What is sea level?

Imagine you were someplace much warmer right now…

Where is sea level?

Imagine you were someplace much warmer right now…

Is there a sea level on land?

Sea level is local and relative

Tide gauge station

Sea surface (what you see)

Relative sea level (RSL) =
sea surface elevation - crust elevation

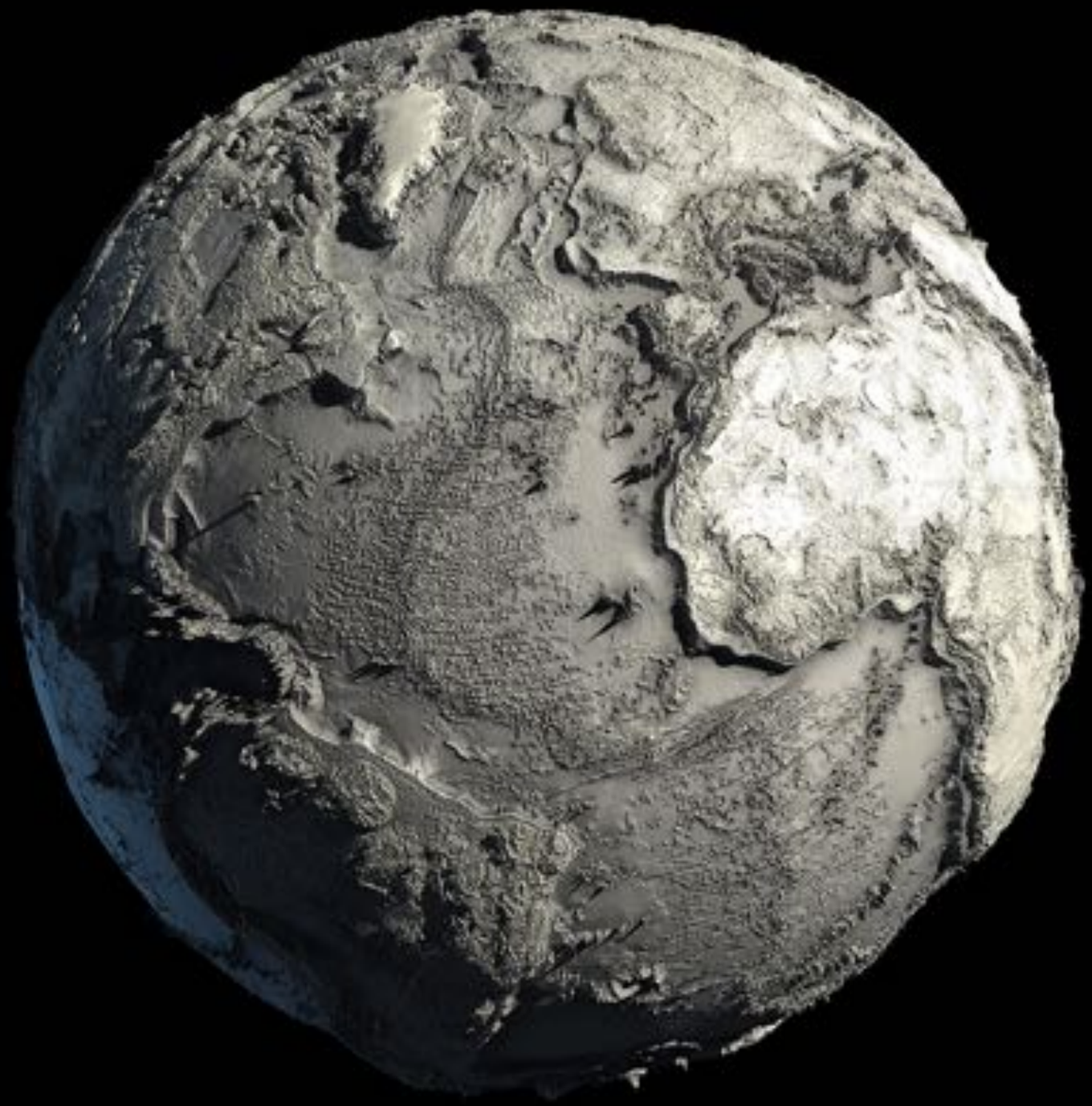
Solid earth (ocean floor)

Schematic adapted from Tamisea et al. 2014

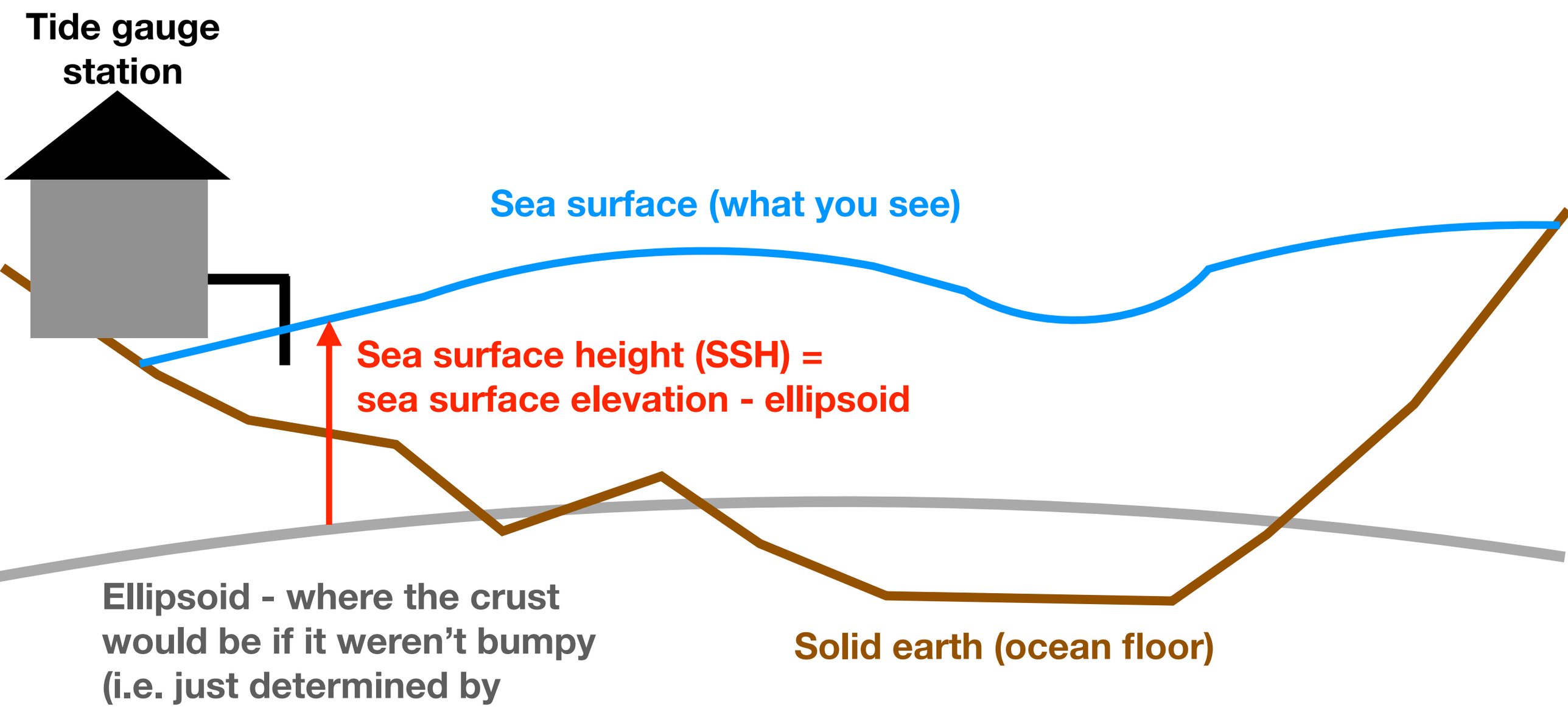
Imagine you were someplace much warmer right now…

Is the sea level different at the top and bottom of a wave/swell?

