

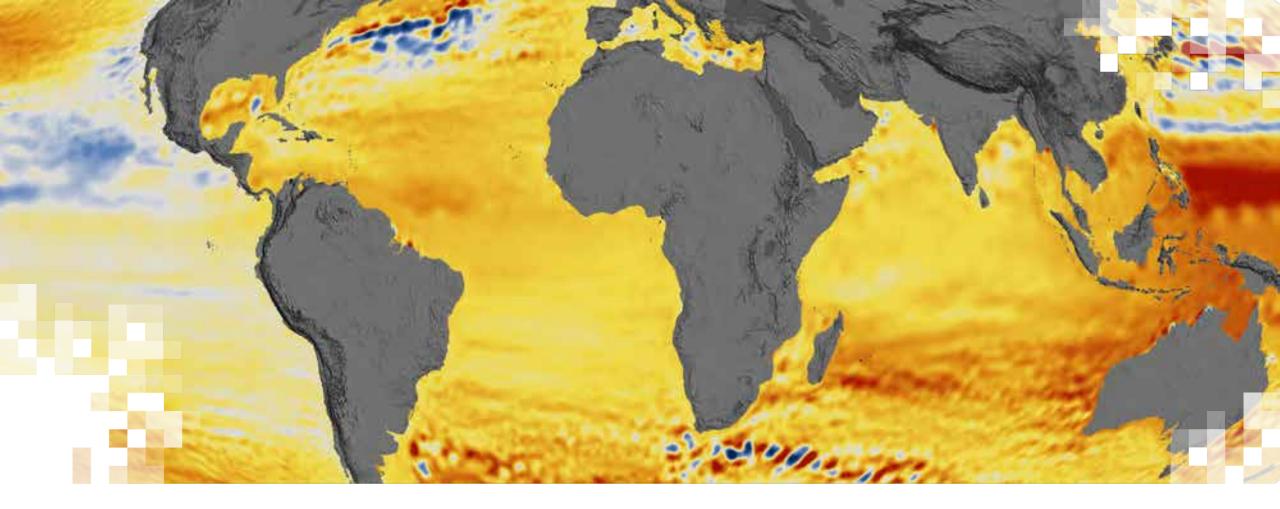


Sea-Level Change Tools for Planning and Decision Support

Part 1: Overview of Sea Level Change – Regional to Global

Angelica Rodriguez (NASA JPL/Caltech), Denis Felikson (NASA GSFC), & Sean McCartney (NASA GSFC/SSAI)

June 10, 2025



About ARSET

## About ARSET

- ARSET provides accessible, relevant, and costfree training on remote sensing satellites, sensors, methods, and tools.
- Trainings include a variety of applications of satellite data and are tailored to audiences with a variety of experience levels.









DISASTERS





**HEALTH & AIR QUALITY** 

WATER RESOURCES

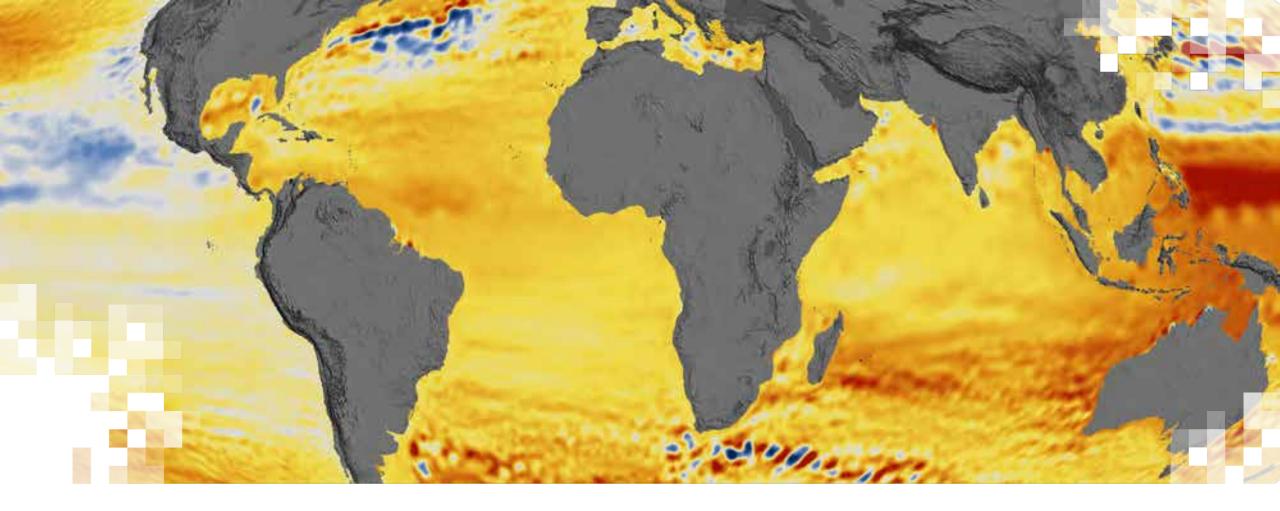


## **About ARSET Trainings**

- Online or in-person
- Live and instructor-led or asynchronous and self-paced
- Cost-free
- Bilingual and multilingual options
- Only use open-source software and data
- Accommodate differing levels of expertise
- Visit the <u>ARSET website</u> to learn more.







## Sea-Level Change Tools for Planning and Decision Support Overview

### **Overview**

- Earth's seas are rising because of a changing climate, and this rate is projected to increase over the next century.
- Due to the warming atmosphere and ocean, ice sheets and mountain glaciers are melting, resulting in the addition of fresh water into the ocean.
- Ocean water expands as it absorbs trapped heat, causing sea levels to rise.
- Data on this increase in the rate of global sea level rise is critical to planners understanding the trajectory of future sea level rise.



Credit: Chris Larsen, NASA's Operation IceBridge mission

## **Training Learning Objectives**



By the end of this training, participants will be able to:

- Identify underlying Earth processes contributing to relative sea-level change at global and regional scales.
- Recognize remote sensing and modeled data used for assessing sea level change on a regional to global scale.
- Describe how coastal communities and infrastructure can be impacted by flooding caused by sea level change.
- Demonstrate how to assess the processes contributing to past and future sea-level change with the Sea Level Explorer tool-at global and regional scales.
- Demonstrate how to access future projections of relative sea-level change under different emissions scenarios with the IPCC AR6 Projection Tool.
- Visualize oceanic and groundwater flooding maps with the Pacific Islands Flooding Tool.



## **Training Outline**





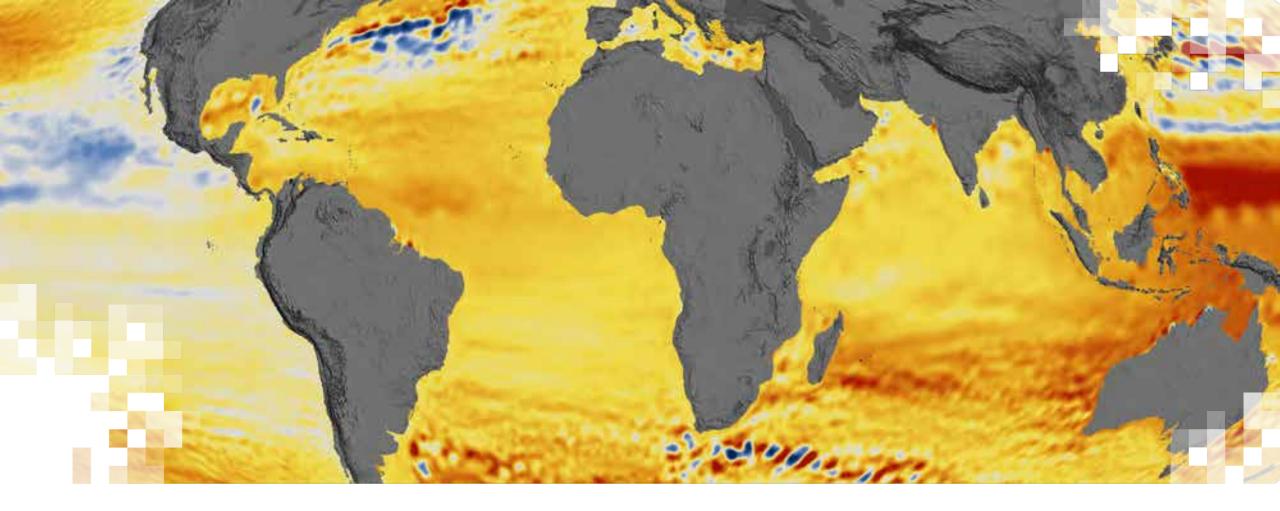
### Homework

Opens June 17 - Due July 1 - posted on training webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment before the given due date.

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Sea-Level Change Tools for Planning and Decision Support Part 1: Overview of Sea Level Change – Regional to Global

## Part 1 Objectives

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By the end of Part 1, participants will be able to:

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- Describe how coastal communities and infrastructure can be impacted by flooding caused by sea level change.
- Demonstrate how to assess the processes contributing to past and future sea-level change with the Sea Level Explorer tool-at global and regional scales.



## **Review of Prior Knowledge**

- Satellite **radar altimetry** is a form of active remote sensing that measures the altitude of a surface from orbit by emitting **radar pulses** and measuring the time it takes for those pulses to return after reflecting off the surface.
- Satellite **laser altimetry** is a form of active remote sensing that measures the altitude of a surface from orbit by emitting **laser pulses** and measuring the time it takes for the reflected pulses to return.
- Subtle shifts in Earth's gravity occur, primarily dominated by water movements from one place to another on and under land, in the ocean, and in the atmosphere.
- Satellite gravimetry is a form of active remote sensing which uses a microwave ranging system, where satellites that follow each other closely in orbit send microwave signals to each other to measure the distance between them. From distance measurements between the two satellites, data can be used to estimate Earth's gravity field to monitor changes in underground and surface water storage, soil moisture, ice sheets and glaciers, and sea level caused by the addition of water to the ocean.



## How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.



Credit: Your Name In Landsat



### Part 1 – Trainers

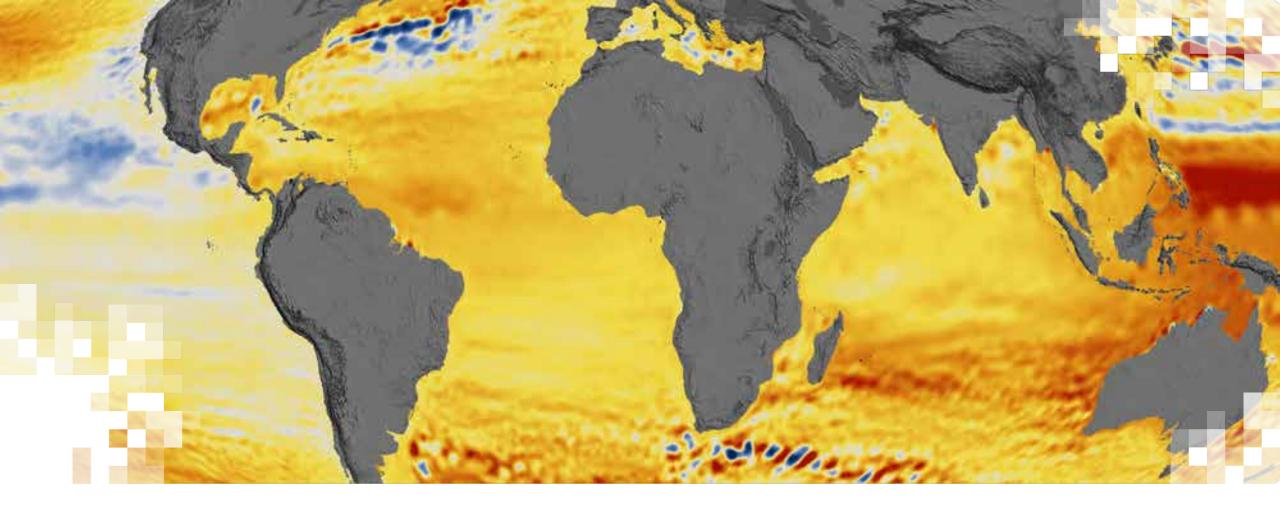
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Dr. Angelica Rodriguez Research Scientist NASA JPL/Caltech



**Dr. Denis Felikson** Research Scientist NASA GSFC





## Sea-Level Change Overview

Angelica Rodriguez, PhD NASA Jet Propulsion Laboratory

## Sea Level Change – A Global Phenomenon

## ВВС

### Sea level rise

<sup>7 Feb 2025</sup> 'We left pieces of our life behind': Indigenous group flees drowning island

Rising sea levels threaten homes in Panama, but not everyone wants to leave.



