

Arctic land ice, global sea level changes and storm surges



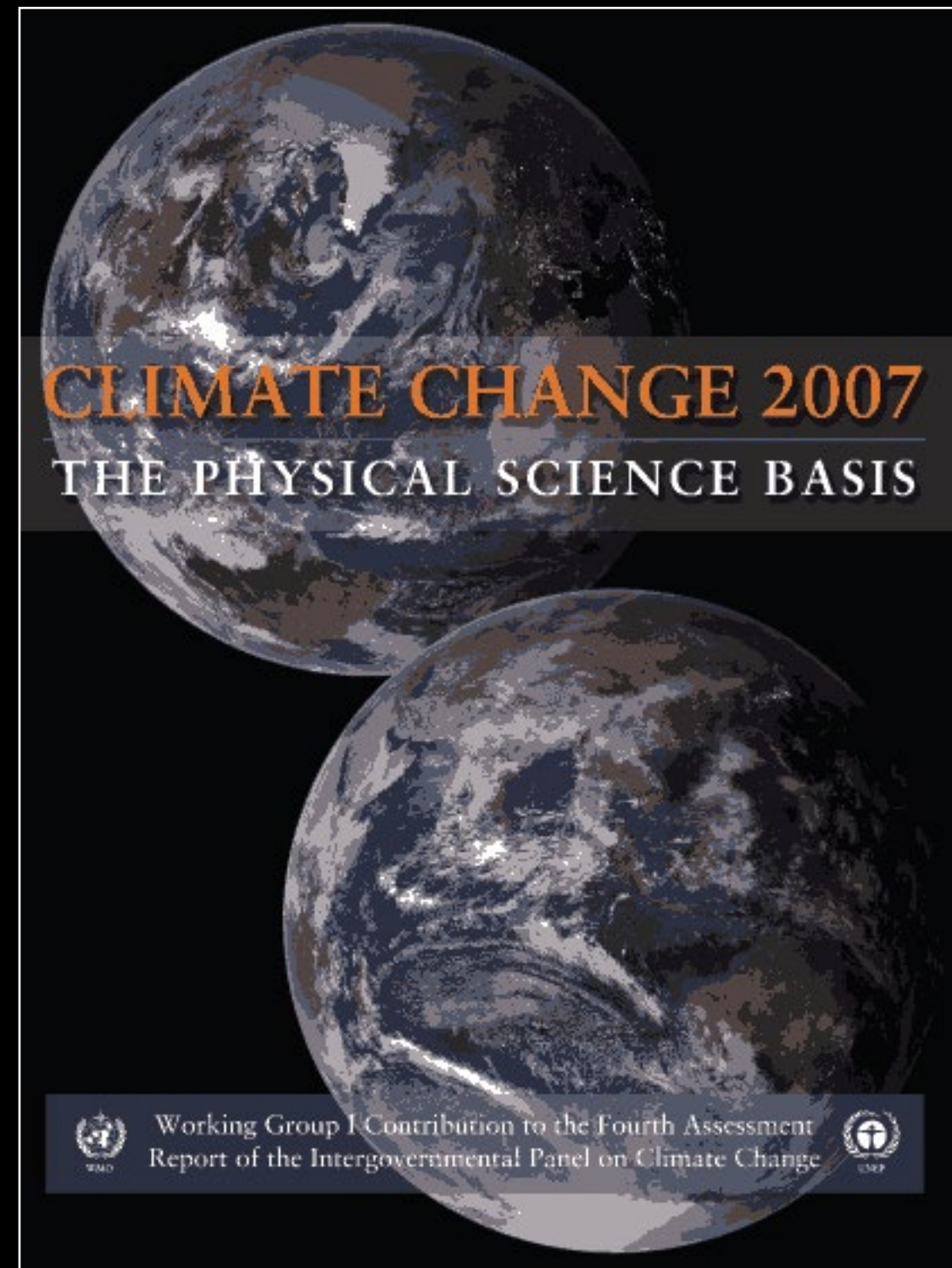
Jason E. Box, professor
GEUS – Geological Survey of Denmark and Greenland
Department of Glaciology and Climate
jeb@geus.dk
@climate_ice



Climate Thursdays 2024, 12-09-2024, 08.00 – 08.30

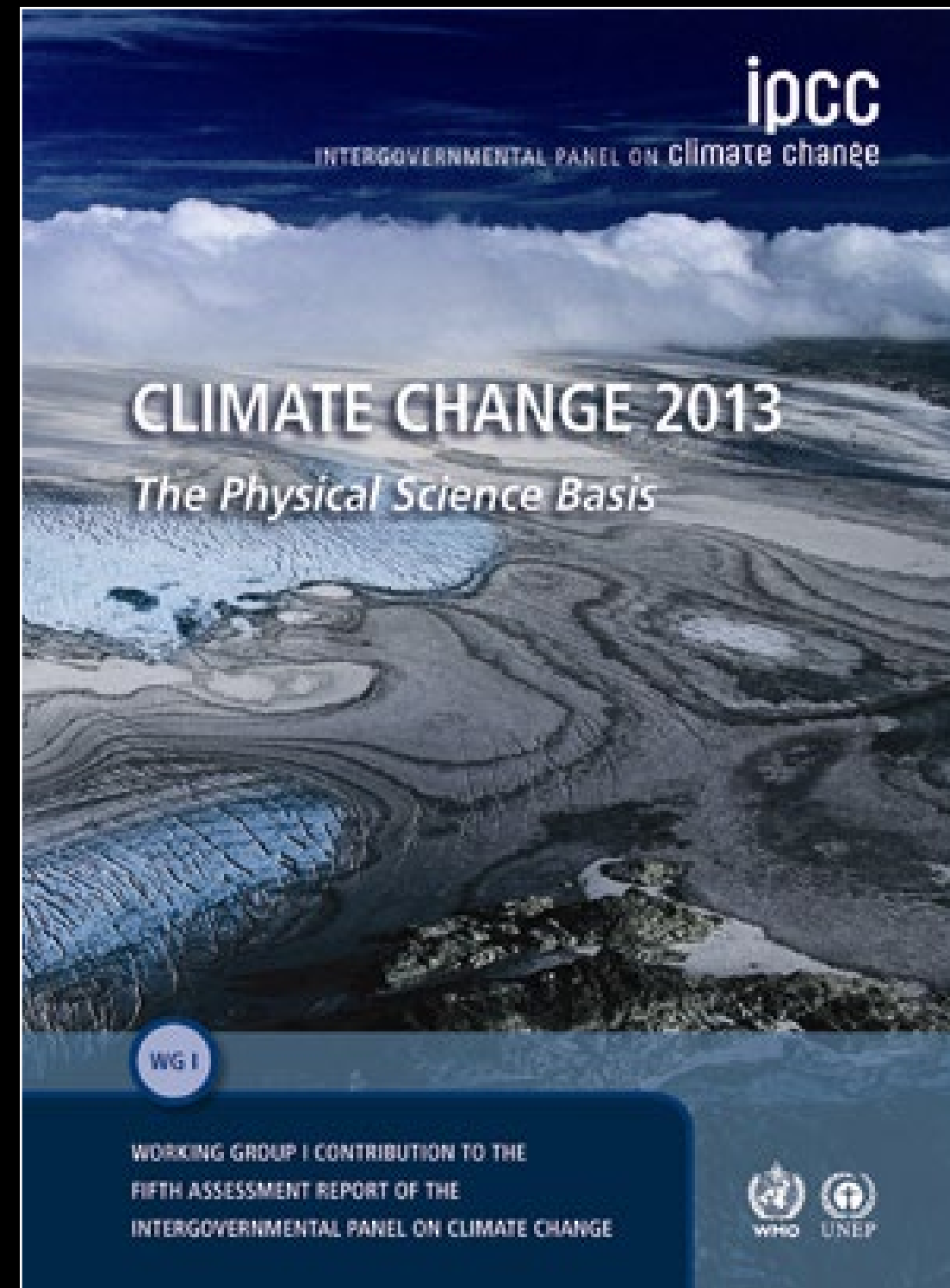
Intergovernmental Panel on Climate Change (IPCC) reports

