & Zoning	Map	planning
State Lands Commission	Map	granted lands vulnerability assessment
Federal agency	Risk Finder	environmental planning & risk analysis
County/State Office of planning	Scenario 2100 data	research and long-range planning
County Utilities Authority	Map	resiliency planning
Federal agency	Map	NEPA environmental assessments
County Board of County Commissioners	Guide on using Climate Central tools within NFIP CRS	CRS planning
State Department of Conservation and Recreation	Map	relocation of facilities
City in Maryland	Risk Finder	data collection for comprehensive plan update
City in New Hampshire - Planning Department	Scenario 2100	planning & zoning
City in California	Risk Finder Fact Sheet	FEMA Grant
State Department of Transportation	Risk Finder Forecast Data	Grant application

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Climate Central Resources


Risk Finder

Coastal Risk Screening Tool

Picturing Our Future

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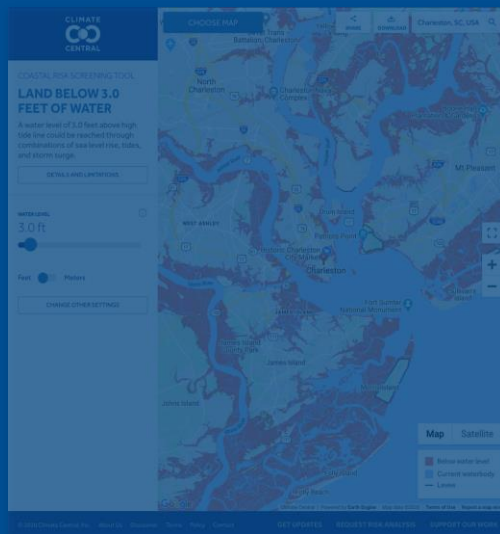
Risk Finder

- Web tool for assessing sea level rise and coastal flood risk
- Hyper-localized information
- Incorporates 100+ GIS datasets - mainly from federal sources including NOAA, the Census, DOE, DOI, EPA, FCC, FEMA, and USGS
- Downloadable fact sheets, spreadsheets, and more

Risk Finder Demo

Surging Seas RISK FINDER

Enter a coastal place

What Is at Risk?

Tutorial video
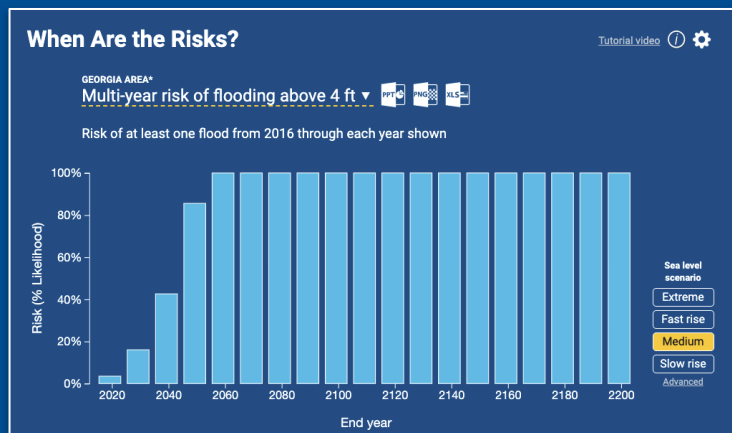
Population | Buildings | Infrastructure | Contamination Risks | Land

Total population below 5 ft in Charleston County XLS

Population: All ▾	Total
Population	64,974
Caucasian population	50,694
Low social vulnerability population	48,953
Population of color	14,925
African-American population	12,975
Medium social vulnerability population	12,848
High social vulnerability population	3,174

Sources: *Raw population data,* Census 2010*; elevation data,* lidar*; administrative boundaries,* US Census*.* Details

Values exclude sub-5ft areas potentially protected by levees or other features. ?

Choose a threat to map using the scrollable list above

Total population below 5 ft in Charleston County by zip code ▾ PPT PNG XLS

Population

	9,900
	7,600
	5,900
	2,700

Water level (ft)

5

-10
-9
-8
-7
-6
-5
-4
-3
-2
-1

English

Surging Seas **RISK FINDER**

Enter a coastal place
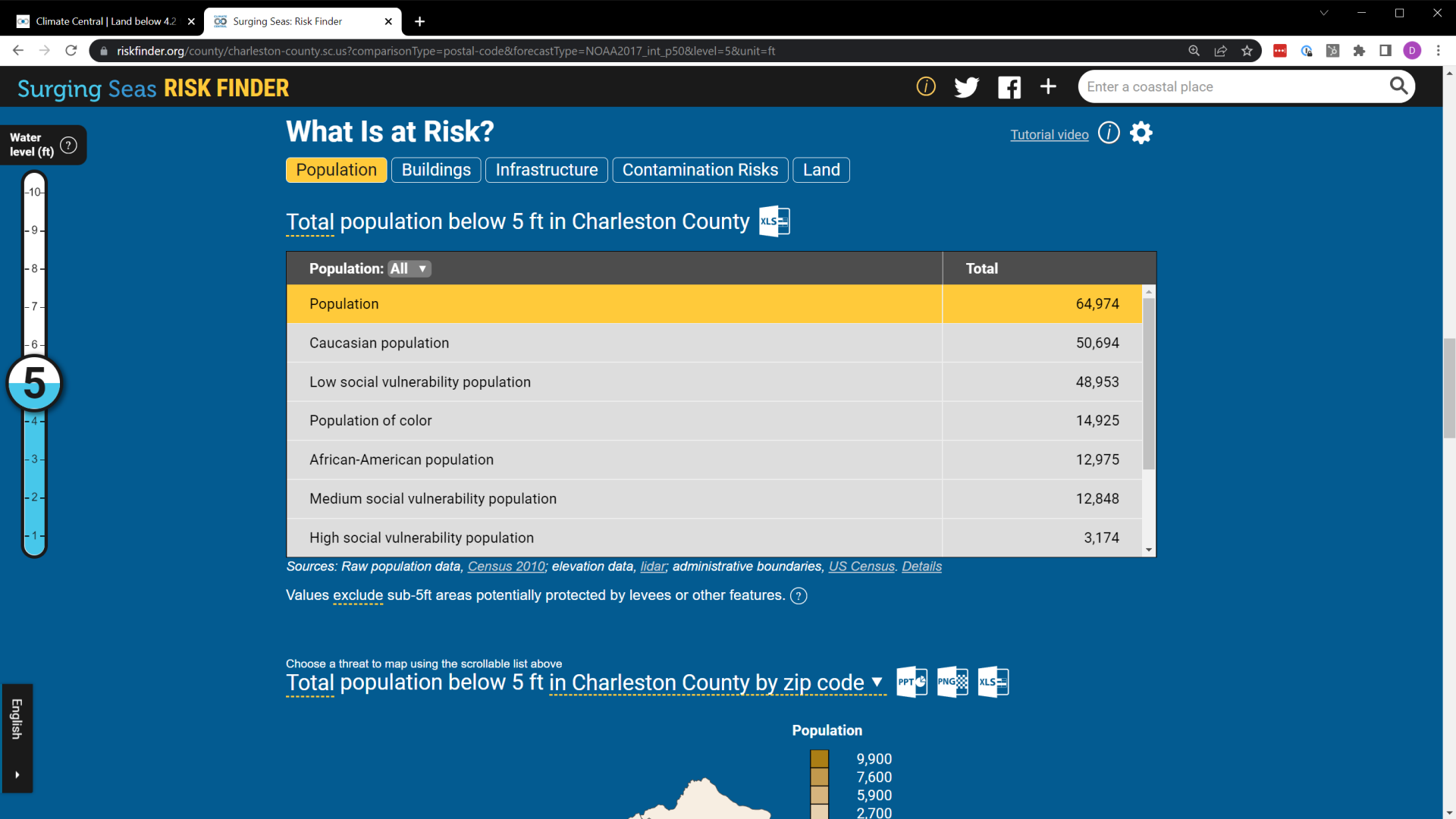
Water level (ft)

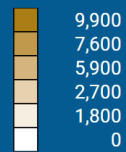Values exclude sub-5ft areas potentially protected by levees or other features.

Choose a threat to map using the scrollable list above
Total population below 5 ft in Charleston County by zip code ▼

Population

	9,900
	7,600
	5,900
	2,700
	1,800
	0

Legend values are bin upper limits

Top threats on map

29466	9,910
29412	7,582
29455	6,440
29464	6,253
29414	5,859

Sources: Raw population data, Census 2010; elevation data, lidar; administrative boundaries, US Census. Details

Values exclude sub-5ft areas potentially protected by levees or other features.
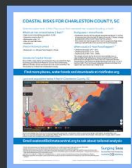
COASTAL RISKS FOR CHARLESTON COUNTY, SC

Selected water level: 5 feet. May occur from sea level rise, coastal flooding, or both.

What's at risk on land below 5 feet?[1,2]

- High social vulnerability population: 3,200
- Hazardous waste sites: 35
- Wastewater sites: 14
- Miles of road: 880 miles
- Hospitals: 6

5 feet in historical context [3,4]

- Statistical 1-in-100 year flood height: 3.9 feet

Unnatural Coastal Floods[5]

Since 1950, a tide station at Charleston has recorded 637 days exceeding local National Weather Service flood thresholds. Without climate-driven sea level rise, the count would be 176. The station is 3 miles from Charleston County.

Rising seas = more floods[4]

- Charleston County, SC has already experienced about 11 inches of sea level rise over the last 92 years of records. Climate change is projected to drive much more rise this century.
- This raises the starting point for storm surges and high tides, making coastal floods more severe and more frequent.

When could a 5-foot flood happen?[3,4,6]

- Likelihood by 2030: 8% – 14%
- Likelihood by 2050: 21% – 58%
- Likelihood by 2100: 76% – 100%

The ranges shown derive from the intermediate low vs. intermediate high global sea-level scenarios from a 2017 NOAA technical report for use in the U.S. National Climate Assessment, which point to projected local rises of 2.1 vs. 6.6 feet by 2100. The more heat-trapping pollution emitted, the higher that sea-level rise is likely to be.

Find more places, water levels and downloads at riskfinder.org

Land and population below 5 feet in Charleston County, SC
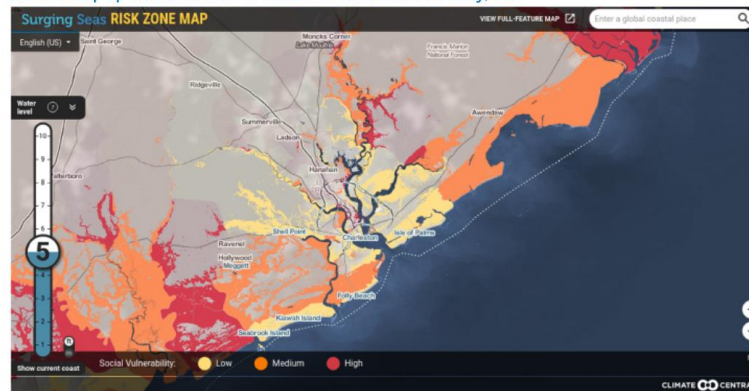
Social vulnerability (e.g. from low income) compounds coastal risk. Land below 5 feet is colored according to the legend. Surging Seas uses

