中国地质大学
China University of Geosciences

CoEco Symposium

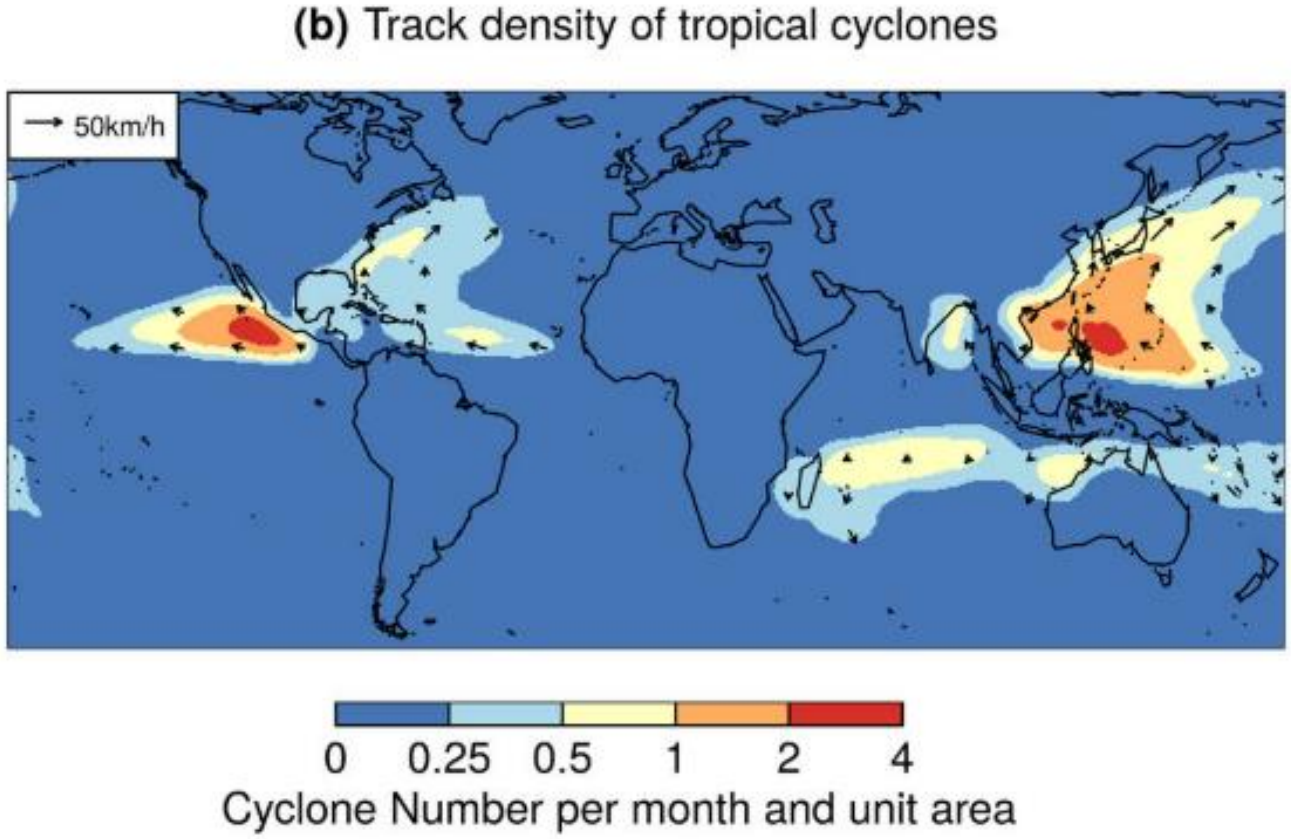
Potential impacts of the increasing coastal flooding on mangrove forest ecosystem

Liu Zhenhai

2021/04/18

Track density of tropical cyclones

- The **highest occurrence probability** is observed in the eastern Central American, and **northern southeast Asia**.
- Cyclonic atmospheric flows cause strong surface winds and low atmospheric pressure at the sea surface with consequent high metrological tides, but also can lead to intense precipitation.



Mangrove forests distributions

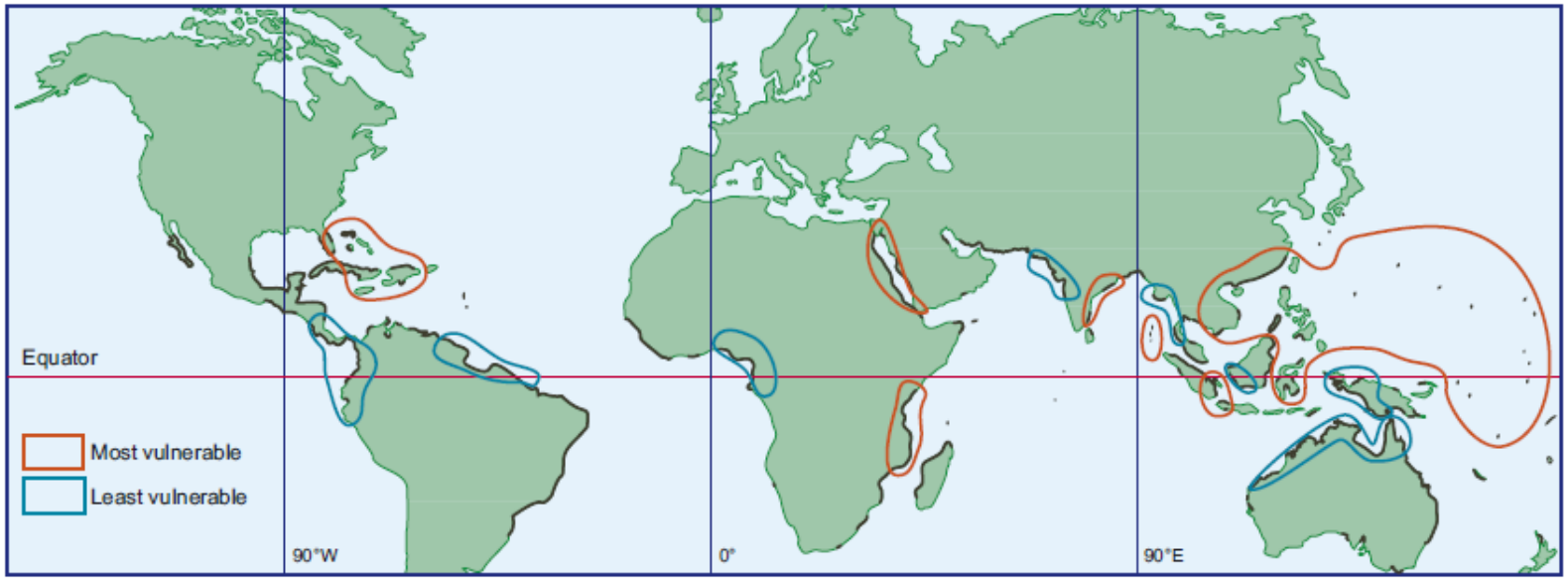
- The total mangrove area accounts for 0.7% of total tropical forests of the world.
- The mangroves grow in river deltas, lagoons and estuarine complexes; they also occur on colonized shorelines and islands in sheltered coastal areas with locally variable topography and hydrology.
- The largest extent of mangroves is found in Asia (42%) followed by Africa (20%), North and Central America (15%), Oceania (12%) and South America (11%).

