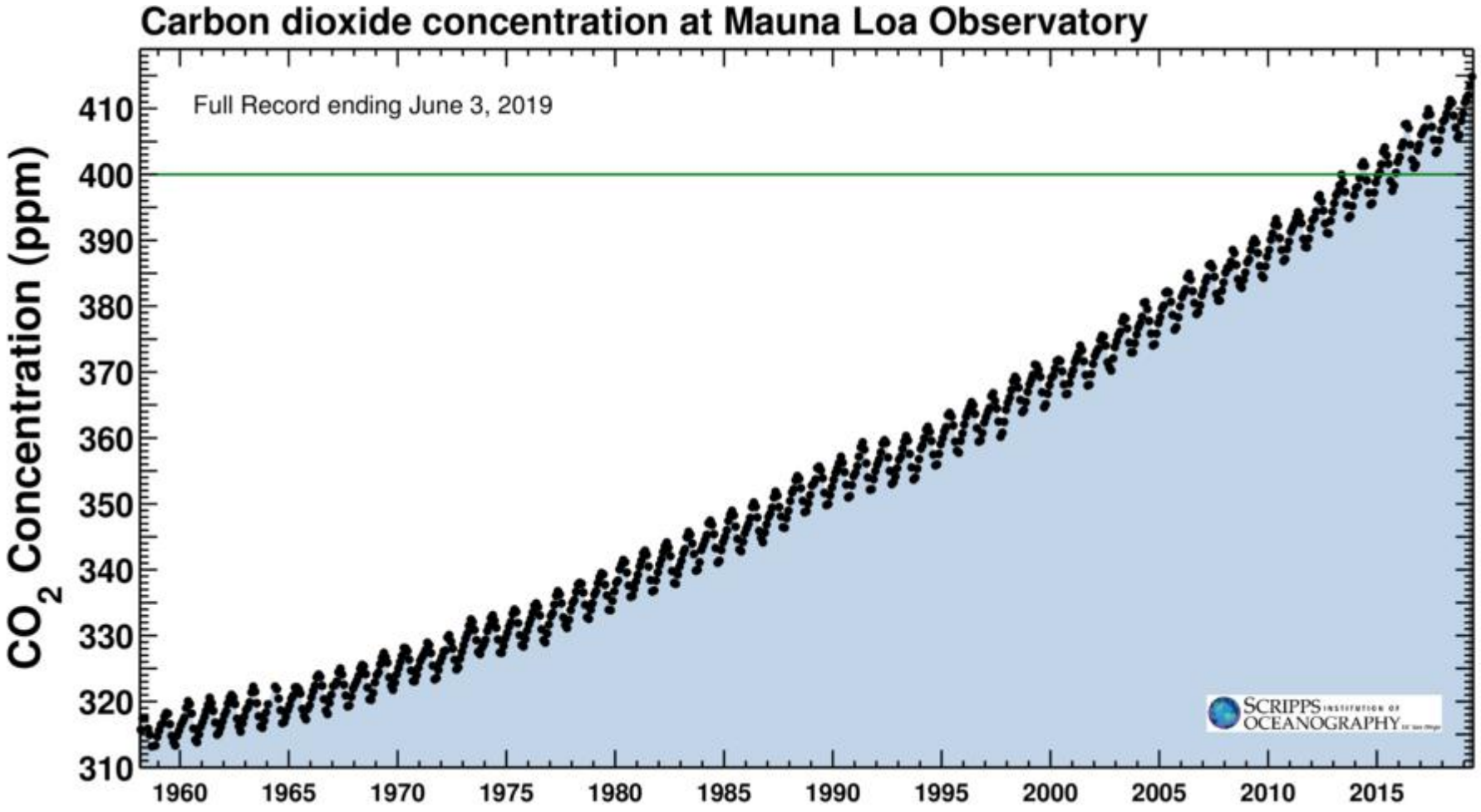
The Passing of the White Silence: Climate Change in the Arctic

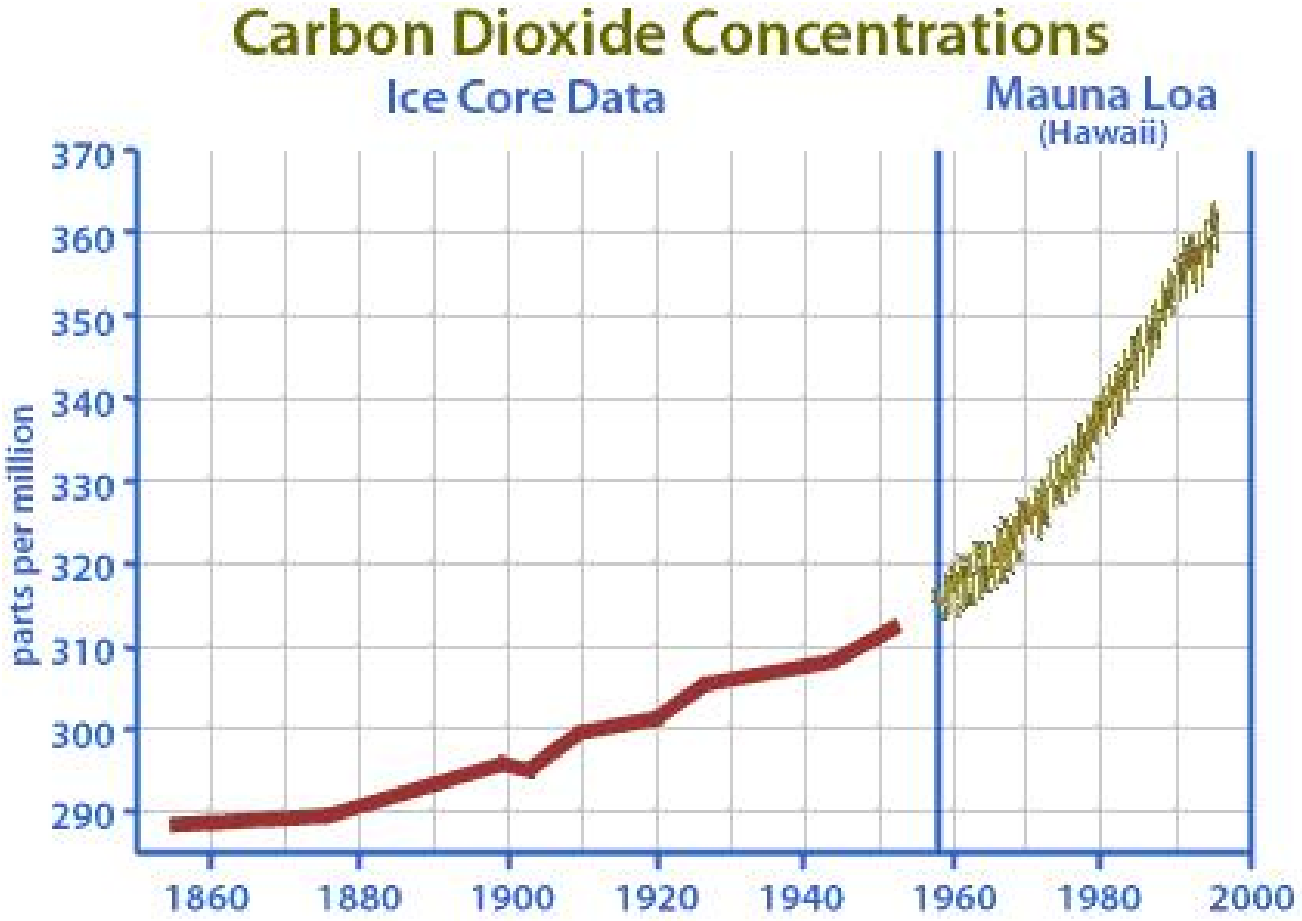
Leonid Polyak

Byrd Polar & Climate Res. Ctr., Ohio State Univ.

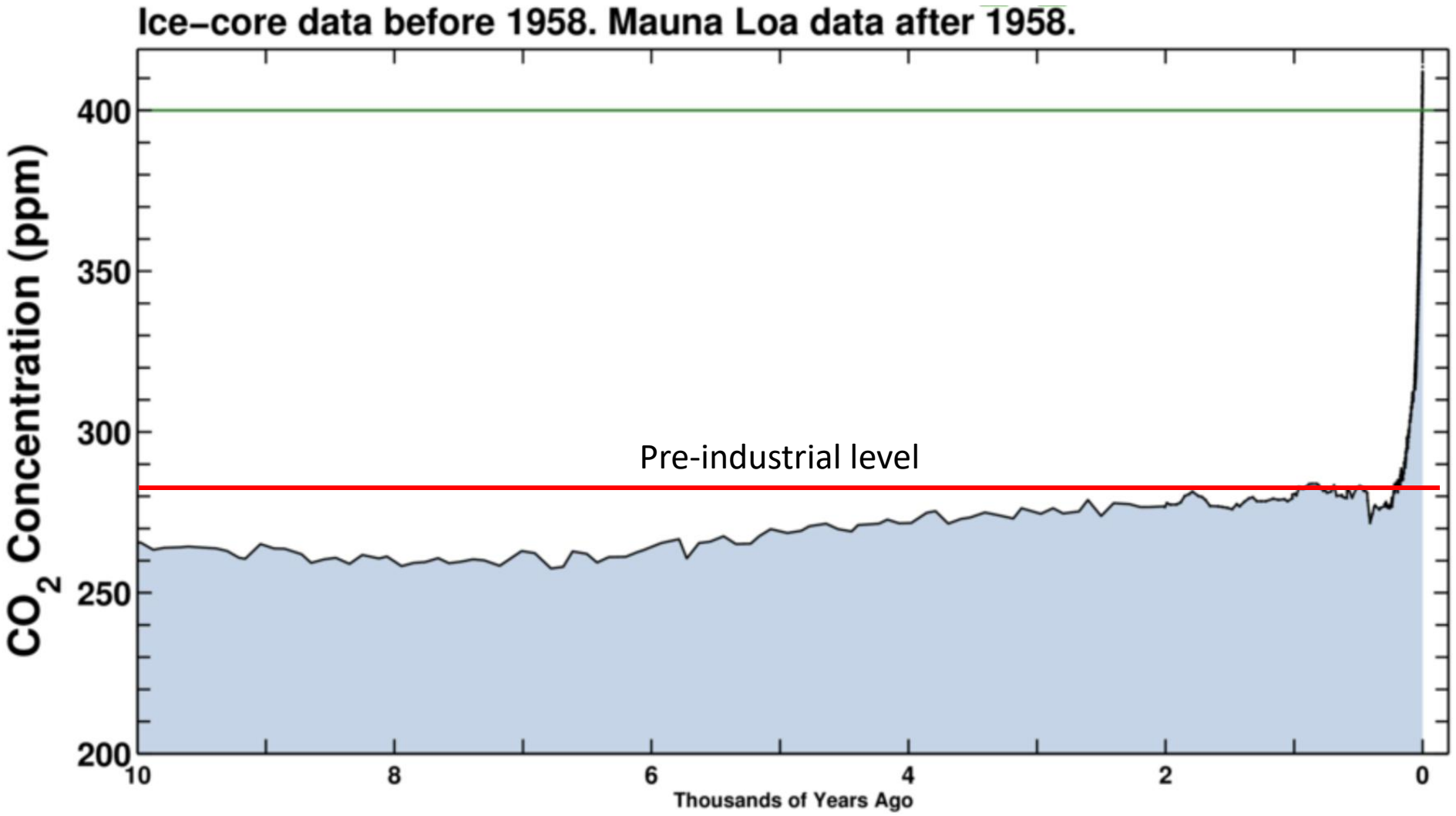
New record in atmospheric CO_2 concentration: 415 ppm



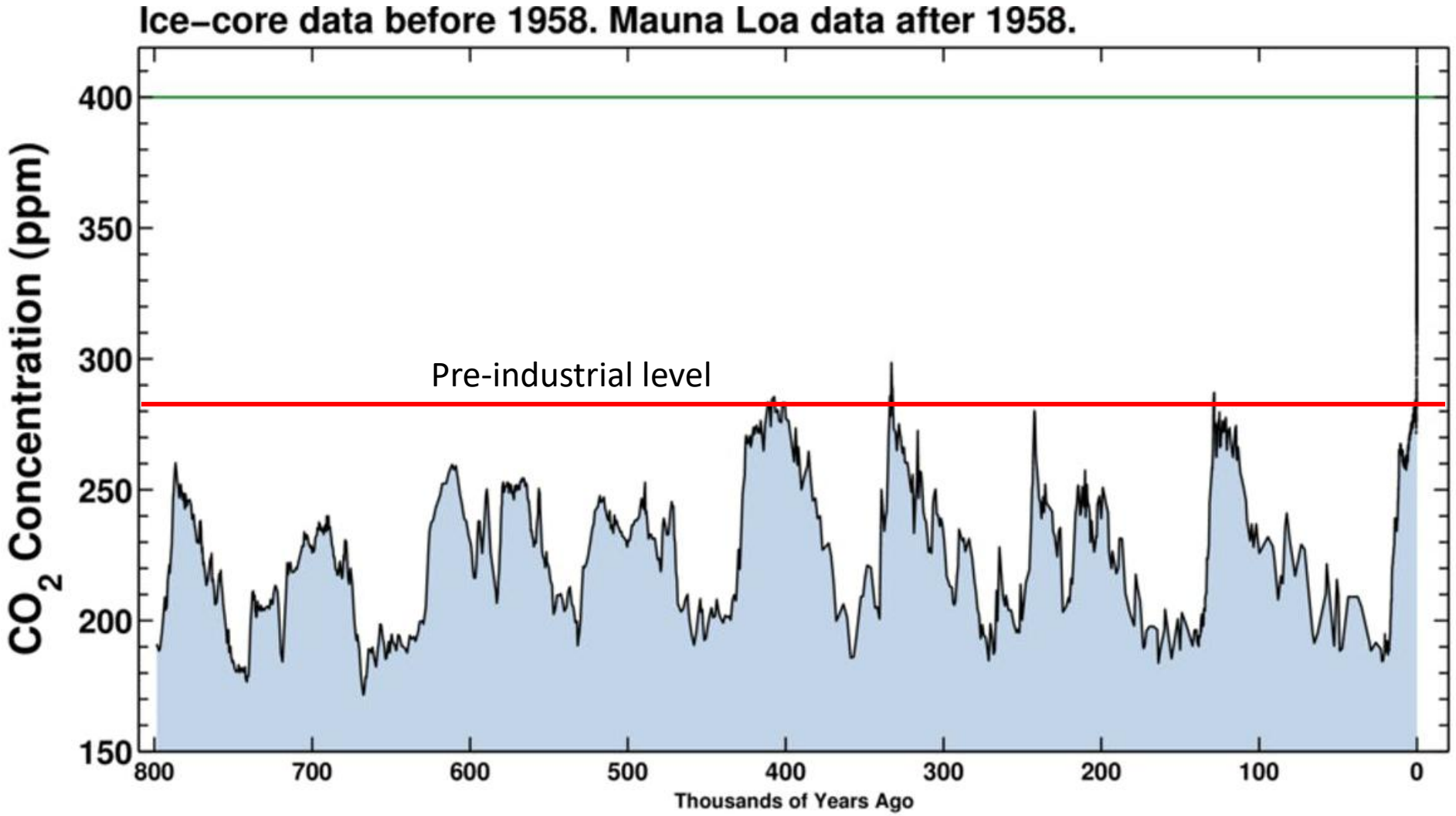
Atmospheric content: direct and proxy measurements