Risk Finder Excel Downloads

33	TABLE: SEA LEVEL RISE AND COASTAL FLOOD EXPOSURE IN CHARLESTON COUNTY, SC ON LAND BELOW 1-10 FT											
34												
35			Elevation relative to local high tide line (Mean Higher High Water)									
36		Unit	< 1ft	< 2ft	< 3ft	< 4ft	< 5ft	< 6ft	< 7ft	< 8ft	< 9ft	< 10ft
37												
38	BY TOTALS											
39	High social vulnerability population	Count	473	899	1632	2642	3745	4999	6291	7727	9430	11715
40	Medium social vulnerability population	Count	1702	3263	5900	9548	13566	17998	22864	28492	34538	40295
41	Low social vulnerability population	Count	6652	13050	22949	36767	52652	68998	85527	102485	117799	132578
42	Property value	$Million	2345	4816	9226	14464	19460	23818	27603	31069	34280	37251
43	Population	Count	8827	17212	30480	48956	69963	91995	114681	138704	161767	184588
44	Caucasian population	Count	7122	13672	23918	38178	54386	70931	87548	104607	120161	135311
45	Population of color	Count	1806	3725	6877	11278	16286	22005	28327	35577	43358	51307
46	African-American population	Count	1474	3148	5919	9761	14089	19064	24573	30963	37907	44970
47	Asian population	Count	169	305	512	813	1170	1548	1964	2387	2765	3151
48	Hispanic population	Count	310	540	887	1372	1955	2601	3298	4070	4868	5712
49	Native American population	Count	64	116	194	317	472	643	814	999	1182	1371
50	Homes	Count	4629	9149	16770	27087	38355	49628	60884	72733	83925	94723
51	Hospitals	Count	1	1	2	3	6	11	13	15	18	22
52	Schools	Count	0	3	5	9	15	22	32	40	46	52
53	Colleges and Universities	Count	0	1	3	5	6	6	7	12	14	15
54	Libraries	Count	0	0	3	3	6	7	7	7	8	11
55	Theater, music & arts buildings	Buildings	0	0	0	0	1	2	2	2	3	4
56	Museums	Count	0	0	2	3	5	6	6	7	8	8
57	Houses of worship	Count	0	6	16	24	34	46	65	94	121	145
58	Government buildings	Count	0	5	12	27	41	49	53	64	77	90
59	Roads	Miles	28	116	333	621	905	1169	1413	1651	1887	2120
60	Federal roads	Miles	2	3	6	11	18	24	31	37	45	58
61	Local roads	Miles	24	104	301	563	817	1048	1263	1469	1668	1860

Risk Finder Excel Downloads

	LEVEL	ID	NAME	LAT	LON
31	SEA LEVEL RISE AND COASTAL FLOOD EXPOSURE OF HAZARDOUS WASTE SITES IN CHARLESTON COUNTY, SC ON LAND BELOW 1				
32					
33	LEVEL	ID	NAME	LAT	LON
34	0f	110002178875	ISLE OF PALMS WWTP	32.793333	-79.788333
35	1f	110000618859	VA MEDICAL CENTER RESEARCH	32.78533	-79.95333
36	2f	110012223575	MEDICAL UNIV OF SC FT JOHNSON DNR	32.751371	-79.898543
37	2f	110009261887	CALHOUN PARK AREA	32.78993	-79.92695
38	3f	110046539983	RITE AID #11608	32.78344	-79.94494
39	3f	110002255416	EXXON LOCATION 4 0277	32.78375	-79.94435
40	3f	110004941877	LEGARE PAINT & BODY SHOP	32.796	-80.10839
41	3f	110001665555	MUSC RUTLEDGE TOWERS	32.78381	-79.94438
42	3f	110002255639	CITY OF CHARLESTON E BAY CALHOUN DRAINAG	32.78821	-79.93088
43	3f	110002197471	MCCLARYS PAINT BODY SHOP	32.791187	-79.880653
44	3f	110002185046	FT SUMTER TOUR BOAT FACILITY NATIONAL PARK SI	32.79015	-79.92696
45	3f	110008567577	MAGWOOD SEAFOOD	32.78885	-79.88474
46	3f	110002197284	SANI TECHNOLOGY ENVIRONMENT LLC	32.849645	-79.954603
47	4f	110002239649	SALMON DREDGING	32.83208	-79.94458
48	4f	110002253702	U S PLYWOOD	32.78197	-79.9276
49	4f	110007836431	BP OIL-SITE #24126	32.80023	-79.94839
50	4f	110004937542	S C STATE PORTS AUTHORITY	32.78068	-79.9258
51	4f	110038531666	PROTECTED BEHICLE ACQUISITION	32.865021	-79.969589
52	4f	110042075394	PVI ACQUISITION LLC	32.865021	-79.969589
53	4f	110002237053	ATLANTIC TIRE & BATTERY FORMER	32.80407	-79.94559
54	4f	110002258832	MORRISON DRIVE HOPE CENTER SITE	32.805075	-79.94146
55	4f	110004937775	SCE & G- FLEET MAINT CTR	32.806043	-79.946705

Climate Central Resources
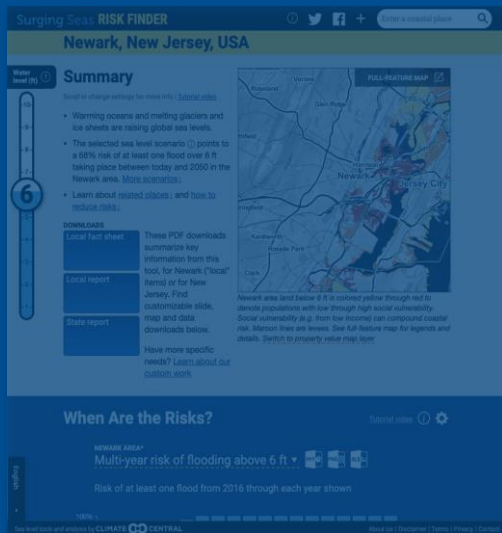
Risk Finder

Coastal Risk Screening Tool

Picturing Our Future

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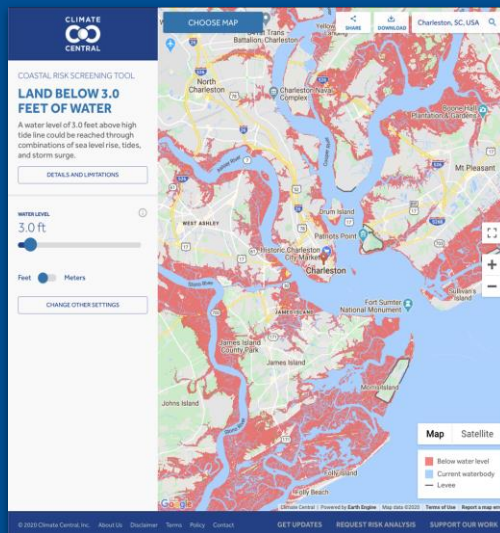
Coastal Risk Screening Tool

- Interactive sea level rise and coastal flood map
- Easy-to-use Google Maps interface
- Customize year, pollution scenario, sea level rise model, etc.
- View risk by...

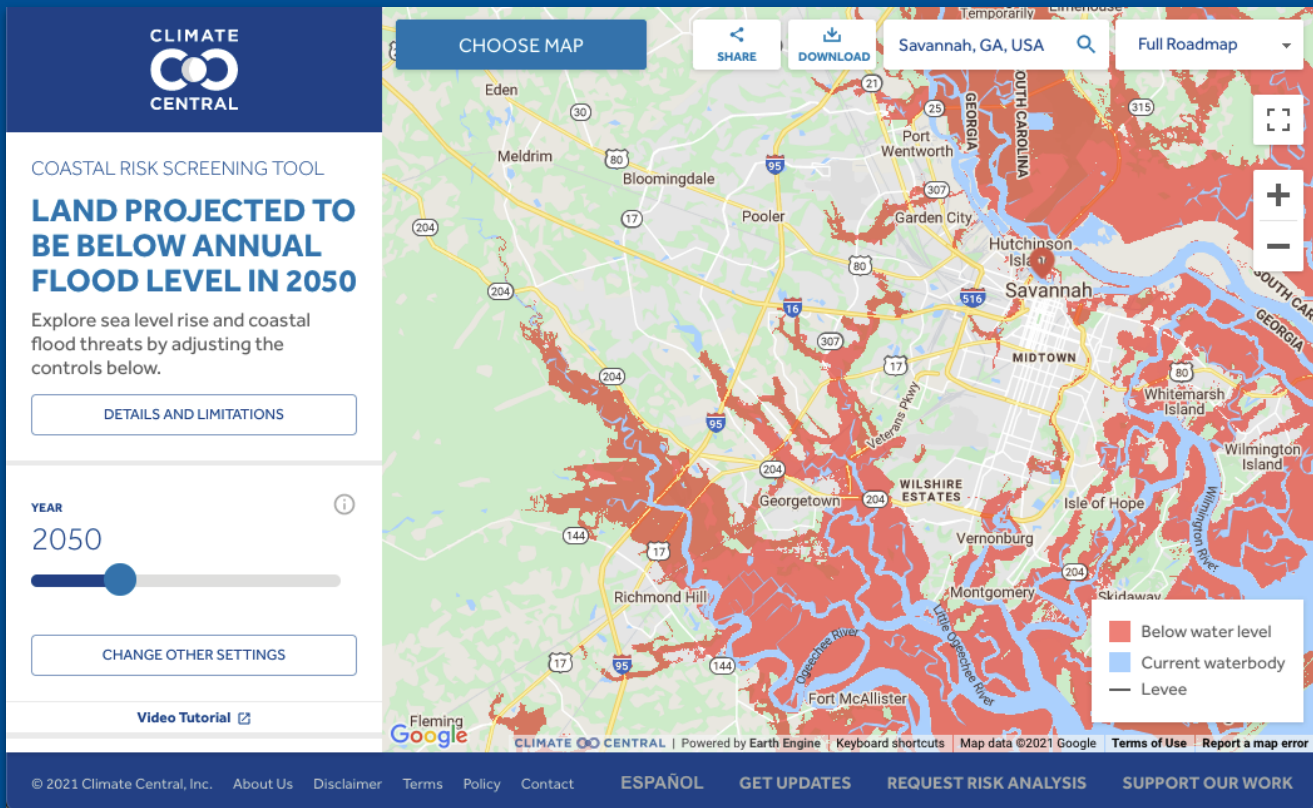Year

Water
Level

Temperature

Ice Sheets

Elevation
Dataset

Affordable
Housing

Coastal Risk Screening Tool Demo

Climate Central Resources

Risk Finder

Coastal Risk Screening Tool

Picturing Our Future

CLIMATE ⚭ CENTRAL

Picturing Our Future

- 1,000+ visualizations of locked-in future sea levels after different amounts of global warming
- Iconic places in 121 cities in 43 countries
- Multimedia presentation

Images　　　　　　Videos　　　　　　Gifs　　　　　　Sliders

WHICH CLIMATE FUTURE WILL WE CHOOSE?

CLIMATE CENTRAL

If we sharply cut carbon pollution
(1.5°C global warming)

