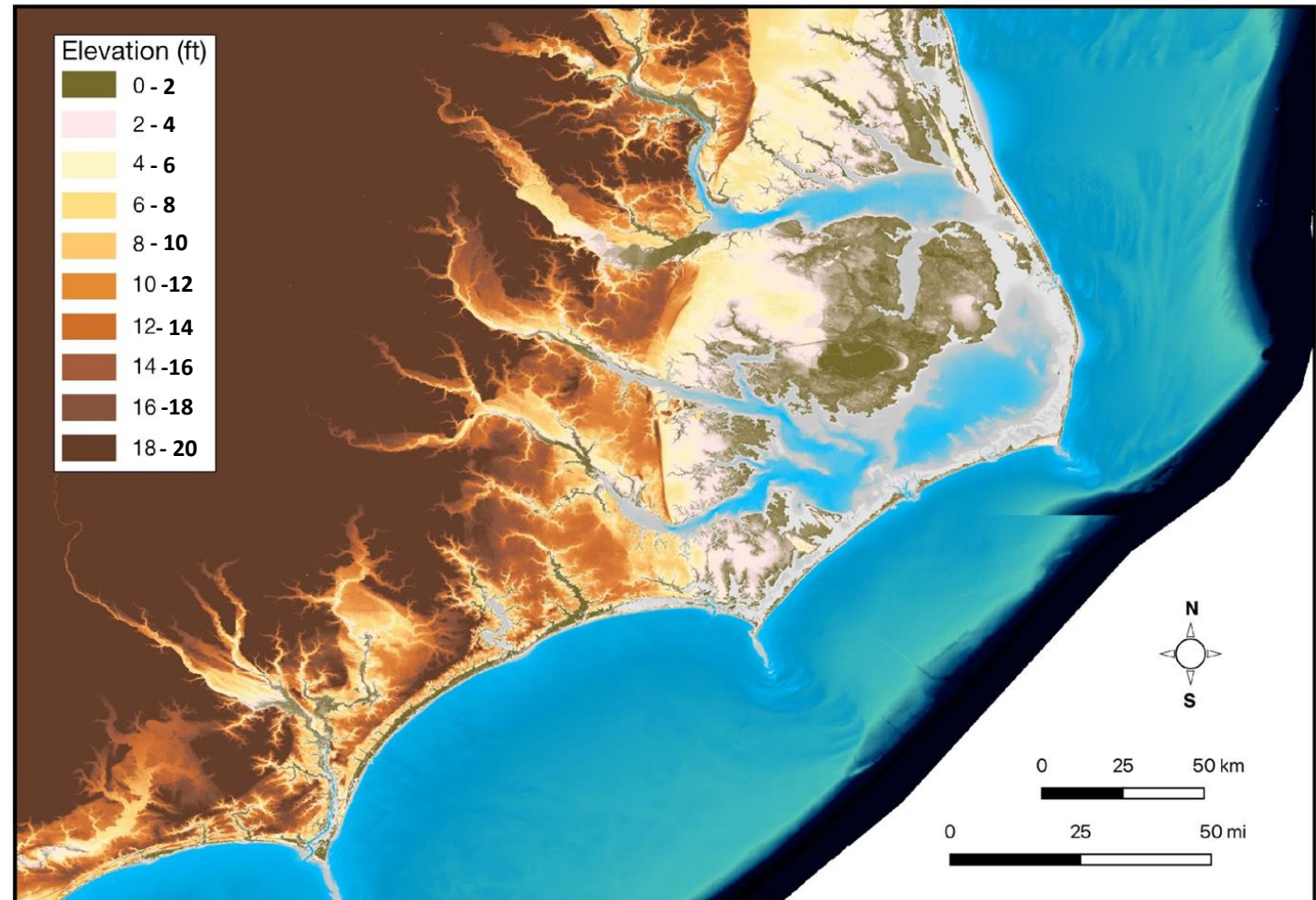


Sea Level Rise in North Carolina: Context, Impacts and Summary of Science Panel Update

Presented by the NC Coastal Resources Commission Science Panel

Science Panel Chair: Laura J. Moore (UNC-CH)

*Science Panel Members: Kevin Conner (USACE), Reide Corbett (ECU), **Andrea Hawkes (UNCW)**, **Joseph Long (UNCW)**, Jesse McNinch (USACE), A. Brad Murray (Duke U.), Martin Posey (UNCW), Spencer Rogers, Greg (Rudi) Rudolph (Sulmara)*



Credit: Reide Corbett, ECU

Overview

- Terminology and history
- Why does SLR pose such a challenge for NC?
- Key Points from 2024 Science Panel SLR Update
- What SLR impacts are already being experienced and will be experienced in the future?



Credit: NASA; 1999 Post-Hurricane Floyd

Global Mean Sea Level Rise (GMSL) vs. Relative Sea Level (RSL)

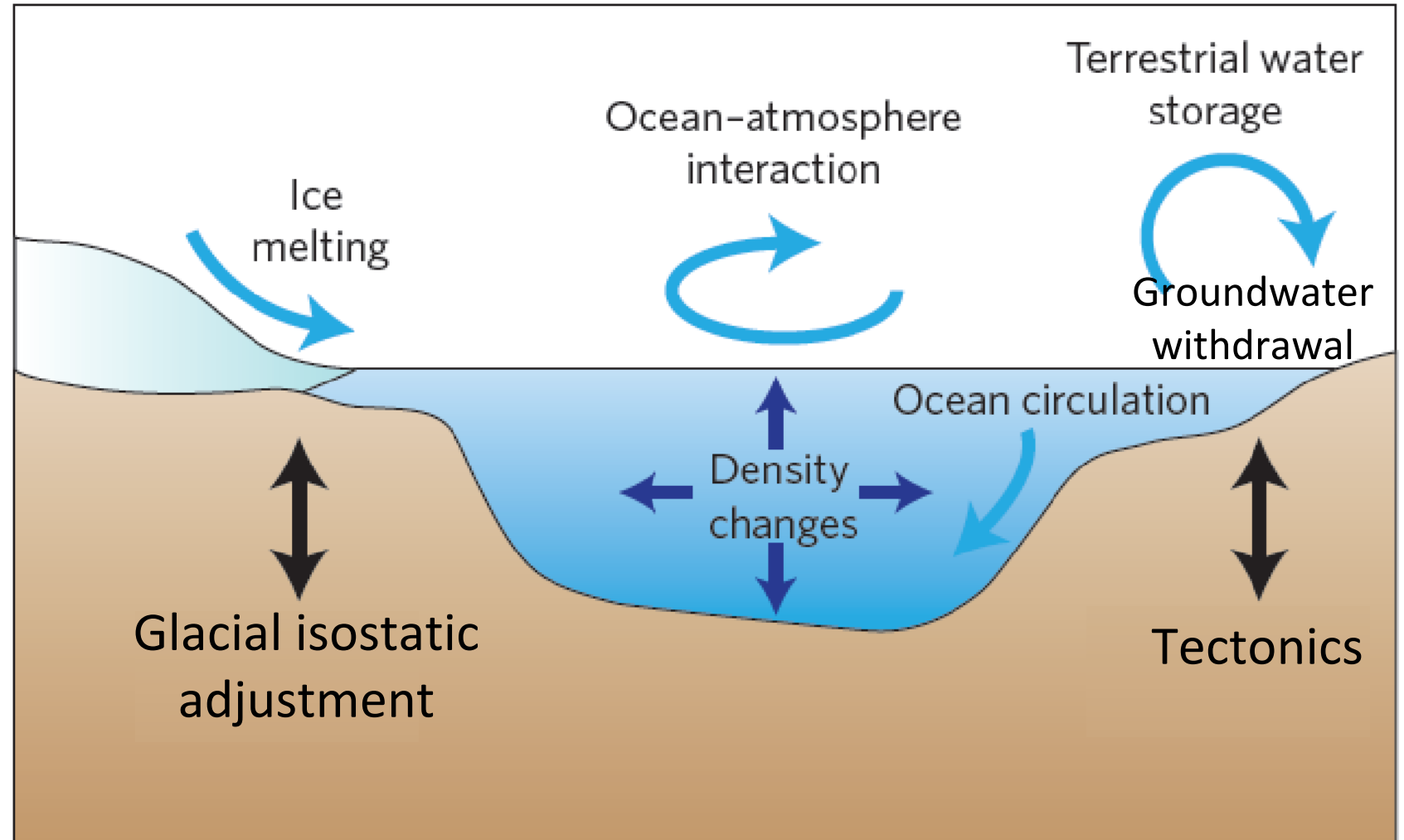
GMSL depends on:

- Melting of land ice
- Water density (temp, salinity)

RSL depends on:

- Local water level (winds, tides, ocean currents)
- Local land motion (glacial adjustment, tectonics, groundwater & oil withdrawal)

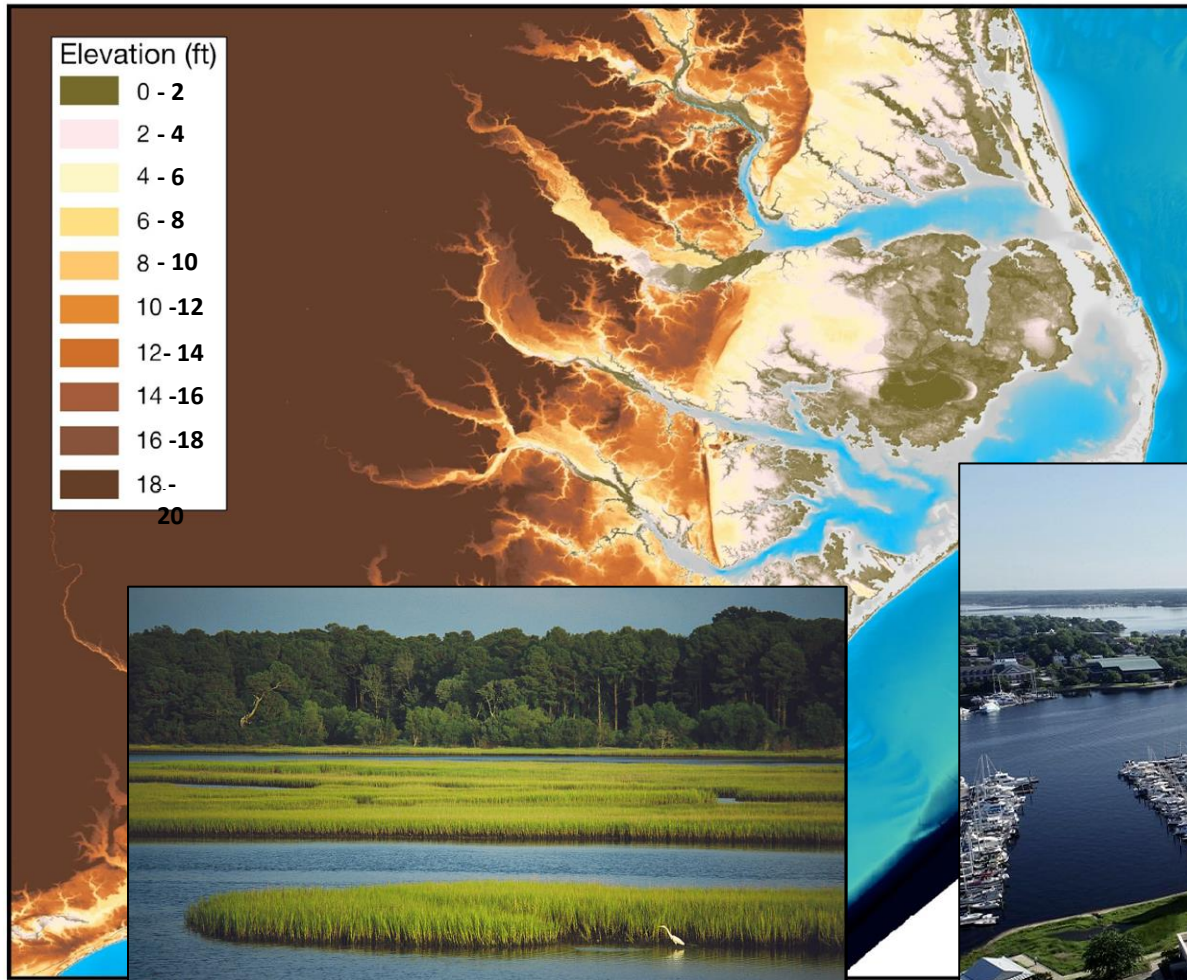
$$RSLR = Ocean + Land$$



Modified from NRC 2012

Estuaries, marshes, barrier islands: inherently low-lying and dynamic

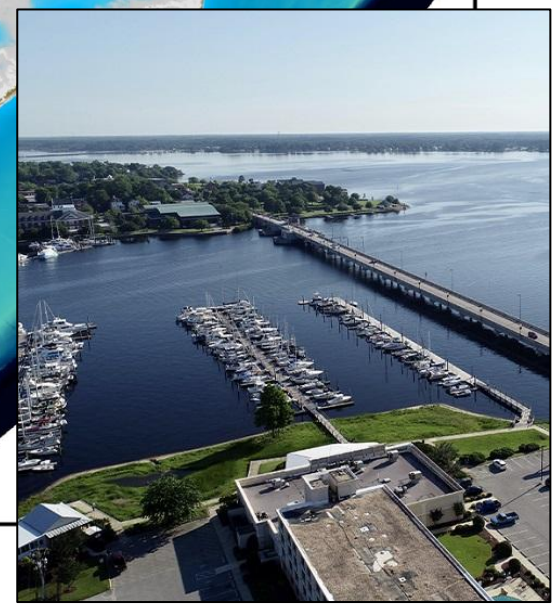
Credit: Reide Corbett, ECU



Credit: Brett Clark/UNC CAS



Credit: DEQ

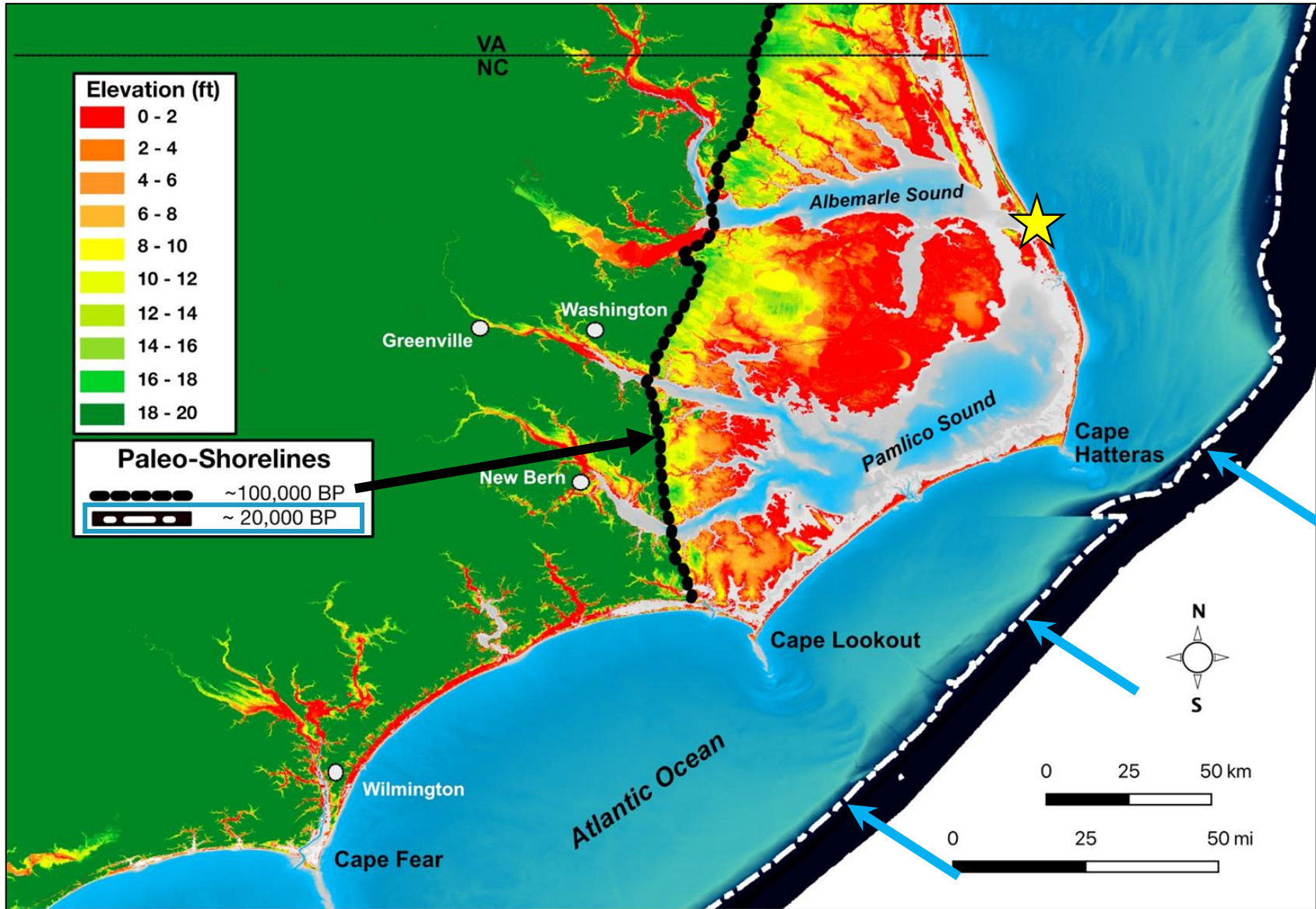
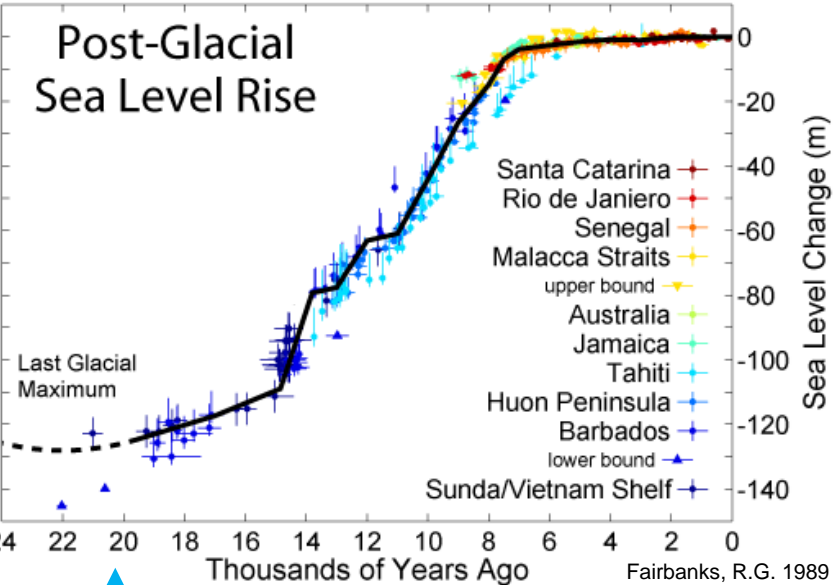


Credit: Emerald Isle Realty

Our coastal landscapes are built by processes at sea level:

- Marsh grasses capture sediment carried by tides
- Barrier islands are built by waves

The boundary between land and sea can shift markedly over time



At present and projected rates, SLR is occurring on timescales that affect humans.

Credit: Reide Corbett, ECU

What does the latest science say about future SLR in NC?

(Summary)

- A multi-agency task force provides SLR projections and assessments of high tide flooding probabilities for eight regions in the U.S. (**Sweet et al., 2022**)¹.

¹ “Global and Regional Sea Level Rise Scenarios for the United States” prepared by the U.S. Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force