Mangrove forests distributions of the world – 2000.

Giri, C., 2011, Global Ecology and Biogeography

Vulnerable regions to climate change

- Some mangroves will survive and perhaps even thrive with the predicted changes in climate.
- Given all of the confounding responses by mangroves to increases in humidity, CO2, and sea level, the most realistic scenario is to delimit the most and least vulnerable forests.
- The most vulnerable regions are marked by red lines and the northern southeast Asia is the main region of it.

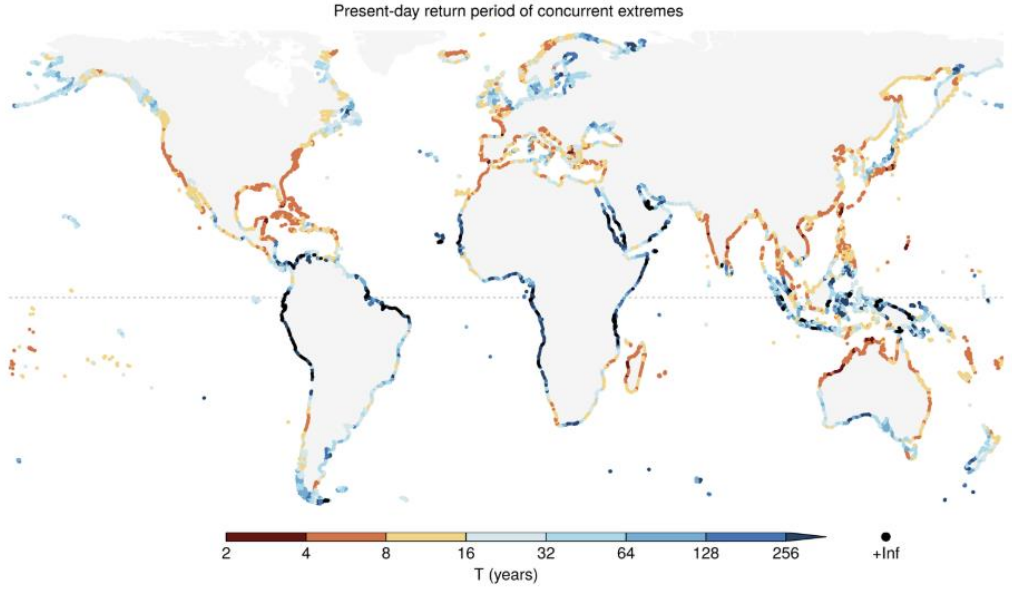


The most and least vulnerable regions to climate change of the world's mangrove forests

(Alongi, D.M., 2008, Estuarine, Coastal and Shelf Science)

Return period of co-occurring extremes

- Part of the reason of the vulnerability of the northern southeast Asia is the frequent concurrent extremes in precipitation and meteorological tide.
- The short return period can be found in the northern southeast Asia.
- Under a high emissions scenario, the probability of compound coastal flooding would increase globally by more than 25% by 2100 compared to the present.

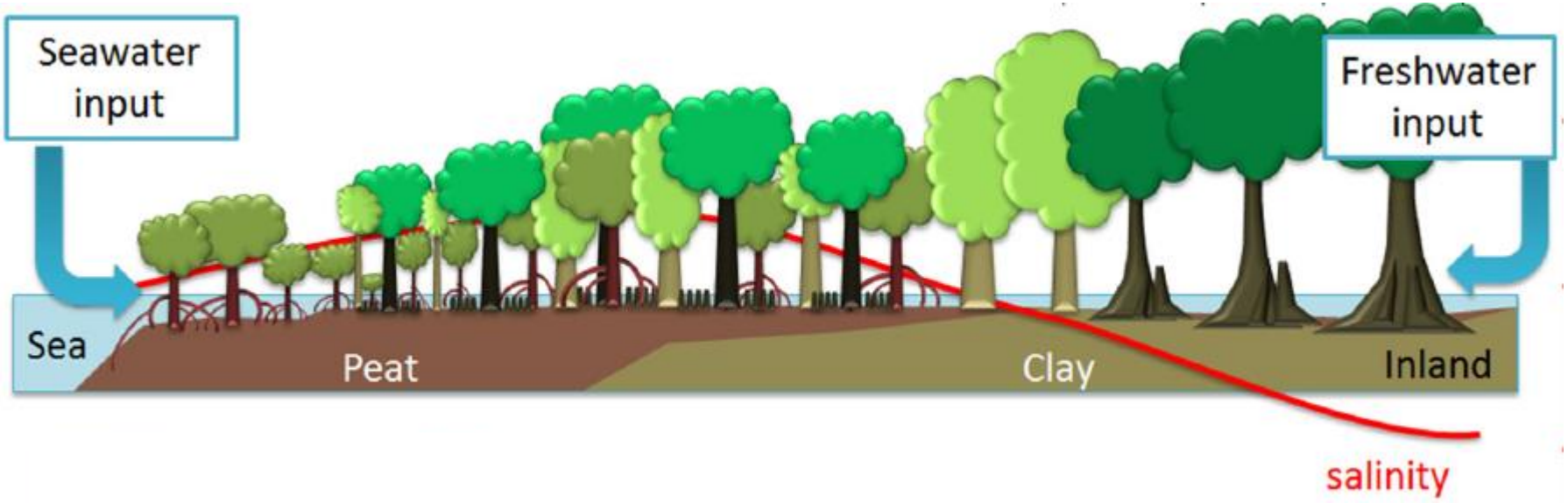


Present-day return period of concurrent extremes in precipitation and meteorological tide (1980–2014)