If we keep our current carbon path
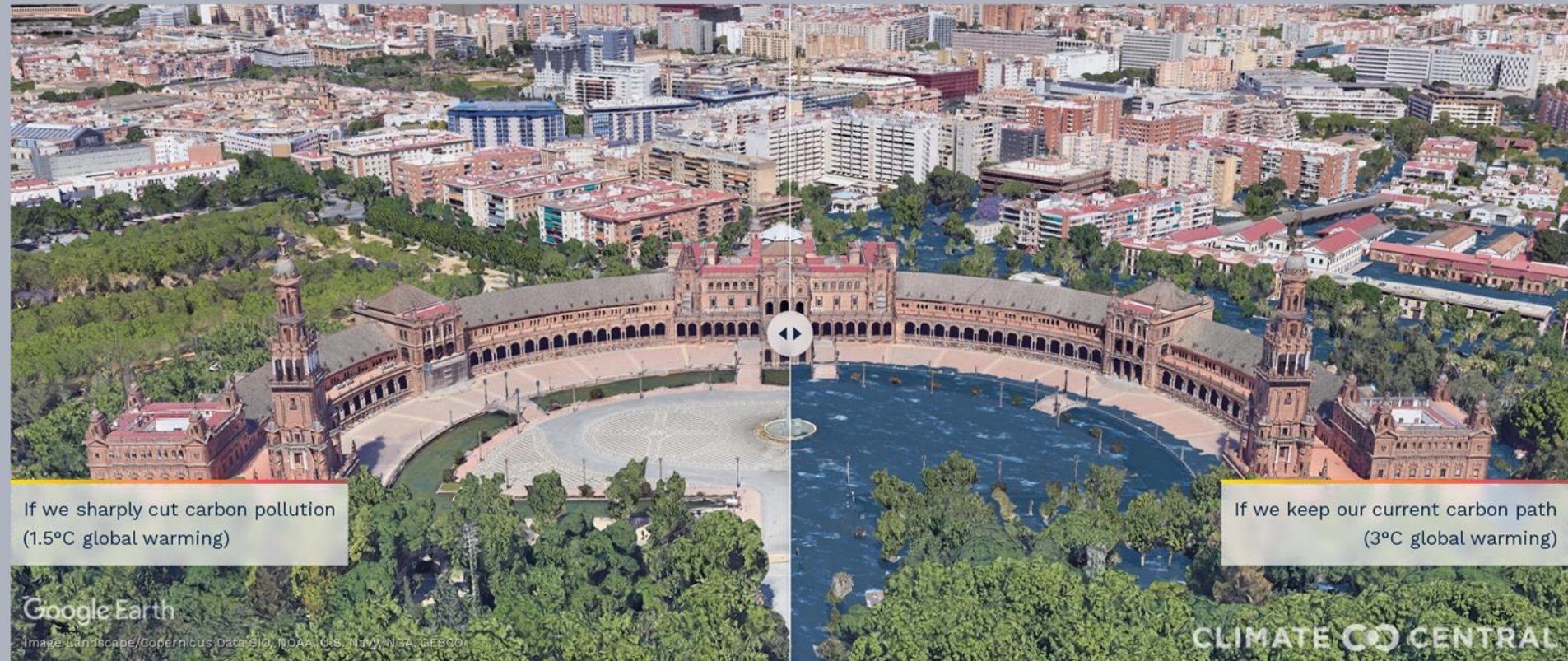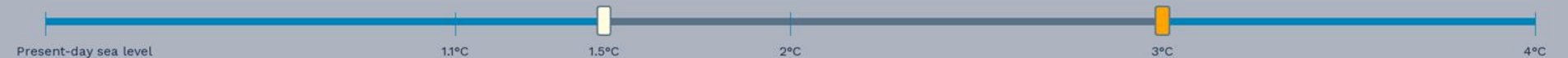(3°C global warming)

CLIMATE ⚭ CENTRAL

CLIMATE CENTRAL

HAVANA

If we cut pollution sharply

Which Future Will We Choose?

At the UN Climate Conference in November, decisions by world leaders will set a path for Seville's ultimate sea level.

PLAZA DE ESPAÑA, SEVILLE, SPAIN

If we sharply cut carbon pollution
(1.5°C global warming)

If we keep our current carbon path
(3°C global warming)

Google Earth

Image Landscape/Copernicus Data SIO, NOAA, U.S. Navy, NGA, GEBCO

CLIMATE CENTRAL

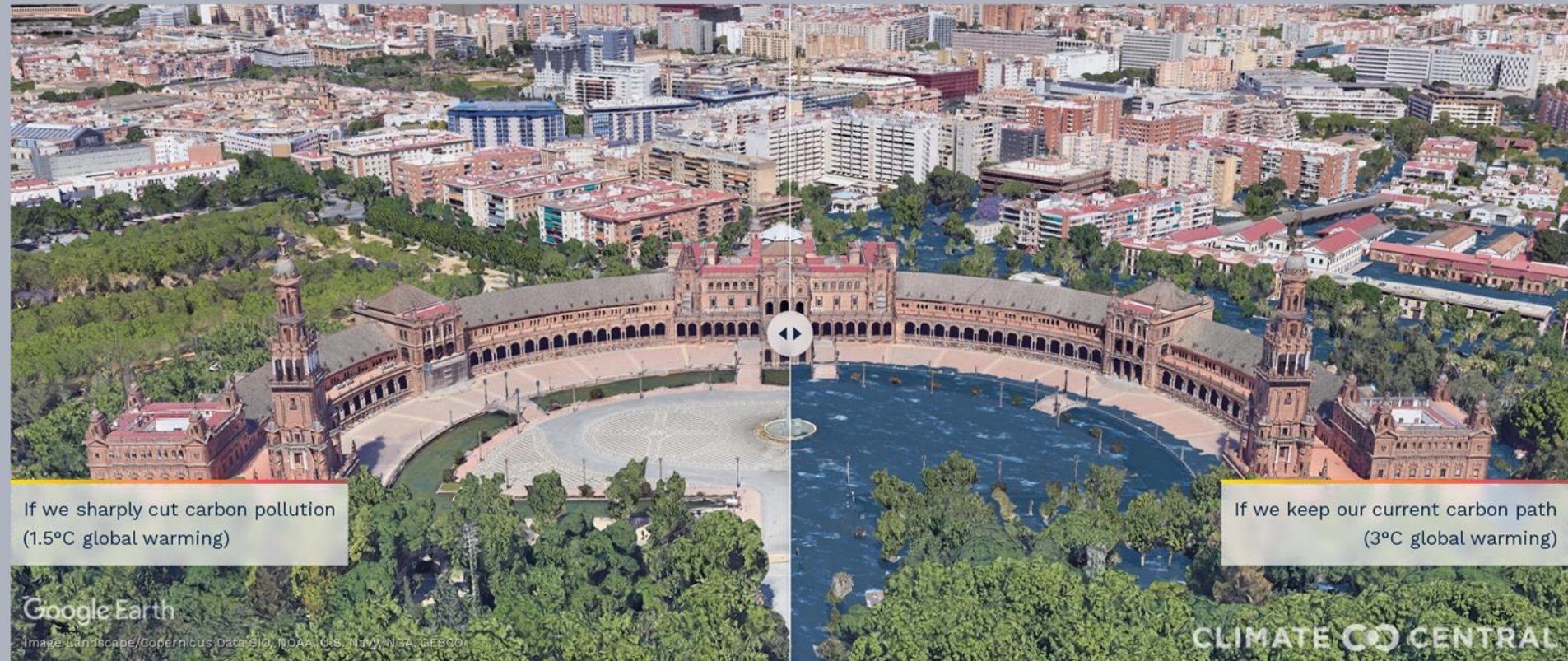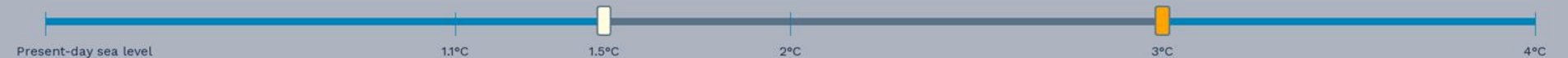Present-day sea level   1.1°C   1.5°C   2°C   3°C   4°C

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Image Landscape/Copernicus Data SIO, NOAA, U.S. Navy, NGA, GEBCO

CLIMATE CENTRAL

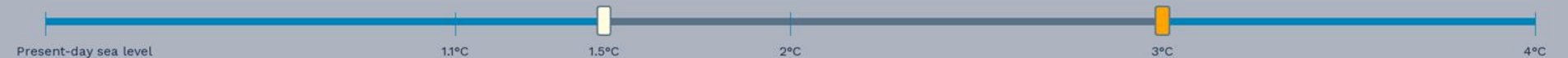Present-day sea level   1.1°C   1.5°C   2°C   3°C   4°C

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Google Earth

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CLIMATE CENTRAL

Present-day sea level   1.1°C   1.5°C   2°C   3°C   4°C

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If we keep our current carbon path
(3°C global warming)

Google Earth

Image Landscape/Copernicus Data SIO, NOAA, U.S. Navy, NGA, GEBCO

CLIMATE CENTRAL

Present-day sea level   1.1°C   1.5°C   2°C   3°C   4°C

Picturing Our Future Demo

See Visuals

See risk maps ⧉ | See the research ⧉

Search locations

Search by keyword

+ Media Type

– Region ●

- [ ] Africa
- [ ] Asia
- [ ] Oceania
- [ ] Europe
- [✓] North America
- [ ] South America

+ Temperature

Found sea level rise visuals for 73 locations. Click to view full-size.

List | Map

Plaza de la Catedral
Havana, Cuba

| PHOTOREALISTIC IMAGE | NORTH AMERICA | 1.5°C | 3°C | ANIMATED GIF |

National Mall/United States Capitol
Washington D.C., District of Columbia, United States

| PHOTOREALISTIC IMAGE | NORTH AMERICA | 1.5°C | 3°C | ANIMATED GIF |

Space Center Houston
Houston, Texas, United States

| FLYOVER VIDEO | NORTH AMERICA | 1.5°C | 3°C |

Atlantis Bahamas
Paradise Island, Bahamas

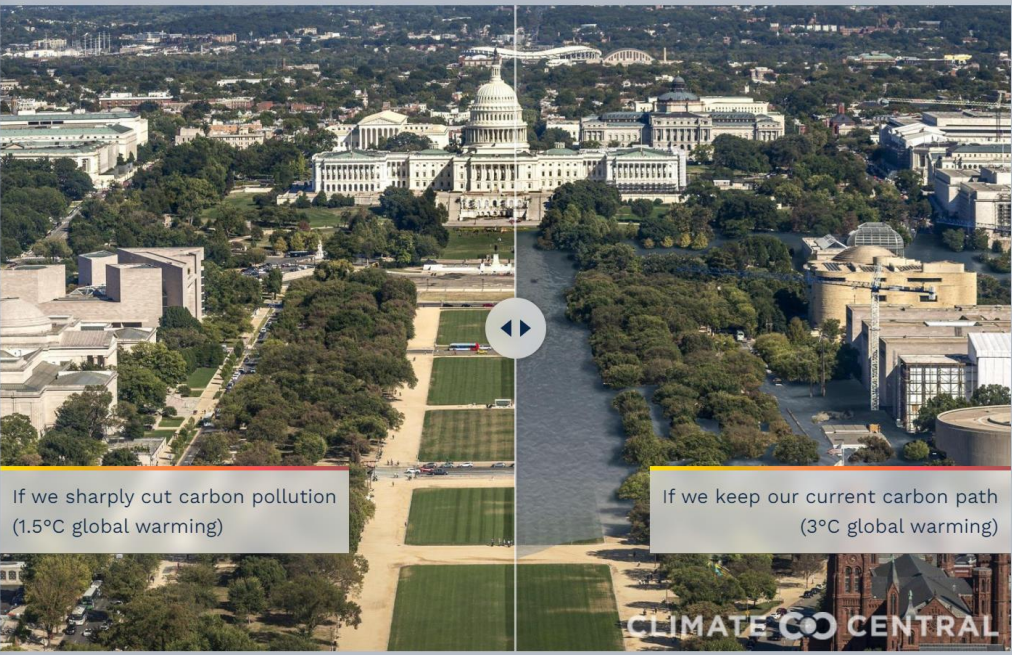| GOOGLE EARTH IMAGE | NORTH AMERICA | 1.5°C | 2°C | 3°C | 4°C | PRESENT-DAY SEA LEVEL | 1.1°C | ANIMATED GIF |

Which Future Will We Choose?

Climate and energy choices this decade will influence how high sea levels rise for hundreds of years.

NATIONAL MALL/UNITED STATES CAPITOL, WASHINGTON D.C., DISTRICT OF COLUMBIA, UNITED STATES

Download ▾ | Share | Animated GIF | Embed | View on Map

If we sharply cut carbon pollution (1.5°C global warming)

If we keep our current carbon path (3°C global warming)

CLIMATE ∞ CENTRAL

1.5°C   3°C

Coming Soon: *FloodVision*

Sea Level Rise & Social Vulnerability Workshops

Completed Training Workshops

- CA Certification Training, October, 2020
- SE & Gulf Certification Training, August, 2020
- Maryland, October, 2019
- Honolulu, HI, April, 2018
- North Charleston, SC, October, 2017
- Eastern Shore, MD, August, 2017
- Orlando, FL, June, 2017
- Pensacola, FL, April, 2017
- Gulfport, MS, October, 2016
- Houston, TX, September, 2016
- Wilmington, NC, April, 2016
- Gulfport, MS, August, 2015

https://sealevel.climatecentral.org/responses/workshops/

Seeking Your Input

We'd welcome a chance to speak with you for 20-30 minutes about what new tool features you think would be useful. Please email us at sealevel@climatecentral.org.