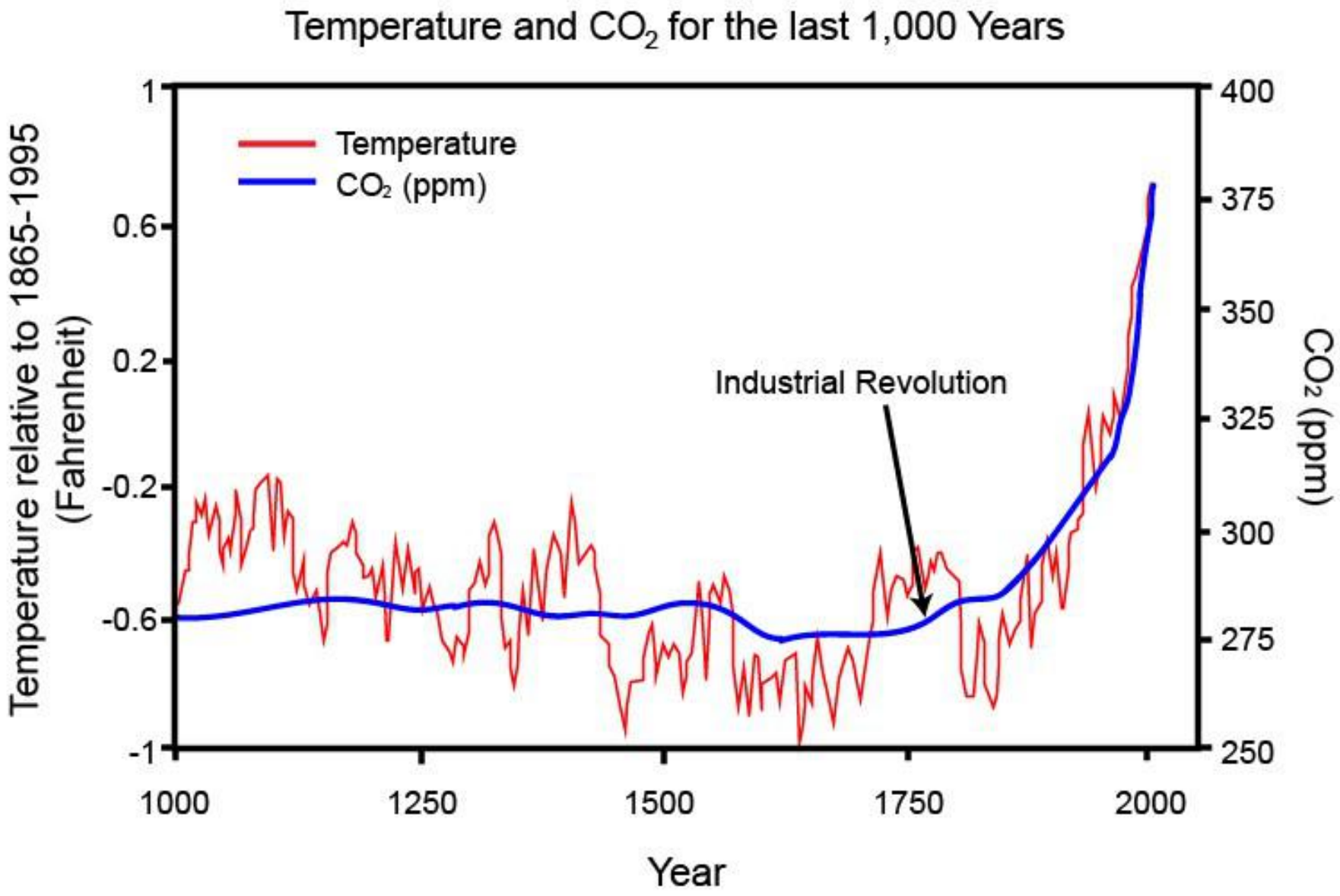
The Holocene (10,000 years) perspective



Glacial Pleistocene (800,000 years) perspective



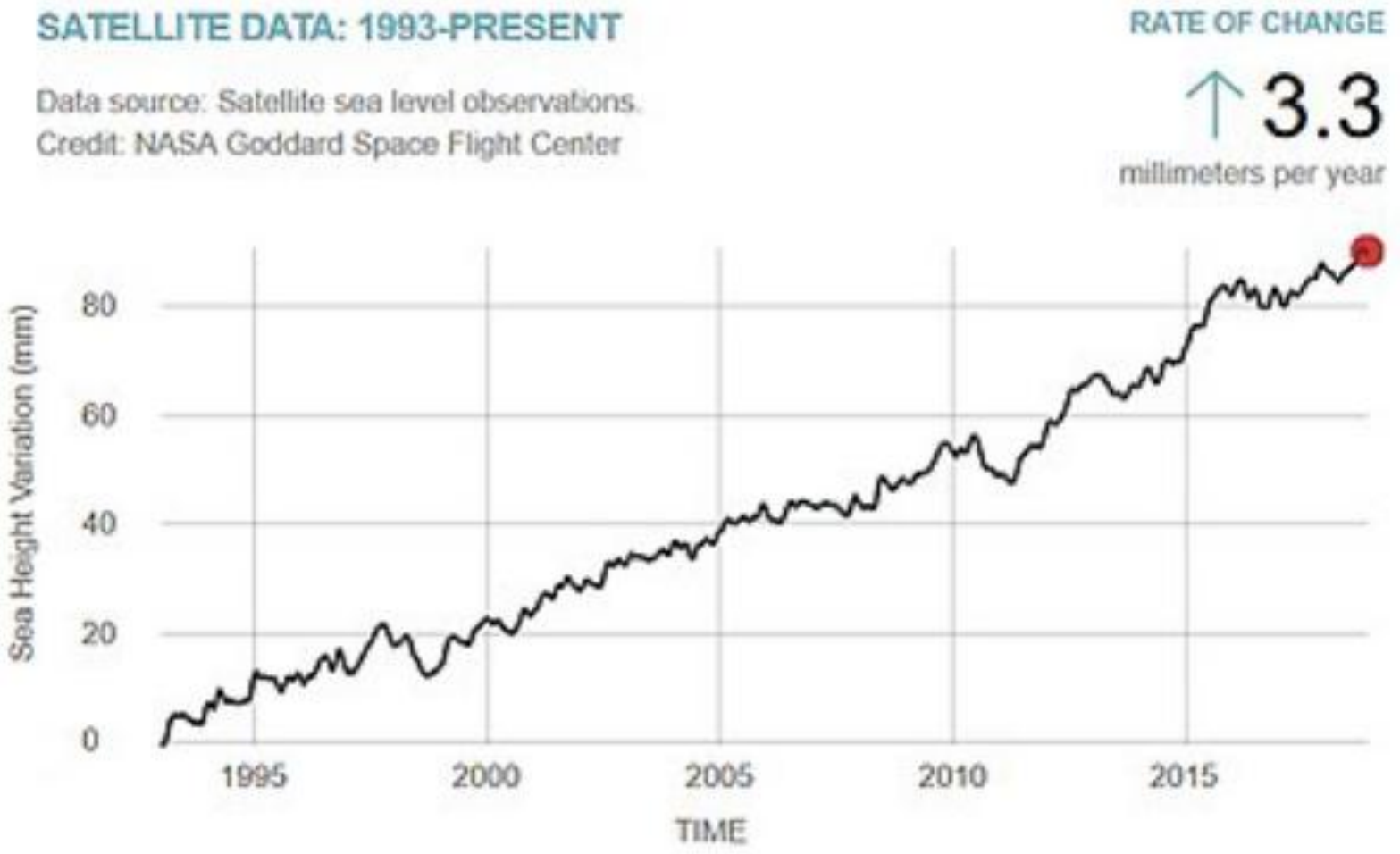
Atmospheric CO_2 concentration and air temperature



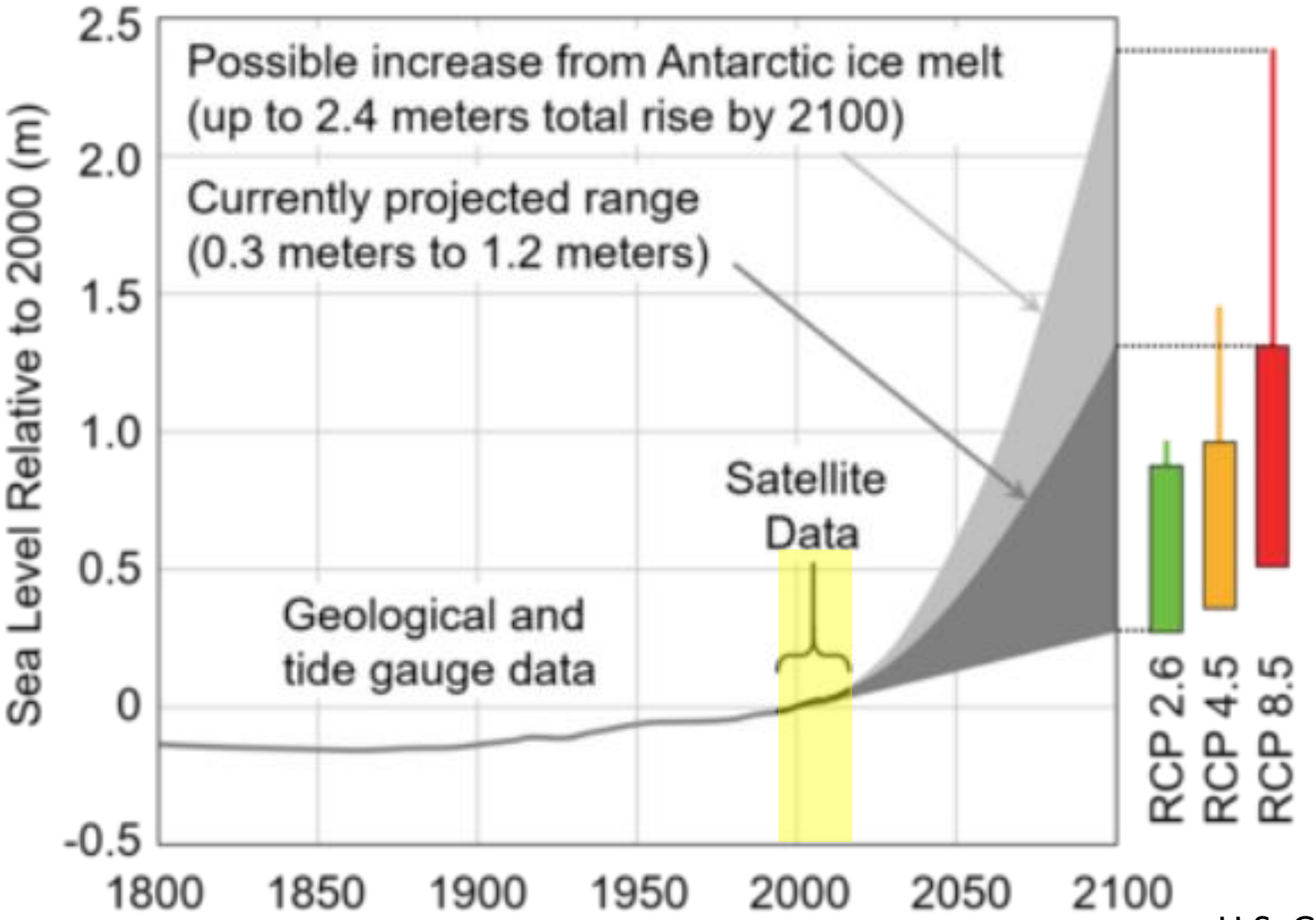
Impacts of climatic warming

- Higher temperatures
- Climate imbalances
- Extreme events
- Ice and snow melting
  - Sea-level rise
  - Permafrost thawing