Bevacqua, E., 2020, Communications Earth & Environment

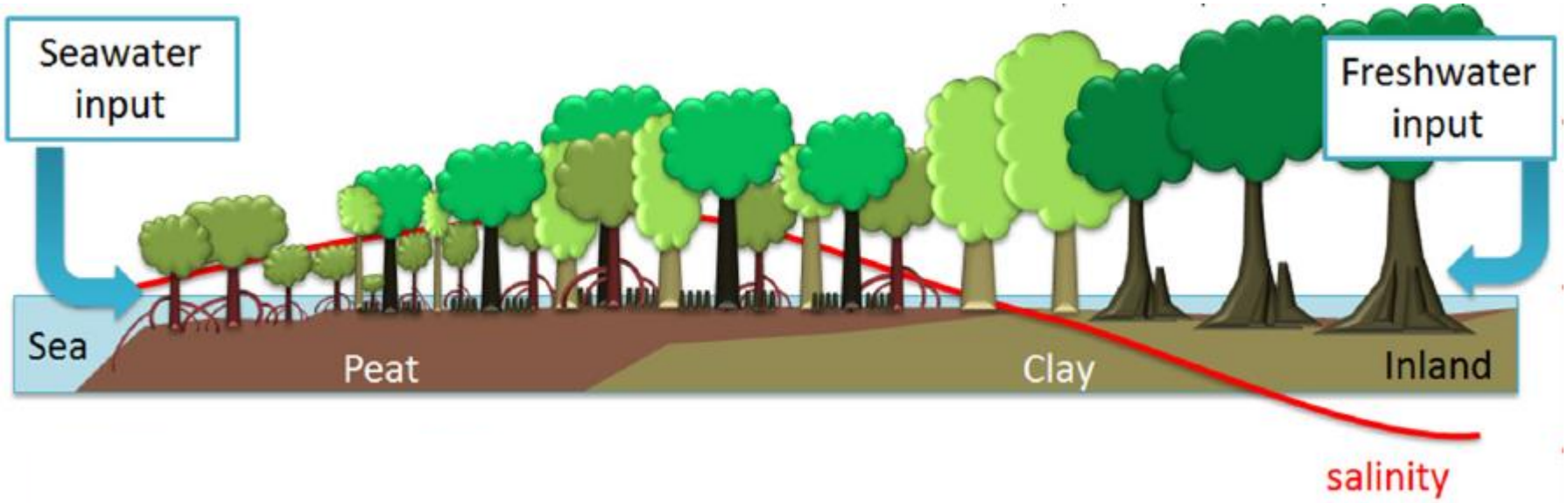
Seawater and freshwater

- Hydrology plays a major role in relation with tides, seaward, and freshwater inputs, landward.
- As salt-tolerant trees, mangroves grow in coastal saline or brackish water and could effectively buffer coastal communities from storm surges.



Seawater and freshwater

- Precipitation patterns are likely to lead to variational fluvial sediment and salinity in the estuarine mangroves.
- Changes in precipitation patterns may affect the patterns of freshwater inflow, diminishing salinity concentration in consequence, and affecting mangroves growth and their distribution.
- In these estuarine systems, high freshwater inputs could potentially lead to mangrove loss and replacement by riparian flood forest vegetation.

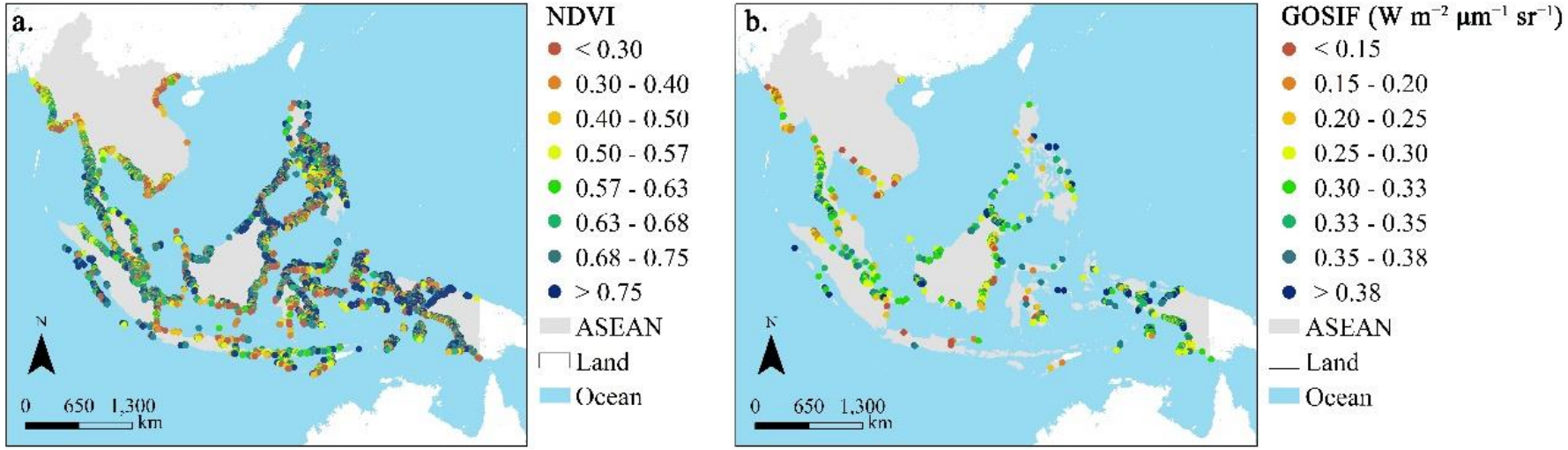


Question

- If there have different stability (resistance and resilience) of mangrove ecosystems, when the flood with different salt level occurs