Thank you

Dan Rizza

drizza@climatecentral.org

CLIMATE CENTRAL

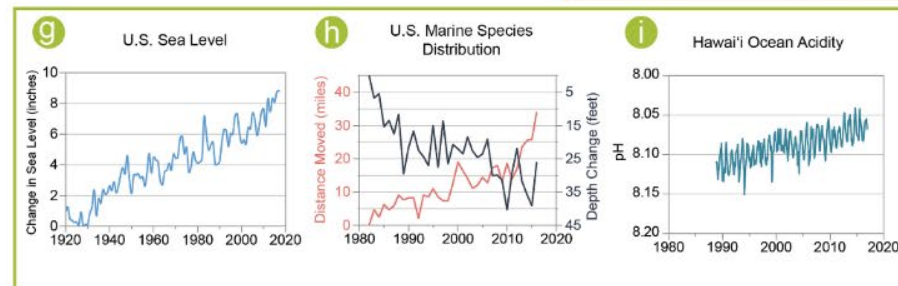# Climate Change Impacts on Sea Level Rise at the Local Level
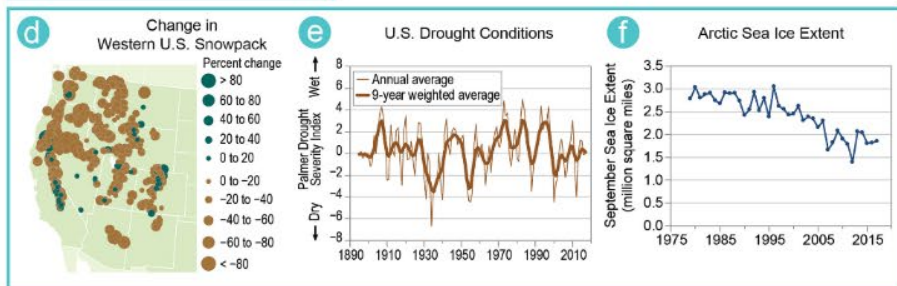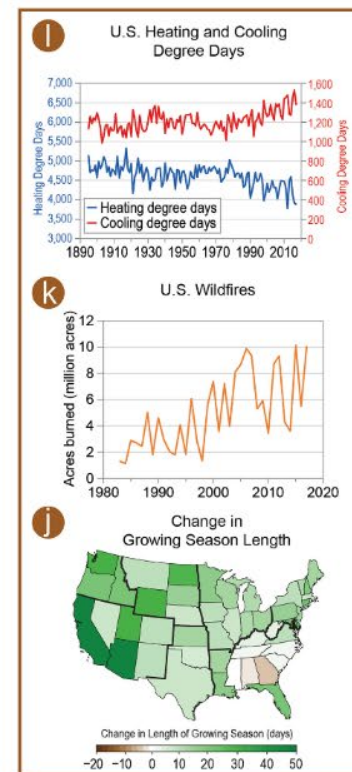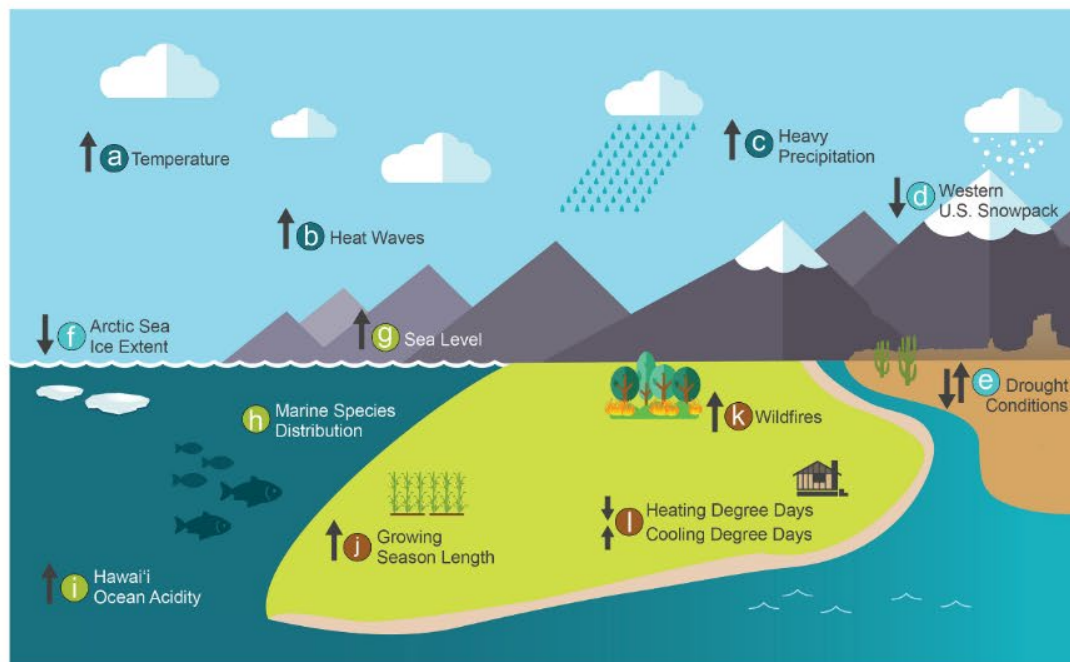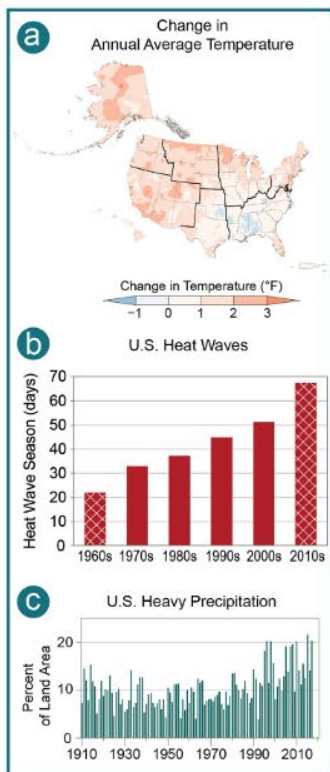
Doug Marcy

NOAA Office for Coastal Management

APA – *Sustainability & Resilience Series*
Technology Tools for Sustainability
5/13/2022

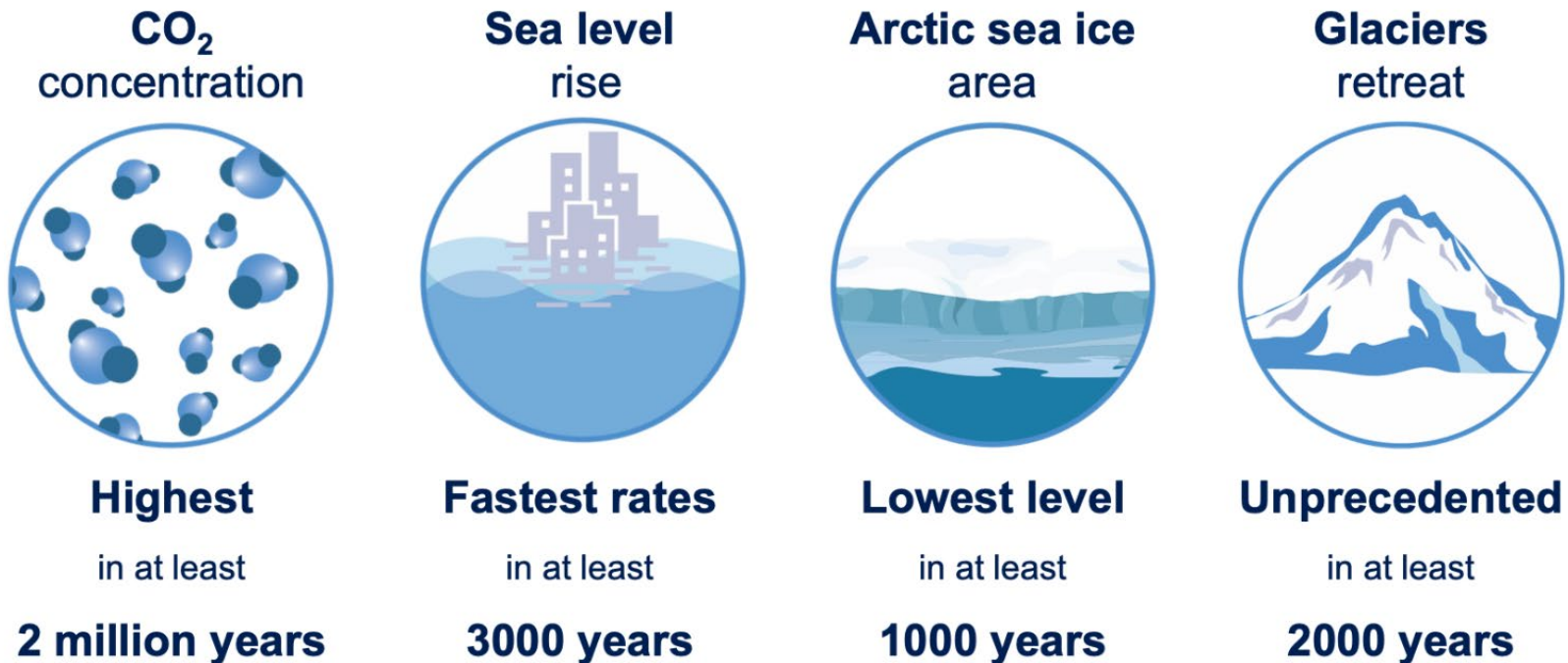# Climate Change Indicators

OFFICE FOR COASTAL MANAGEMENT
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Intergovernmental Panel on Climate Change Sixth Assessment Report

CO$_2$ concentration	Sea level rise	Arctic sea ice area	Glaciers retreat
Highest	**Fastest rates**	**Lowest level**	**Unprecedented**
in at least	in at least	in at least	in at least
2 million years	**3000 years**	**1000 years**	**2000 years**

