Navigating To Resilience Through The Nations Fastest Rate of Relative Sea Level Rise In American Samoa

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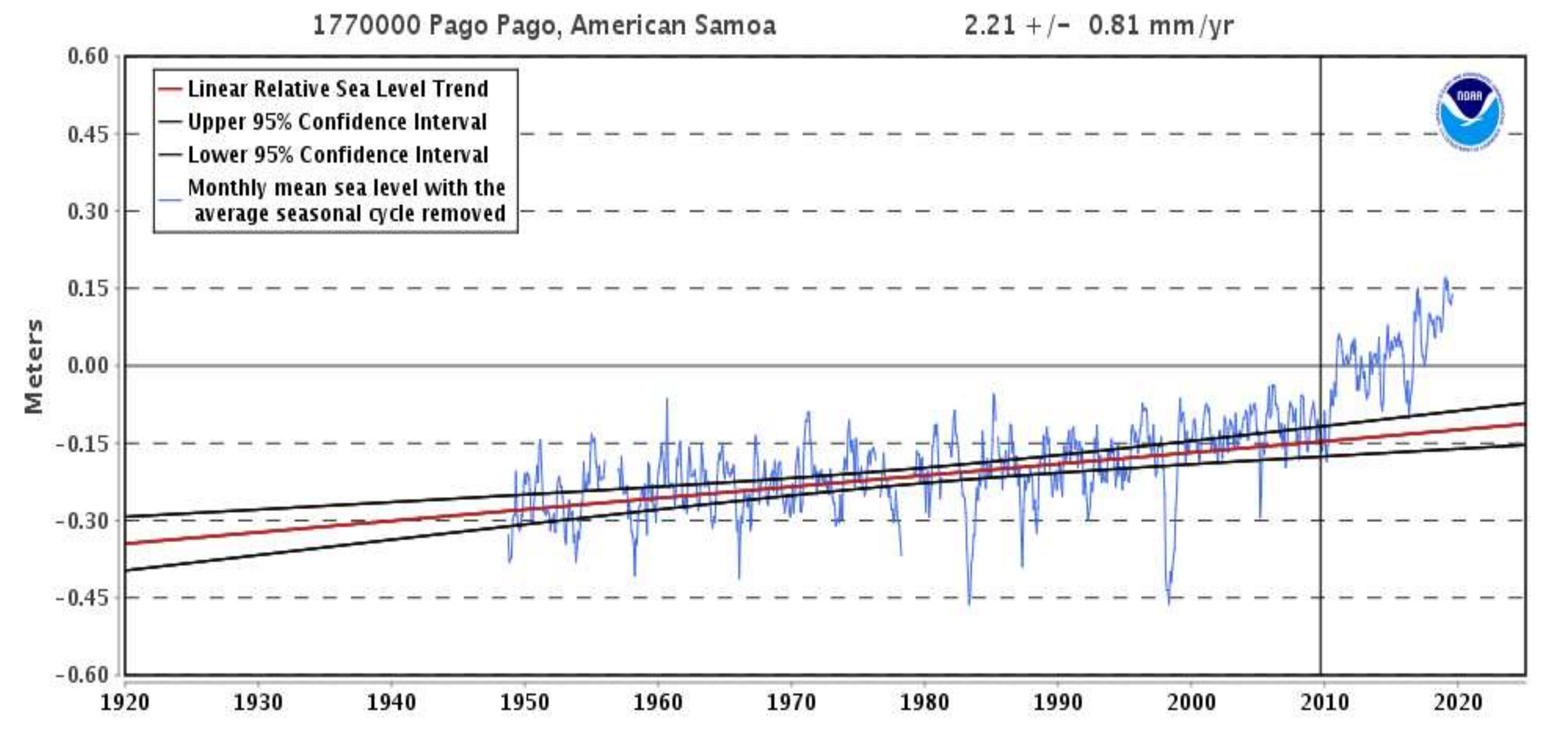
2009 Tsunami

- An earthquake doublet (8.1 and 8.0 magnitude) occurred at the Tongan Trench on Sept 29, 2009
- Tsunami wave hit Samoan islands ~ 14 minutes after the quake
- Tragically almost 200 died
- Unknown lasting legacy of subsidence

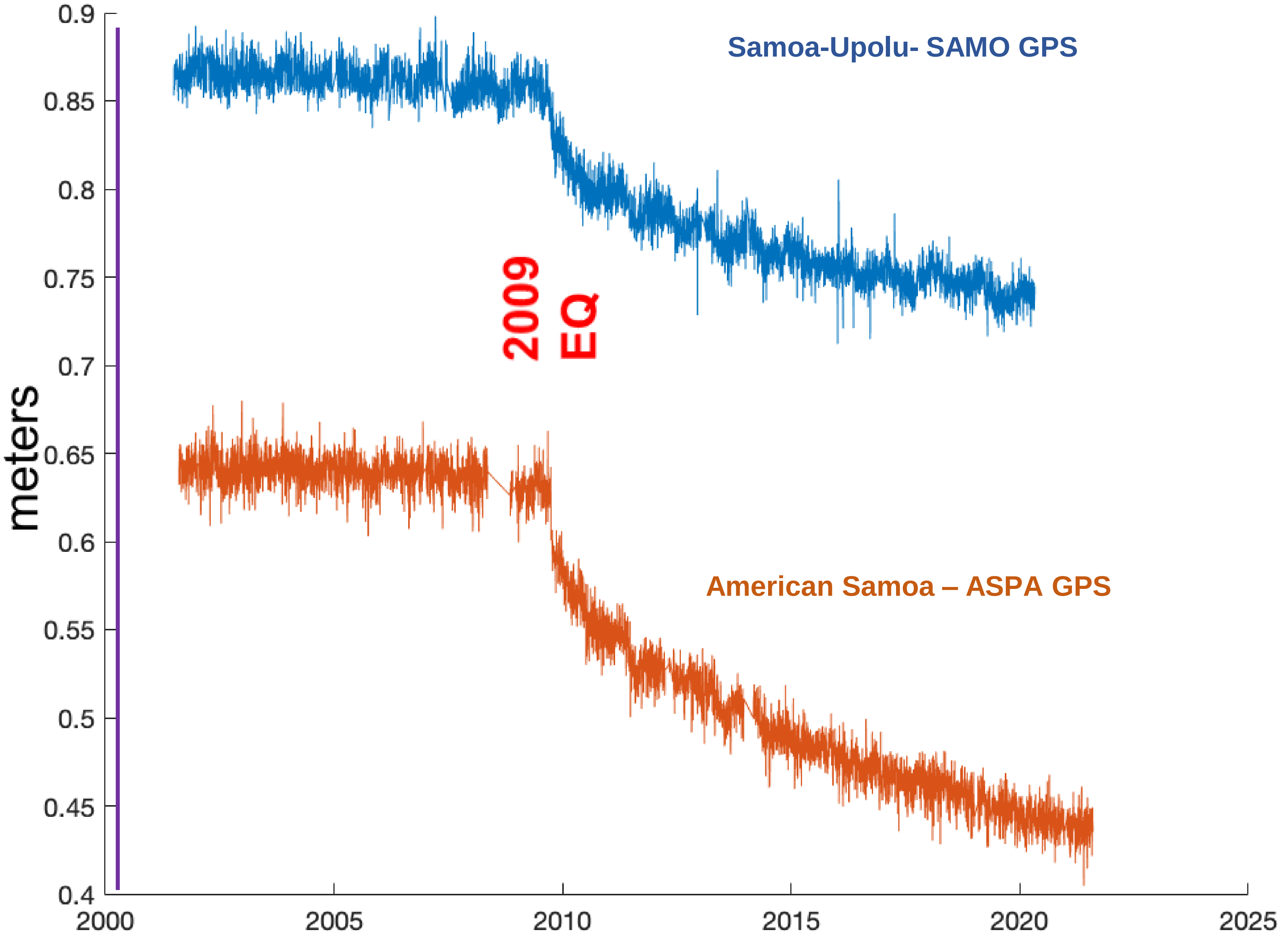

NPSA

Relative Sea Level Rise in Pago Pago

Subsidence
= 16 mm/yr or
0.6 in/yr
Historical rate
= 2.2 mm/yr or
0.08 in/yr –
current rate
= 3.2mm/yr or
0.13 in/yr
Modern rate
= 19.2 mm/yr or
0.76 in/yr



CORS Data



http://geodesy.unr.edu/NGLStationPages/stations/ASPA.sta https://www.sonel.org/spip.php?page=gps&idStation=631