AR4



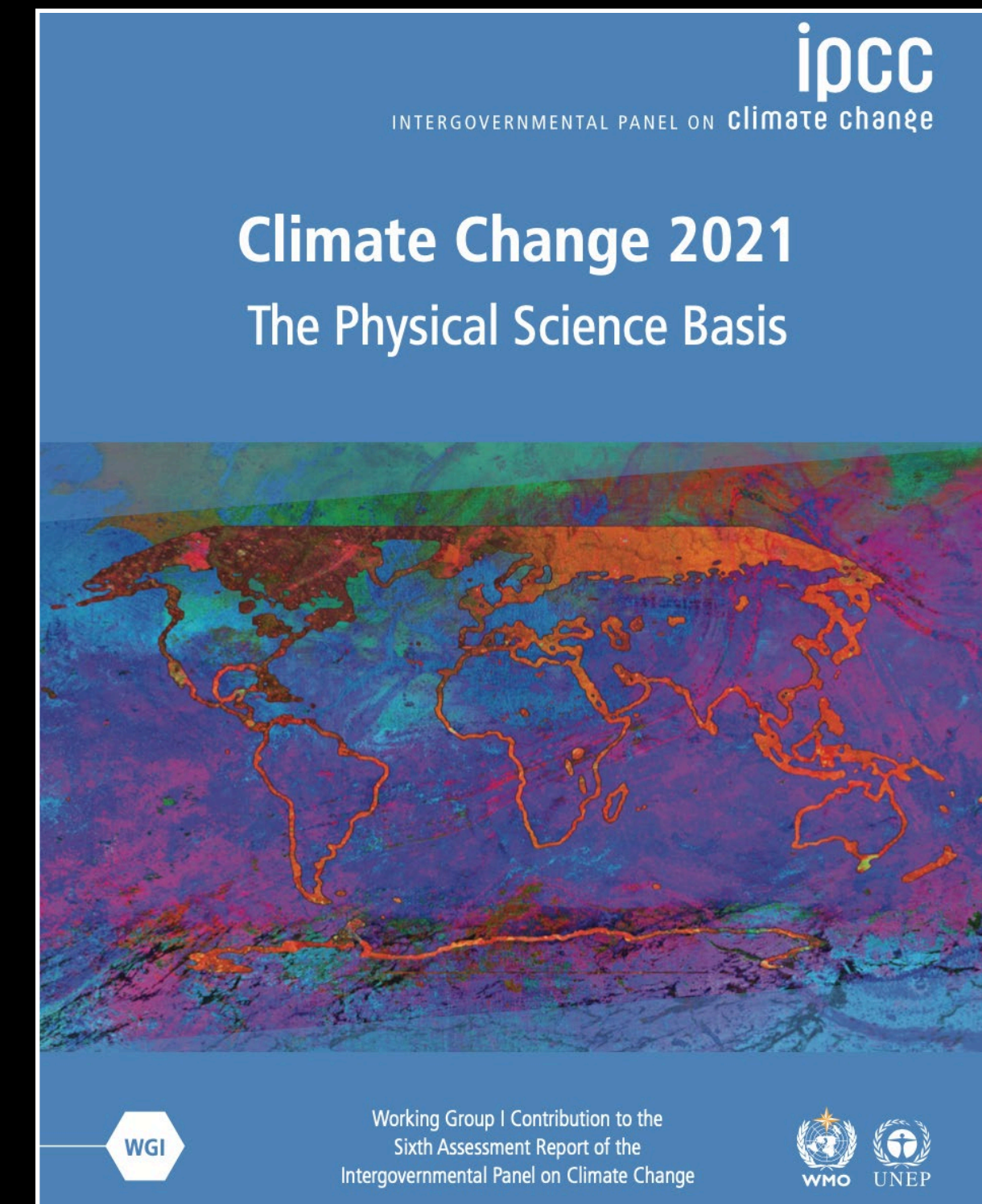
2007

AR5



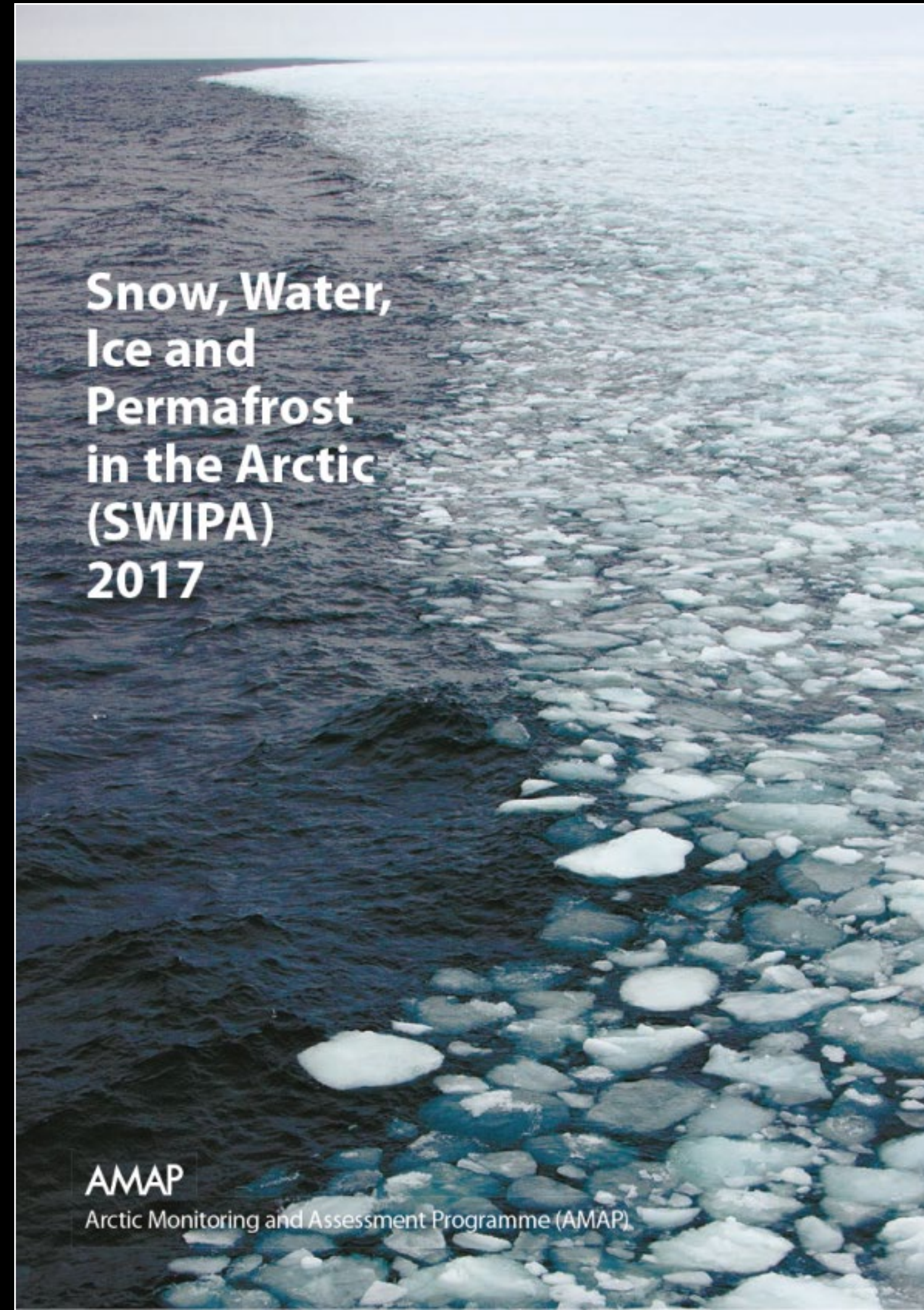
2013

AR6



2021

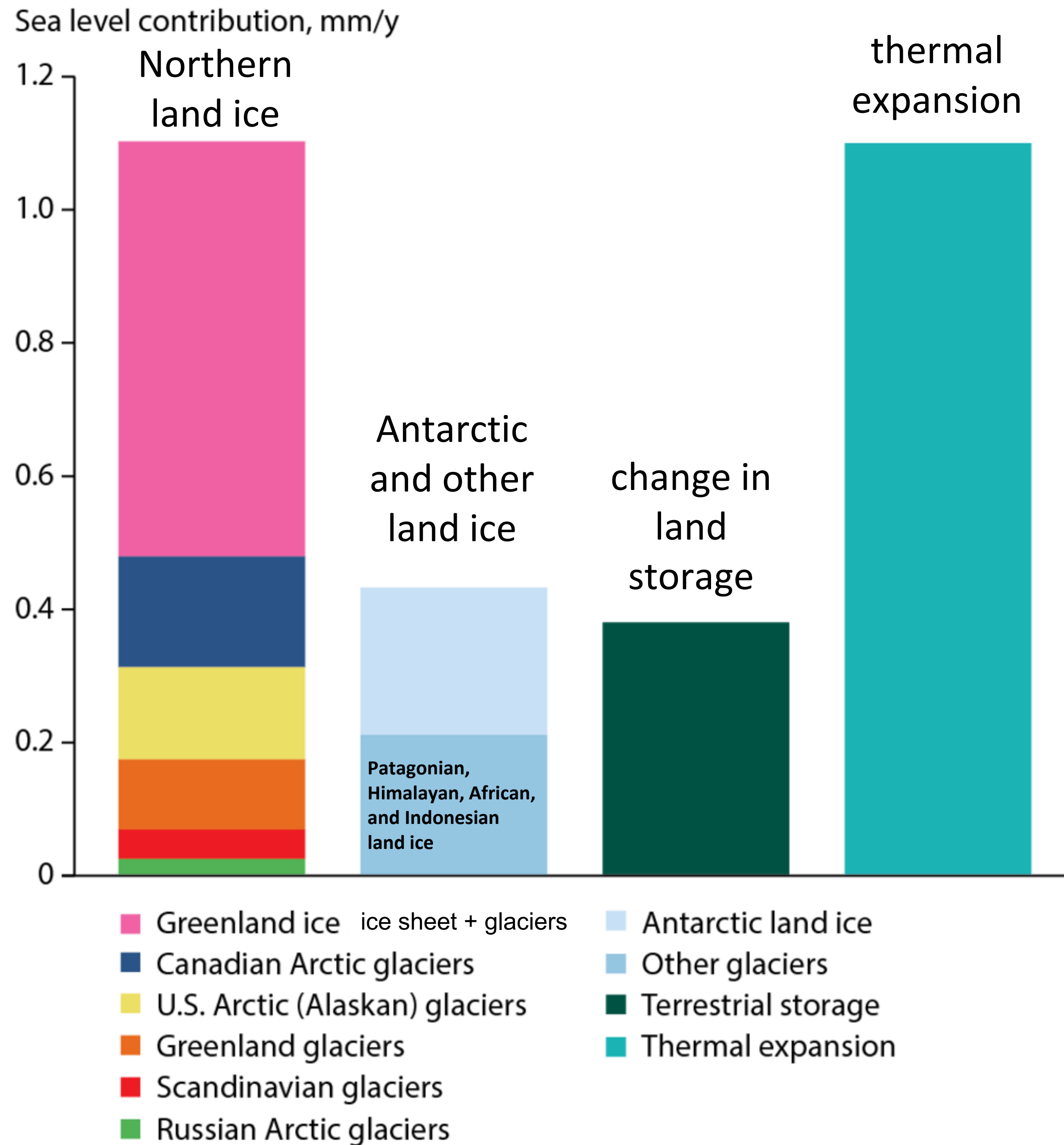
Arctic Monitoring and Assessment Program (AMAP)



2017

Global Sea Level Budget

SWIPA 2017
Chapter 9
2017 Snow, Water, Ice and
Permafrost in the Arctic
(SWIPA) 2017 (Oslo, NO:
Arctic Monitoring and
Assessment Programme
(AMAP)) xiv + 269 pp



Greenland peripheral glaciers

The first complete inventory of the local glaciers and ice caps on Greenland

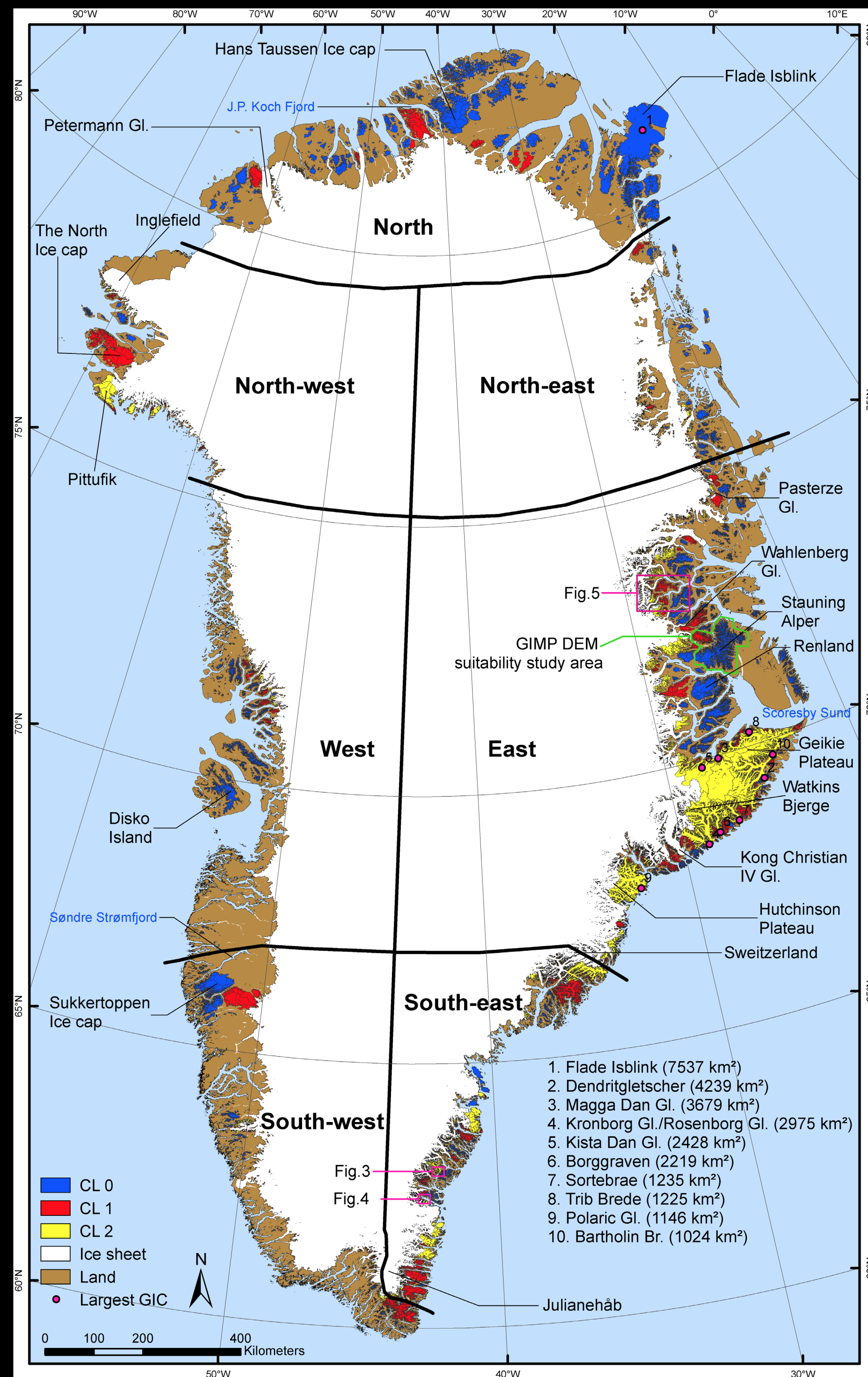
P. Rastner¹, T. Bolch^{1,2}, N. Mölg¹, H. Machguth^{1,3}, R. Le Bris¹, and F. Paul¹