The spatial distribution of mangrove

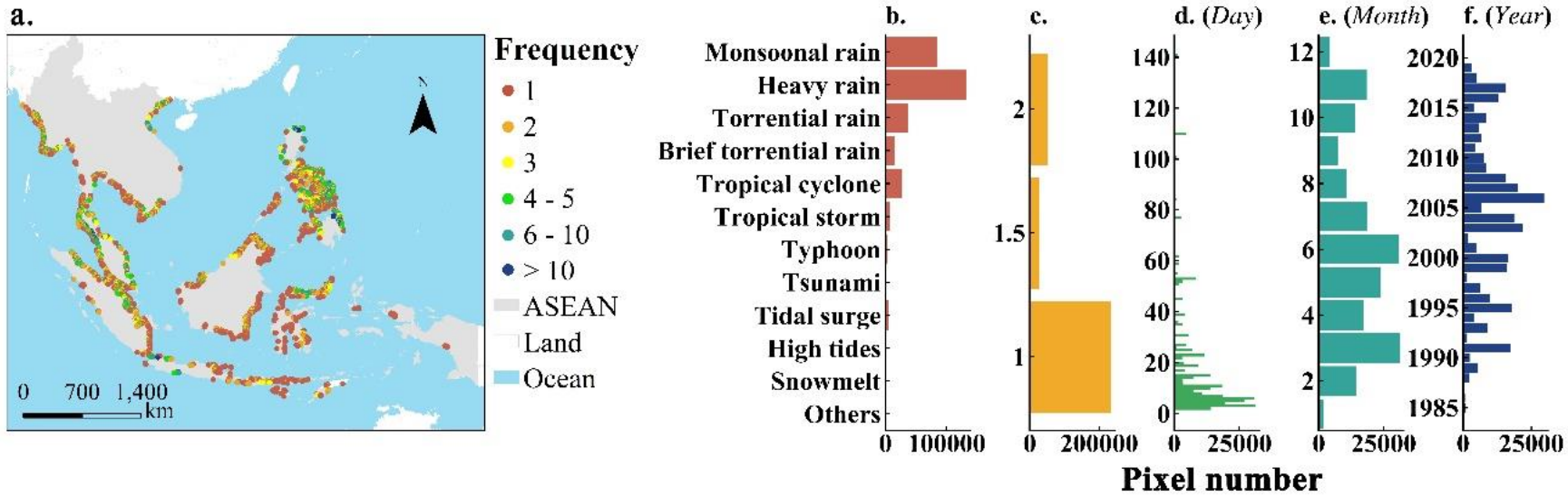
- A large amount of mangrove is distributed in the southeast Asia. The high vegetation index of mangrove, containing NDVI and GOSIF, is mainly distributed in the Philippines and Indonesia.



The spatial distribution of NDVI (a) and GOSIF (b) in ASEAN mangrove region. The number of dots represents the mean value of NDVI from 2000 to 2019 and the mean value of GOSIF from 2001 to 2018 at one pixel, respectively.

Statistical information of flood events

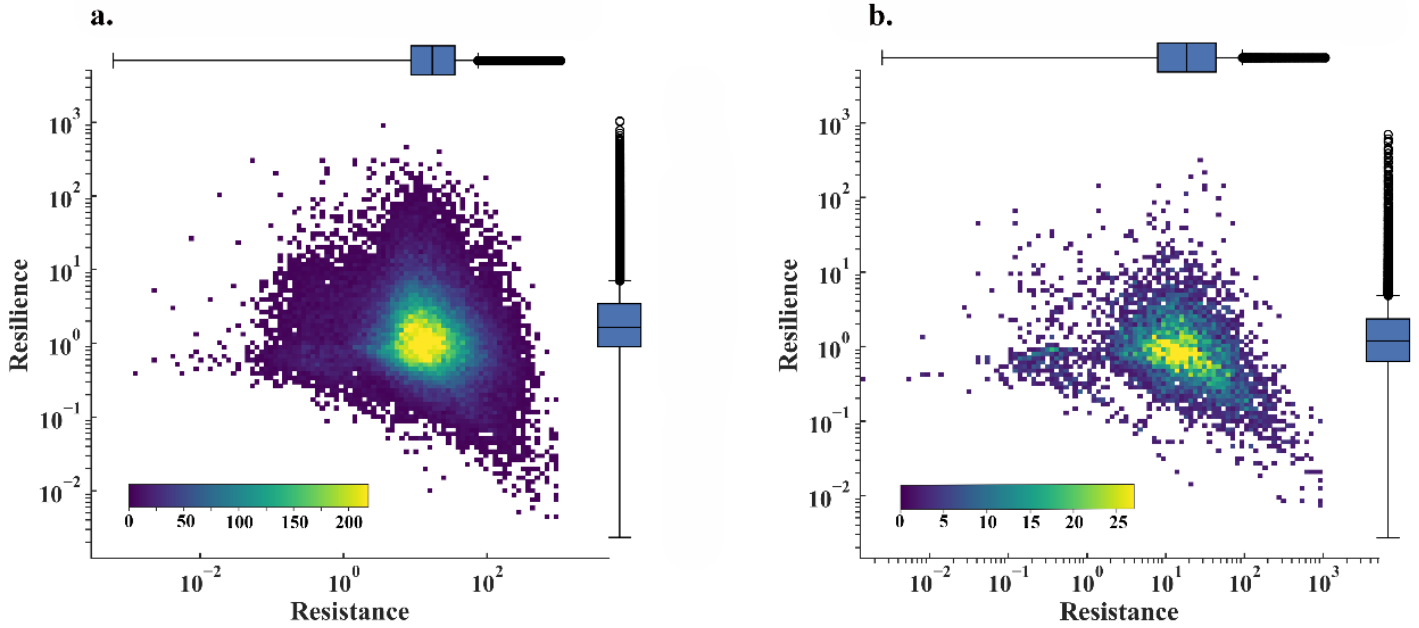
- We first assess the spatial and temporal variations of different extreme coastal flooding events from 1985 to 2019.
- The high incidence areas of coastal flood events are mainly distributed around the equator and Philippine Islands, and heavy rain and monsoonal rain are the primary causes of coastal flood formation.



Statistical information of flood events in the ASEAN mangrove region from 1985 to 2019 underlying DFO. (a) The spatial distribution of occurring frequency. The number of dots represents the occurring frequency of flood events at one pixel. The distribution of main cause (b), severity (c), duration (d), occurring month (e) and year (f) of flood events. The x-axis of (b–f) represents the accumulative pixel number of flood events occurring regions.

Resistance and resilience

- Second, the stability of mangrove forest ecosystems to the coastal flooding were analyzed through the disparity of resistance and resilience calculated by MODIS NDVI datasets.
- NDVI has lower average resistance to flood events caused by extreme precipitation (28.17), compared to the seawater floods (37.33).
- However, NDVI has similar resilience to different coastal flood events (3.73 and 3.47).

