

# In-house Sharing Session 3

## The Basic of Climate Change Part II

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GoToWebinar  
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Norwegian Ministry  
of Foreign Affairs

Implemented by:



Norwegian Institute  
of International  
Affairs



# Climate Change & Sea Level Rise

# Sea Level Rise projections from IPCC AR5 2013

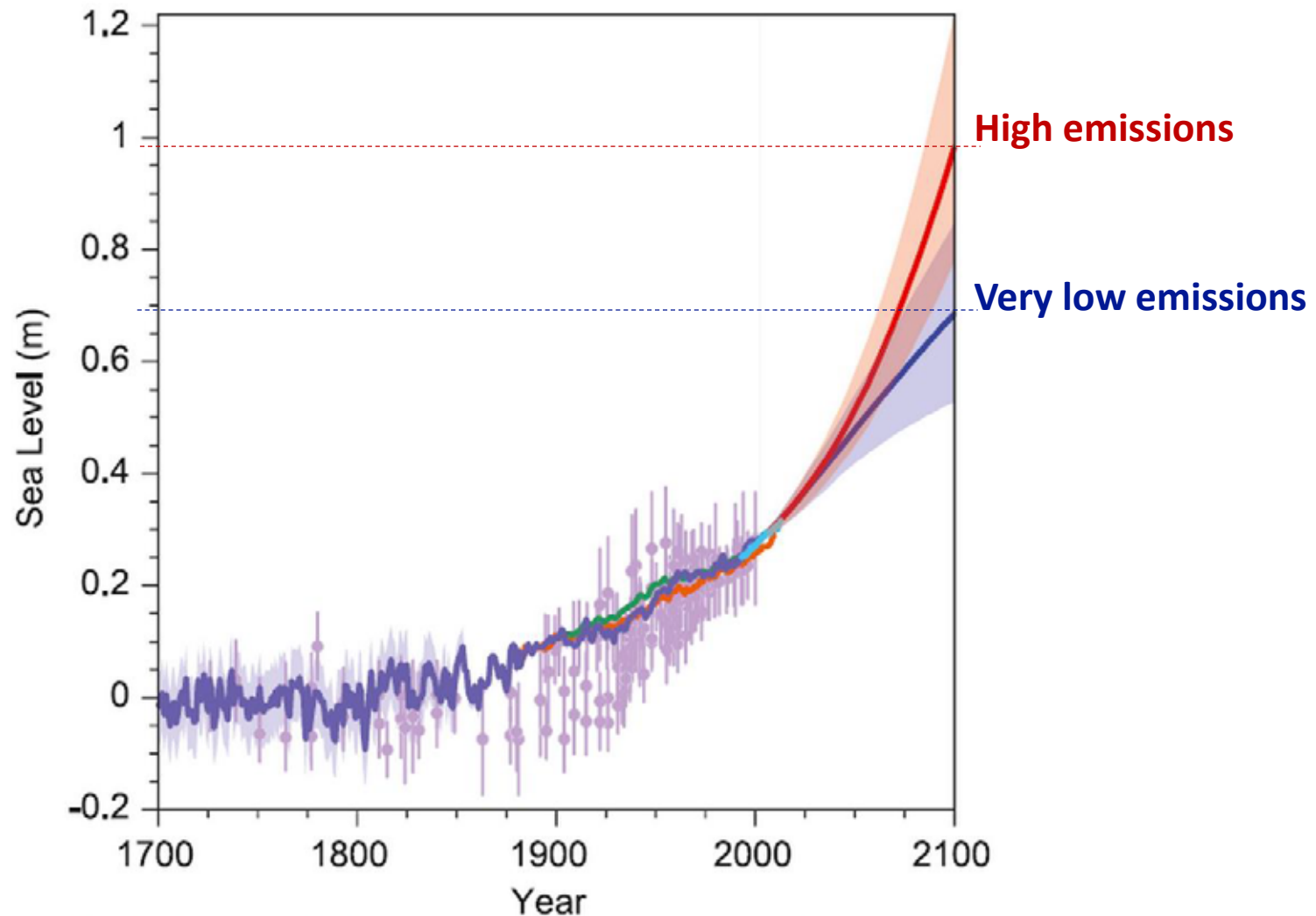
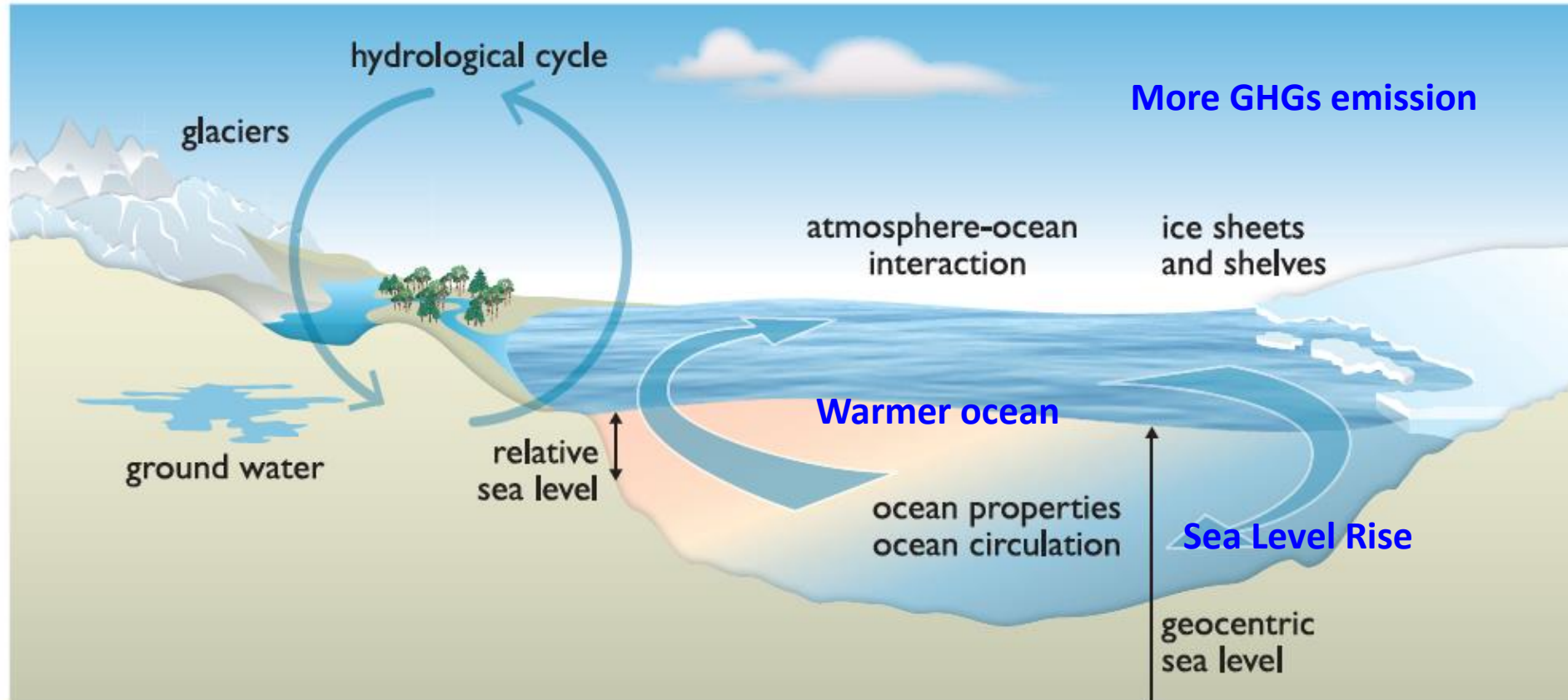


Fig. 1. Past and future sea-level rise. For the past, proxy data are shown in light purple and tide gauge data in blue. For the future, the IPCC projections for very high emissions (red, RCP8.5 scenario) and very low emissions (blue, RCP2.6 scenario) are shown. Source: IPCC AR5 Fig. 13.27.

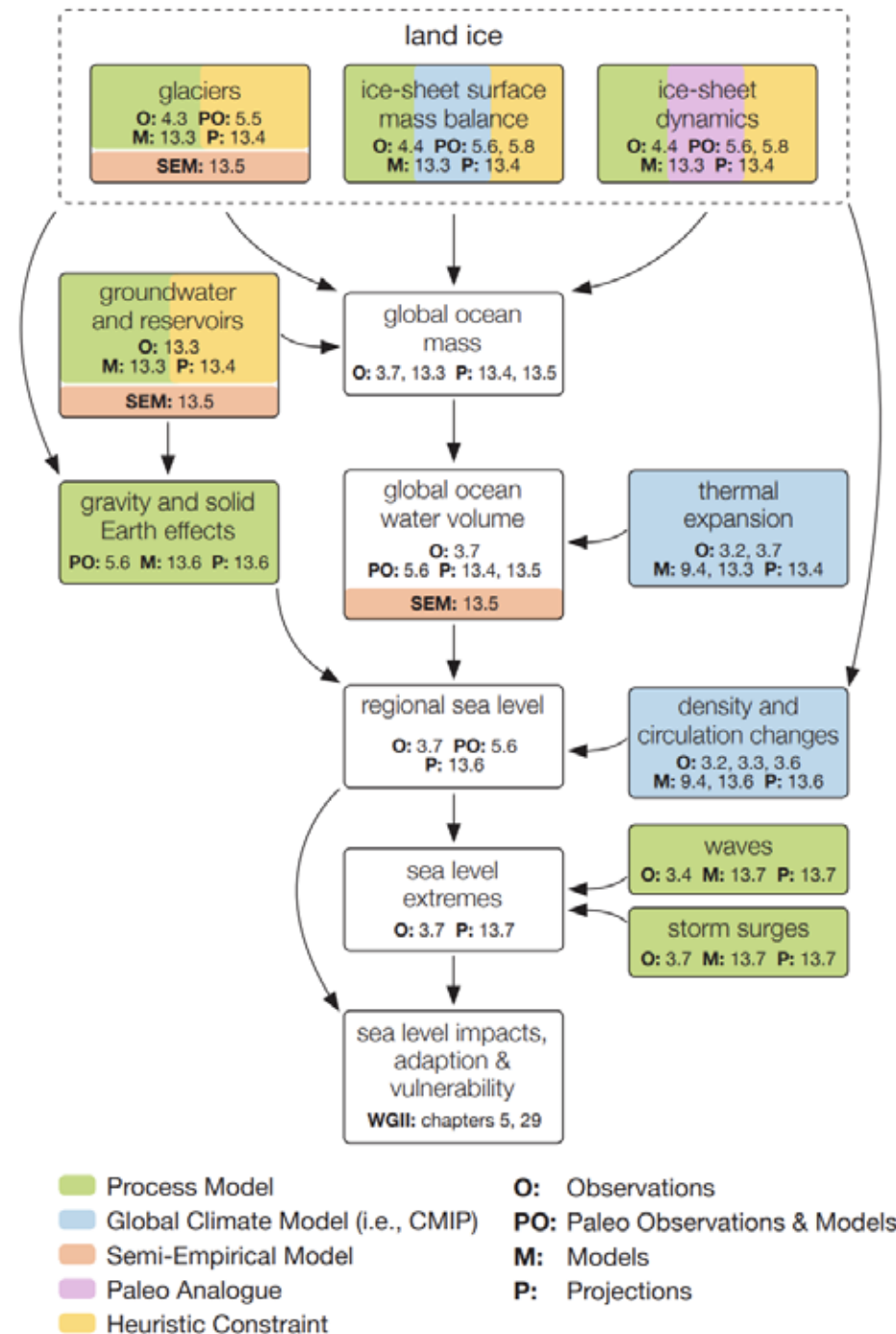
# Sea Level Change: Processes & Components



