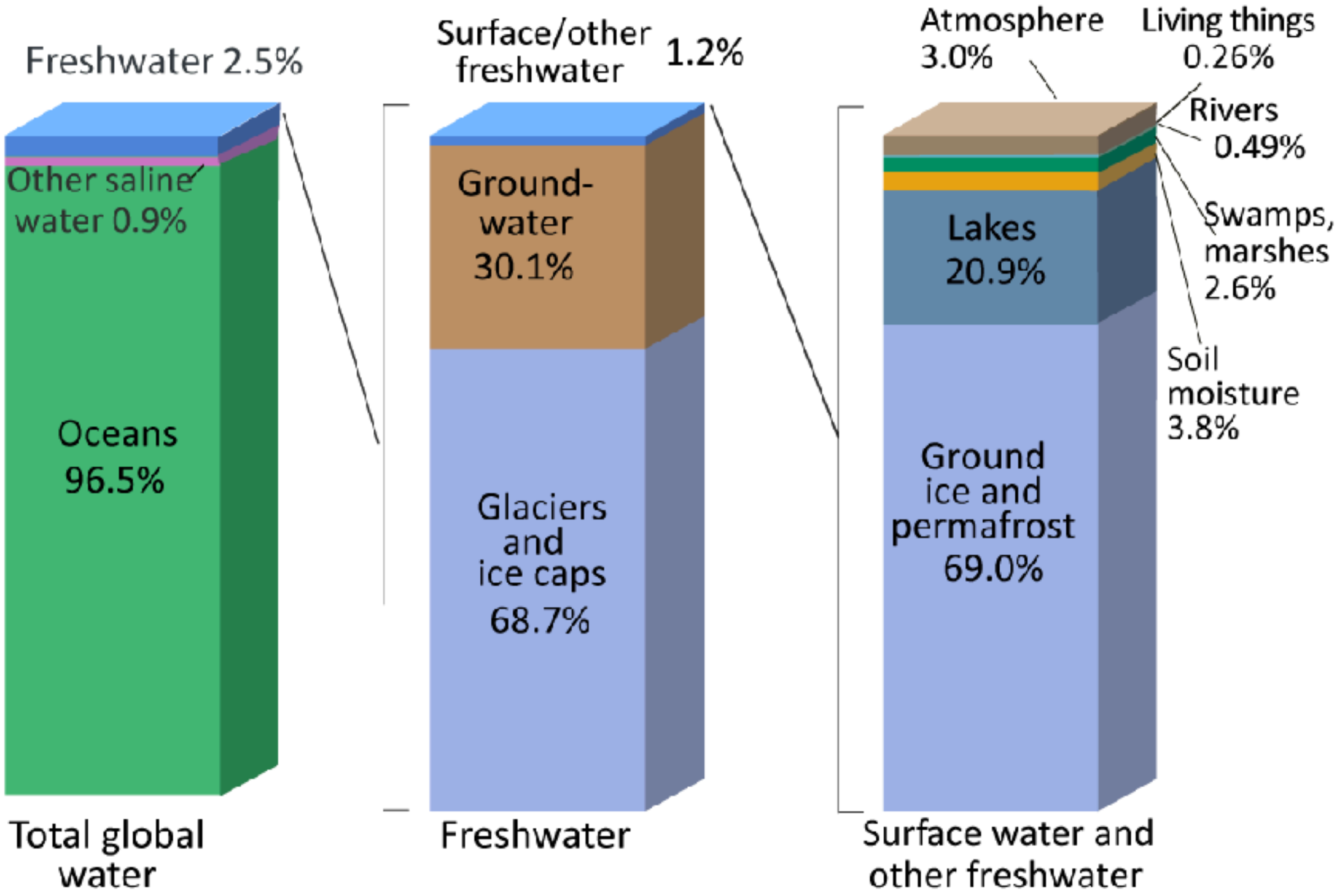
Towards Glacier Conservation: Preserving Glaciers in a Warming Climate

Prof. Sławek Tułaczyk, Earth and Planetary Sciences, UCSC

#Firstgen = first generation to go to high school and college

Where is Earth's Water?



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources. (Numbers are rounded).

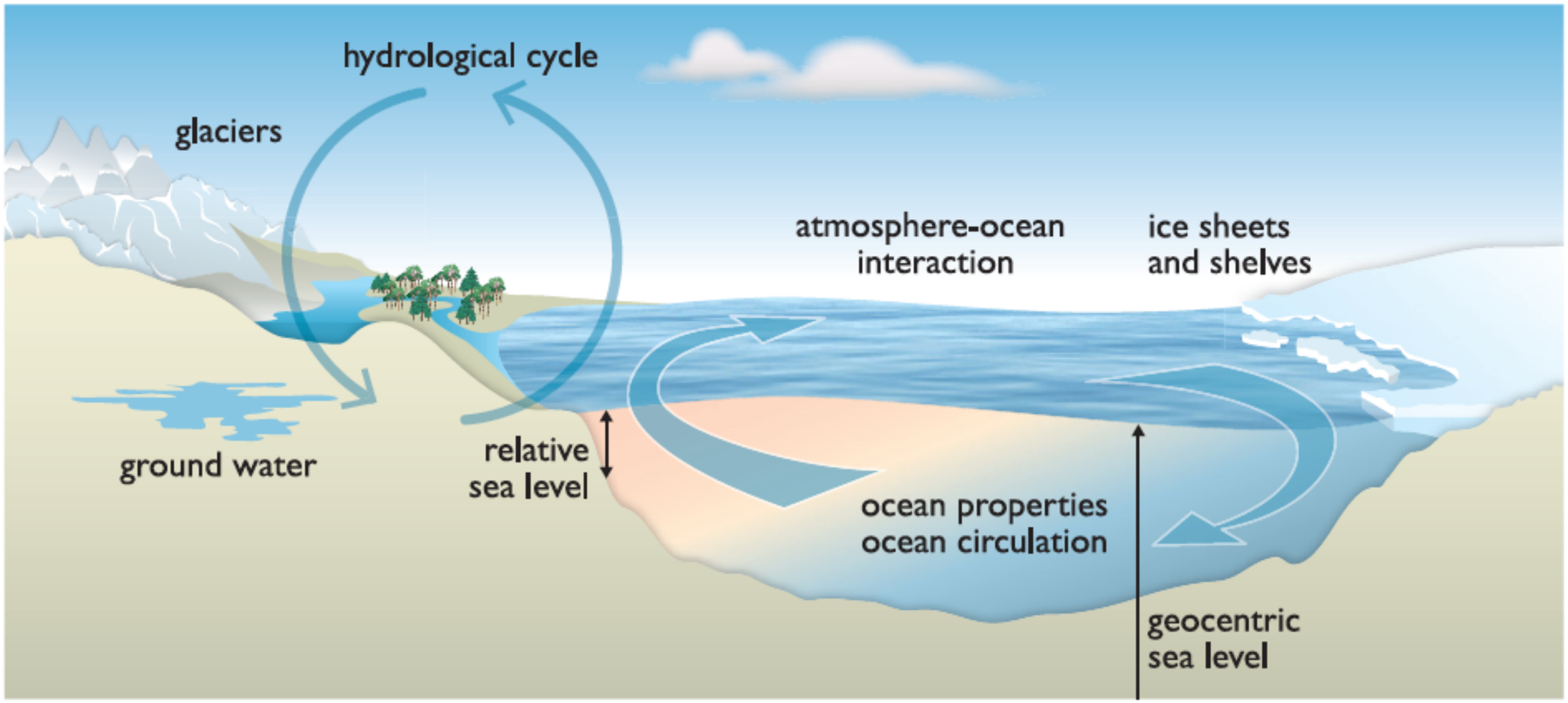
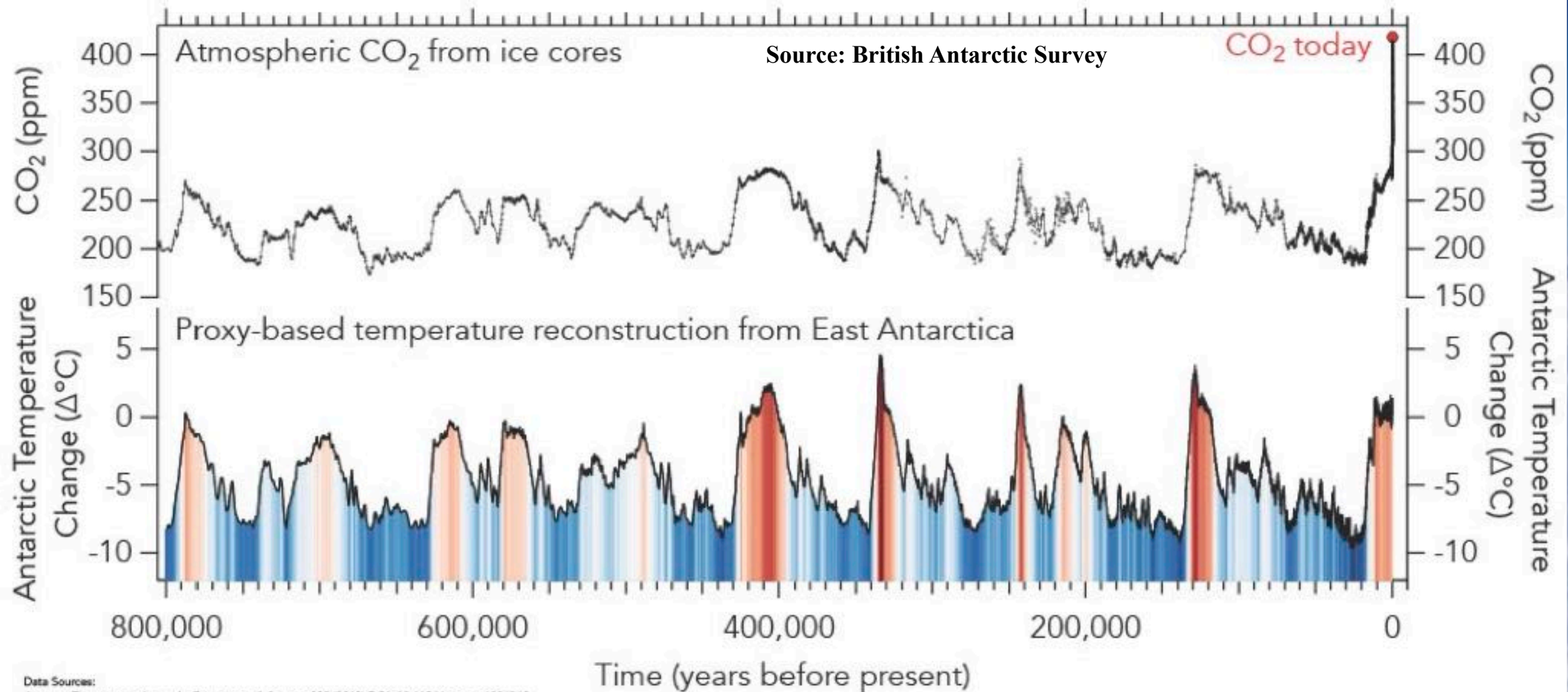


Figure 13.1 | Climate-sensitive processes and components that can influence global and regional sea level and are considered in this chapter. Changes in any one of the components or processes shown will result in a sea level change. The term 'ocean properties' refers to ocean temperature, salinity and density, which influence and are dependent on ocean circulation. Both relative and geocentric sea level vary with position. Note that the geocenter is not shown.