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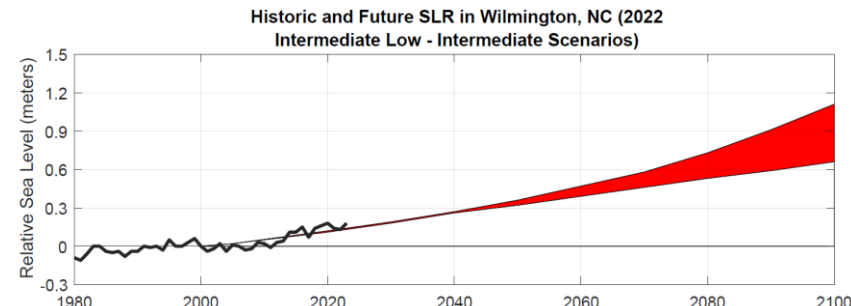
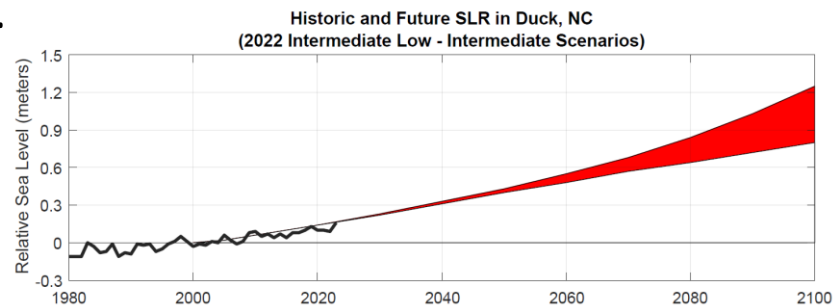
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- Emissions are **on track for a sea level rise of 2 -7 feet by 2100** (Intermediate-Low – Intermediate Scenarios). These projections are less certain because they strongly depend on future greenhouse emissions scenarios.
- RSLR in NC varies, with higher rates in the north relative to the south, largely due to differences in vertical land motion.



Credit: Dr. William Sweet, NOAA

¹ “Global and Regional Sea Level Rise Scenarios for the United States” prepared by the U.S. Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force

What are the (ongoing and) future impacts of SLR in NC?

Because the *elevation of infrastructure is fixed*, SLR is experienced as increases in flood frequency and extent.

This is already happening.

This will become more pronounced over the coming decades, century.



Credit: Laura Moore



Credit: Adobe Stock Images



Credit: Beaufort Business Association

Also... increased storm flooding and impacts, increases in erosion rates, rising water table and saltwater intrusion...

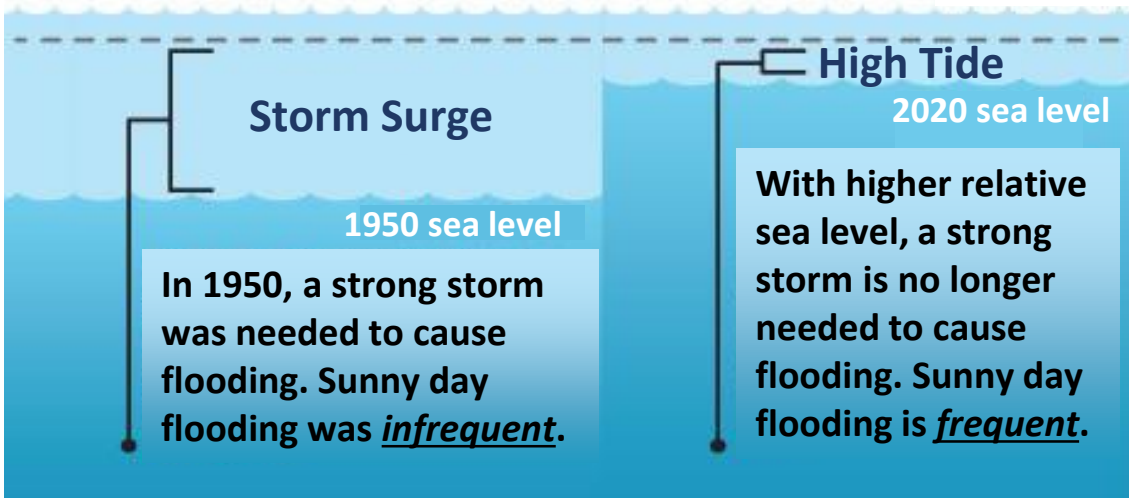
Increases in high-tide (sunny day) flooding

Tides are now propagating on higher sea level and inundating low-lying infrastructure.