IPCC AR6 Working Group I – Summary for Policy Makers

Historical Land and Sea Temperature

From USGCRP NCA4
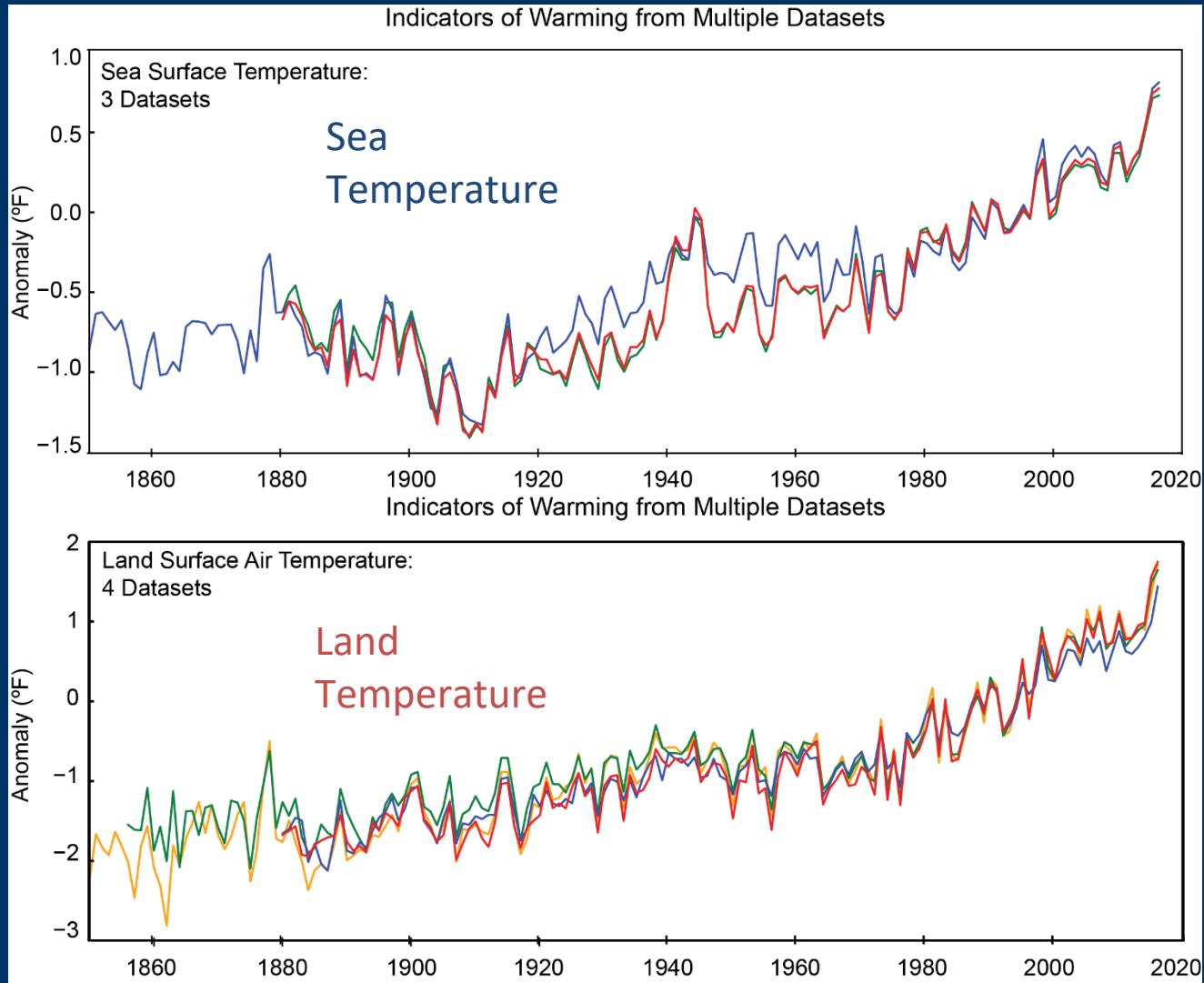
Historical Sea Level Rise
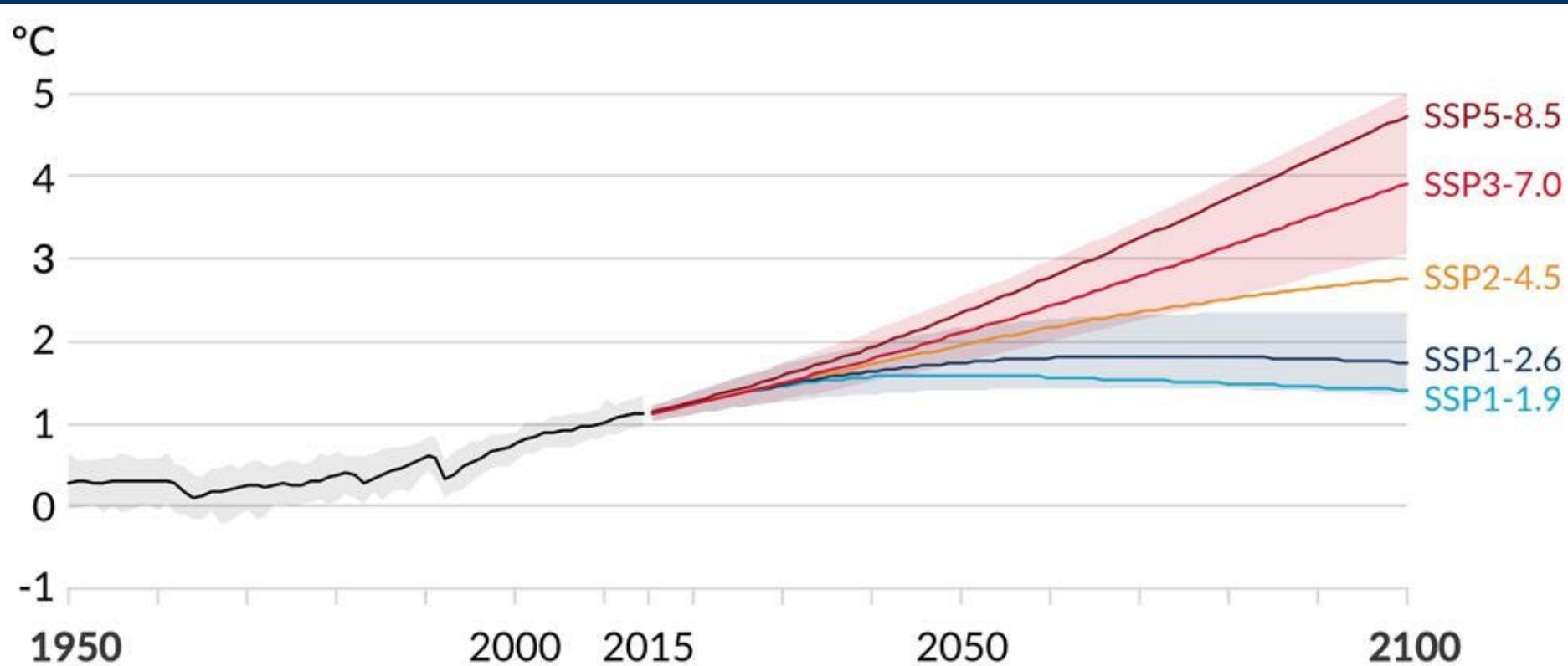
a) Causes of global mean sea level rise

b) Contiguous United States versus global mean sea level

- Glaciers
- Greenland Ice Sheet
- Antarctic Ice Sheet
- Terrestrial Water Storage
- Thermosteric expansion

- Sum of contributing processes
- Observed global mean sea level
- Sea level along contiguous US

OFFICE FOR COASTAL MANAGEMENT
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Future Temperature
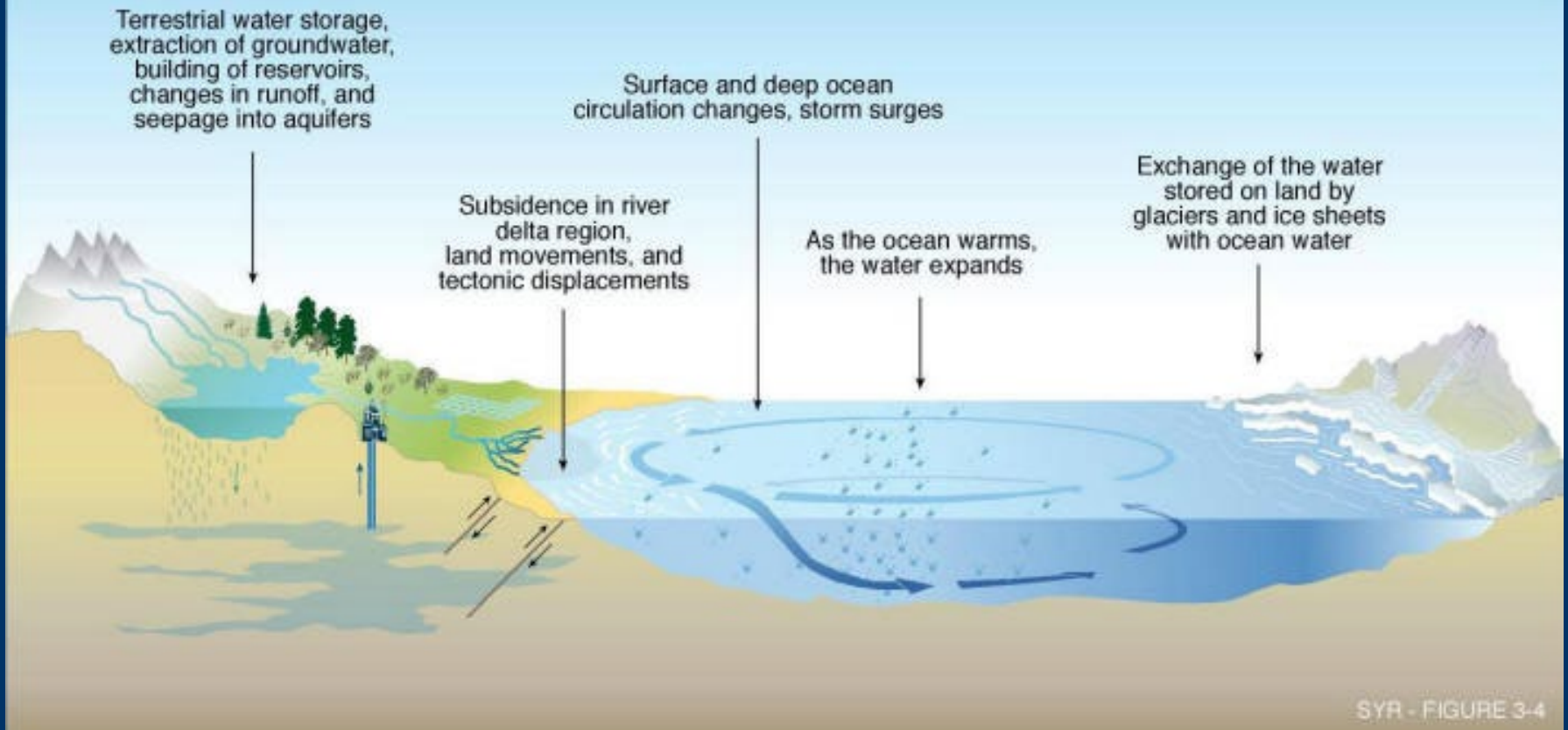
OFFICE FOR COASTAL MANAGEMENT
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Sea Level Change

What causes the sea level to change?

Terrestrial water storage, extraction of groundwater, building of reservoirs, changes in runoff, and seepage into aquifers

Surface and deep ocean circulation changes, storm surges

Subsidence in river delta region, land movements, and tectonic displacements

As the ocean warms, the water expands

Exchange of the water stored on land by glaciers and ice sheets with ocean water

SYR - FIGURE 3-4

National Sea Level Rise

Then

1920

2020 (Now)

10-12 inches higher

2050 (Future)

additional 10-12 inches

- Projections vary by location.

- 10-12 inch rise in last 100 years; same amount of rise projected in next 30 years.

- Results: profound shift in coastal flooding over next 30 years.

- Results: damaging floods projected 10+ times as often.

2022 Sea Level Rise Technical Report

- Federal Interagency Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Task Force
- Most up-to-date sea level rise projections available
- Key input for 5th National Climate Assessment
- Data informs sea level rise adaptation plans at all scales