Only two major sources of potential sea level rise (SLR)

Greenland =
24 feet of SLR

Antarctica =
186 feet of SLR

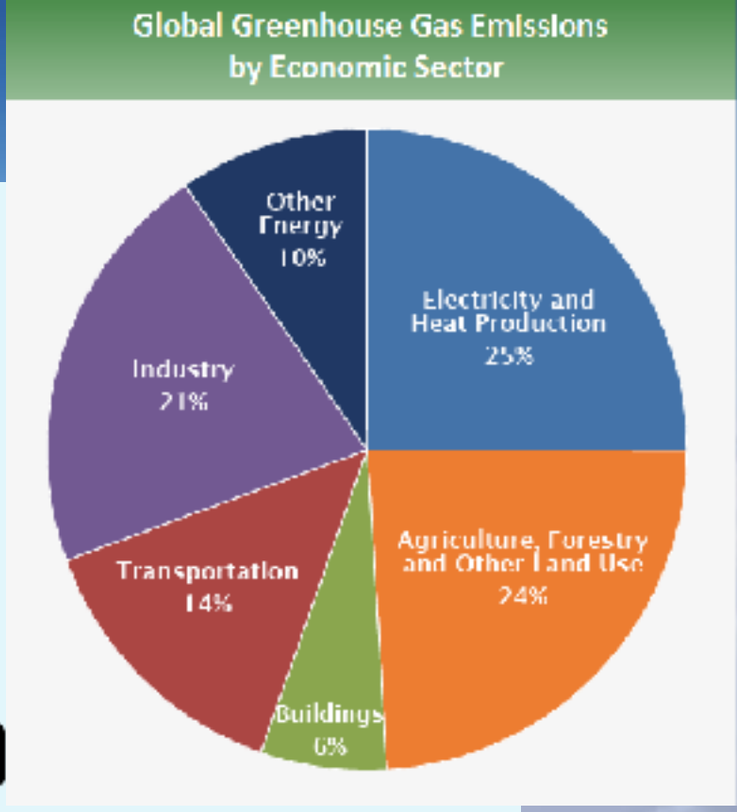


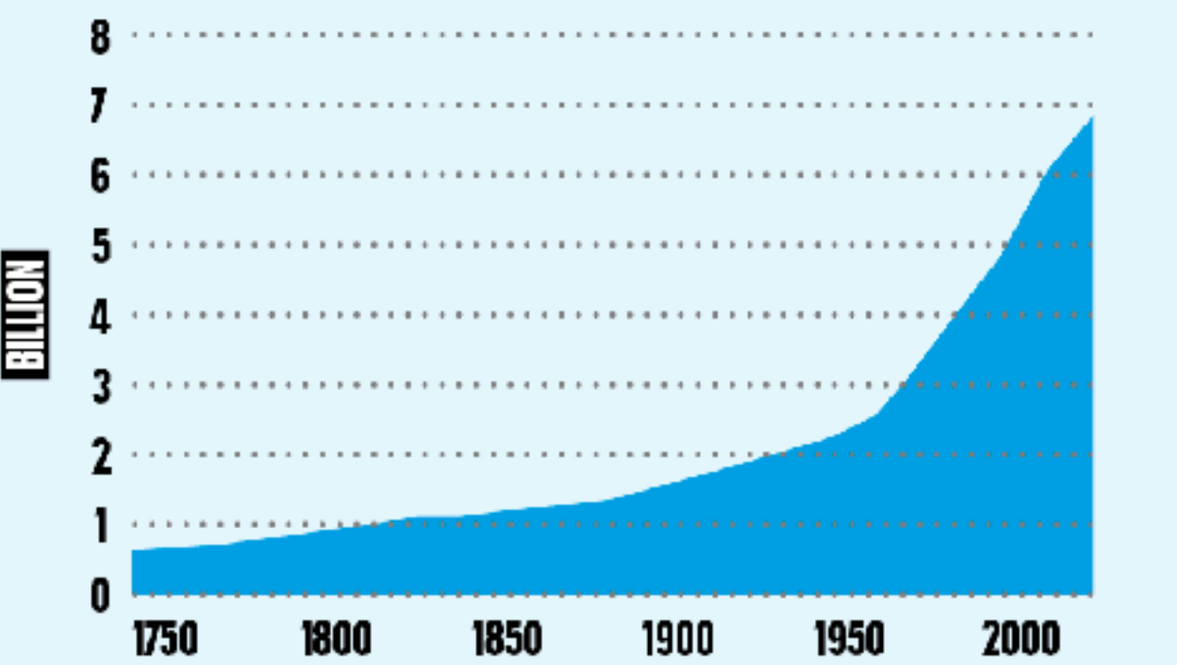
Source: British Antarctic Survey

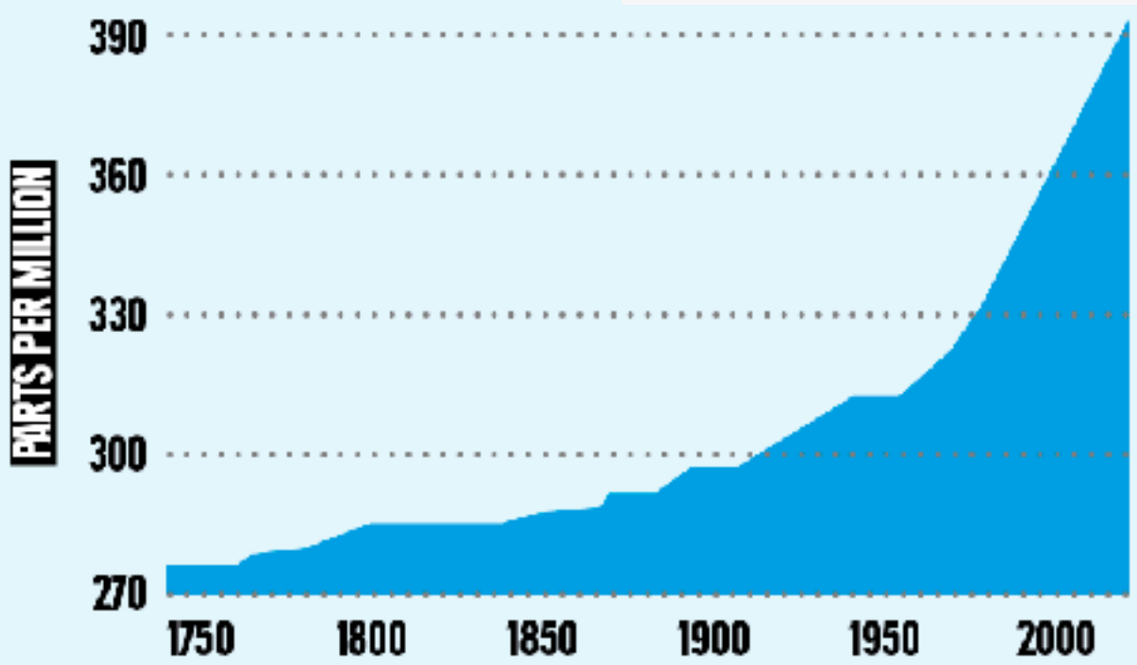
Data Sources:
Antarctic Temperature Anomaly: Parrenin et al, Science 339 (2013) DOI: 10.1126/science.1226368
Atmospheric CO_2: Petit et al., Nature 399, 429 (1999); Fischer et al., Science 283, 1712 (1999); Monnin et al., EPSL 224 (2004); Siegenthaler et al., Science 310, 5752 (2005); Lüthi et al., Nature 453, 379–382 (2008) Loulergue et al., Nature 453, 383–386 (2008); Bereiter et al., PNAS 109, 9755–9760 (2012); Ahn et al., Global Biogeochem. Cycles, 26 (2012); Mitchell et al., Science 342, 6161 (2013); Marcott et al., Nature 514, 616–619 (2014); Bauska et al., Nature Geoscience 8, 383–387 (2015); Rubino et al., Earth Syst. Sci. Data, 11, 473–492 (2019); Nehrbass-Ahles et al., Science 369, 6506 (2020); Shin et al., Clim. Past 16, 2203–2219 (2020) Lee et al., Clim. Past 16, 1691–1713 (2020);Bauska et al., Nature Geoscience 14, 91–96 (2021); NOAA/GML (gml.noaa.gov/ccgg/trends/)
Figure made by Thomas Bauska

Ice cores show a strong correlation between carbon dioxide concentration in the atmosphere and temperature changes.

POPULATION AND CO_2 EMISSIONS, 1750-2015







The industrial revolution enabled rapid growth in human population and living standards after millenia of relative stagnation. It was and still is powered by fossil fuels (80% of global energy consumption is satisfied by fossil fuels). Nuclear provides 10% and all renewables 10%.

Source: United Nations, 2017

Annual CO_2 emissions

Carbon dioxide (CO_2) emissions from fossil fuels and industry. Land use change is not included.