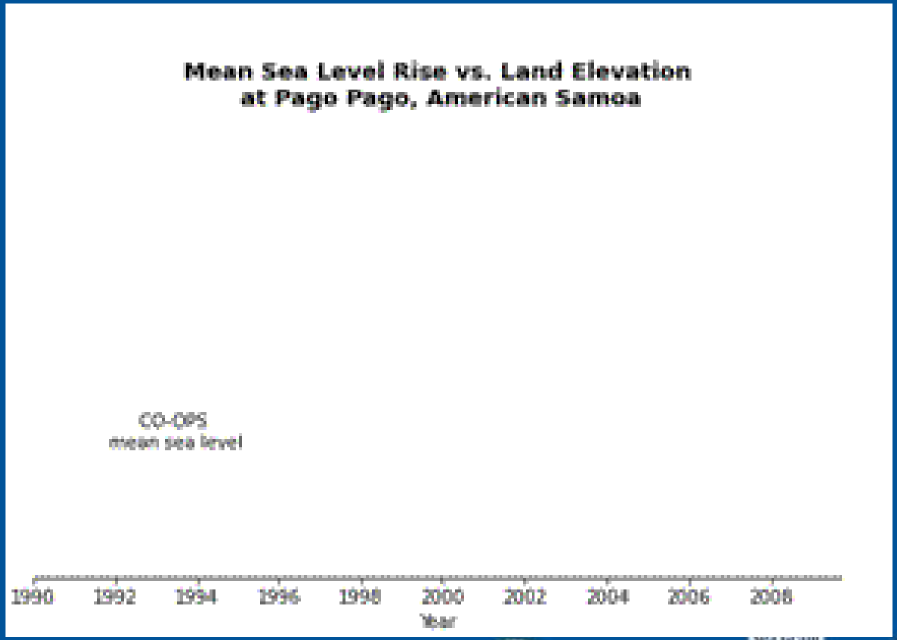
University of

AS RSLR in last 11 years > previous 100 years

- "Following the earthquake, relative sea levels on Tutuila Island rose 250 millimeters (9.8 inches) in just 11 years. The increase was captured by NOAA's water level station between September 2009 and January 2020."

- Before 2009 our RSLR was 9.5 inches

per 100 years!



From: https://tidesandcurrents.noaa.gov/news_posts/article.html?post=1

Reefs – the original wave breaks

Losing our shores

Faga'alu shoreline along Matafao Elementary circa 1967 (above left) and 2014 (above right).

Coastal flooding

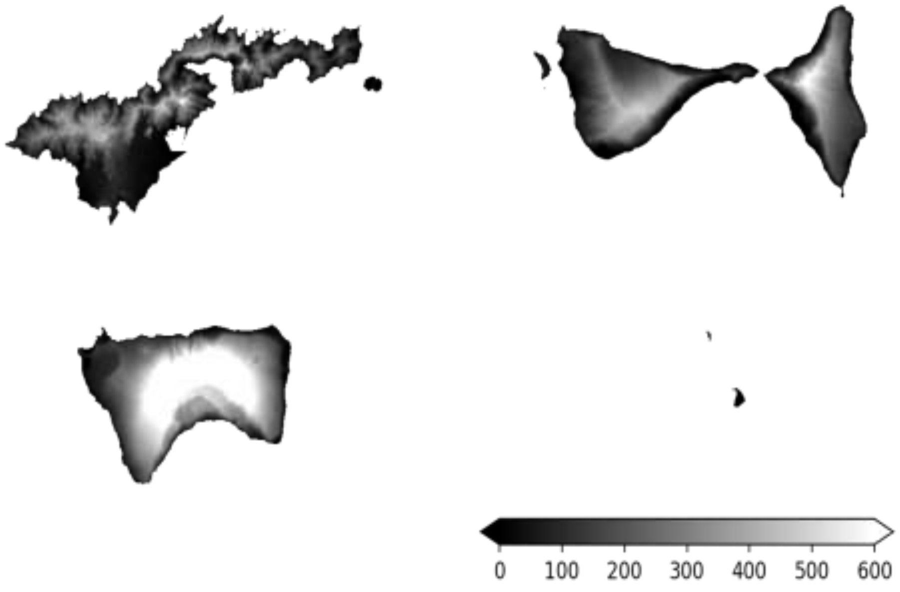
‘i Sea G Progra

From the science background to the viewer

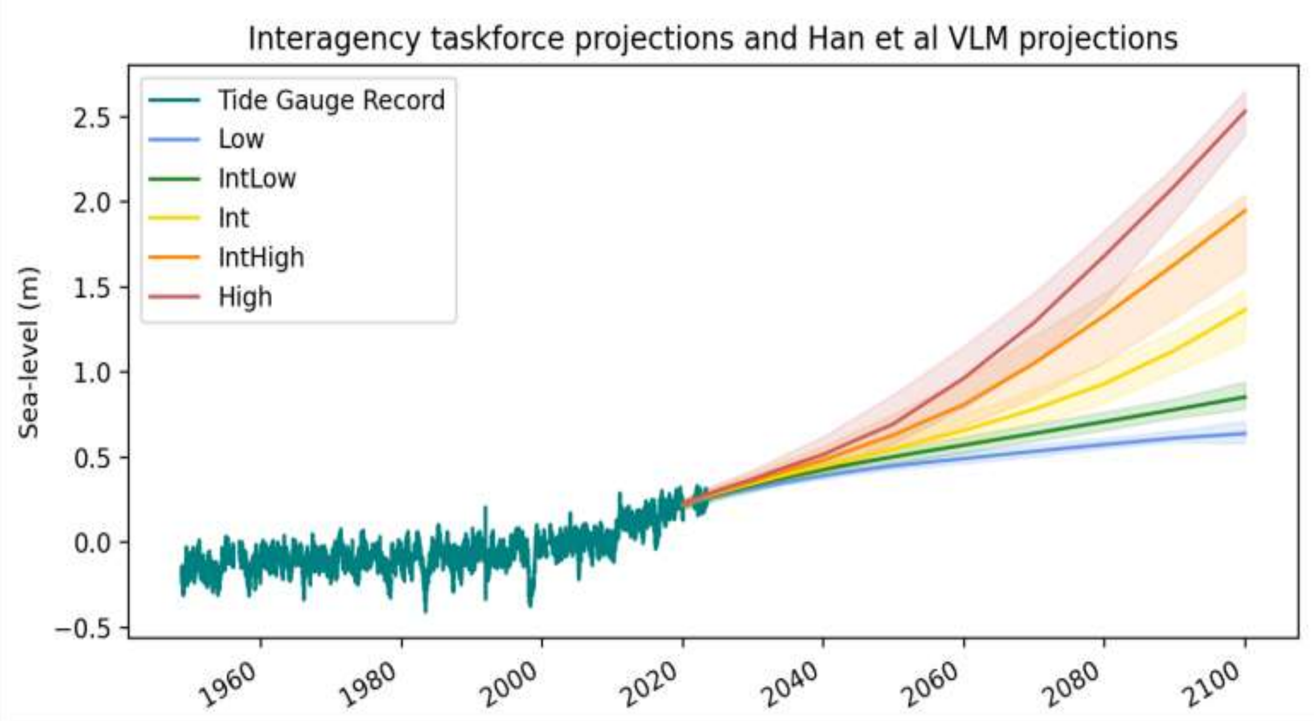
How did we build the viewer?