Latin America

- Coastal communities world-wide are grappling with changes occurring along the interface between the ocean and society.
- Media coverage on the topic is vast, as leaders
  from smallest of seaside towns to the global stage are faced with decisions on how best to respond.



#### BBC News - Sea Level

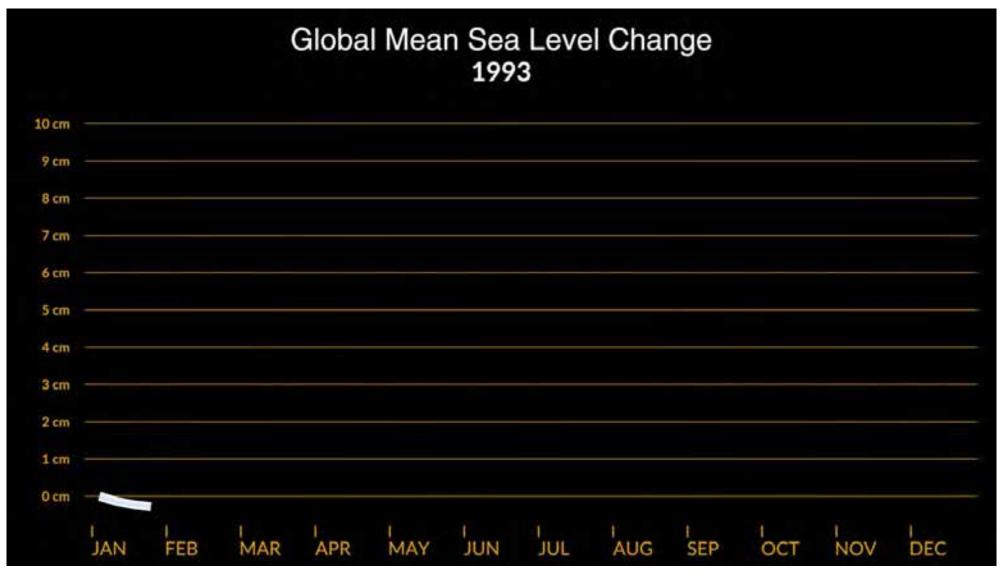


## What exactly is happening?

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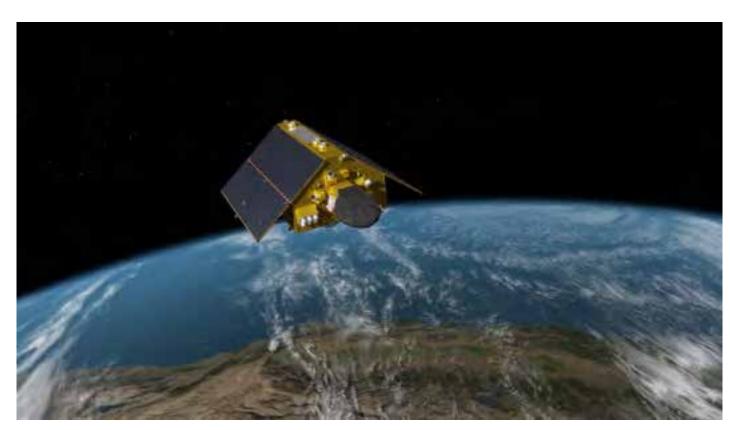


## The Average Height of Global Ocean is Increasing Year Over Year





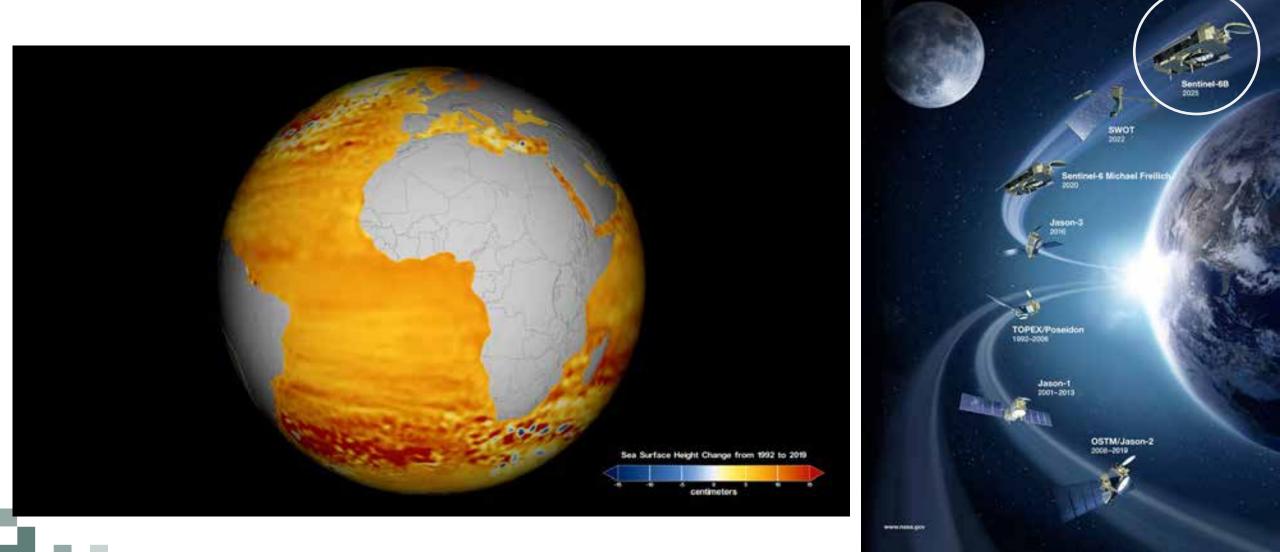
## NASA Satellites Observe the Ocean's Surface Topography, or Sea Level



- Ocean topography satellites transmit radar pulses directly downwards (at nadir) and measures the time it takes for the pulse to reflect off the surface and return to the satellite, essentially measuring the range to the closest point on the surface within a relatively large footprint.
- Data is collected along a narrow strip directly beneath the satellite.
- Radar altimetry provides a measurement of absolute, or geocentric, sea level.



## Sea Level is Increasing Globally and Regionally

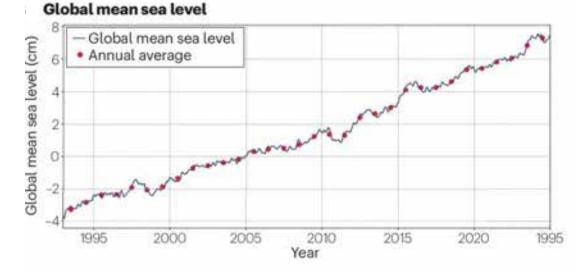




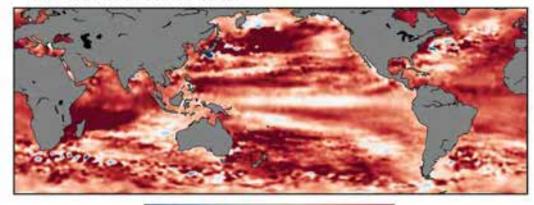
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## Global Sea Level Rose 0.59cm in 2024 Relative to 2023, Reaching a Total Increase of 10.5 cm Over the 31-Year Satellite Record

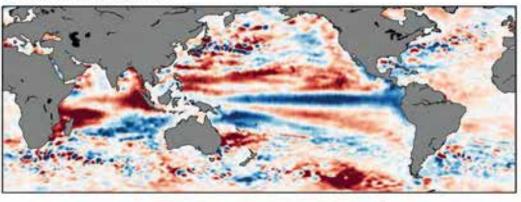


2024 relative to 1992-2023



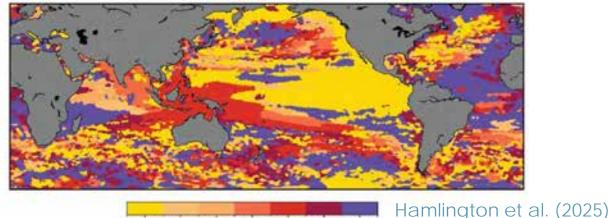
-10.0 -7.5 -5.0 -2.5 0.0 2.5 5.0 7.5 10.0 Sea level change (cm)

#### 2024 relative to 2023



-10.0 -7.5 -5.0 -2.5 0.0 2.5 5.0 7.5 10.0 Sea level change (cm)

Year of highest annual sea level



<=2018 2019 2020 2021 2022 2023 2024 Year





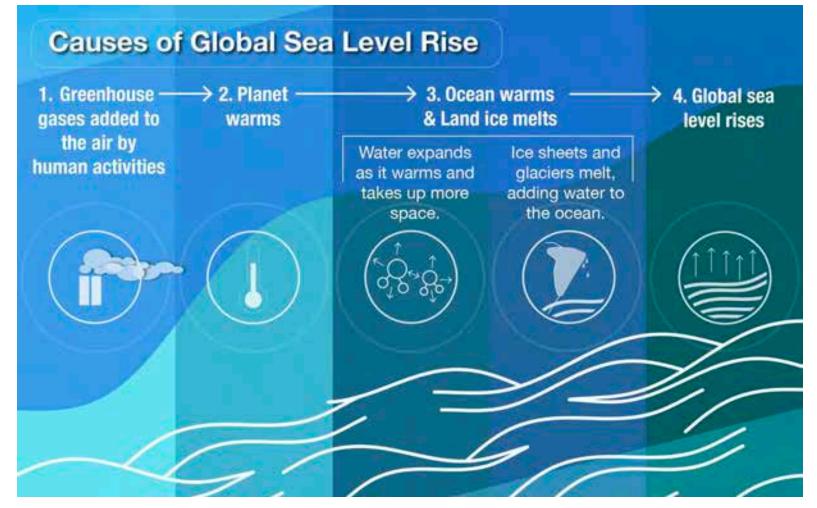
## Will this continue? To answer that, we need to know what is causing the observed acceleration in sea level rise.



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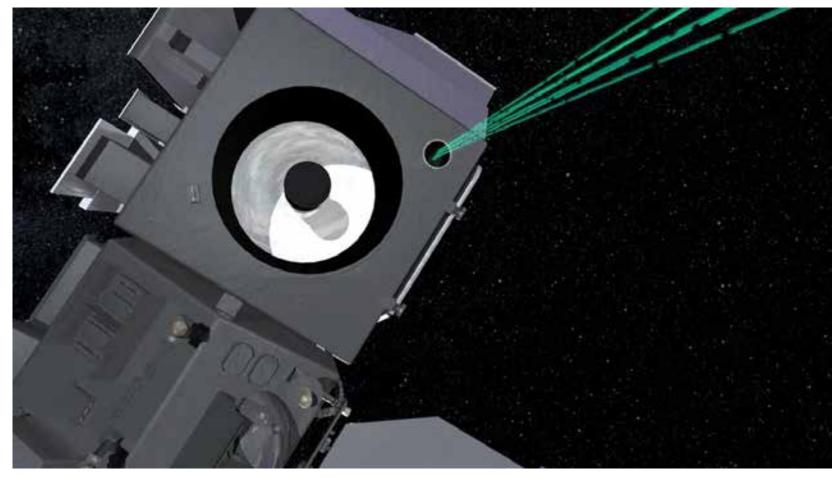
## In the Global Average, there are Two Main Processes that are Causing Sea Level to Rise



Changes in terrestrial water storage, or how much freshwater is transferred from land to the ocean, also influence global sea level change but in a smaller percentage.