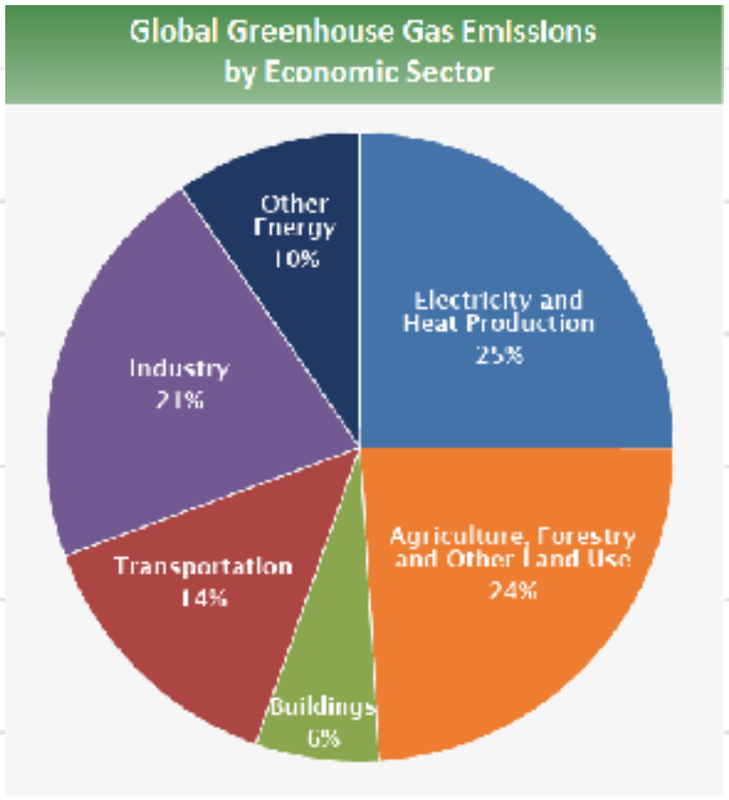
Our World in Data

LINEAR | LOG

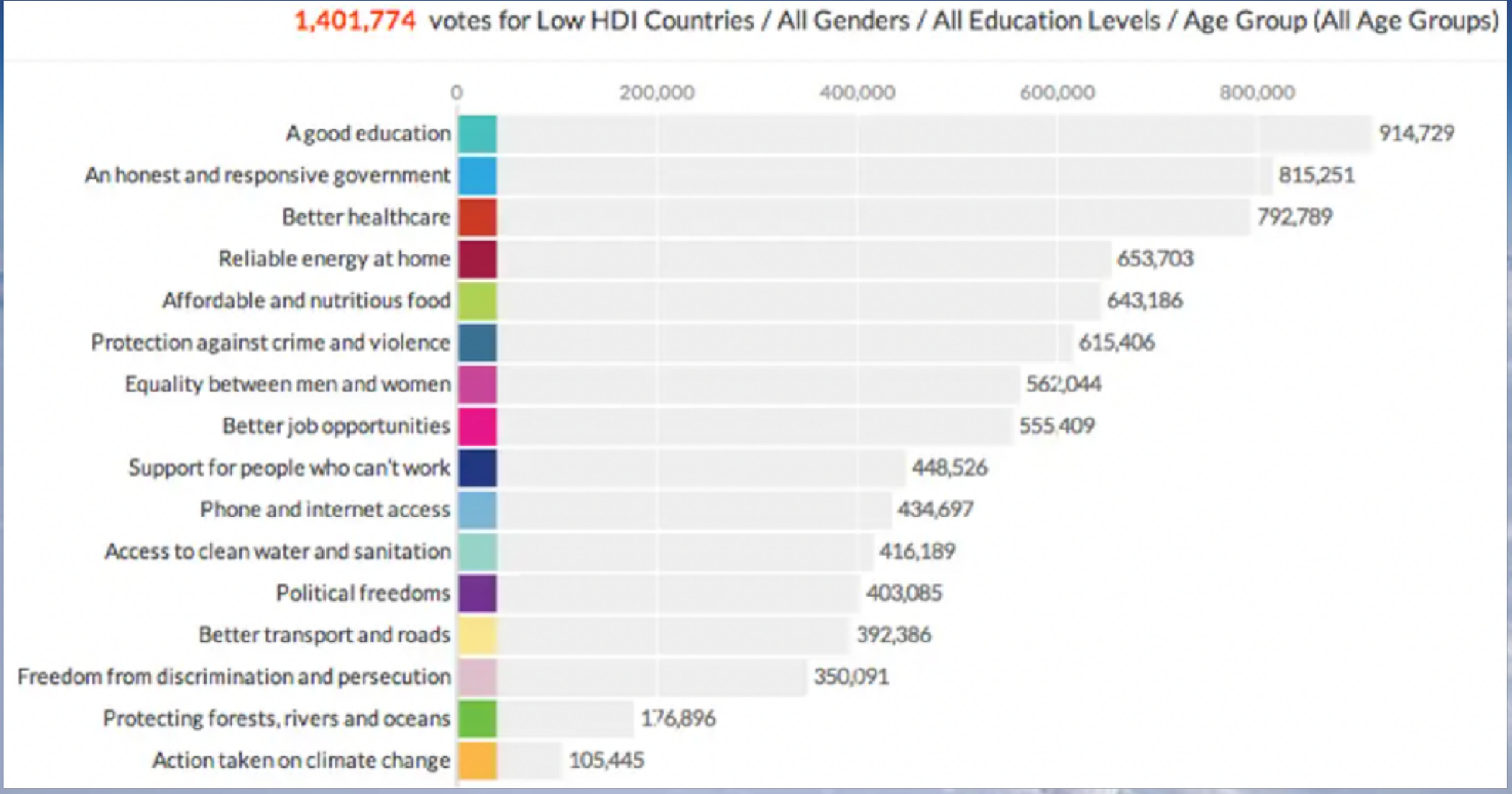
Add country or region

All together

Relative change

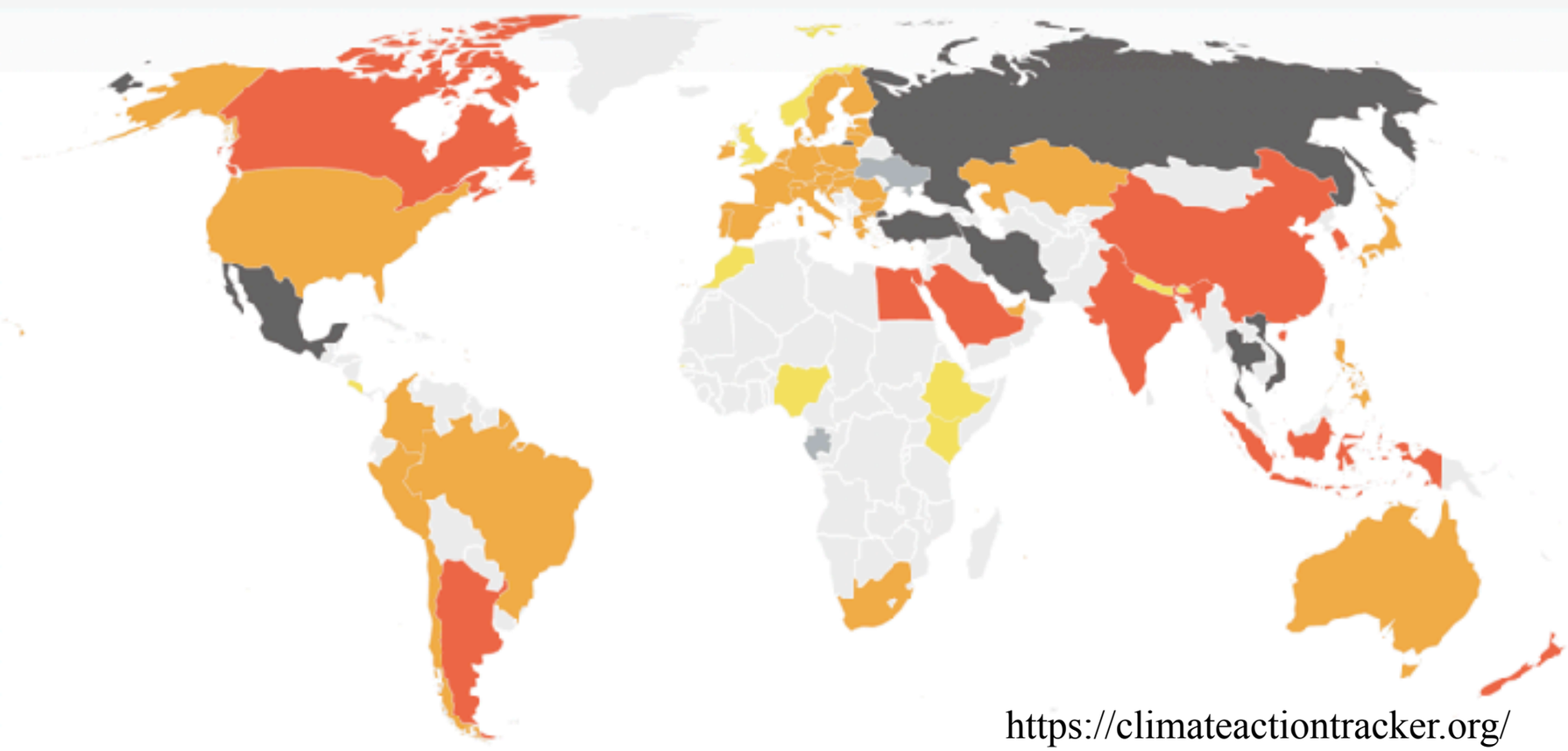


Decarbonization is slow and expensive. In 1980 N. America and Europe emitted 66% of all carbon. Now they account for 25% of carbon emissions. Population growth and industrialization are rapidly increasing emissions from other regions. For instance, China (18% of global population) consumes high fraction of global resources: 55% of coal, 59% of cement, 56% of nickel, 50% of steel, 50% of copper, 47% of aluminum, 46% of pork.



First World problem? People care about climate change when they can afford it.

(UN My World 2015 Survey results for Low Human Development Index Countries)



Assessments of:

AVIATION
Find out more

SHIPPING
Find out more

https://climateactiontracker.org/

The maps displayed are for reference only.