Source: IPCC (2013), AR5, Chapter 13, Figure 13.1

# 3 Different kinds of “Sea Level”

1. Global or eustatic sea level
2. Regional sea level
3. Local or relative sea level



# 1. Global Sea Level

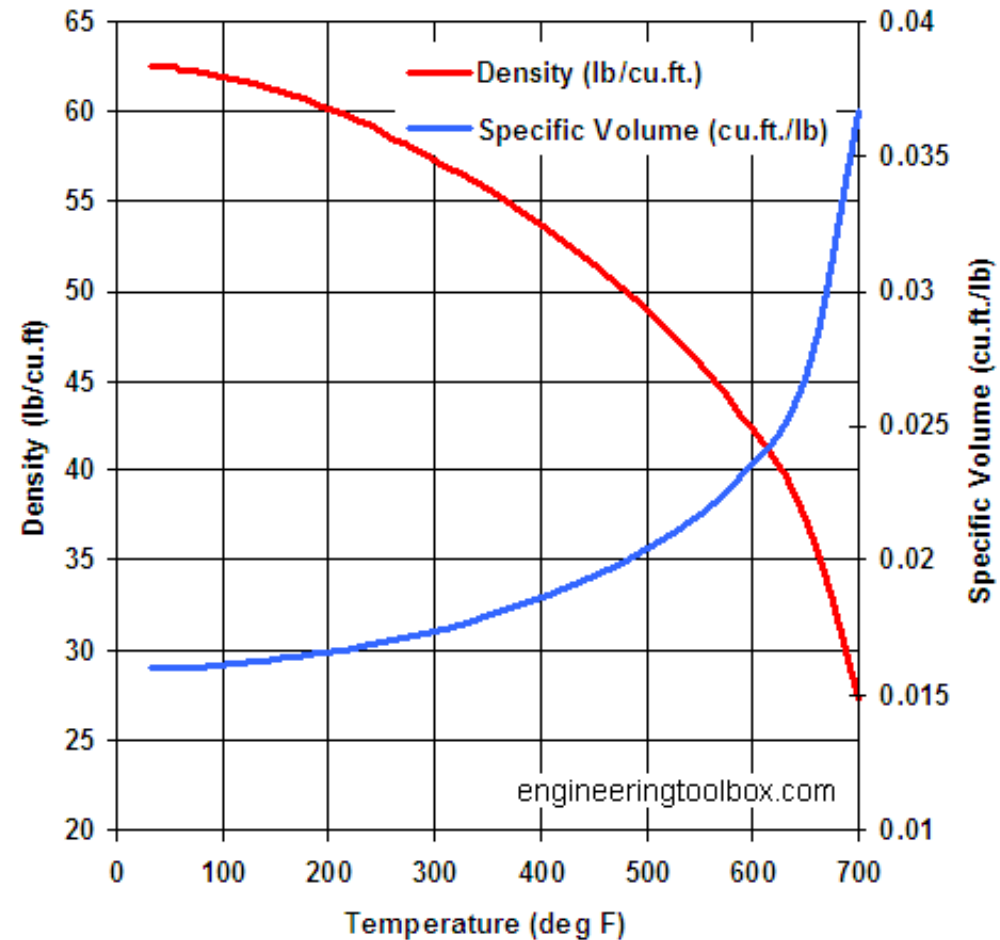
## Global Mean Sea-Level Rise (GSLR):

- Average sea-level change of the Earth's oceans
- Does not include vertical land motion
- Sea-level rise changes globally by
  - Density changes (e.g. [thermal expansion](#) by ocean warming)
  - Increases in volume of water (e.g. ice sheet [melting](#))

# Thermal expansion of sea water

Due to density and temperature

- Increase from 25 to 26 degrees Celsius, upper 100m would deepen by 3cm



# Glacial Melt

- **Glacier** in mid- high elevations depend on snow precipitation to accumulation
- Warmer ocean > increased evaporation > increased precipitation in form of rain rather than snow
- Melting **ice sheets**: Greenland & Antarctica



### Closer to IPCC's “worst scenario”

- Greenland and Antarctica lost 6.4 trillion tonnes of ice between 1992 and 2017 – pushing global sea levels up by 17.8 millimetres
  - Of the total sea level rise coming from melting polar ice sheets, around 60% (10.6 millimetres) was due to Greenland ice losses and 40% was due to Antarctica (7.2 millimetres)
  - If that holds true it would put 400 million people at risk of annual coastal flooding by 2100
- [Prof Andrew Shepherd from the University of Leeds](#) (12 March 2020)



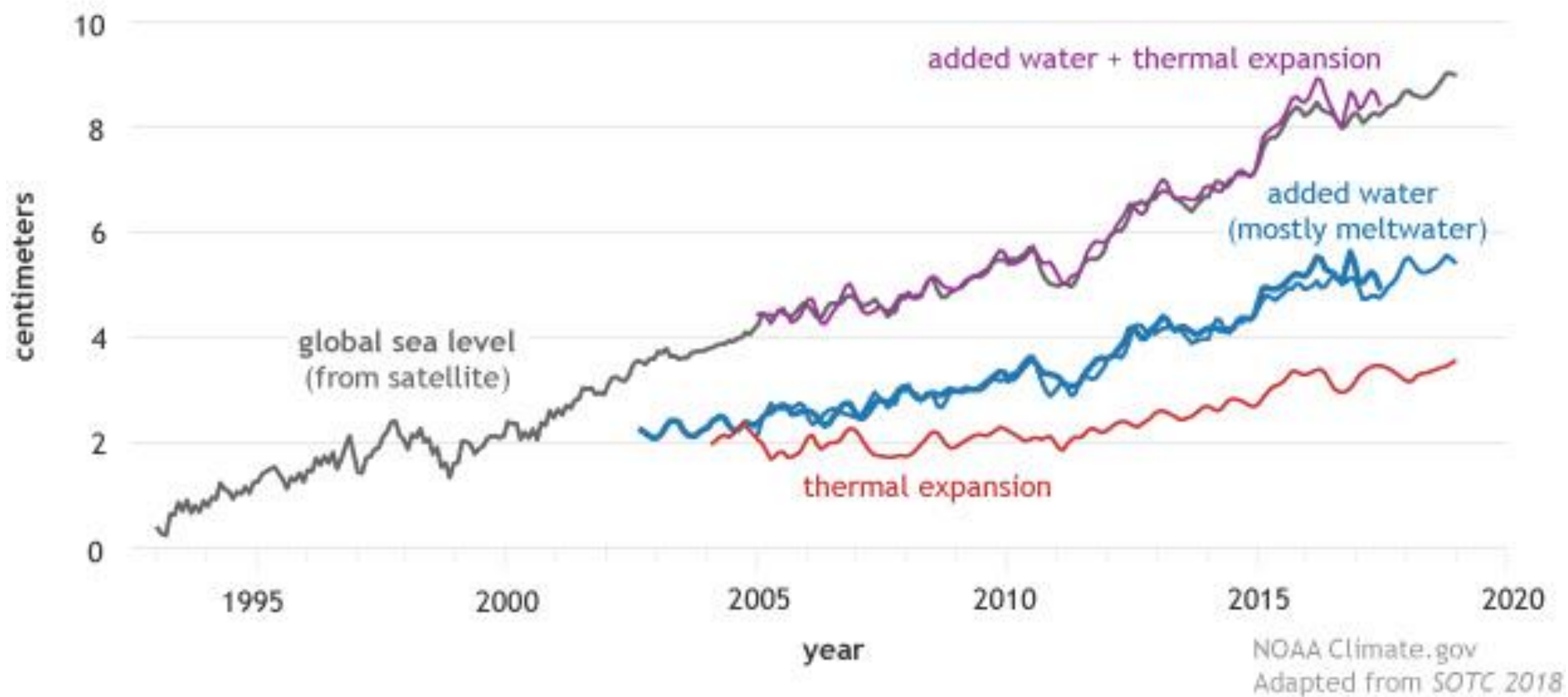
"If all of Greenland is melted, it will contribute 6m to sea-level rise. But the impact is much greater for Antarctica, if the Antarctic Ice Sheet melts completely, sea levels could go up by about 60m"

- [Sea level rise expert Benjamin Horton from the Nanyang Technological University \(NTU\)](#)

"During the exceptionally warm Arctic summer of 2019, Greenland lost 600 billion tons of ice—enough to raise global sea levels by nearly a tenth of an inch (2.2 millimeters) in just two months."

- [Nasa Climate Change](#)

## Contributors to global sea level rise (1993-2018)



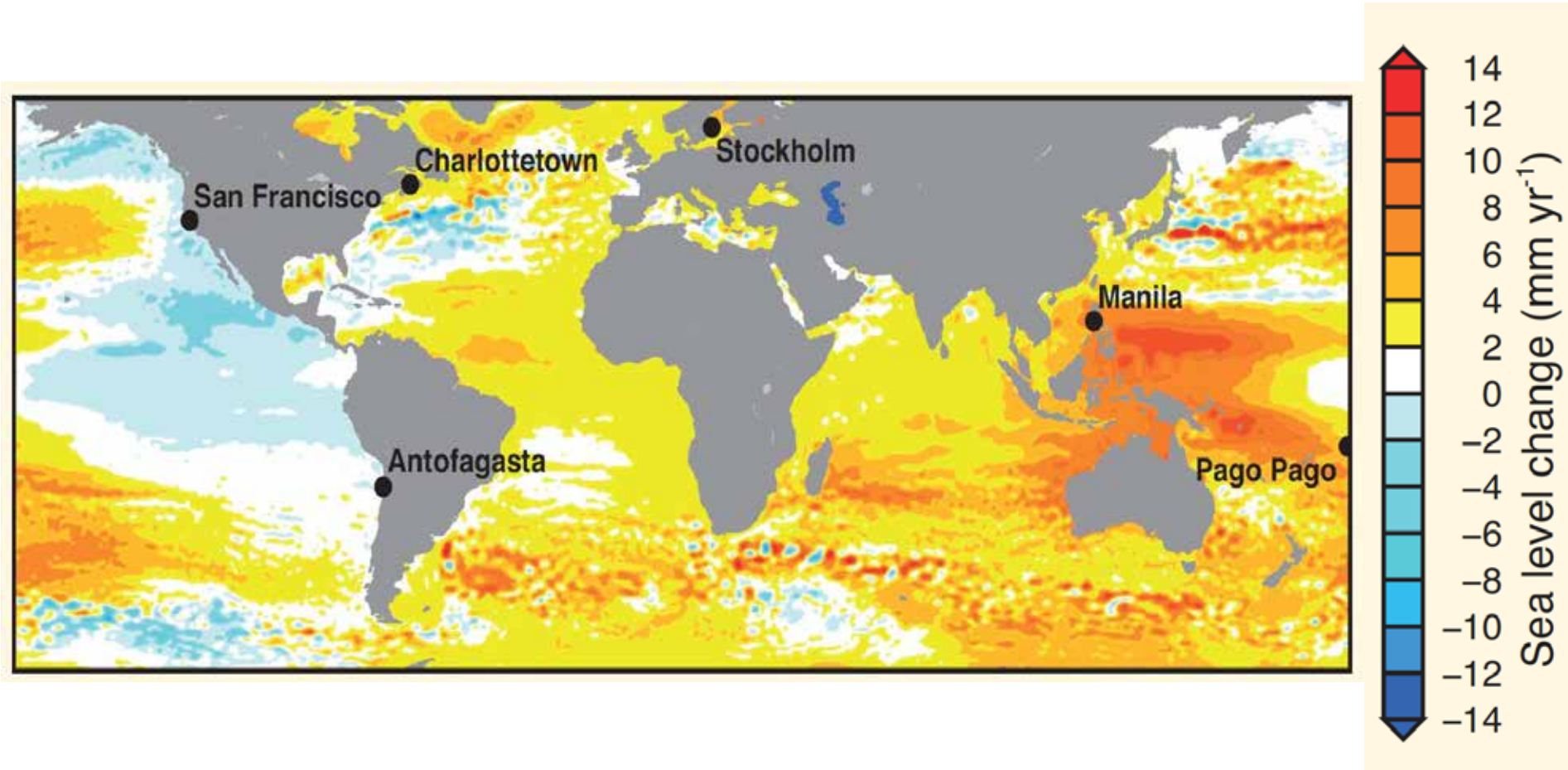
## 2. Regional Sea Level

- Average sea-level change over a region of the Earth's oceans

## 3. Local Sea Level

- Also known as relative sea level change
- ❖ Regional and local sea level changes are affecting each other

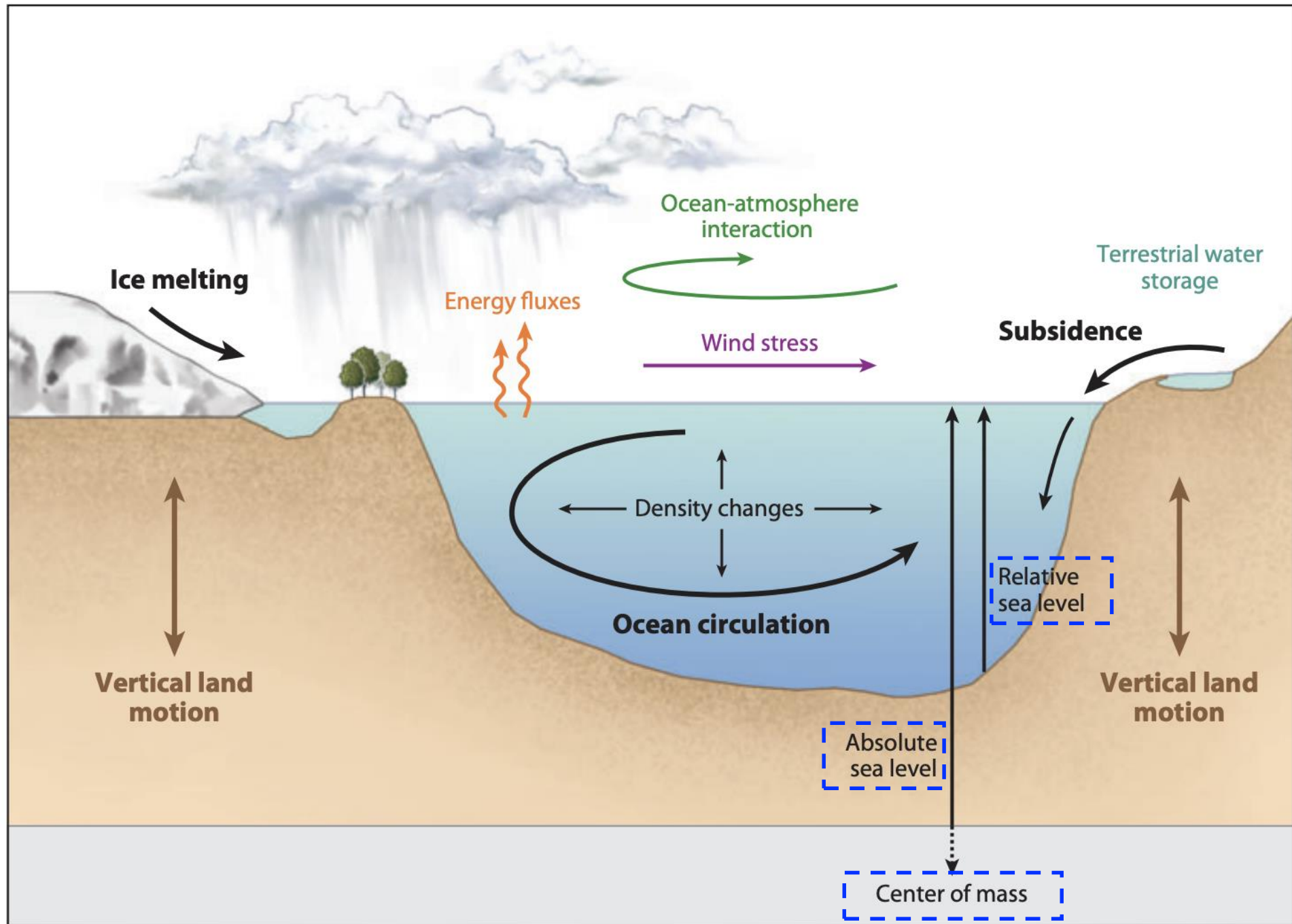
# Rates of change in sea surface height (geocentric sea level) for the period 1993–2012 from satellite altimetry