Datasets

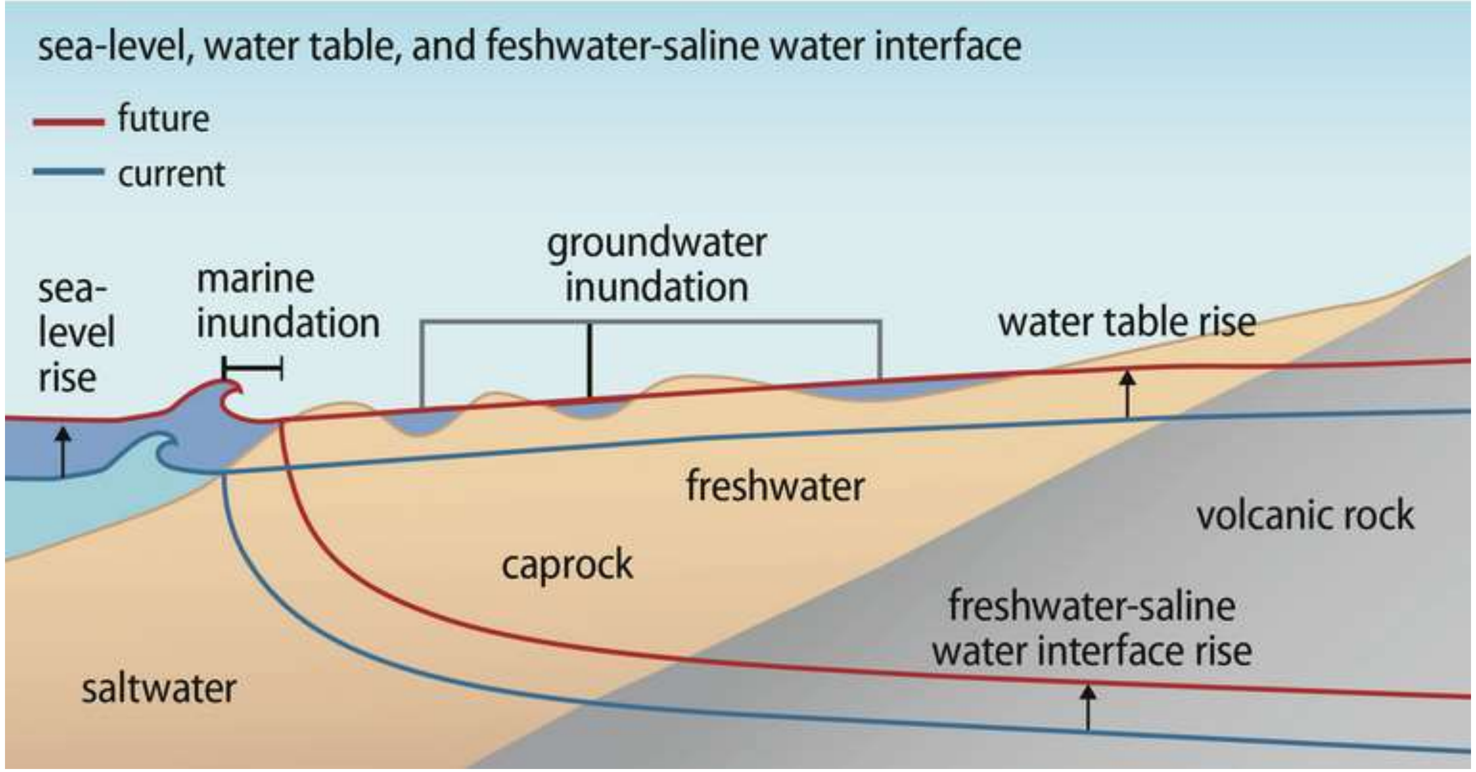
Digital Elevation Model (DEM)



Sea-level Projections



Model
Passive flooding



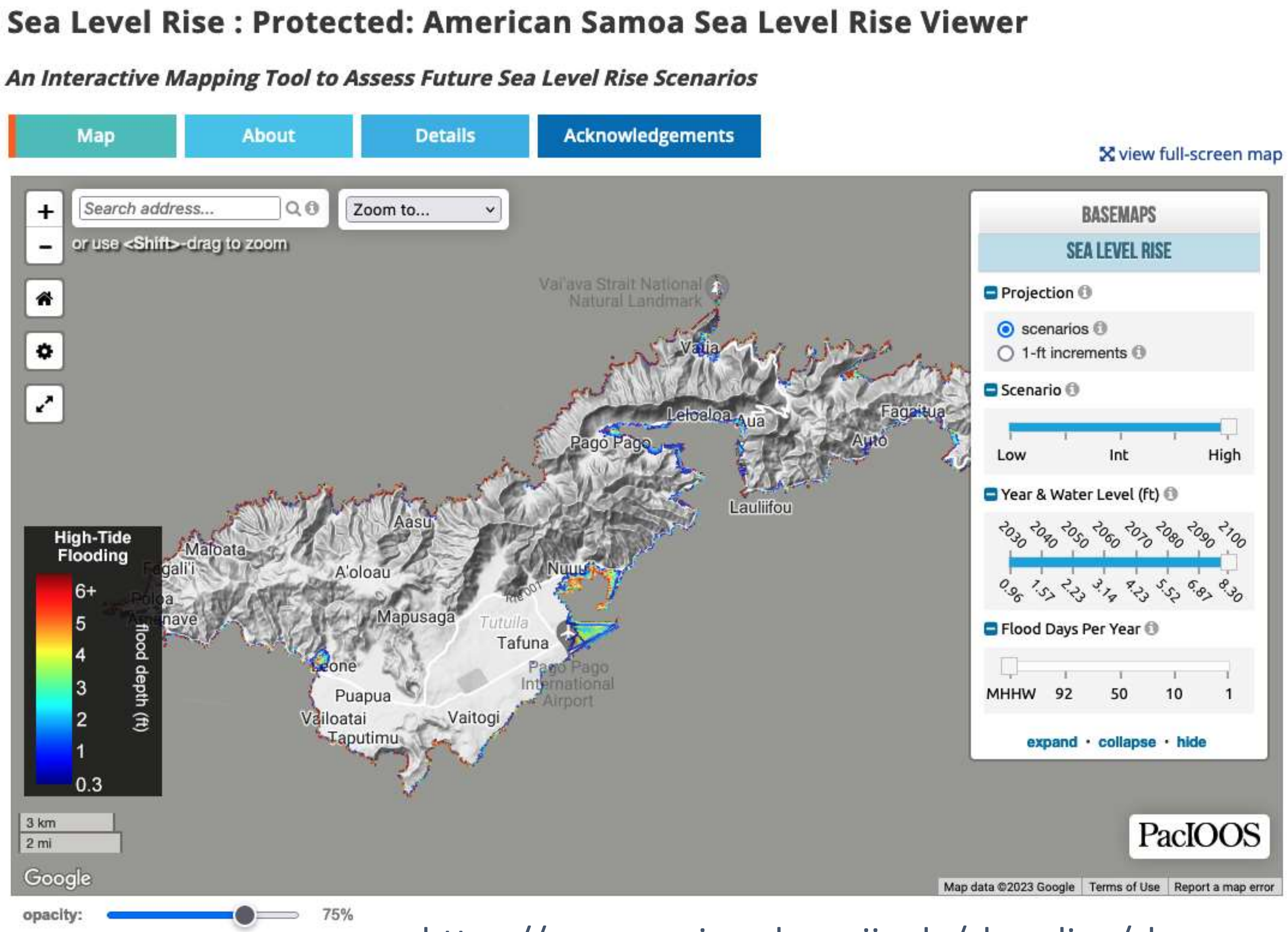
https://www.pacioos.hawaii.edu/shoreline/slr-hawaii/ (Adapted from *Rotzoll and Fletcher, 2012)*

- Passive flooding (often called "bathtub") model simulates sea-level rise by raising uniformly the water level along the coast.
- We assume non-hydrologically connected areas are flooded by groundwater inundation under projected sea-level due to the rise of the water table.
- This model tends to underestimate flooding as it does not involve physical dynamic processes (e.g., waves and erosion).

Relative sea-level rise viewer

Outline and demonstration

- Sea-level rise layers (showing water depth):
  - For each five scenarios and each decade until 2100.
  - 1-foot increments.
  - Flooding events occurring 50, 20 and 1 days per year.



https://www.pacioos.hawaii.edu/shoreline/slr-amsam/

Thank you! Fa’afetai tele!
Questions?