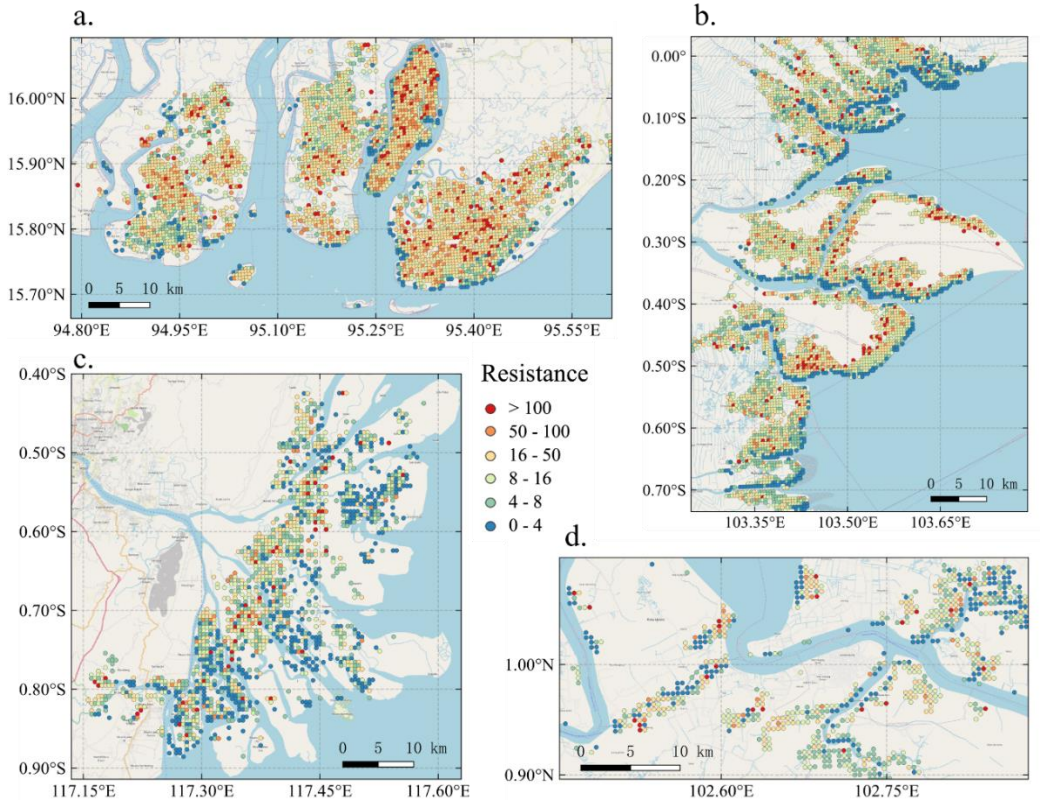


The resistance and resilience of NDVI to flood (a) and tsunami (b) events. The various color represents the number of pixels with same coordinates.

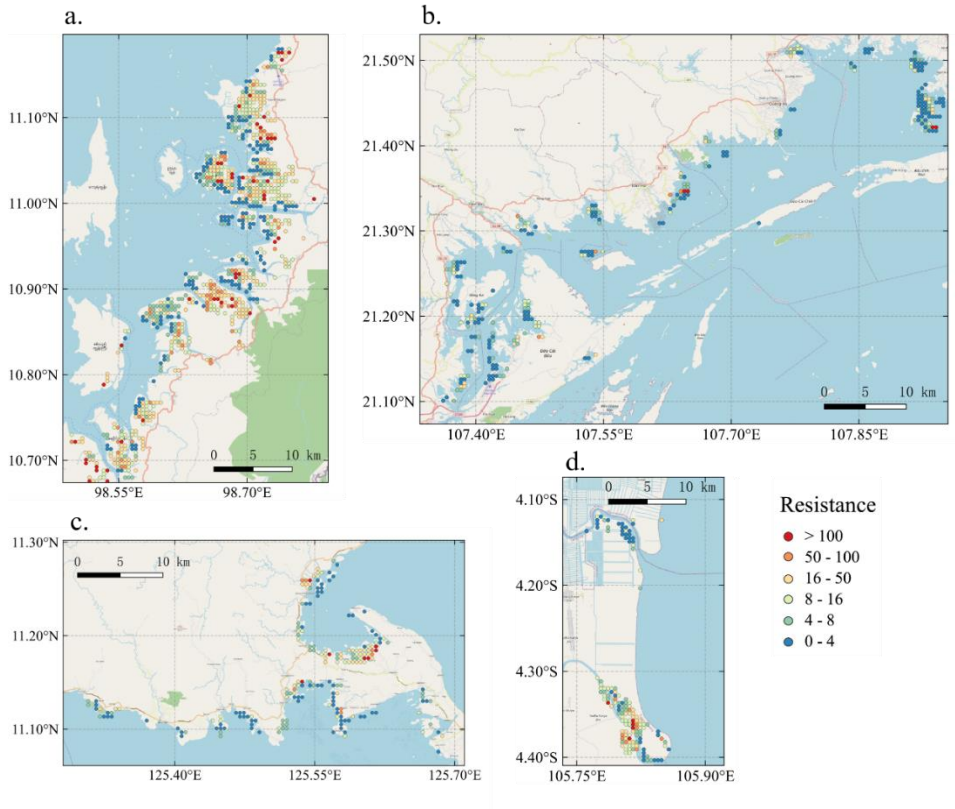
	mean resistance	mean resilience
Flood	28.17	3.73
Tsunami	37.33	3.48

Resistance for selected mangrove regions of the SEA

- Mangroves that are closest to oceans or rivers generally have low resistance, especially to freshwater flooding events