Source: IPCC (2013), AR5, Chapter 13, FAQ13.1, Figure 1

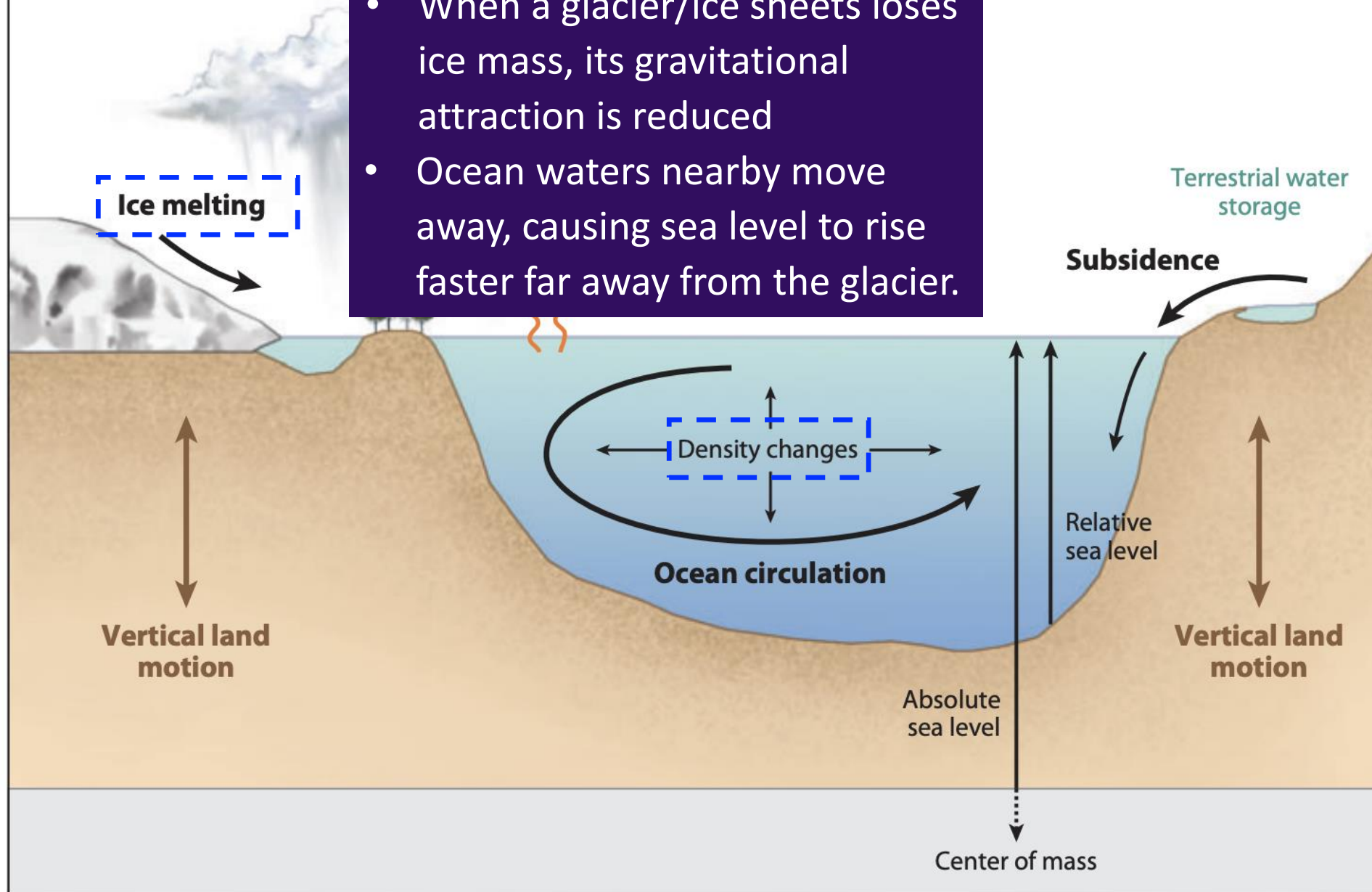
Why Does Regional/Local Sea Level Change Differ  
from the Global Average?





## Sea level fingerprint

- When a glacier/ice sheets loses ice mass, its gravitational attraction is reduced
- Ocean waters nearby move away, causing sea level to rise faster far away from the glacier.



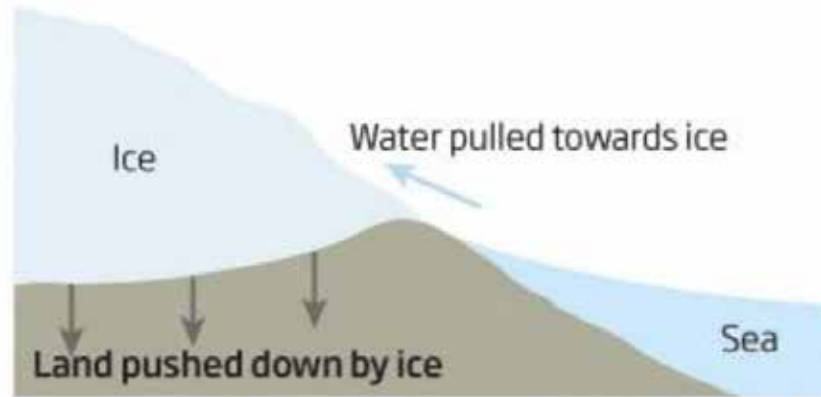
# Ups and downs

©NewScientist

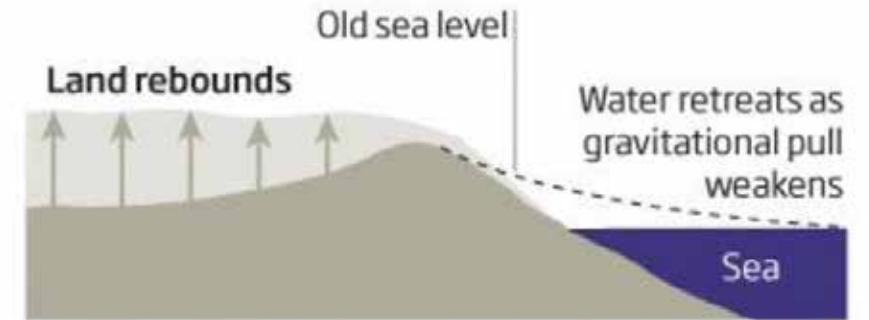
Ice sheets are so large that their gravity pulls water towards them. When they melt this attraction is lost, causing the sea level around them to fall

## Sea Level Fingerprint

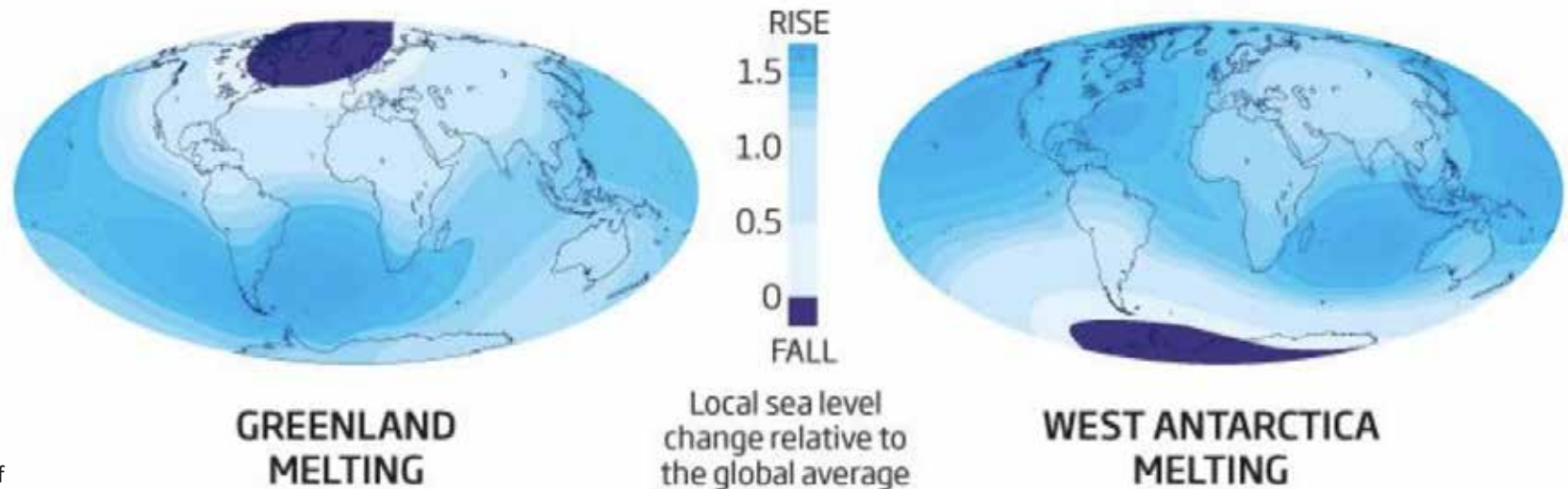
WITH ICE



NO ICE

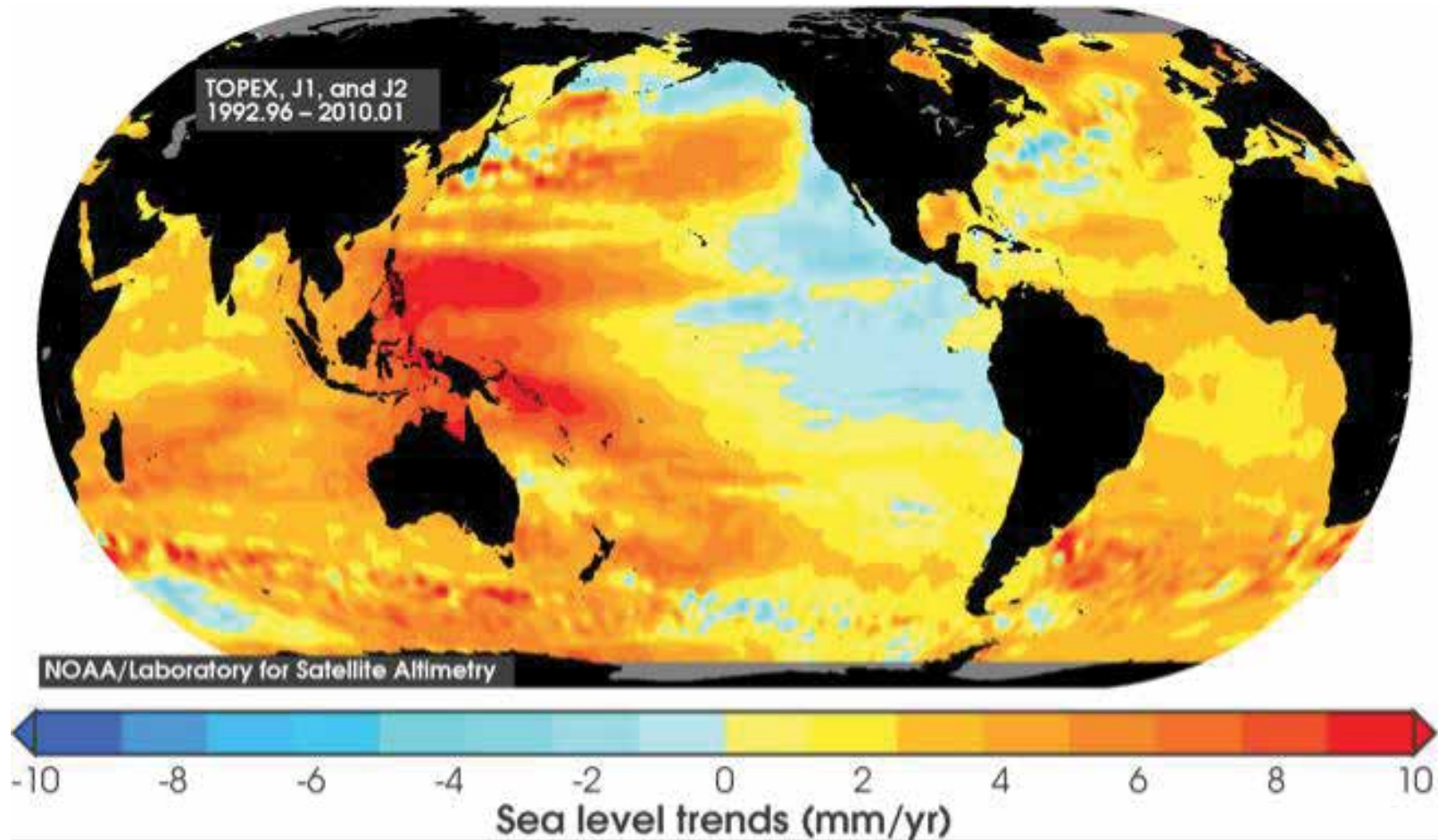


This means the global pattern of sea level rise caused by climate change will vary depending on which ice sheet melts