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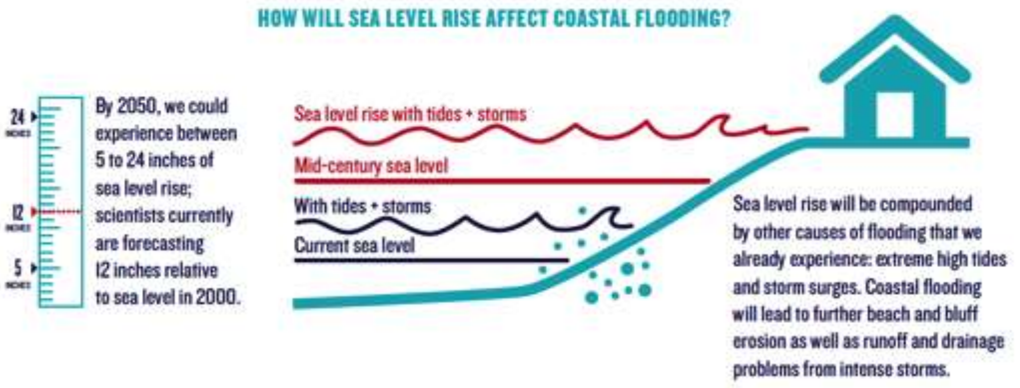
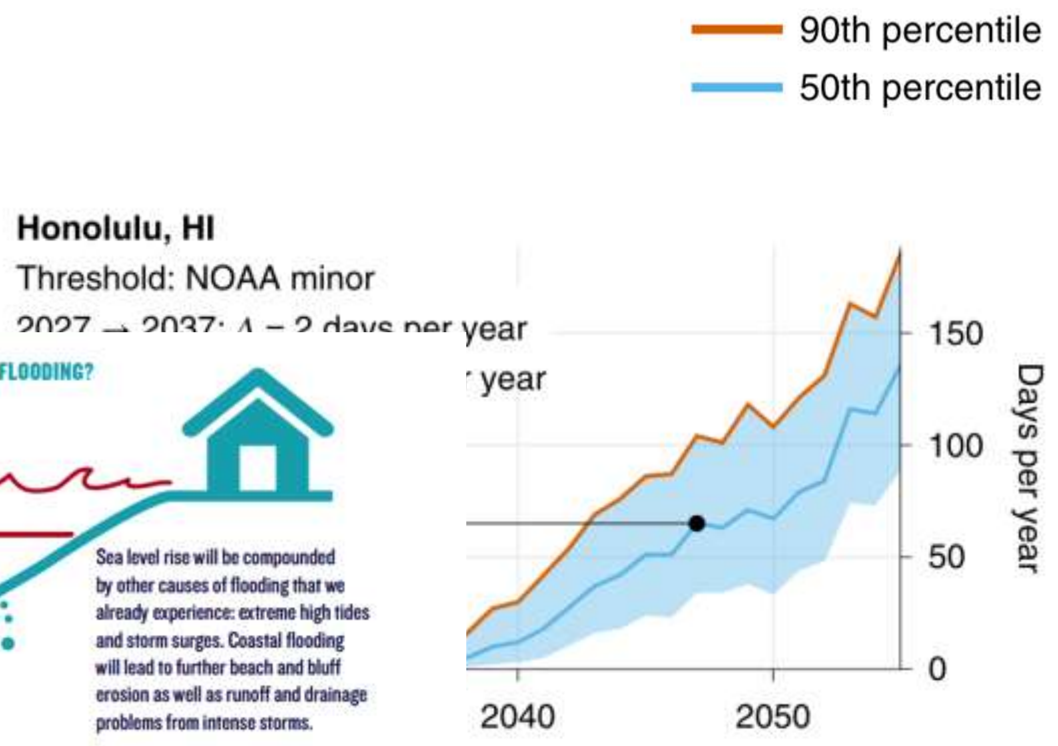
High tide flooding days

- Sea-level rise influences the frequency of high tide flooding events.

- A low-lying locatic flooded a few tim tens of times per eventually that lo flooded under a ty



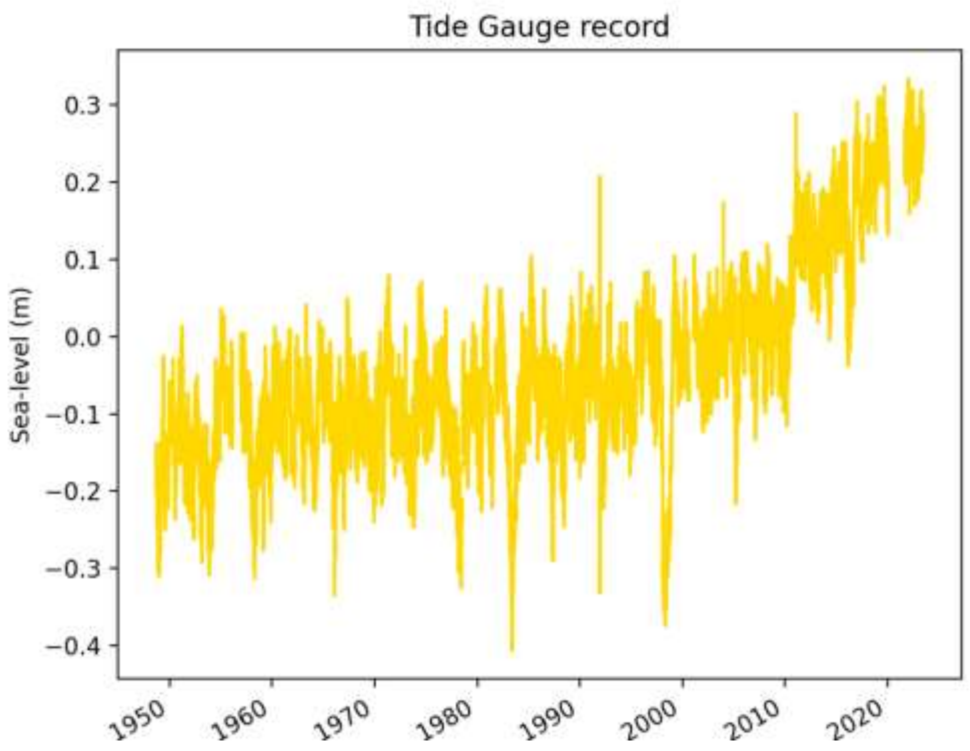


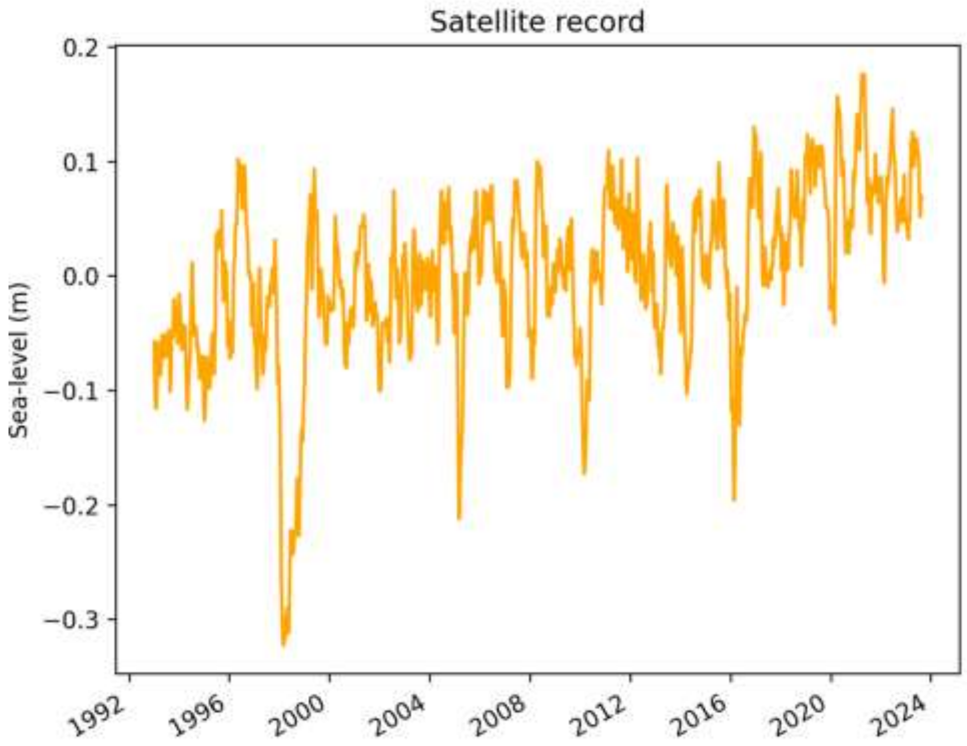
(Thompson *et al,* 2021)

- Any particular year may have substantially more or less flooding events depending on local climate variability (such as the El Niño, La Niña cycle) and year-to-year variability in the tides due to changes in the alignment of the Earth, Moon, and Sun.