The Earth without oceans - what happens when you drop a lot of water on this sphere(oid)? Why?

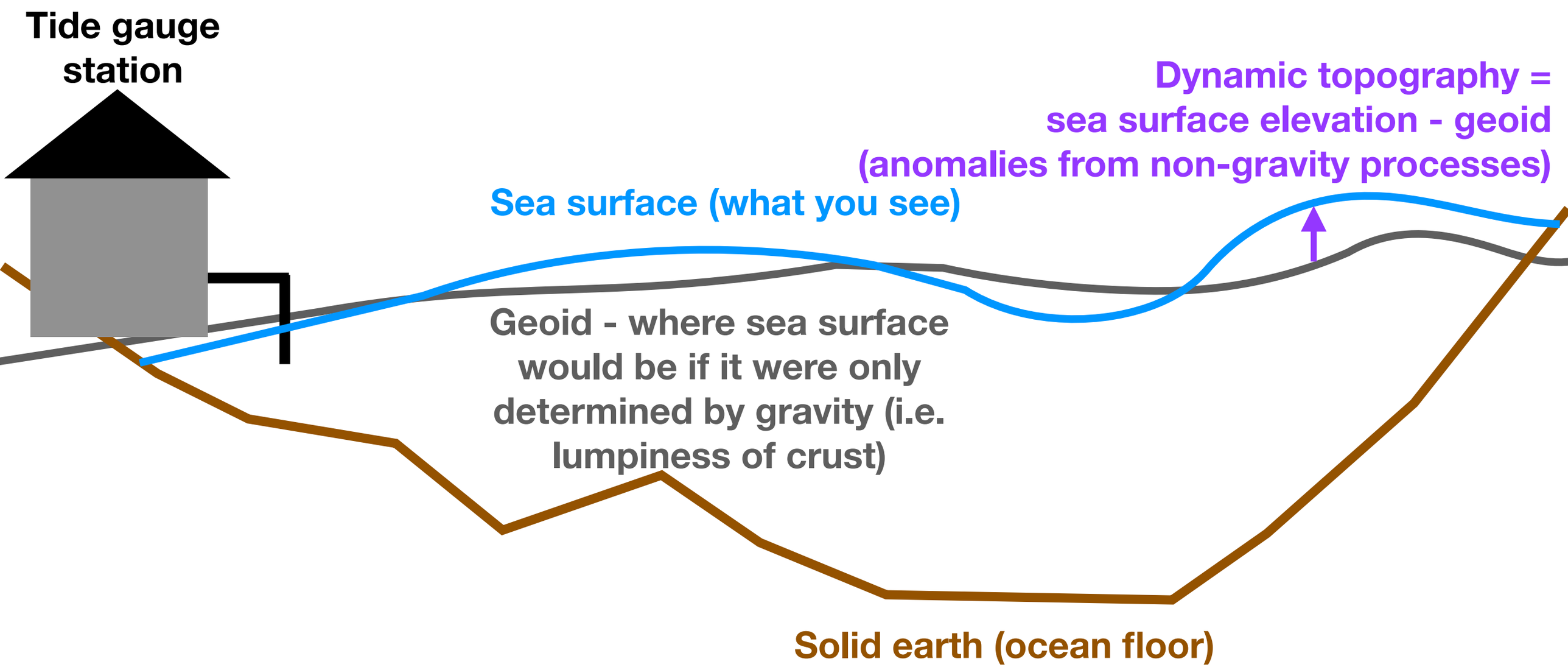


Sea level is local and relative



Schematic adapted from Tamisea et al. 2014

Sea level is local and relative and reference-dependent



Schematic adapted from Tamisea et al. 2014

Some terminology

- Relative sea level (RSL): the local water level minus crustal elevation

- Global mean sea level (GMSL): the sea surface height averaged equally over the global ocean area (this is what we usually mean when we talk about “sea level rise”)

- Vertical datum: a vertical point in space (relative to center of earth) against which other elevations are referenced - important for sea level measurements

    - NAVD88: North American Vertical Datum of 1988 - the current benchmark for all water levels in North America, based on a tidal benchmark in Quebec

    - NGVD29: National Geodetic Vertical Datum of 1929 - the old benchmark (still used by some) based on a mean of a certain set of long-running tide gauges in N. America

What is local “mean” sea level?

- Because local sea level is changing on many time scales - there is no such thing as a fixed sea level reference (hence the need for a datum)

- For practical purposes we distinguish between:

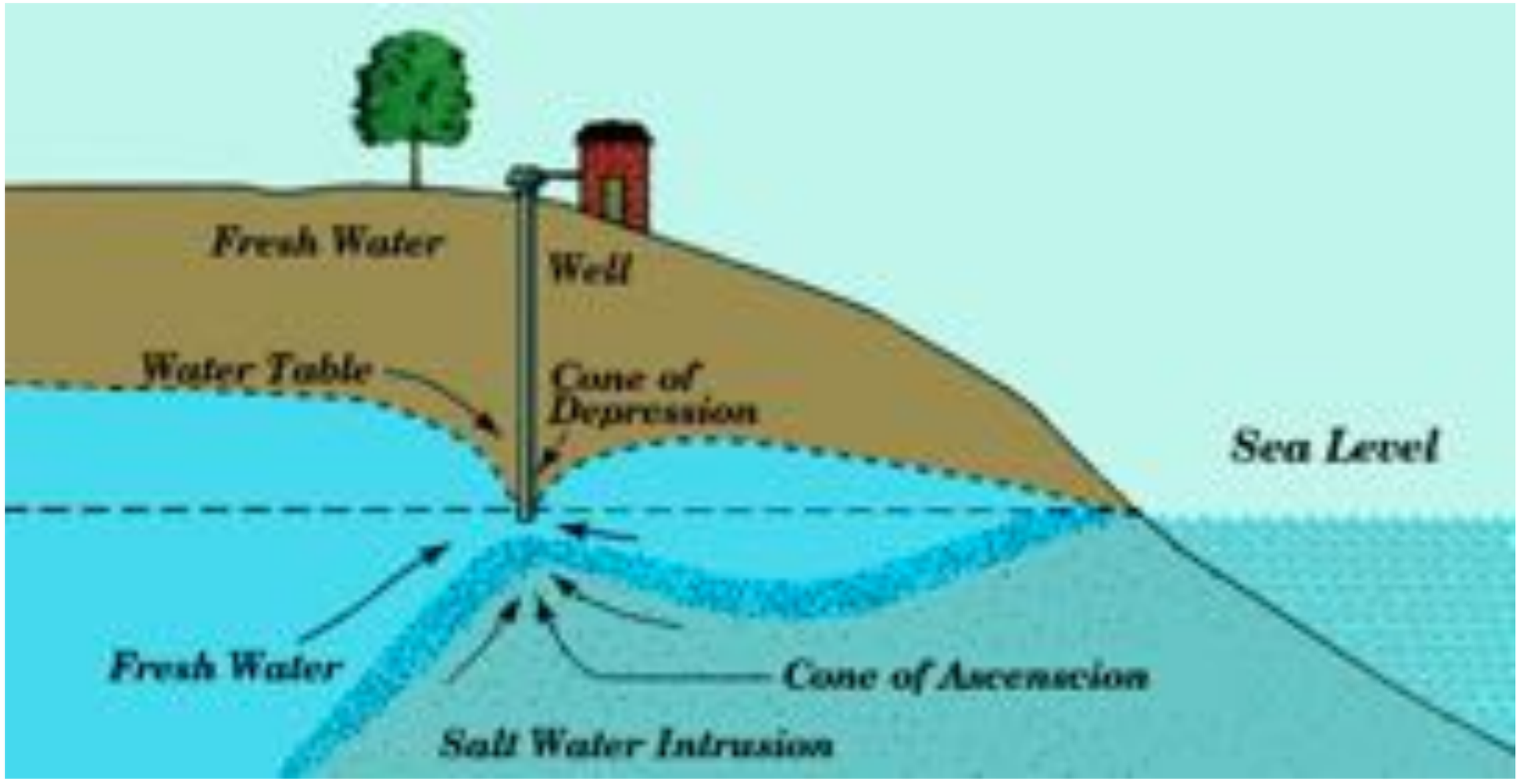
  - Mean Higher High Water (MHHW): for a given location - the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch (1983-2001) - the “typical” highest water that we expect to observe on a daily basis)