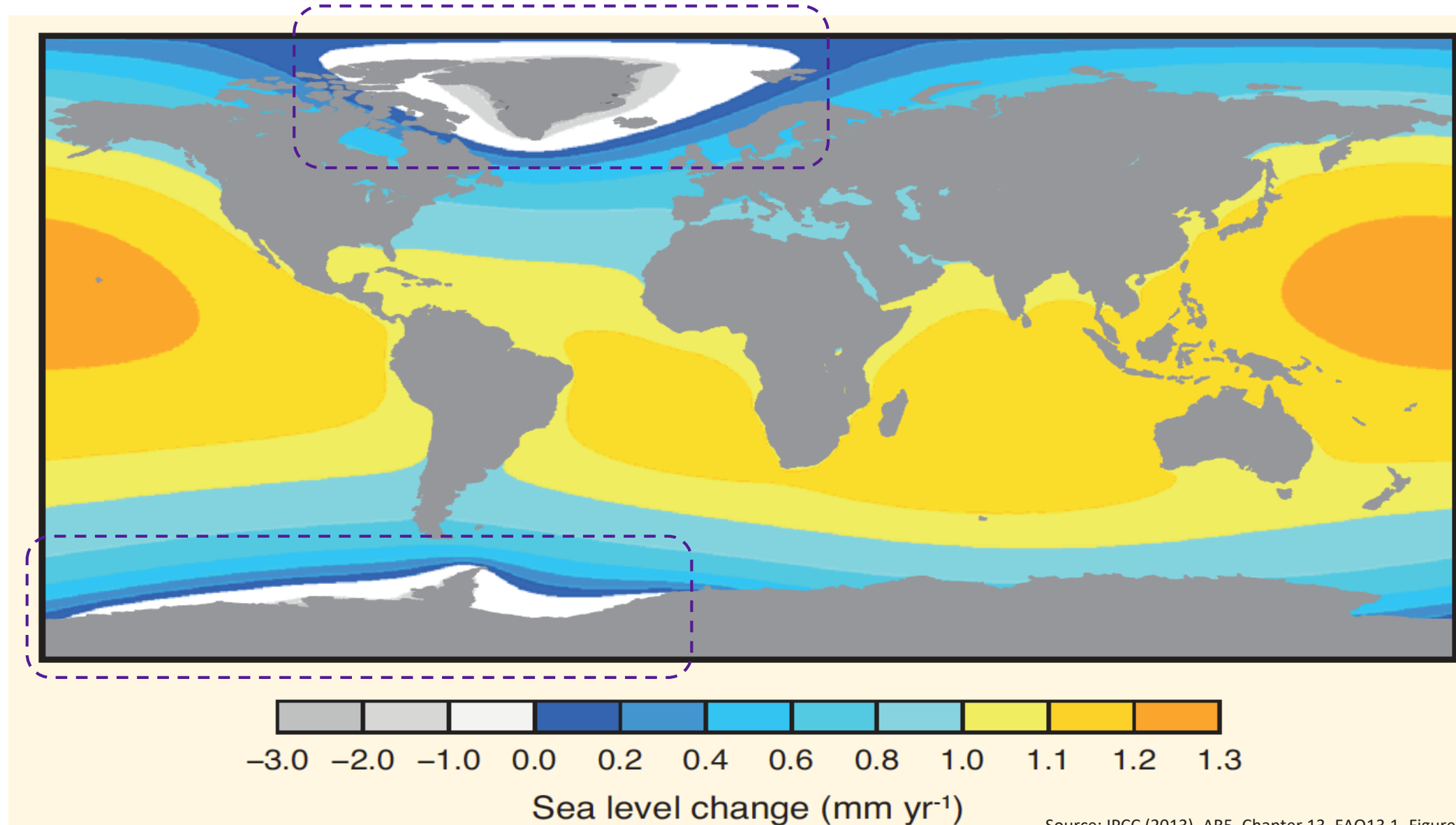


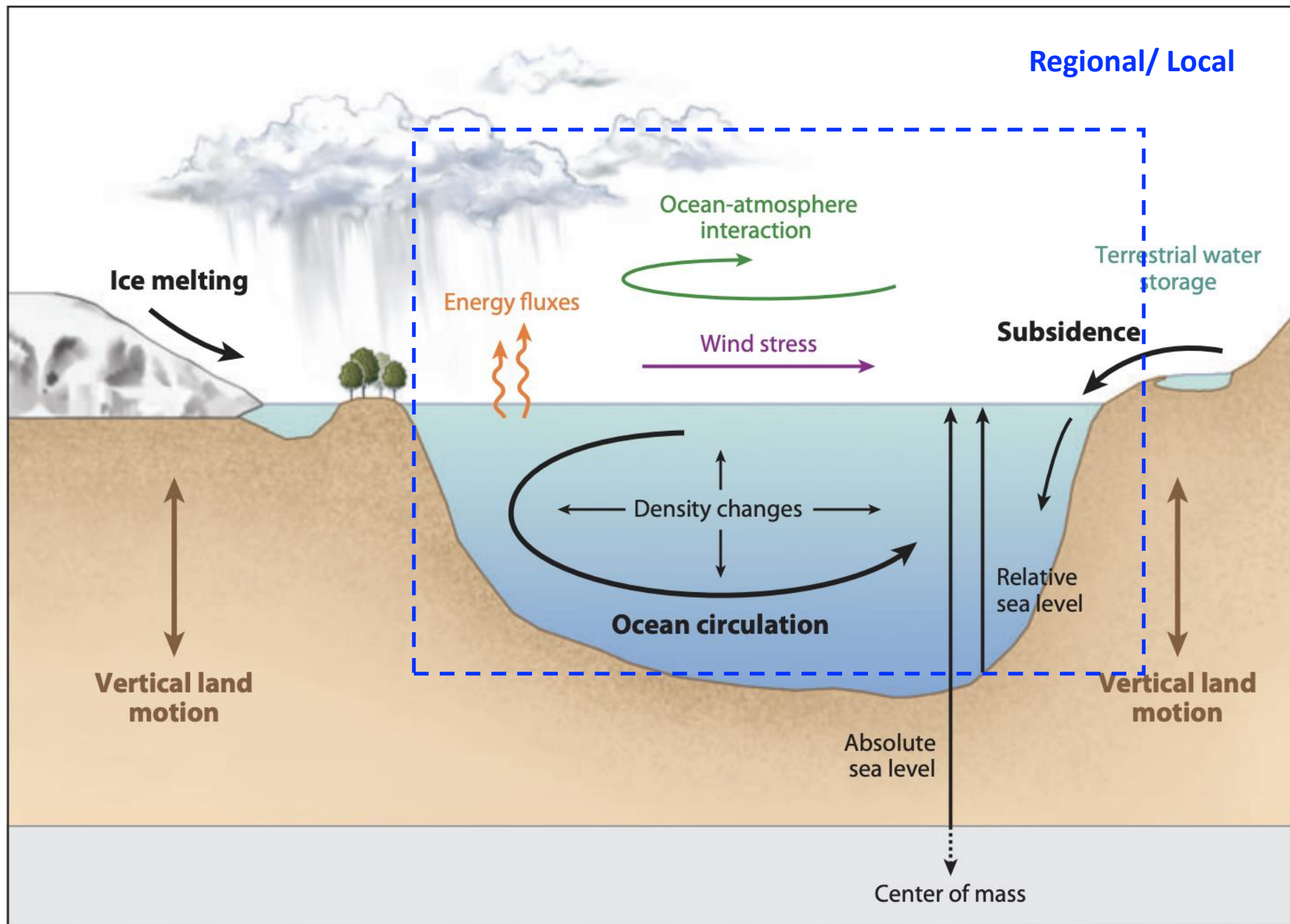


The sea surface is not flat. Sea level and sea level trends are not uniform over the globe.



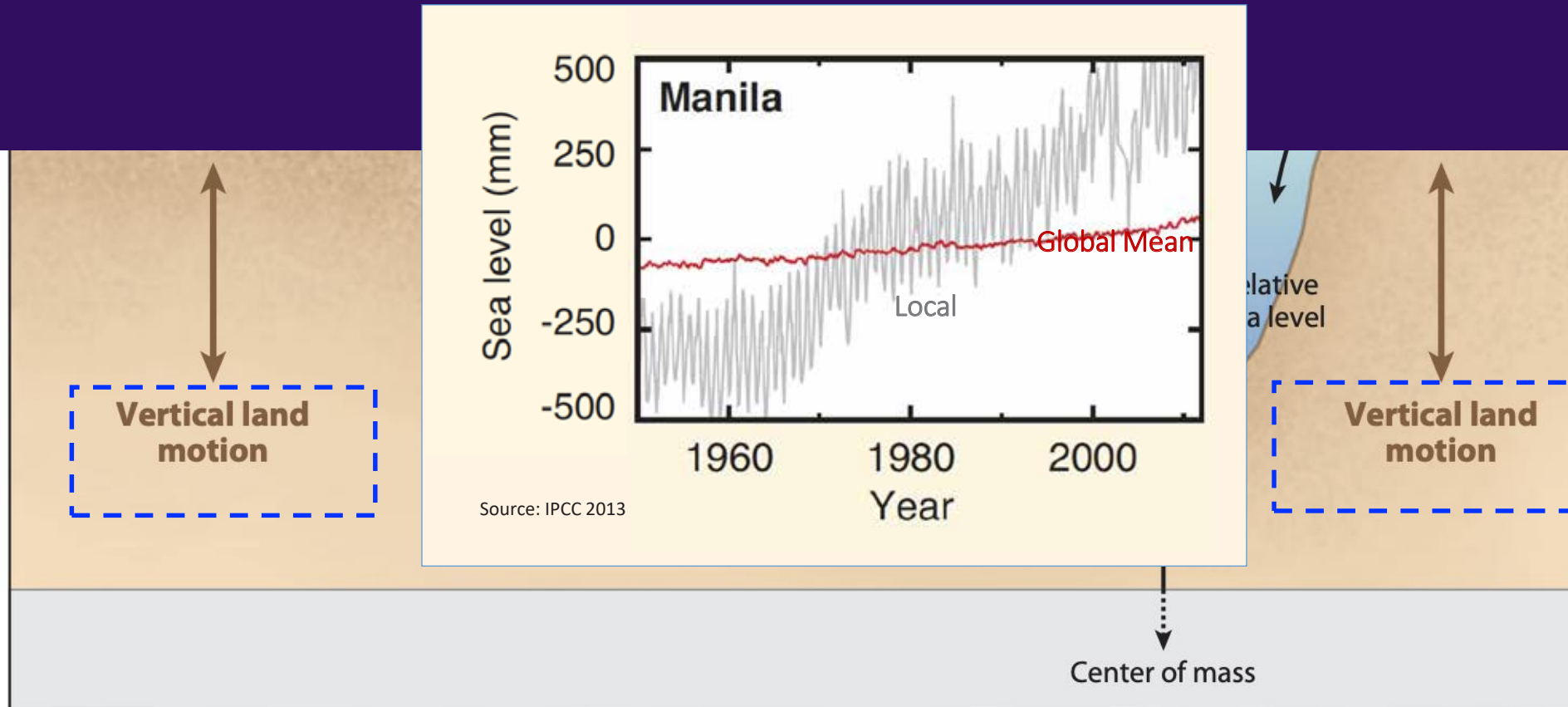
## Melting of the Greenland and the West Antarctic ice sheets at rates of 0.5 mm/yr





## Changes in land elevation

- Natural ongoing land deformation (uplift or subsidence)  
E.g. response to the melting of ancient ice sheets at Stockholm: steady fall in sea level - caused by uplift of this region after the melting of a large (>1 km thick) continental ice sheet at the end of the last Ice Age
- Tectonic, earthquake, tsunami
- Anthropogenic land subsidence: Manila - caused by intensive groundwater pumping



Is El Nino a phenomena of  
anthropogenic climate  
change?