Cartoon by Emily Greenhalgh,
<https://www.climate.gov/print/741789>

Sunny
Day
Flooding →

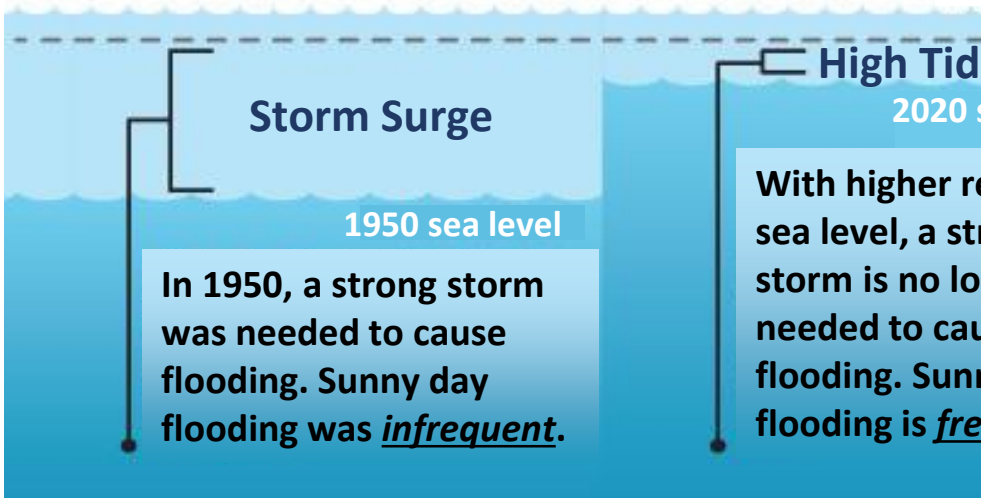


Modified from NOAA and
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Tides are now propagating on higher sea level and inundating low-lying infrastructure.



Increase in storm flooding - *Annual storm in Beaufort- today*



Increases in storm flooding - *Annual storm in Beaufort- 0.25 m (0.8 ft)*



Increases in storm flooding - *Annual storm in Beaufort- 0.5 m (1.6 ft)*



Increases in storm flooding - *Annual storm in Beaufort- 1.0 m (3.3 ft)*



USGS Coastal Flooding Tool

<https://www.usgs.gov/apps/hera/floodTool.php>



Availability:

- California coast and San Francisco Bay except for Del Norte, Humboldt, and Mendocino Counties
- Eastern FL, GA, SC, NC, VA

Storm Scenarios:

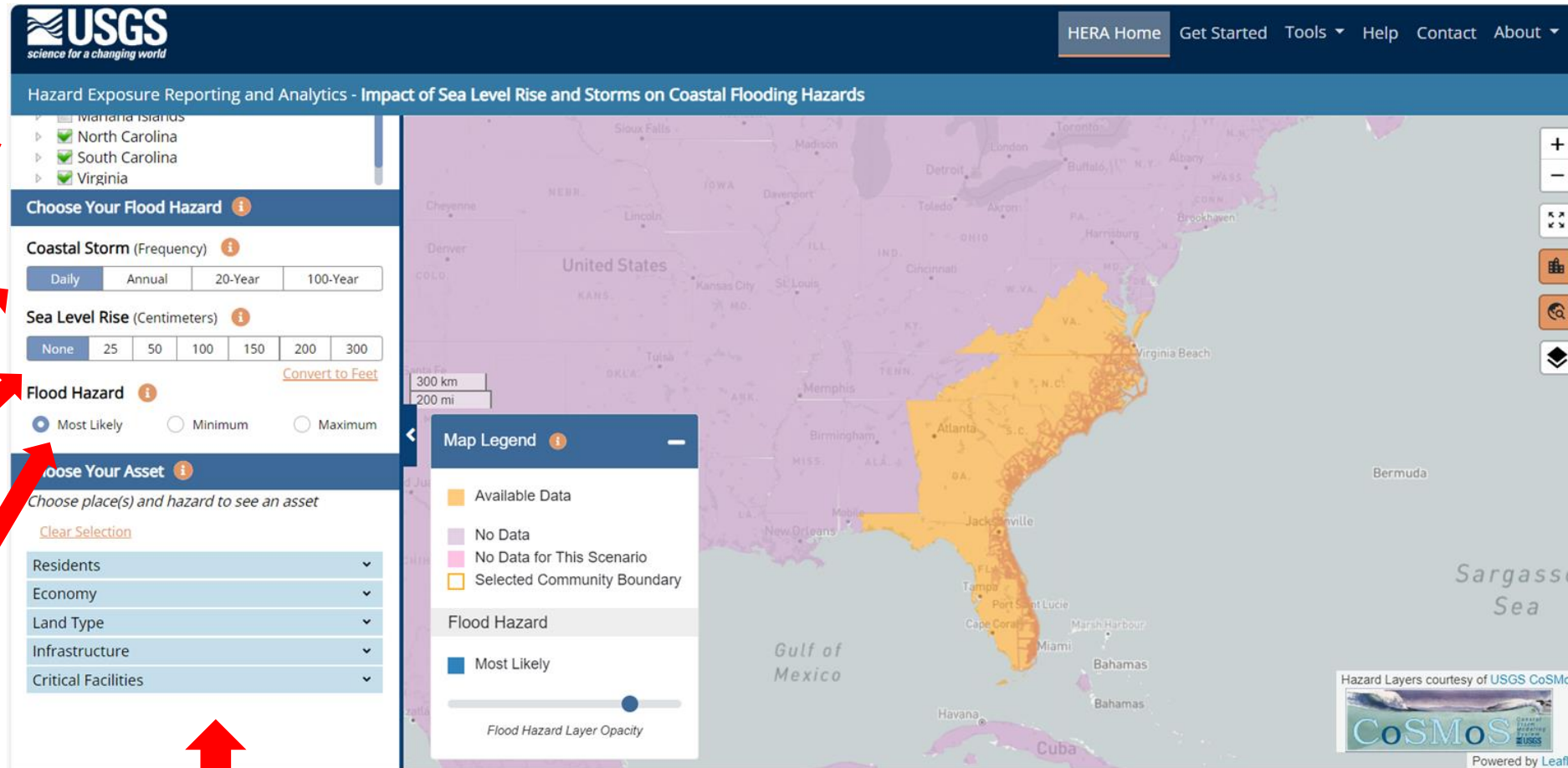
daily, annual, 20-yr, 100-yr

Sea level rise scenarios:

None, 25, 50, 75, 100, 150, 200, 300 (cm)

Hazard zones:

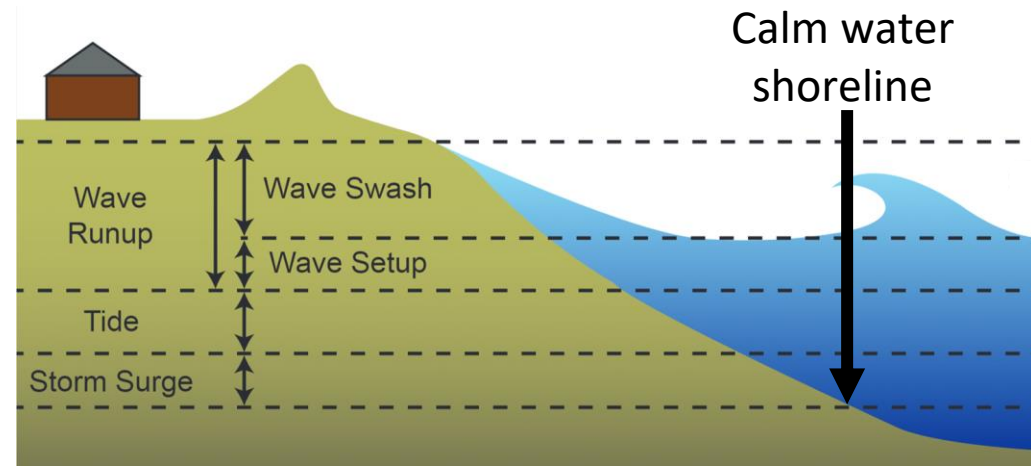
most likely, minimum, maximum



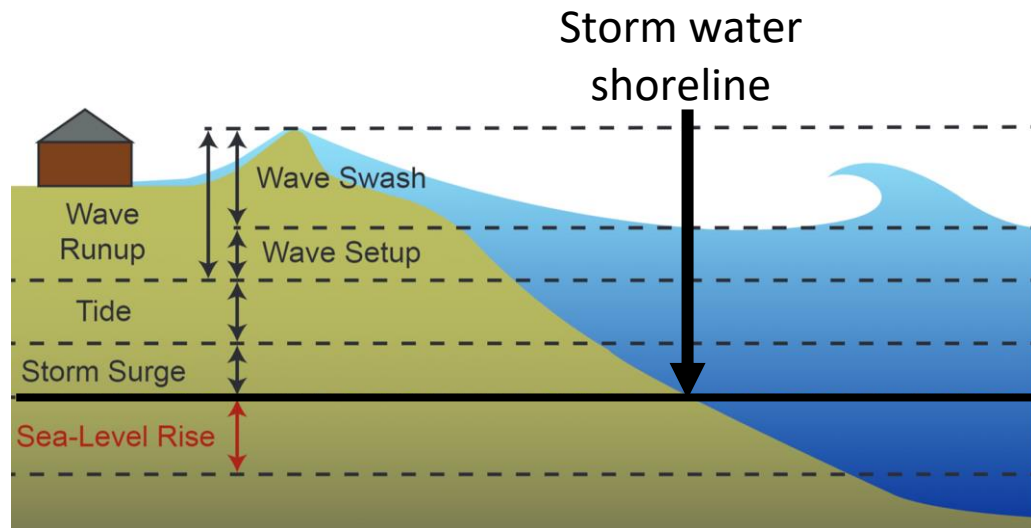
The screenshot shows the USGS Coastal Flooding Tool interface. At the top, there is a navigation bar with 'HERA Home', 'Get Started', 'Tools', 'Help', 'Contact', and 'About'. Below this is a header for 'Hazard Exposure Reporting and Analytics - Impact of Sea Level Rise and Storms on Coastal Flooding Hazards'. The main content area is divided into several sections: 'Choose Your Flood Hazard' with options for Coastal Storm (Frequency) and Sea Level Rise (Centimeters); 'Flood Hazard' with radio buttons for Most Likely, Minimum, and Maximum; and 'Choose Your Asset' with a dropdown menu for Residents, Economy, Land Type, Infrastructure, and Critical Facilities. A map of the United States is displayed on the right, with a legend for 'Map Legend' showing 'Available Data', 'No Data', 'No Data for This Scenario', and 'Selected Community Boundary'. A 'Flood Hazard Layer Opacity' slider is also visible. A red arrow points from the 'Assets of interest' text to the 'Choose Your Asset' section.

Assets of interest

Storm waves will be more impactful

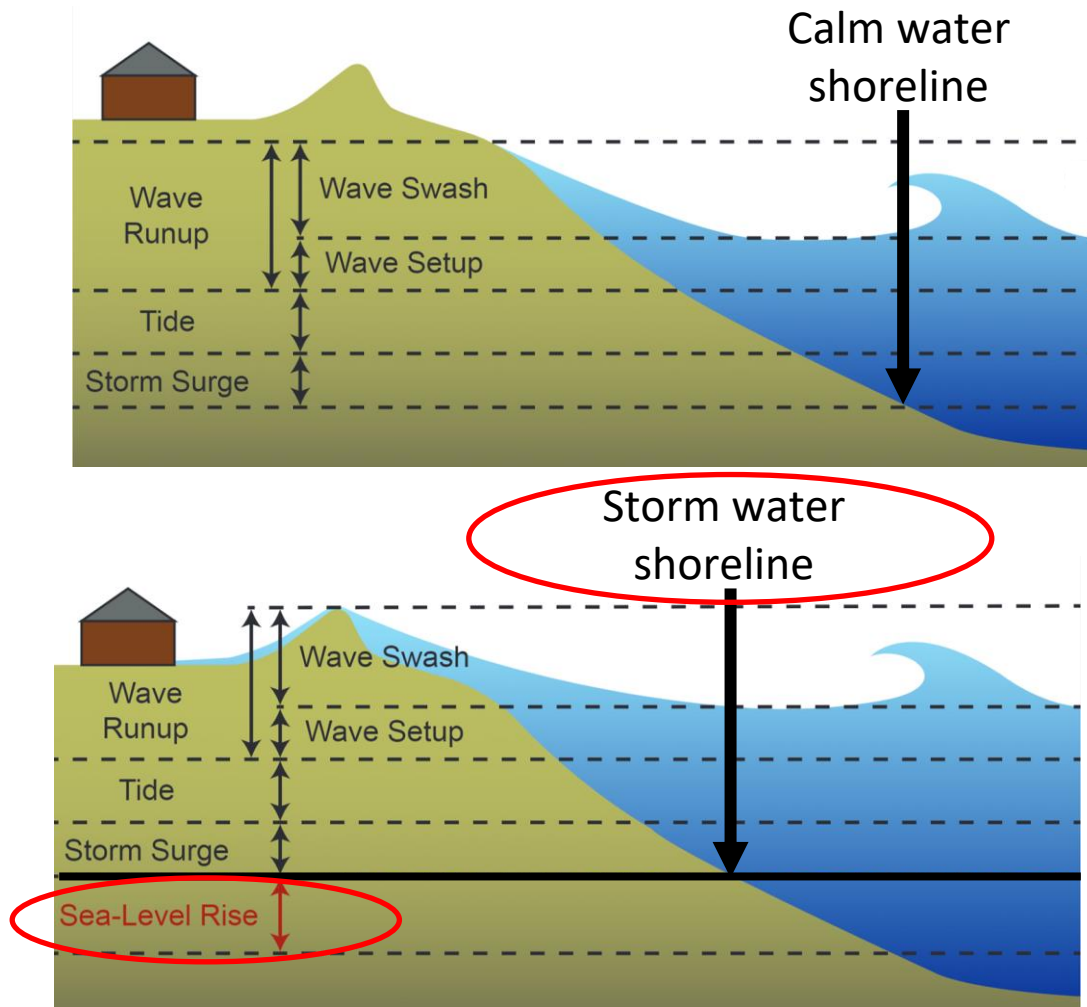


- Surge and wave action raise water level during storms.
- Higher water level brings zone of wave action into contact with dunes, homes, roads, etc.