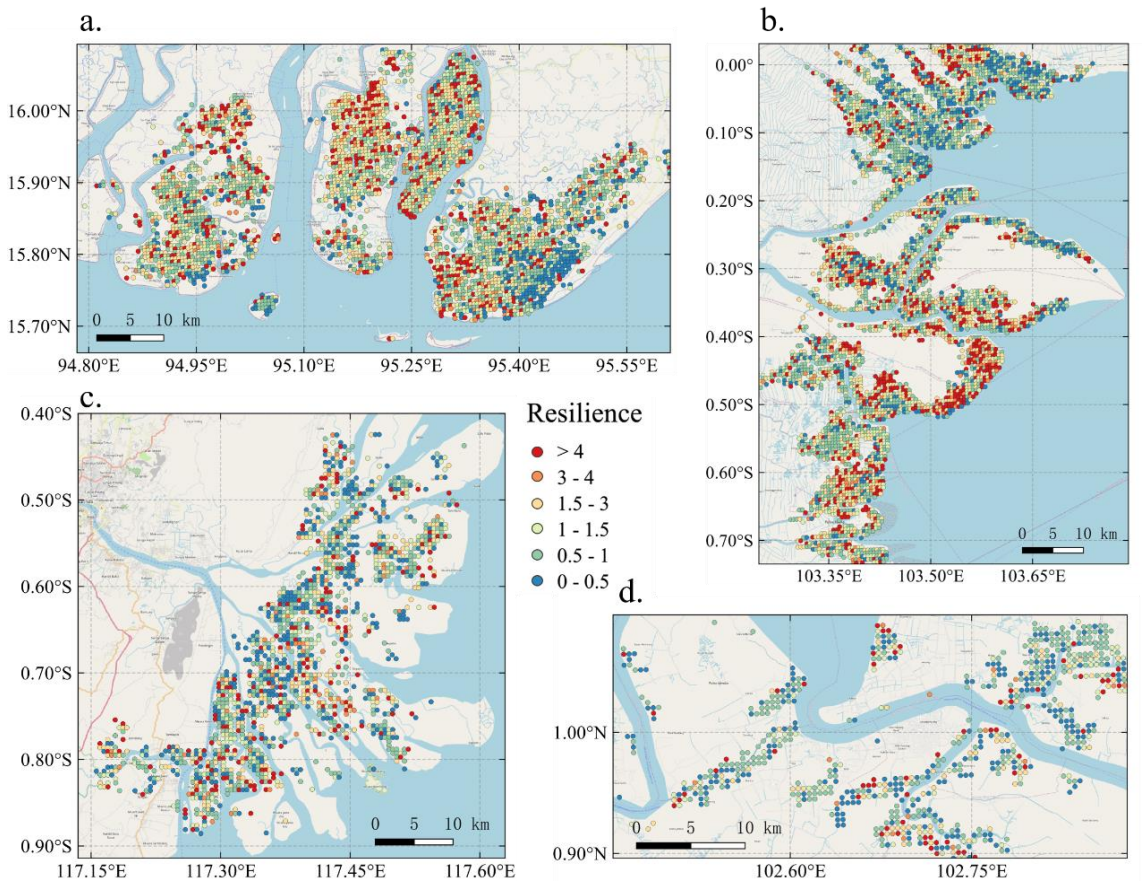
The resistance of NDVI to freshwater flood.



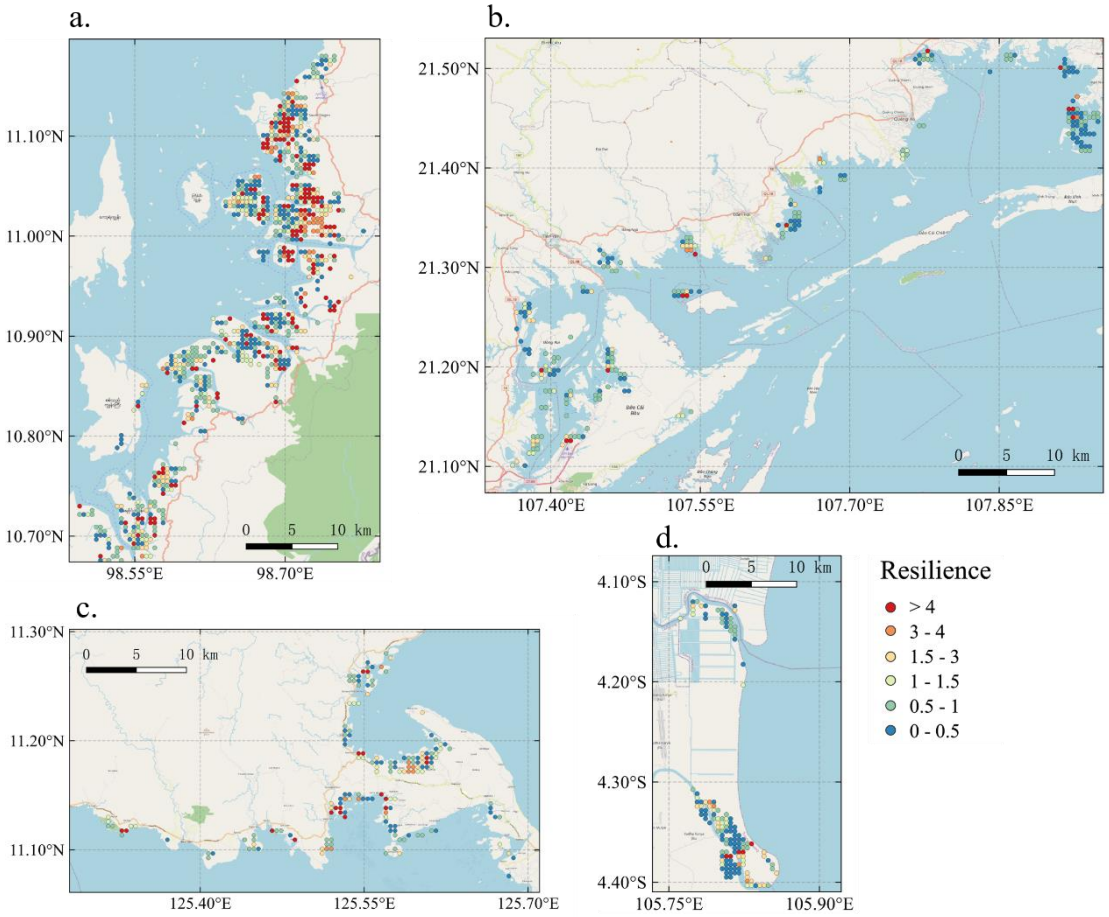
The resistance of NDVI to tsunami.