## NASA Measures Ice Sheet Change Using Satellite Laser Altimetry

- NASA's ICESat-2 mission continues key elevation observations begun by the original ICESat satellite (2003 to 2009) and Operation IceBridge (2009 through present).
- A multiple-beam laser sends 10,000 pulses of light to the ground each second. A small fraction of the light photons bounce off Earth's surface and return to the instrument, where a photon-counting detector times their flight.



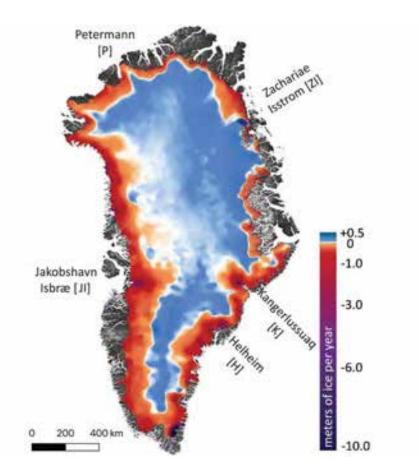
• Similar to radar altimetry, ICESat-2 provides a measurement of the Earth surface elevation below.

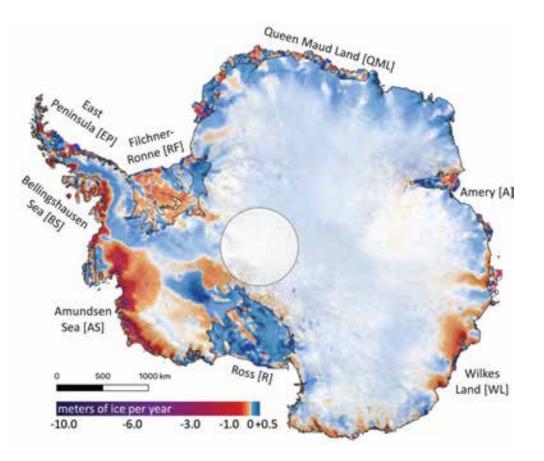
NASA Scientific Visualization Studio



## NASA Measures Ice Sheet Change Using Satellite Laser Altimetry



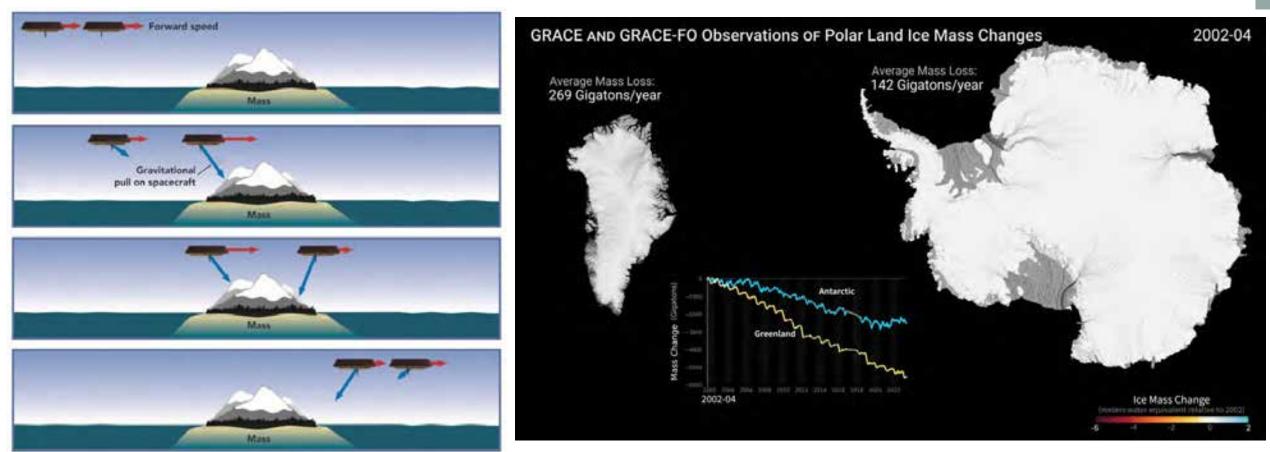




Smith et al. (2020)



## NASA Measures Ice Mass Loss Using Satellite Observations of Earth's Gravity

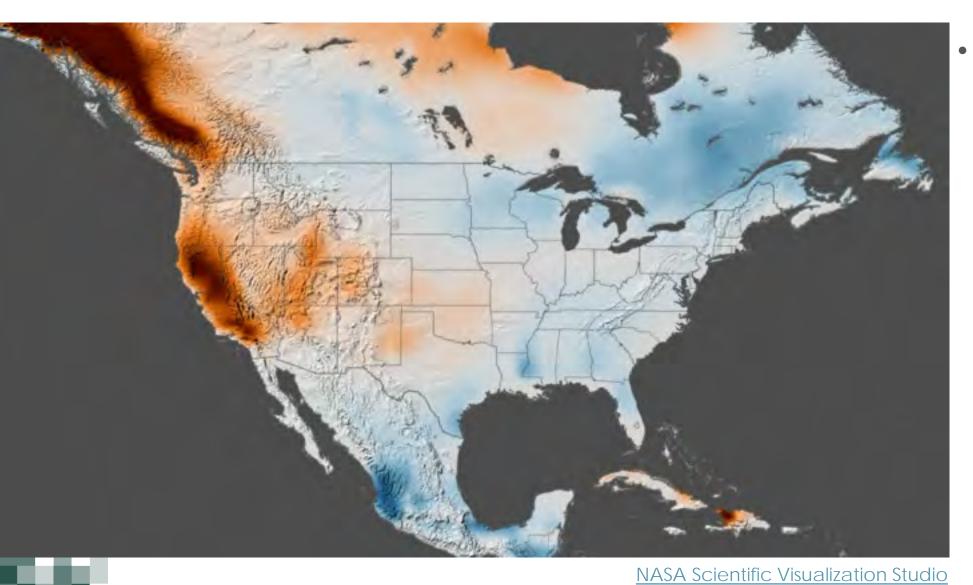


The GRACE-FO mission is a successor to the original GRACE mission (2002–2017). A microwave ranging system detects minuscule changes in the distance between the satellites, which responds to spatial changes in Earth's gravity field. Mapping the gravity field over time provides details on the redistribution of mass across the globe.

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## **GRACE-FO** also Provides Estimates of Land Water Storage

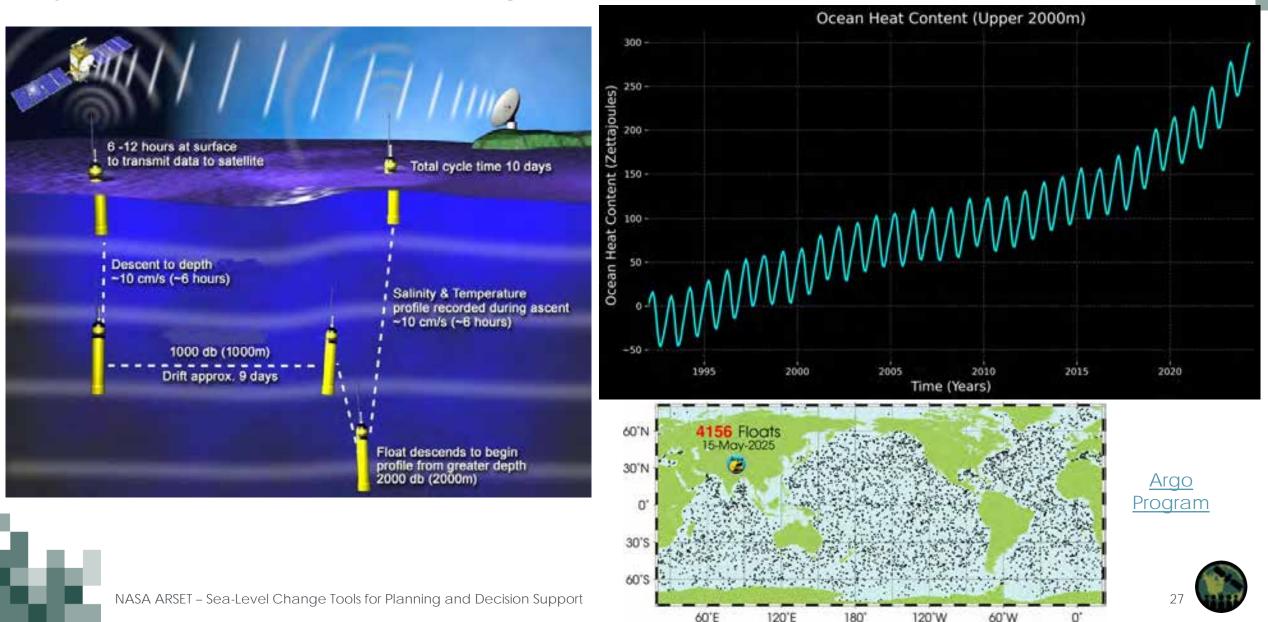


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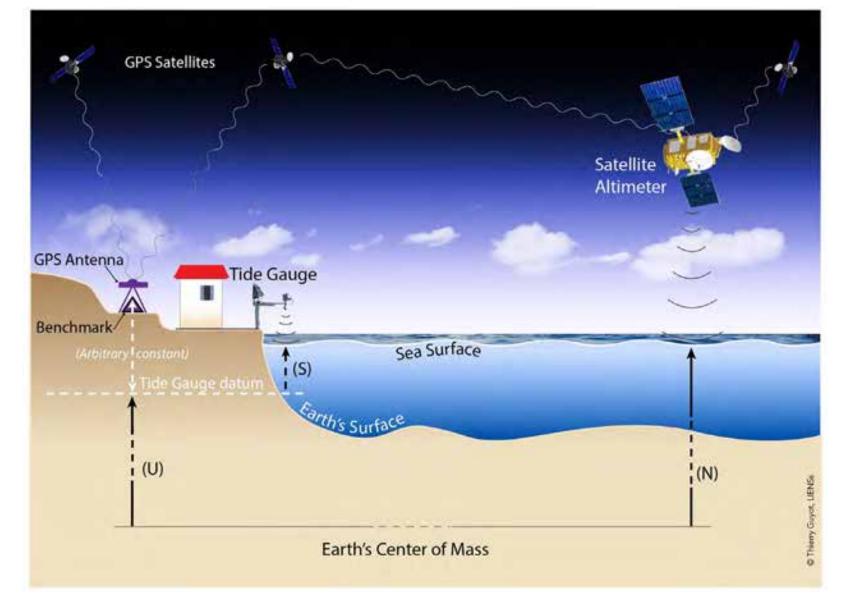
While terrestrial land water storage changes are generally a secondary contributor, in terms of magnitude, to the long-term sea level trend budget, the proper accounting of both human activity and water cycle variability is necessary for accurate sealevel budget closer on various time and space scales.



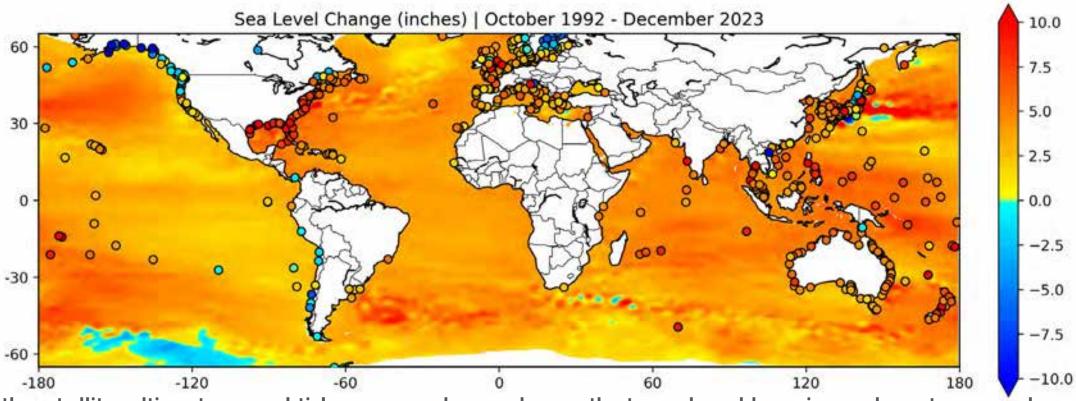
## Ocean Heat Content between the Surface and 2000m Depth is Observed by a Global Network of Profiling Floats



## Tide Gauges also Measure Relative Sea Level



## Different Measurement Systems, Same Conclusion (Mostly)



 Both satellite altimeters and tide gauges have shown that sea level has risen almost everywhere over the last 30 years.