¹Department of Geography, University of Zurich, Zurich, Switzerland

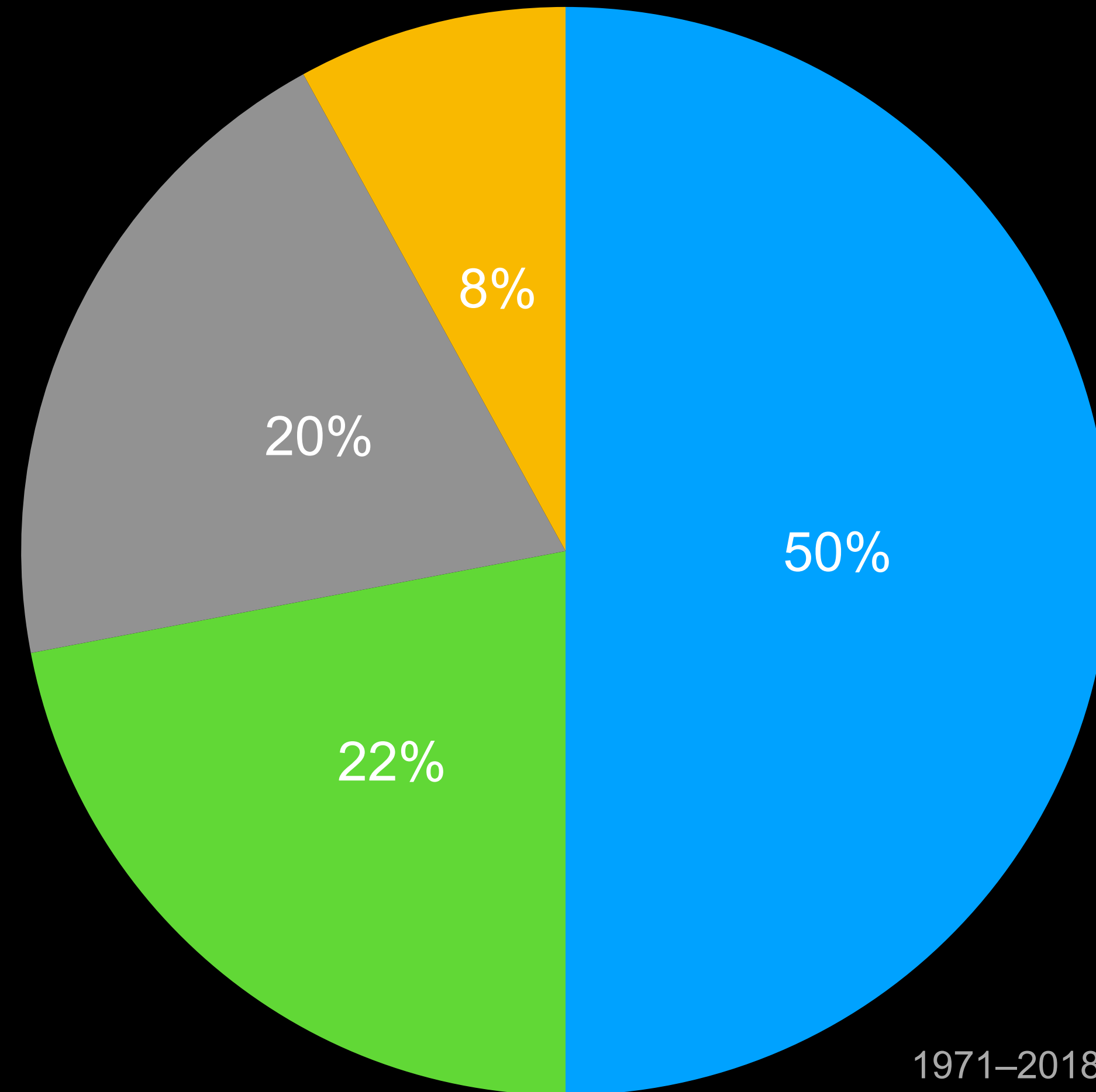
²Institute for Cartography, Technische Universität Dresden, Dresden, Germany

³Marine Geology and Glaciology, Geological Survey of Denmark and Greenland – GEUS, København, Denmark

The Cryosphere, 6, 1483–1495, 2012
www.the-cryosphere.net/6/1483/2012/
[doi:10.5194/tc-6-1483-2012](https://doi.org/10.5194/tc-6-1483-2012)



sea level budget



1971–2018 IPCC AR6 2021

■ Thermal expansion

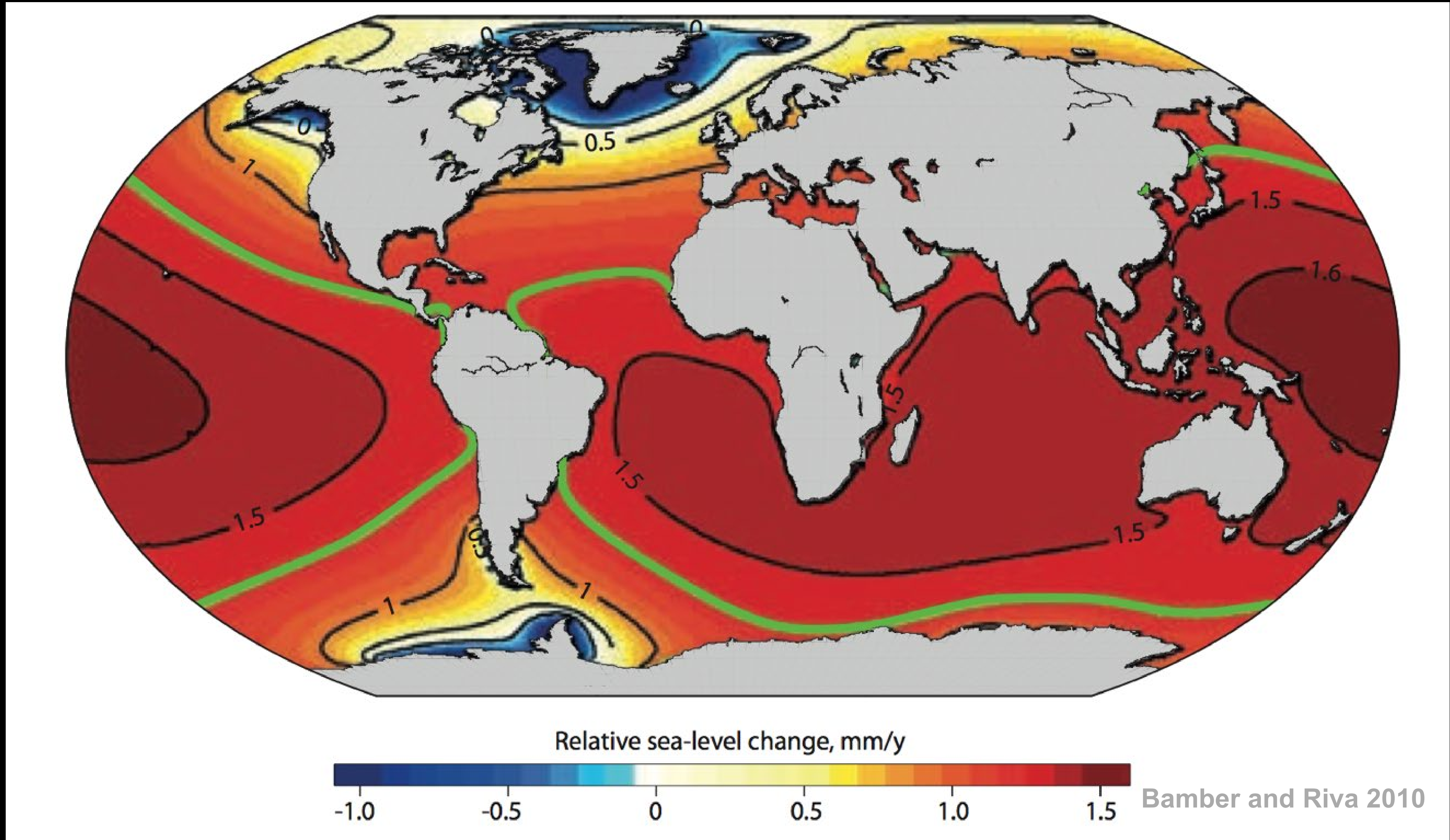
■ Glacier loss

■ Ice sheet reduction

■ Groundwater extraction

* gravitational effects, local isostasy and ocean circulation changes make sea level rise non-uniform