Sea level satellite observations 1993-2018

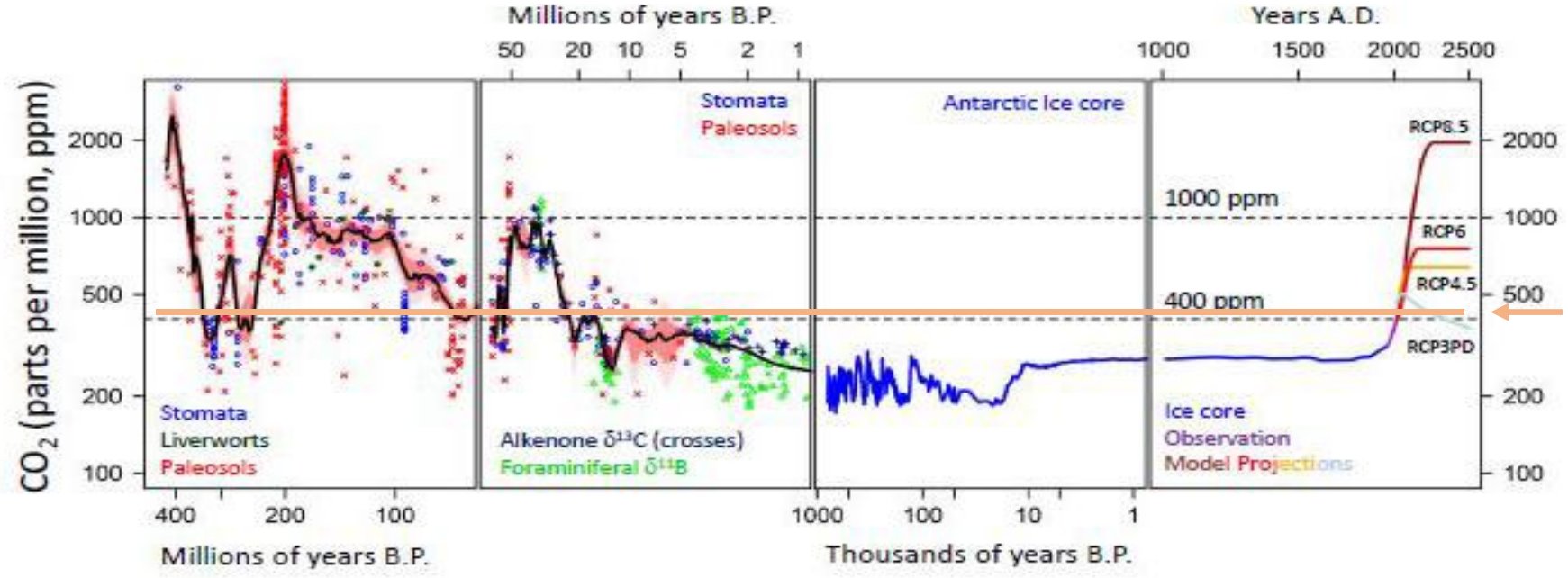


Global Mean Sea Level History and Projections



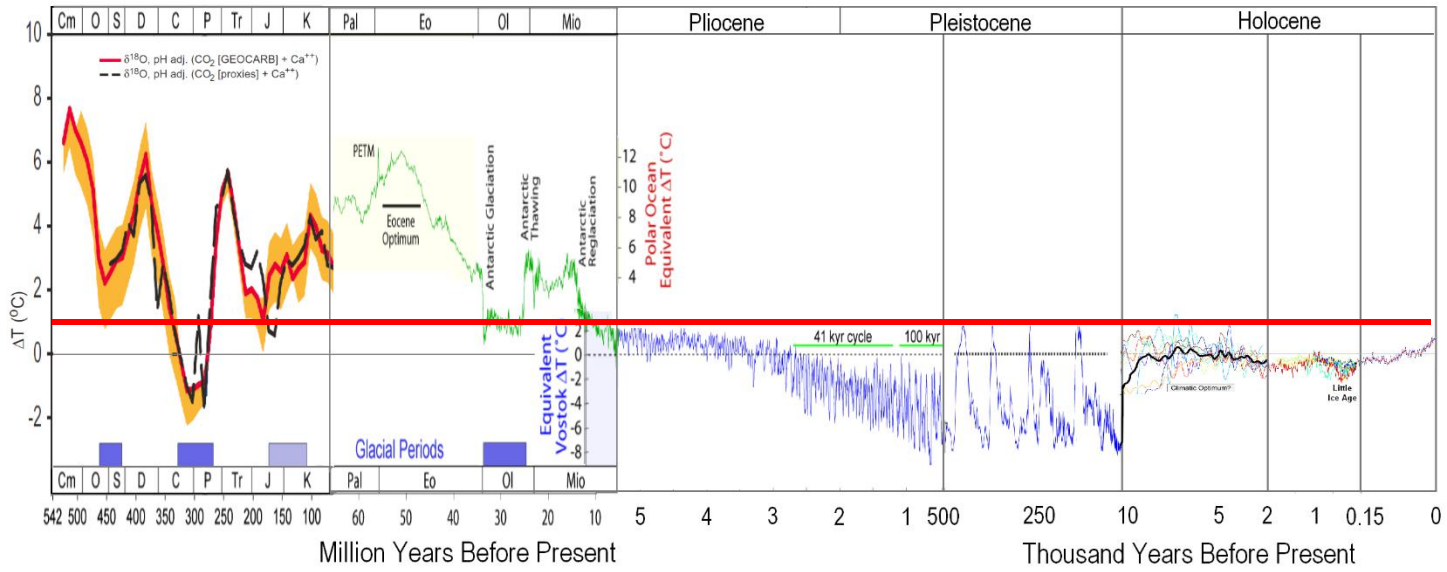
U.S. Global Change Res Program for the Fourth National Climate Assessment, 2017

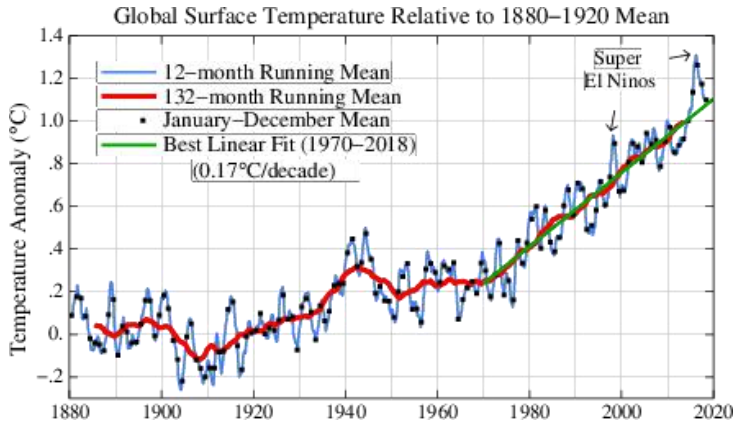
Cenozoic (500,000,000 years) perspective