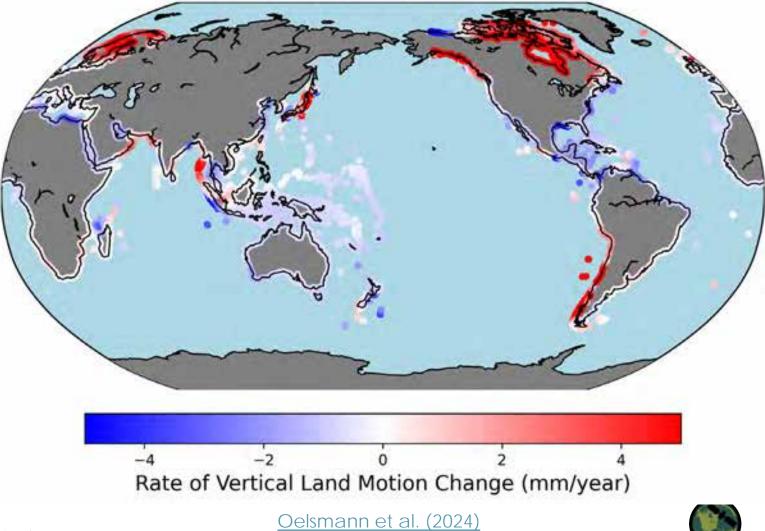
 Satellite altimeters measure only the height of the ocean, while tide gauges measure the sea surface height relative to land. Where the land is moving, we can see big differences in the measurements from satellite altimeters and tide gauges.



## Vertical Land Motion (VLM)

- VLM is caused by a combination of several things:
  - Glacial isostatic adjustment (GIA)
  - Tectonic activity
  - Surface mass loading changes
  - Other localized effects on the compaction or uplift of the land surface (natural or anthropogenic)

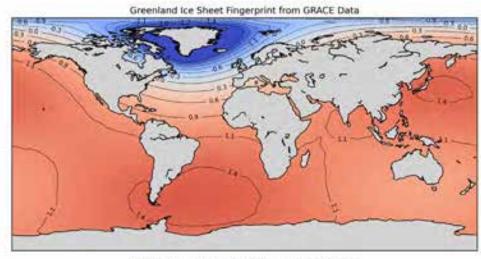
Vertical Land Motion (VLM) from 1995 to 2021



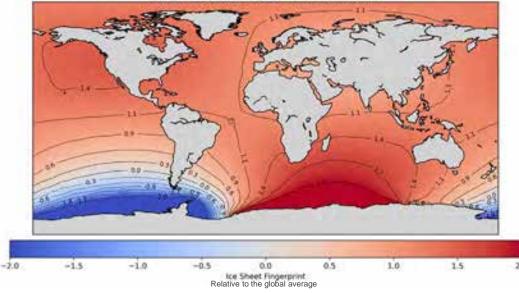
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## Other Factors Affect Local Sea Level As Well – Ice Sheet Fingerprints





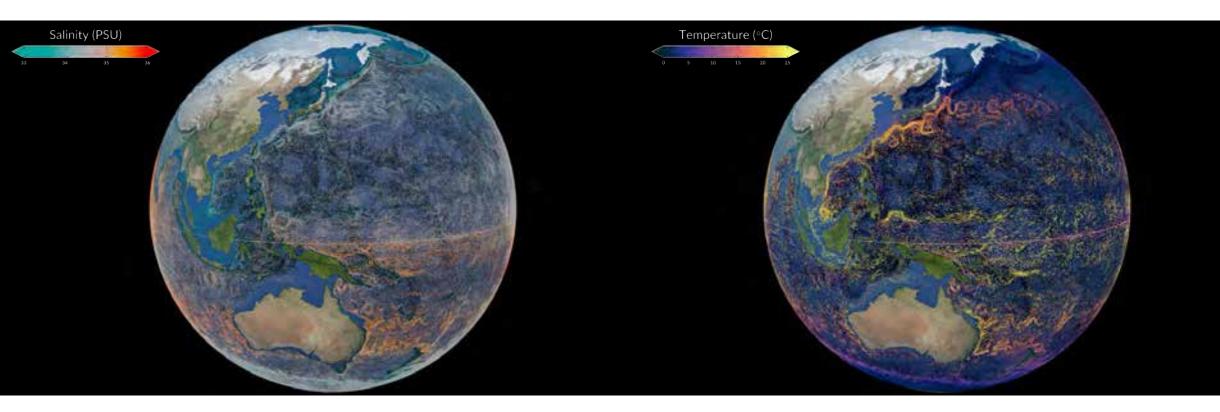
Antarctic Ice Sheet Fingerprint from GRACE Data



- When ice sheets melt, the redistribution of melted water induces changes to the gravity, rotation, and shape of the Earth.
- These patterns are known as ice sheet fingerprints.
- The further away from where ice is melting, the more sea level rise that location will get. Areas that are far away from the Greenland and Antarctic Ice Sheets are most impacted by sea level rise from ice melting.
- The net effect is the combination of the individual ice sheet fingerprints superimposed on the effects of other melting sources.



## Other Factors Affect Local Sea Level As Well – Sterodynamics



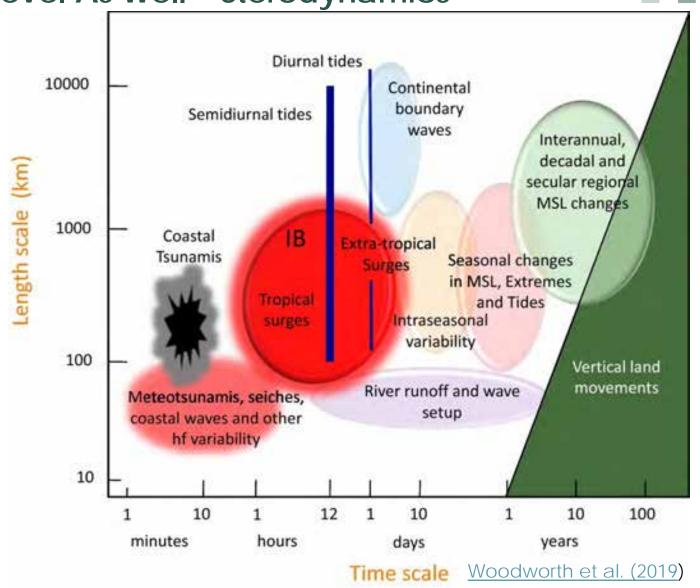
- Steric changes refer to variations in sea level due to changes in the density of seawater, which can be affected by temperature and salinity. These steric changes can lead to regional variations in sea level, as different parts of the ocean experience varying rates of warming and changes in salinity.
- Ocean currents play a crucial role in transporting heat and distributing seawater across the globe.

NASA Scientific Visualization Studio



### Other Factors Affect Local Sea Level As Well – Sterodynamics

• **Dynamic changes** involve the redistribution of water masses due to ocean currents, wind patterns, and atmospheric pressure systems.







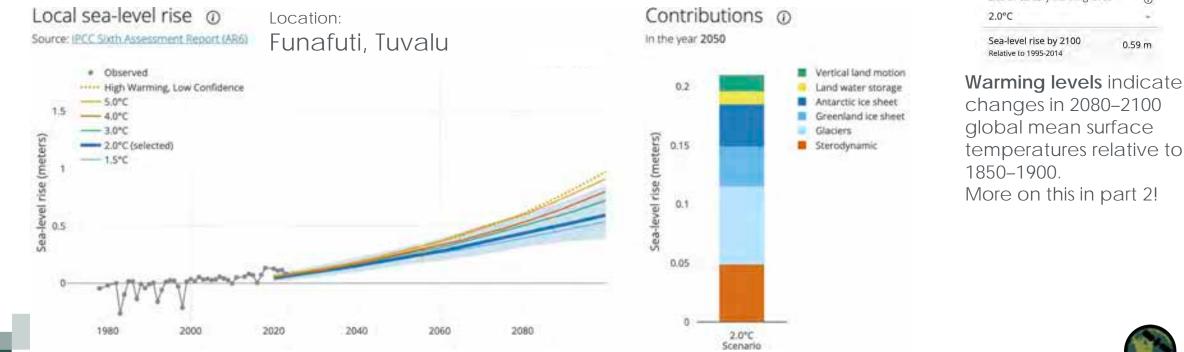
## So how will the average (mean) sea level change in the future?

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## Using Consensus Knowledge of Modeled Physical Processes and Statistics Informed by Data Records, Future Sea Level can be Projected

- The Intergovernmental Panel on Climate Change Sixth Assessment Report (AR6) sea level
  projections are built using comprehensive assessments of a wide range of physical processes
  contributing to future sea level changes. The report integrates results from global climate models
  and specialized research on individual components affecting sea level, such as ice sheet dynamics,
  ocean thermal expansion, glacier melt, and land water storage changes.
- AR6 provides a probabilistic framework that accounts for both well-understood mechanisms and more uncertain aspects of future sea level rise.



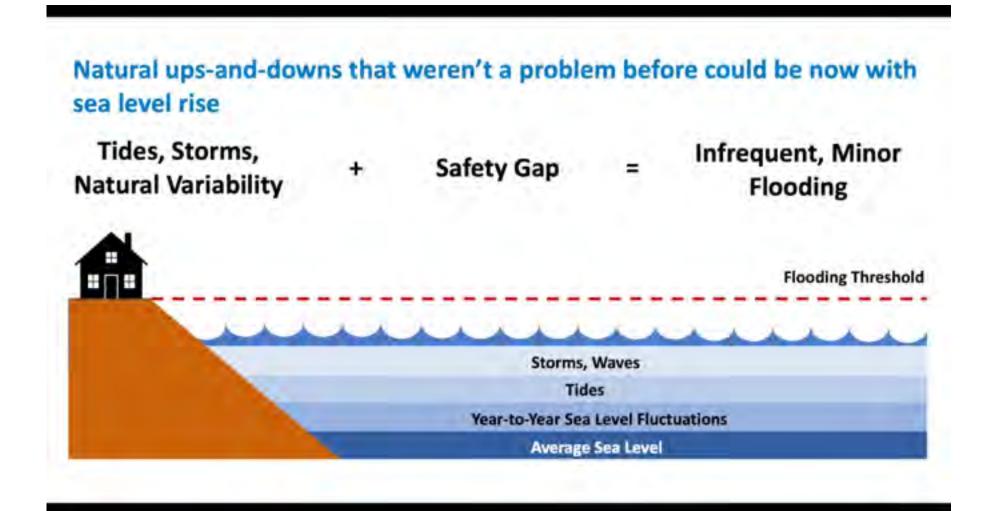


## How will this affect our coasts in the future?



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Dynamic Variations in the Local Sea Level Combine, Resulting in Fluctuations of the Waterline Along a Stretch of Coast



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## **High-Tide Flooding**

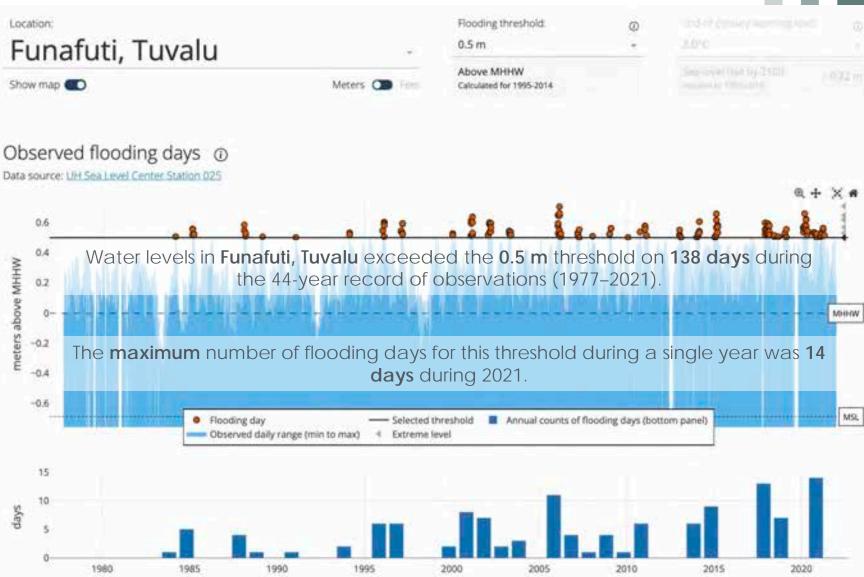
- High tide flooding, sometimes referred to as nuisance flooding, sunnyday flooding, or king tide flooding, refers to inundation occurring at water elevations above the normal high tide level.
- This can be caused by both overflow of oceanic water, as well as upward percolation of the subsurface water table.





