

Past and Future Sea-level Change

Understanding sea-level change on a local scale for a climate-resilient Singapore

To further advance our understanding of rising sea-levels in Singapore and the Southeast Asia region, the Centre for Climate Research Singapore (CCRS) is carrying out the Third National Climate Change Study (V3) to produce sea-level projections, informing climate adaptation strategies (e.g. for coastal protection and food security) for a climate-resilient Singapore.

The Impacts of Sea-level Rise on Singapore

Land Erosion

Rising seas move shoreline materials and sediments. Hence, sea-level rise causes coastal areas such as beaches to recede (move further inland) and erode.



Coastal Flooding

- Rising sea levels could cause permanent flooding of coastal and low-lying areas.
- When combined with higher tides and more frequent storm surges, the frequency and intensity of extreme sea-level events increase. A flood that used to happen once every 100 years could happen once every 10 years.



Loss of Biodiversity

- Rising sea levels reduce the areas of mudflats, marshes and intertidal habitats.
- When there are no uplands available for organisms to migrate, these organisms and their habitats will be lost.

Drivers of Global Sea-level Rise

Global mean sea level has been rising at a rate of about 3–4 mm/year during recent decades. The two main drivers of global sea-level rise are:

1 Melting glaciers and ice sheets in Greenland and Antarctica

2 Thermal expansion of ocean water due to rising temperatures

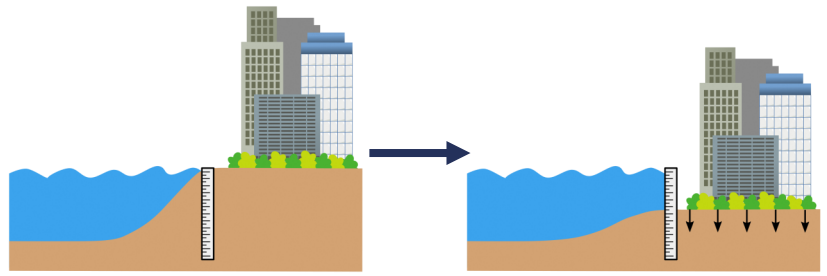
However, sea-level rise is not uniformly distributed around the globe due to the Earth's rotation and gravitational field.



Drivers of Local and Regional Sea-level Change

Vertical Land Motion (VLM)

- The uplift or subsidence of the **local** land surface.
- Earthquakes and groundwater extraction are some factors driving VLM.
- VLM affects **relative sea level**.



For example, if sea level were to stay constant but the land sinks, sea level is in fact rising relative to the inhabitants on land.