You are here

Temperature of Planet Earth



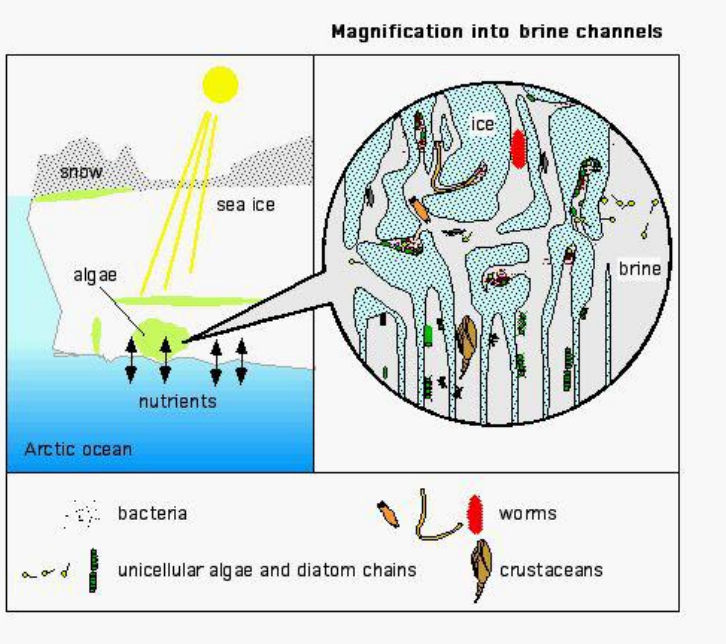


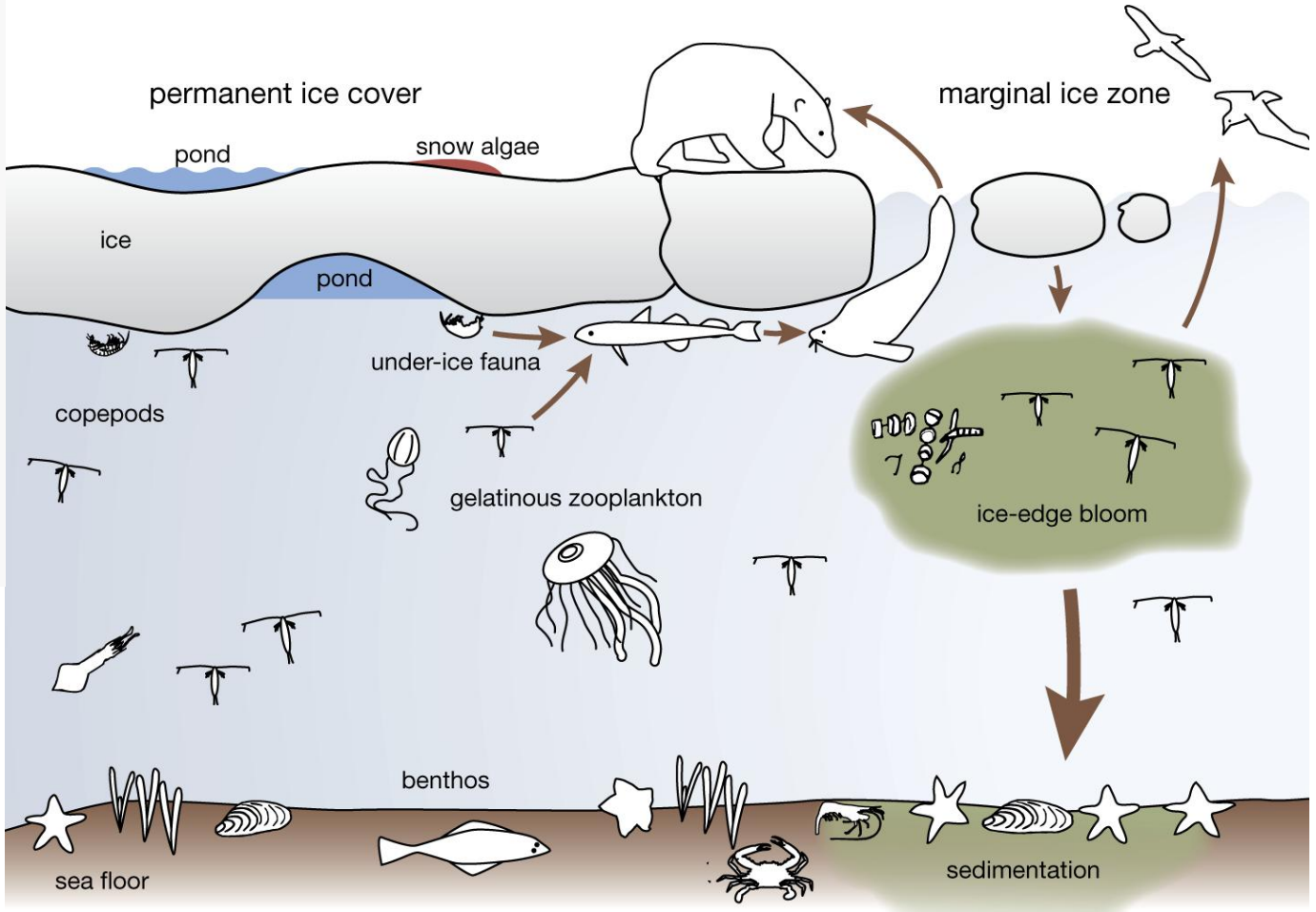
Polar areas of the Earth

Arctic sea ice

Arctic permafrost

Sea-ice effects on biota





Arctic population

Population distribution: composition by main regions

100 %
50 %
0 %
50 %
100 %
Indigenous
Non-indigenous

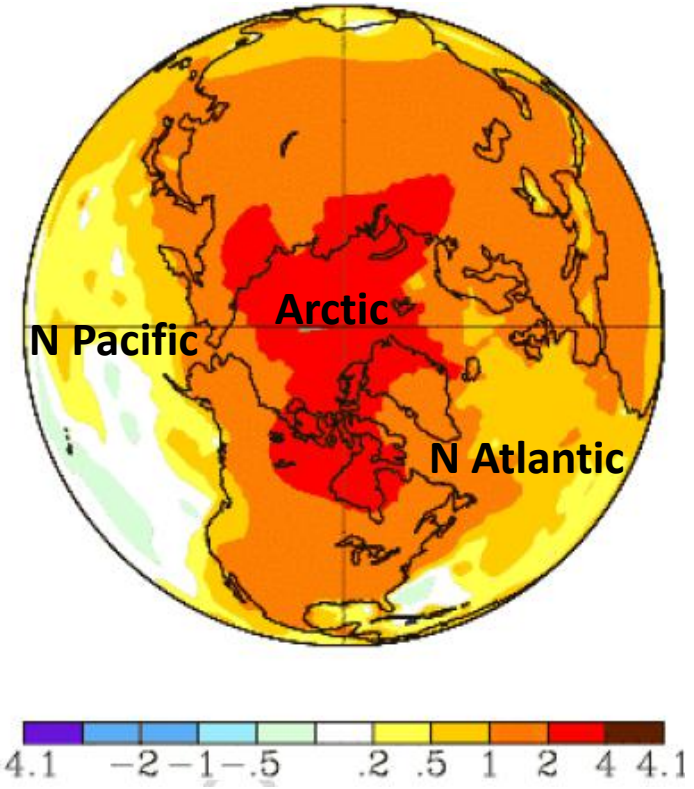
Population centres

300,000 170,000 60,000 30,000 • 3,000 and less

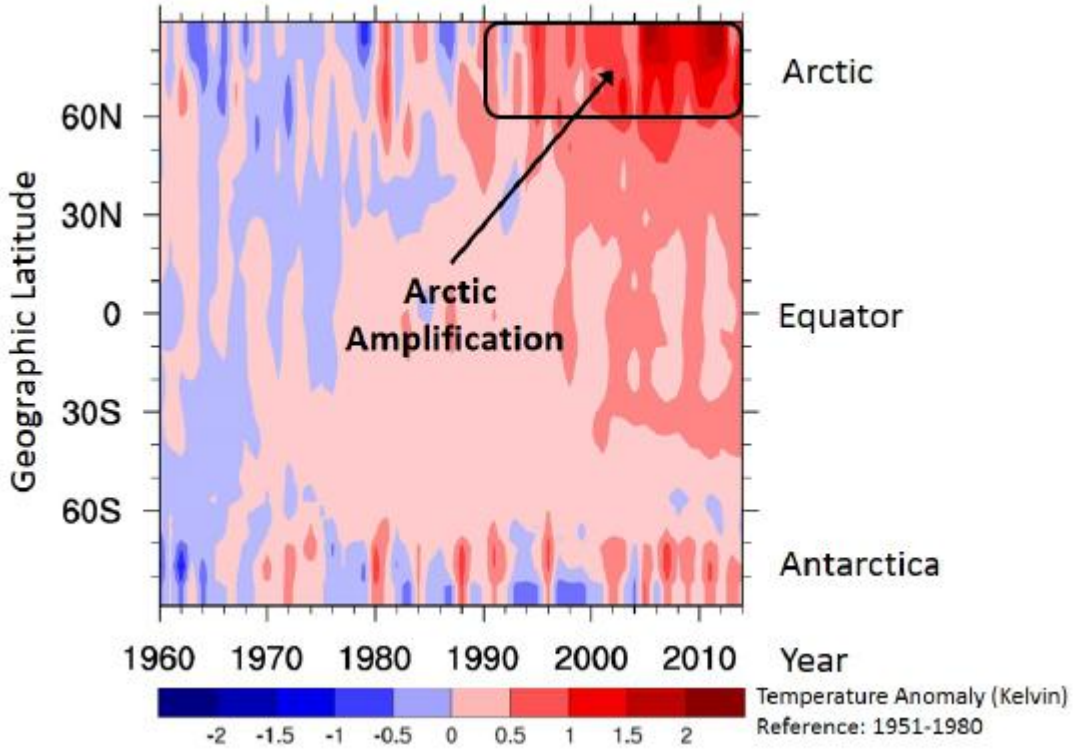
Oil and gas fields
Large mines
Main transport routes for raw materials
Potential routes for raw materials

A.O. : Autonomous okrug

Amplified warming in the Arctic



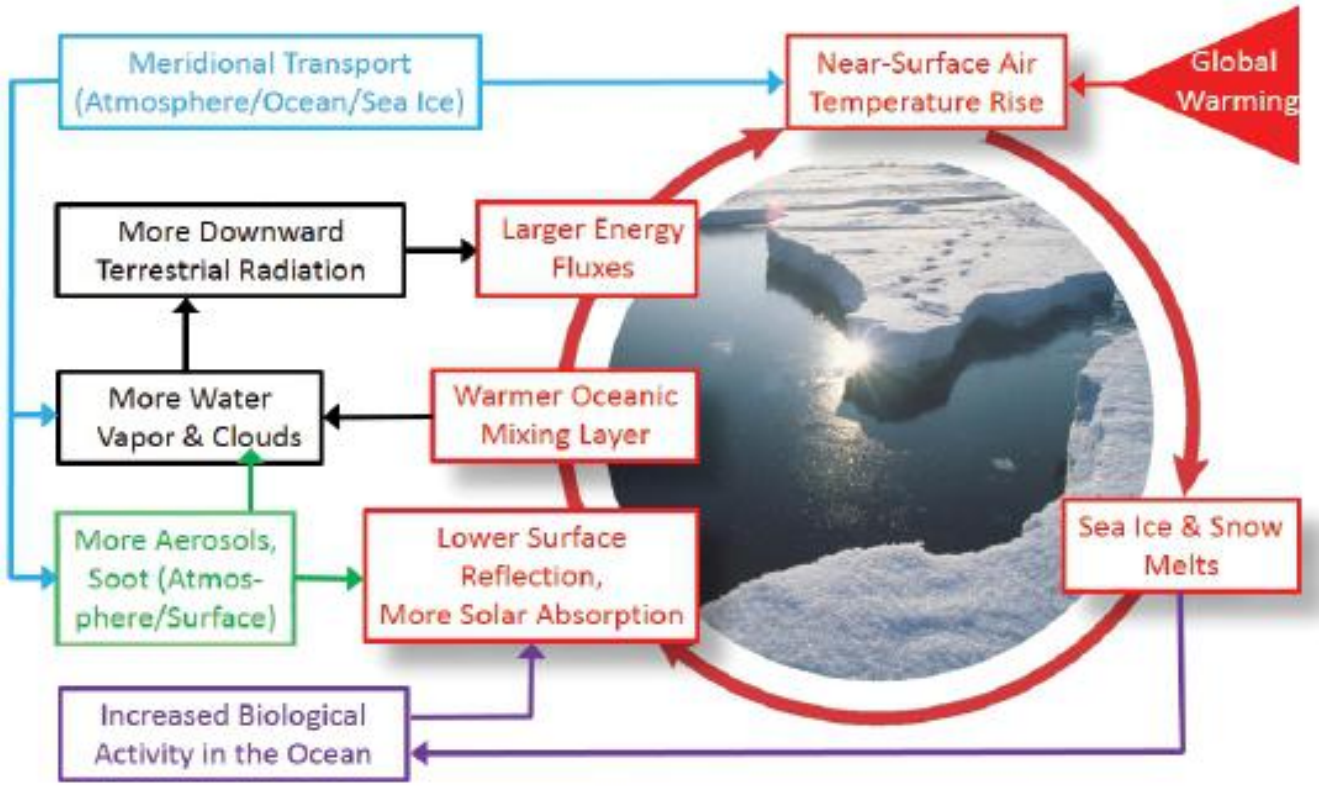
Change of annual surface air T (°C), 1963-2012



Yearly T anomalies from 1951–1980 mean

Data: NASA Goddard Institute for Space Studies

Possible feedback mechanisms for Arctic amplification



Red - surface albedo effect

Blue – meridional atmospheric/oceanic transport

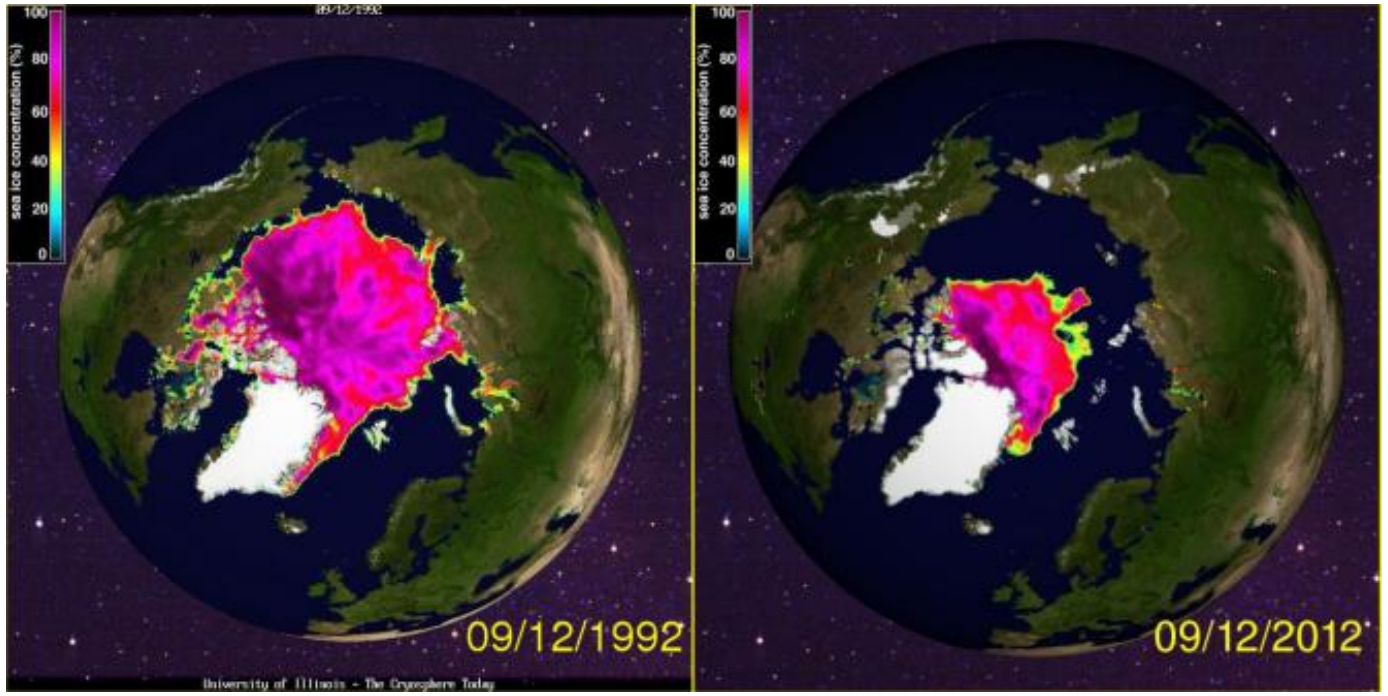
Black - effects of water vapor and clouds