LAST UPDATE: *July 2023*

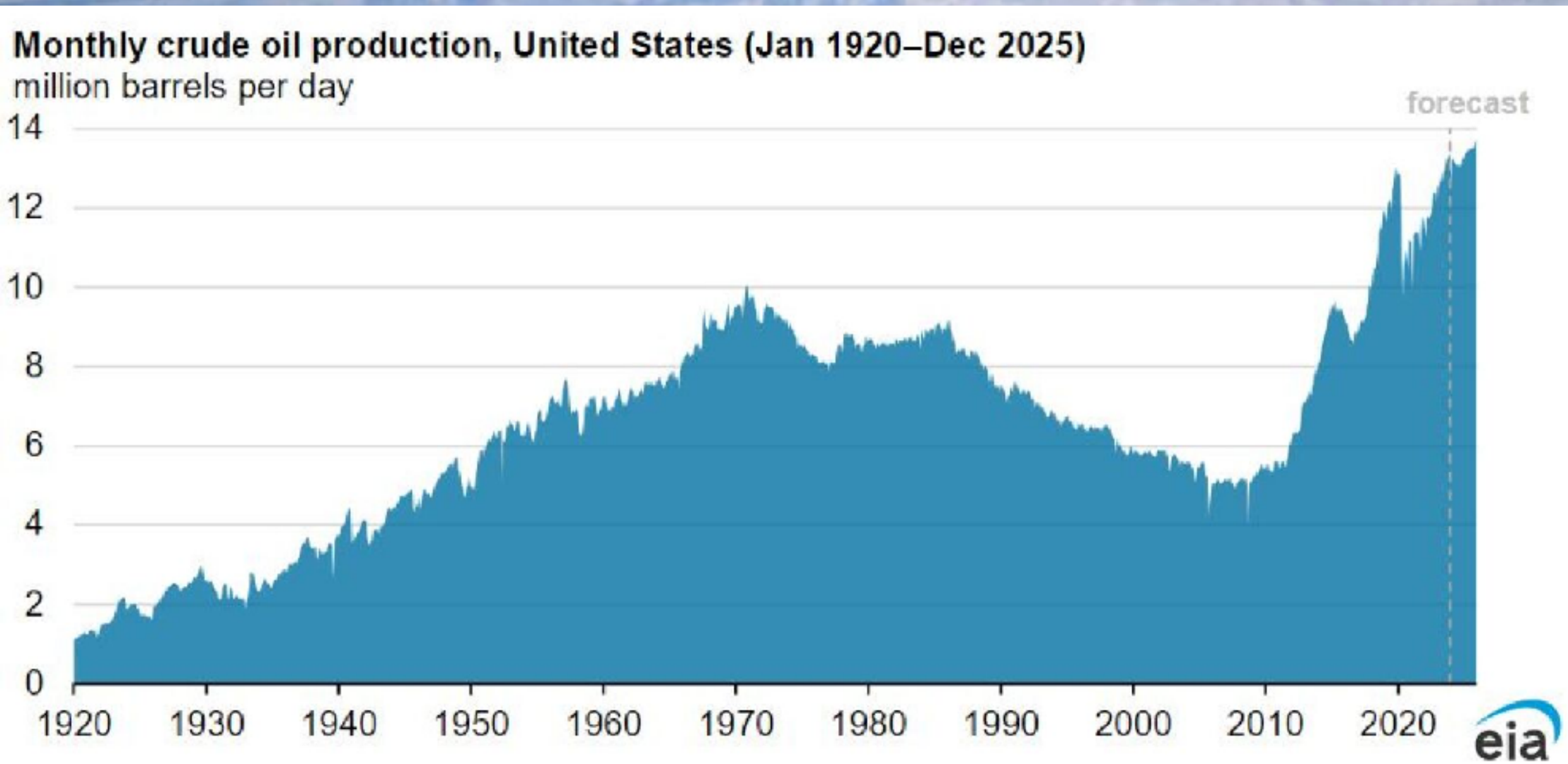
CRITICALLY INSUFFICIENT | HIGHLY INSUFFICIENT | INSUFFICIENT | ALMOST SUFFICIENT | 1.5°C PARIS AGREEMENT COMPATIBLE

Seven years after Paris Agreement went into effect, practically all countries are missing the target to keep warming to <1.5 degrees C.

Just in one year (2022), China approved building 100 new coal power plants and India approved 10. China has a total of 1,142 such power plants, India has 282 and USA has 210. The cold hard fact is that modern industry and population still demands fossil fuels to satisfy energy needs. Example of slow progress: Electric car sales are increasing but only 2% of all passenger vehicles in the World were electric in 2022.

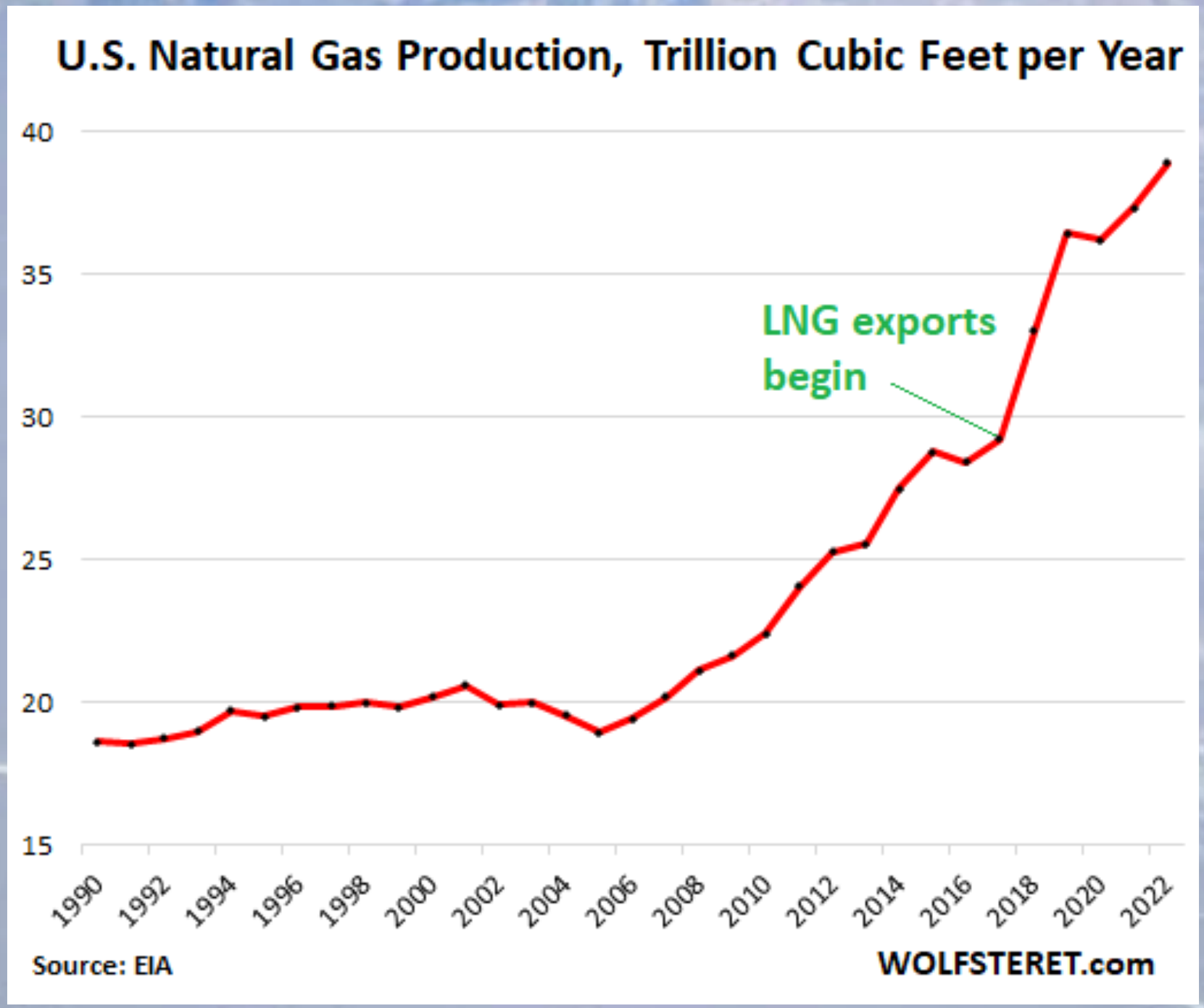
US oil production increased by about 2.5 times since 2008.

Politicians may promise climate action but need to keep fuel cheap for the people they represent.

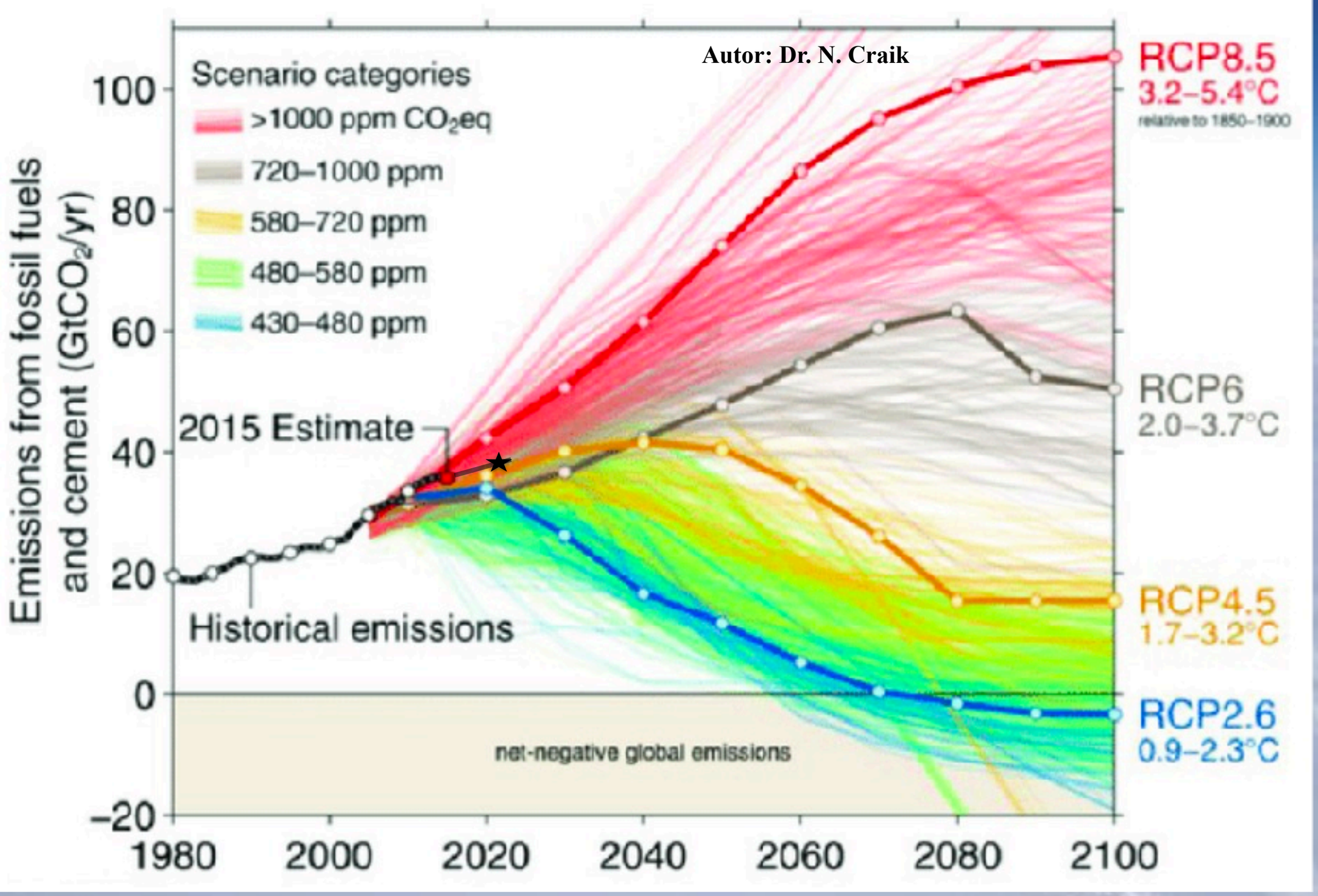


US natural gas production more than doubled between 2005 and 2023

Politicians may promise climate action but need to keep heating and electricity cheap for the people they represent.

