Part 1 Questions & Answers Session A

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Sean McCartney (sean.mccartney@nasa.gov) or Denis Felikson (denis.felikson@nasa.gov).

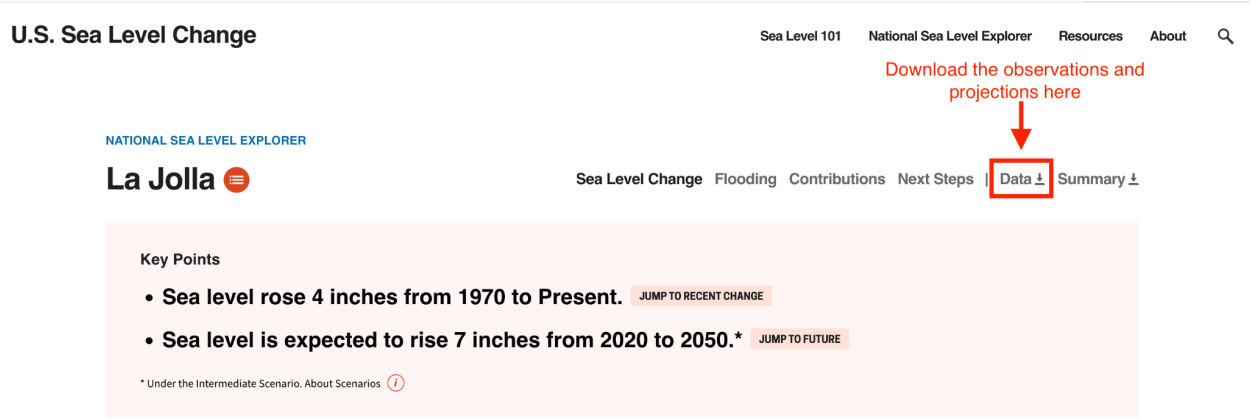
Question 1: Is it possible to monitor ocean height in mangrove ecosystems when there is thick vegetation?
Answer 1: Nadir radar altimetry is limited in its ability to observe coastal regions due to contamination of the waveform returns by land masses. Typically, mangrove systems fall within the ~20 km mask that is applied to the global ocean topography observations. There are retracked datasets that attempt to address this limitation, and these are improved upon by the recent, novel Ka-band Radar Interferometer observations from the Surface Water and Ocean Topography (SWOT) satellite. Though this mission was not mentioned in the training, SWOT is an advancement on traditional nadir altimetry and is, for the first time, enabling remote observations of coastal sea level from space. An excellent paper on this topic is:
Kica, S., Pavelsky, T. M., Fayne, J. V., & Williams, B. A. (2025). SWOT Water Surface Elevation in Herbaceous Wetlands of Florida's Everglades. Geophysical Research Letters, 52, e2025GL114956. https://doi.org/10.1029/2025GL114956.

Question 2: Are the Interagency Sea Level Rise Task Force projections/scenarios being phased out (e.g., Intermediate, Intermediate-High, etc.)?
Answer 2: The US government has historically attempted to provide regular updates to its synthesis of the most recent science related to sea level change across the country through the Technical Report structure. For the time-being, the current version remains the standard for the nation until another update is released.

Question 3: Do you have world sea level records before 1993? If yes, where can we find that information?
Answer 3: Yes, many tide gauges around the world have records that go back to well before 1993. The data can be obtained from the Permanent Service for Mean Sea Level (PSMSL): https://psmsl.org/data/obtaining/.

Question 4: How reliable is the sea level measurement from a satellite altimeter along the coastline considering the degrading signal close to the coastline? What precautions should I take when using the data?
Answer 4: Satellite radar altimetry measurements of ocean height that are close to the coastline can be corrupted by land. This happens when there is land within the radar "footprint", which can be several tens of kilometers in size. In NASA's global, gridded data products of ocean height, these measurements are ignored and not used in the creation of the data products.