Green - effects of aerosol particles

Purple - increased oceanic biological activity

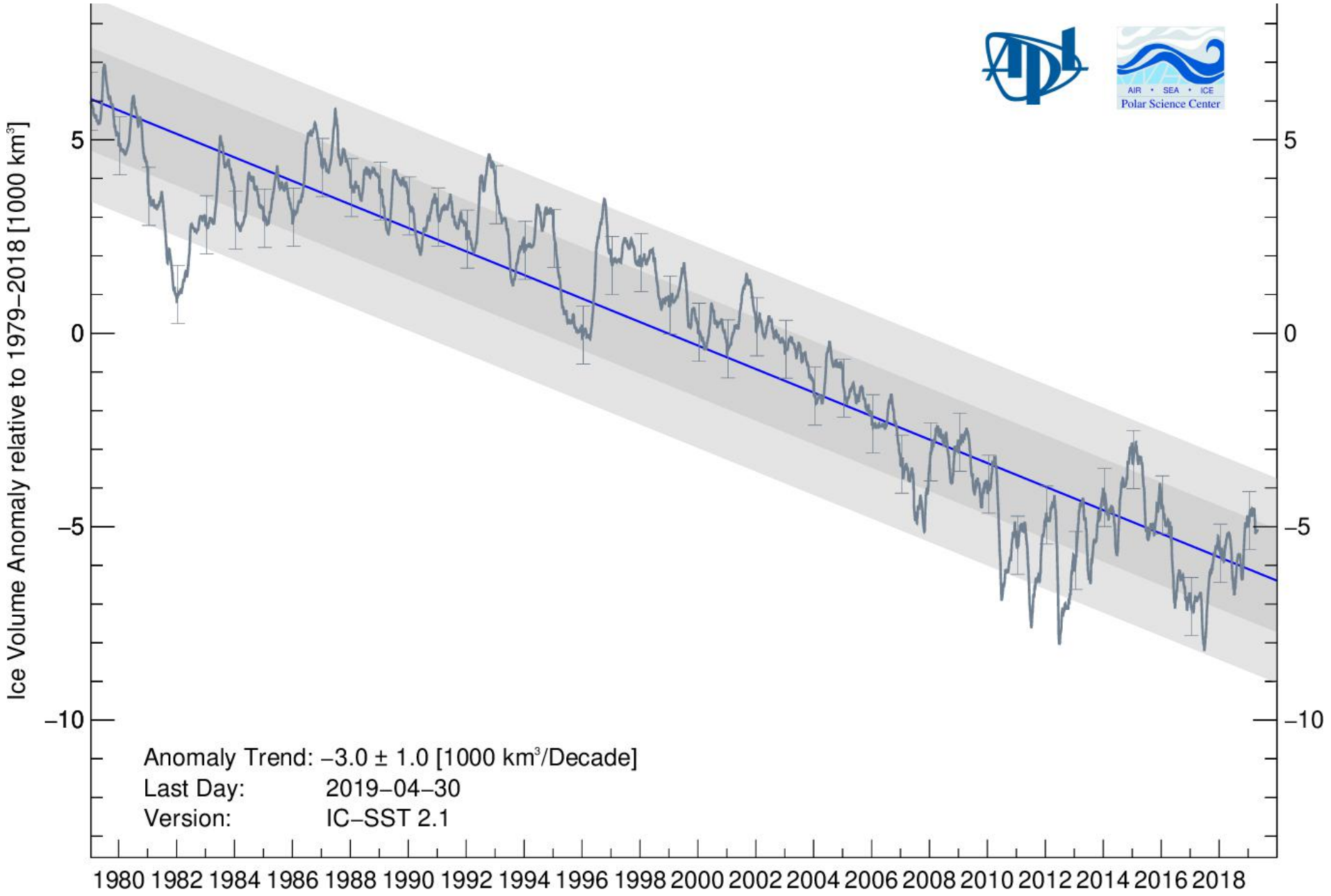
from Wendisch et al., Eos 2017

Change in Arctic sea-ice concentrations

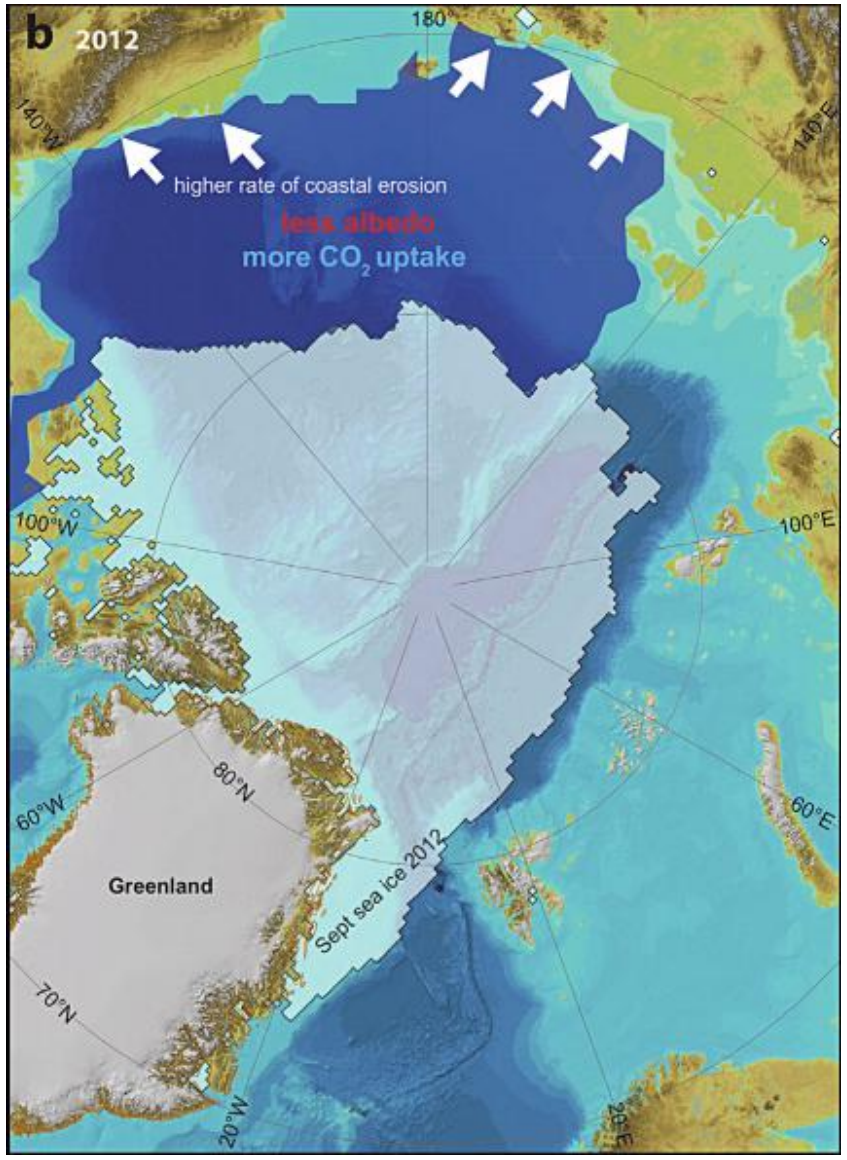


U. Illinois, Cryosphere Today, http://arctic.atmos.uiuc.edu/cryosphere

Arctic sea ice volume anomaly, 1980-May 2019



Impacts of sea-ice loss



from Jakobsson et al., QSR, 2014

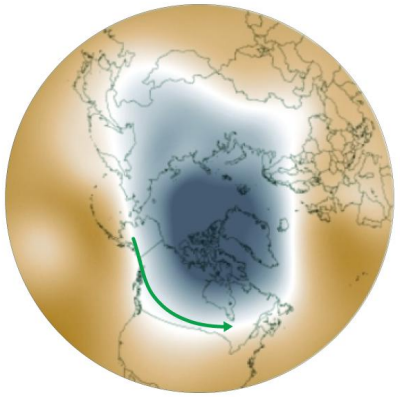
Hemispheric/Global

- Weather in mid-latitudes
- Freshwater effect on North Atlantic
- CO_2 balance, methane emissions

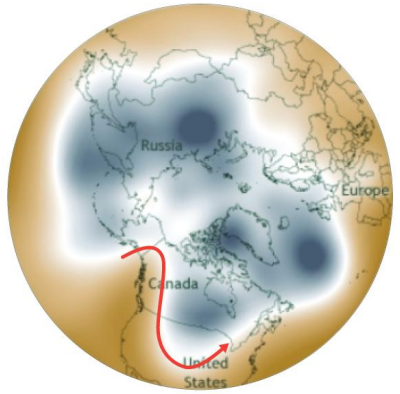
Arctic

- Ecosystems, biodiversity
- Socio-economic (indigenous peoples, shipping, resource developments)

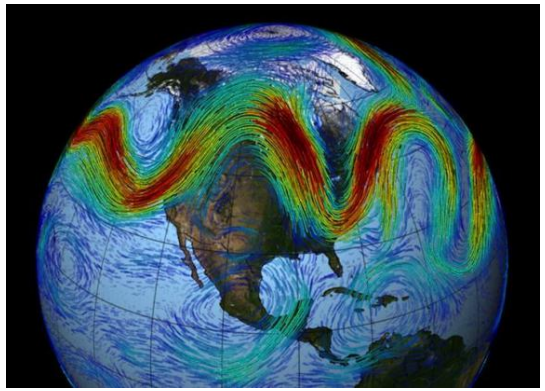
Impacts: Polar Jet Stream → weather in mid-latitudes



Typical sea-ice cover:
compact PJS configuration



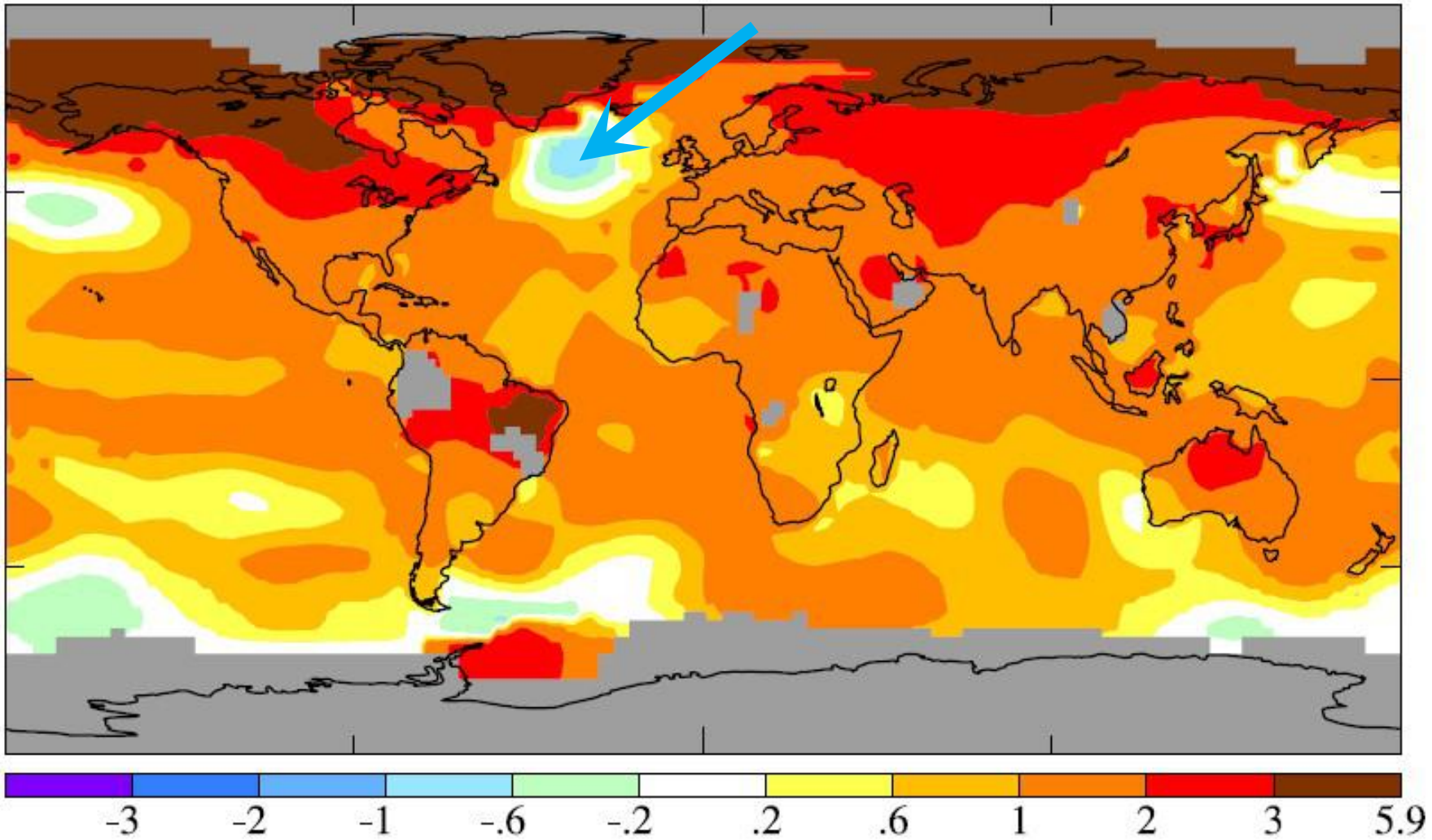
Reduced sea-ice cover:
wavy PJS (Polar Vortex)



NASA,
http://www.giss.nasa.gov/research/news/20120313/629341main_Earth_jet_stream.jpg

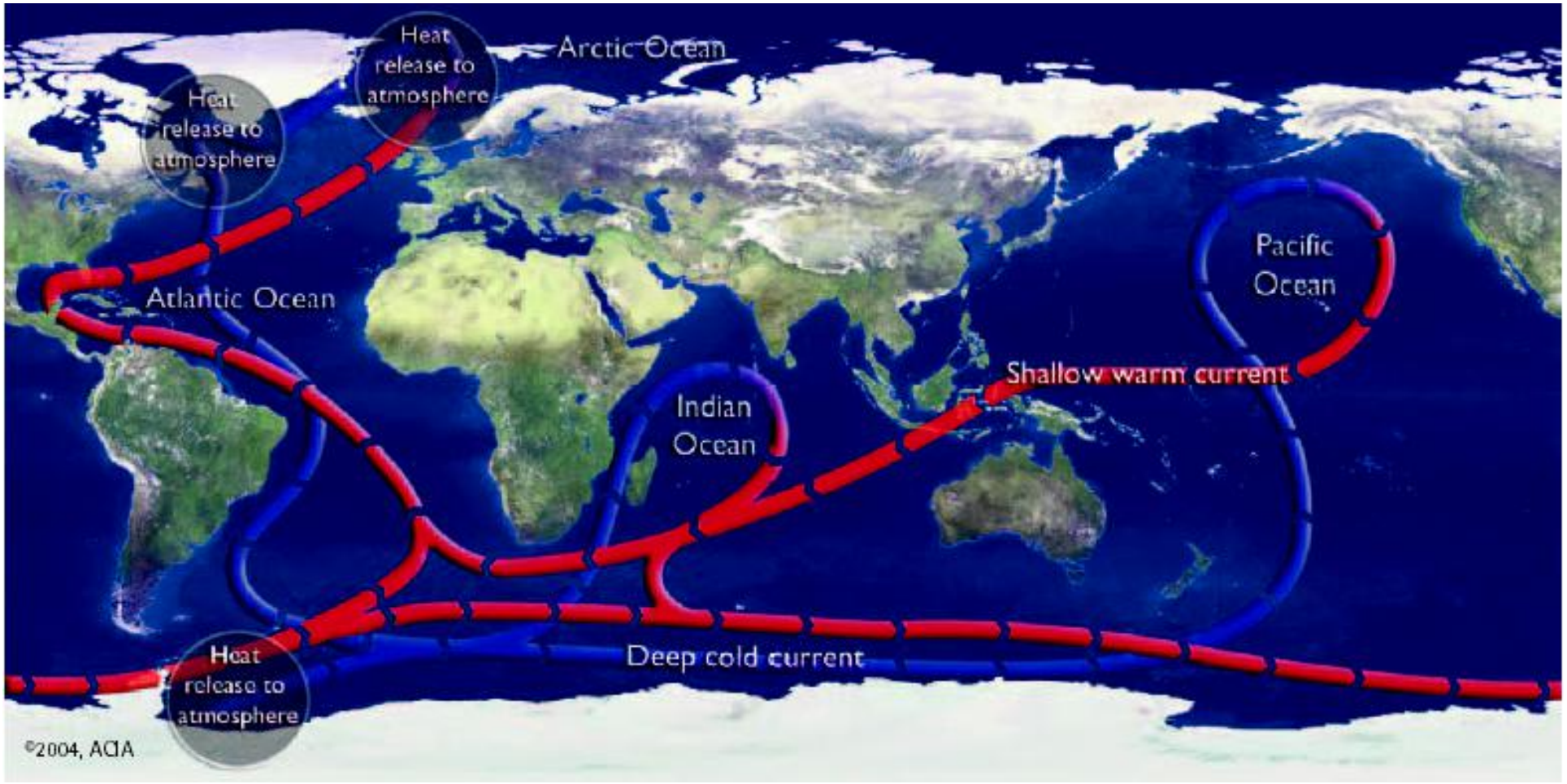
Super warm Arctic & “cold spot” in the North Atlantic

On time scales >20 yr, the largest impact is from melting Arctic sea ice (Sevellec et al., NatClimChange 2017)



Global surface T anomalies, 2016 vs 1880-1920 (Goddard Space Flight Center)

Global circulation ‘conveyor belt’