2022 Sea Level Rise Technical Report
CONTENT

- Sea level rise scenarios at global, U.S., regional, and local levels

- Observation trends and extrapolations from 1970-2050

- Extreme water level probabilities for various heights

- Description of scientific data and methods employed

2022 Sea Level Rise Technical Report
KEY TAKEAWAYS

- U.S. Coast: average 10-12 inches sea level rise in next 30 years.
  - Equals change seen over past 100 years.
  - Rates will be lower or higher in different regions.
- Results: More extreme tides and damaging storm surges.
- Results: Profound shift in coastal flooding over next 30 years. By 2050, "moderate" (typically damaging) flooding likely to occur 10+ times more often.
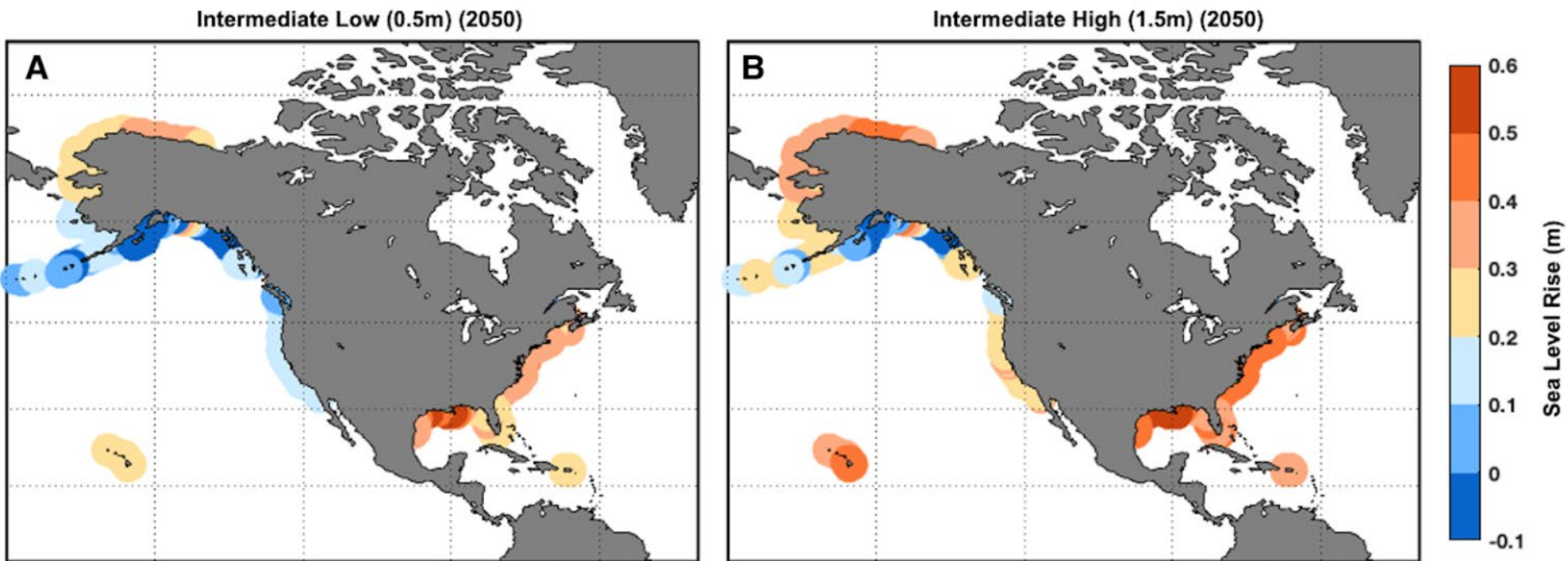
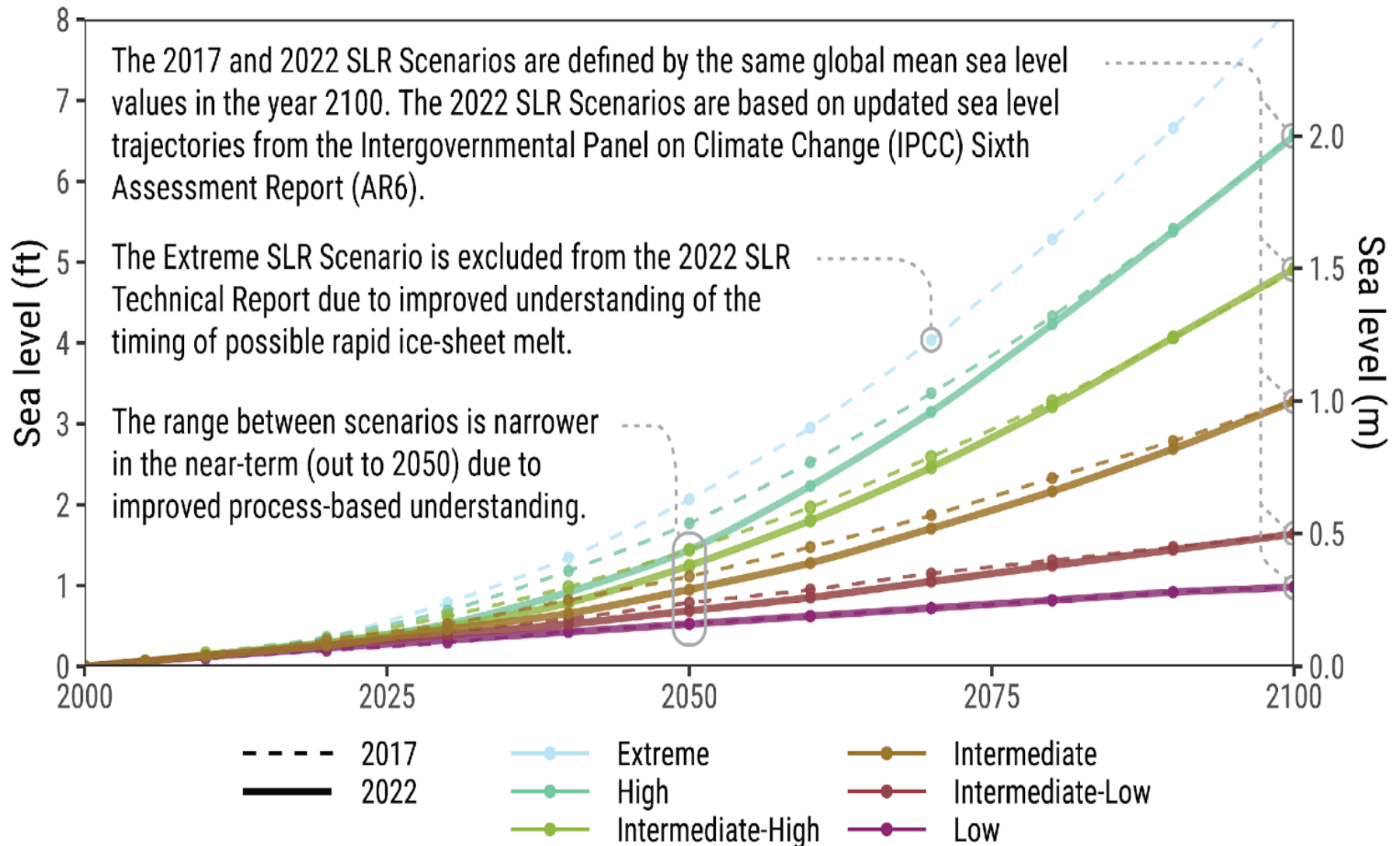# 2022 Sea Level Rise Technical Report

KEY TAKEAWAYS

- Emissions Matter: Likely at least two additional feet by 2100 due to current emissions alone. Rising emissions could cause a sea level spike upwards of 7 feet by 2100.
- Greater certainty than previous projections for the next 30 years.
- Uncertainty increases after 2050, and is highly dependent on future emissions.
- Continued observations will enhance future predictions.

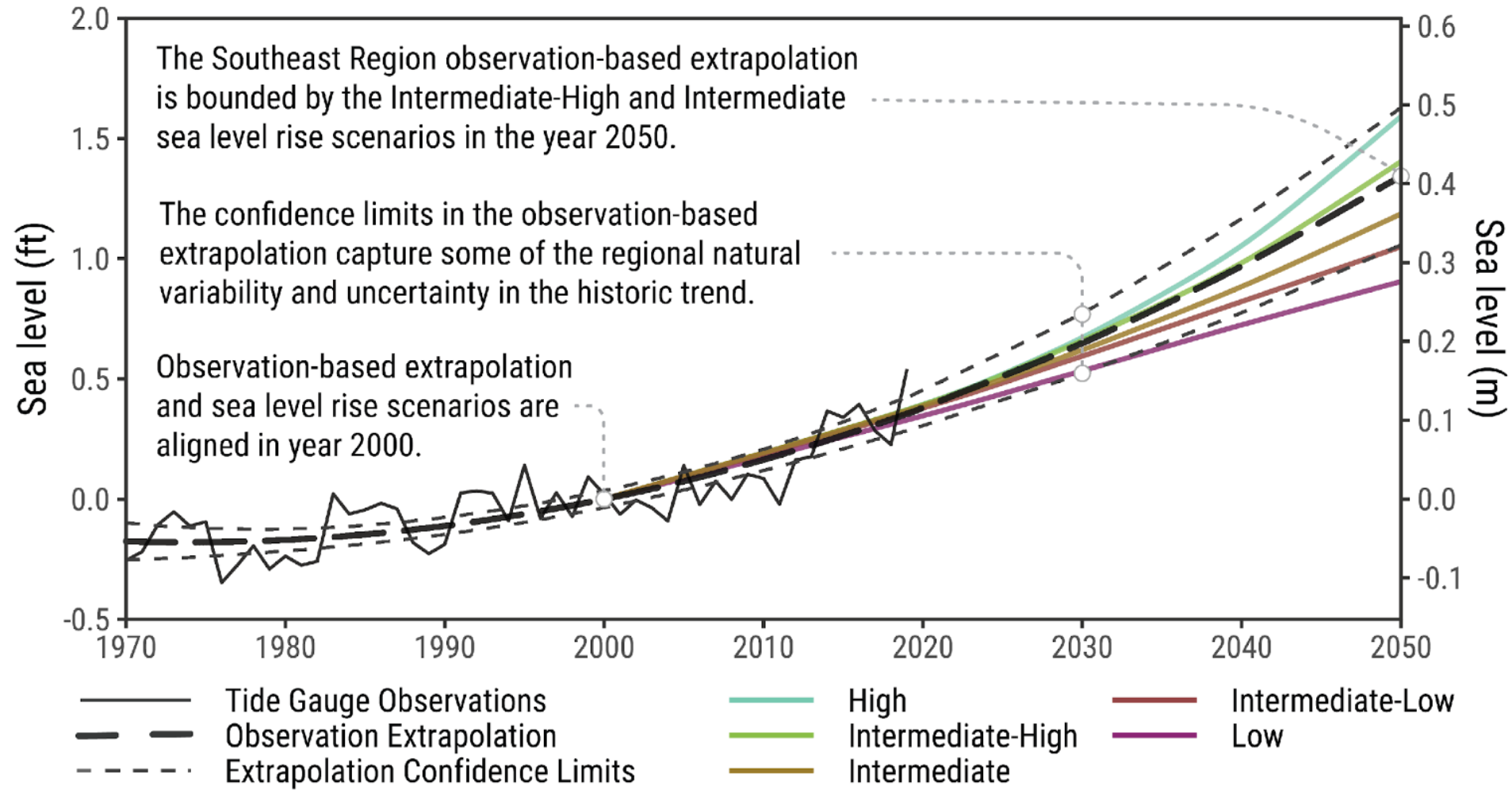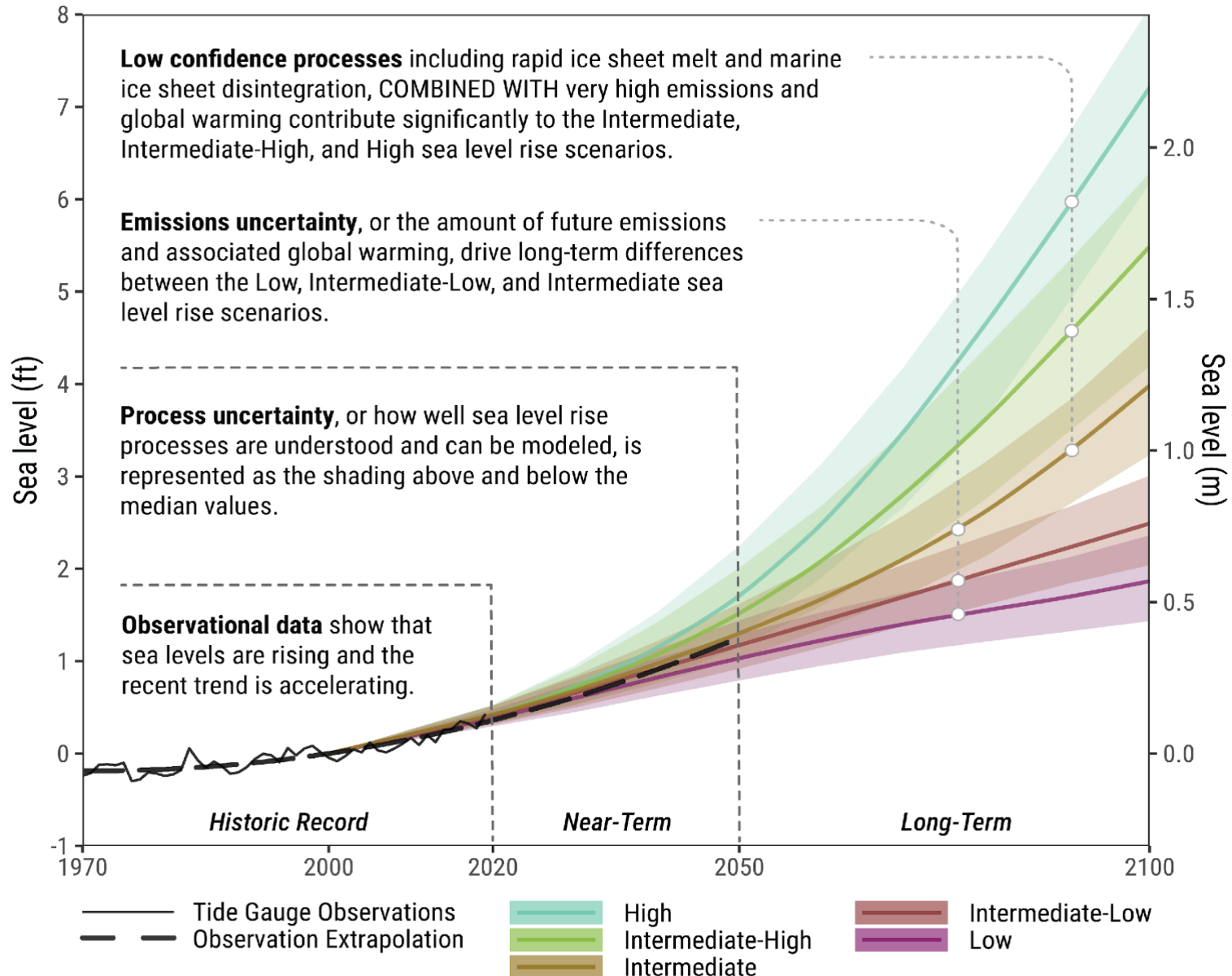# Near-Term Sea Level Change (2020-2050)

Intermediate Low (0.5m) (2050)

Intermediate High (1.5m) (2050)

Sea Level Rise (m)

Sweet et al, 2022

What has changed from 2017?