## **High-Tide Flooding**

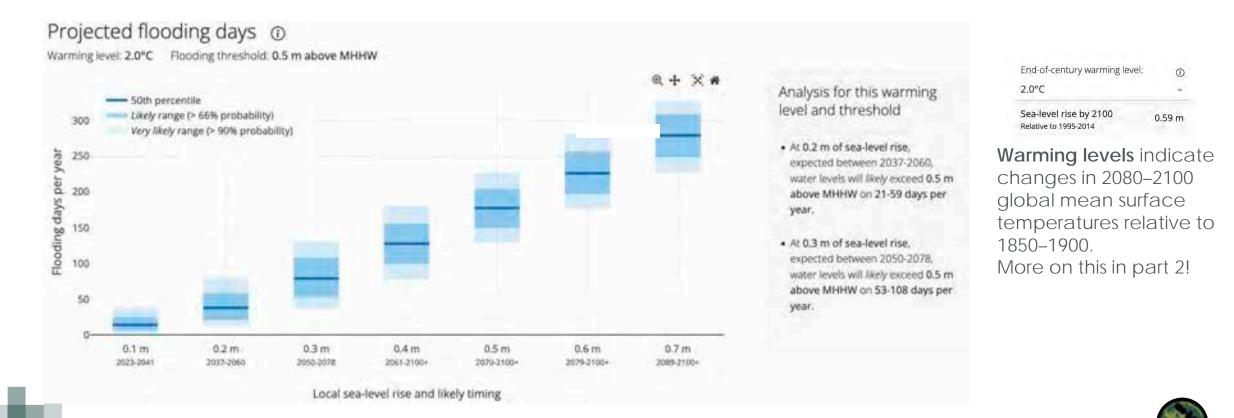
- Tide gauges can give an indication of how severe the flooding may be by providing observations of how much higher the water level was than previously recorded high values.
- In many places around the world, high-tide flooding is occurring more frequently every year.
- Take, for example, the tide gauge at Funafuti, Tuvalu.
- We can use mean sea level projections to project the number of flooding days in the future.





## Using Consensus Knowledge of Modeled Physical Processes and Statistics Informed by Available Data Records, Future Sea Level can be Projected

- Part 2 of this training will go into further details on:
  - AR6 projections of mean sea level
  - How local sea level projections are combined with historical tidal data to determine plausible ranges for the number of high tide flood days per year out to 2100



## Increasing Mean Sea Level can have Far-Reaching Consequences

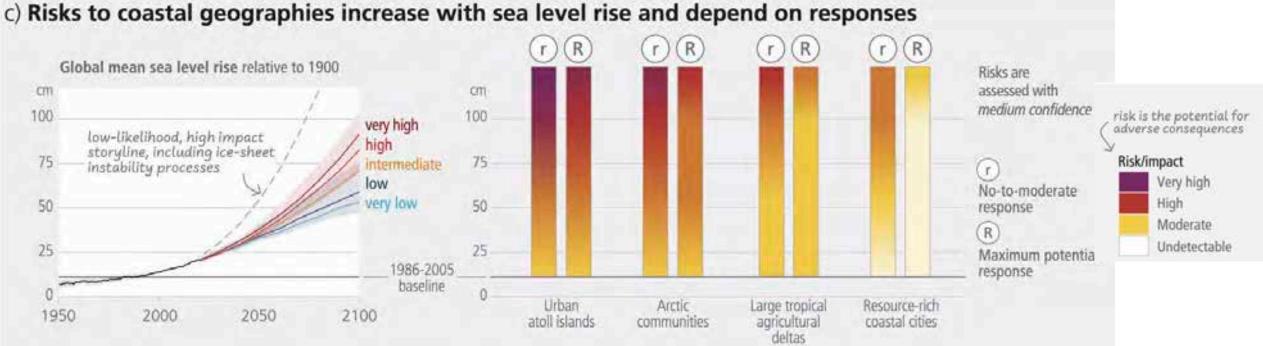


- Direct impacts from sea level rise include increases in flooding, coastal erosion, saltwater intrusion, elevated groundwater, and landscape changes.
- Cascading impacts result from the direct impacts and include infrastructure and property damage, health risks, economic challenges, and habitat loss.



## Projections can be Used to Assess Vulnerability to Future Impacts and **Inform Adaptation Planning**

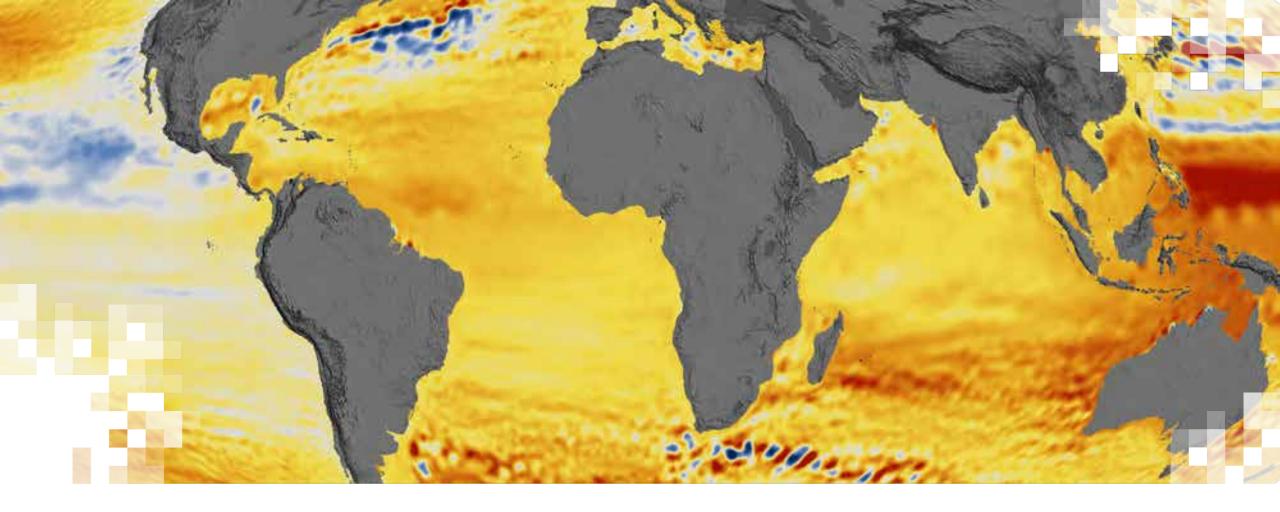




Variations in coastal landscapes and environments, social and economic factors, and coastal development all play a role in determining how sea level rise impacts are felt in different locations and by different communities.







## Sea Level Explorer Tool

Denis Felikson, PhD NASA Goddard Space Flight Center

## **Overview of Tools**

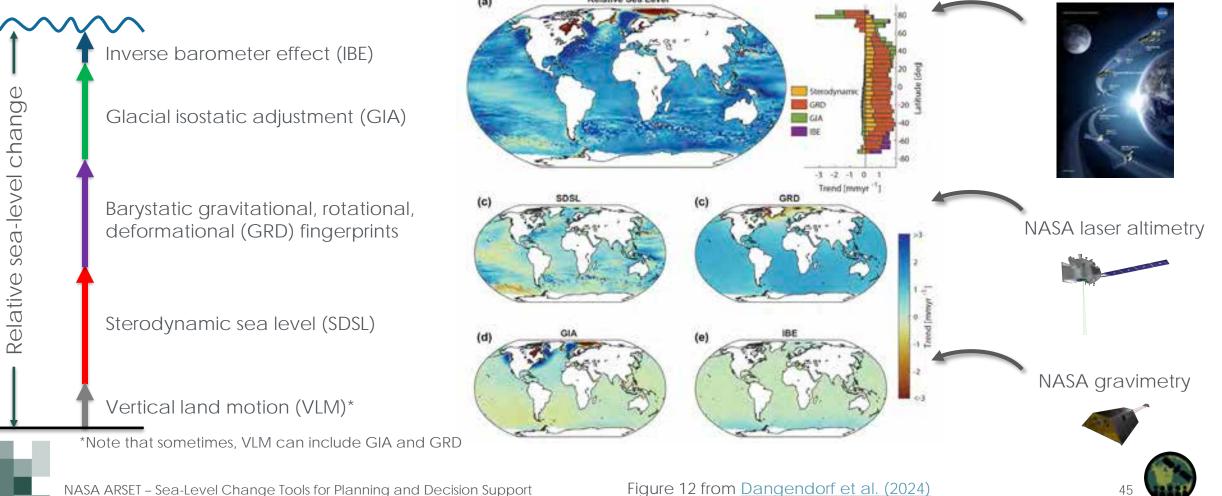


- In this training, we focus on three tools for accessing sea-level change information:
  - <u>Sea Level Explorer</u>: provides high-level synthesis of past, present, and future sea-level rise and impacts for coastal locations around the world
  - <u>IPCC AR6 Projections Tool</u>: provides easy access and visualization of the sea-level projection data from the IPCC 6th Assessment Report (AR6)
  - <u>Pacific Islands Flooding Analysis Tool</u>: decision-relevant assessments of how sea-level rise and other factors will affect the frequency and extent of high-tide flooding for Pacific Islands
    - This is currently being expanded to global scale.
- There is consistency in the underlying datasets and methodology across these three tools.
- Information comes from peer-reviewed papers and assessment reports.



## **Sea-Level Reconstructions Within the Sea Level Explorer**

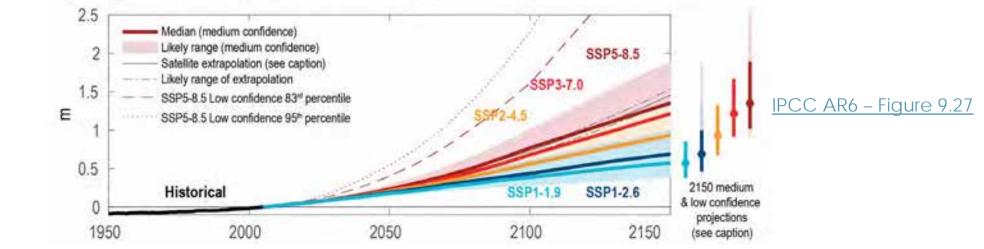
Historical sea-level and contributions from individual components can be reconstructed by combining tide gauge records with satellite observations.