# Why Does Regional/Local Sea Level Change Differ from the Global Average? (Cont.)

Also, **short time spans** (hours to years) natural climate variability

- El Niño and the Pacific Decadal Oscillation
- These climate variations alter surface winds, ocean currents, temperature and salinity, and hence affect sea level
- The influence of these processes will continue during the 21st century

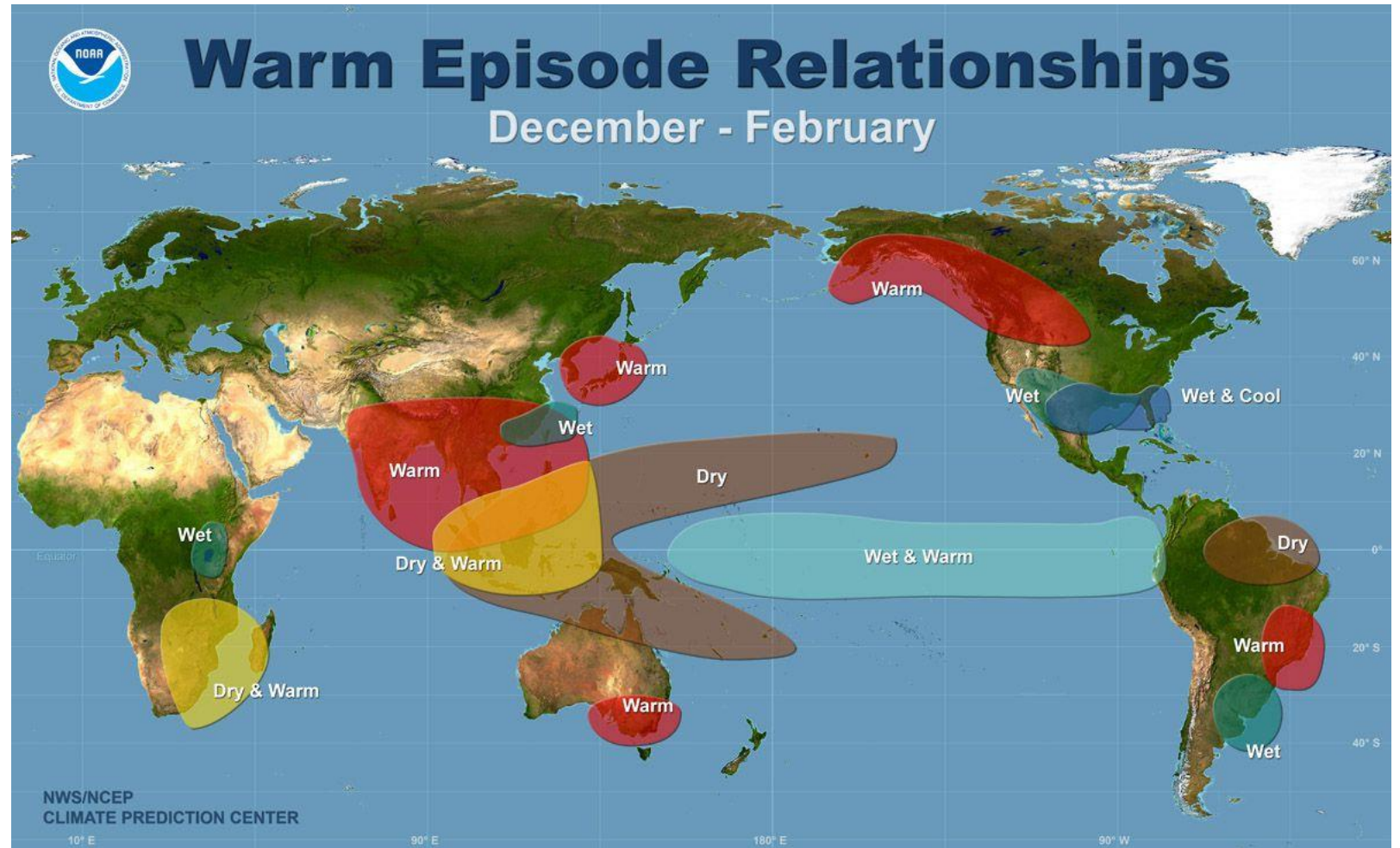
Over the 21st century, effects from the **longer-term trends** (decade to century) are expected to be dominance

- Main contributor to sea level change in most regions: changes in volume of ocean water and land ice

# El Niño event: Occur irregularly at 2 to 7 years interval

Regional sea levels are strongly affected because of **ocean temperatures**:

- Western South America experiences a substantial rise, due to the warmer water, while SE Asia will see a small decrease in sea level.
- As El Niño brings rain to South America, it brings droughts to Indonesia and Australia.
- The last major El Nino event occurred in 2015
- Heavy rain, flooding and drought
- Though is a **natural phenomena**, the impacts are intensified due to climate change



*Survey:*

*“Climate change could be caused by the natural variations.  
True or false?”*

The [UN's World Meteorological Organisation \(WMO\)](#) predicts above-average sea surface temperatures in many parts of the world, which will lead to higher than normal land temperatures **even without El Niño**

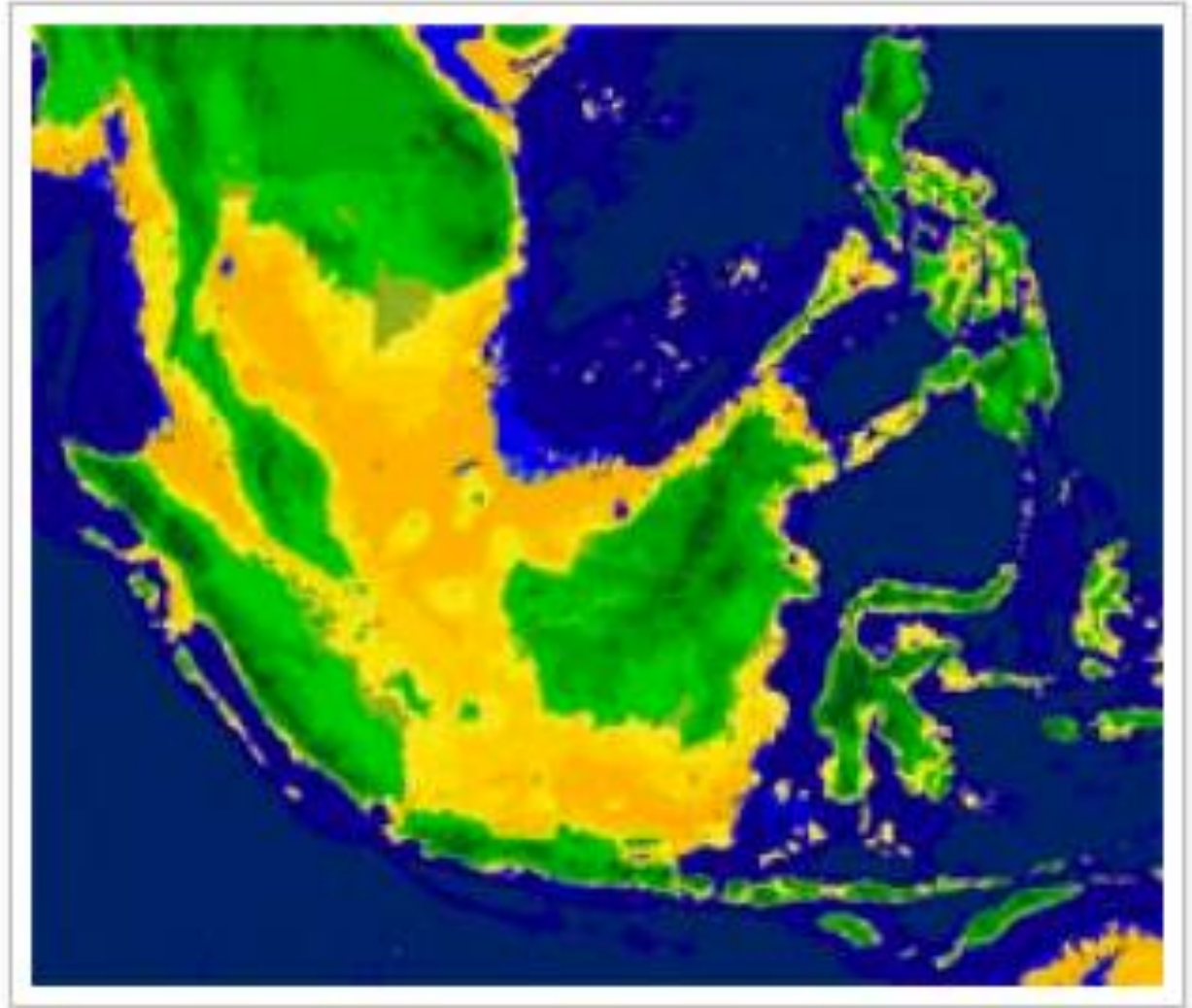
**“The signal from human-induced climate change was now as powerful as the natural phenomenon”**



# How sea level rise matters in Southeast Asia

## SE Asia and Asia Pacific shoreline at last glacial maximum (approximate)

The yellow and orange areas were **dry land** just 16,000 years ago, when there was much more water locked in continental ice.



*Sixteen thousand years ago surrounding seas were 110 meters lower than today. (Credit: Maps drawn by Clara Simpson, Field Museum, University of Chicago.)*

In the PAST & RECENT:

*Who Suffers Most from Extreme Weather Events?*  
(1999 – 2018)

# Climate Risk Index: Ranking 1999 - 2018

1 - 10 11 - 20 21 - 50 51 - 100 >100 No data

Countries most affected by extreme weather events (1999-2018)

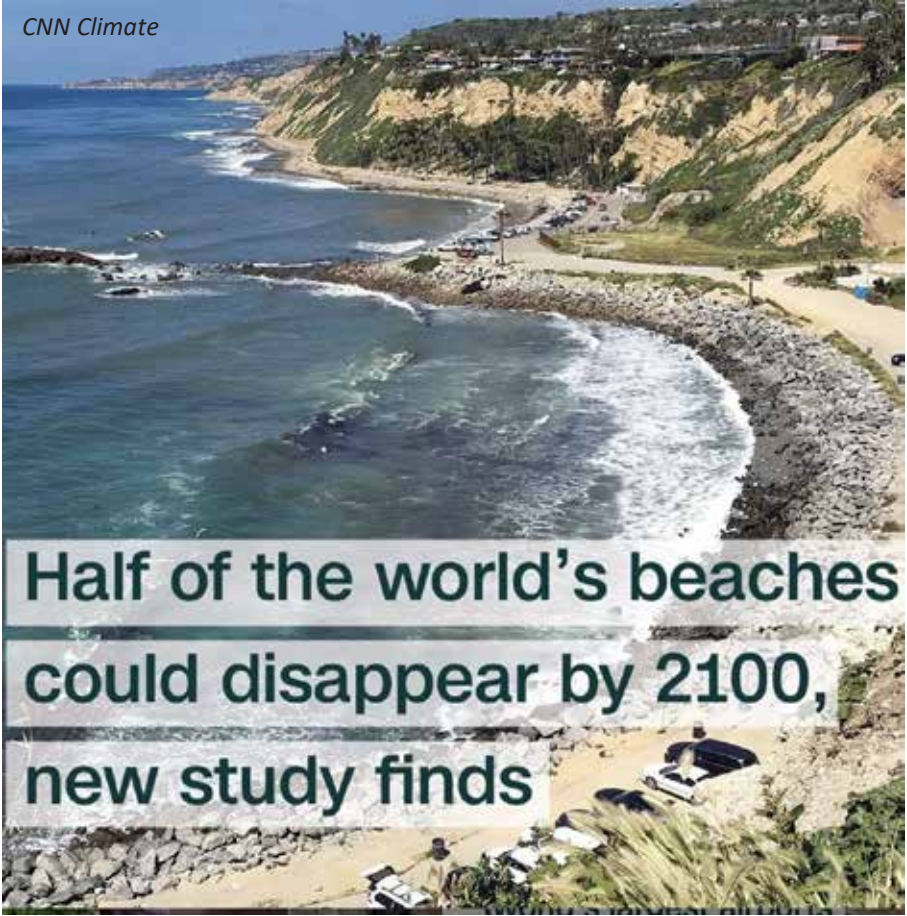
Countries most affected by extreme weather events (1999-2018)

- 1 Puerto Rico
- 2 Myanmar; >90% of losses or deaths in a year
- 3 Haiti
- 4 Philippines
- 5 Pakistan
- 6 Vietnam
- 7 Bangladesh
- 8 Thailand
- 9 Nepal
- 10 Dominica