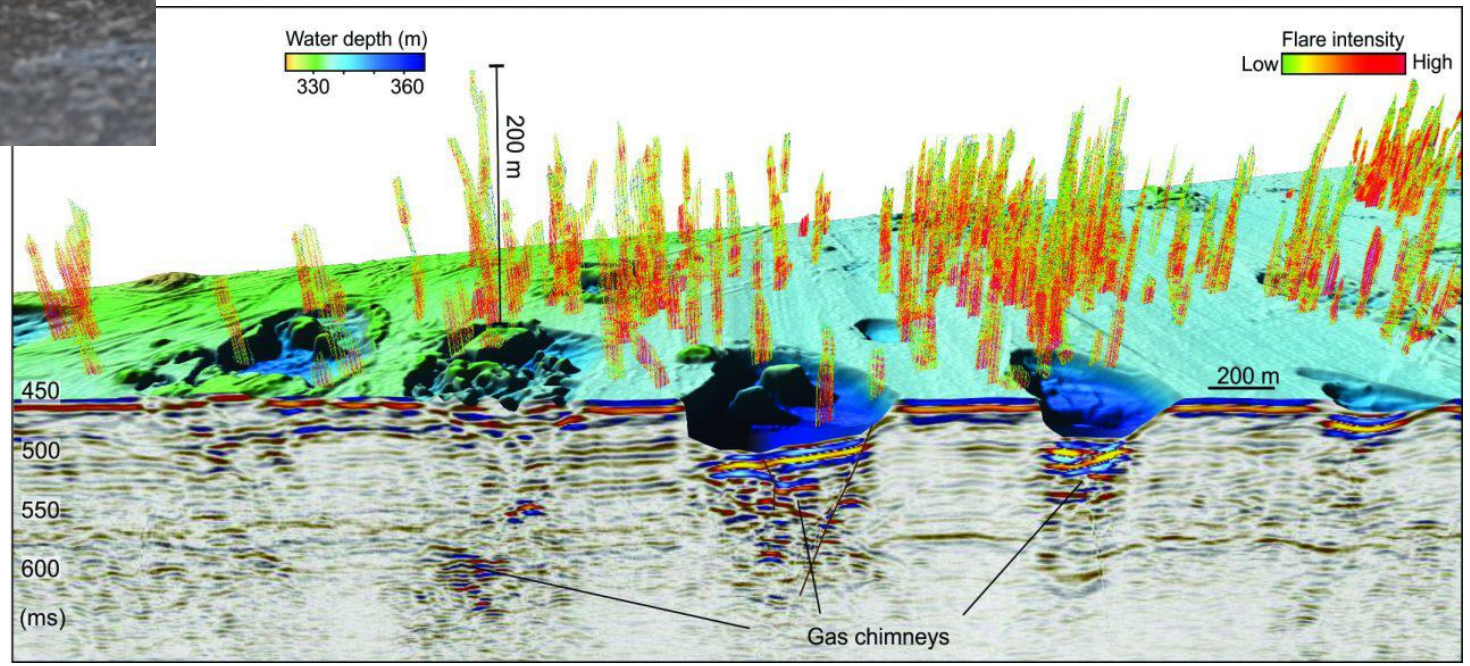
Permafrost degradation and forest invasion

Photosynthesis increase (green) 1981-2005

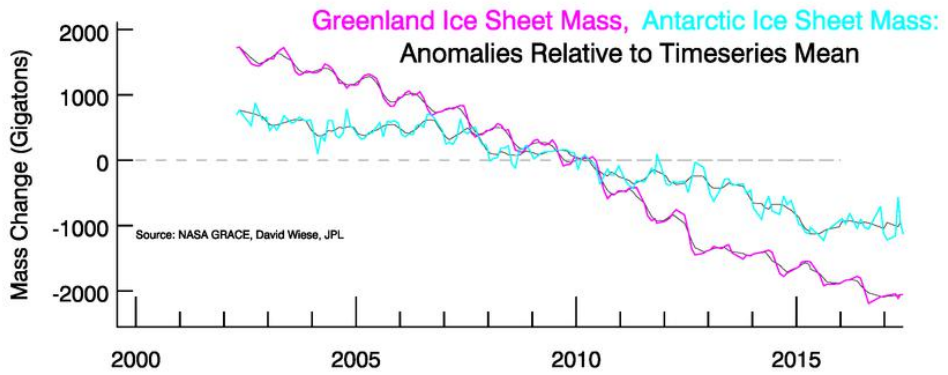
Methane emissions from tundra and Arctic sea floor

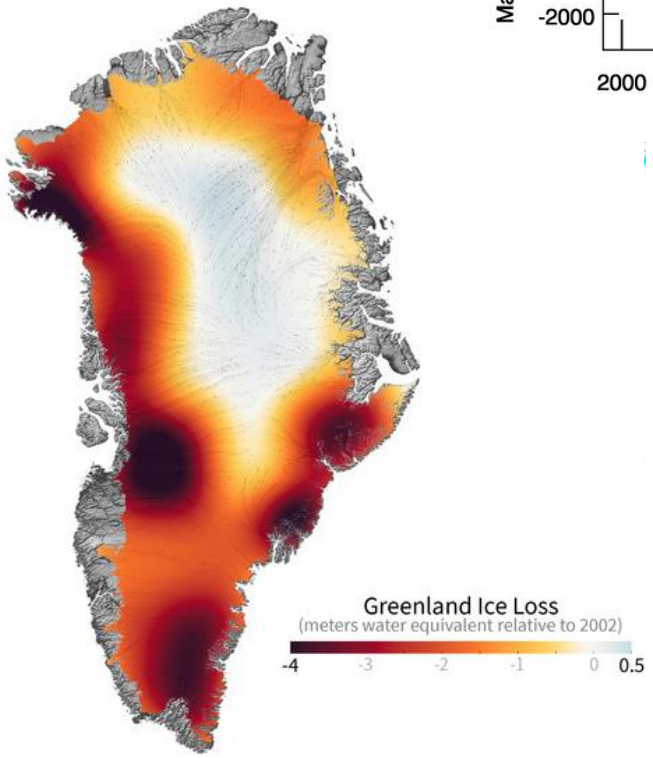
Methane bubbling from under frozen lakes

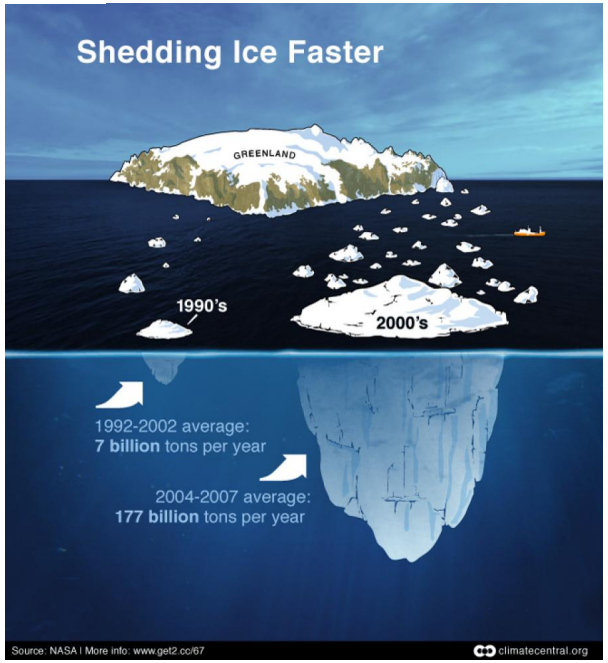
Gas chimneys and methane seepage on the Barents Sea shelf (from Andreassen et al., 2017)



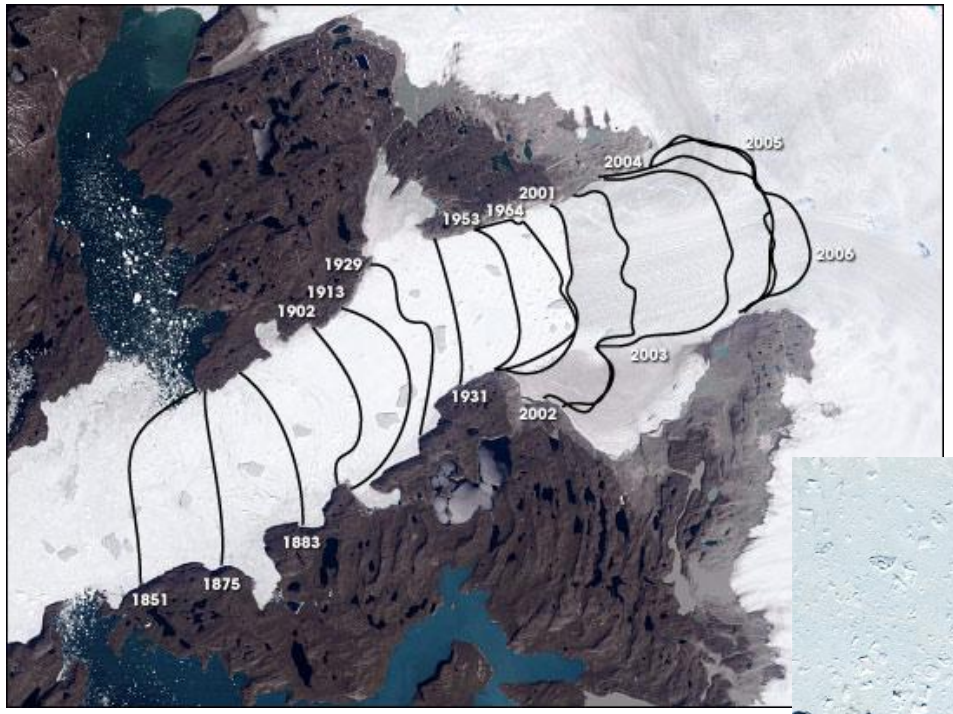
Greenland ice loss

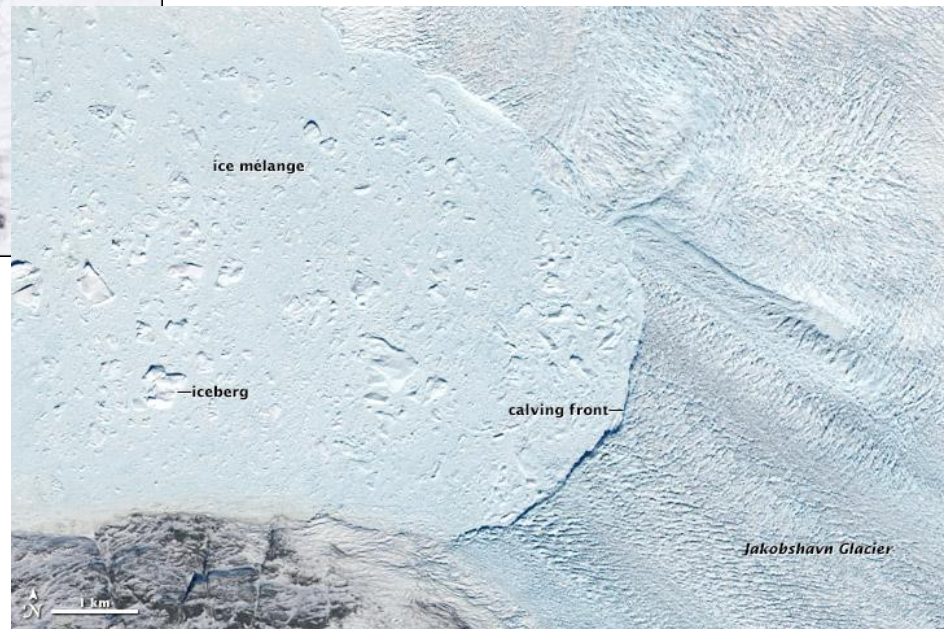




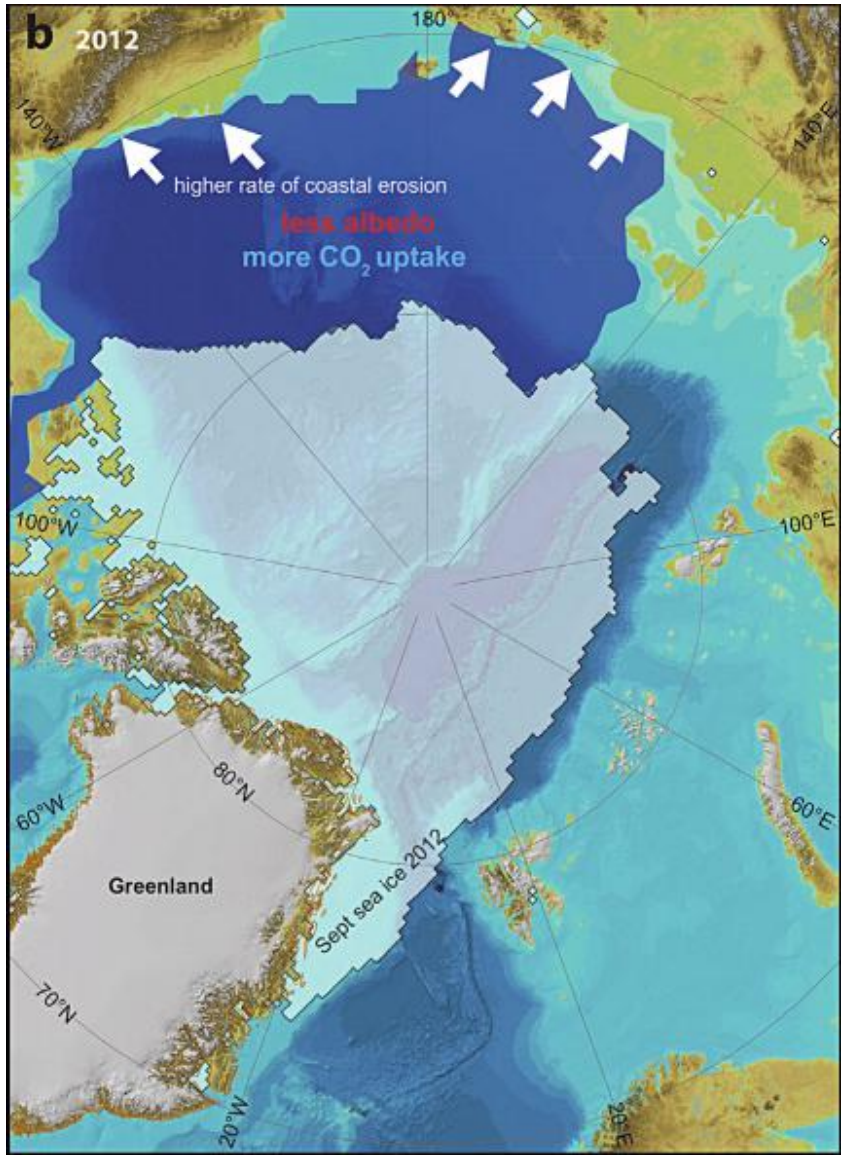


Jakobshavn glacier calving





Impacts of sea-ice loss



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Threats to Arctic ecosystems