NASA radar altimetry

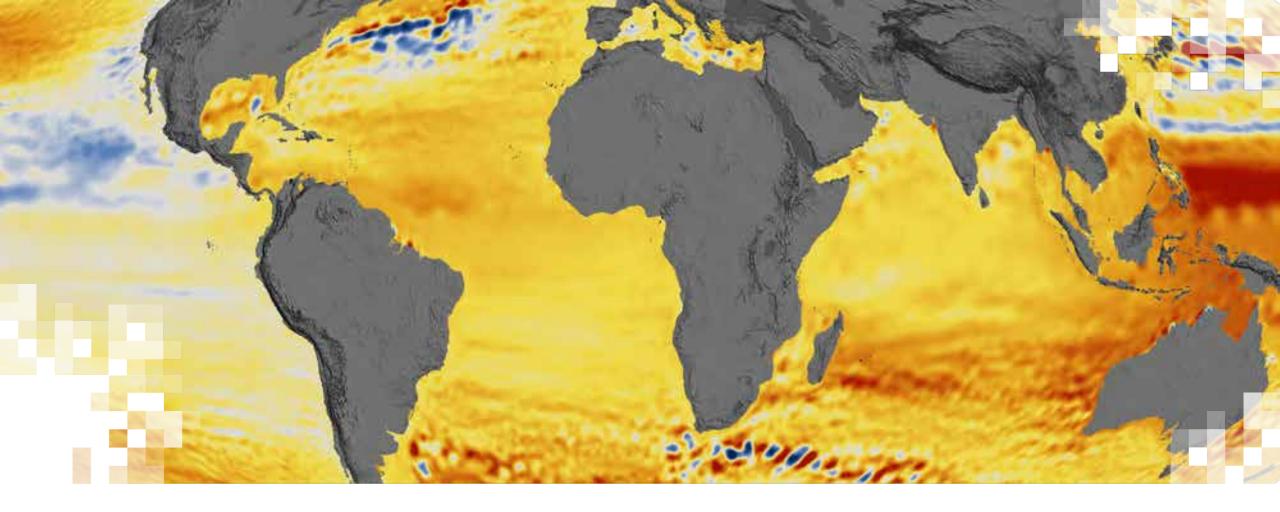
## Sea-Level Projections Within the Sea Level Explorer

- Future projections of sea-level change are from the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6), published in 2021 (<u>IPCC AR6</u>).
  - The IPCC is the United Nations body for assessing the science related to climate change.
- The IPCC AR6 surveys and distills the scientific literature and provides consensus projections on future sea levels across the globe under a range of possible future scenarios called Shared Socioeconomic Pathways (SSPs).
- The AR6 incorporates advances in modeling and understanding of ice sheet dynamics, ocean thermal expansion, and regional variations.
- Part 2 of this ARSET training will provide more details on IPCC AR6 sea-level projections.



Projected global mean sea level rise under different SSP scenarios

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**Demonstration** Sea Level Explorer

#### Introduction to earth.gov/sealevel

#### **Global Sea Level Change**

About Sea Level Change - Sea Level Explorer Vital Signs - Resources - Partners Q

International Partners -

## Sea Level is Rising, Worldwide

Sea level rise is already impacting the lives and livelihoods of coastal communities and low-lying island nations worldwide-and it's accelerating. As sea levels continue to climb and severe consequences become more frequent, understanding local changes on a global scale is critical. This site, developed through an international partnership, offers essential information on current and projected sea level rise to inform coastal communities across the globe.

About Sea Level Change

Sea Level Explorer

Vital Signs Learn more >

#### Sea Level

**Carbon Dioxide** 



WORLD BANK GROUP

An international engagement >

**Global Temperature** 

DP



## Vital Signs

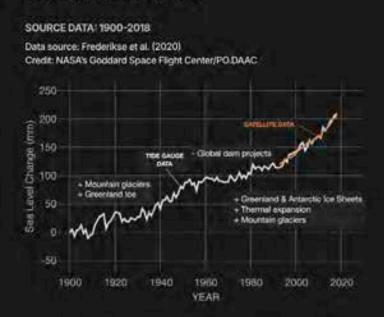






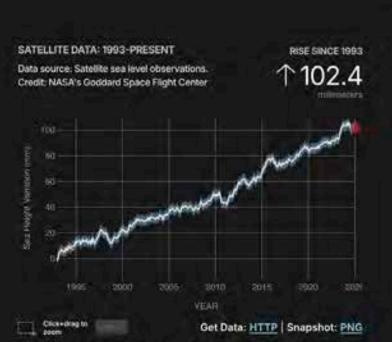
#### Vital Signs: Sea Level

## Sea Level



Sea level rise is caused primarily by two factors related to global warming: the added water from melting ice sheets and glaciers, and the expansion of seawater as it warms. The first graph tracks the change in global sea level since 1993, as observed by satellites.

The graph on the left, which is from coastal tide gauge and satellite data, shows how much sea level changed from about 1900 to 2018. Items with pluses (+) are factors that cause global sea level to increase, while minuses (-) are what cause sea level to decrease. These items are displayed at the time they were affecting sea level.

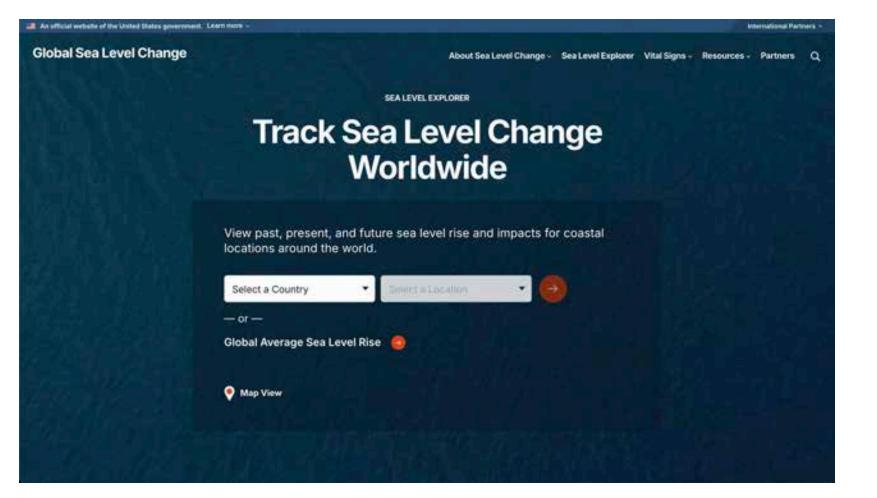


This graph tracks the change in sea level since 1993, as observed by satellites. The data shown are the latest available, with a four- to five-month delay needed for processing. (Source)

Note: You now need to create an Earthdata account to access NASA's sea level data. Register here for free. Once logged in, click "HTTPS" under the "Satellite Data" chart on this page to access the data. ×



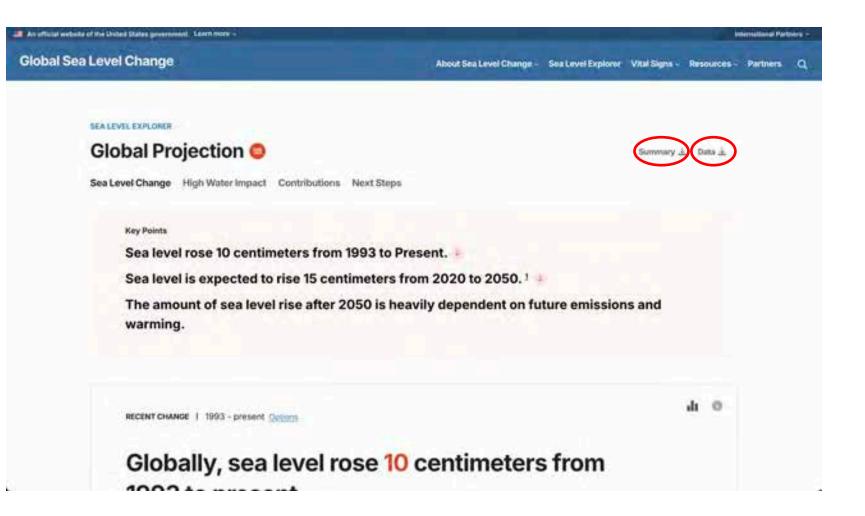
#### **Sea Level Explorer**



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## Sea Level Explorer: Global Average (Overview)





## Sea Level Explorer: Global Average (Historical)

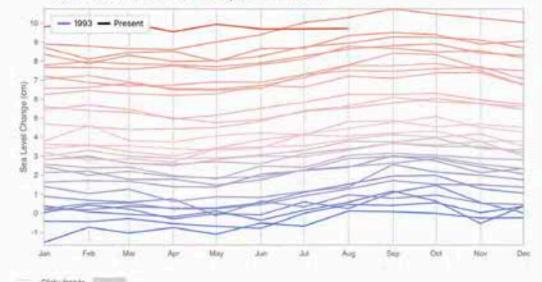
## Globally, sea level rose 10 centimeters from 1993 to present.

#### Sea Level Annual Cycle Over Time, 1993 - present

Updated: 4/1/2025

This chart shows the change in sea level measured by satellite altimetry over time globally. The movement of <u>nearby land</u> is added to show the change in relative sea level. Sea level goes up and down throughout the year from things like tides and changes in seasons. Some years may also be higher than o.... more

#### Total sea level rise: 1993 - Present, 10.3 centimeters



Key Points

Global warming is causing sea level to rise almost everywhere.

There are ups and downs from year-to-year associated with natural fluctuations in the ocean. The thicker line shows where sea level is right now.

In most locations, sea level will continue to rise and isn't returning to where it was in the past.



#### Sea Level Explorer: Global Average (Historical)

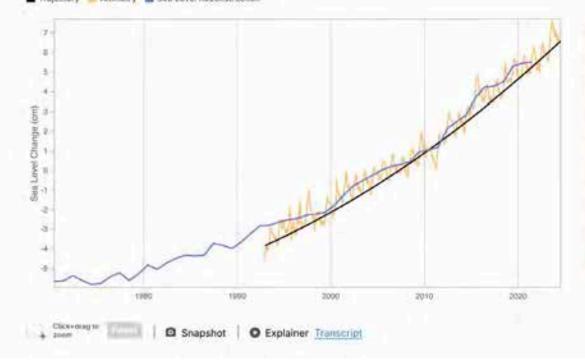
#### - Hide additional figures

#### Satellite Altimetry and Tide Gauge Measurements Over Time

Updated: 4/1/2025

This chart shows the change in sea level over time as measured by a sea level reconstruction (blue) and satellite altimetry (orange) globally. If a tide gauge record is available, sea level measured by the tide gauge is also shown (green). The satellite record started in 1993, while the tide gauge records... more

Trajectory Altimetry Sea Level Reconstruction



#### **Key Points**

Instruments both here on Earth and in space are used to measure sea level change. Comparisons between the data from the instruments give us confidence in our understanding of sea level change.

Tide gauges measure the height of the sea relative to land, while satellite altimeters just measure the ocean. Subsidence or uplift of coastal lands can cause differences.

#### Sea Level Explorer: Global Average (Historical)

#### Summary of Tide Gauge Measurement Data, 1970-Present

The table below shows how fast the sea level is changing each decade and the total change across selected years based on tide gauge measurements. The first column shows the decade. The second column is the rate of change over that decade. This tells us how fast sea levels are changing. The large... more

Time Frame	RATE (cm/yr)	VALUE (cm)	
1990s	0.24	1.7	Key
2000s	0.30	3.0	Usin data
2010s	0.37	3.7	whic
2020s	0.39	2.0	In m
1970 - Present	0.33	10.4	sea l used
			911.9

Points

Jsing the trajectory of the past data, we can see that the rate at which sea level is rising is changing over time.

n many locations - but not all sea level is rising faster than it used to, just like putting our foot on the gas pedal.



## Sea Level Explorer: Global Average (Future)

FUTURE | 2050, SSP2-4.5 Scenario Options

di 0

# Under the SSP2-4.5 scenario, global sea level is expected to rise 15 centimeters from 2020 to 2050, with a likely range from 13 to 20 centimeters.

For comparison, the sea level rose 10 centimeters from 1993 to present.

Under the SSP2-4.5 scenario, there is a 3% chance of exceeding 1 meter of global sea level rise by 2100. Learn more >



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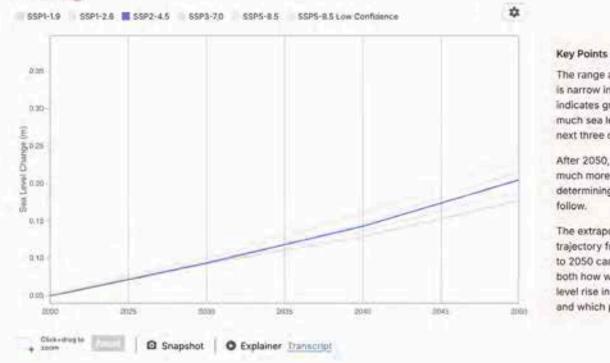
#### Sea Level Explorer: Global Average (Future)

#### Sea Level Rise for Global Projection from 2020 - 2050

#### Updated: 4/1/2025

This chart shows the sea level rise globally from 2020 to 2050 based on the different SSP or global warming level scenarios. All values are referenced to the year 2005. The bolded line is the currently chosen scenario, which can be changed at the top of the page. The likely ranges for each scenario can al... more

#### Scenarios (i)



The range across the scenarios is narrow in the near-term, which indicates greater certainty in how much sea level will rise in the next three decades.