Datasets

Tide gauge and satellite



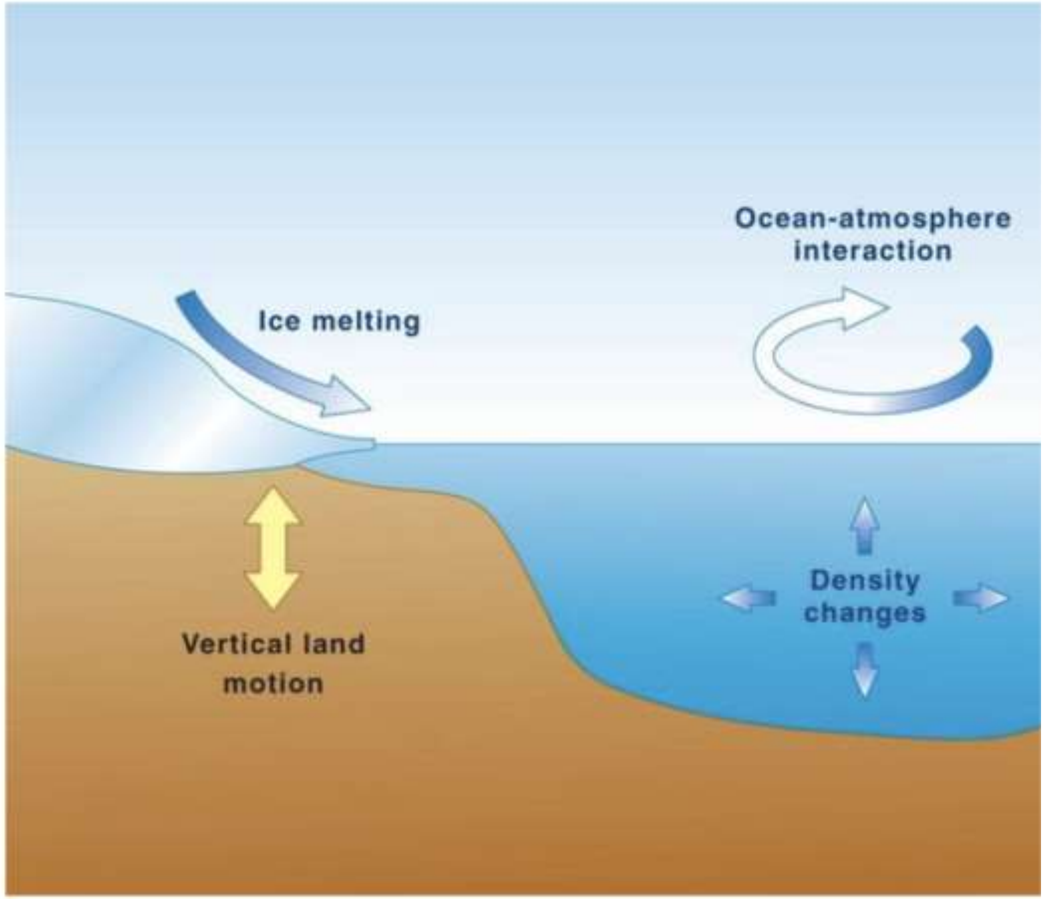


- Tide gauge data from the UHSLC (https://uhslc.soest.hawaii.edu/data/)
- Recording since 1948

- Satellite record from Copernicus (European Space Agency) (https://data.marine.copernicus.eu/product/SEALEVEL_GLO_PHY_L4_NRT_OBSERVATIONS_008_046/description)
- Recording since 1993

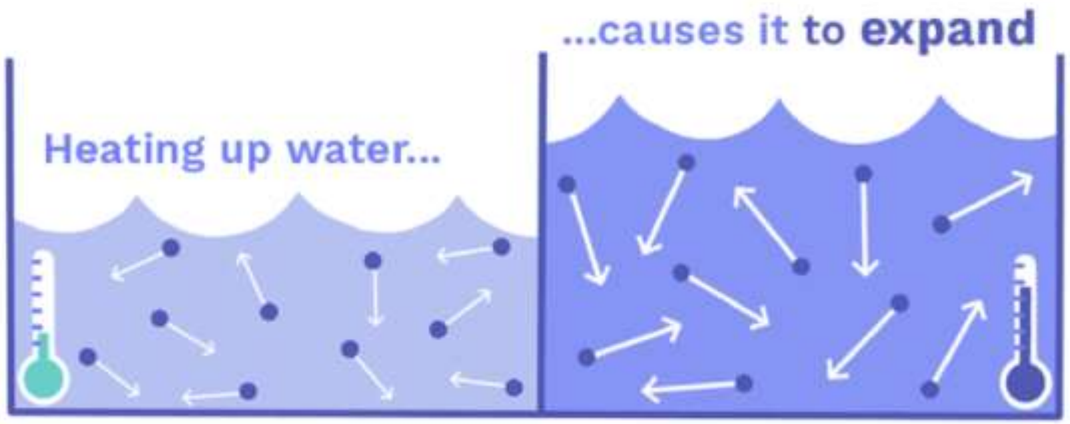
What is driving sea-level rise?

Thermal expansion



(Milne *et al,* 2009)

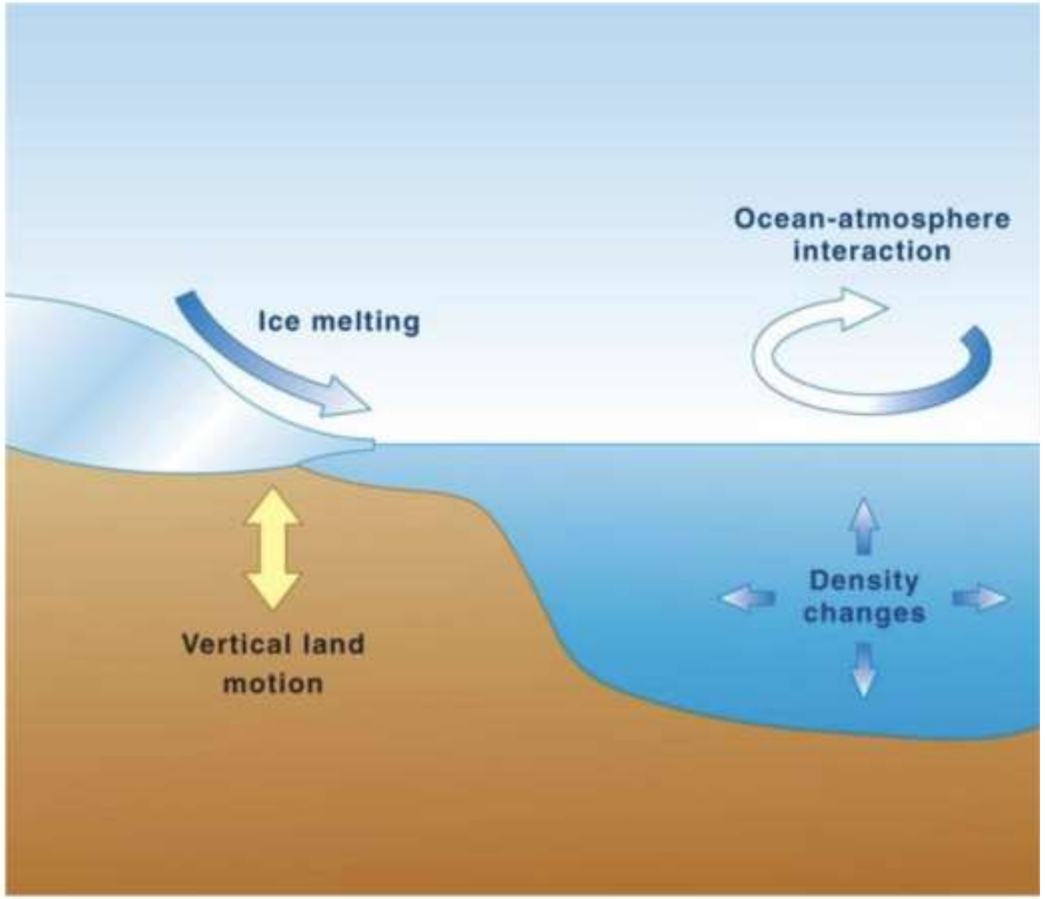
- Thermal expansion is mainly responsible for global sea-level rise.
- When the water warms, it takes up a larger volume (it expands because the molecules are agitated).



From https://climatescience.org/advanced-climate-sealevel-rise

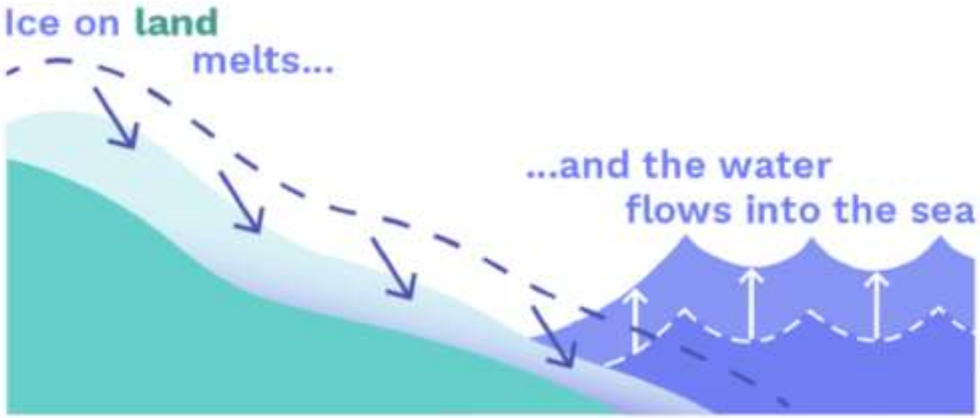
What is driving sea-level rise?