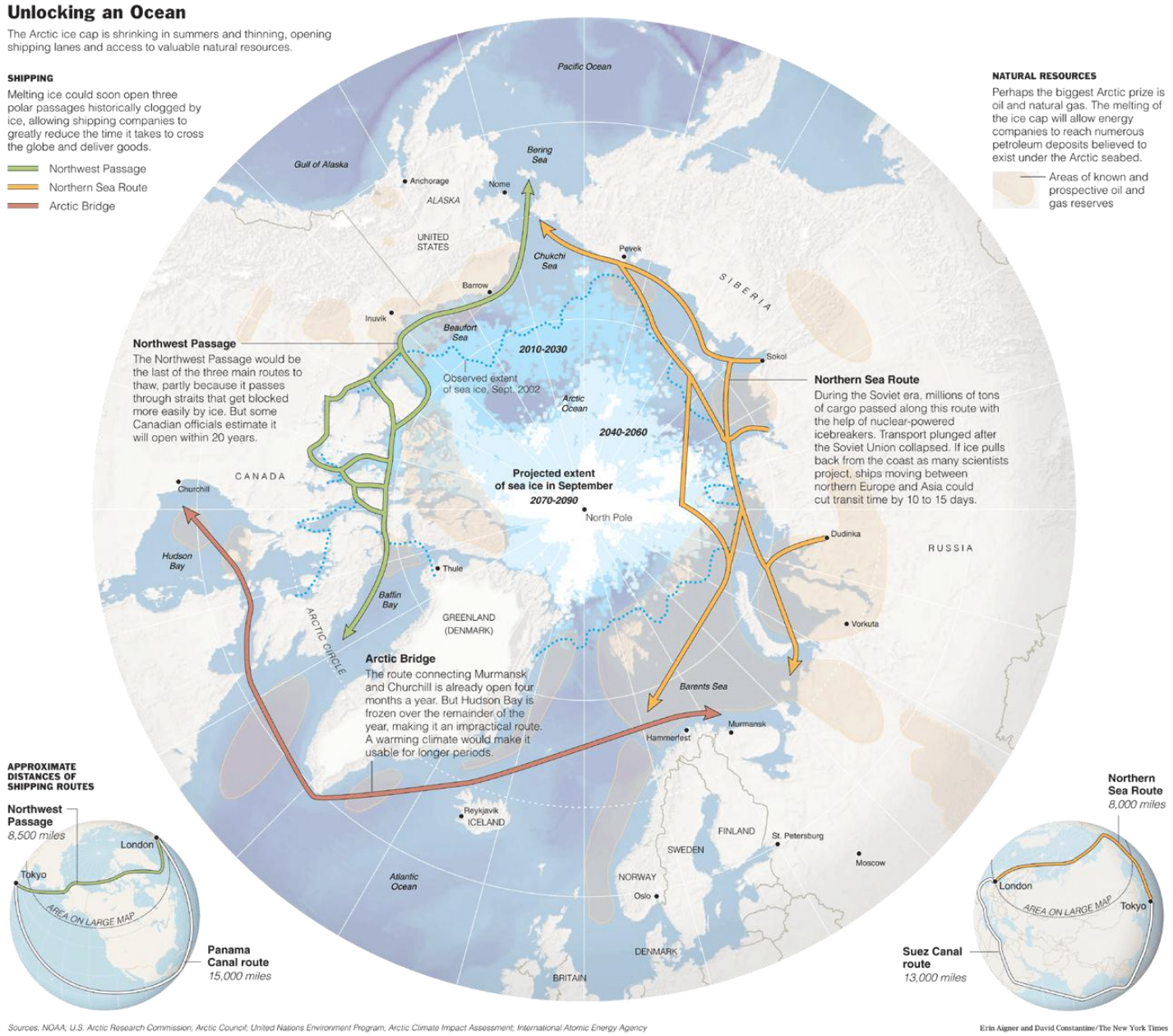
- Disappearance of sea ice
- Invasion of low-latitude species
- Acidification