Ocean Sterodynamics

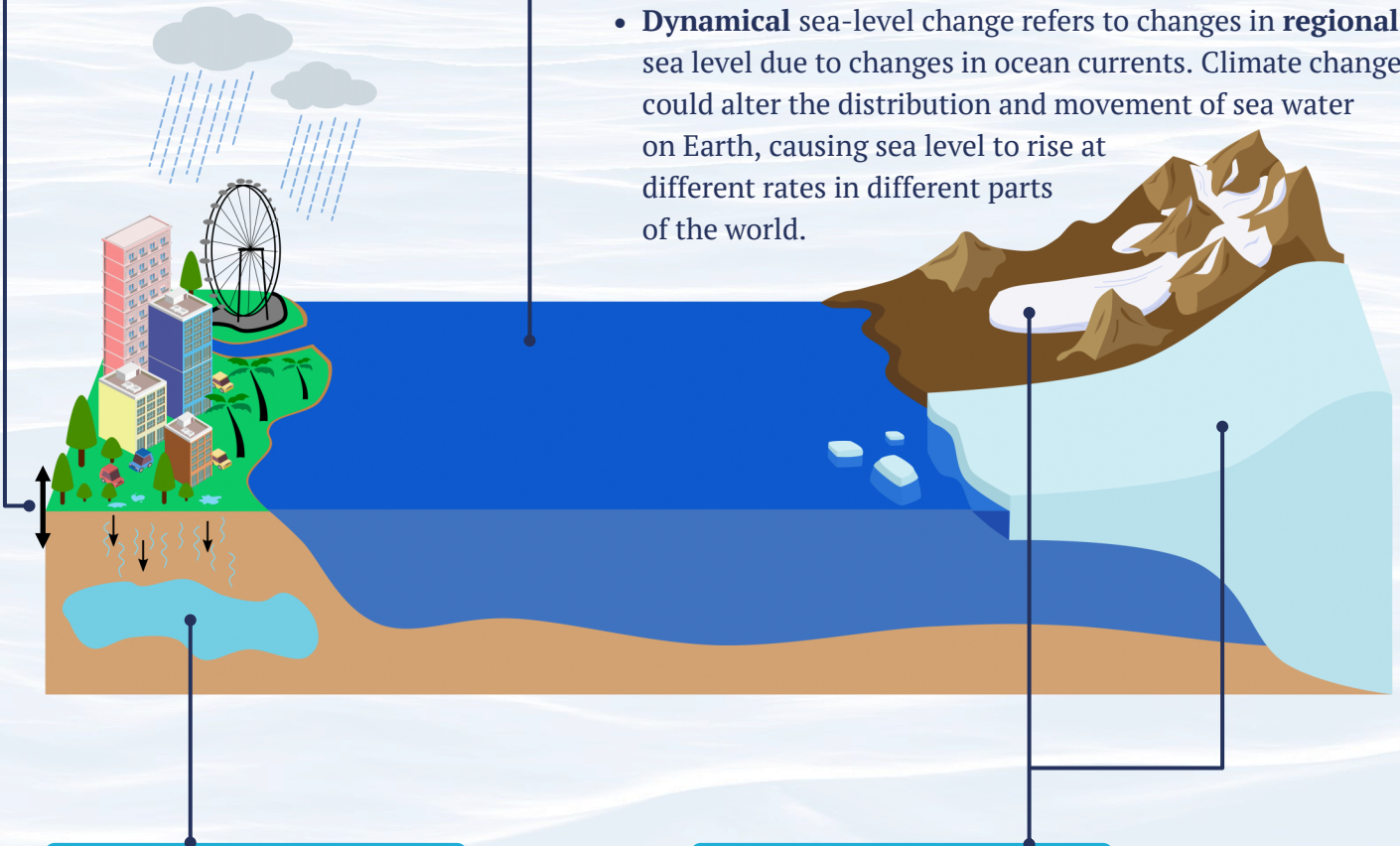
- “Sterodynamics” is derived from two words, “steric” and “dynamics”.
- **Steric** sea-level change is due to thermal expansion or contraction of the ocean on a **global** scale.
- **Dynamical** sea-level change refers to changes in **regional** sea level due to changes in ocean currents. Climate change could alter the distribution and movement of sea water on Earth, causing sea level to rise at different rates in different parts of the world.

Land Water Storage

- Changes in water stored on land that cause changes in sea level at a **regional** and **local** scale.
- These changes, such as extracting groundwater, could alter the eventual amount of water in the ocean. If this amount is increased, global mean sea level will rise.

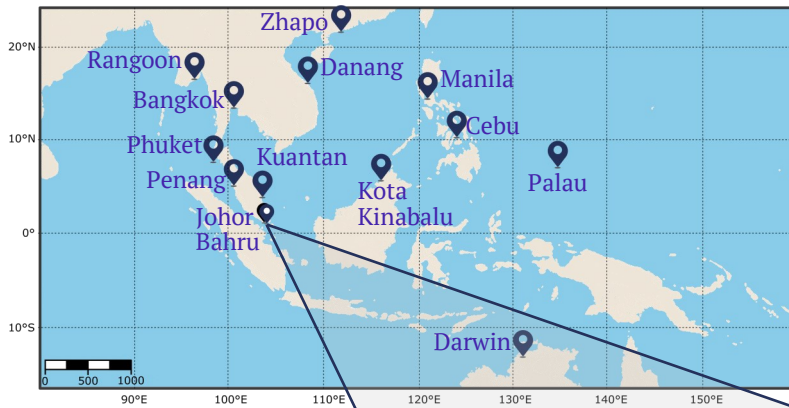
Ice Sheets & Glaciers

- A large fraction of Earth’s fresh water is locked up in glaciers and the Greenland and Antarctic ice sheets.
- When global mean surface temperature increases, the glaciers and ice sheets that sit on land lose mass into the oceans. This not only results in global mean sea-level rise, but also a non-uniform rise in different regions.