sea level rise is concentrated in the tropics

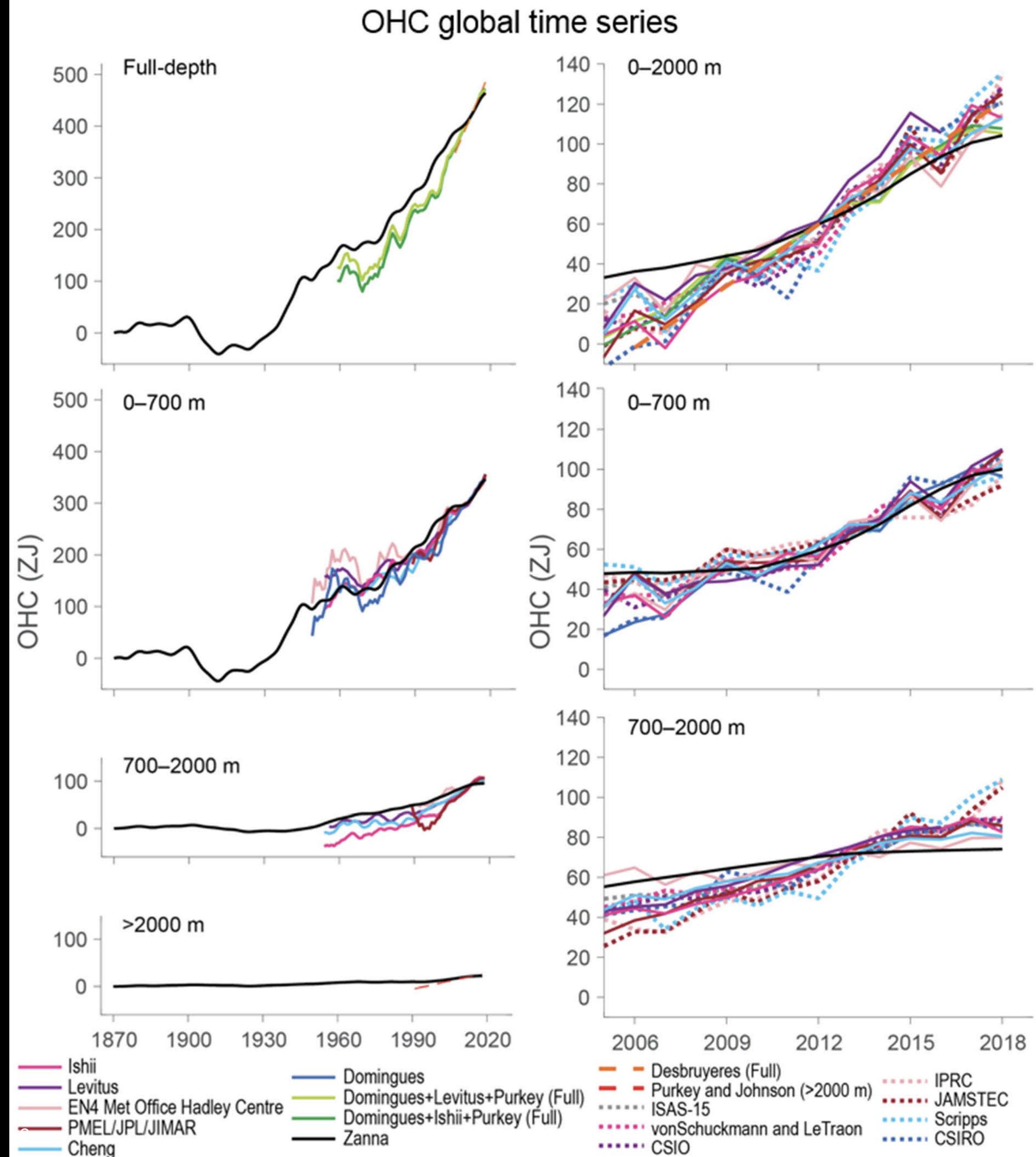


~500 ZJ increase in ocean heat content

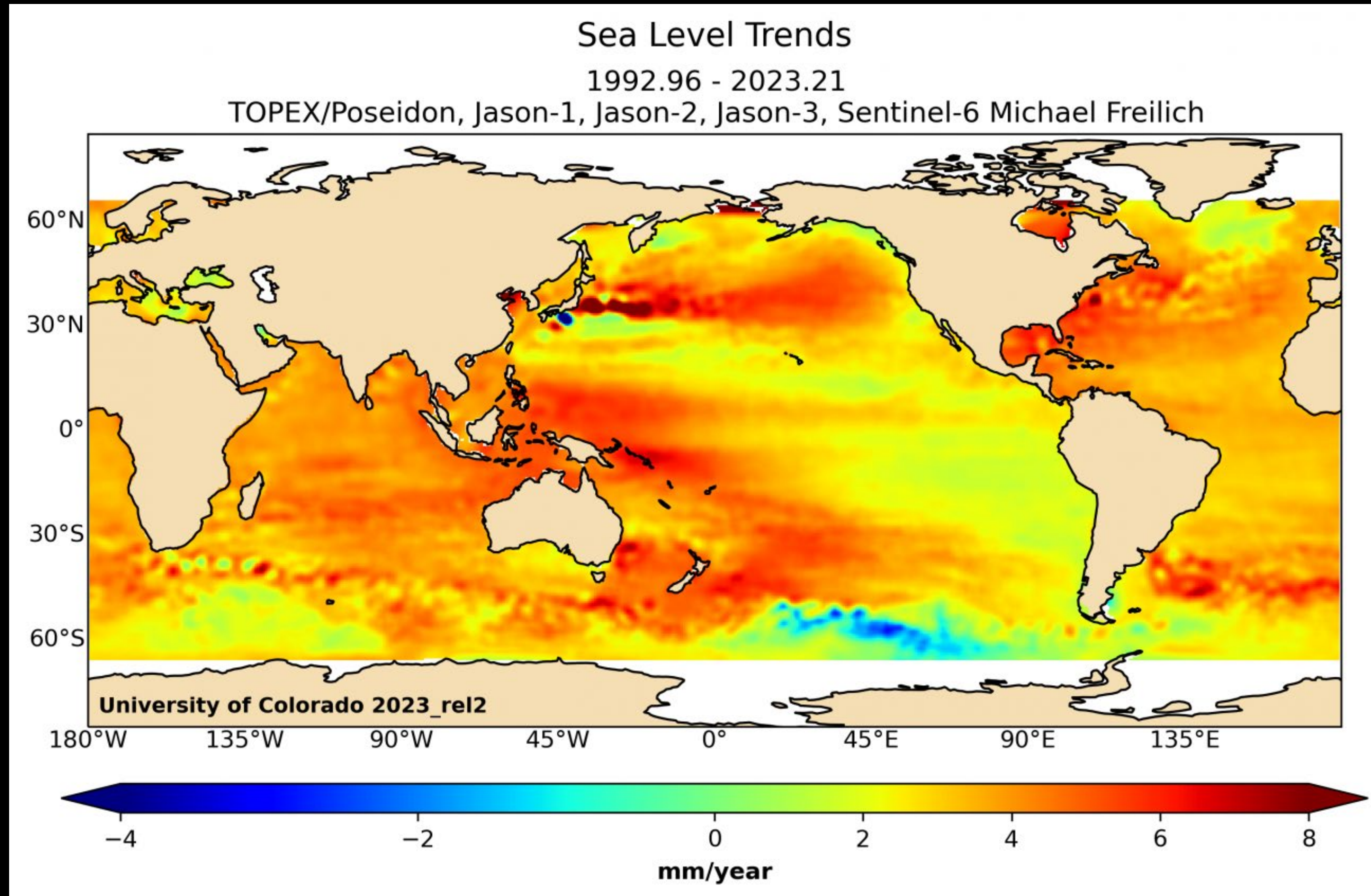
tera (1000^4), peta (1000^5), exa (1000^6), zetta (1000^7), and yotta (1000^8)

Consumption of primary energy worldwide reached nearly 584 exajoules in 2019,

<https://www.statista.com/statistics/265598/consumption-of-primary-energy-worldwide>