Question 5: Are projected tide gauge datasets directly available for download; and if so, through what platforms (e.g., NASA GitHub)?
Answer 5: Sea level at a specific location can be searched for using the Sea Level Explorer landing page: https://earth.gov/sealevel/sea-level-explorer/, by selecting the desired location from the drop down menu. Use the "Data" button with the download icon at the top right of the station page to download the historical and projected datasets. An example for La Jolla, CA is below.



Question 6: Can you add Guam to the Pacific Flooding Analysis Tool? I see you have Saipan, Commonwealth of the Northern Mariana Islands (CNMI).
Answer 6: Working with the University of Hawaii Sea Level Center, the NASA Sea Level Change Team hopes to expand the Pacific Flooding Analysis Tool, but this is dependent on sustained funding levels by the US federal government. Please continue to check this tool in the future to see whether new locations have been added.

Question 7: With sea level rise, would there be any negative impact on coastal communities whose main economic activity is fishing?

Answer 7: There is potential for sea level rise to impact a fishing economy through coastal infrastructure impacts and shifting marine habitats. These impacts are tightly coupled to changing storm intensity and ocean warming patterns that can change the boundaries of marine ecosystems.

Question 8: Is it possible to retrieve sea level data for a specific location on Sea Level Explorer?

Answer 8: Yes, the Sea Level Explorer tool provides historical and projected sea level change for specific cities and countries. The NASA gridded sea level data is available globally and can be used to assess the differences between the specified locations within the explorer and the location of interest by analyzing the nearest grid points.

Question 9: Has the East Antarctic Ice Sheet been losing ice mass in the last two decades? If yes, then at what rate?

Answer 9: According to the study by Smith et al. (2020), the East Antarctic Ice Sheet has actually gained mass at a rate of about 90 gigatonnes per year over the 2003-2019 time period. This is equivalent to a sea level drop of 4 mm over this time. But the mass loss across the rest of the Antarctic Ice Sheet, including the West Antarctic Ice Sheet and the Peninsula, has outweighed the gains in East Antarctica. The entire Antarctic Ice Sheet (East, West, and Peninsula) has lost 118 gigatonnes per year and has contributed 5.2 mm to sea level rise over 2003-2019.

Question 10: If we talk particularly about the Antarctic Ice Sheet, then does the choice of ice density matter in evaluating mass balance? Do we need to take different snow density values if we want to calculate the accurate mass balance using radar altimeters?

Answer 10: This is a great question and points to a very active research topic. To convert altimeter measurements into mass, we need to know the density of the material underneath the altimetry measurements. This can be complicated and lead to uncertainty. We rely on ground based data and models to estimate density but because the Antarctic Ice Sheet is so remote and so large, the ground based data is sparse. A recent study by Medley et al. (2022) is a good starting point for learning more about this topic.

Question 11: The panelists emphasize the combination of altimetry and tide gauge data in measuring sea level rise. How is this done in areas with no tide gauges? For instance, the entire West African coastline has just five tide gauges.

Answer 11: In places where there are no tide gauges, it is necessary to rely on satellite measurements. For the most part, tide gauges and altimetry observations agree on sea level change magnitudes, rates, and acceleration, with the exception of locations where there is large vertical land motion.

Question 12: I visited the NASA Sea Surface Height (SSH) website. There are different SSH products on the site. Could you please explain the dataset and which is most appropriate to monitor absolute sea level?
Answer 12: A good starting point is the latest Level 4 gridded dataset produced by the NASA Jet Propulsion Laboratory: NASA-SSH Simple Gridded Sea Surface Height from Standardized Reference Missions Only Version 1. This dataset provides a measurement of geocentric sea level from satellite altimetry, which is a measure of the height of the sea surface relative to the center of mass of the Earth. This dataset is used within the Sea Level Explorer tool that was presented in the training.

Question 13: Is sea level rise unavoidable? The last three decades record shows that the sea level is steadily rising. Though the scientific community is trying hard to give awareness to world leaders, nothing is working out significantly to reduce global warming.
Answer 13: While there is inertia within the climate system that will lead to prolonged changes in sea level, decreasing future greenhouse gas emissions can reduce the amount and rate of global sea level rise, and we will discuss this in more detail during Part 2, next week.