Resilience for selected mangrove regions of the SEA

- This pattern is not found in resilience



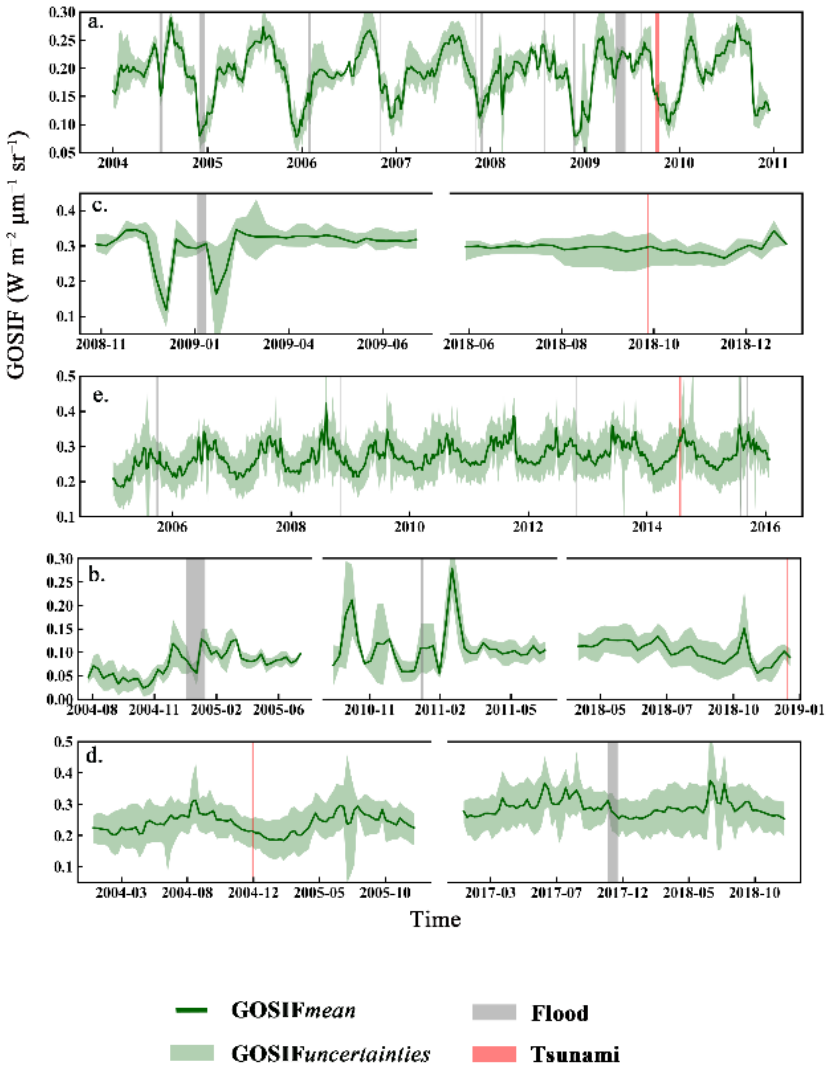
The resilience of NDVI to freshwater flood.



The resilience of NDVI to tsunami.

Mean GOSIF at tsunami-happened regions

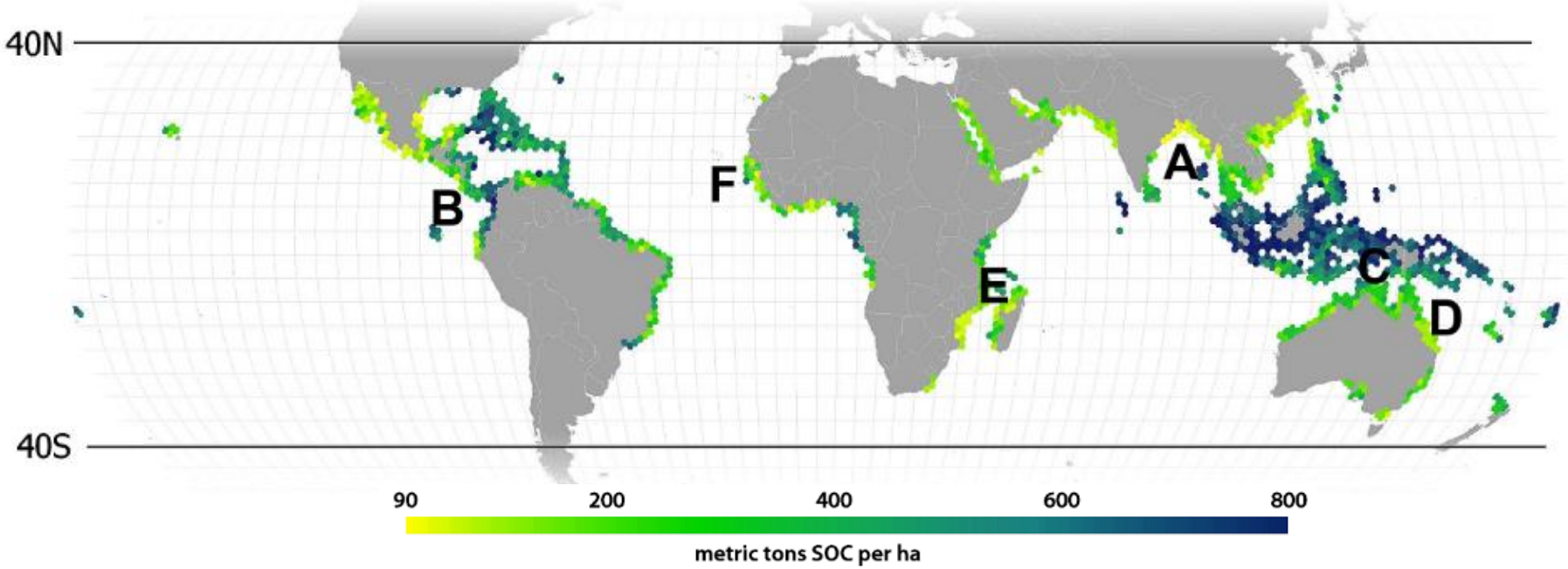
- Third, we examine the potential influences of the increasing and consecutive extreme coastal flooding on mangrove forest based on GOSIF datasets.
- Freshwater flood events are often accompanied by a large decrease in GOSIF value, which is not apparent after seawater floods.
- The increase of freshwater inflow will diminish salinity concentration and affect the growth of mangrove vegetation, and then decrease the productivity of forests after flood events.



Mean GOSIF at tsunami-happened regions in the ASEAN mangrove domain. The uncertainties of GOSIF are represented by the shaded green band, which upper and lower bounds derived from the minimum and maximum GOSIF at tsunami-happened regions. Shaded gray and red bands indicate the occurrence of flood and tsunami, respectively.

Global distribution of mangrove soil carbon stocks

- Mangroves in East Asia store a lot of soil organic matter.