sea level trends depend on ocean circulation changes

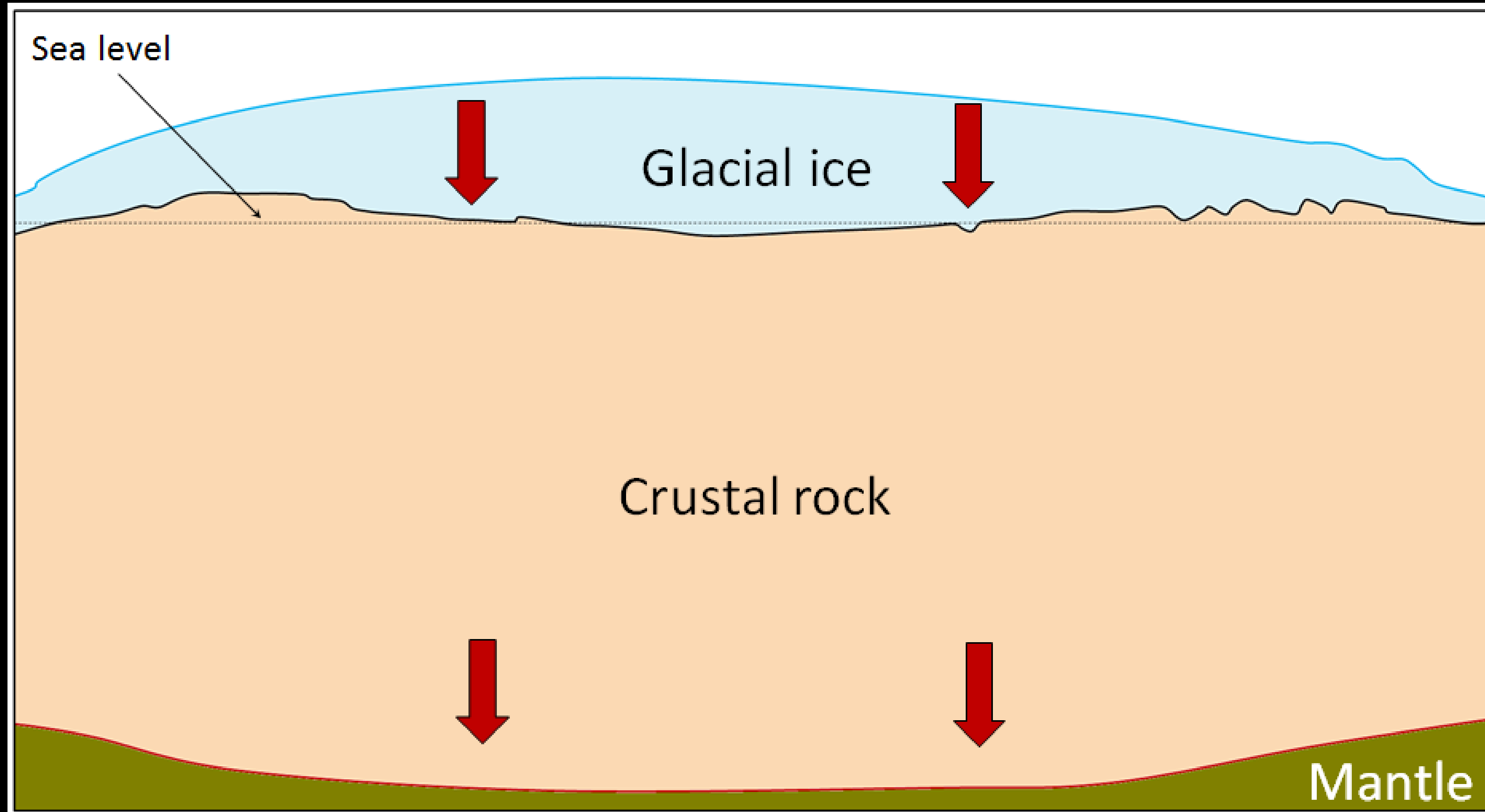


isostasy

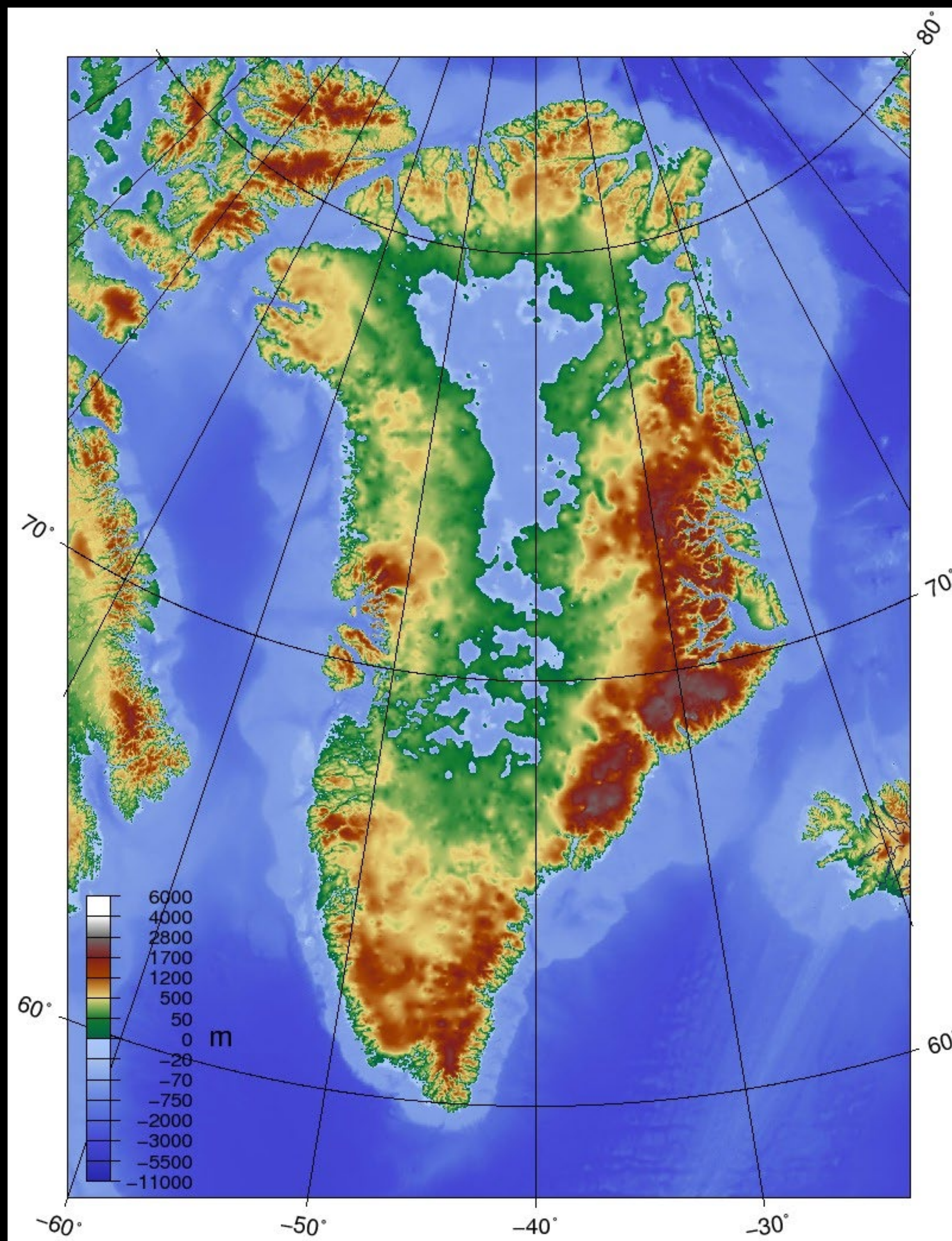


Credit @Freepik

isostasy



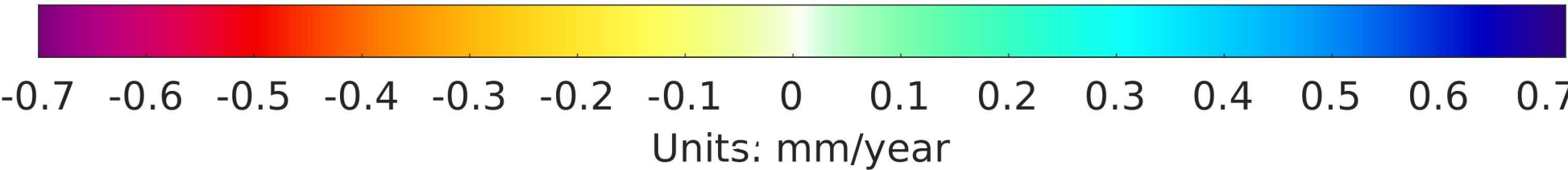
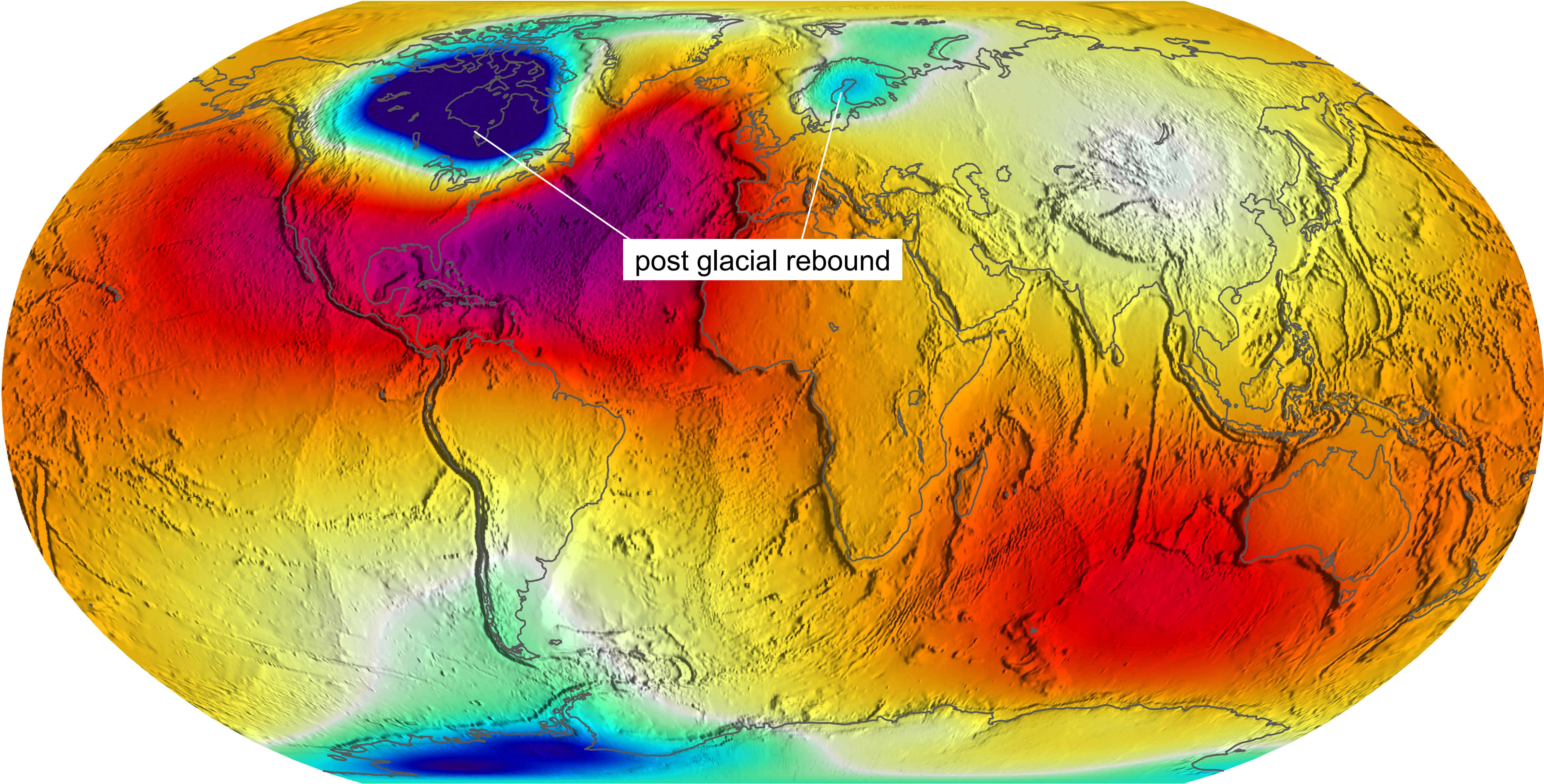
isostasy



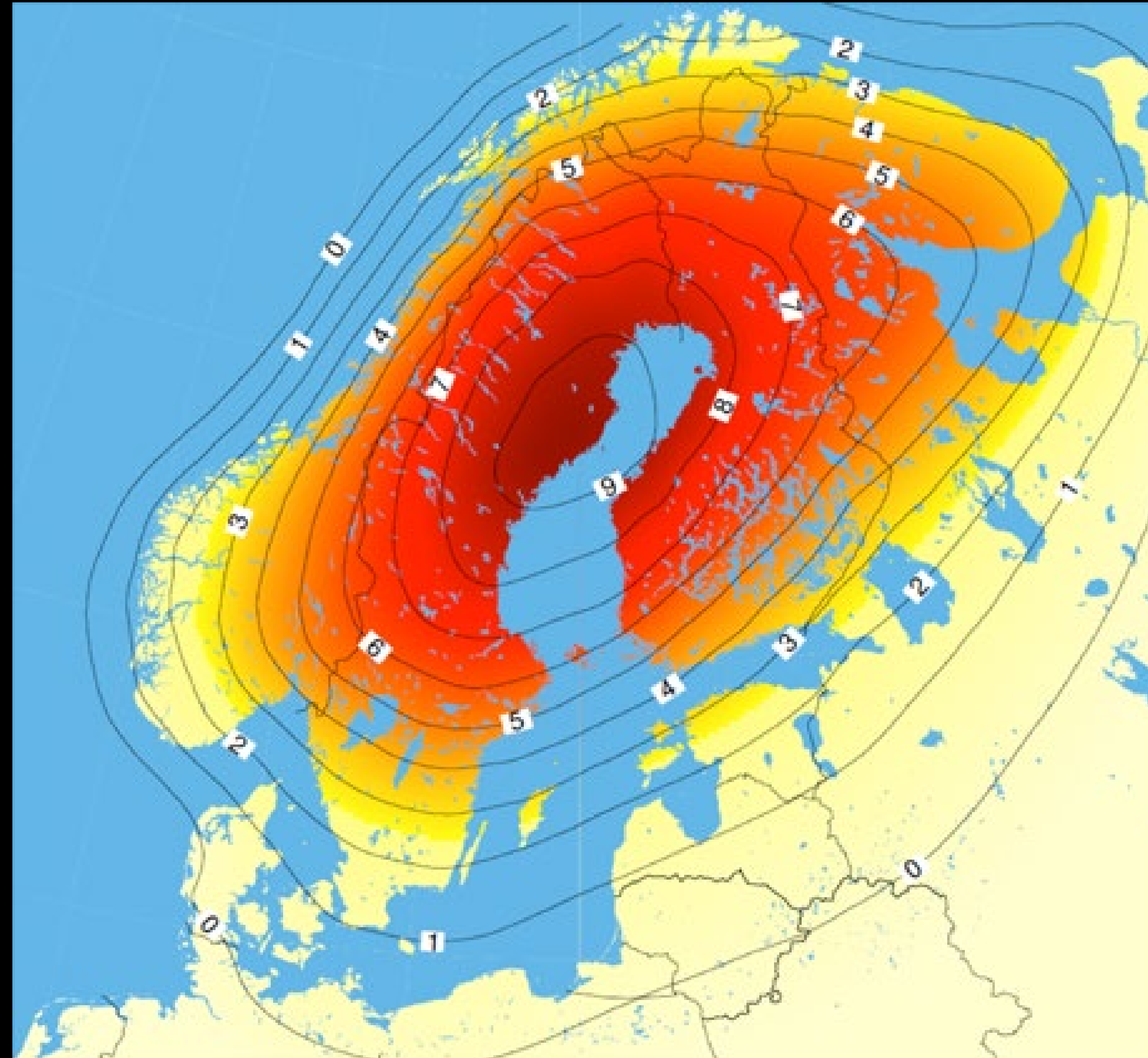
BedMachine 3

glacial isostatic adjustment

Glacial Isostatic Adjustment (ICE6G-D, Peltier et al., 2018) geoid trend, in [mm/yr]

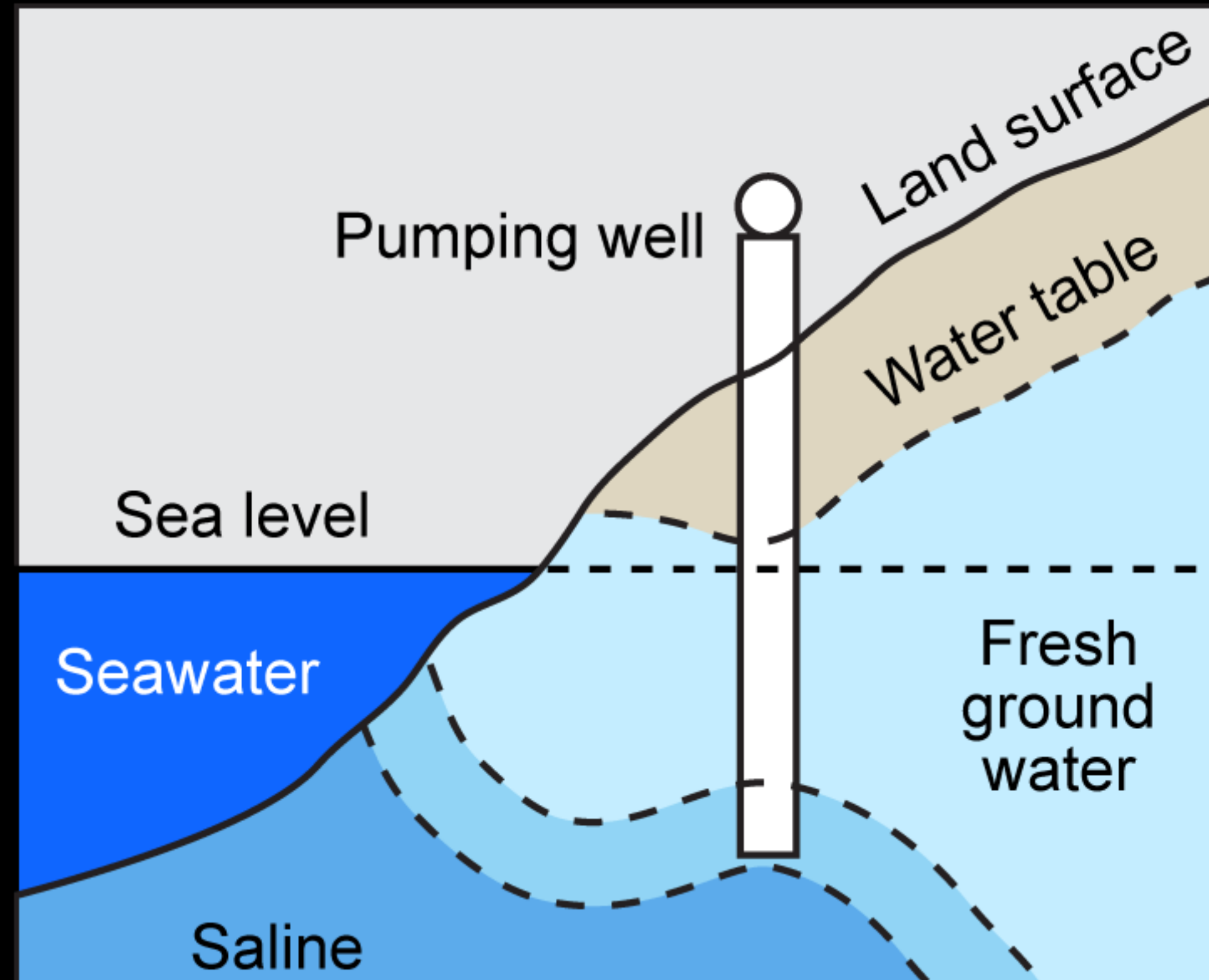


post glacial rebound (glacial isostatic adjustment)