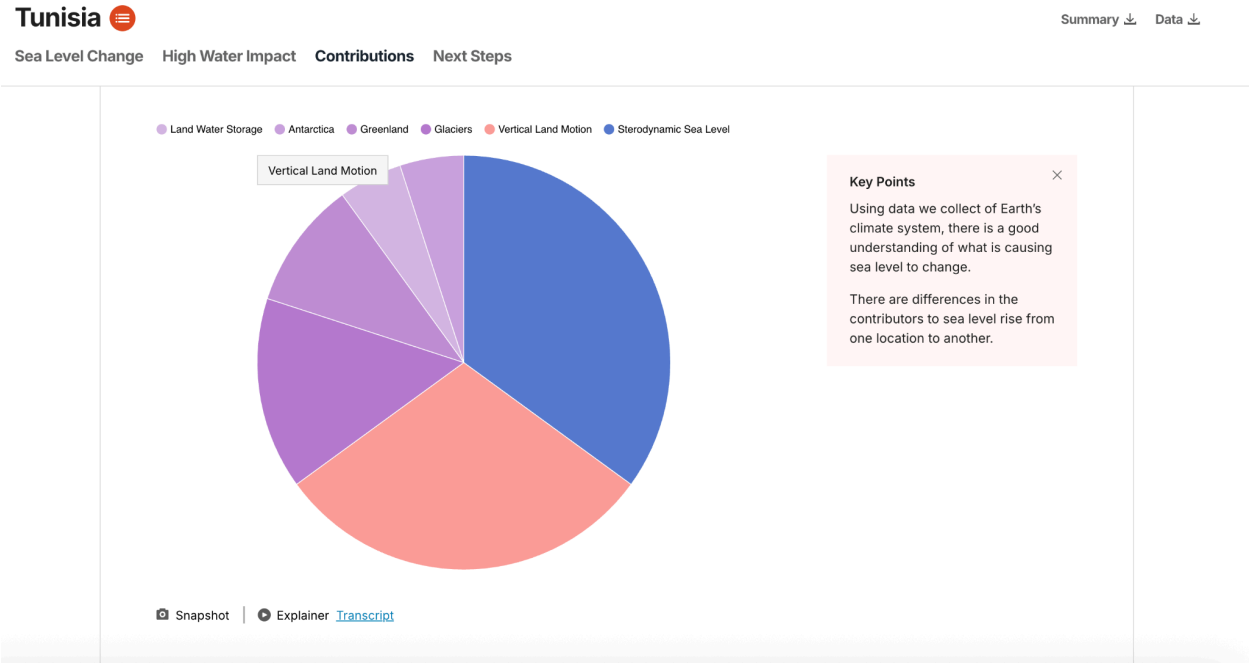
Question 14: How is El Niño Southern Oscillation (ENSO) incorporated into regional sea level rise (SLR) projections, particularly in the Pacific? During consecutive La Niña years, SLR is higher than average in the Western Pacific.
Answer 14: The projections are based on climate models that do represent ENSO. However, the projection itself is based on an ensemble which averages out the ENSO variations. Thus, the projection should be considered as separate from the interannual variability that will enhance or depress any given projection value.

Question 15: On Sea Level Explorer I saw data from Rio de Janeiro and Cananéia only. Is it to be expected for NASA to include data from other cities and regions? What are the criteria for this available data?

Answer 15: The cities included are currently tied to the availability of a long-term tide gauge record to capture past flooding events. In the future, we will work to expand out to other locations and include more cities by incorporating other sources of data.

Question 16: How do you search specifically for sea level change due to Antarctic and Greenland ice sheets using the sea level change tools?

Answer 16: This can be found in the "Contributions" tab for a given location. As an example, here is the breakdown of contributions for Tunisia:



Question 17: Do we have any datasets for lake water level changes as well?