After 2050, emissions become much more important in determining which path we will follow.

The extrapolation of the trajectory from observations out to 2050 can help us understand both how well we understand sea level rise in a particular location and which path we might be on.



## Sea Level Explorer: Global Average (Contributions)



Sea Level Change High Water Impact Contributions Next Steps

#### **Key Points**

Global Projection 🔤

SEA LEVEL EXPLORER

Sea level change from 1993 to present came from 60% ice sheets and glaciers, 0% vertical land motion, and 40% changes in sterodynamic sea level.

Sea level change in 2050 is expected to come from 59% ice sheets and glaciers, 0% vertical land motion, and 41% changes in sterodynamic sea level. <sup>1</sup>

RECENT CHANGE

1 0

Globally, sea level change from 1993 to present mainly came from 60% ice sheets and glaciers, 0% vertical land motion, and 40% changes in sterodynamic sea level.



## Sea Level Explorer: Global Average (Historical Contributions)

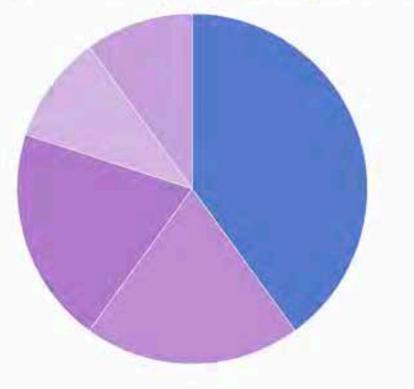
#### Contributors to Local Sea Level Change, 1993 - present

Updated: 4/1/2025

X

This pie chart shows the percentage contributed by different factors to the sea level change globally from 1993 to present. The main cause of global sea level rise is increasing greenhouse gas emissions warming the planet. This warming is causing ice sheets and glaciers to melt (purple), which add fresh... more

🐘 Land Water Storage 🖉 Antarctica 🐞 Greenland 🐞 Glaciers 👛 Vertical Land Motion 🏚 Sterodynamic Sea Level



#### **Key Points**

Using data we collect of Earth's climate system, there is a good understanding of what is causing sea level to change.

There are differences in the contributors to sea level rise from one location to another.



## Sea Level Explorer: Global Average (Future Contributions)

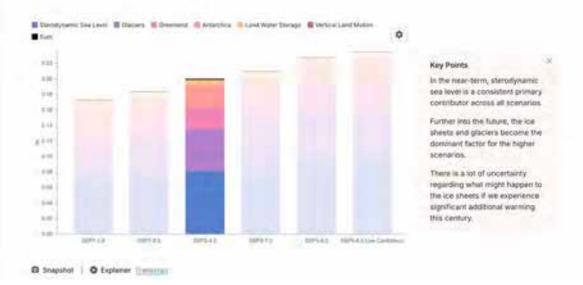
Individual Process Contributions for Each Sea Level Scenario

FUTURE | 2050, SSP2-4.5 Scienario Quencia.

Global sea level change in 2050, under the SSP2-4.5 scenario, is expected to come from 59% ice sheets and glaciers, 0% vertical land motion, and 41% changes in sterodynamic sea level.

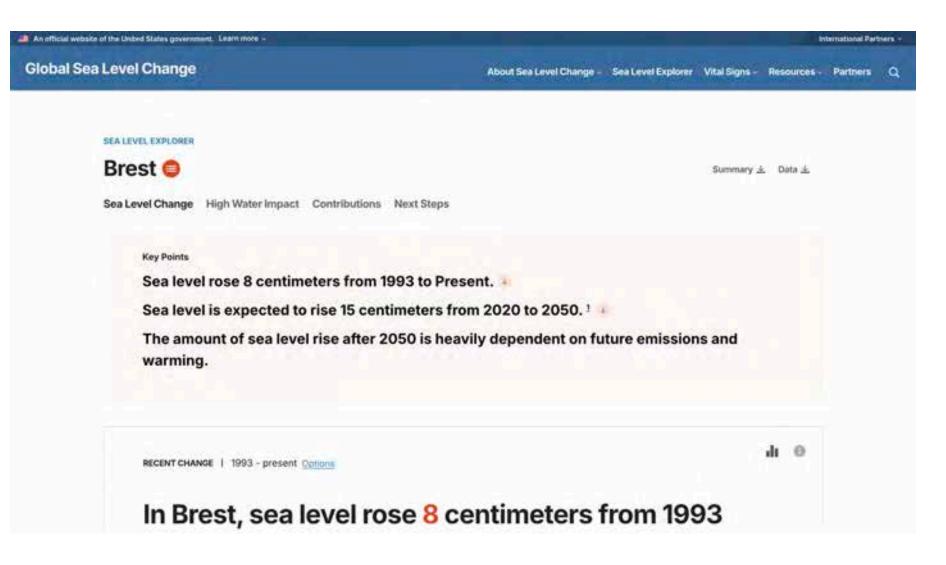
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**Updated:** 4/92025



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## Sea Level Explorer: Brest, France (Overview)



#### Sea Level Explorer: Brest, France (Historical)



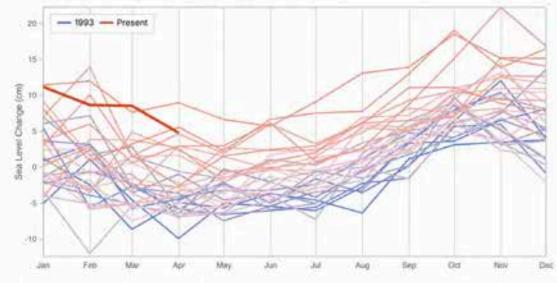
# In Brest, sea level rose 8 centimeters from 1993 to present.

#### Sea Level Annual Cycle Over Time, 1993 - present

#### Updated: 4/1/2025

This chart shows the change in sea level measured by satellite altimetry over time in Brest. The movement of <u>nearby land</u> is added to show the change in relative sea level. Sea level goes up and down throughout the year from things like tides and changes in seasons. Some years may also be higher than o.... more





#### **Key Points**

Global warming is causing sea level to rise almost everywhere.

There are ups and downs from year-to-year associated with natural fluctuations in the ocean. The thicker line shows where sea level is right now.

In most locations, sea level will continue to rise and isn't returning to where it was in the past.



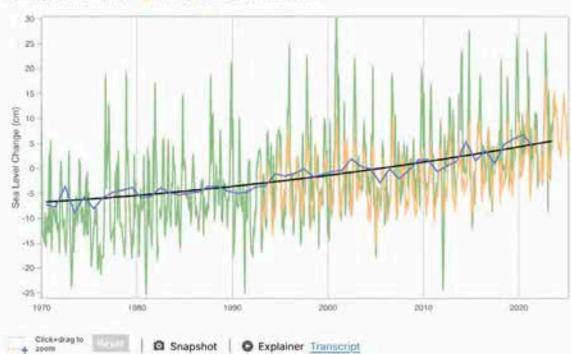
#### Sea Level Explorer: Brest, France (Historical)

#### Satellite Altimetry and Tide Gauge Measurements Over Time

Updated: 4/1/2025

×

This chart shows the change in sea level over time as measured by a sea level reconstruction (blue) and satellite altimetry (orange) in Brest. If a tide gauge record is available, sea level measured by the tide gauge is also shown (green). The satellite record started in 1993, while the tide gauge records... more



#### 📕 Tide gauge 📕 Trajectory 📒 Altimetry 📕 Sea Level Reconstruction

#### Key Points

Instruments both here on Earth and in space are used to measure sea level change. Comparisons between the data from the instruments give us confidence in our understanding of sea level change.

Tide gauges measure the height of the sea relative to land, while satellite altimeters just measure the ocean. Subsidence or uplift of coastal lands can cause differences.

#### Sea Level Explorer: Brest, France (Historical)

#### Summary of Tide Gauge Measurement Data, 1970-Present

The table below shows how fast the sea level is changing each decade and the total change across selected years based on tide gauge measurements. The first column shows the decade. The second column is the rate of change over that decade. This tells us how fast sea levels are changing. The large... more

Time Frame	RATE (cm/yr)	VALUE (cm)	
1970s	0.12	1.2	
1980s	0.16	1.6	
1990s	0.20	2.0	
2000s	0.24	2.4	
2010s	0.28	2.8	
2020s	0.34	1.0	
1970 - Present	0.23	12.3	

Key Points

Using the trajectory of the past data, we can see that the rate at which sea level is rising is changing over time.

×

In many locations - but not all sea level is rising faster than it used to, just like putting our foot on the gas pedal.

#### Sea Level Explorer: Brest, France (Future)

FUTURE | 2050, SSP2-4.5 Scenario Options

In Brest, under the SSP2-4.5 scenario, sea level is expected to rise 15 centimeters from 2020 to 2050, with a likely range from 11 to 20 centimeters.

For comparison, the sea level rose 8 centimeters from 1993 to present.

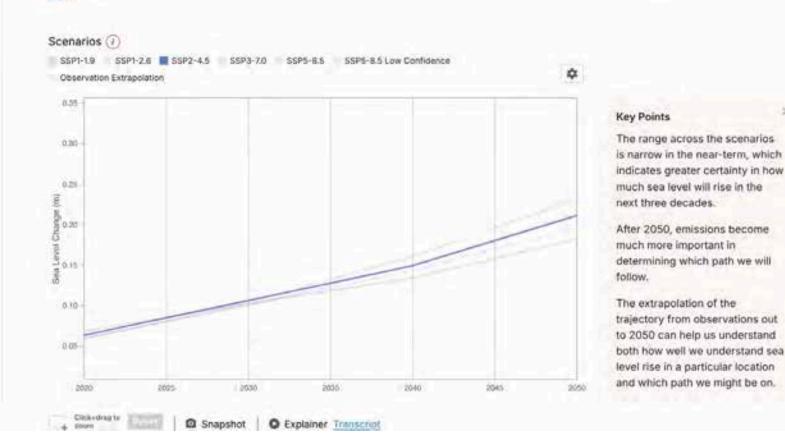
Under the SSP2-4.5 scenario, there is a 3% chance of exceeding 1 meter of global sea level rise by 2100. Learn more >

#### Sea Level Explorer: Brest, France (Future)

#### Sea Level Rise for Brest from 2020 - 2050

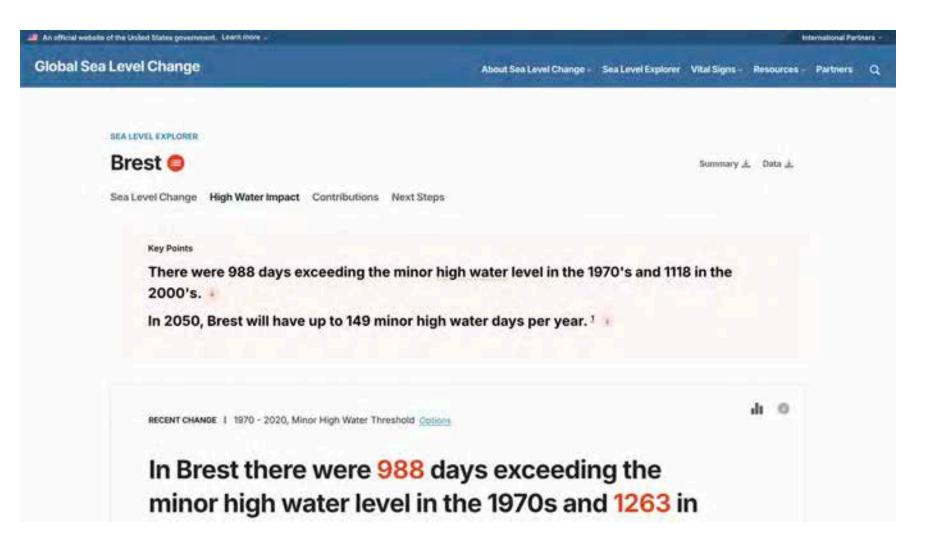
Updated: 4/1/2025

This chart shows the sea level rise in Brest from 2020 to 2050 based on the different SSP or global warming level scenarios. All values are referenced to the year 2005. The bolded line is the currently chosen scenario, which can be changed at the top of the page. The likely ranges for each scenario can al... more





## Sea Level Explorer: Brest, France (High Water Impact)



## Sea Level Explorer: Brest, France (High Water Impact)

RECENT CHANGE | 1970 - 2020, Minor High Water Threshold Options

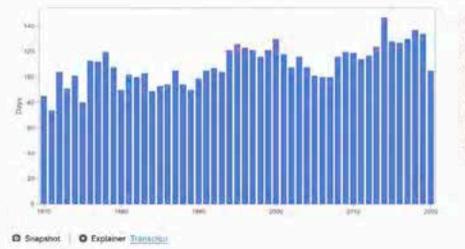
# In Brest there were 988 days exceeding the minor high water level in the 1970s and 1263 in the 2020s.