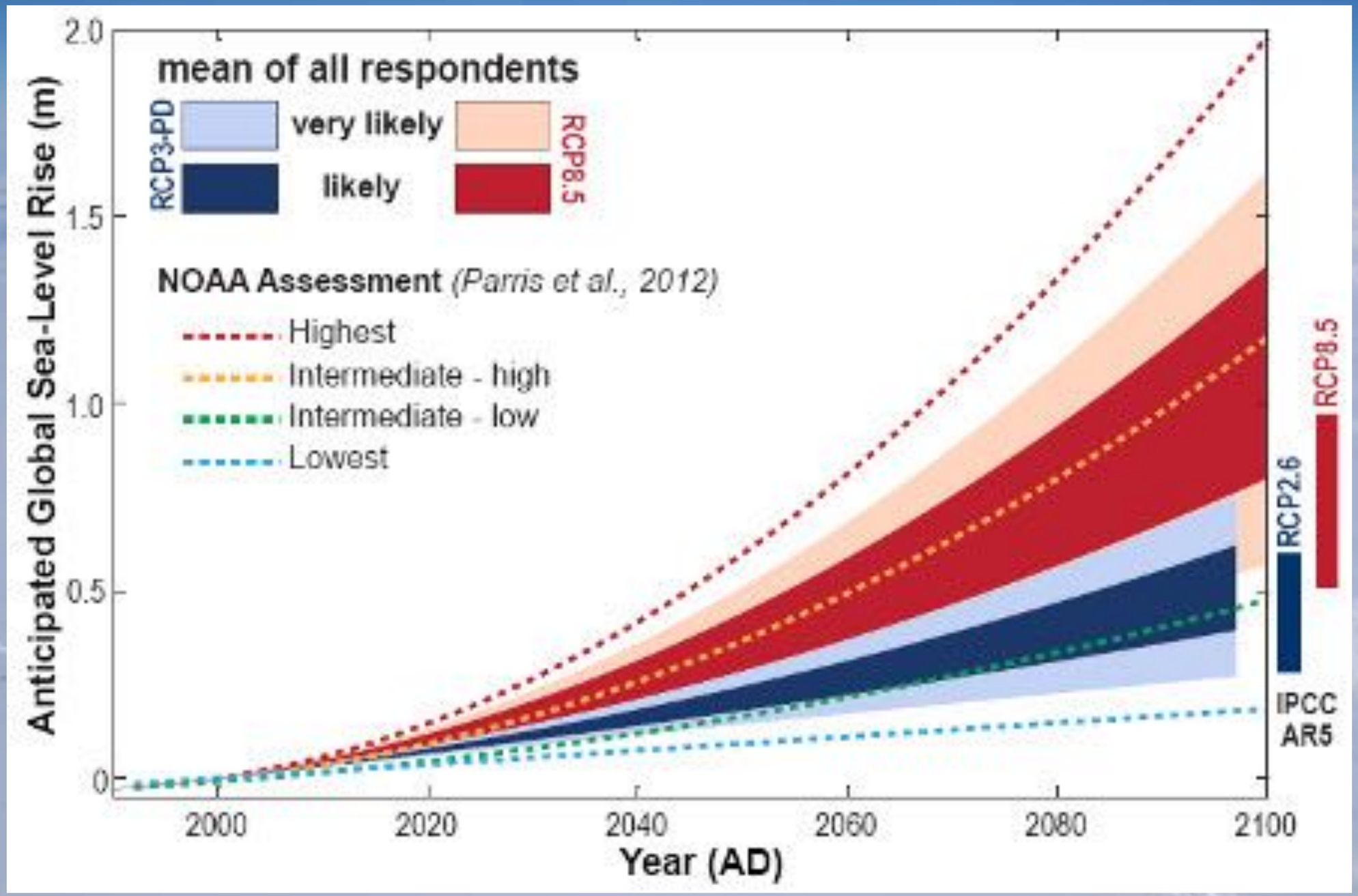


Autor: Dr. N. Craik



Future emissions are uncertain.

Niels Bohr: ”*Forecasts are difficult, especially about the future*”



Global sea-level rise predictions up to 1-2 m by 2100

Financial losses from such sea level rise may reach $10 to $20 trillion globally (Brown et al., 2021).

explorer.adaptingtorisingtides.org

ART Bay Area Sea Level Rise and Shoreline Analysis Maps « Adapting to Rising Tides

ART Bay Shoreline Flood Explorer

LEARN EXPLORE DOWNLOAD ABOUT

Get Involved

Select Language

Enter address or location...

108"
96"
84"
77"
66"
52"
48"
36"
24"
12"
0"
Total Water (MHHW+)

Marin County
San Rafael
Vallejo
Antioch
Concord
Contra Costa County
San Francisco County
Oakland
San Leandro
Livermore
Alameda County
Fremont
San Mateo County

ONE MAP, MANY FUTURES

Total Water Level | Choose a Scenario

66" **Total Water Level** represents similar flooding above MHHW under the following scenarios:

Sea Level Rise +	Storm Surge
24"	100-year
30"	50-year
36"	25-year
42"	5-year
48"	2-year
52"	King tide

LEGEND

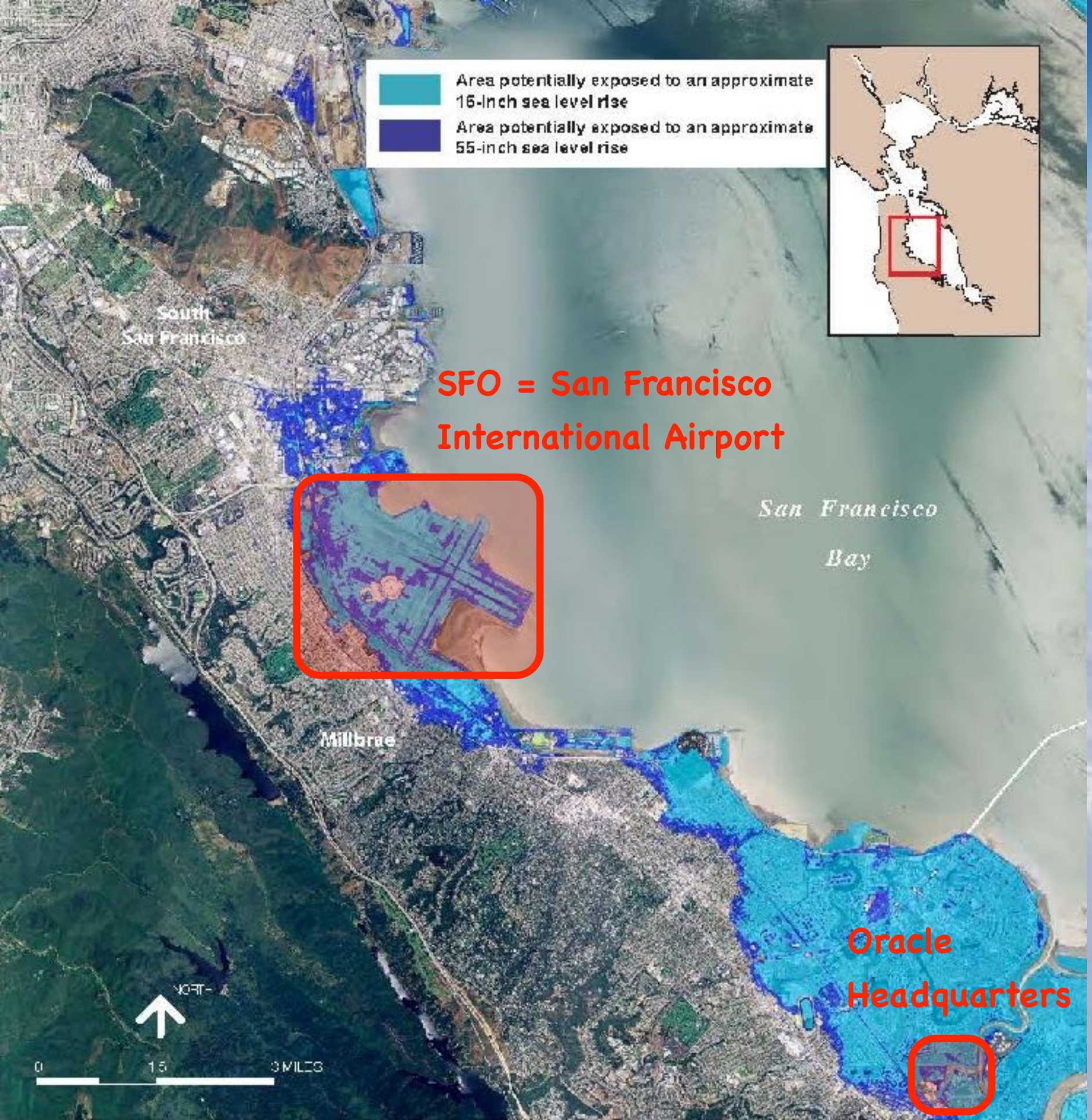
Toggle layers on/off and control transparency below. Use Slider at left to control Total Water Level displayed.