The 2017 and 2022 SLR Scenarios are defined by the same global mean sea level values in the year 2100. The 2022 SLR Scenarios are based on updated sea level trajectories from the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6).

The Extreme SLR Scenario is excluded from the 2022 SLR Technical Report due to improved understanding of the timing of possible rapid ice-sheet melt.

The range between scenarios is narrower in the near-term (out to 2050) due to improved process-based understanding.

What else is new?

How confident are we?

Low confidence processes including rapid ice sheet melt and marine ice sheet disintegration, COMBINED WITH very high emissions and global warming contribute significantly to the Intermediate, Intermediate-High, and High sea level rise scenarios.

Emissions uncertainty, or the amount of future emissions and associated global warming, drive long-term differences between the Low, Intermediate-Low, and Intermediate sea level rise scenarios.

Process uncertainty, or how well sea level rise processes are understood and can be modeled, is represented as the shading above and below the median values.

Observational data show that sea levels are rising and the recent trend is accelerating.

Historic Record   Near-Term   Long-Term

Sea level (ft) · Sea level (m)

—— Tide Gauge Observations
– – Observation Extrapolation

High
Intermediate-High
Intermediate
Intermediate-Low
Low

Gridded Sea Level Rise Data (with Tide Gauges Overlaid)

Sweet et al, 2022
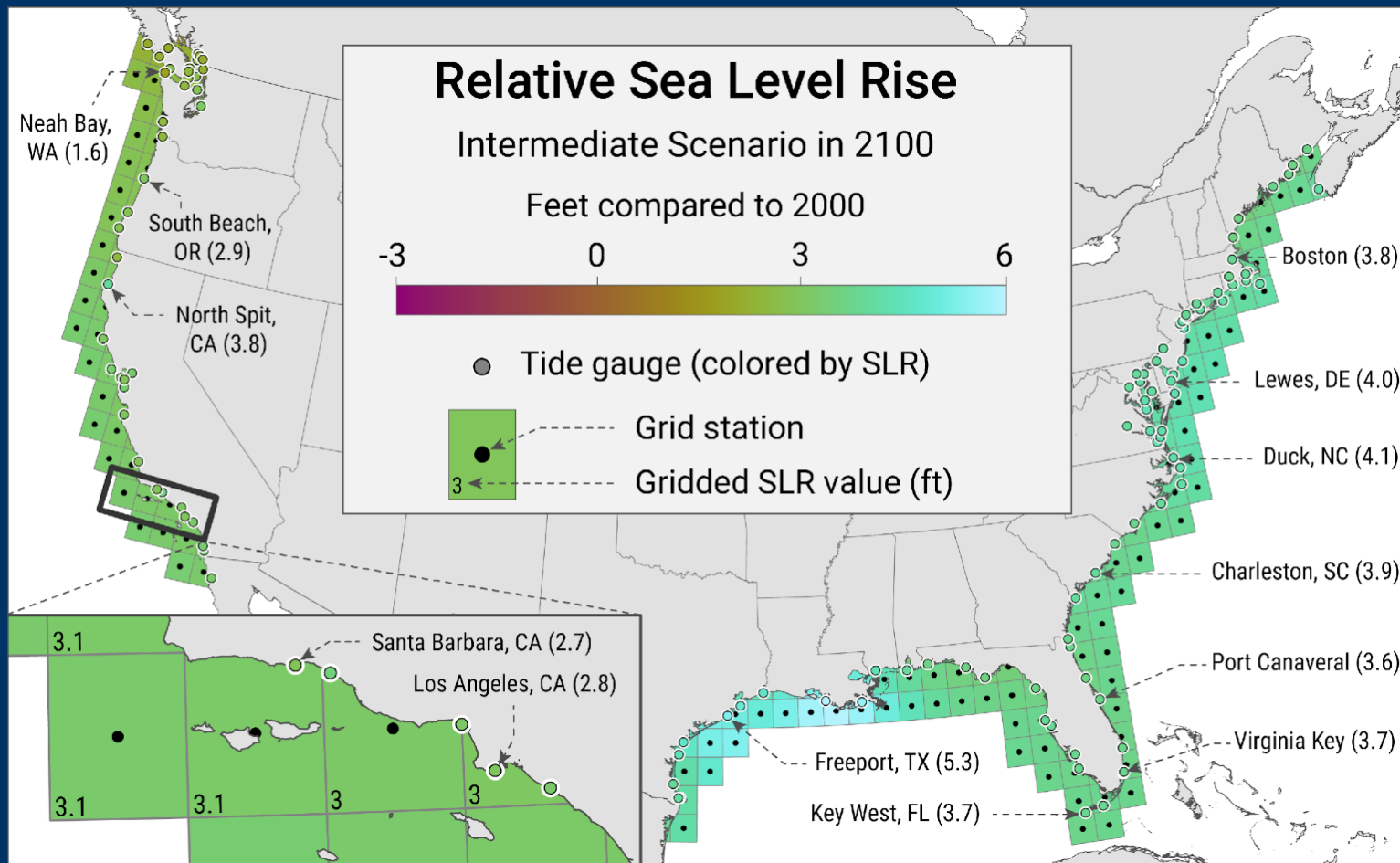
Local Sea Level Rise

8774770 Rockport, Texas · 5.86 +/- 0.48 mm/yr

Legend:
- Linear Relative Sea Level Trend
- Upper 95% Confidence Interval
- Lower 95% Confidence Interval
- Monthly mean sea level with the average seasonal cycle removed

Y-axis: Meters (0.60 to -0.60)
X-axis: 1920 to 2020

1.92 feet in 100 years

tidesandcurrents.noaa.gov

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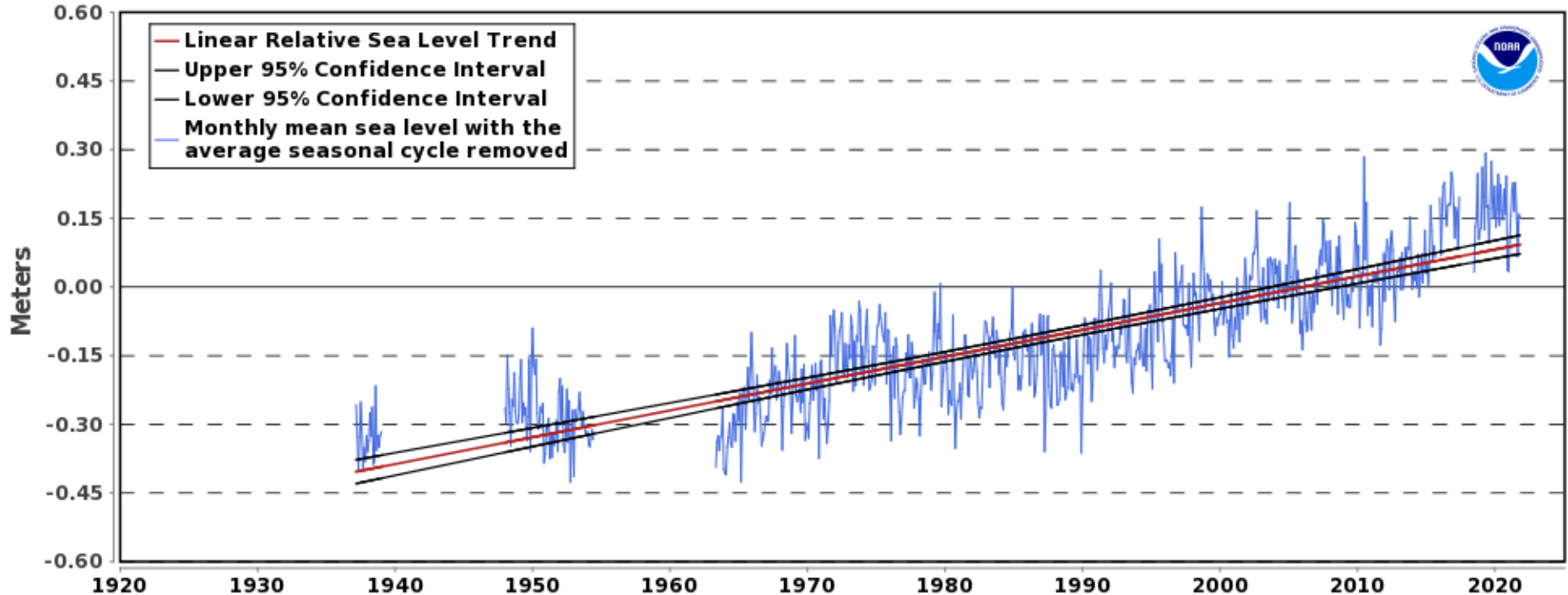
Increase in High Tide Flooding Events

Sweet et al, 2022

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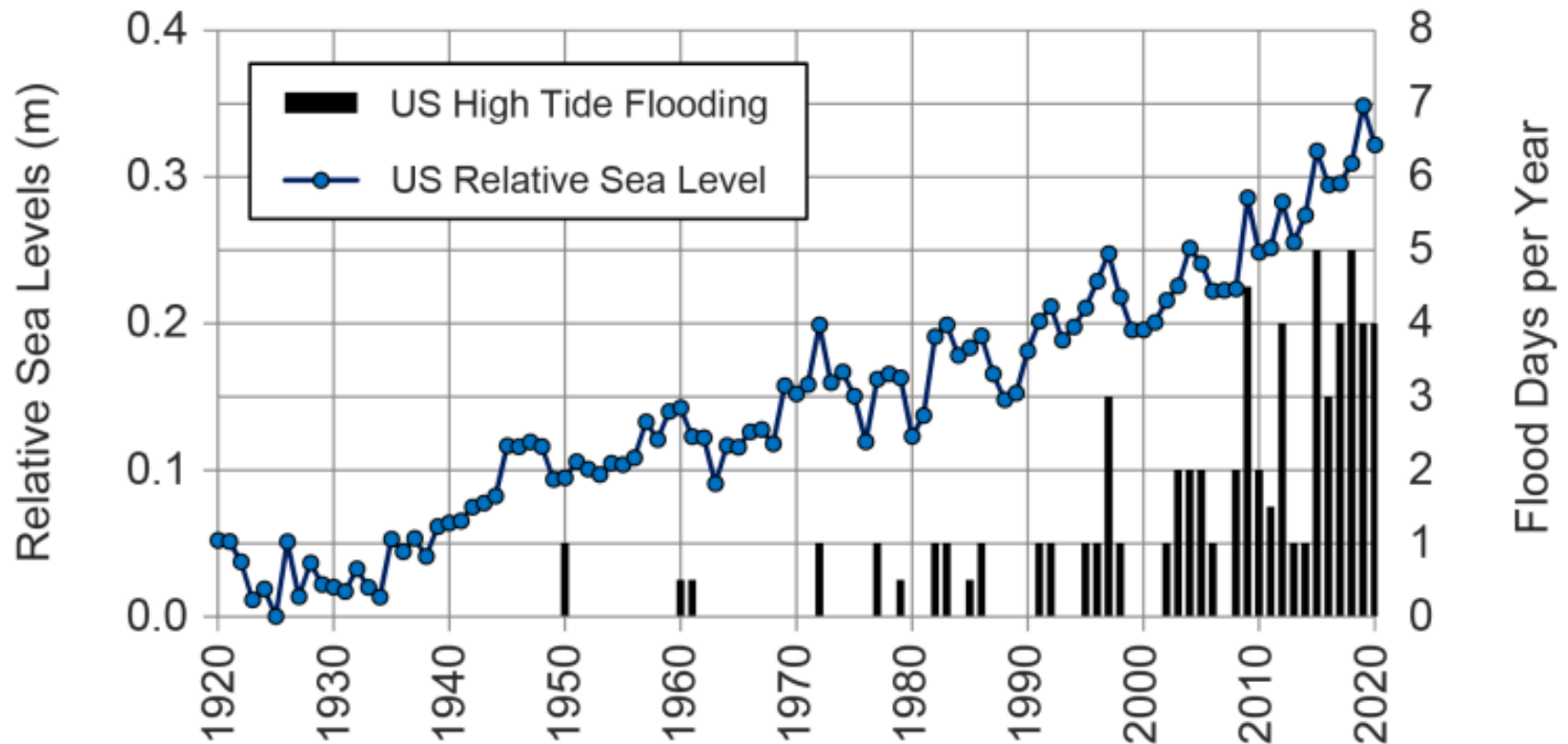
High Tide Flooding Averages