Fennoscandian land uplift (mm/yr) relative to the centre of the Earth.

groundwater extraction



groundwater extraction

Jakarta, the fastest-sinking city in the world

13 August 2018

Share 

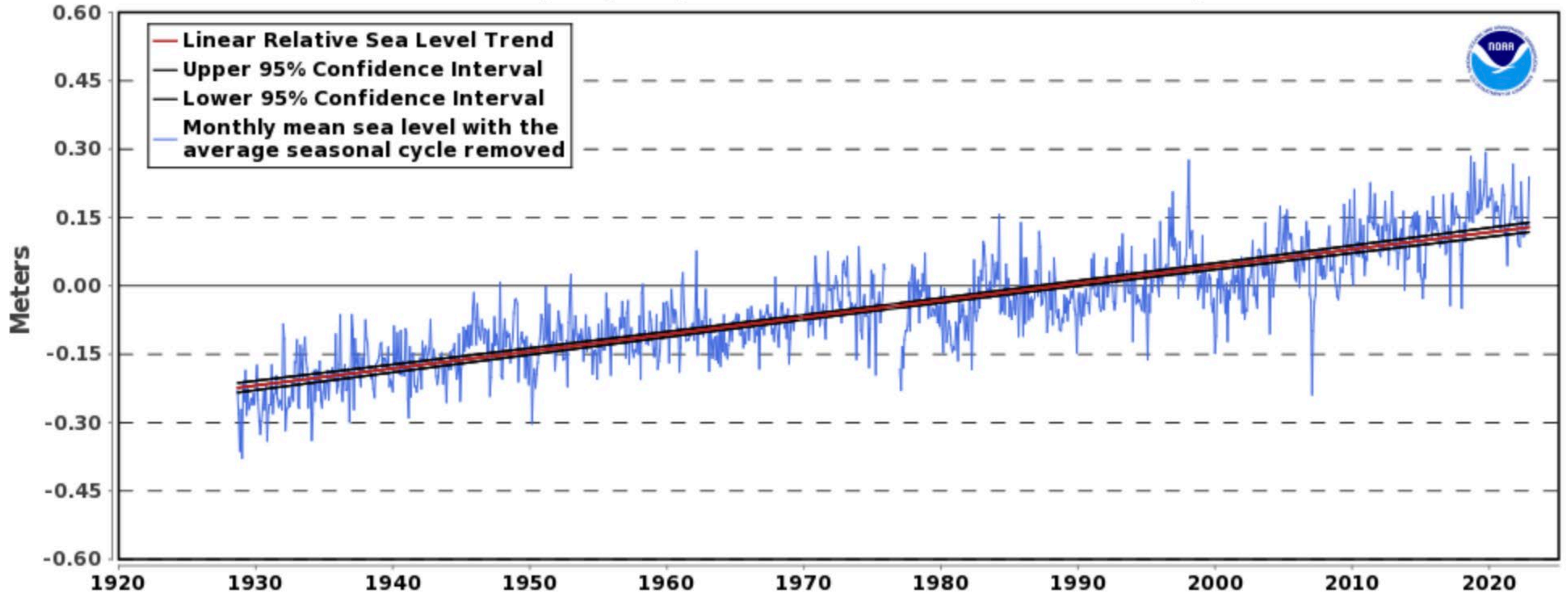
Mayuri Mei Lin & Rafki Hidayat
BBC Indonesian



Relative Sea Level Trend 8575512 Annapolis, Maryland

8575512 Annapolis, Maryland

3.73 +/- 0.20 mm/yr



[EXPORT TO TEXT](#)

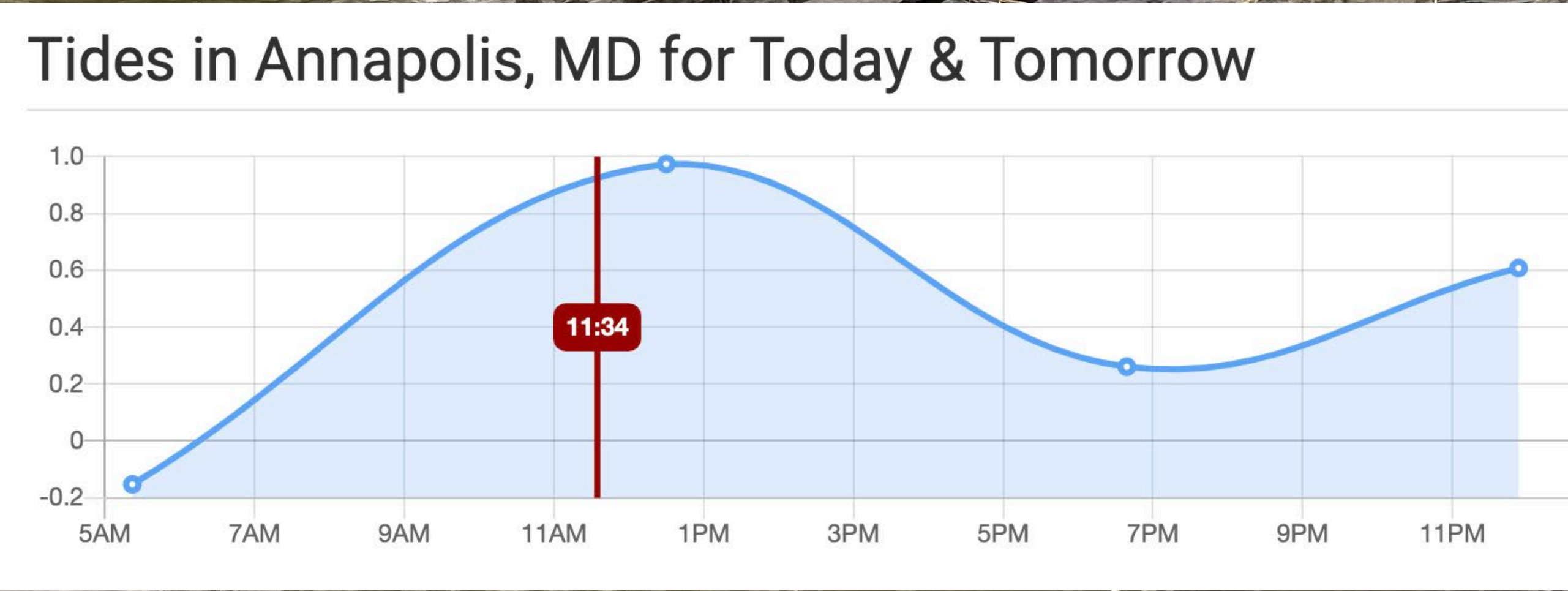
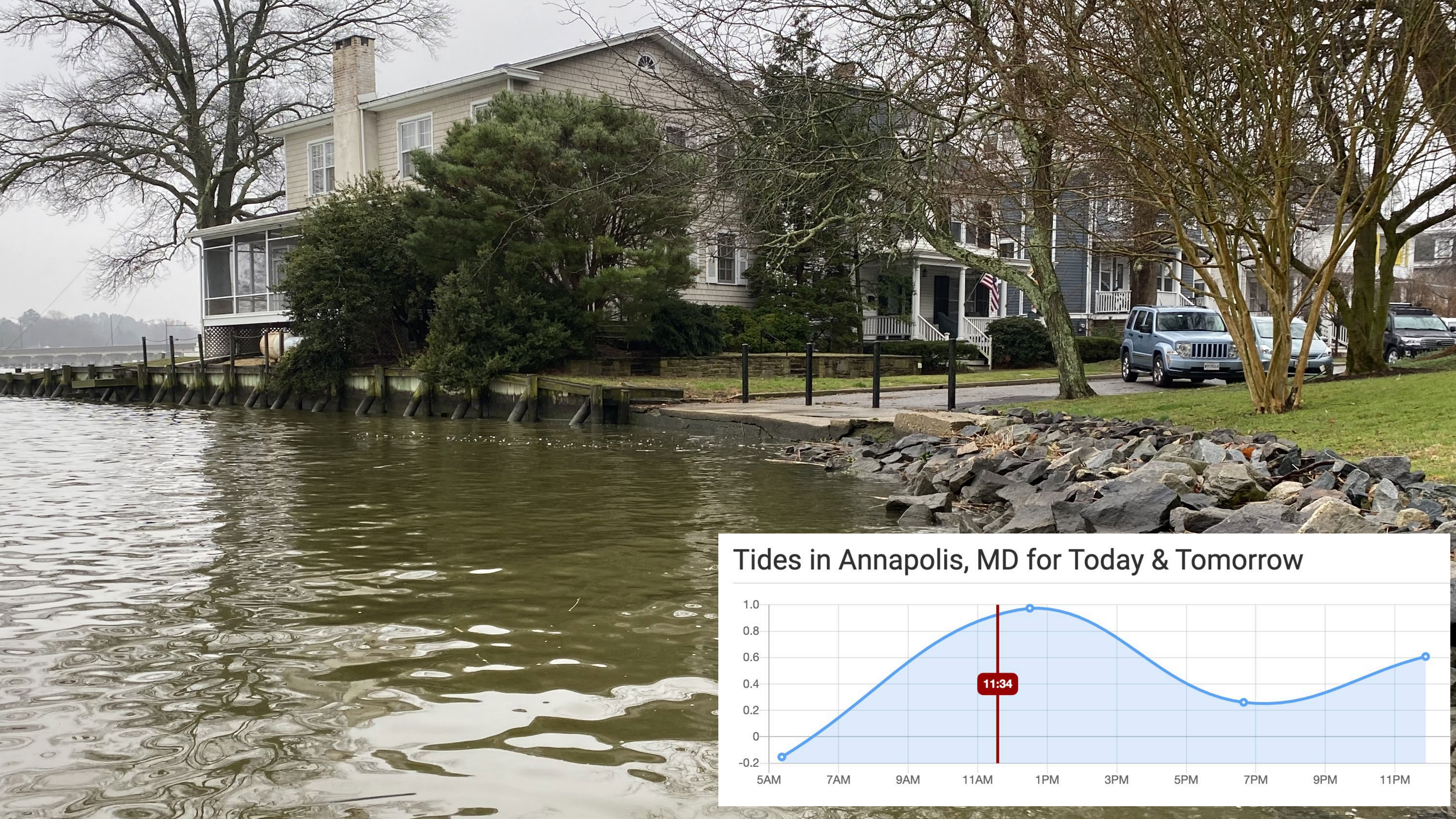
[EXPORT TO CSV](#)

[SAVE IMAGE](#)