Depth of Flooding

Transparency:

- 12+ feet
- 10 - 12 feet
- 8 - 10 feet
- 6 - 8 feet
- 4 - 6 feet
- 2 - 4 feet
- 0 - 2 feet

Areas outside of sea level rise and storm surge flooding extent could potentially be subject to

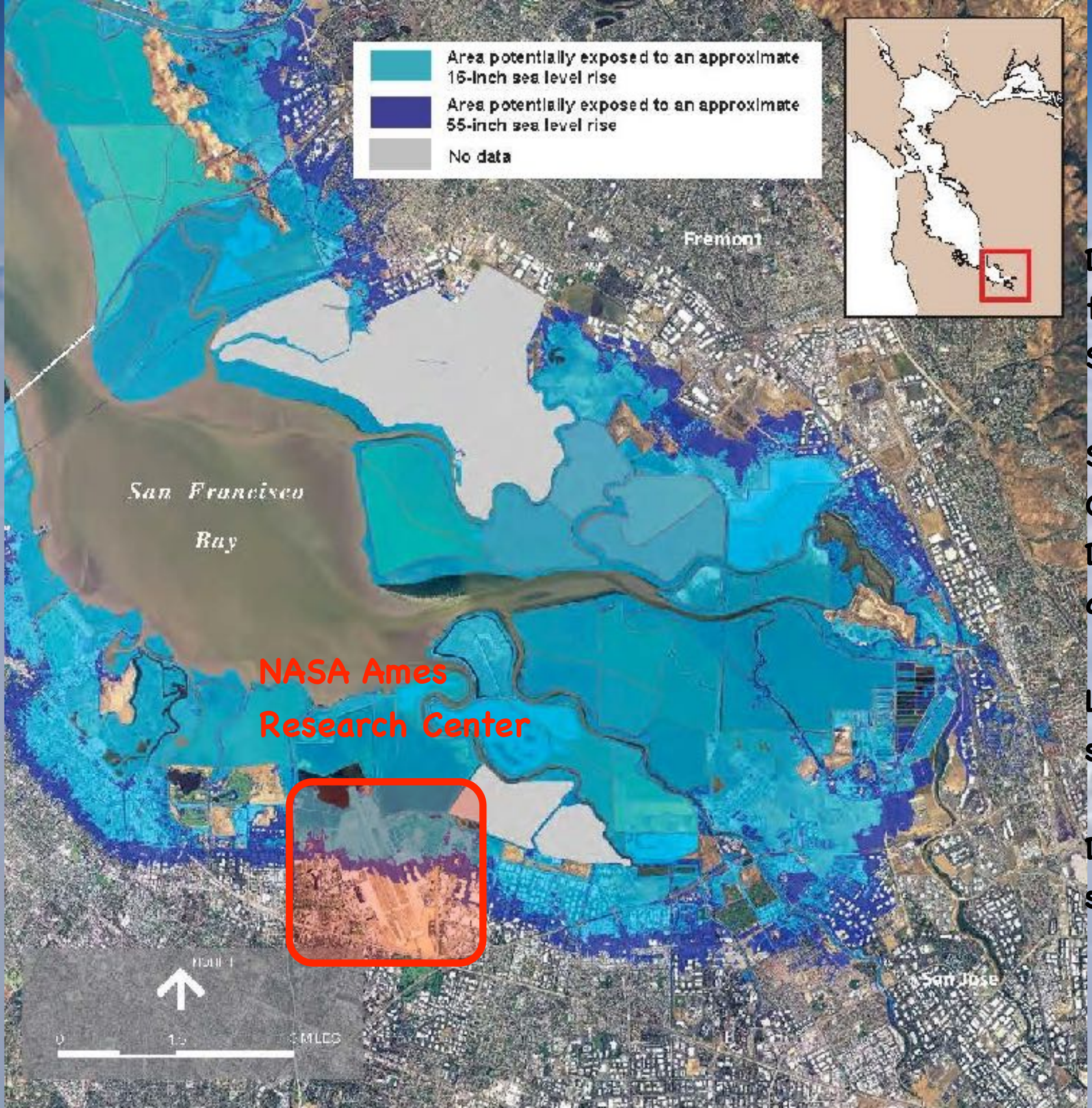


Direct coastal flooding du
to sea-level rise for West
SF Bay area

Source: Bay Area
Conservation and
Development Commission
and USGS

Light blue = 40cm
sea level rise by 2100

Dark blue = 127cm
sea level rise by 2100



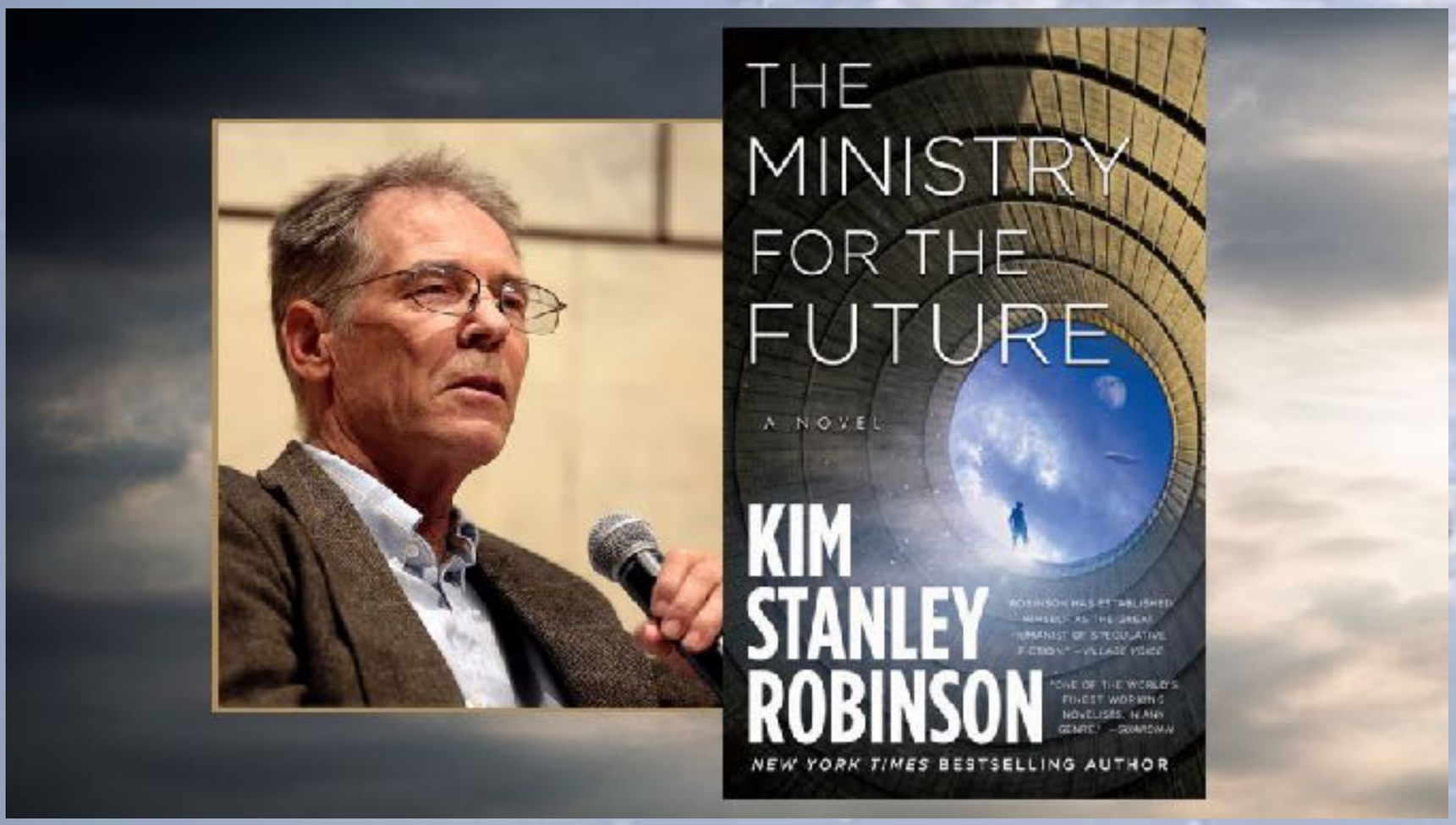
Direct coastal flooding du
to sea-level rise for South
SF Bay area

Source: Bay Area Conservation and Development Commission and USGS

Light blue = 40cm sea level rise by 2100

Dark blue = 127cm sea level rise by 2100

How to protect glaciers if plans for carbon emission reductions will fail?