  - Flood/water level: instantaneous sea level experienced over more than 5 minutes (i.e. not including ocean waves)

  - Other tidal datums can be used for other purposes

https://tidesandcurrents.noaa.gov/

Why different time scales of sea level matter



- years of exposure to seawater: saltwater infiltration of water table

Why different time scales of sea level matter

- months of exposure to seawater: concrete foundations start to erode

Why different time scales of sea level matter

- hours-days of exposure to seawater: undercarriage on a car corroded

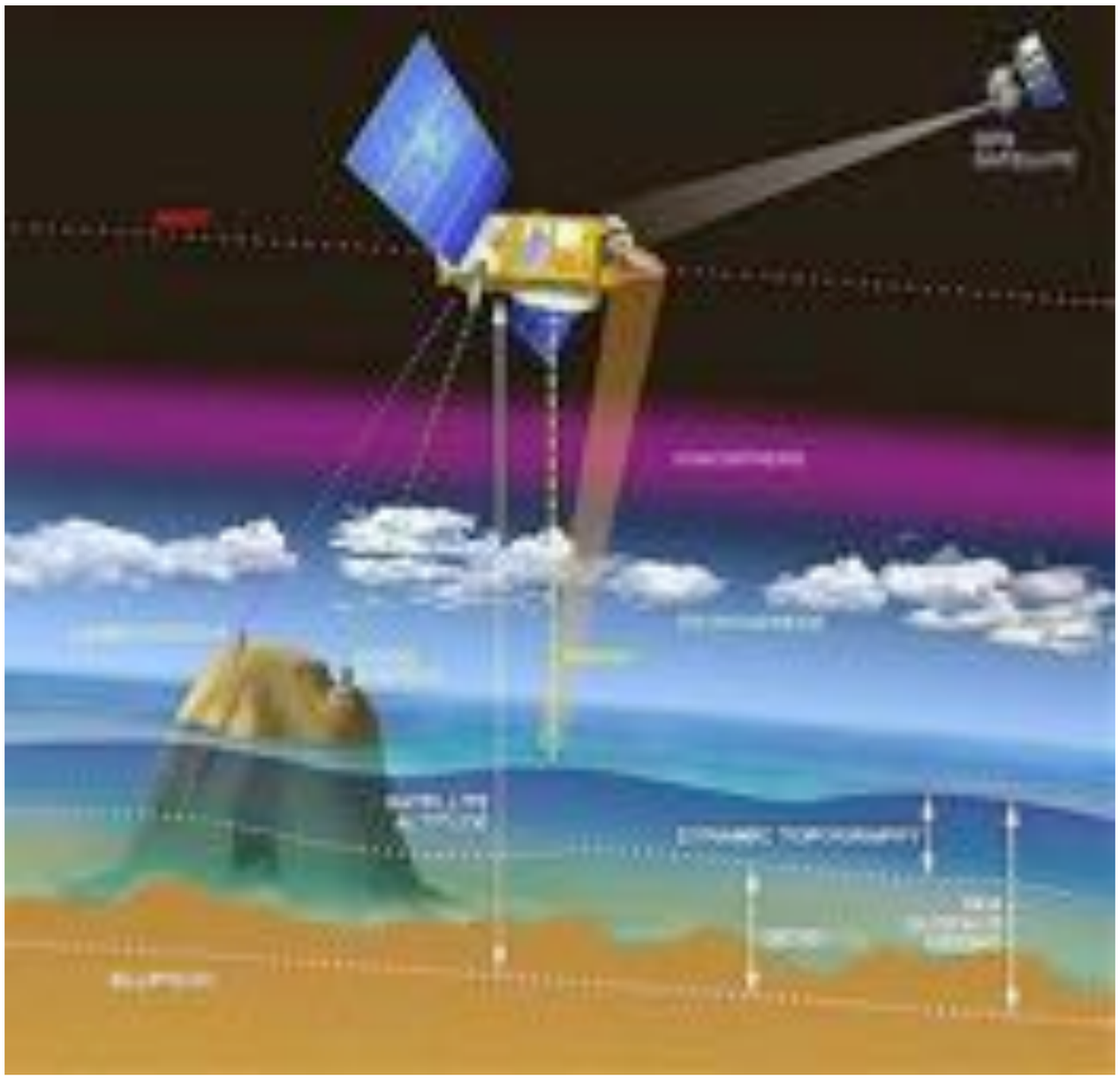
Why different time scales of sea level matter

- minutes-hours of exposure to seawater: landscaping, many types of plants not viable