After Vitousek et al., 2017

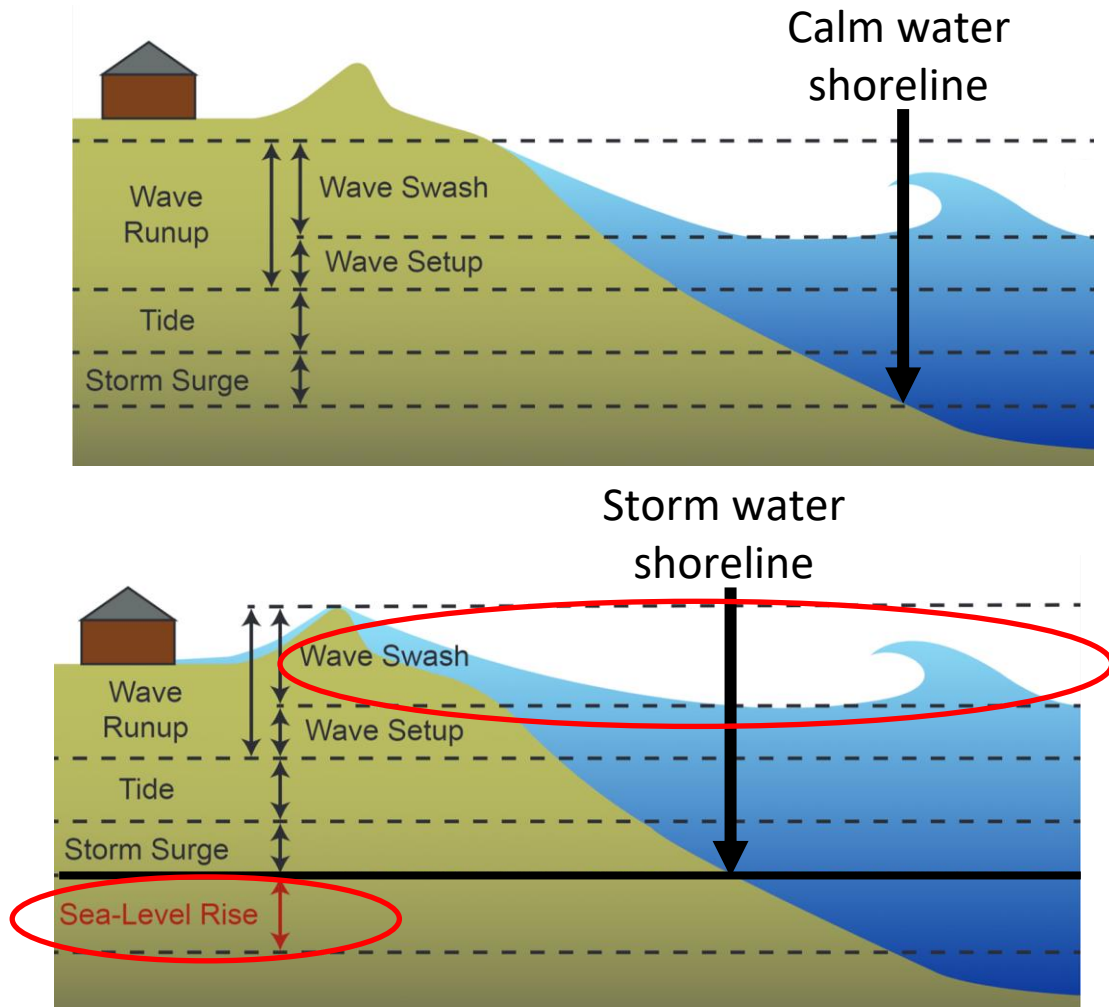
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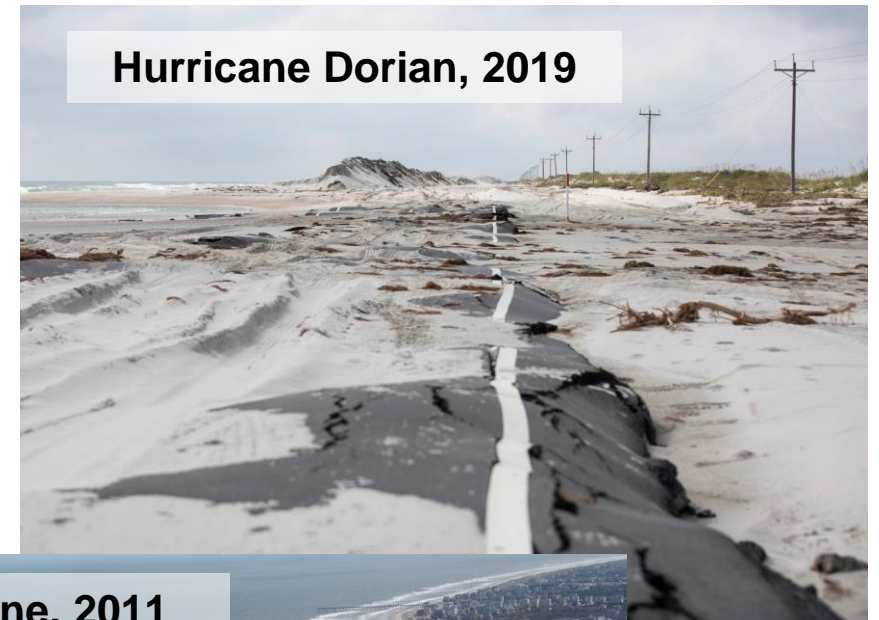
After Vitousek et al., 2017

- Surge and wave action raise water level during storms.
- Higher water level brings zone of wave action into contact with dunes, homes, roads, etc.
- Higher sea level (i.e., relatively lower land elevation) means storm impacts will be more severe.

Storm waves will be more impactful



After Vitousek et al., 2017



Credit: The News and Observer, Julia Wall

Credit: U.S. Geological Survey

Increases in background shoreline erosion rates



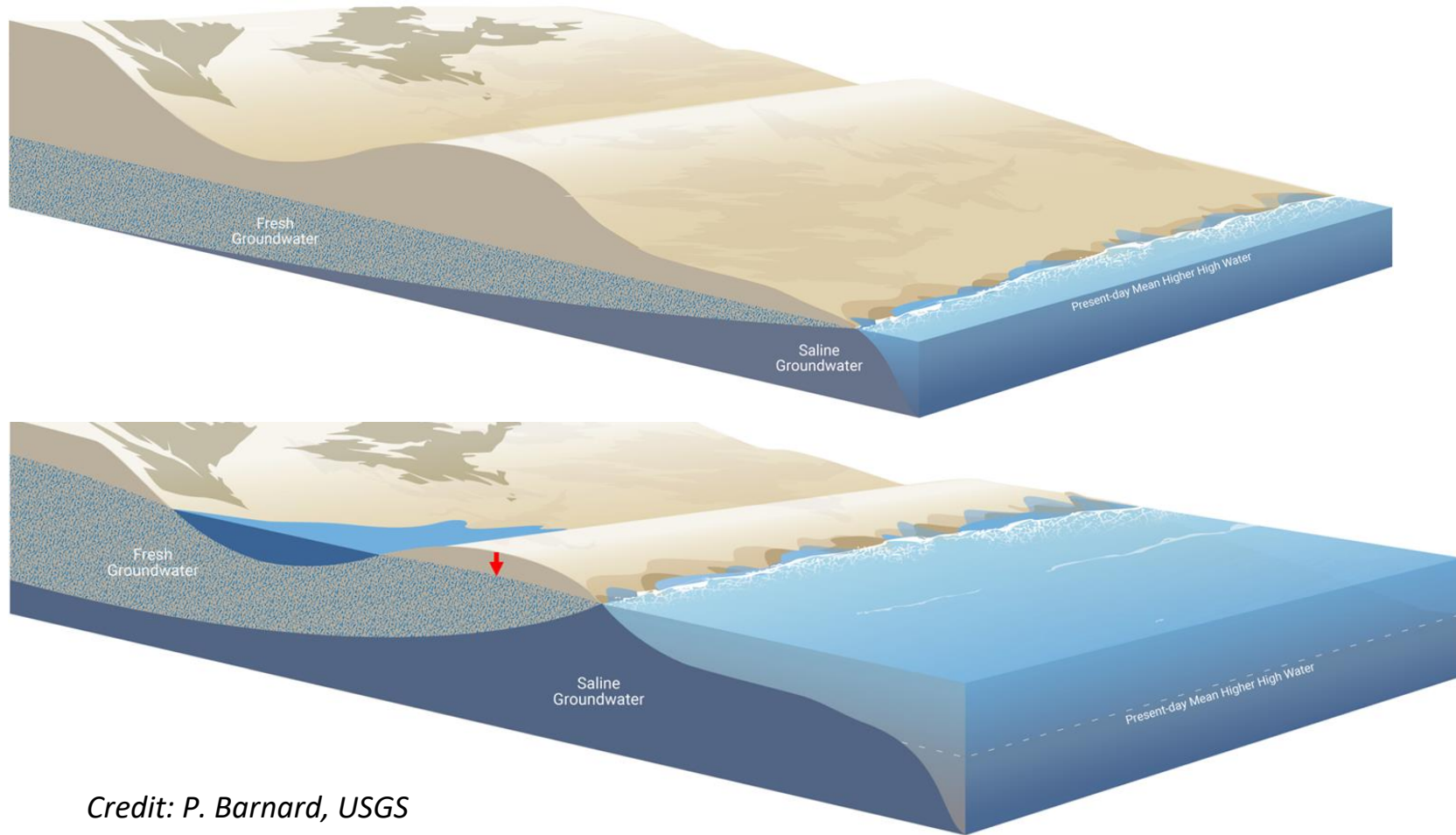
- The ocean shoreline erodes over time where more sand is lost from the shoreline than supplied.
- Losses related to sea level rise will increase and so background, long-term erosion rates will increase.