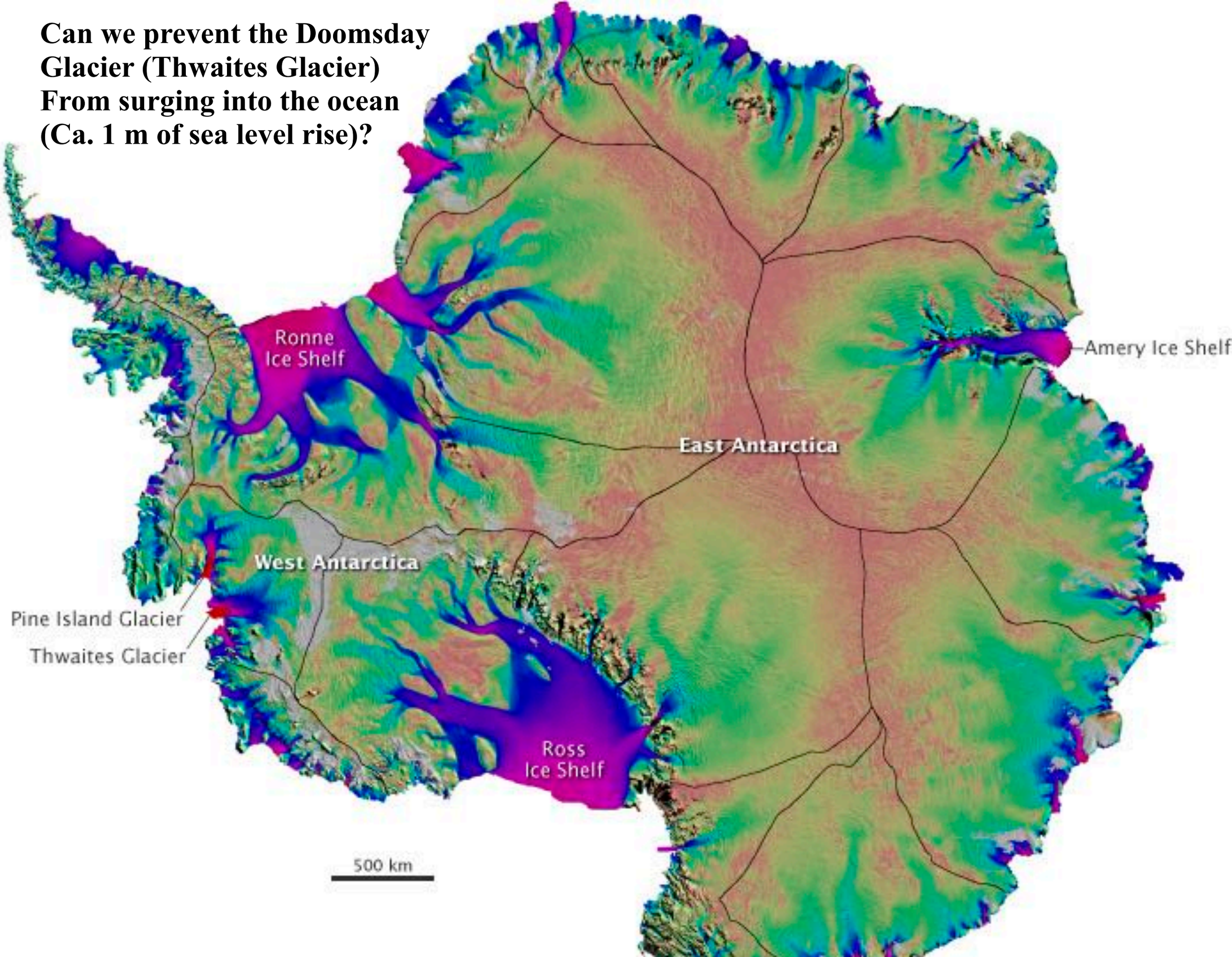
OPINION INTERVIEW

Let's put the freeze on sea level rise

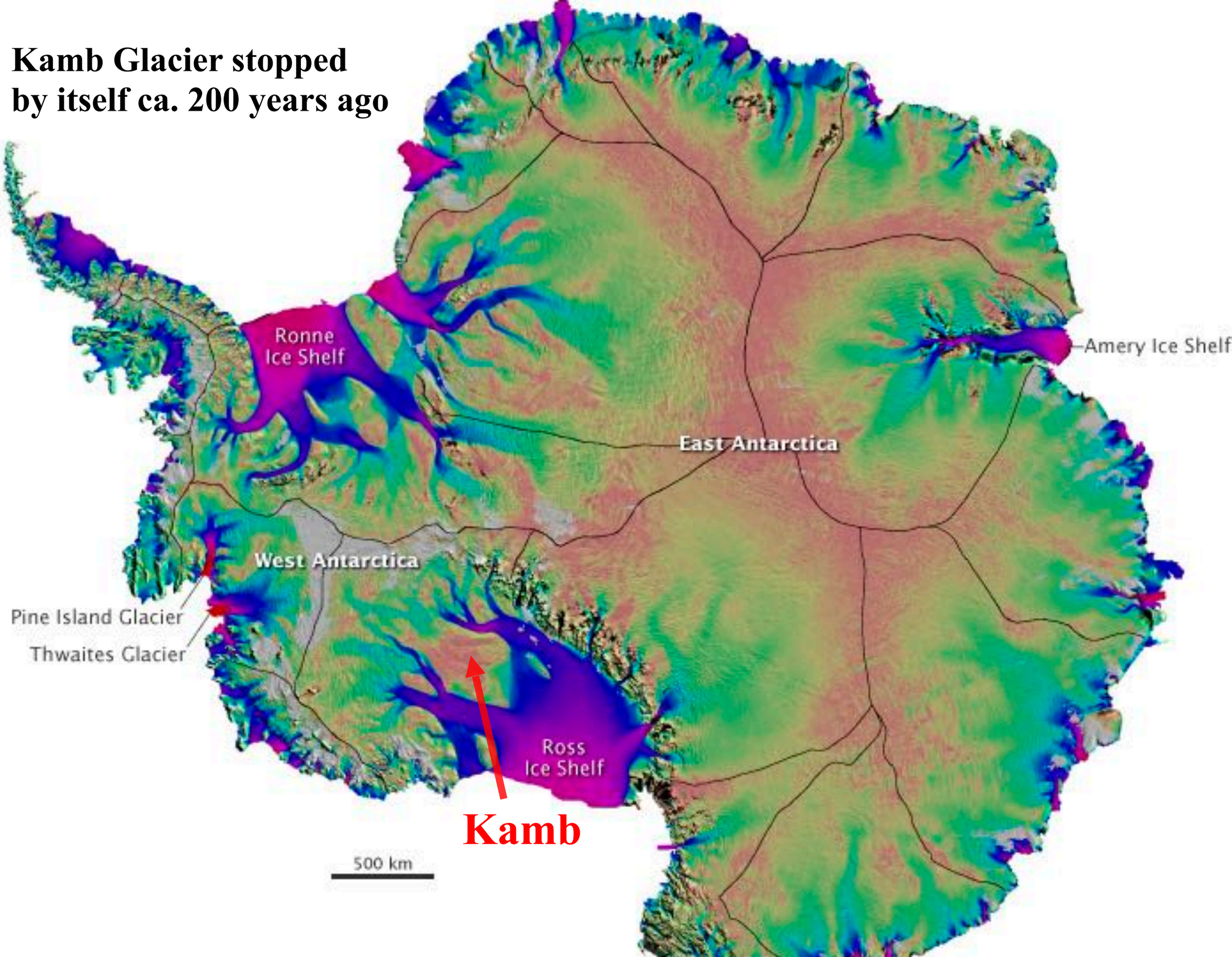
The oceans are set to swallow our coastlines, says **Slawek Tulaczyk**, who suggests a truly radical solution

By Anil Ananthaswamy, New Scientist, 05/23/15

Can we prevent the Doomsday Glacier (Thwaites Glacier) From surging into the ocean (Ca. 1 m of sea level rise)?

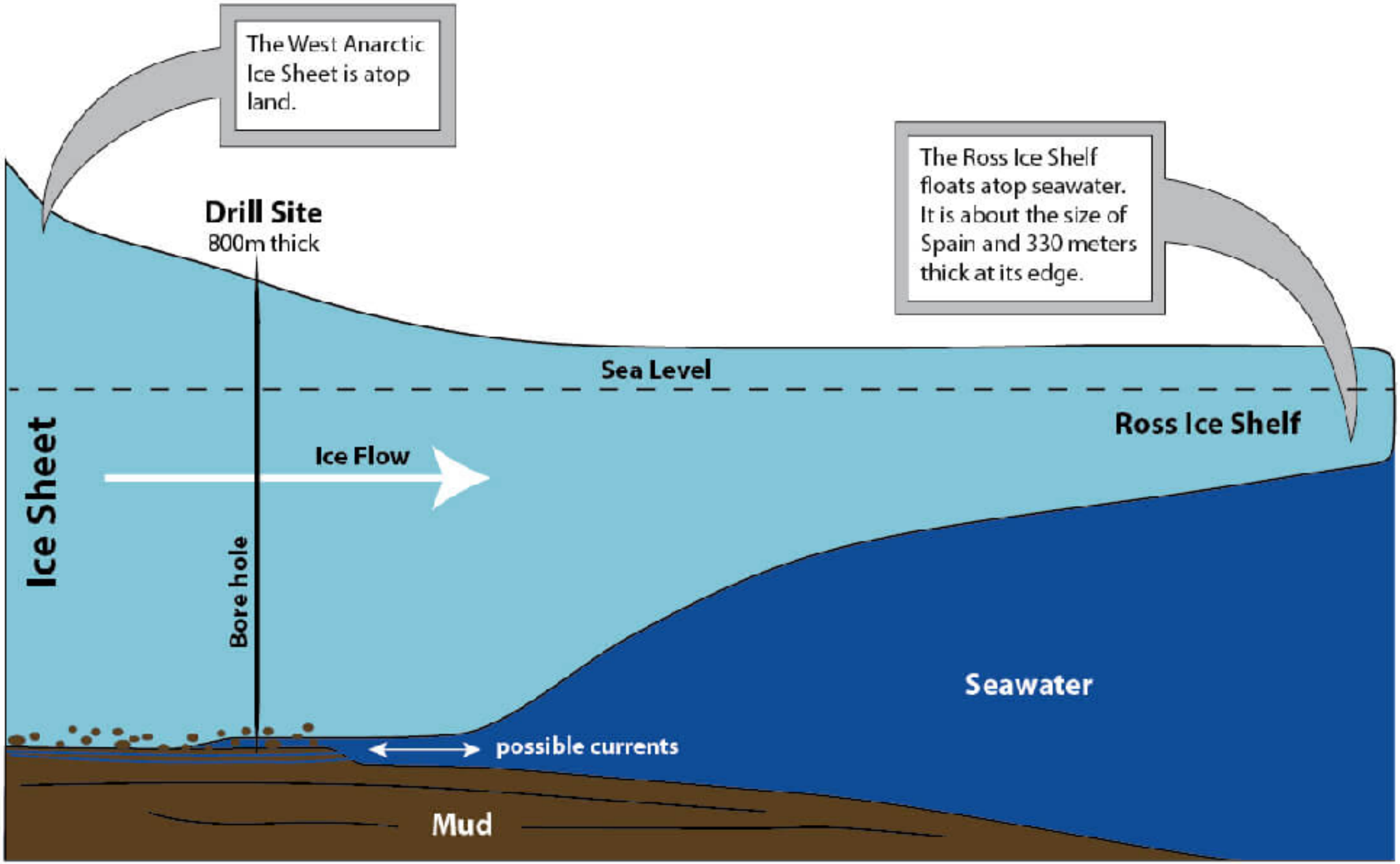


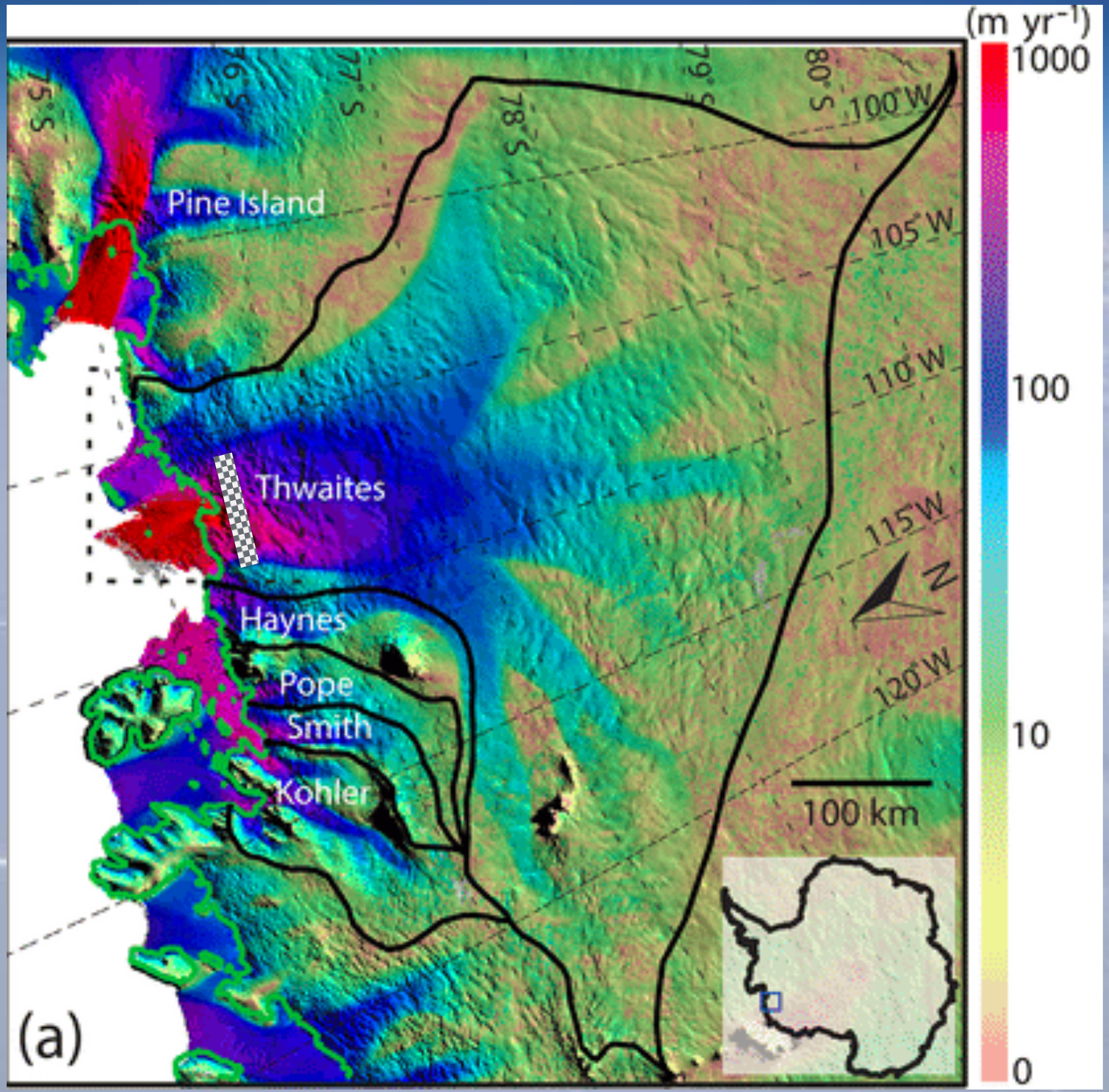
Kamb Glacier stopped by itself ca. 200 years ago