Why different time scales of sea level matter

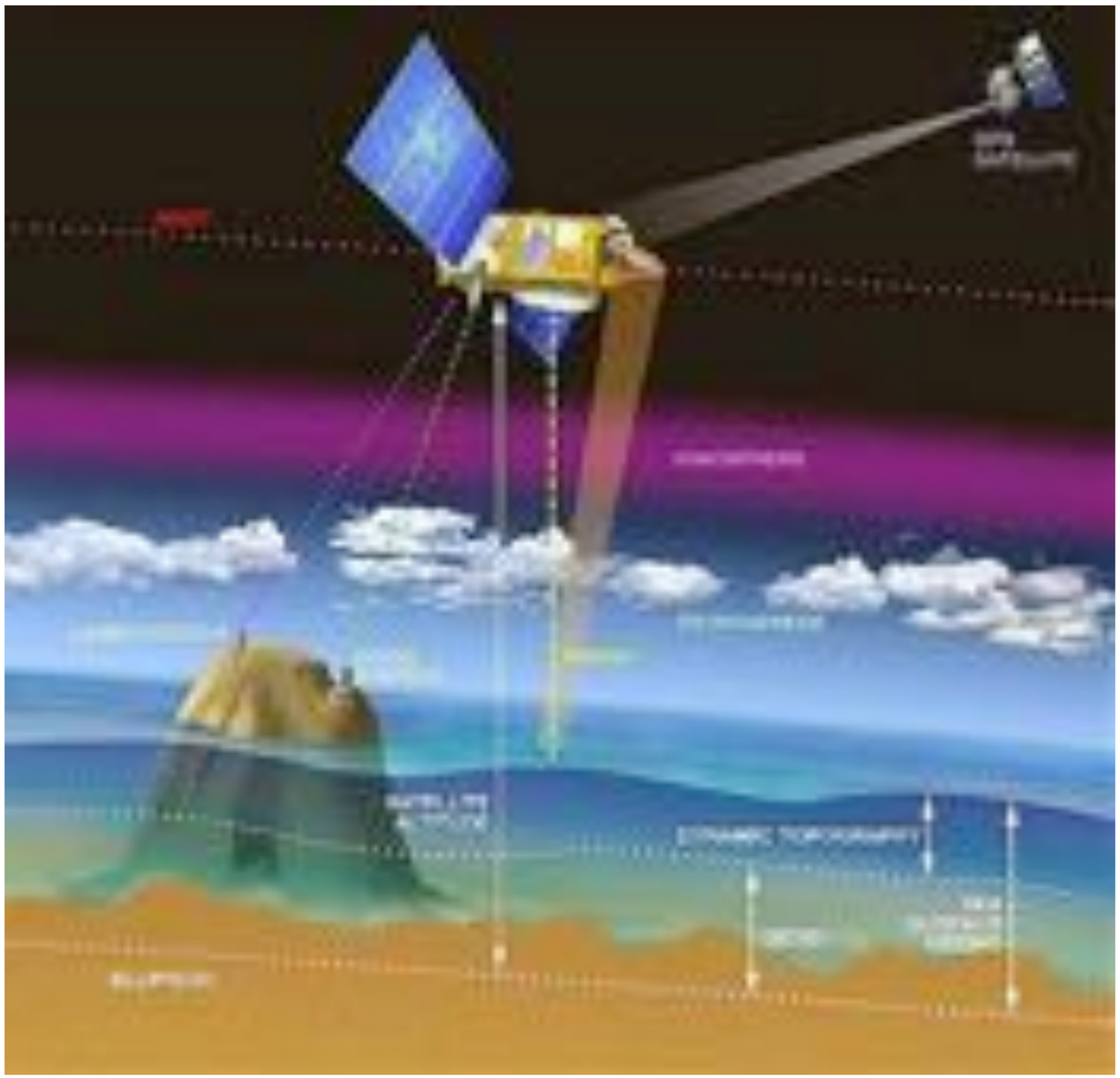
- seconds-hours of exposure to seawater/repeated wave action: beaches erode

How do we measure sea level?



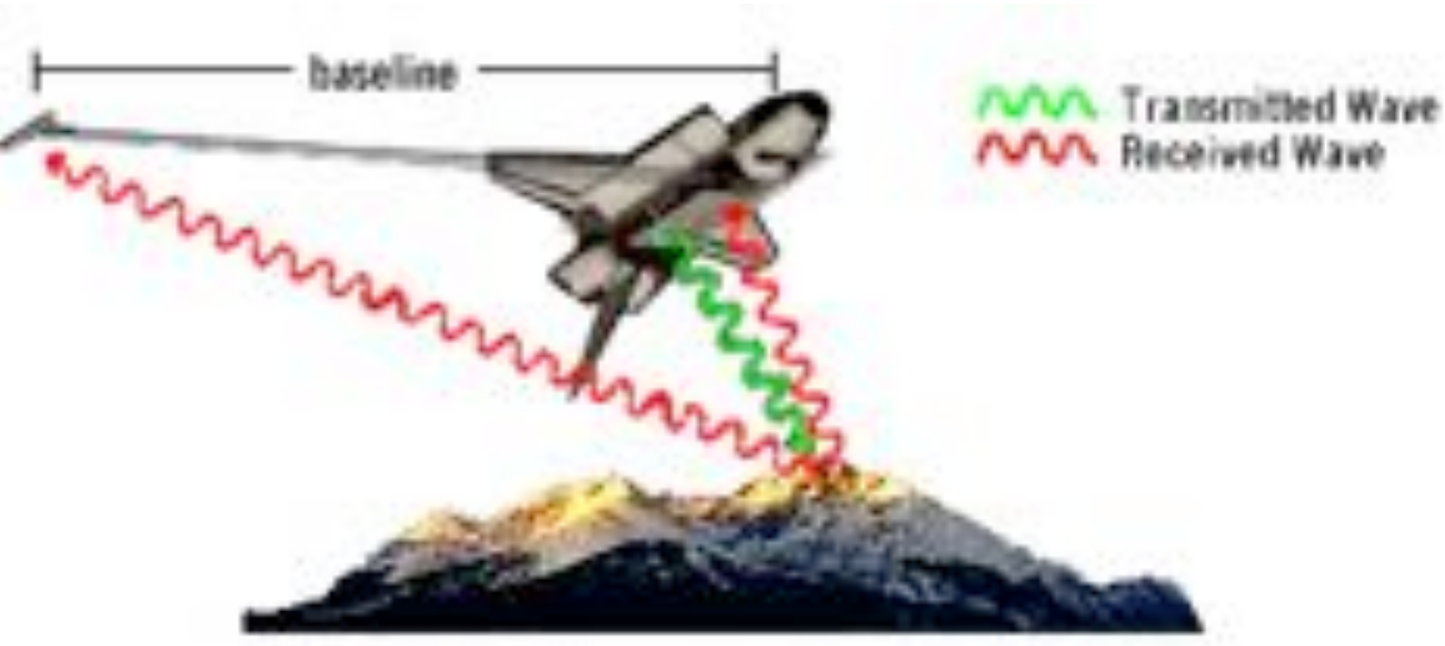
Altimeter measures distance from satellite to ocean surface based on return time of a radar or laser signal - great spatial coverage, poor resolution near coast

How do we measure sea level?



Altimeters are also used to map the near-shore land surface and provide elevation of land which is important for estimating future inundation from sea level rise

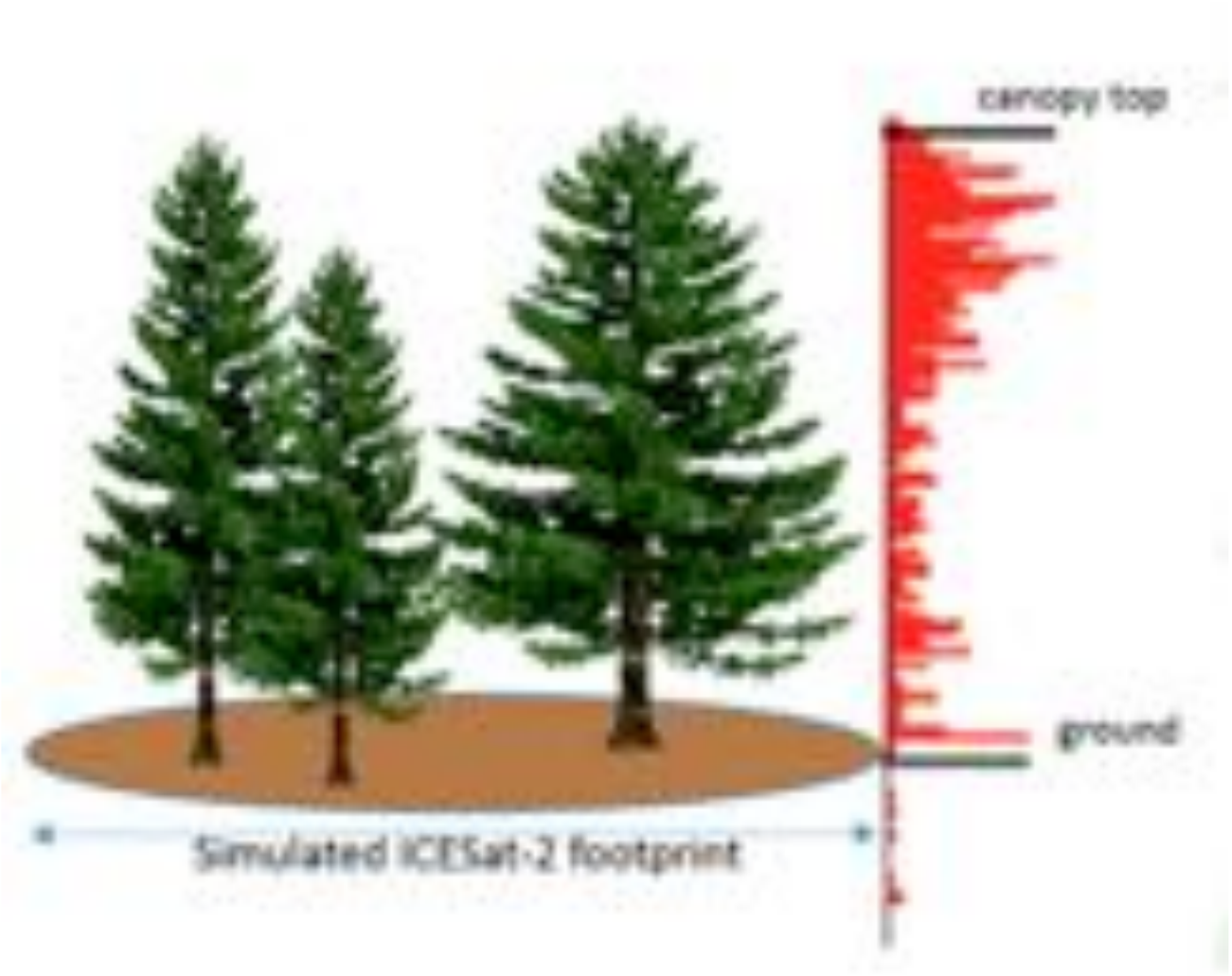
How do we measure sea level?