Answer 17: Here are two NASA satellite datasets that provide measurements of lake water levels and changes:

1. Surface Water and Ocean Topography (SWOT) Mission: https://podaac.jpl.nasa.gov/dataset/SWOT_L2_HR_LakeAvg_D
2. Ice, Cloud and land Elevation Satellite 2 (ICESat-2) Mission: Along Track Inland Surface Water Data (ATL13) and Mean Inland Surface Water Data (ATL22)

Question 18: Can the Sea Level Explorer site be used to map spatially for a specific area, such as how much area is submerged over certain areas? Or can we do searches for a specific jurisdiction, i.e., individual islands of the Caribbean?

Answer 18: The Sea Level Explorer tool only provides site-specific projections as time series', not spatially varying inundation mapping.

Question 19: How will regional sea level rise vary over the next 100 years due to the combined effects of melting polar ice sheets, ocean currents, land movements, and climate feedback—and how can we accurately model and prepare for these changes?
Answer 19: The sea level value will vary regionally, as explained in the training.

Question 20: Is there evidence from the imagery where populations are being threatened or displaced in the Americas?
Answer 20: This is not a quantity that is observed by the satellites discussed in this training.

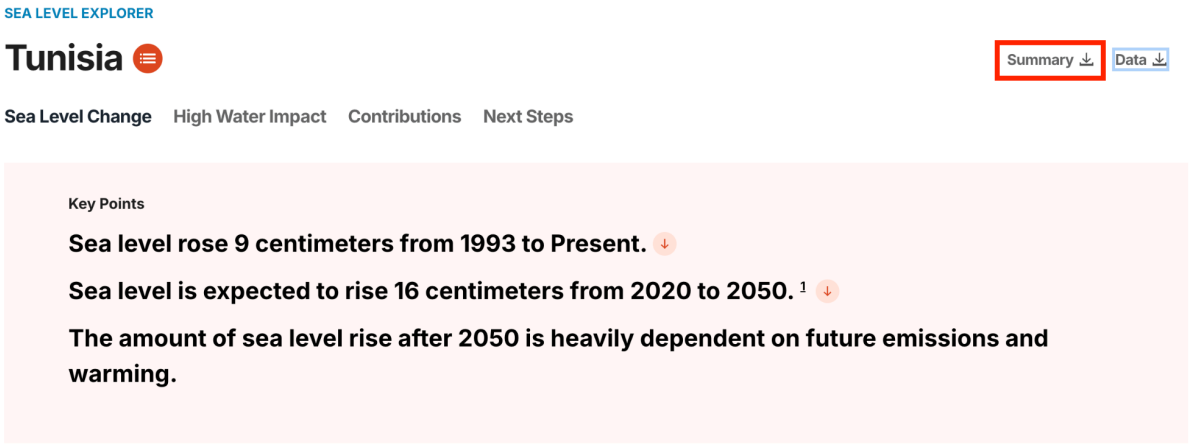
Question 21: What measures are being considered to improve tide gauge coverage in under-equipped regions, such as West Africa, to ensure more reliable sea level rise data? To what extent do regional sea level rise projections incorporate the socio-economic dynamics of coastal communities, especially those that rely on artisanal fishing?
Answer 21: Tide gauge installations are driven by a variety of factors including funding and capacity to maintain the instrumentation. The University of Hawaii Sea Level Center works with a variety of organizations to help facilitate this and is among many other partners who seek to deliver water level information.

Socio-economic dynamics are incorporated into projected emissions scenarios that are used by climate models to simulate future atmospheric and oceanic warming (see Part 2 of the training for more information on this). The projections themselves are a purely physical representation of the Earth System's response to the given level of greenhouse gas concentration within each forcing scenario.

Question 22: Does sea level change affect the quantity and quality of freshwater (rivers/lakes)?
Answer 22: Typically lakes are isolated from the impacts of sea level rise. However saltwater intrusion, both above- and below-ground is a concern for coastal freshwater bodies. The landward migration of the saltwedge within estuaries and their associated rivers is an active area of research, as is the salinization of coastal groundwater reservoirs.