Addition of water



(Milne *et al,* 2009)

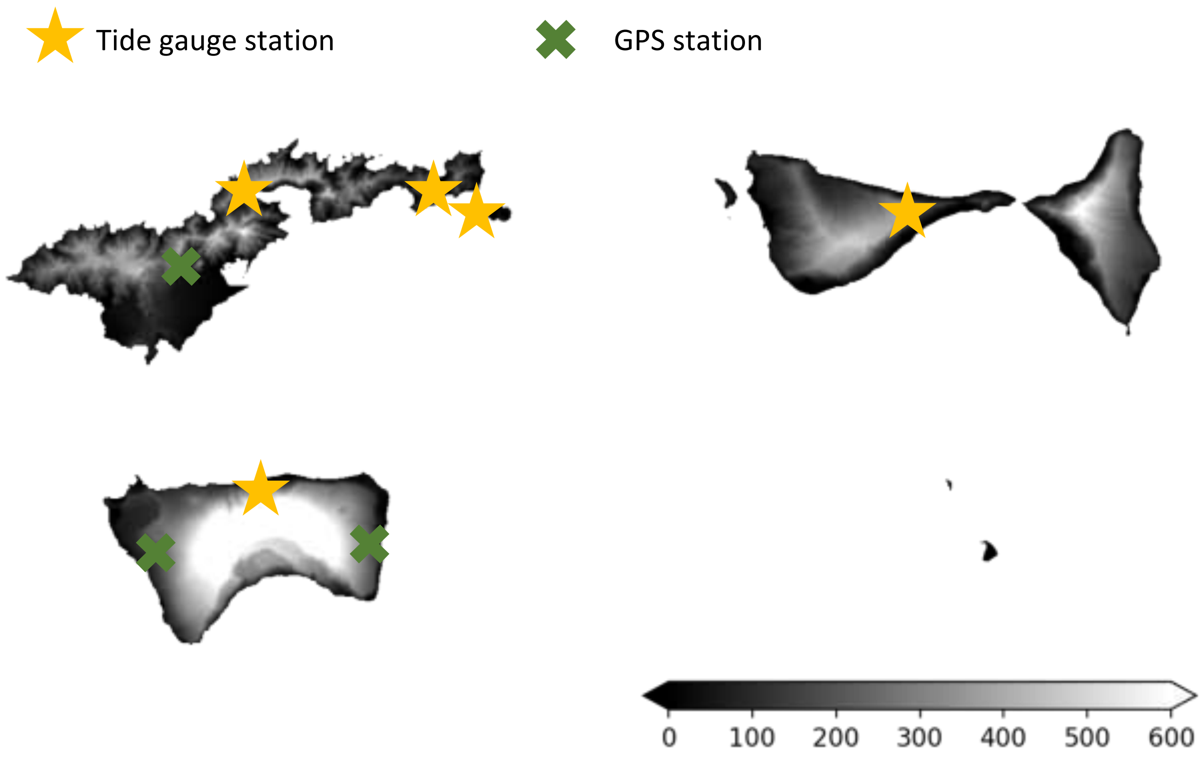
- Addition of water from on land storage (e.g., ice sheets and glaciers) is the second main driver for global sea-level rise.
- As shown on the diagram below, when ice melts on land it enters the ocean, rising sea-level.



From https://climatescience.org/advanced-climate-sealevel-rise

Updates

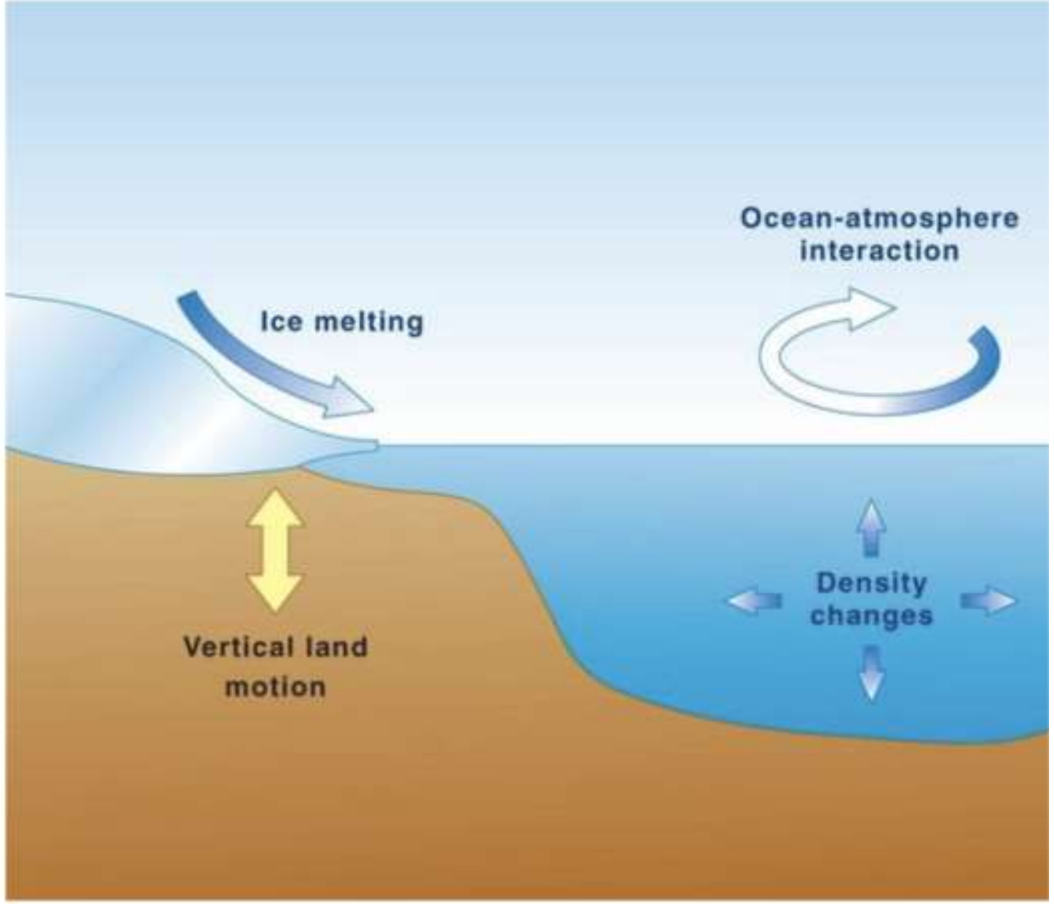
New data stations



- UHSLC deployed tide gauge stations in:
  - Aunu’u & 'Au'asi
  - Ofu & Ta’ū
- GPS stations in:
  - Ta’u (2 stations)
  - Tutuila
- New DEM coming in 2023
- Model and projections will be improved using the new data.

What is driving sea-level rise?

Vertical Land Motion – Land Subsidence



(Milne *et al,* 2009)