We understand the mechanism of this natural stoppage. We need to research if other large glaciers could be stopped as well.

Water beneath ice is what makes glaciers slide towards the ocean




(m yr⁻¹)
1000
100
10
0
75°S
76°S
77°S
78°S
79°S
80°S
100°W
105°W
110°W
115°W
120°W
Pine Island
Thwaites
Haynes
Pope
Smith
Kohler
N
100 km
(a)

Rotterdam

London

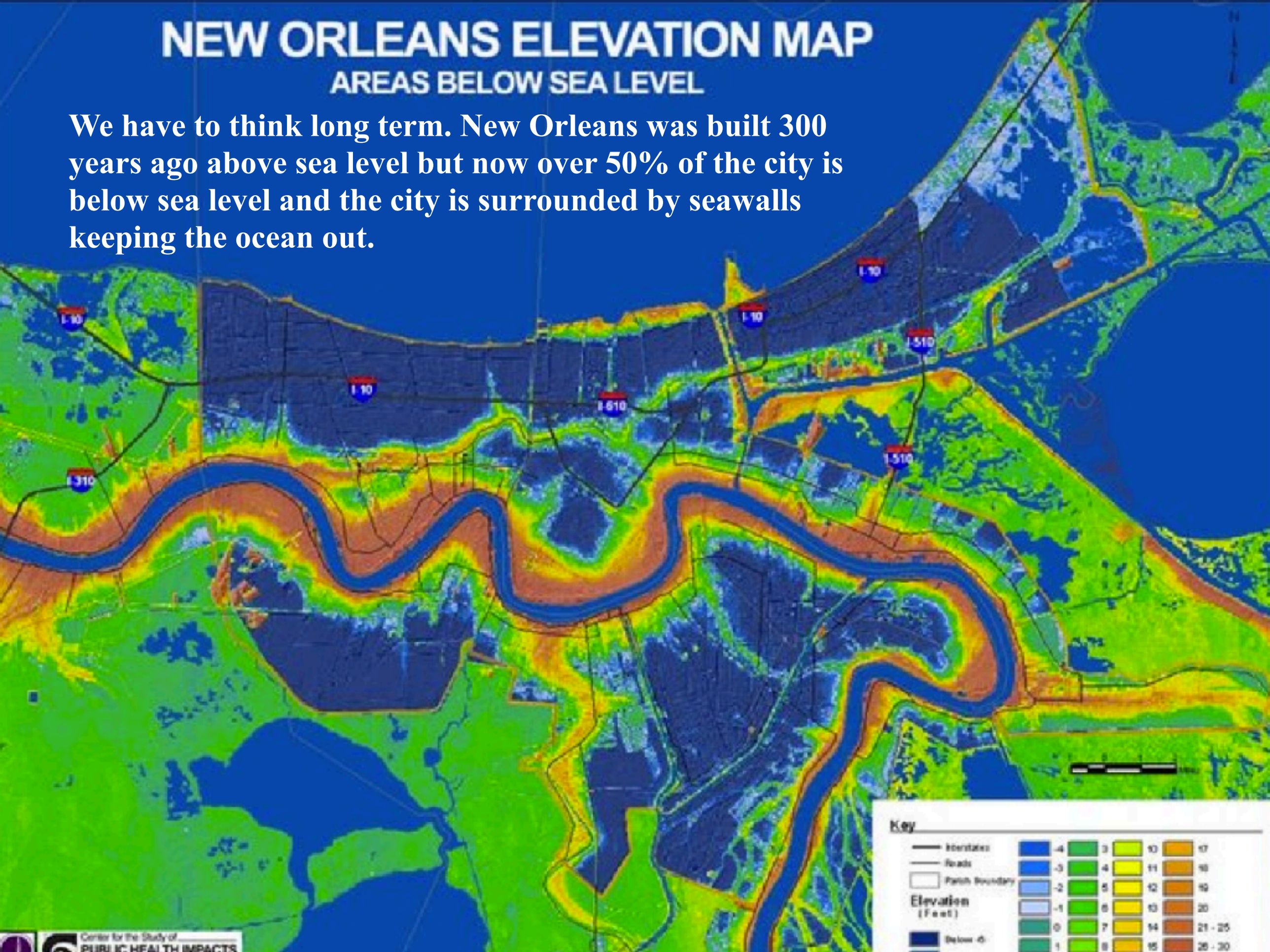
New Orleans

Venice

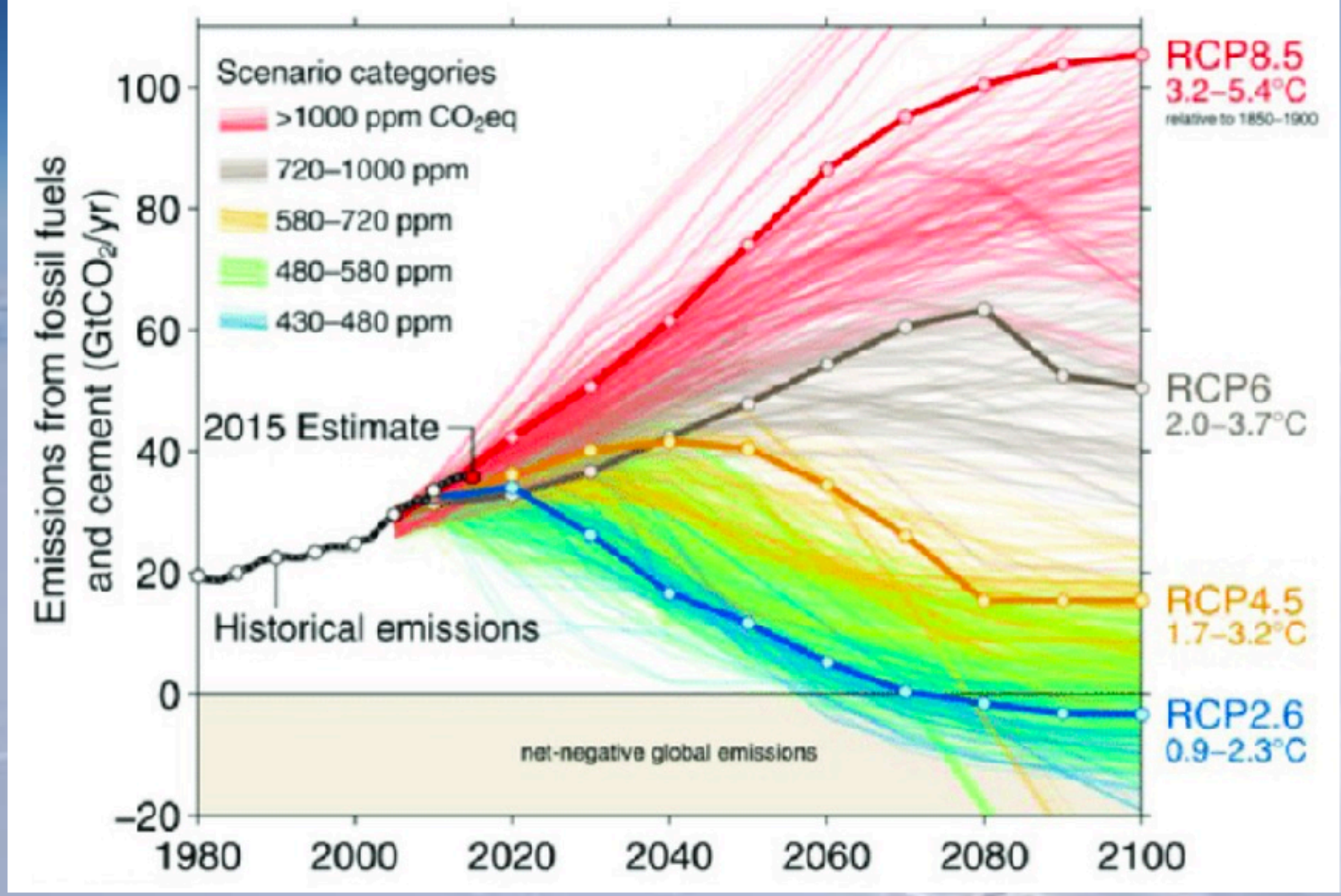
NEW ORLEANS ELEVATION MAP

AREAS BELOW SEA LEVEL

We have to think long term. New Orleans was built 300 years ago above sea level but now over 50% of the city is below sea level and the city is surrounded by seawalls keeping the ocean out.



Center for the Study of PUBLIC HEALTH IMPACTS



Perhaps it is time to research the possibilities for actively protecting polar glaciers from disappearing due to climate warming? If we succeed, we will preserve these amazing environments and slow down sea level rise.

Summary:

- There is no guarantee at this point that humanity will be able to slow down carbon emissions sufficiently to avoid large and rapid climate warming

- Hence, we need to actively research glacier preservation to counteract the impact of warming on these amazing polar environments

- We already have a pretty good idea how we can try to do this but more field research needs to be done (e.g., start with small glaciers and work our way up to larger ones)