Question 23: To calibrate these kinds of tools I always look to some known point where I know there are high tides that are not so known like in Gabes, Tunisia, because it is a place in the Mediterranean that has higher changes. If it is included, I can trust the data. If it is missing, I will not consider it as a well informed tool, just that general data are there. I found Gabes missing in the tool. How are specific locations included?

Answer 23: The Global Sea Level Explorer aggregates information by country or other geographic region and does not directly display data from specific tide gauges. However, data from the tide gauge in Gabes, Tunisia is used to inform the information presented. Use the “Summary” button in the Global Sea Level Explorer to see more information:



Question 24: How are the measurements done when tsunami waves affect tide gauge locations?

Answer 24: The spatial scales of tsunami waves are large, and therefore, their signal is detectable far away from their break point. Thus, even if one or more tide gauges in the vicinity of a tsunami is lost, there are ways to utilize distant tide gauge observations to corroborate the event characteristics with known mathematical representations of the wave’s propagation.

Question 25: Can AI be used in measuring sea level in the Sundarban region of India to protect coastal ecosystems and biodiversity? Is there any data in this regard?

Answer 25: AI cannot measure sea level. However, machine learning techniques to understand future sea level rise and its physical impacts are being developed, and this is an active area of research.

Question 26: What will be the probable impact of sea level rise on mangrove ecosystems?
Answer 26: This is an active area of research but key factors in this discussion include the migration of sedimentation patterns and higher salinity values from offshore to onshore, as well as the impact of storm processes on the plant structures as the water level rises.

Liang, X., Dai, Z., Mei, X., Wang, R., Zeng, W., & Fagherazzi, S. (2025). Hurricanes induced irreversible large-scale loss of mangrove forests. Geophysical Research Letters, 52, e2025GL115692. https://doi.org/10.1029/2025GL115692

Question 27: If we measure snow density using a snow fork instrument in some parts of Antarctic Ice Sheet, when used to calculate mass balance it gives different values (for example, a snow density of 917 kg/m3 will give more mass balance value compared to in-situ density taken as approx. 300 kg/m3). So, can we do a sensitivity analysis of mass balance by using different density values over the AIS?
Answer 27: This is a great question and points to a very active research topic. To convert altimeter measurements into mass, we need to know the density of the material underneath the altimetry measurements. This can be complicated and lead to uncertainty. We rely on ground based data and models to estimate density but because the Antarctic Ice Sheet is so remote and so large, the ground based data is sparse. A recent study by Medley et al. (2022) is a good starting point for learning more about this topic.

Question 28: To which benchmark the ocean measurement is done? Regardless of the means.
Answer 28: Within the Global Sea Level Explorer's High Water Impact section, for each location, the value of mean-higher-high-water (MHHW) is computed over the period from 1983-2001. A day with high water is counted if the daily maximum sea level exceeds MHHW plus 40 cm (minor), 60 cm (moderate), or 80 cm (major). It should be noted that an exceedance of these thresholds does not necessarily indicate a

noticeable and impactful flood. Exceedances of such thresholds are useful for tracking changes over time, however.

Satellite observations of sea level are reported relative to reference surfaces, such as the geoid or mean sea surface. It is important to understand which surface the sea surface height anomaly is relative to due to the fact that there are many different versions of these surfaces and they are regularly updated as more data becomes available to determine them.

Part 1 Questions & Answers Session B

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Sean McCartney (sean.mccartney@nasa.gov) or Denis Felikson (denis.felikson@nasa.gov).

Question 1: I am working on a coastal vulnerability index (CVI). I want to add geotechnical variables into CVI. How can I add shoreline changes into QGIS?
Answer 1: There are a number of variables that you might want to consider. In order to provide more pointed guidance, we would need to know what metrics are of interest to the index.

Question 2: What are impacts of sea level rise on estuaries or fish nursery habitats?
Answer 2: Estuarine habitats are typically exposed to tidal fluctuations and are often bound by wetlands which can regularly be inundated. However, as sea level rises the zonation of various flora and fauna that live along or within the estuary can shift in response to changing salinity gradients that can migrate landward with higher mean sea level.

Question 3: I wish to know how to download data provided by Sea Level Explorer in GeoTIFF format at the local level in order to perform analysis in QGIS.