Radar signals being transmitted and recieved in the SRTM mission (image not to scale).

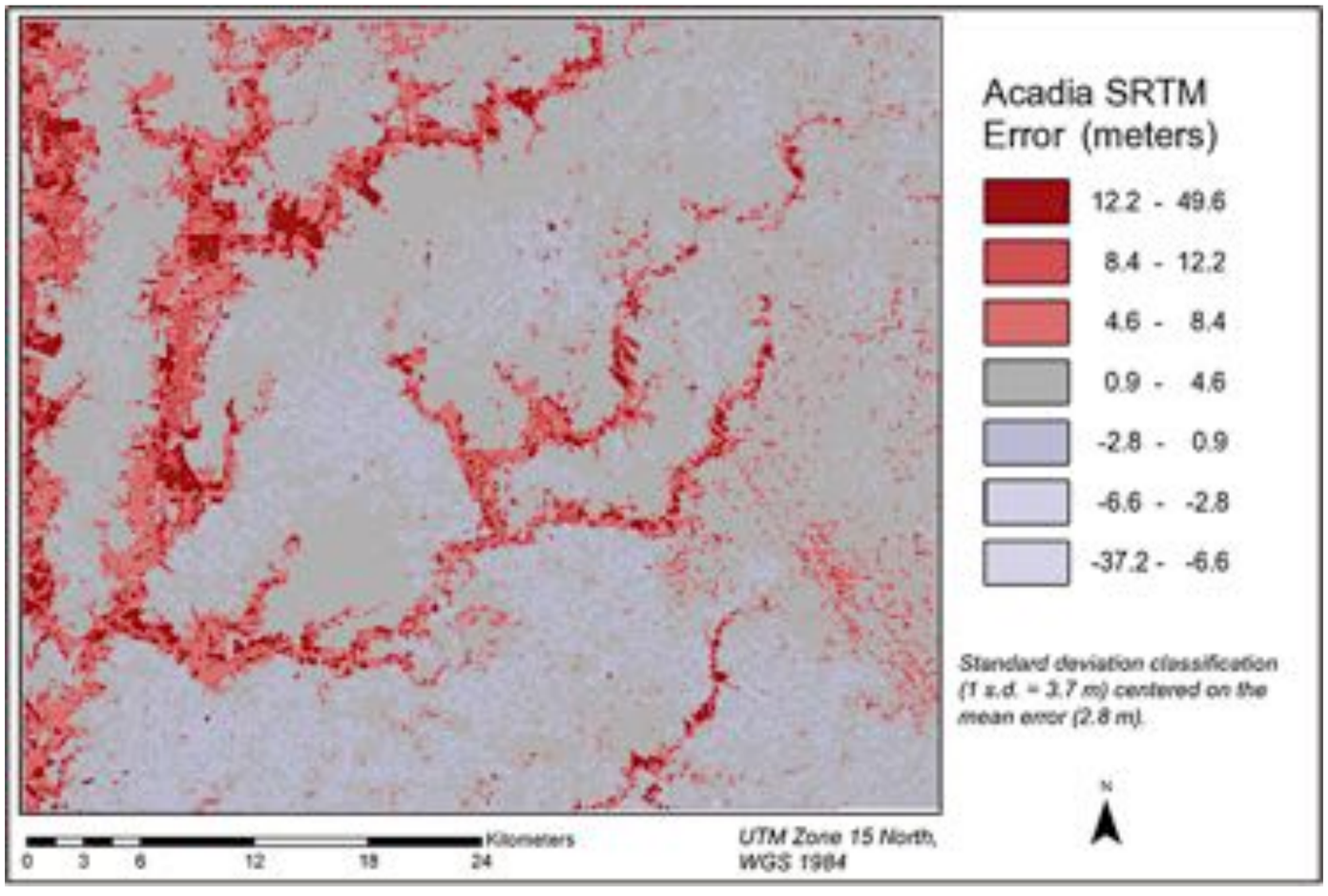
The Satellite Radar Topography Mission (SRTM) was a radar aboard the Space Shuttle that worked with a radar aboard the shuttle and another some distance away to measure the ground elevation at high resolution - current USGS standard