Photo Credit: *Virginian Pilot Online*

Photo Credit: *USGS; Google Maps; Paul Horn/InsideClimate News*

Rising water table



Credit: P. Barnard, USGS

- As sea level rises it causes coastal groundwater levels to rise.
- Flooding inland and on barrier islands occurs through subsurface connections to the sea.

Rising water table



Manteo, NC 2018, Stormwater Drainage

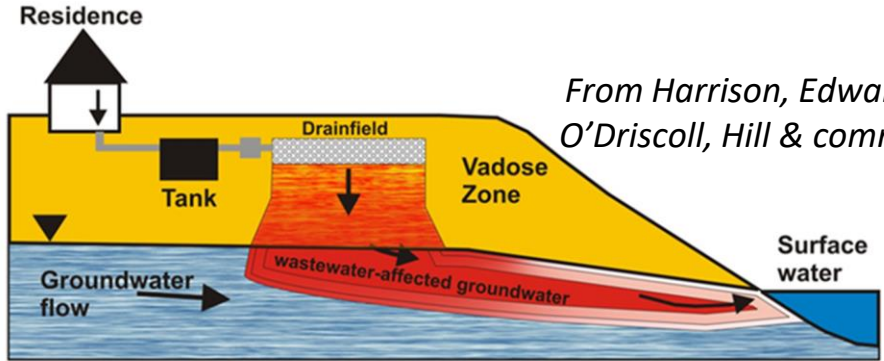


Ponding Water during Rain Events

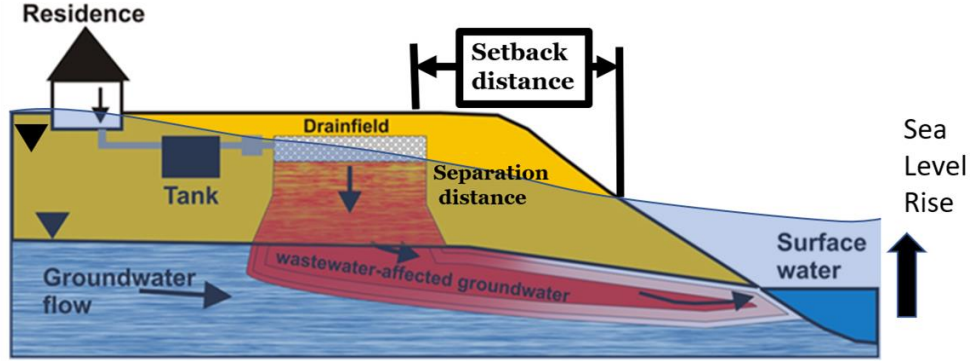
Credit: Island Free Press



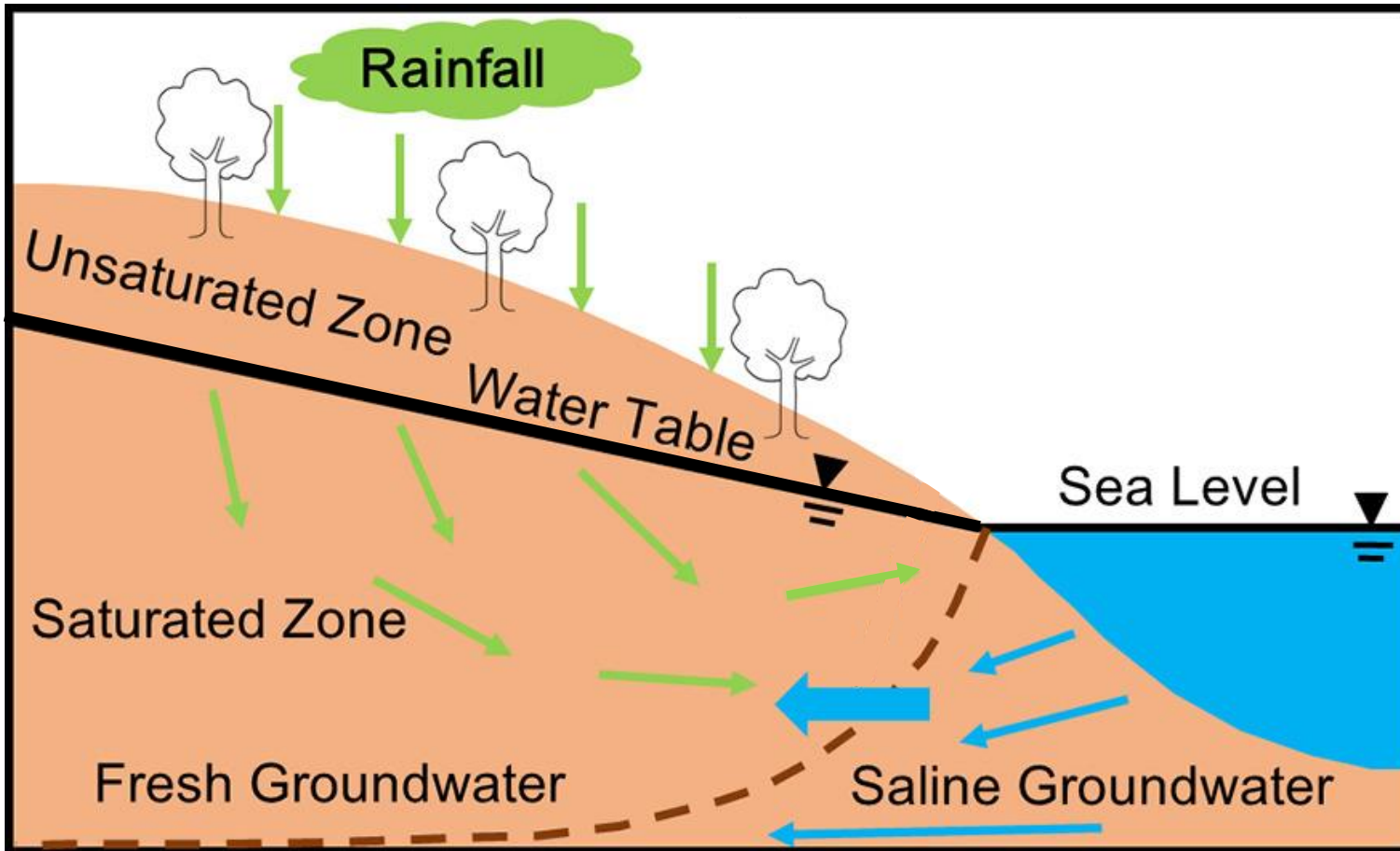
Septic System Failure



From Harrison, Edwards, Humphrey, O'Driscoll, Hill & community partners



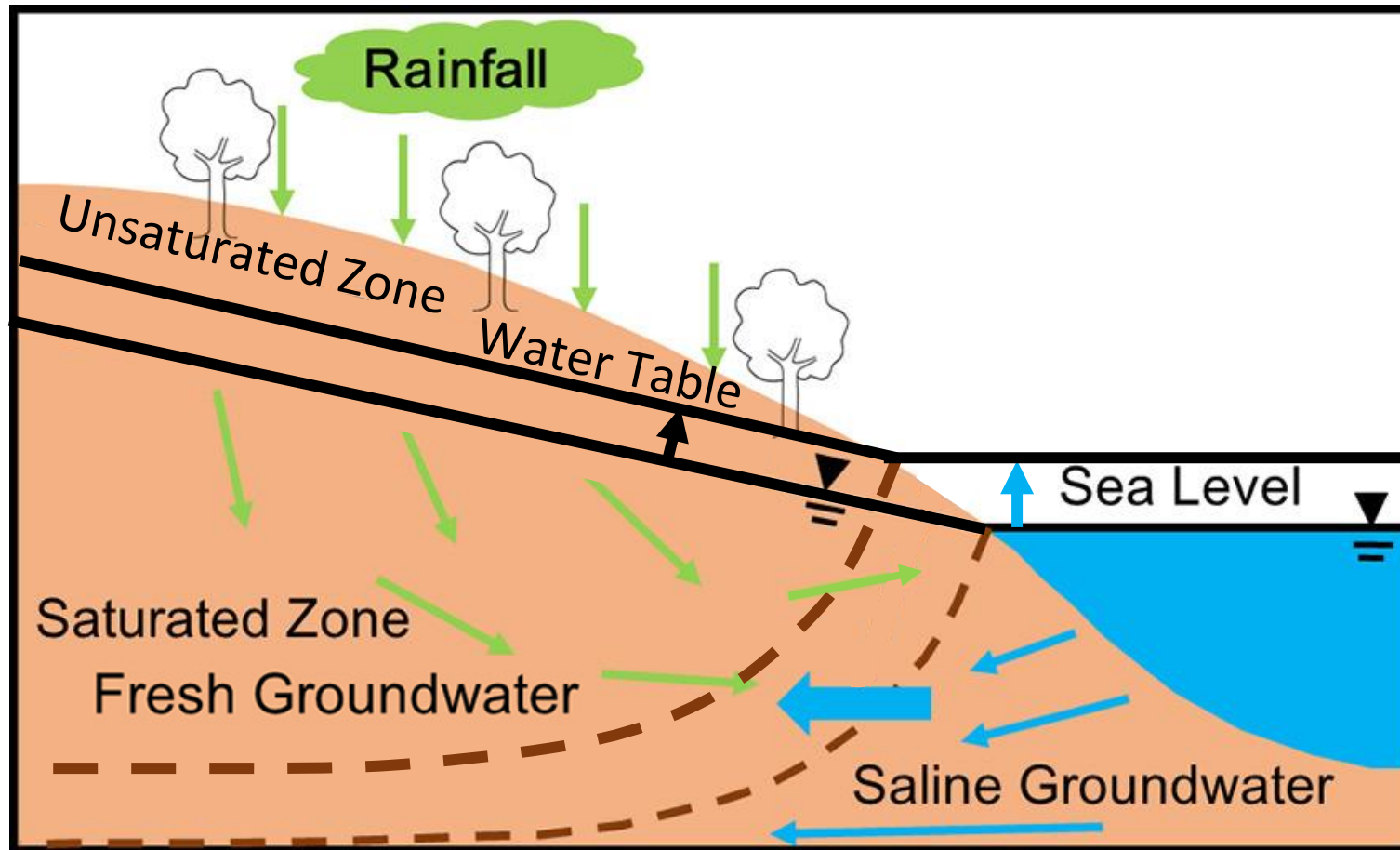
Increasing saltwater intrusion



Modified from Xiao et al., 2018

- As sea level rises it pushes the boundary between freshwater and saltwater landward.
- Pumping of coastal aquifers also pulls the boundary landward.

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Increasing saltwater intrusion

Conversion of forest to marsh



Credit: Andrea Hawkes