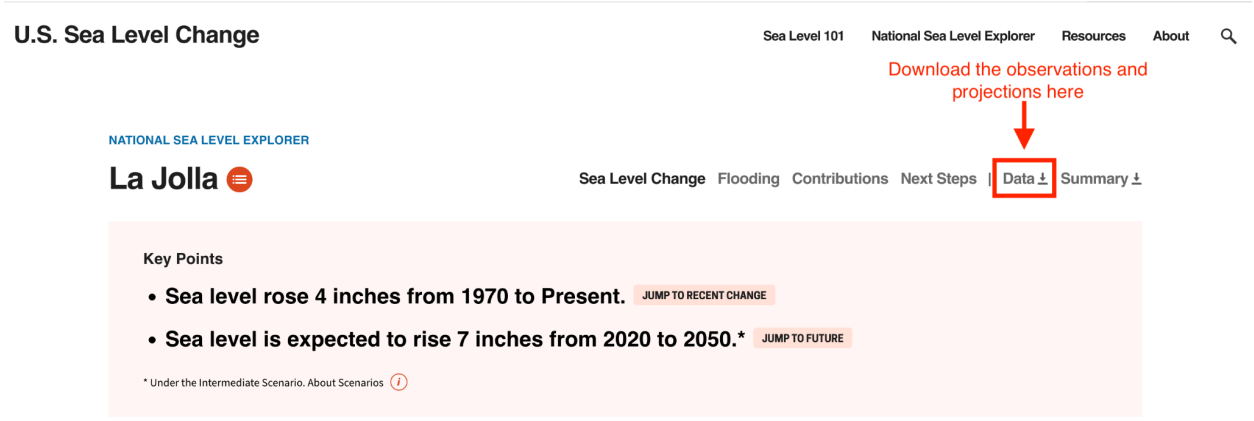
Answer 3: The data shown within the Sea Level Explorer is provided as figure images and as Excel files for download at the top right of the station page. The historical data and projections are provided in a tabular format (i.e., time series'), not a spatially varying format, and are therefore not suitable for GIS.

Question 4: How can I download the sea level data for a country?
Answer 4: Sea level for a specific country can be searched for using the explorer landing page: https://earth.gov/sealevel/sea-level-explorer/, by selecting the drop down menu. Use the "Data" button at the top right to download the data.

Question 5: How can we relate sea level changes to coastline variations from the perspective of remote sensing?
Answer 5: This training is focused on sea level specifically, but there are satellites that observe changes in coastal geomorphology, such as NASA's upcoming mission NISAR.

Question 6: I also want to know if the collection of sea level rise data is available in the Google Earth Engine (GEE) platform and how to get the script.
Answer 6: GEE determines which data they pull into their system and NASA does not provide specific GEE services. You can contact GEE for support or to request that datasets be added to their catalog from the NASA archives.