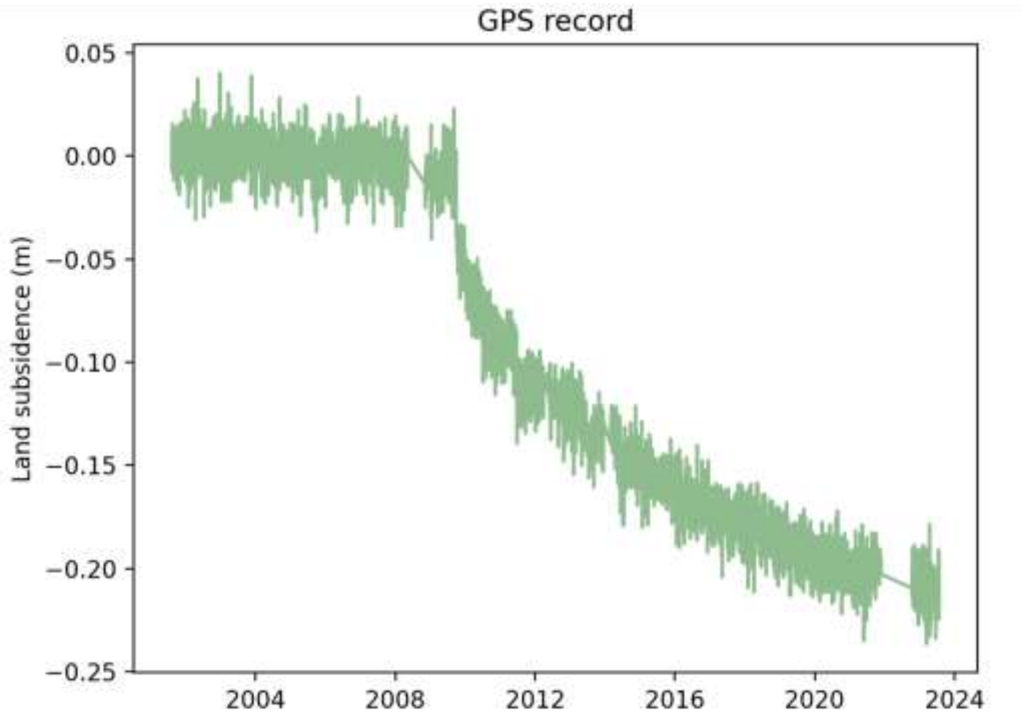
- Regionally, land subsidence (downward vertical land motion) can influence sea-level rise.
- It is sometimes referred to as relative sea-level rise.
- Here, in American Samoa, land has been subsiding quickly. Land subsidence is the main cause of relative sea-level rise.

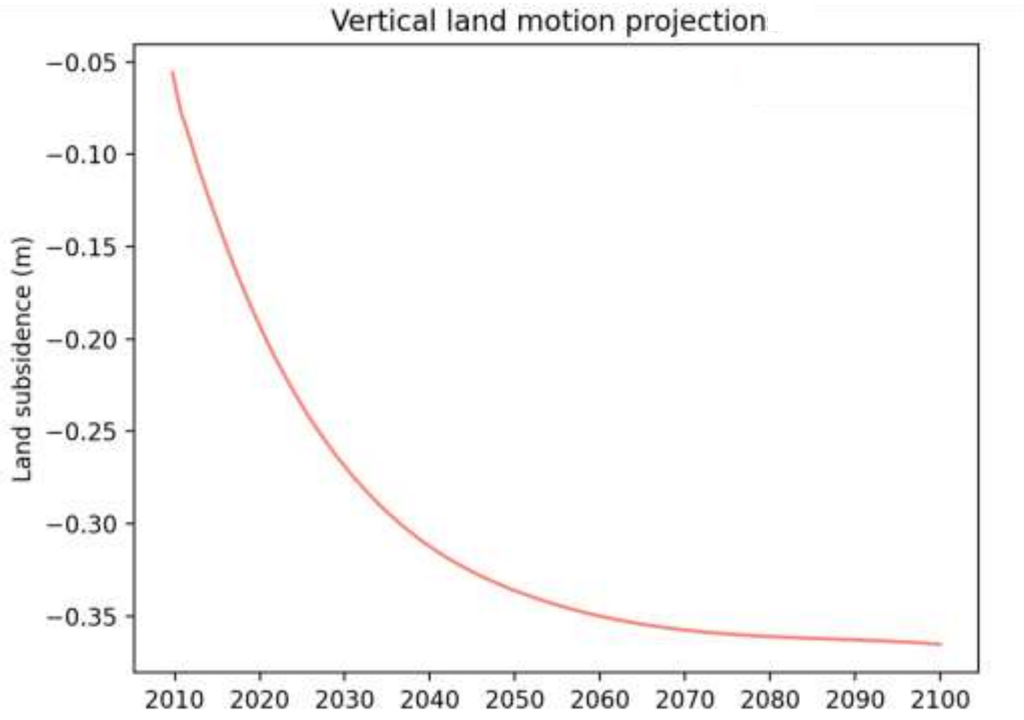
Outline

1. Science background
    1. What is driving sea-level rise?
    2. Extreme high tide flooding
2. How did we build the viewer?
    1. Datasets
        1. Difficulties and limitations
        2. Updates – new data stations
    2. Passive flooding method
    3. Viewer demonstration

Datasets

GPS record and land subsidence projections





- GPS from the Nevada Geodetic Laboratory (http://geodesy.unr.edu/NGLStationPages/stations/ASPA.sta)
- Record since 2001

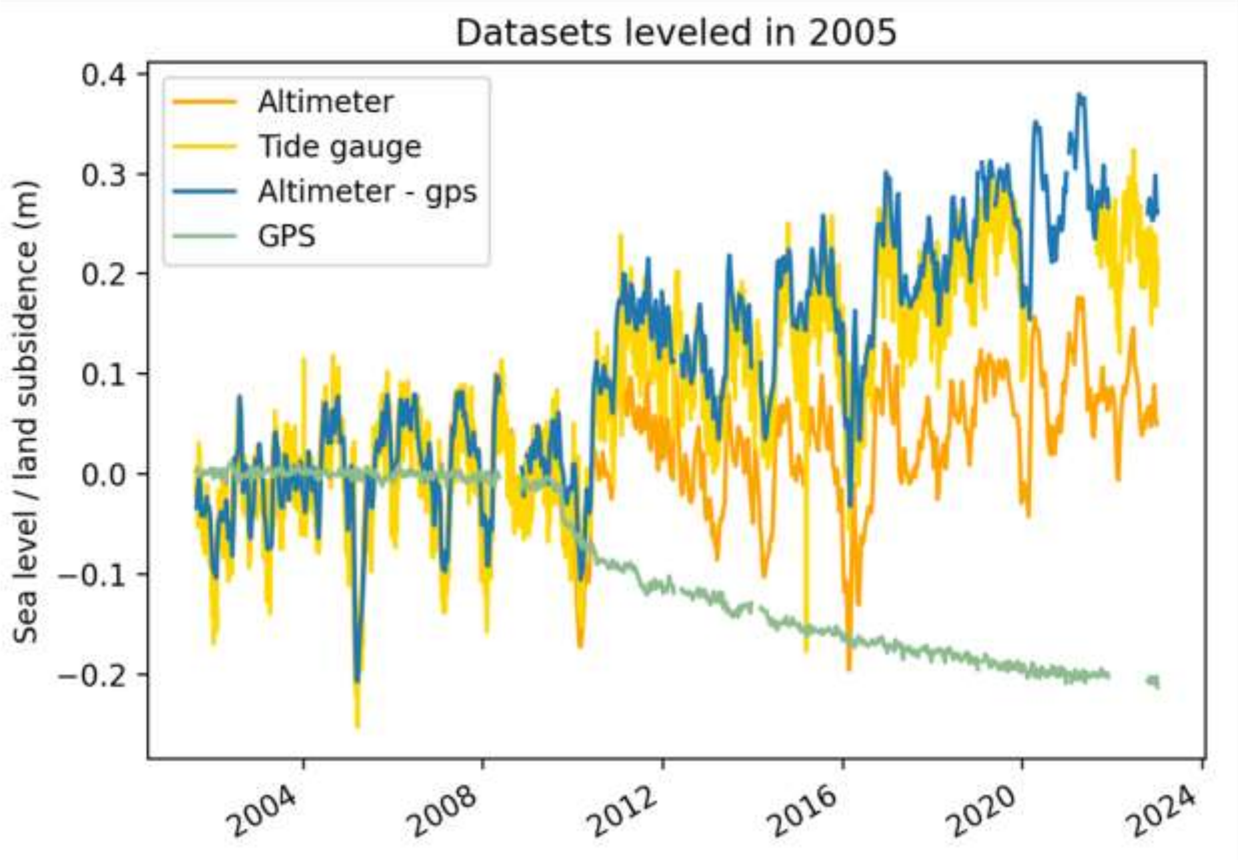
- Land subsidence projections (vertical land motion) from Han *et al* (https://doi.org/10.1029/2018JB017110)
- Projections until 2100

Updates & Next Steps

- Semi-permanent CORS stations installed in Ta’u in July, 2022
- Topo-bathy LiDAR flown in December, 2022 by Woolpert, funded by NOAA NGS
- Tide gauges installed in Auasi, Aunu’u, Ta’u harbor, and Ofu harbor in April 2023
- NOAA NGS benchmark survey in July, 2023
- Release of Relative Sea Level Rise Viewer in September, 2023
- Next steps: wave inundation modeling (PacIOOS) and reef crest height monitoring (UH Sea Level Center)