Then (2000)

2 days

Now (2020)

4 days – twice as frequent as in 2000

Future (2050)

25 to 75 days – up to 19 times as frequent as in 2020

- Some regions have 400 - 1,100% increase in frequency.

- Acceleration is seen at 80% of East and Gulf Coast locations.

- By 2050, minor high tide flooding is normal occurrence at most locations.

Physical Factors Directly Contributing to Coastal Flood Exposure
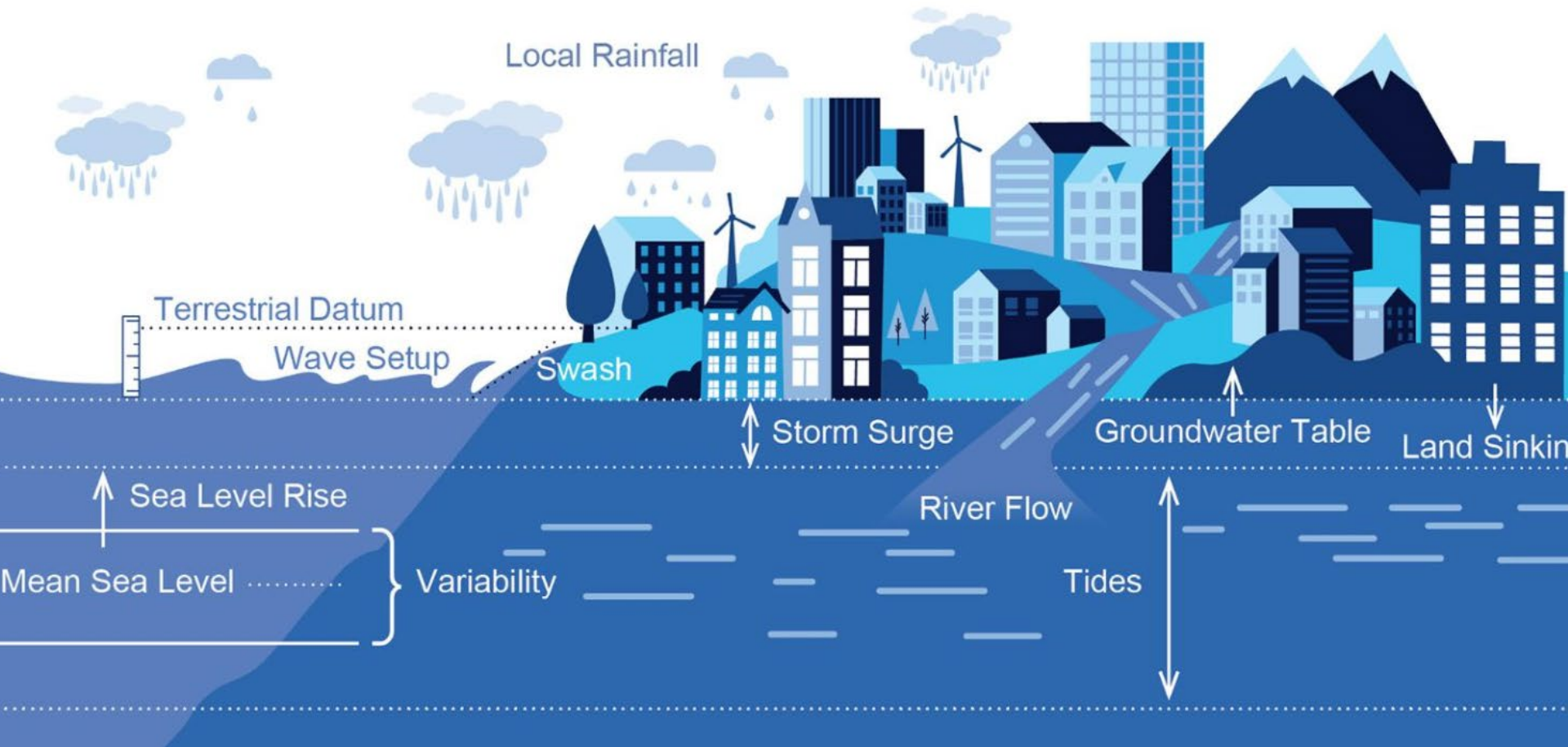
SLR Will Make Future Storms Worse

FIGURE 3: Storm Surge and High Tides Magnify the Risks of Local Sea Level Rise

Sea level sets a baseline for storm surge—the potentially destructive rise in sea height that occurs during a coastal storm. As local sea level rises, so does that baseline, allowing coastal storm surges to penetrate farther inland. With higher global sea levels in 2050 and 2100, areas much farther inland would be at risk of being flooded. The extent of local flooding also depends on factors like tides, natural and artificial barriers, and the contours of coastal land.

Local factors such as tides and coastal profile will influence extent of floodplain.

Combined Flooding

Storm Surge

Extreme Rainfall

Tides, Storm Surge, and Waves and SLR

Wind Waves

Highest Tide / King Tide

Regional Oceanographic

Water Can't Drain and Backs Up

https://coast.noaa.gov/stormwater-floods/

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Implications for Local Planning
MIXED NEWS

- Narrower range of possible scenarios until 2050, so more certainty
- Rate of sea level rise has accelerated over the last few decades
- More time to plan for the highest levels than previously projected (though unabated emission levels could change this)
- The tidal flooding regime shift predicted over the next 30 years means planning can't wait

Consider Risk Tolerance, Type of Asset

- Some use higher scenarios because they are risk averse and know building a little higher buys extra protection from compound flooding (e.g. storm surge, heavy precipitation events)
- Cost is a factor. Elevating a building an extra foot is different than elevating a major road an extra foot.
- For natural infrastructure, the narrower range of possible scenarios helps avoid the "over building" that impacts ecosystem benefits

Selecting a SLR Scenario (example)

- A 2.0 foot increase will be used for short-term, less vulnerable investment, such as a parking lot.

- A 3.0 foot increase will be used for more critical longer term investments, such as emergency routes and public buildings.
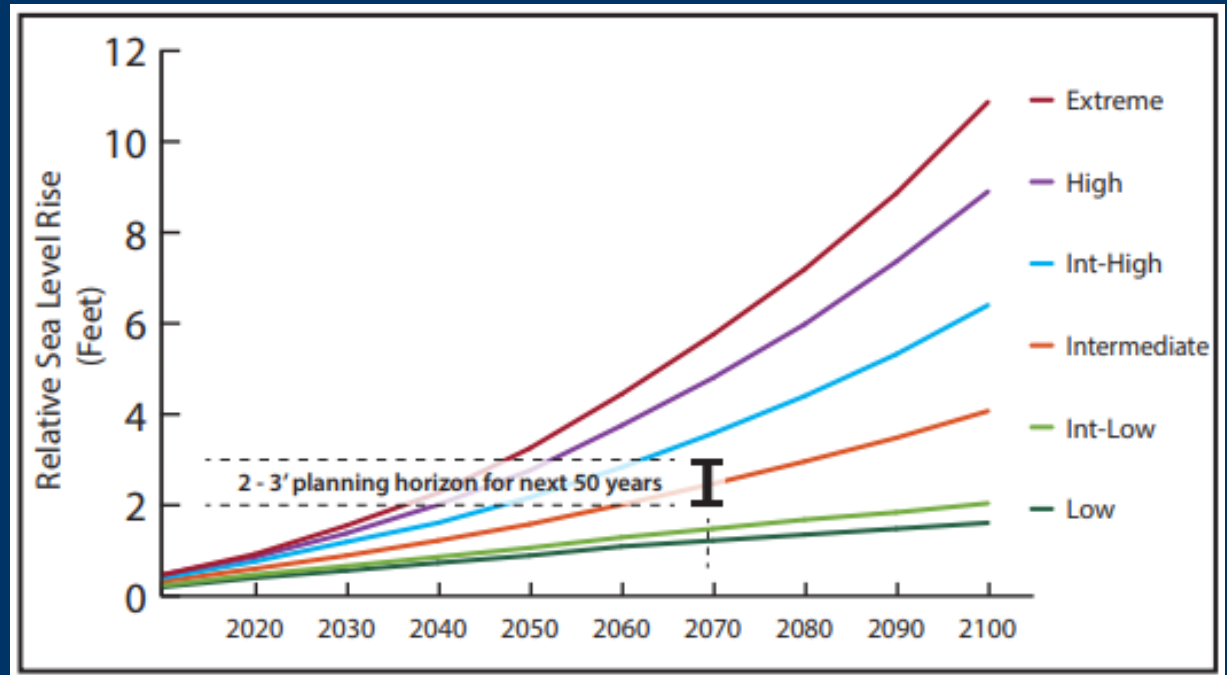
From City of Charleston Sea Level Rise Strategy Document Draft Revision

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What Are We Going To Do?

Digital Coast
Coastal Inundation Topics Page

Sea Level Rise Viewer

Visualize scenarios and impacts using local maps and photos

https://coast.noaa.gov/digitalcoast/tools/slr.html

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Lake Level Viewer

Great Lakes

Visualize rising and dropping lake levels and impacts

Office for Coastal Management

https://coast.noaa.gov/digitalcoast/tools/llv.html
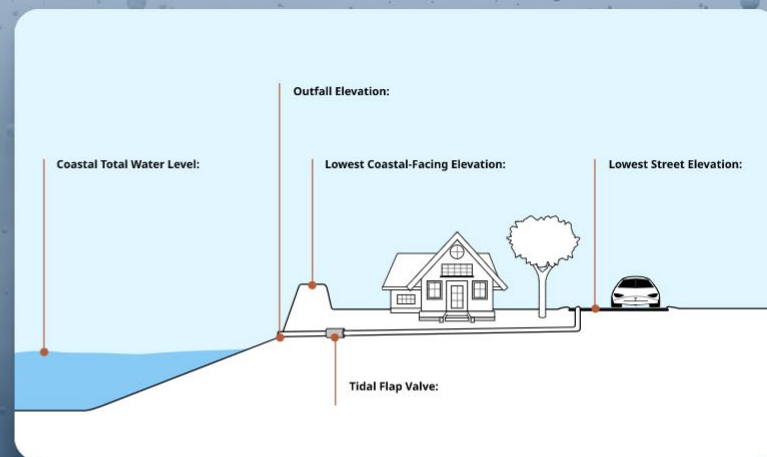
Questions?

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