A side note on altimetry bias and sea level vulnerability



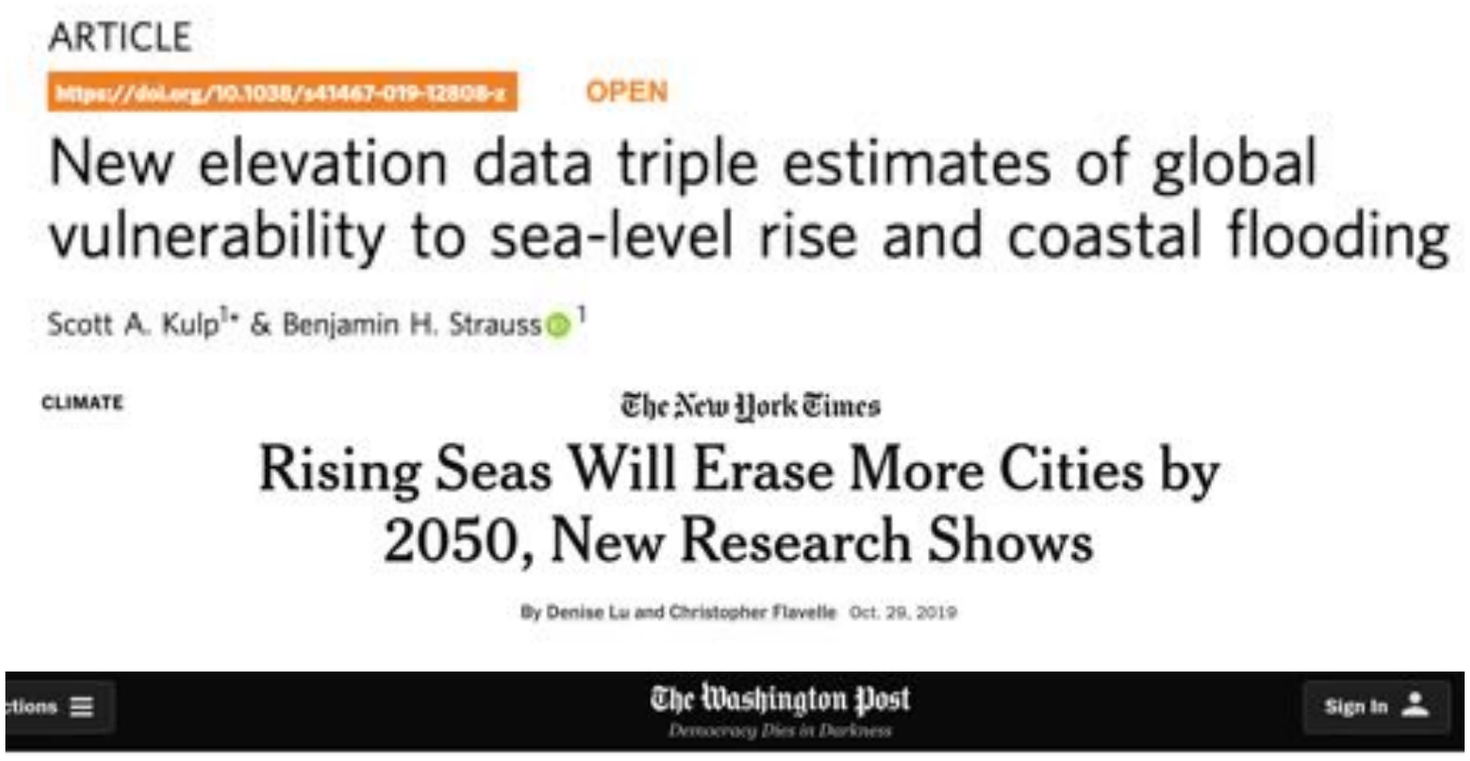
The problem: altimeters sometimes measure the tops of vegetation or buildings on land instead of the land surface

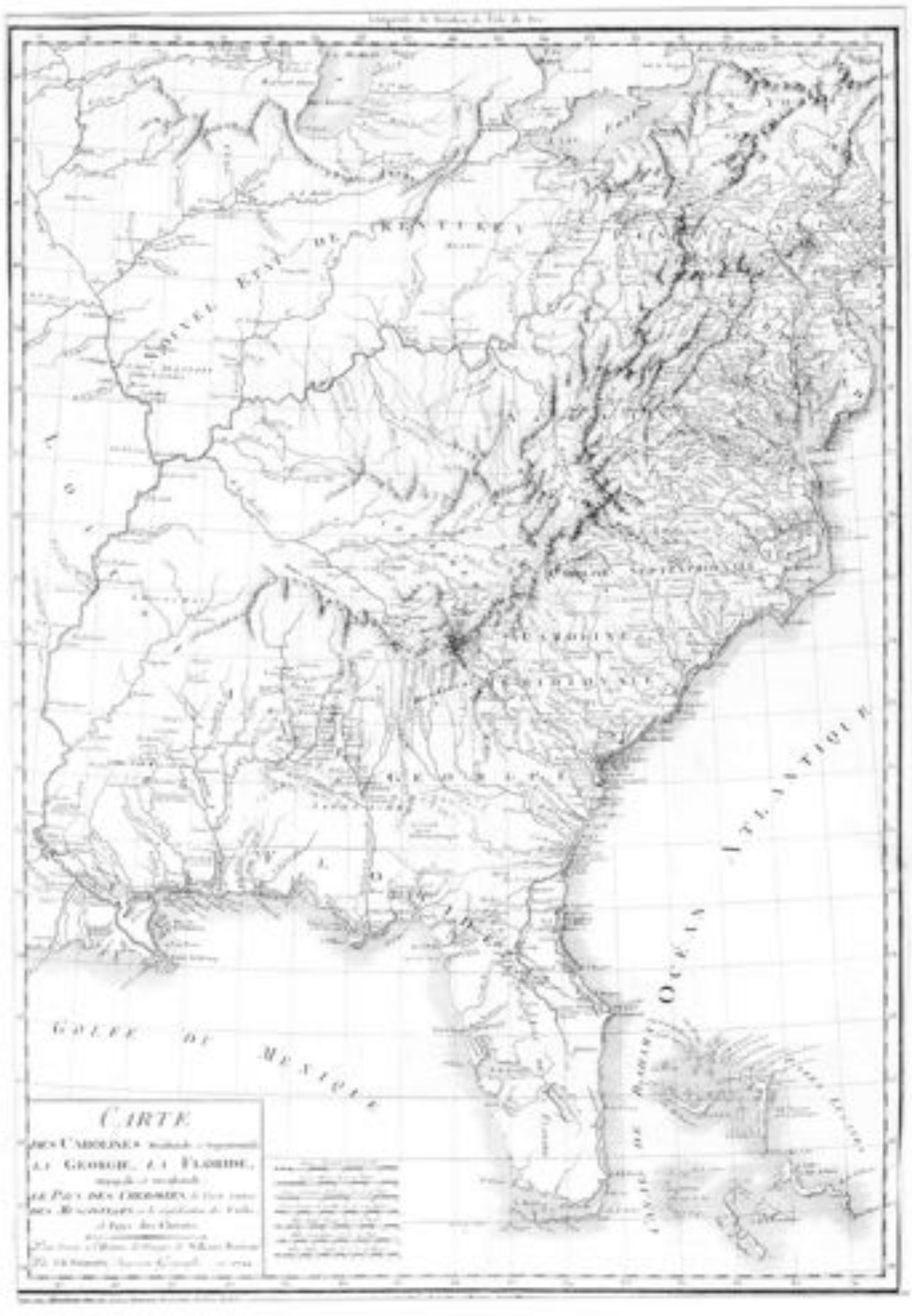
A side note on altimetry bias and sea level vulnerability



The result: many digital elevation models (DEMs) used to estimate vulnerability to SLR have a “too high” bias

A side note on altimetry bias and sea level vulnerability





A typical map of the SE US coast around 1800 - meh

Tide gauges in the US

The earliest tide gauges in the US were installed to facilitate more detailed mapping of the US coastline at the behest of Thomas Jefferson in 1807.