E.g. floods, storms, droughts and wildfires



CNN Climate



Half of the world's beaches  
could disappear by 2100,  
new study finds

In the FUTURE:

*Flood Threat & Inundation  
(2050)*

Land projected to be **below the elevation** of an **average annual flood level** in 2050

**Vietnam, Indonesia, and Thailand** are among countries that could be threatened by **permanent inundation by 2100**



# With moderate emissions cuts (RCP 4.5): Current population below the elevation of an average annual flood in 2050

## Top 6 countries:

1. China (93mil people)
2. Bangladesh (42mil people)
3. India (36mil people)
4. **Vietnam (31mil people)**
5. **Indonesia (23mil people)**
6. **Thailand (12mil people)**



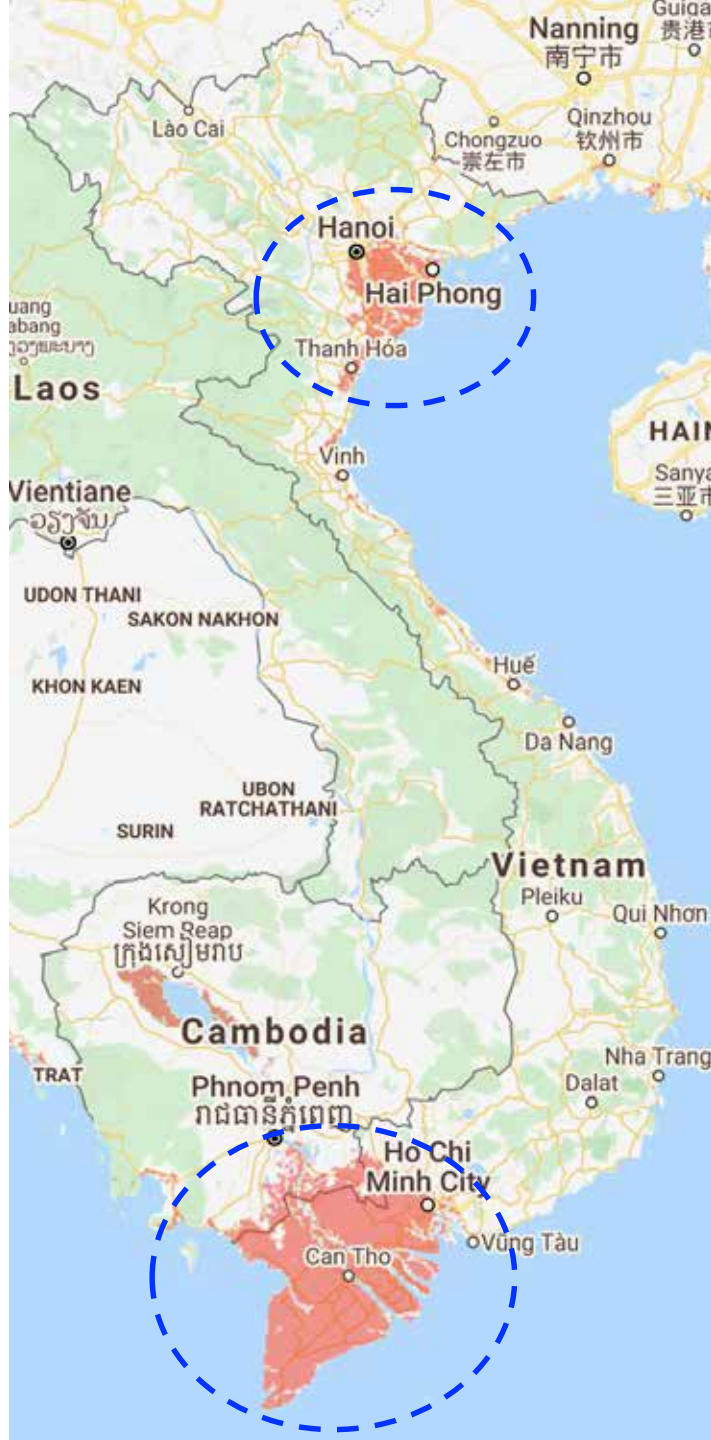
**ONLY 3** ASEAN member states:  
**66mil** people in total

10 ASEAN member states?

# Flood Inundation in 2050

Lands at Risk in ASEAN Member States:  
Capitals at risk





## VIETNAM

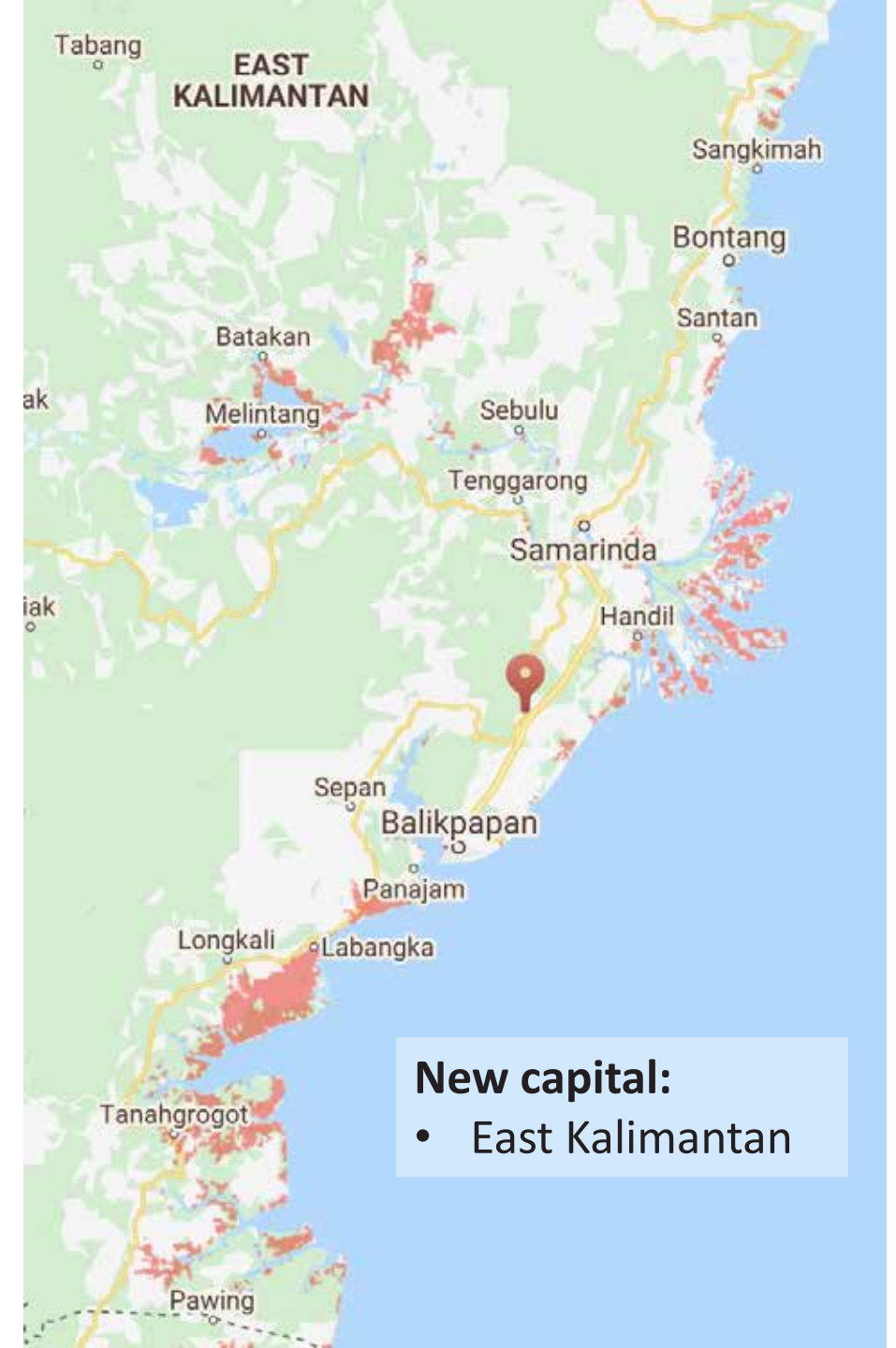
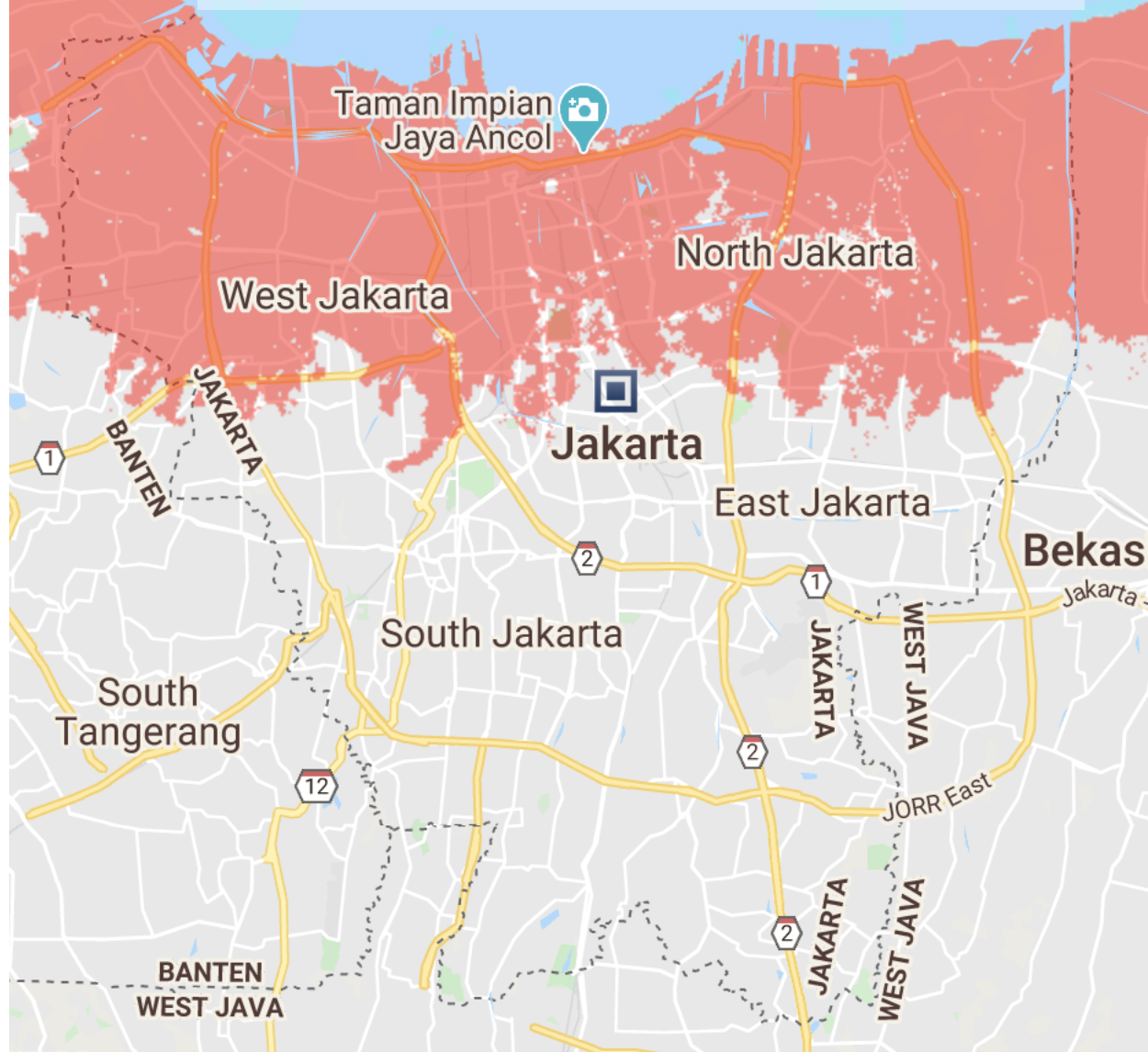
High density of population:  
Hanoi – Capital  
Ho Chi Minh City – business district