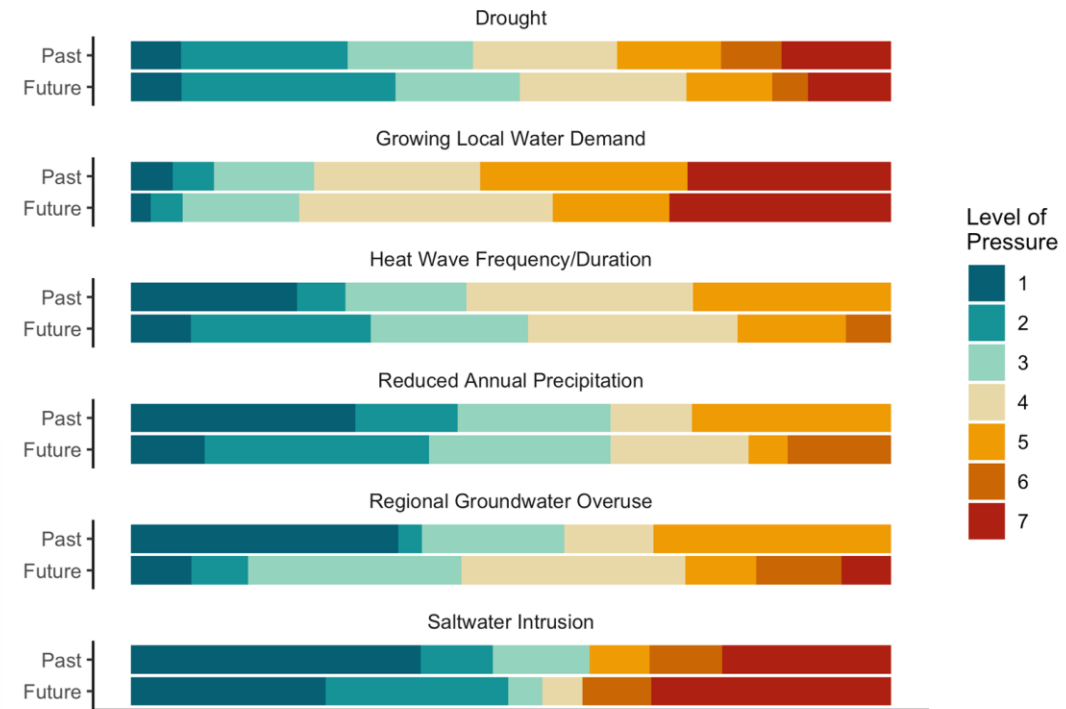
Salinization of agricultural land



Credit: climatehubs.usda.gov

Decreased drinking water supply

Water operators in NC coastal plain are concerned that saltwater intrusion will affect water delivery.



Bell et al., 2021

Summary

- Distinguishing between GMSL and RSL is important.
- NC coastal landscapes are inherently low-lying and sea level has been much lower, and much higher in the past.
- Observations and modeling are consistent in projecting at least 1 foot of sea level rise for the Southeast by 2050.

Summary

- Distinguishing between GMSL and RSL is important.
- NC coastal landscapes are inherently low-lying and sea level has been much lower, and much higher in the past.
- Observations and modeling are consistent in projecting at least 1 foot of sea level rise for the Southeast by 2050.
- In NC sea level is rising faster in the north than in the south.
- Impacts are already being felt, and will worsen, including increases in high tide flooding, storm impacts, erosion and rising water table and saltwater intrusion.