Difficulties & limitations

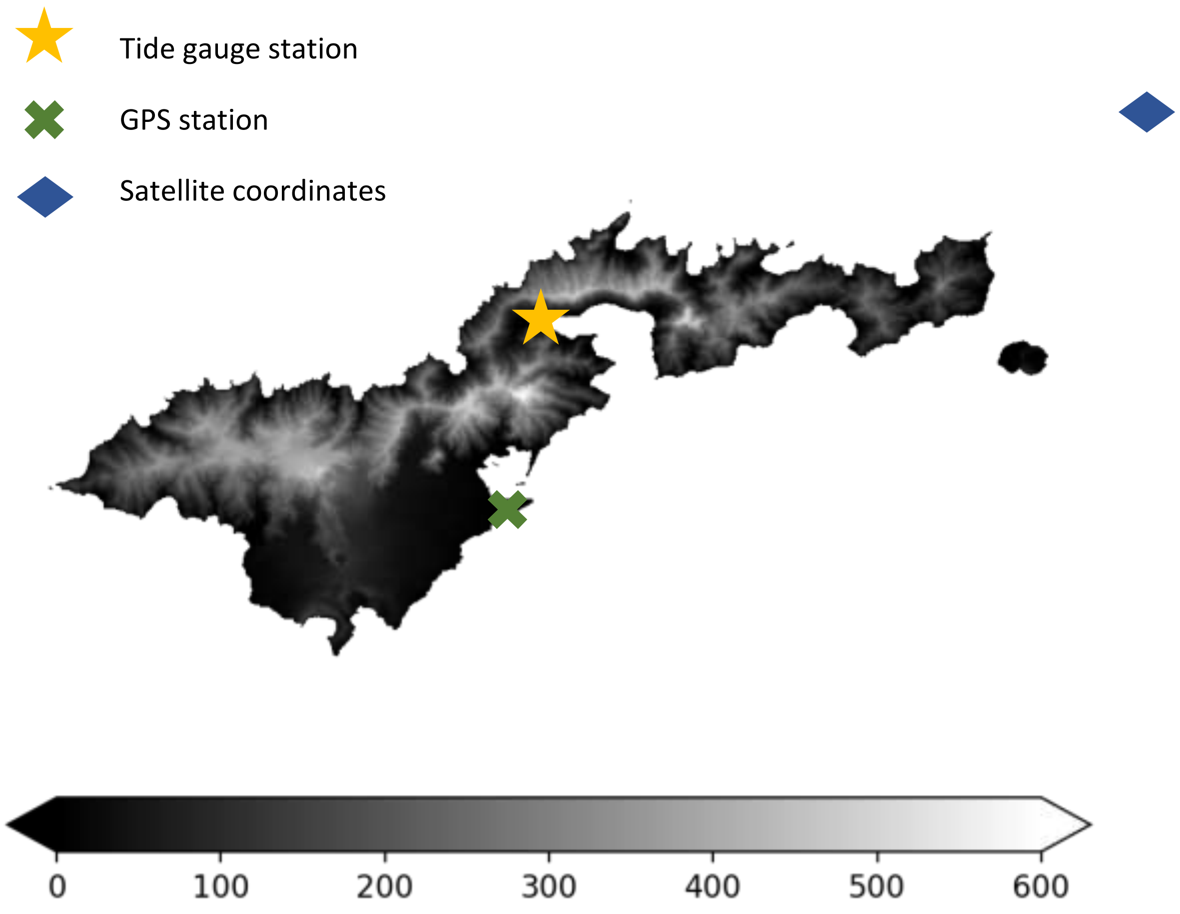
Leveling



- All datasets were leveled at 0 in 2005 (i.e. the mean value in 2005 is 0).
- The DEM has also been adjusted to match MSL=0m in 2005.
- The blue line (Altimeter – gps) conforms that the rapid increase of sea-level rise is induced by land subsidence.
- Assuming MSL=0 in 2005, American Samoa has experienced 22.28cm of sea-level rise (of which 19.56cm are due to land subsidence).

Difficulties & limitations

Low resolution



- The resolution of the DEM is low, and it does not include variations from land subsidence since 2012.
- Data stations are on different locations on the island.
- All stations are on Tutuila – very limiting for the other islands.

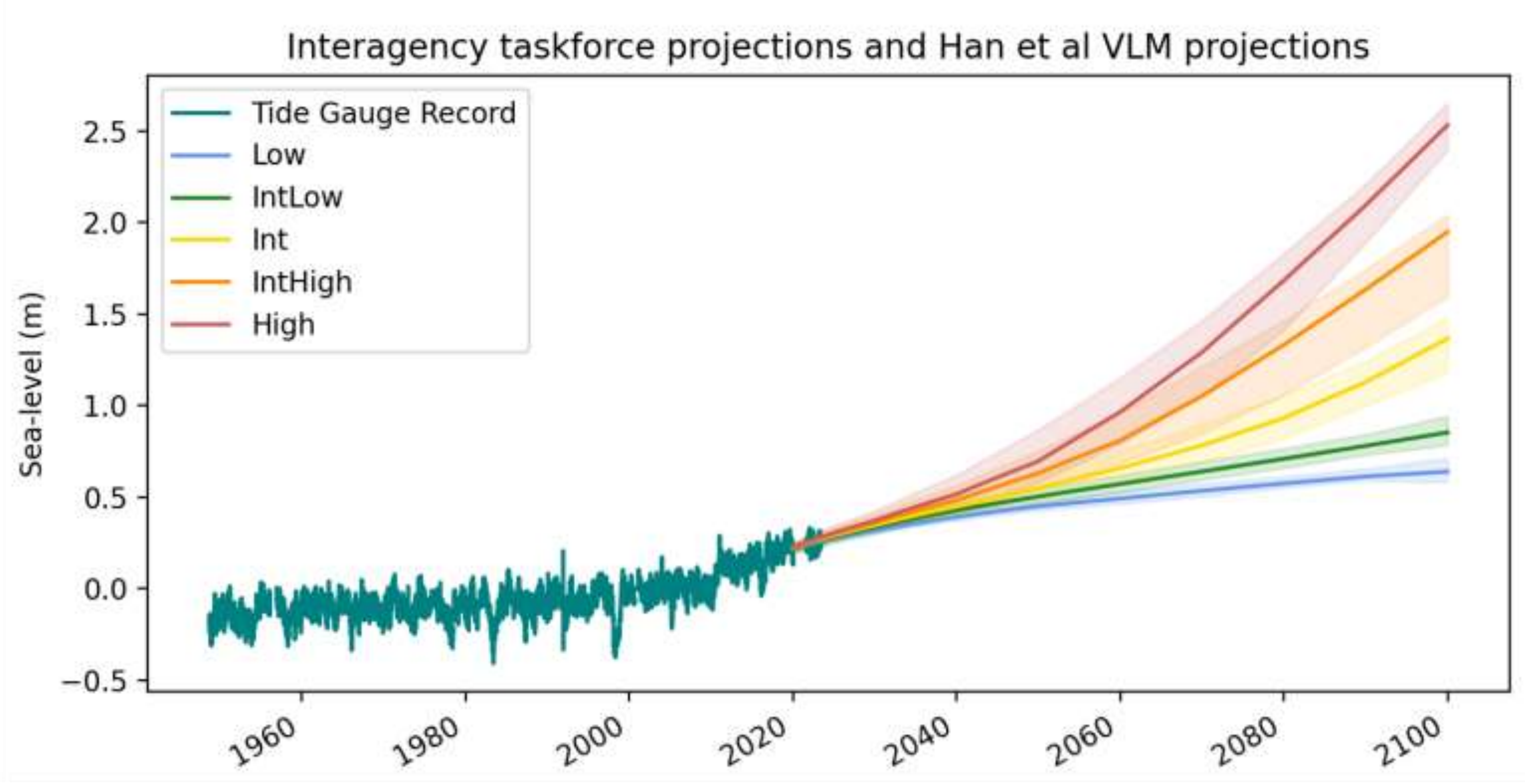
Growing tool

Feedback and improvements

- It is a growing tool. As more datasets become available, we will update the viewer.
  - Running the layers on a higher resolution DEM.
  - Adding a layer of the land subsidence variability.
- We are more than happy to get your feedback and will make it happen if possible.

Datasets

Sea-level projections



- Sea-level projections from the Interagency Task Force with updated land subsidence projections from Han *et al.* (https://sealevel.nasa.gov/task-force-scenario-tool?psmsl_id=539)
- Projections are divided into five scenarios ranging from Low to High. Low is characterized by the lowest levels of greenhouse gases emissions while high suggests very high greenhouse gases emissions and reaching climatic tipping points.