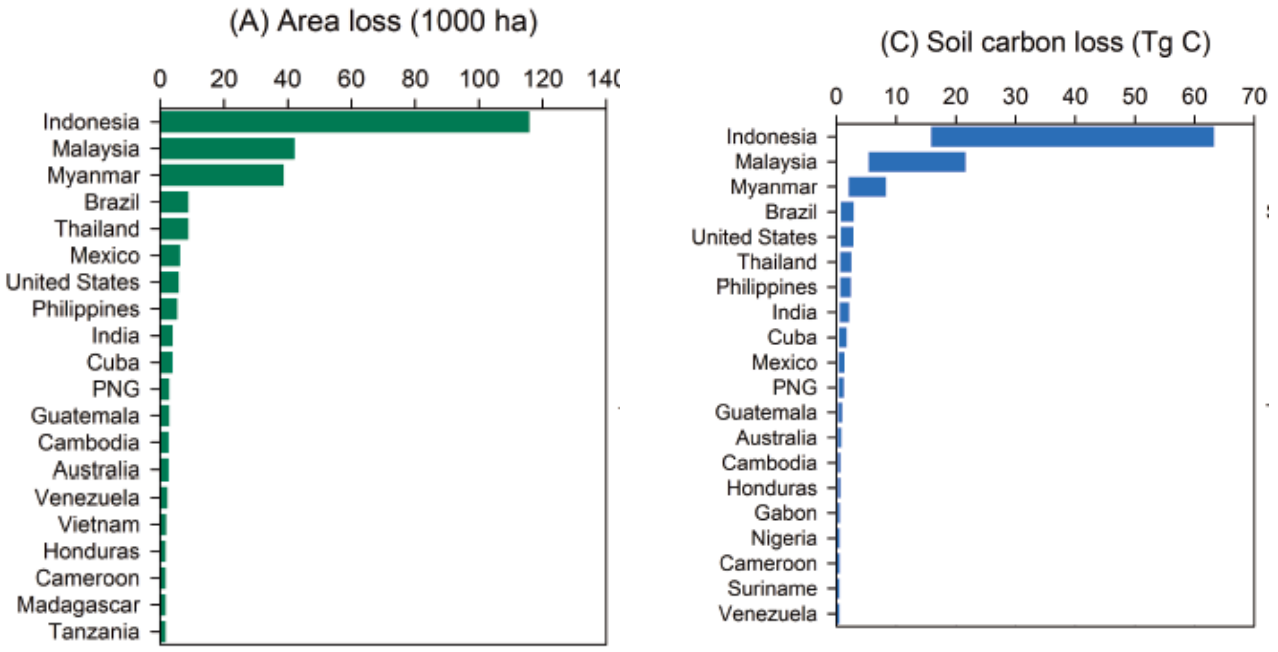


Global distribution of mangrove soil carbon stocks for the top meter of soil (hex bin area ~19000km^2) and detailed maps (30m resolution) for selected mangrove regions of the world

Sanderman, J., Hengl, T., Fiske, G., et al., 2018. A global map of mangrove forest soil carbon at 30 m spatial resolution. Environ. Res. Lett. 13 (5).

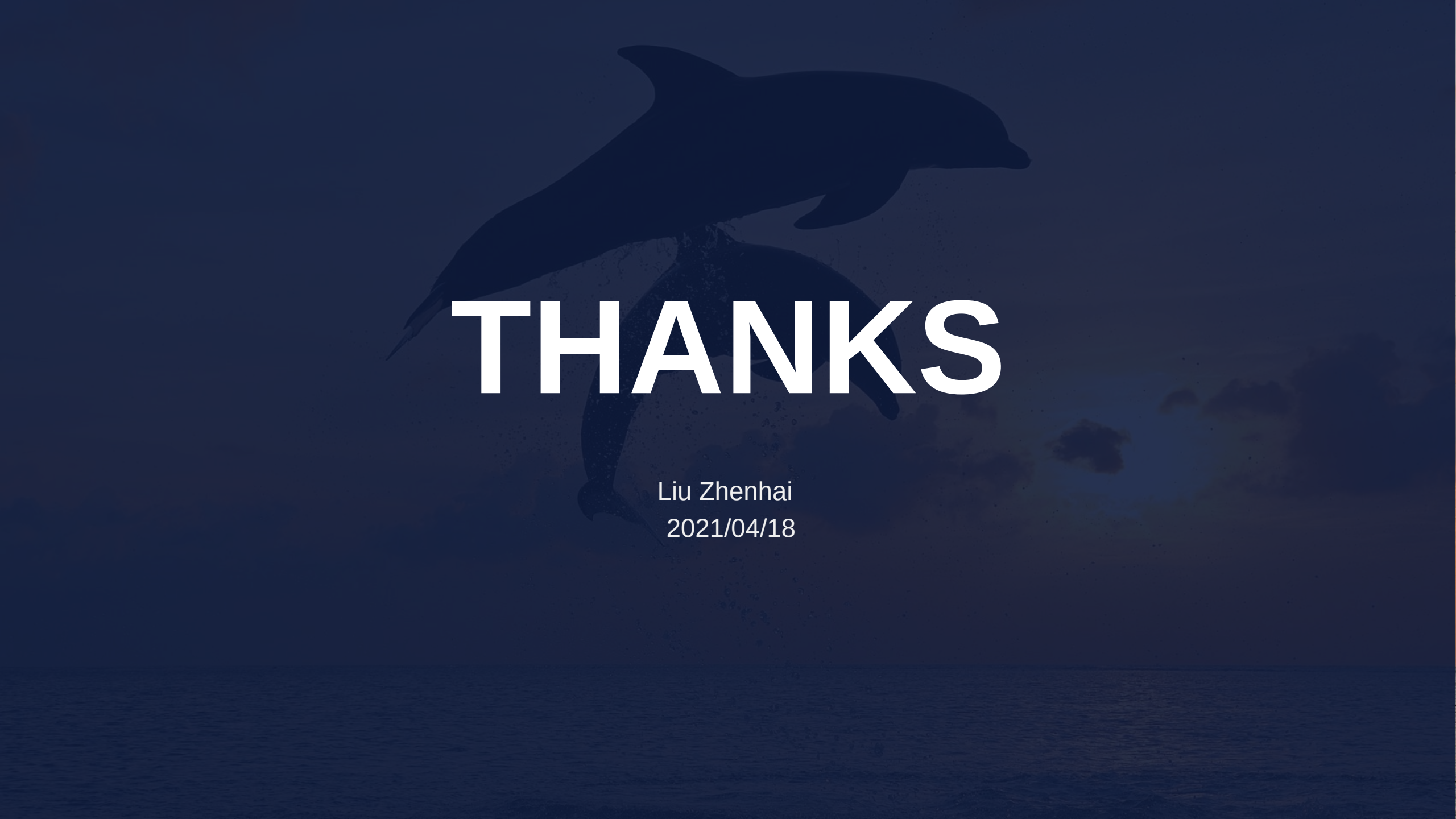
The loss of mangrove and soil organic carbon

- Many mangroves and soil carbon in Southeast Asia have been reduced due to deforestation and climate change.
- We think this is an interesting question what whether changes in precipitation and tidal patterns will affect mangroves and the soil carbon storage in future scenarios, especially for SEA.



Top 20 nation rankings for (*a*) total mangrove area lost between the years 2000 and 2012, (*c*) total soil organic carbon stocks loss.

Sanderman, J., Hengl, T., Fiske, G., et al., 2018. A global map of mangrove forest soil carbon at 30 m spatial resolution. Environ. Res. Lett. 13 (5).


THANKS
Liu Zhenhai
2021/04/18