Number of Days Each Year with Minor High Water Potential (Historic Data)

Opdated: 4/1/2025

4 0

This chart shows the number of days that exceeded a minor high water level in Brest. While some countries and locations have specific thresholds or amounts of sea level rise where flooding might start to occur, these are not available everywhere. Here three thresholds are created and defined by the ... more



Key Points As sea levels rise, flooding will start to occur more often and with worsening severity.

From past records of sea level, we have seen that many coastal locations are exceeding thresholds that indicate flooding may be occurring more frequently.



#### Sea Level Explorer: Brest, France (High Water Impact)

FUTURE | 2050, SSP2-4.5 Scenario Options

#### In 2050 under the SSP2-4.5 scenario, Brest will have up to 149 minor high water days per year.

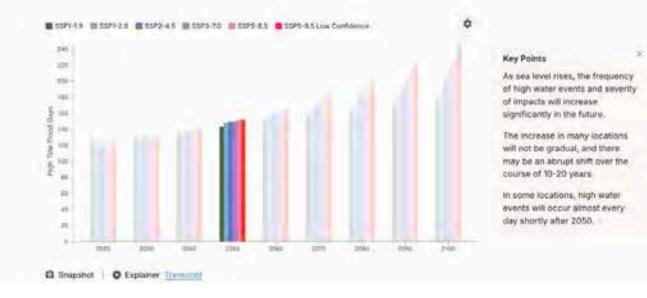
Currently, Brest is averaging 121 minor high water days per year in the last 10 years.



Updated: 4/1/2025

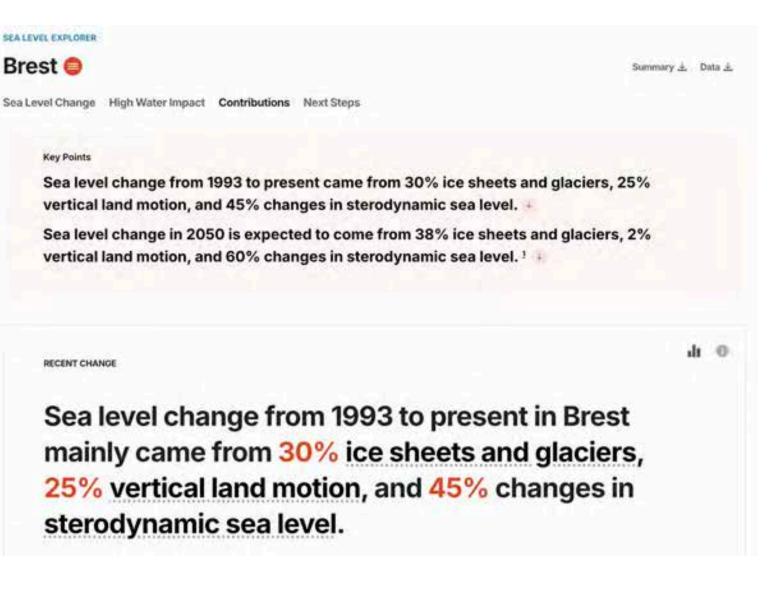
dt. 0

This bar chart shows the number of high water days that is expected during each decade from 2020 to 2100 under different sea level scenarios for Brest. If the number of days reaches 355, then that means that the sea level has risen high enough that high tide will exceed the high water threshold every da... more





## Sea Level Explorer: Brest, France (Contributions)





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70

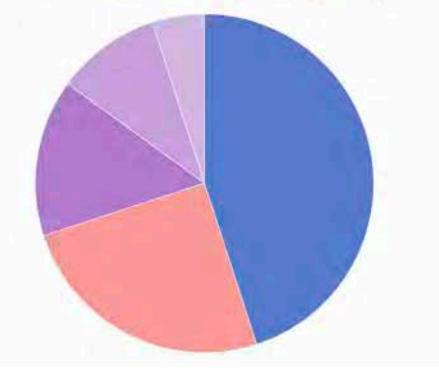
## Sea Level Explorer: Global Average (Historical Contributions)

#### Contributors to Local Sea Level Change, 1993 - present

Updated: 4/1/2025

This pie chart shows the percentage contributed by different factors to the sea level change in Brest from 1993 to present. The main cause of global sea level rise is increasing greenhouse gas emissions warming the planet. This warming is causing ice sheets and glaciers to melt (purple), which add fresh... more

💼 Land Water Storage 🝈 Antarctica 🍈 Greenland 🚳 Glaciers 💮 Vertical Land Motion 🕚 Sterodynamic Sea Level



#### **Key Points**

Using data we collect of Earth's climate system, there is a good understanding of what is causing sea level to change.

There are differences in the contributors to sea level rise from one location to another.

## Sea Level Explorer: Global Average (Future Contributions)

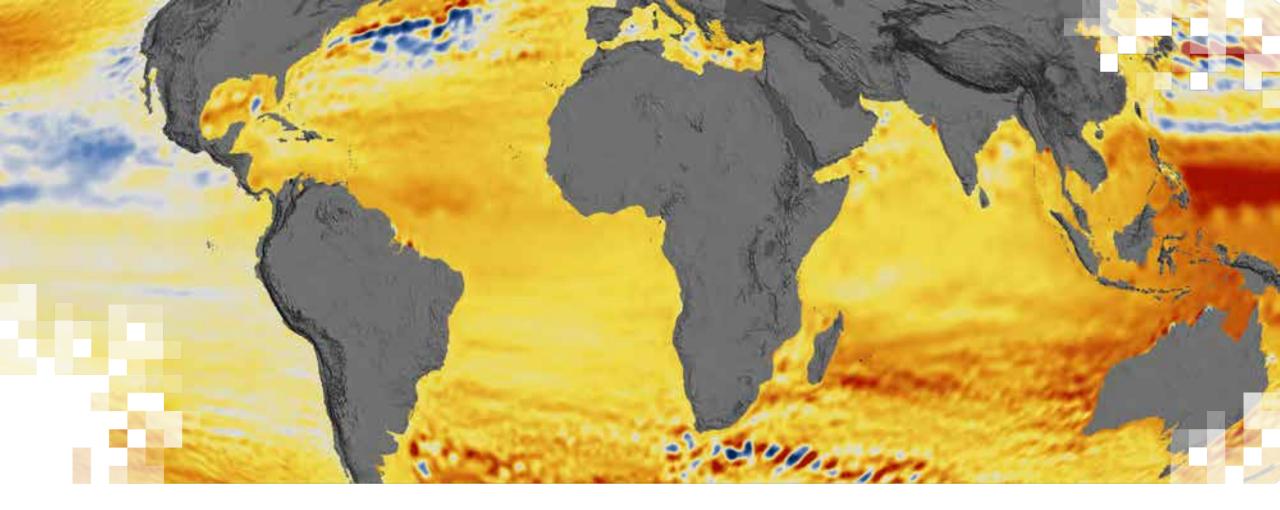
FUTURE | 2050, SSP2-4.5 Scenario Options

4 6

By 2050, under the SSP2-4.5 scenario, sea level change in Brest is expected to come from 38% ice sheets and glaciers, 2% vertical land motion, and 60% changes in sterodynamic sea level.







Part 1: Summary

## Summary

- Processes contributing to sea-level change
  - Greenhouse gases added to air by human activities
  - Planet warms
  - Ocean expands as it warms
  - Ice sheets and glaciers melt, adding water to oceans
  - Global sea level rises
- Impacts of sea-level change
  - High tide flooding (a.k.a., sunny-day flooding)
  - Variations in coastal environments, social and economic factors, and coastal development all
    play a role in determining how impacts are felt in different locations by different communities.
- NASA's unique capabilities in both remote sensing and modeling
  - Radar altimetry (Sentinel-6 Michael Freilich), Laser altimetry (ICESat-2), Gravimetry (GRACE-FO)
- Overview and demonstration of <u>Sea-Level Explorer</u>
  - Provides high-level synthesis of past, present, and future sea-level rise and impacts for coastal locations around the world.



## Looking Ahead to Part 2

- Projecting Future Sea-Level Change
- Framework for Assessing Changes To Sea-level (FACTS)
- Overview and Demonstration of the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) Projections Tool
- Overview and Demonstration of the Pacific Islands Flooding Analysis Tool
  - Oceanic flooding
  - Groundwater flooding

## **Homework and Certificates**

- Homework:
  - One homework assignment
  - Opens on June 17, 2025
  - Access from the <u>training webpage</u>
  - Answers must be submitted via Google Forms
  - Due by July 1, 2025
- Certificate of Completion:
  - Attend all three live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.



#### Acknowledgements

Dr. Angelica Rodriguez Research Scientist NASA JPL/Caltech



**Dr. Denis Felikson** Research Scientist NASA GSFC



## **Contact Information**

Trainers:

- Angelica Rodriguez, PhD
  - <u>angelica.rodriguez@jpl.nasa.gov</u>
- Denis Felikson, PhD
  - <u>denis.felikson@nasa.gov</u>
- Sean McCartney
  - <u>sean.mccartney@nasa.gov</u>

- ARSET Website
- Follow us on Twitter!
  - <u>@NASAARSET</u>
- ARSET YouTube

Visit our Sister Program:

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#### Resources

#### Websites

- Global Sea Level Change About Sea Level Change
- Ocean Surface Topography
- ICESat-2
- <u>GRACE-FO</u>
- Information on current NASA Earth Science satellite fleet
- <u>ECCO</u>

#### References

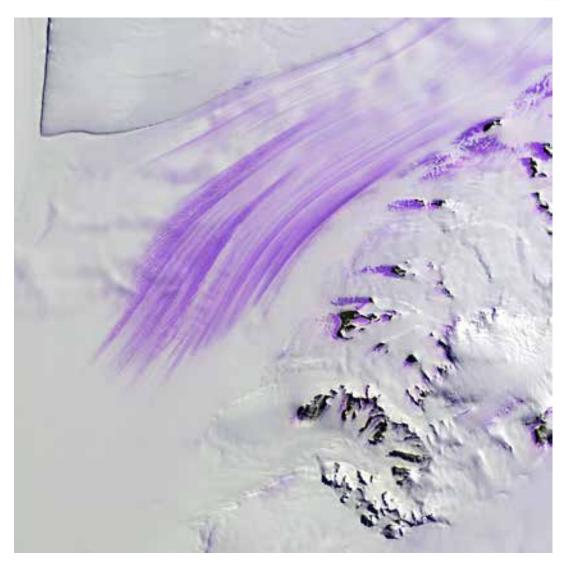
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- Argo Program
- NASA Sea Level Change Portal
- IPCC AR6
- <u>Sea-level projection data</u> from IPCC AR6
- <u>Sea Level Explorer</u> Tool

## **Questions?**

- Please enter your questions in the Q&A box. We will answer them in the order they were received.
- We will post the Q&A to the training website following the conclusion of the webinar.



Credit: USGS, Landsat 8







## **Thank You!**

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