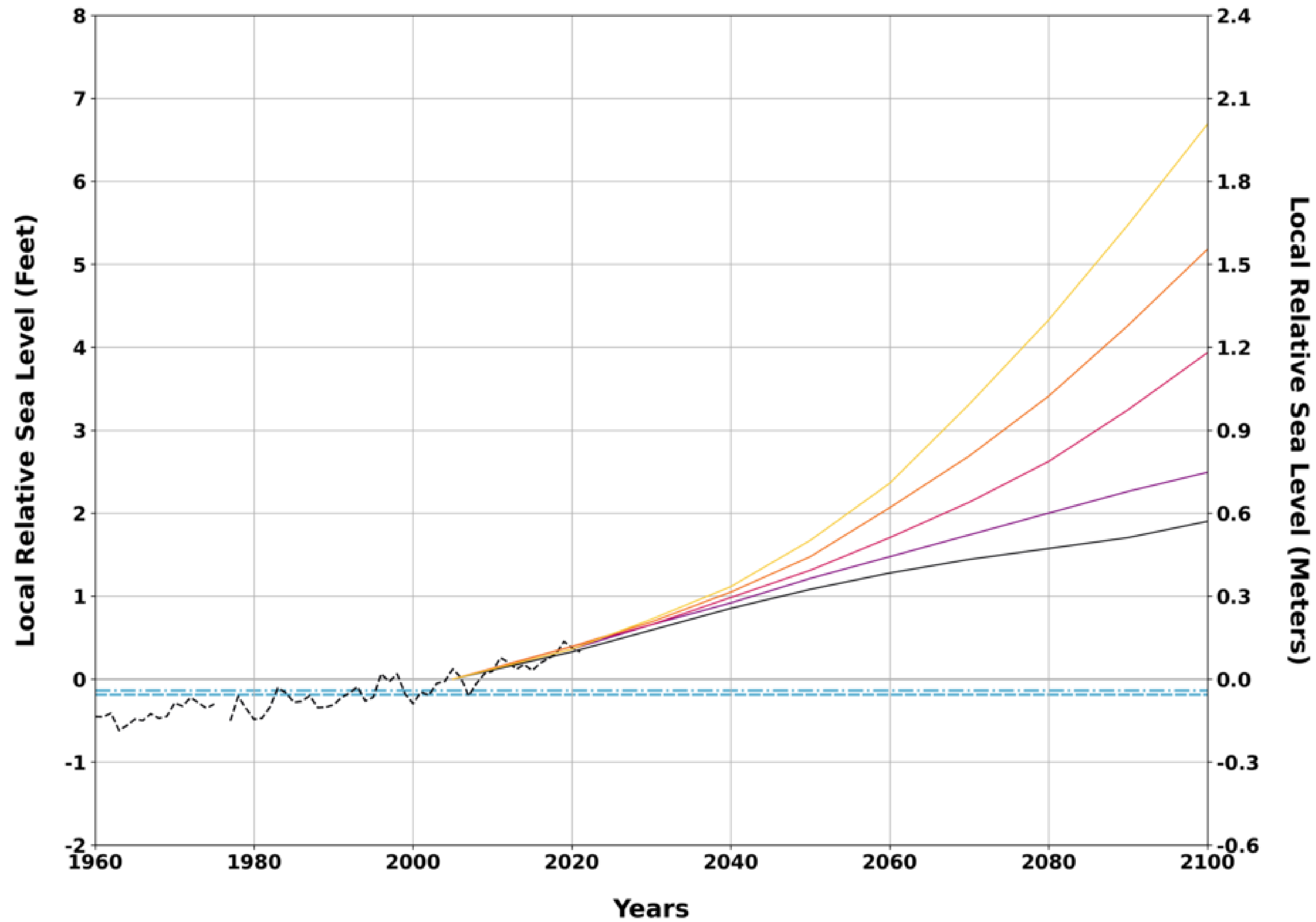
The relative sea level trend is 3.73 millimeters/year with a 95% confidence interval of +/- 0.2 mm/yr based on monthly mean sea level data from 1928 to 2021 which is equivalent to a change of 1.22 feet in 100 years.







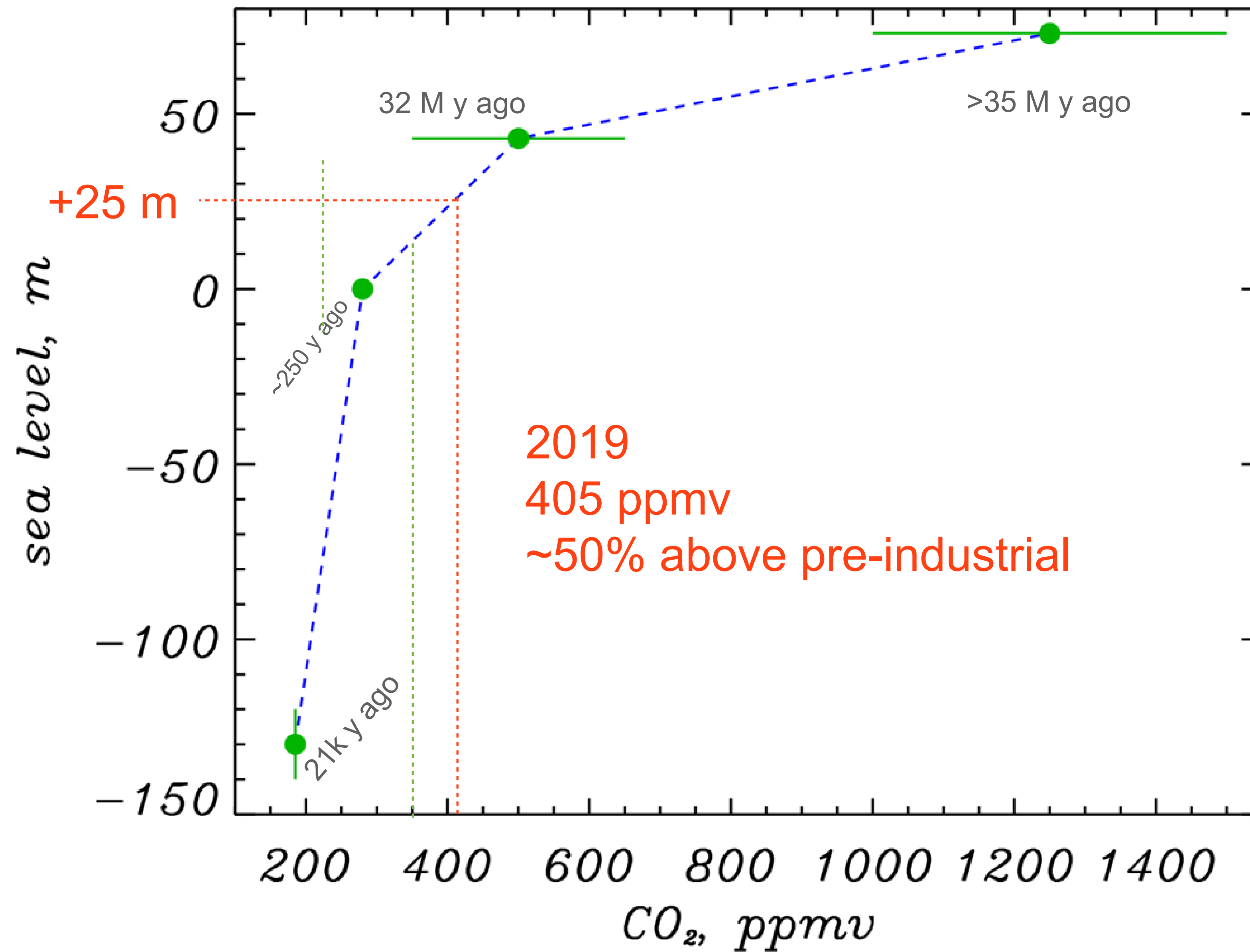
Annual Relative Sea Level Since 1960 and Projections 8575512 Annapolis



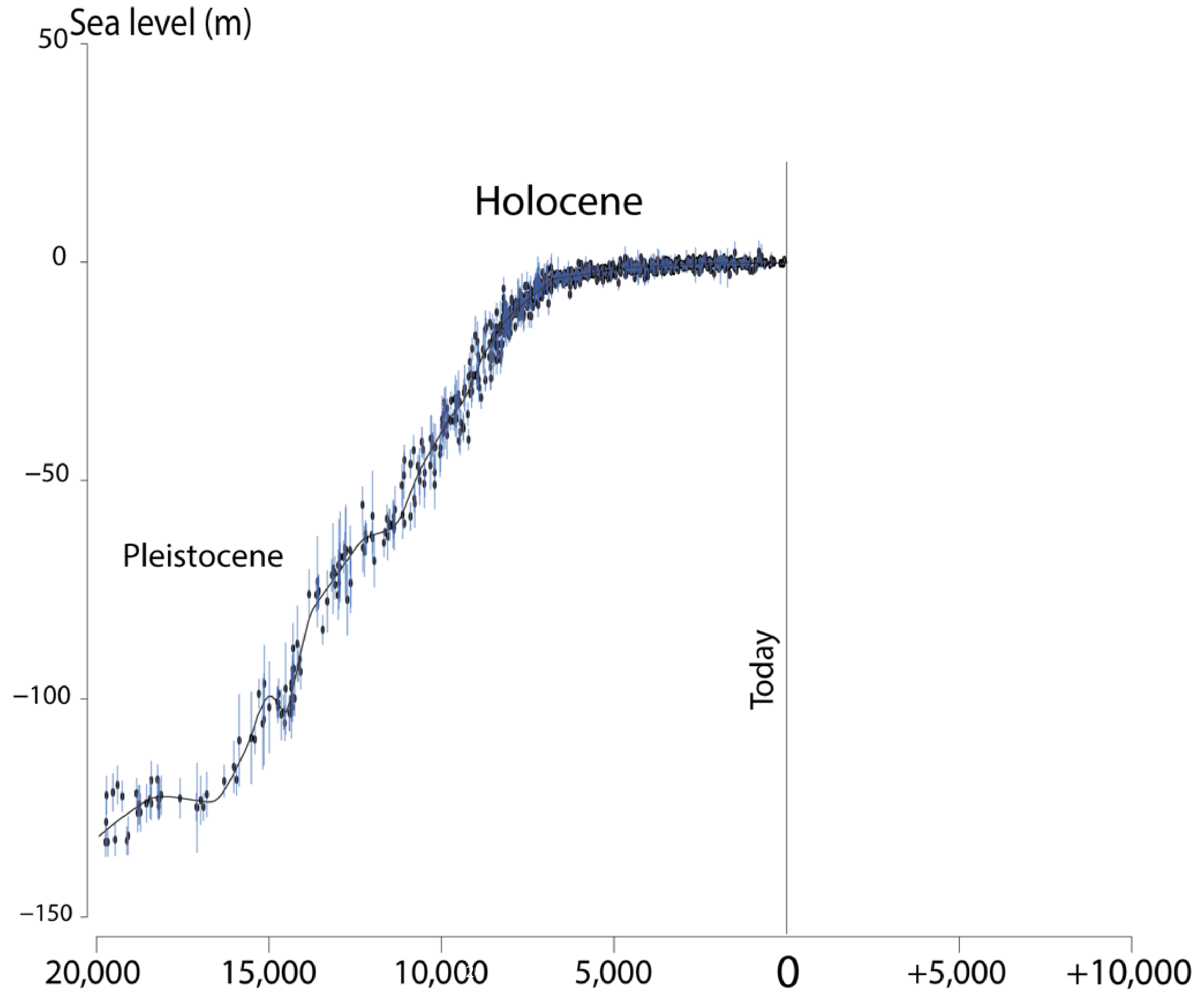
https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8575512