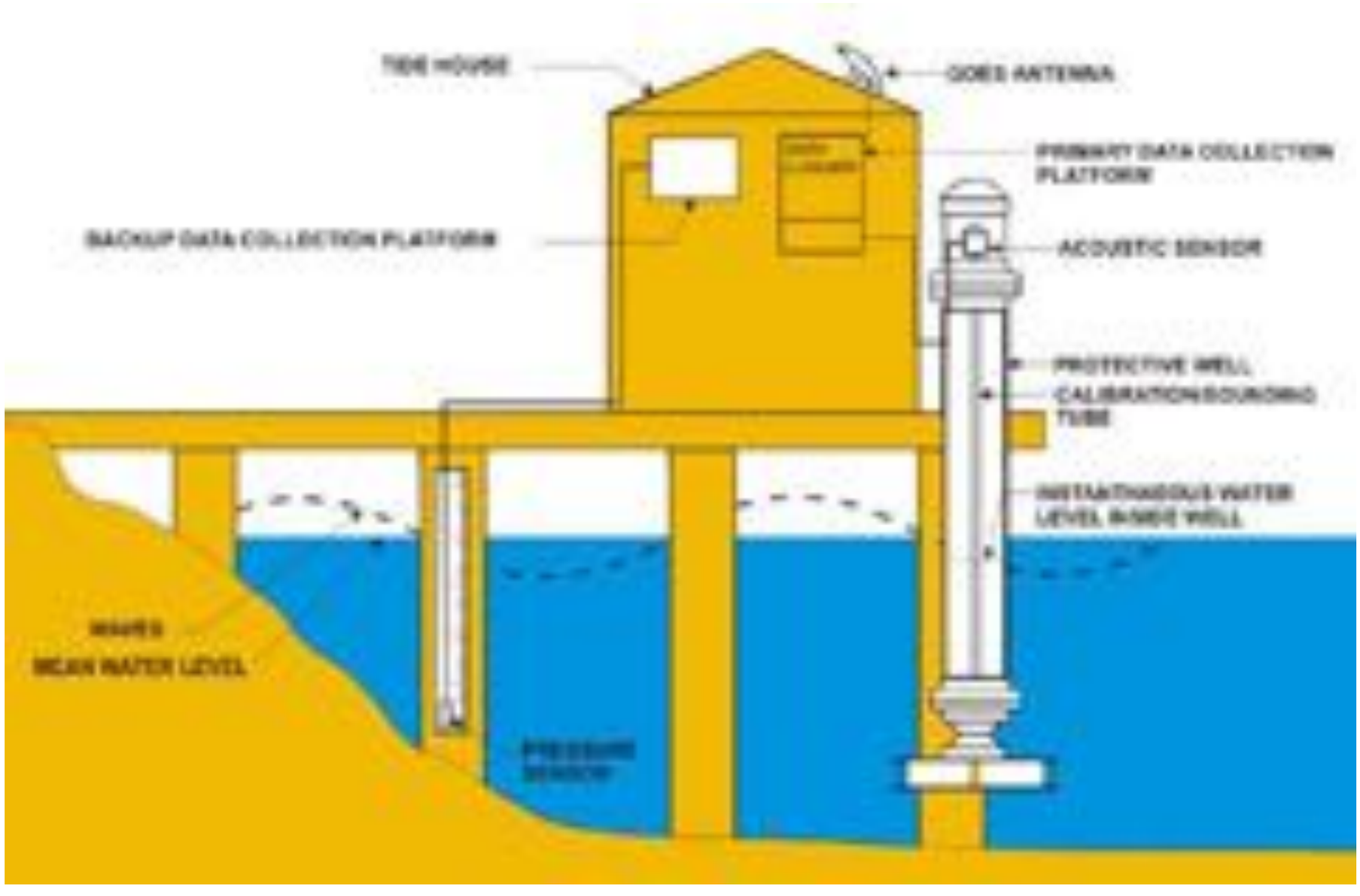
How do we measure sea level?

A US National Coast and Geodetic Survey cartoon of tide gauge installation c. 1950

How do we measure sea level?

To read the tide gauge at Cape Mordvinof on Unimak Island, Alaska, in 1939, scientists had to descend a 60-foot ladder suspended by wires and stakes. (right) Scuba divers check a cliffside tide staff in Glacier Bay, Alaska in 2010.

How do we measure sea level?



Tide gauges measure the distance from a reference position to the ocean surface inside a well at a coastal site - great precision, temporal resolution, poor spatial coverage

How do we measure sea level?

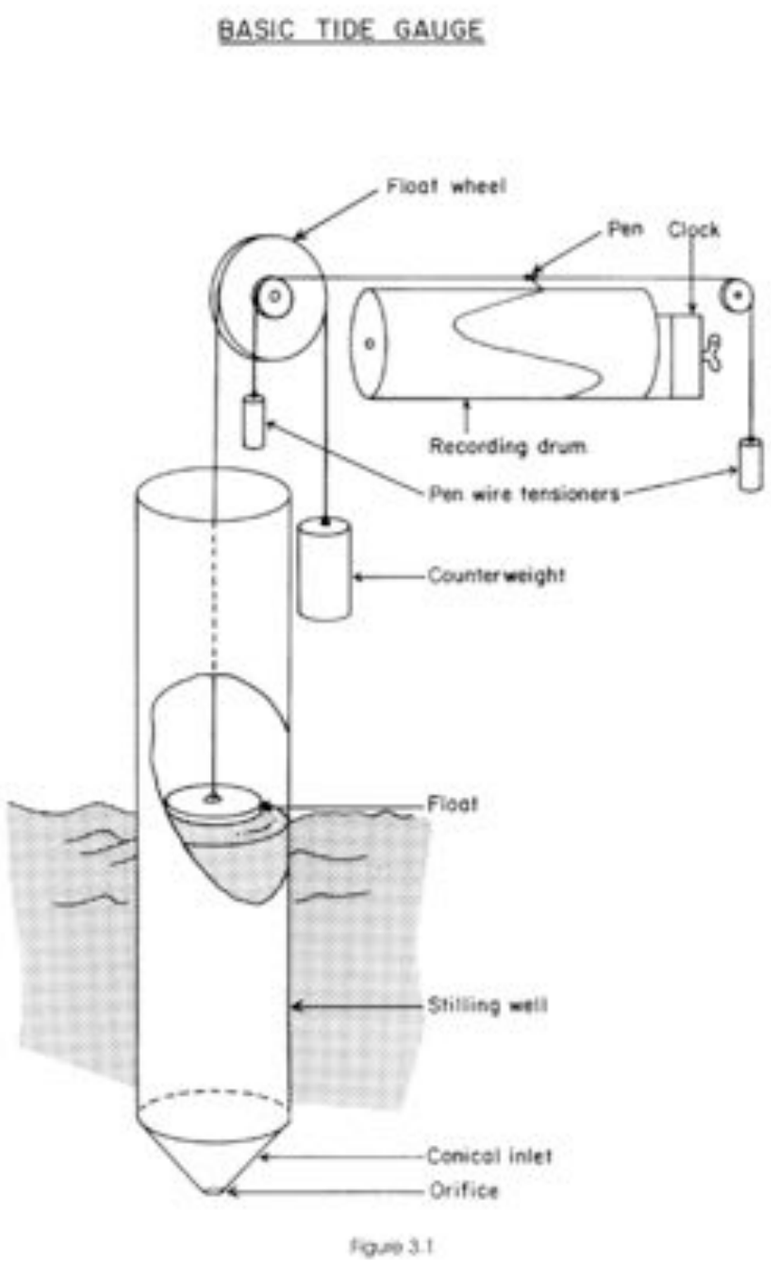
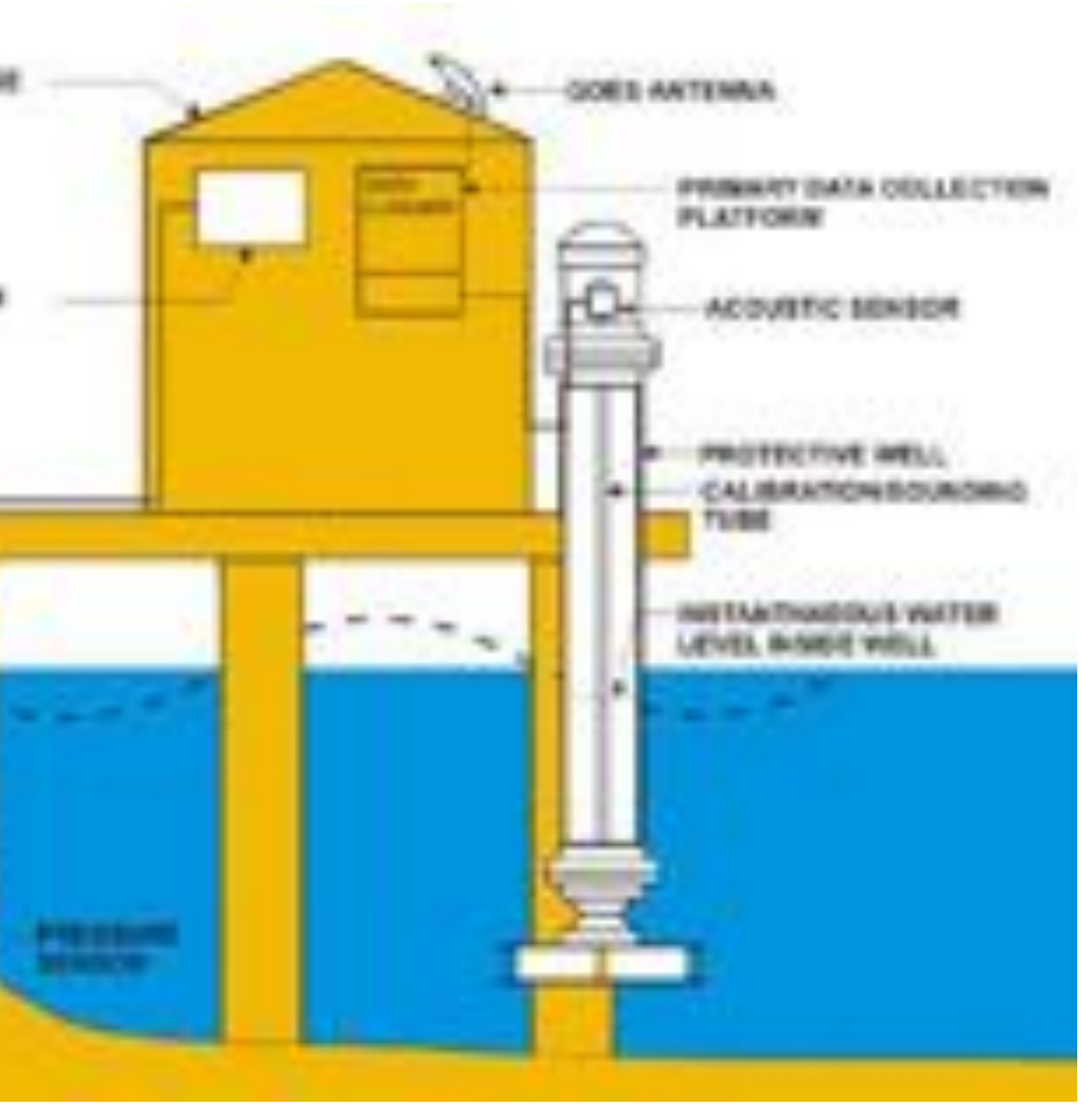