# INDONESIA



### Current capital:

- High density of population
- Almost half of the Jakarta's area is at risk



### New capital:

- East Kalimantan



# THAILAND

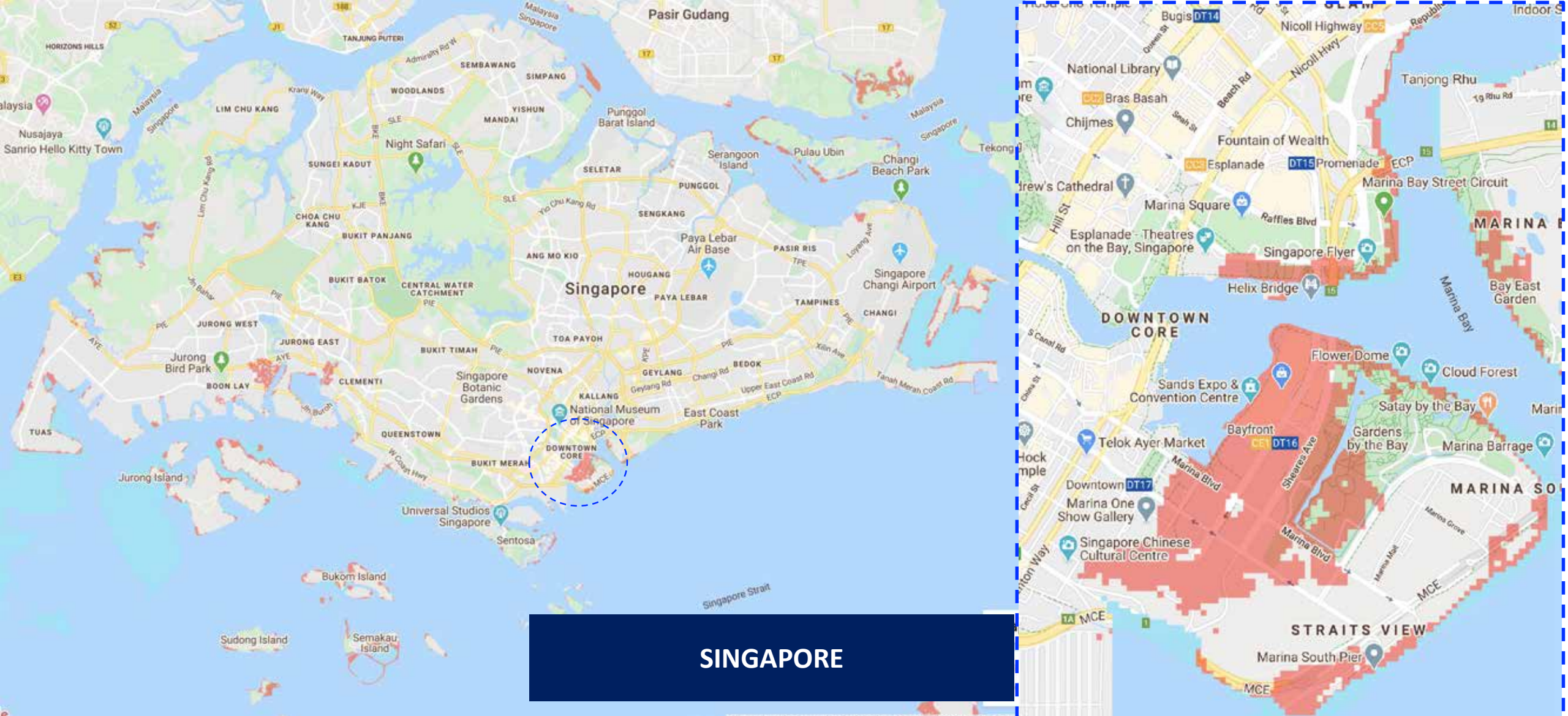


The Chao Praya is tidal in Bangkok and so sea level rise greatly increases the likelihood and severity of this kind of flooding and damage.

Year	2025	2050	2075	2100
Sea-level rise projection (cm)	14	32	58	88
Total flood inundation area (km <sup>2</sup> )	1429	1611	1917	2311
Percentage of total Bangkok area	43%	48%	57%	69%

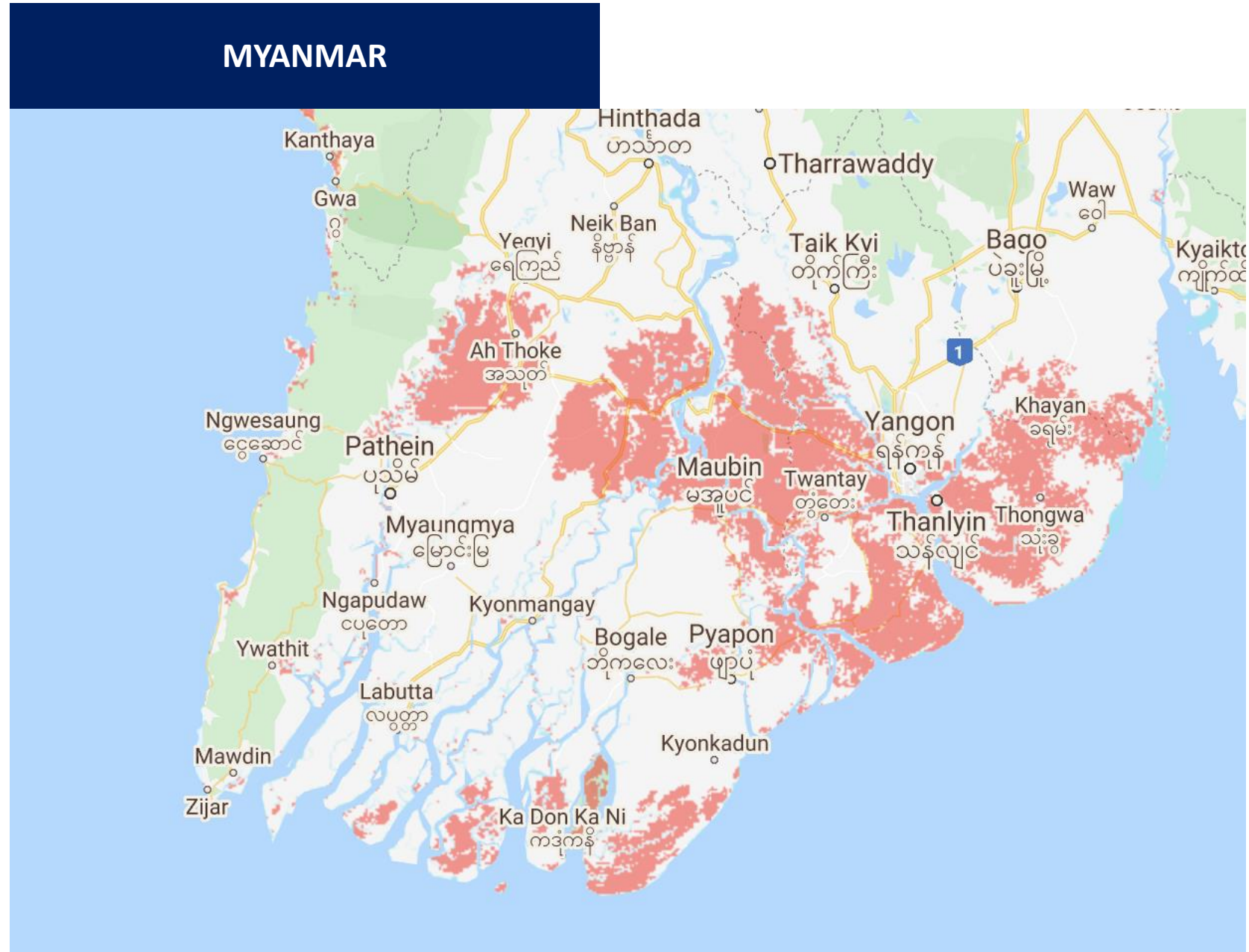
Source: Adapted from Dutta (2011).





Singapore, as a low-lying nation with about 30% of the island less than 5m above the mean sea level  
[Severe sea-level events](#) in Singapore could also start happening once every year by around [2055](#) to 2065, instead of  
once a century (IPCC 2019)



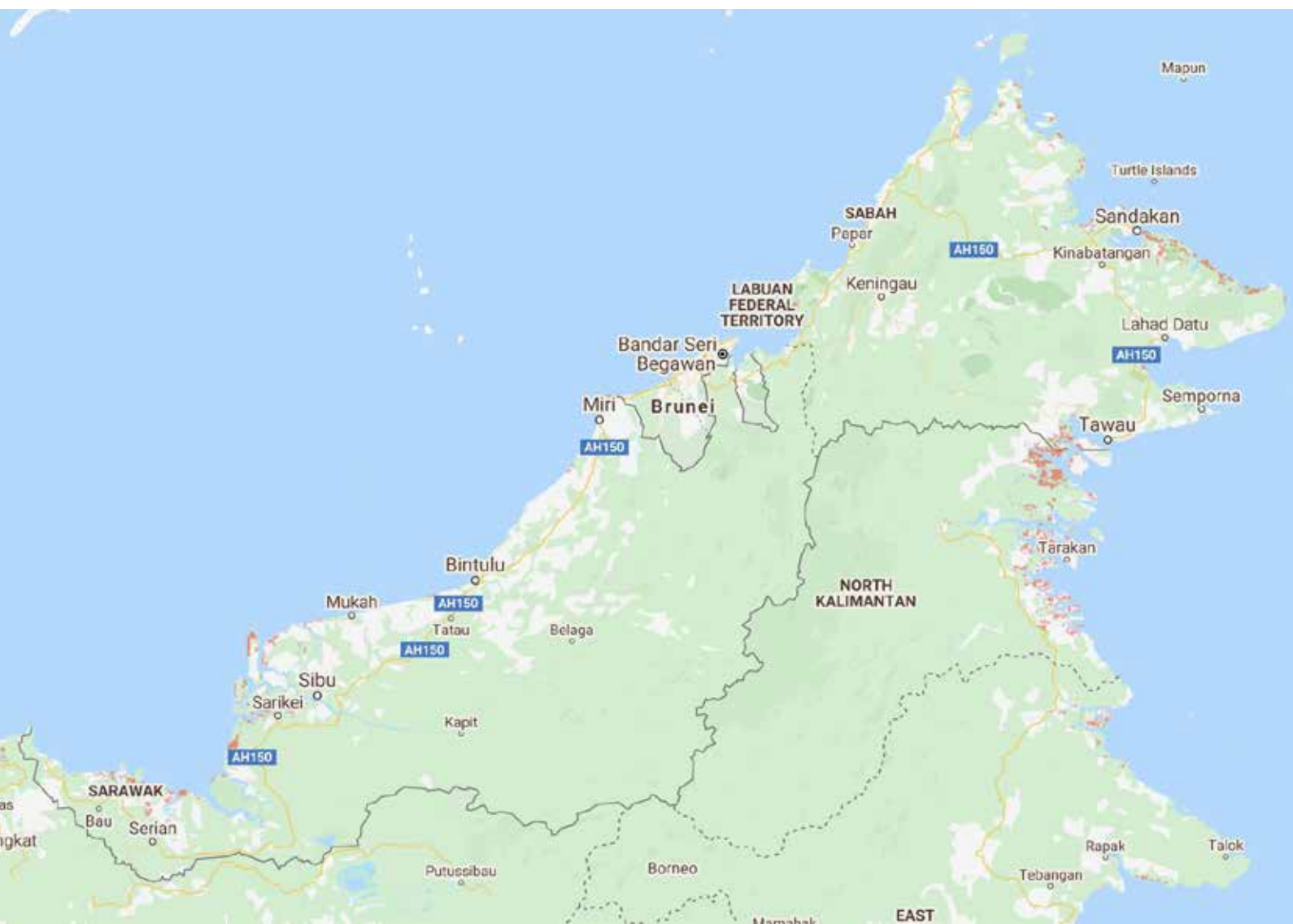


# Flood Inundation in 2050

Lands at Risk in ASEAN Member States:  
Non-capital Areas







# Flood Inundation in 2050

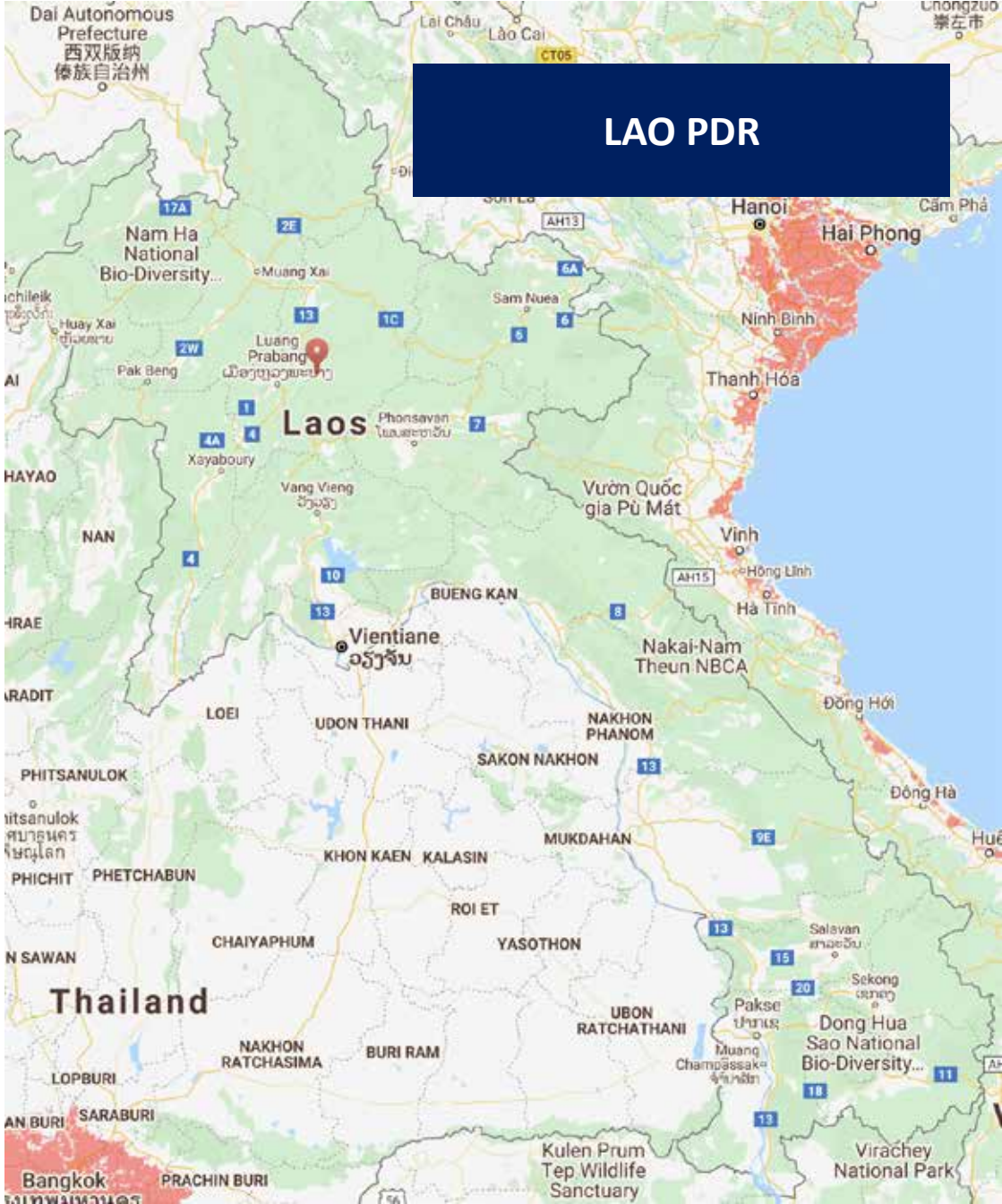
Lands at Risk in ASEAN Member States:  
Relatively less flood inundation