Historical and Future Sea-level Changes in Singapore and the Region

- Based on long-term records from tide gauge stations in Singapore and the region, CCRS investigates how sea level at various locations in the region has changed.

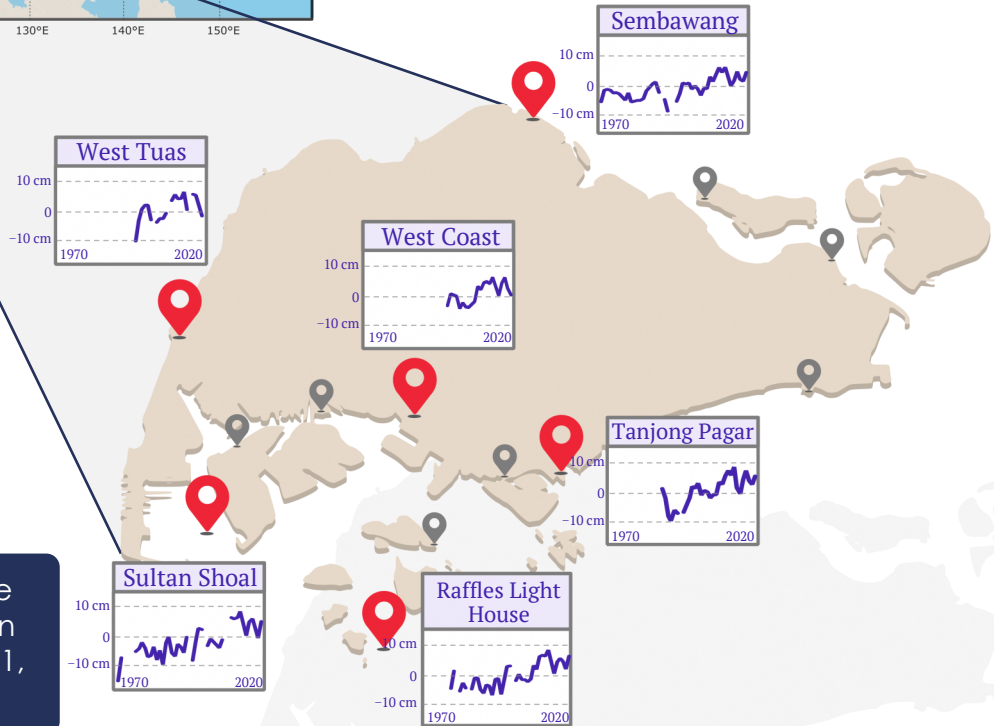


Singapore's Third National Climate Change Study (V3) includes past and future sea-level information for selected sites (marked by dark blue pins) up to 2100.

Singapore's Tide Gauges

- Has long records of more than 30 years, with graph showing how sea level relative to land has changed
- Has short records of less than 30 years

Past sea-level rise in Singapore is comparable to global mean sea-level rise from 1993 to 2021, at 3.5 mm/year.



- Building on the findings from the Intergovernmental Panel on Climate Change (IPCC) Working Group I Sixth Assessment Report (AR6), V3 provides state-of-the-art sea-level projections at six tide gauge stations in Singapore using local tide gauge and VLM data.
- In line with the other climate projections provided in V3, the sea-level projections are also based on three shared socioeconomic pathways (SSP), namely SSP1-2.6, SSP2-4.5 and SSP5-8.5.

Image credit: Page 2, Coastal erosion at Punggol Beach © Ria Tan / www.wildsingapore.com / CC BY-NC-ND 2.0

Centre for Climate Research Singapore

A research centre under the Meteorological Service Singapore and part of the National Environment Agency. It was officially launched in March 2013, with the vision to be a world leading centre in tropical climate and weather research focusing on the Southeast Asia region.

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