Figure 3.1

“Old school” tide gauge - a float and pulley system

How do we measure sea level?



Acoustic sensors came after WW2

How do we measure sea level?

“New school” - a microwave sensor

How do we measure sea level?

“New school”
- an acoustic sensor

How do we measure sea level?

Long-running tide gauges in US (one in GA) - installed over last century

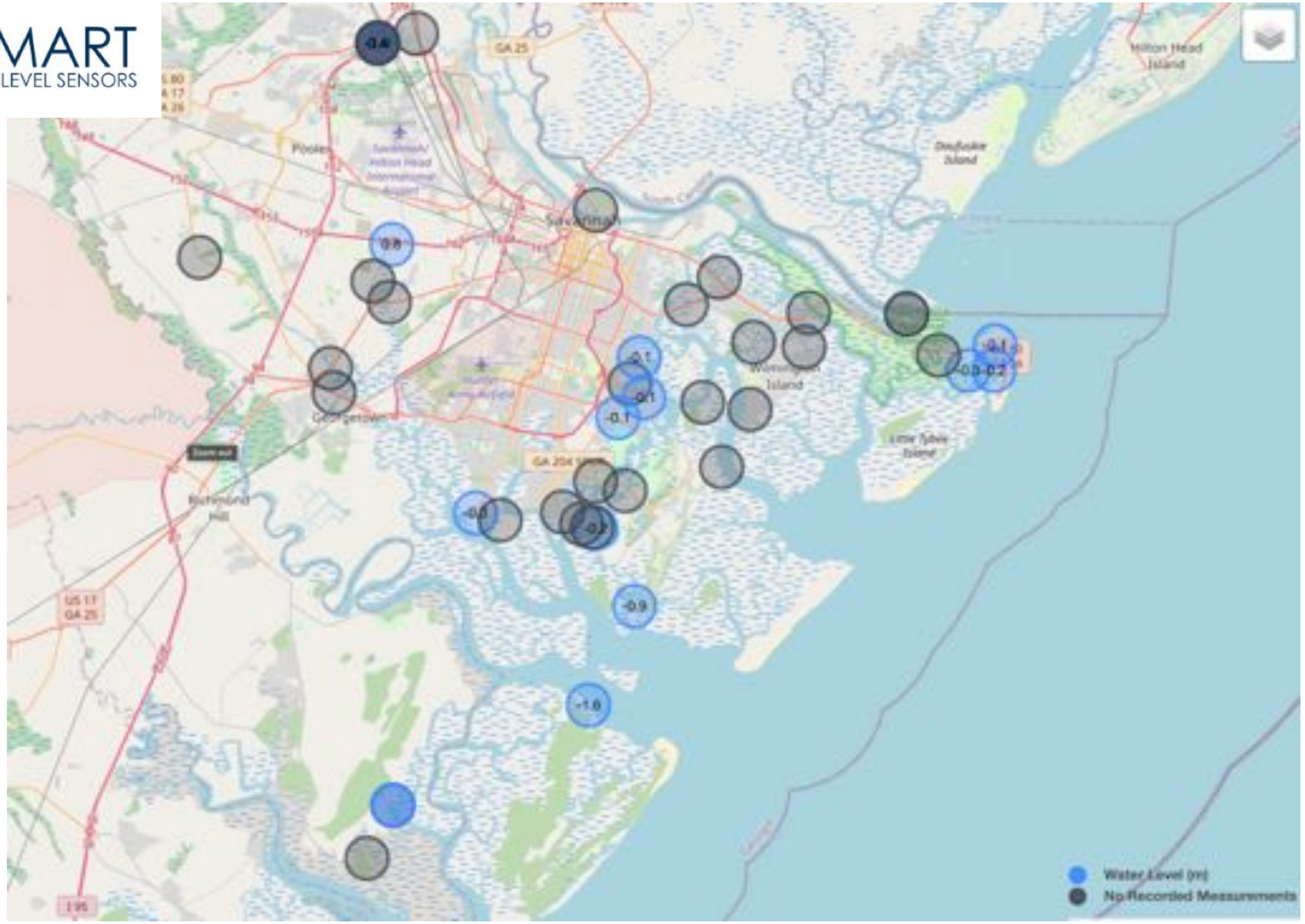
How do we measure sea level?

SMART
SEA LEVEL SENSORS

GT Project to make very cheap internet-connected acoustic SL sensors that can be installed in many more locations than tide gauges

How do we measure sea level?

SMART
SEA LEVEL SENSORS



Lets look at some real data

- https://tidesandcurrents.noaa.gov/
- https://dashboard.sealevelsensors.org/
- Quick questions:
  - How frequent are tides? How large is their amplitude?
  - On what other time scales does the magnitude of tides vary?
  - Over the whole record is there a noticeable change in local sea level? How much (by eye)?