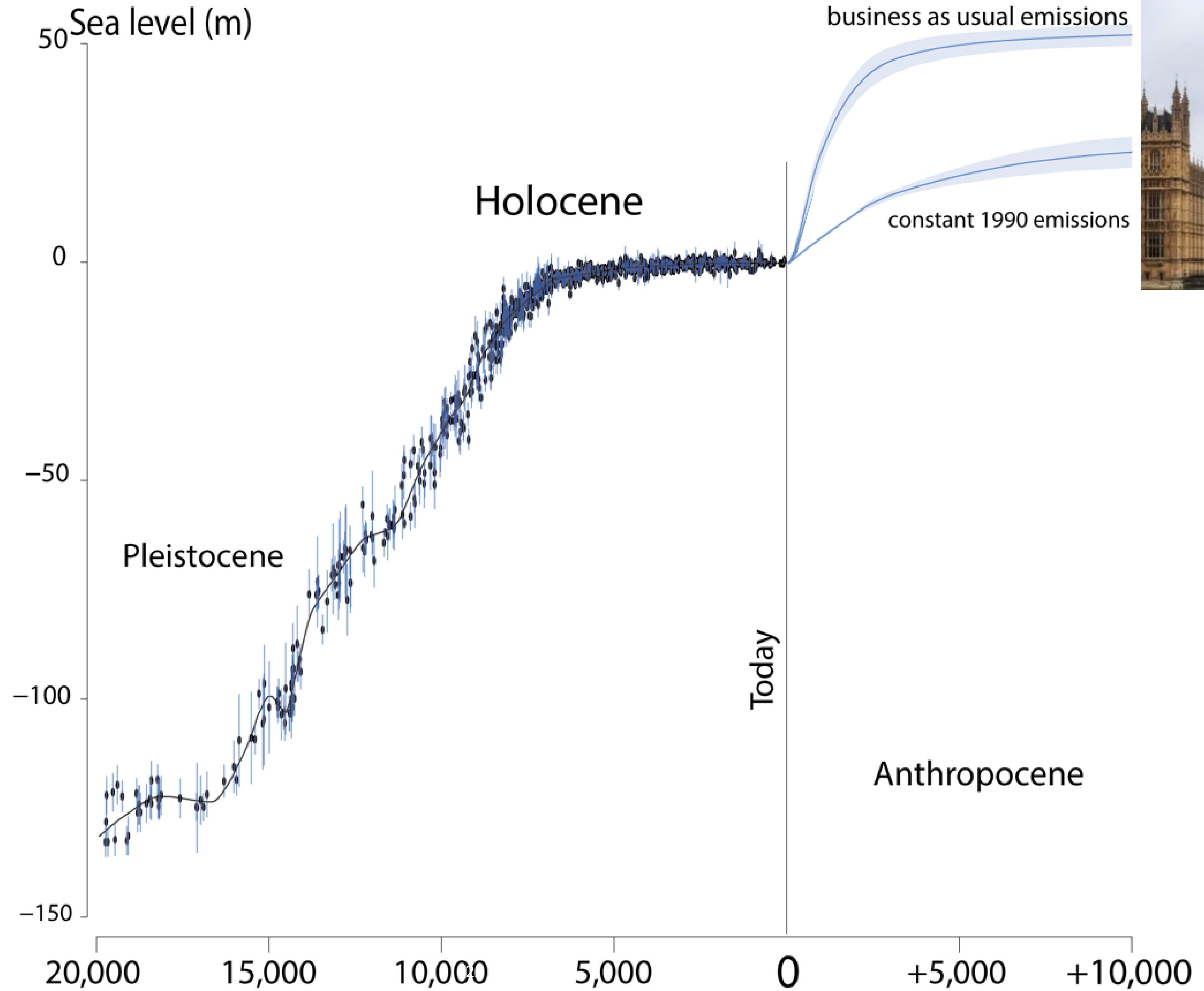
Global Sea Level Vs CO₂



sea level past and future



sea level past and future



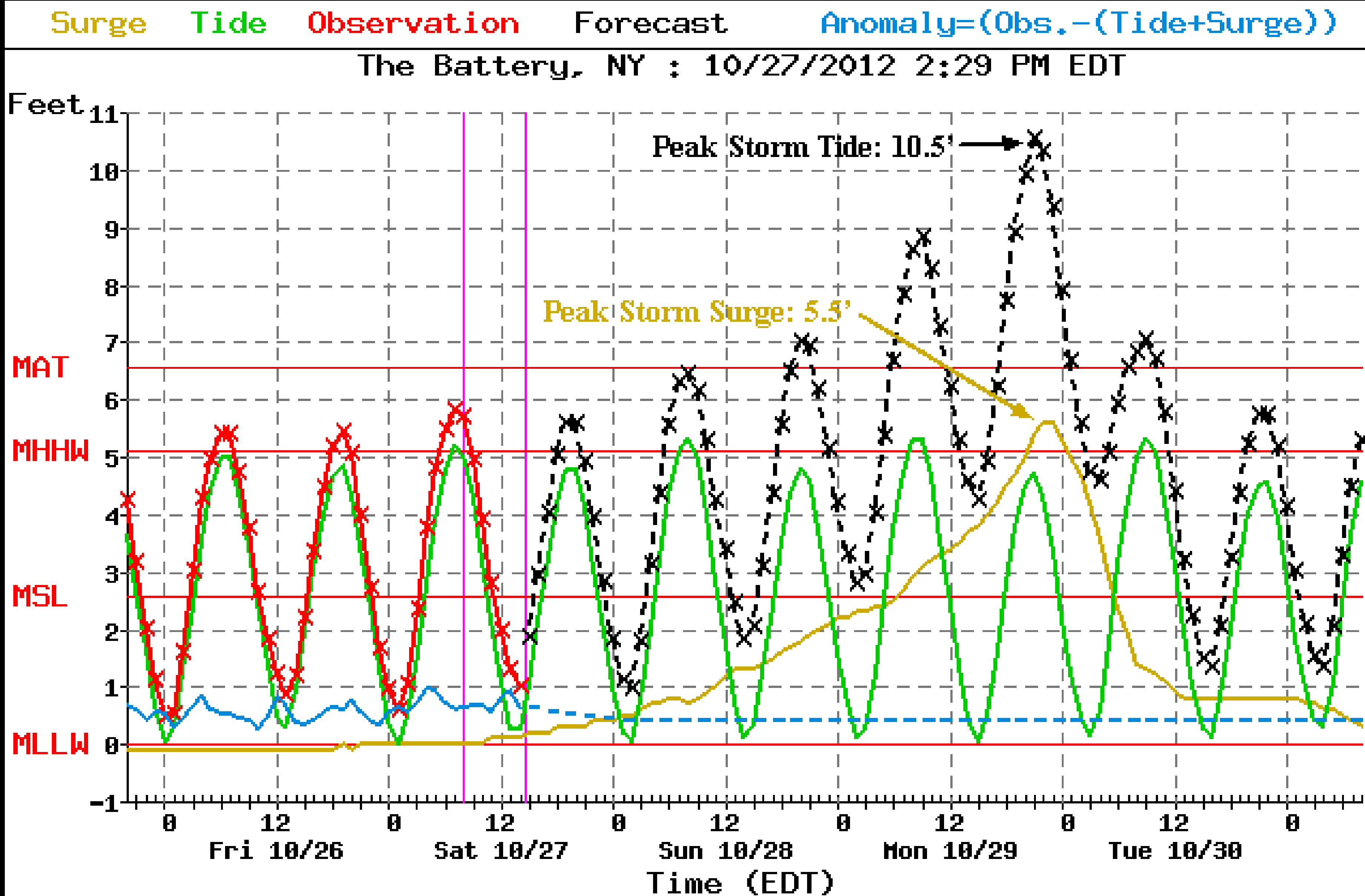


Flooding of Coast, Caused by Global Warming, Has Already Begun

Scientists' warnings that the rise of the sea would eventually imperil the United States' coastline are no longer theoretical.

By JUSTIN GILLIS SEPT. 3, 2016

The
New York
Times

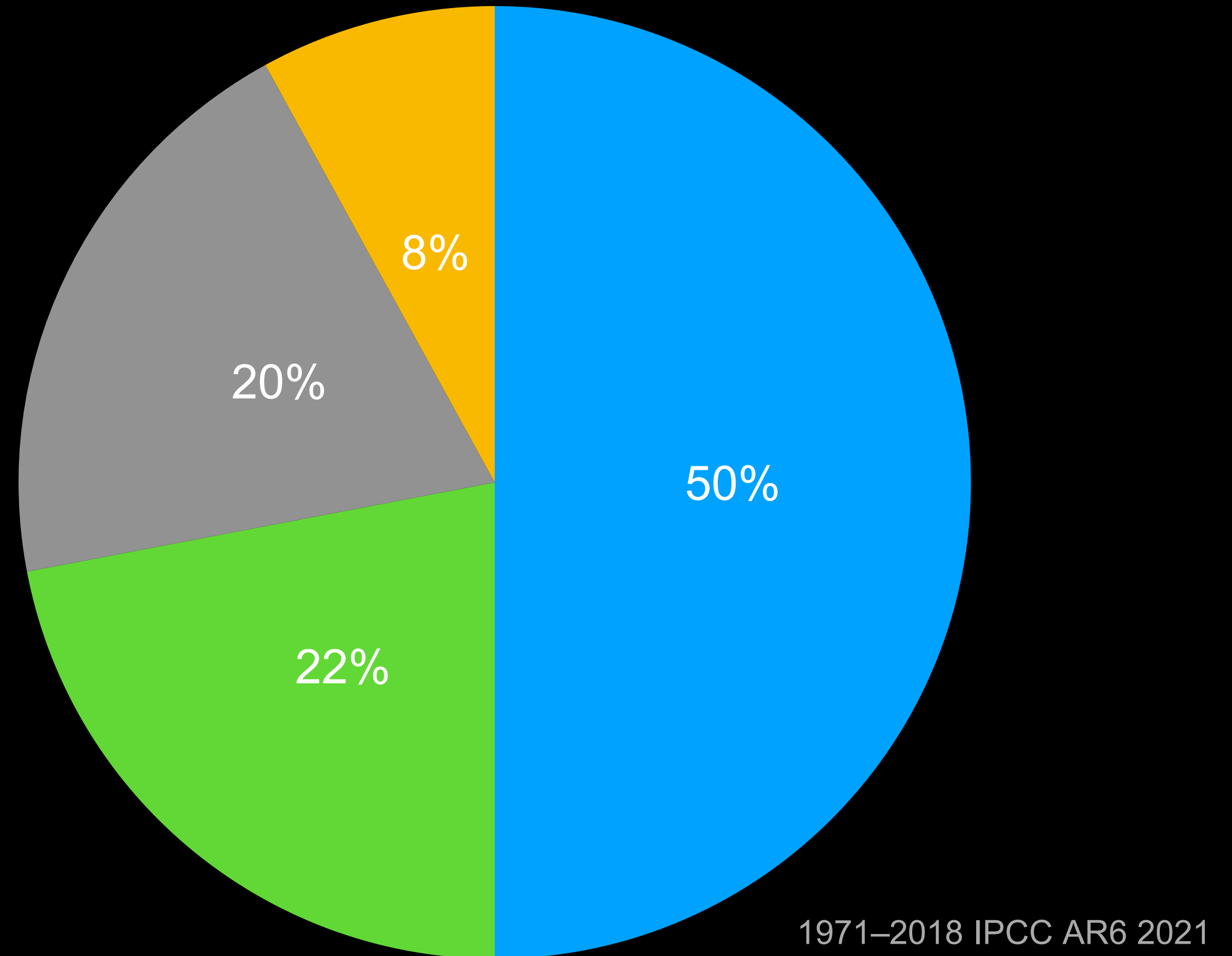


Superstorm Sandy ... Sea level rise + storms surge



multiple factors affect sea level

1. thermal expansion
 2. glacier loss
 3. ice sheet reduction
 4. groundwater extraction
 5. gravitational effects
 6. isostasy
 7. ocean circulation changes
 8. storm surge
- make sea level rise non-uniform



- Thermal expansion
- Glacier loss
- Ice sheet reduction
- Groundwater extraction

* gravitational effects, local isostasy and ocean circulation changes make sea level rise non-uniform