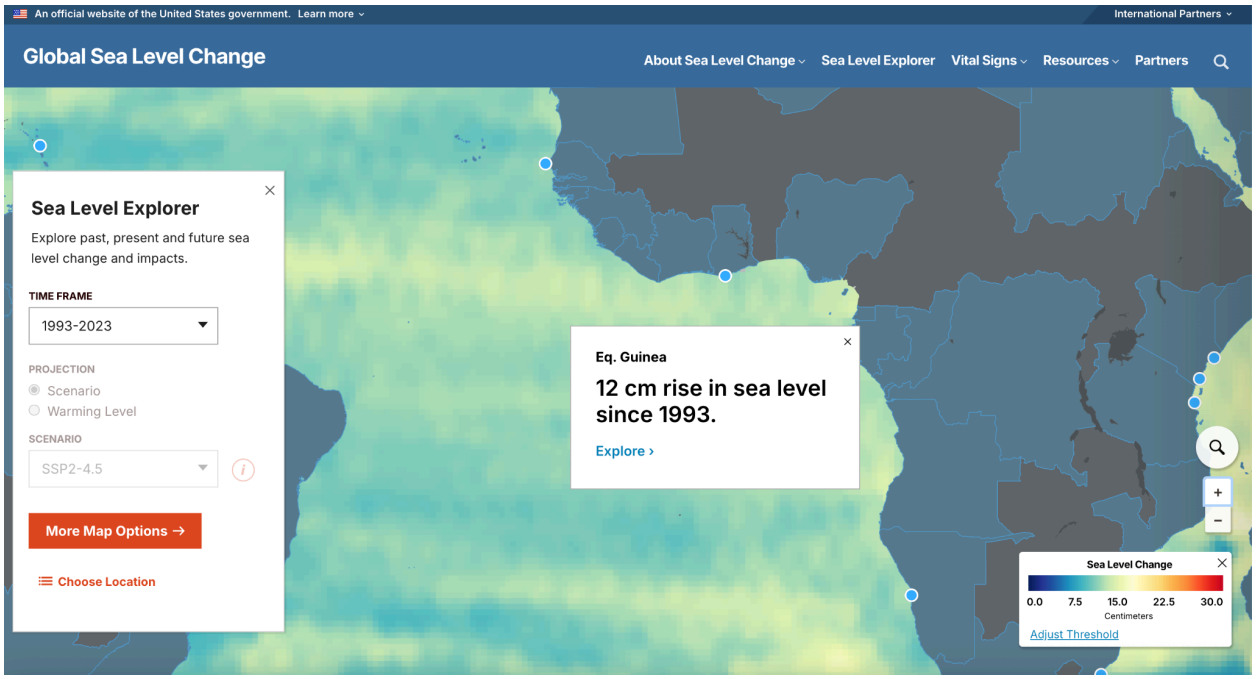
Question 7: Could it be possible to have a short, step-by-step presentation to download data in GeoTIFF and CSV format in the Sea Level Explorer tool? I insist because I face difficulties downloading data.
Answer 7: The CSV can be downloaded using the "Data" button in the top right corner of the station page. The button has a download icon and is right next to the "Summary" button.



Question 8: Since the Sea Level Explorer provides future projections, is there still value in using machine learning to predict sea level rise for a specific country?
Answer 8: Yes. Projections are typically from one of two methods. One method, physical process models are used to simulate changes of all contributors of sea level change – numerical models that can be expensive. Another method is more rooted in observations and uses machine learning techniques from satellite observations and projects out decades. Typically, those machine learning methods do not project out as far, but both are effective and we can learn different things from using both methods.

Question 9: At what threshold, if any, does local ocean depth and the temperature in the water column contribute to local sea level rise?
Answer 9: This is a bit complex. Ocean heat content varies from place to place and depends more on the depth of the thermocline (or the depth of the warmest upper layer), than the total water column depth. Additionally, the salinity value over the water column also contributes to the water mass's density. Together, they determine the steric height of the water column at any given location.

Question 10: I am from Cameroon, and looking at the countries where sea level data is contextualized, I do not see Cameroon among the list of Countries. Which proxy location could be ideal for me? Ivory Coast or Equatorial Guinea?
Answer 10: We suggest using the Equatorial Guinea site as a proxy. From the map view of the Sea Level Explorer:



Question 11: If I want to plot the data in GIS, how can I do that? For Suriname, there is only data for the whole country.

Answer 11: See questions 3 and 7. And yes, for Suriname the data is for the whole country. You can see the EEZ averaging area in the Sea Level Summary for Suriname.

Question 12: How is sea level rise related to coastal groundwater salinization? How much does it impact it? And how can that be assessed?

Answer 12: This is a complex question and depends on several factors including freshwater recharge and the hydraulic conductivity of the region of interest. Please see Adams et al. (2024) for more information:

Adams, K. H., Reager, J. T., Buzzanga, B. A., David, C. H., Sawyer, A. H., & Hamlington, B. D. (2024). Climate-induced saltwater intrusion in 2100: Recharge-driven severity, sea level-driven prevalence. Geophysical Research Letters, 51, e2024GL110359. https://doi.org/10.1029/2024GL110359.