BRUNEI



LAO PDR





# Climate Risk Index: Ranking 1999 - 2018

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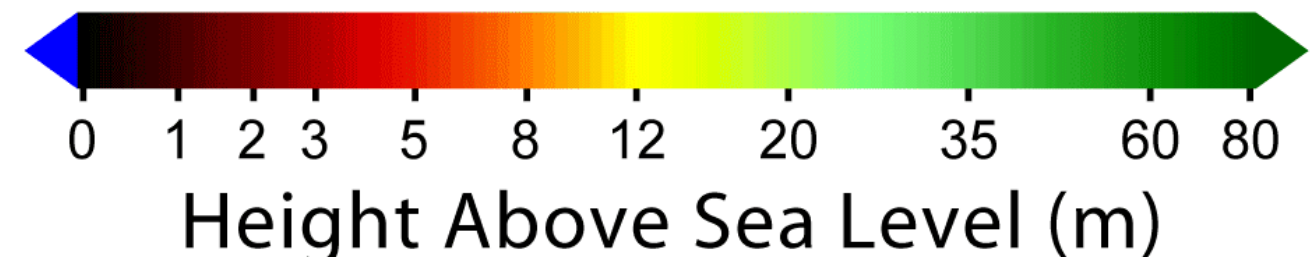
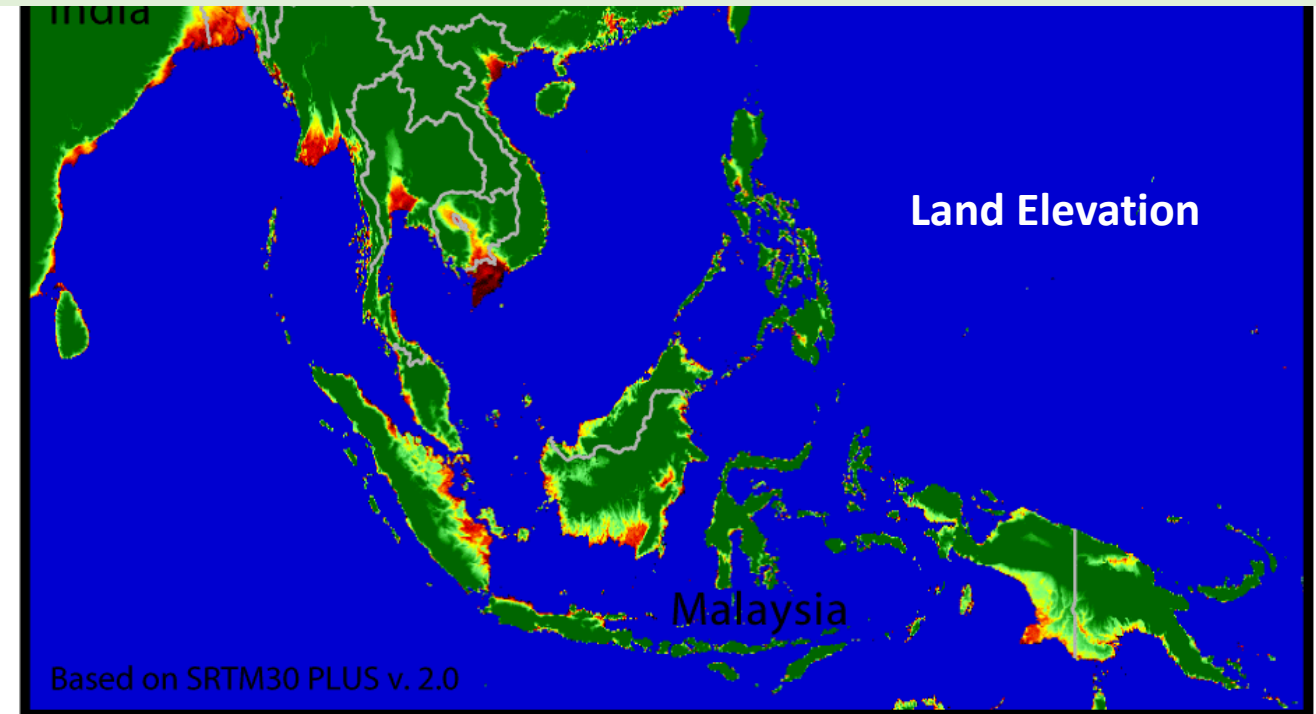
Countries most affected by extreme weather events (1999-2018)

Countries most affected by extreme weather events (1999-2018)

1	<i>Puerto Rico</i>
2	<i>Myanmar</i>
3	Haiti
4	Philippines
5	Pakistan
6	Vietnam
7	Bangladesh
8	Thailand
9	Nepal
10	Dominica

*E.g. floods, storms, droughts and wildfires*

- One of the world's most typhoon impacted places
- Climate change is contributing to stronger typhoons
- Higher sea surface temperatures
- Higher subsurface sea temperatures - remove the natural buffer for cold water up wells from below the ocean's surface
- Stronger typhoons carry more moisture
- Move faster and will be aggravated by sea level rise





## However... the poor minority out there...



- [Sitio Pariahan](#), about 17 km (10.5 miles) north of Manila
- A coastal village in the Philippines that was once an island, and is now without land
- Sinking about 4 cm (1.5 inches) every year, owing largely to land subsidence from the population's overuse of groundwater
- A deep well – the only source of water to bathe, clean, cook and even to drink
- Villagers: "Without a boat, you are paralysed"
- Sea levels caused by global warming could soon make this village unliveable
- *Solar panels are installed on many rooftops for electricity*

# Further Reading

Learn more about El Niño

- <https://www.youtube.com/watch?v=WPA-KpldDVc>

What is global sea level?

- <http://www.youtube.com/watch?v=q65O3qA0-n4>

Ocean and cryosphere

- [https://www.ipcc.ch/site/assets/uploads/2017/09/WG1AR5\\_Chapter02\\_FINAL.pdf](https://www.ipcc.ch/site/assets/uploads/2017/09/WG1AR5_Chapter02_FINAL.pdf)

Sea level change

- [https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5\\_Chapter13\\_FINAL.pdf](https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter13_FINAL.pdf)
- <https://sealevel.nasa.gov/understanding-sea-level/regional-sea-level/ice-mass-loss>
- <https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level>
- Stammer, D., Cazenave, A., Ponte, R. M., & Tamisiea, M. E. (2013). Causes for Contemporary Regional Sea Level Changes. Annual Review of Marine Science, 5(1), 21–46. doi:10.1146/annurev-marine-121211-172406

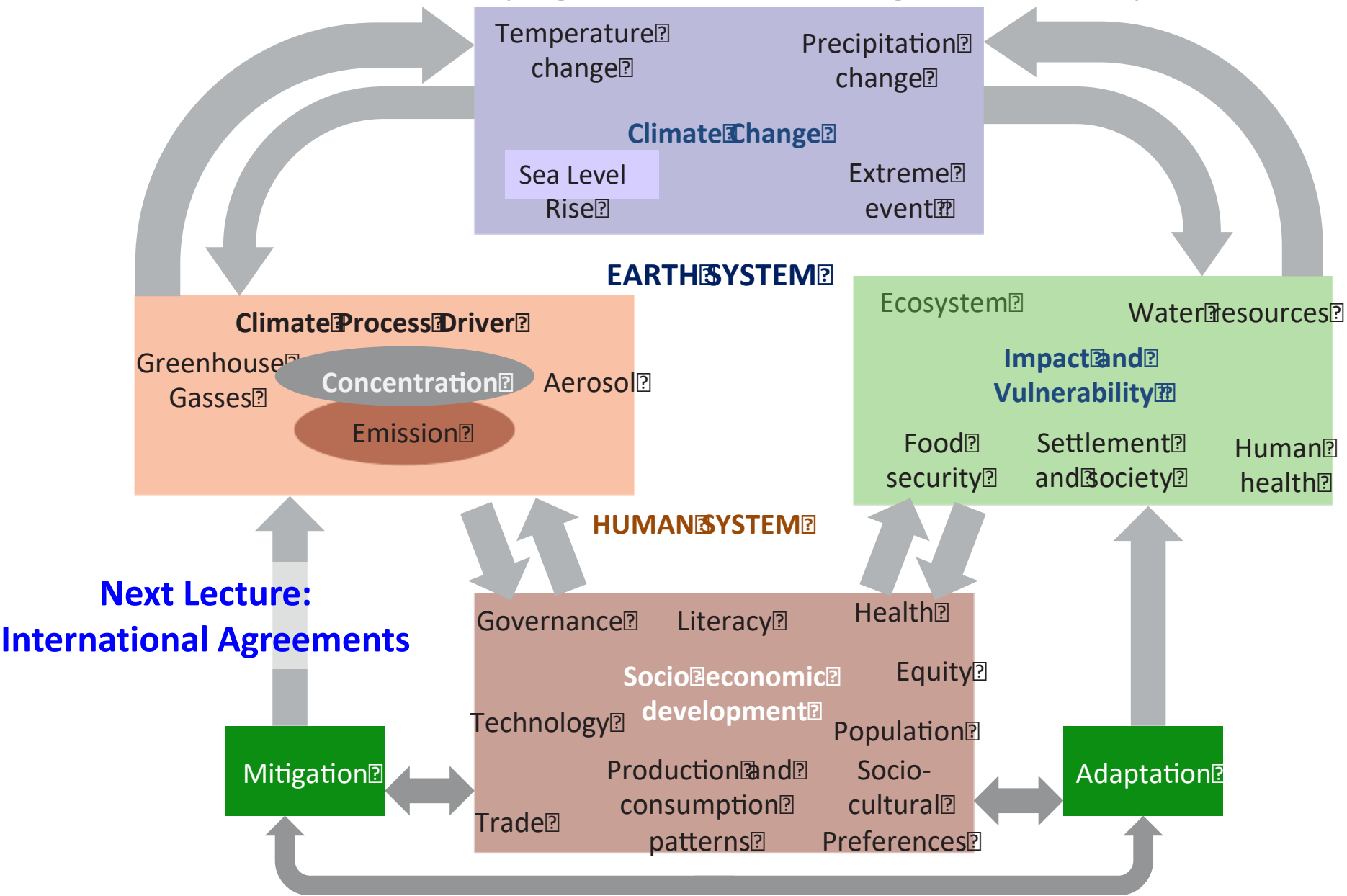
Global climate risk index 2020

- [https://germanwatch.org/sites/germanwatch.org/files/20-2-01e%20Global%20Climate%20Risk%20Index%202020\\_14.pdf](https://germanwatch.org/sites/germanwatch.org/files/20-2-01e%20Global%20Climate%20Risk%20Index%202020_14.pdf)

Flood inundation risk in Southeast Asia

- <https://www.climatecentral.org/news/report-flooded-future-global-vulnerability-to-sea-level-rise-worse-than-previously-understood>
- Kulp, S.A., Strauss, B.H. New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. Nat Commun 10, 4844 (2019). <https://doi.org/10.1038/s41467-019-12808-z>
- Interactive threat maps at coastal.climatecentral.org <http://coastal.climatecentral.org/>

Schematic framework of anthropogenic climate change drivers, impacts and responses



# THANK YOU!

**NEXT...**

## **International Agreements:**

- The United Nations Framework Convention on Climate Change (UNFCCC)
- Kyoto Protocol
- Paris Agreement



Norwegian Ministry  
of Foreign Affairs

Implemented by:



Norwegian Institute  
of International  
Affairs



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