Threats to Arctic humans

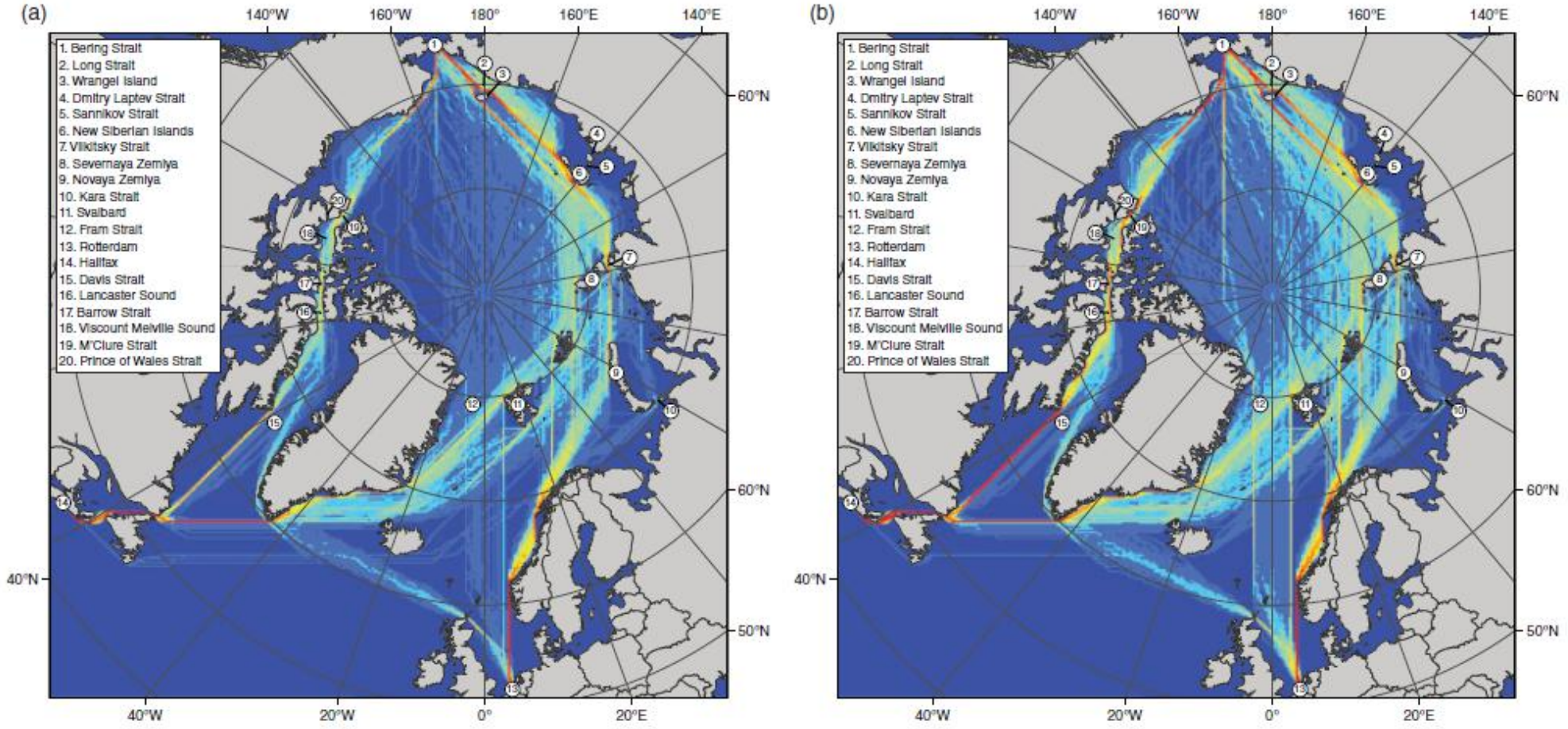
Stress on infrastructure

Beach erosion in Barrow, Alaska

Arctic shipping routes



Modeling changes in shipping routes

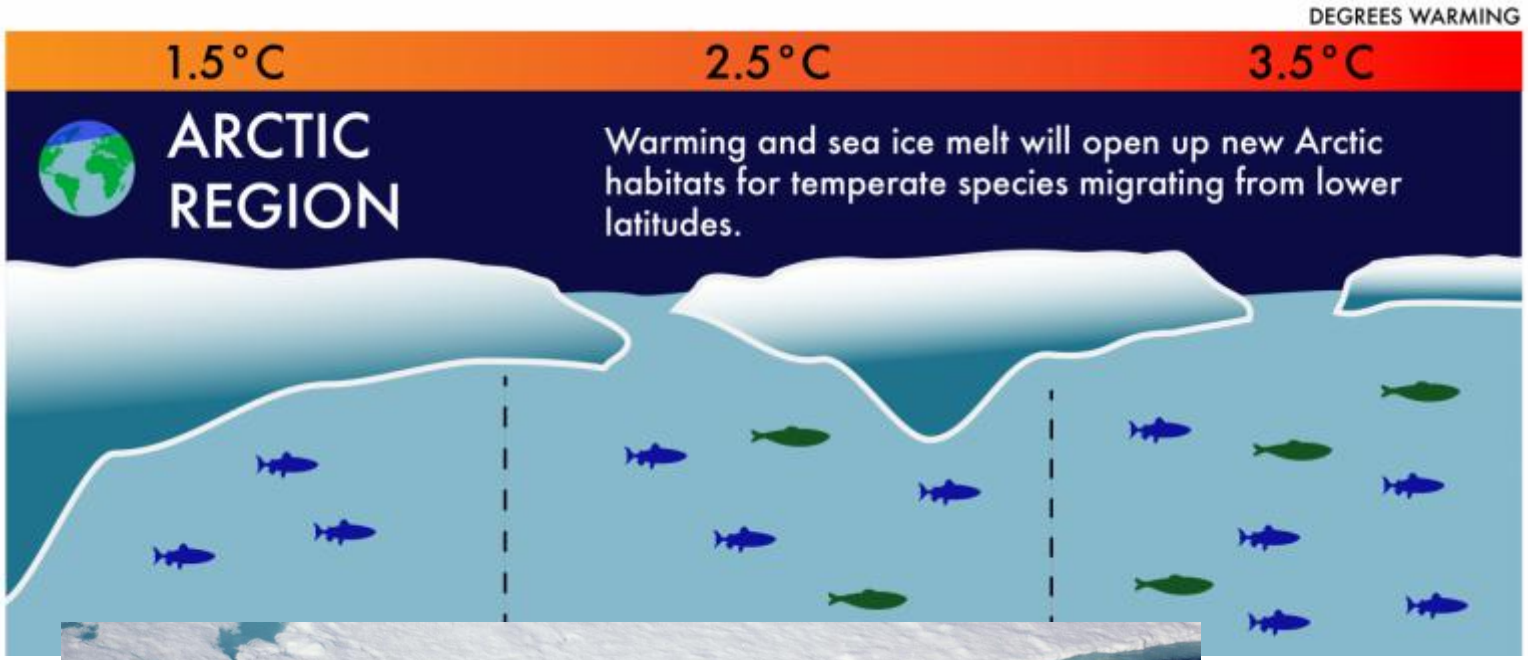


2011-2035

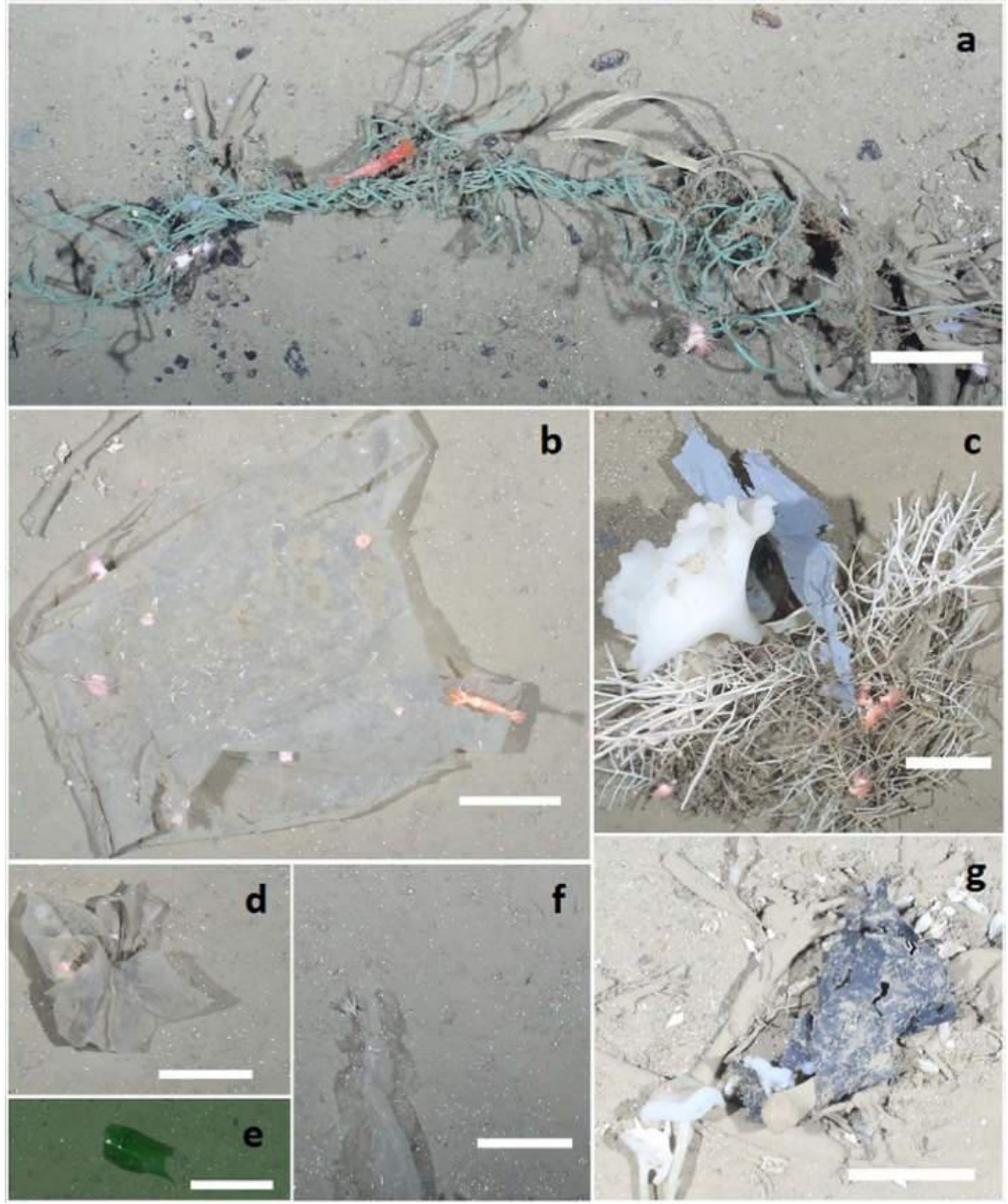
2036-2060

Earth's Future, 2015

Migration of fisheries



Seafloor litter in Fram Strait

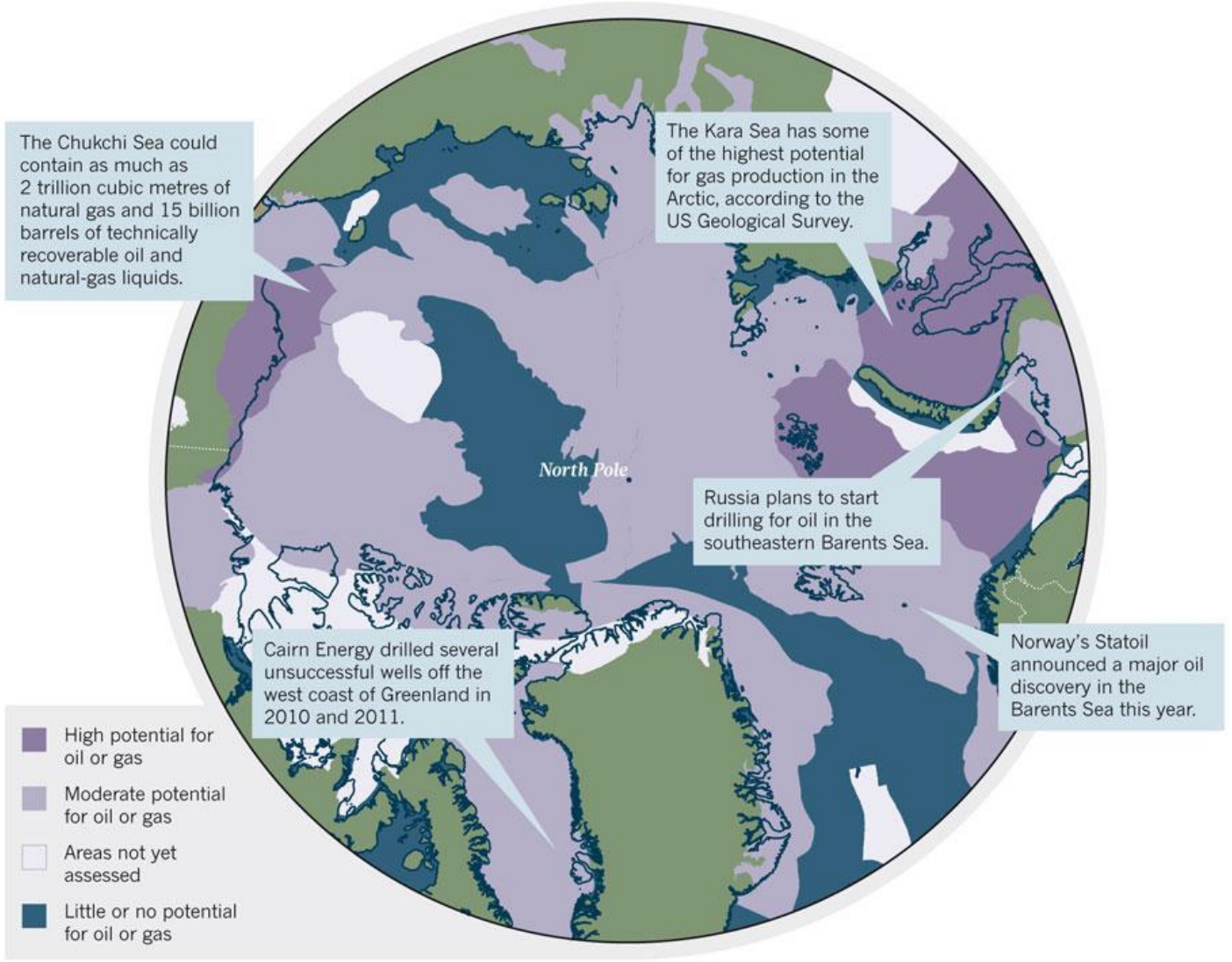


Tekman et al., DSR 2017

The first bulk freighter to pass through the NW Passage was carrying coal

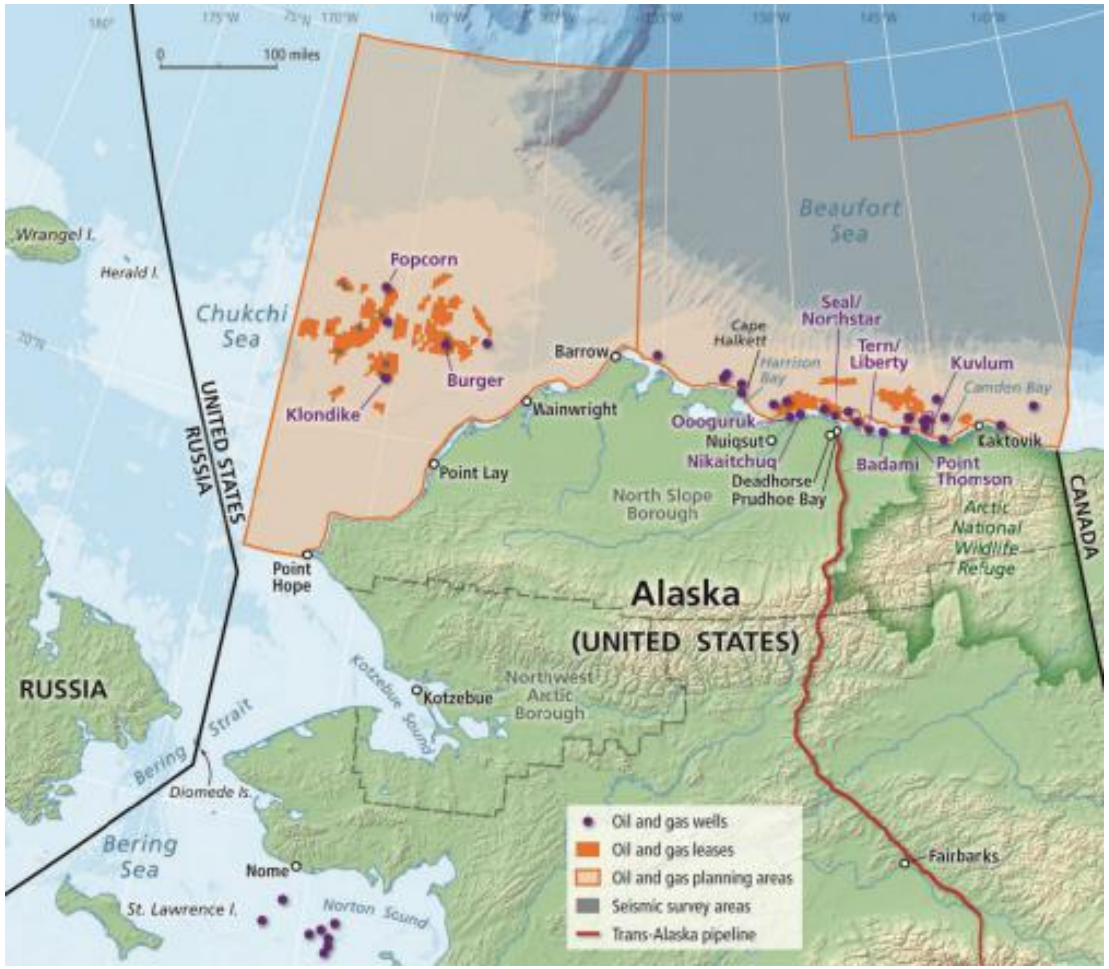
The 225-m *Nordic Orion* along the Northern Sea Route, Vancouver to Finland

Arctic Ocean oil and gas potential



Nature, 2011

Oil and gas planning areas in Alaskan Arctic waters



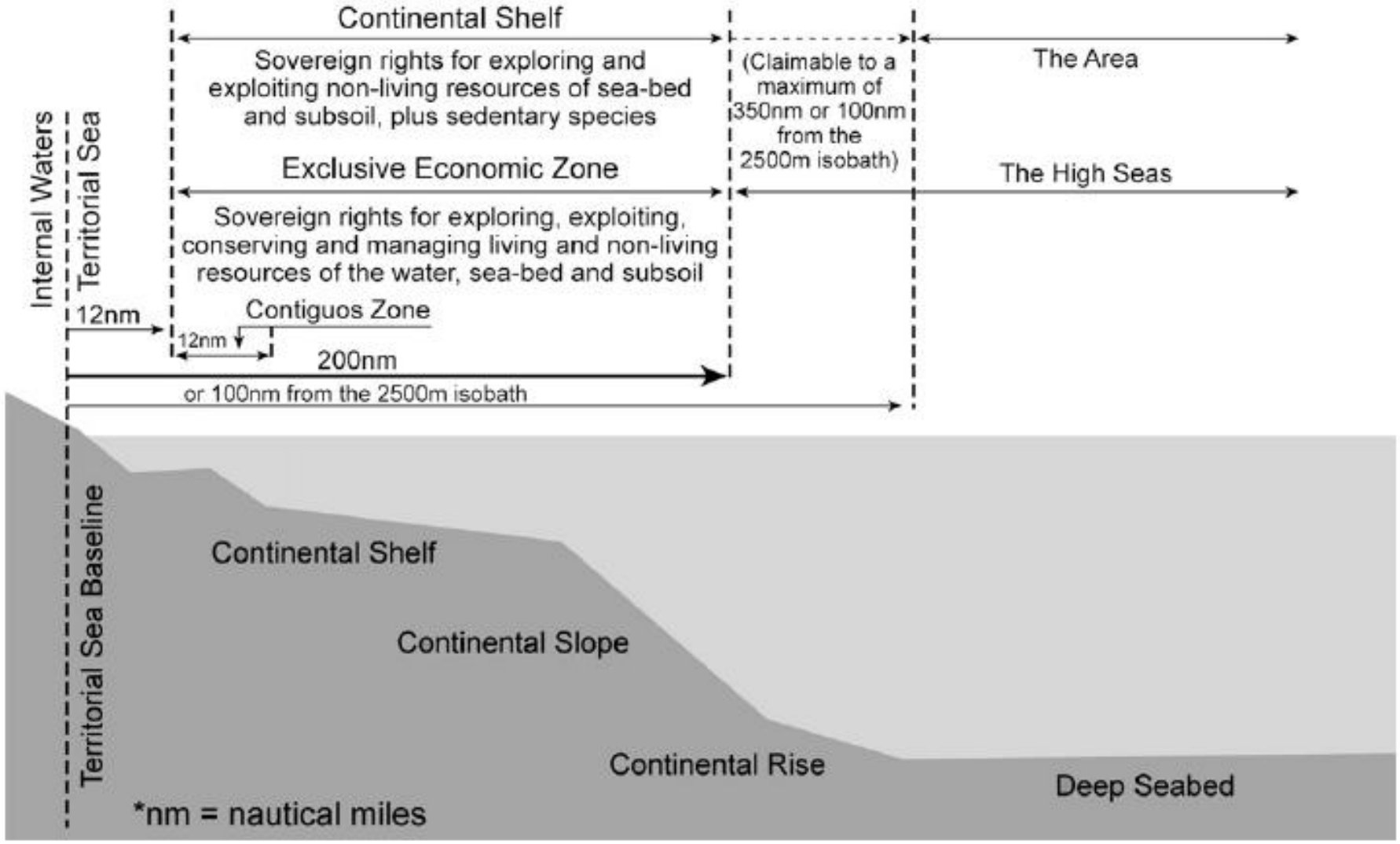
Imagine if the Gulf of Mexico oil spill happened in the Arctic Ocean

Below are two simulated oil slicks each comparable in size to BP's spill in the Gulf of Mexico.

Oiled areas are based on weekly satellite data from late April to late May 2010. The oil spill trajectory illustrates one possible outcome, but ocean currents and winds could vary the footprint of an actual spill (for example, pushing oil onshore in the Chukchi Sea or offshore in the Beaufort Sea).

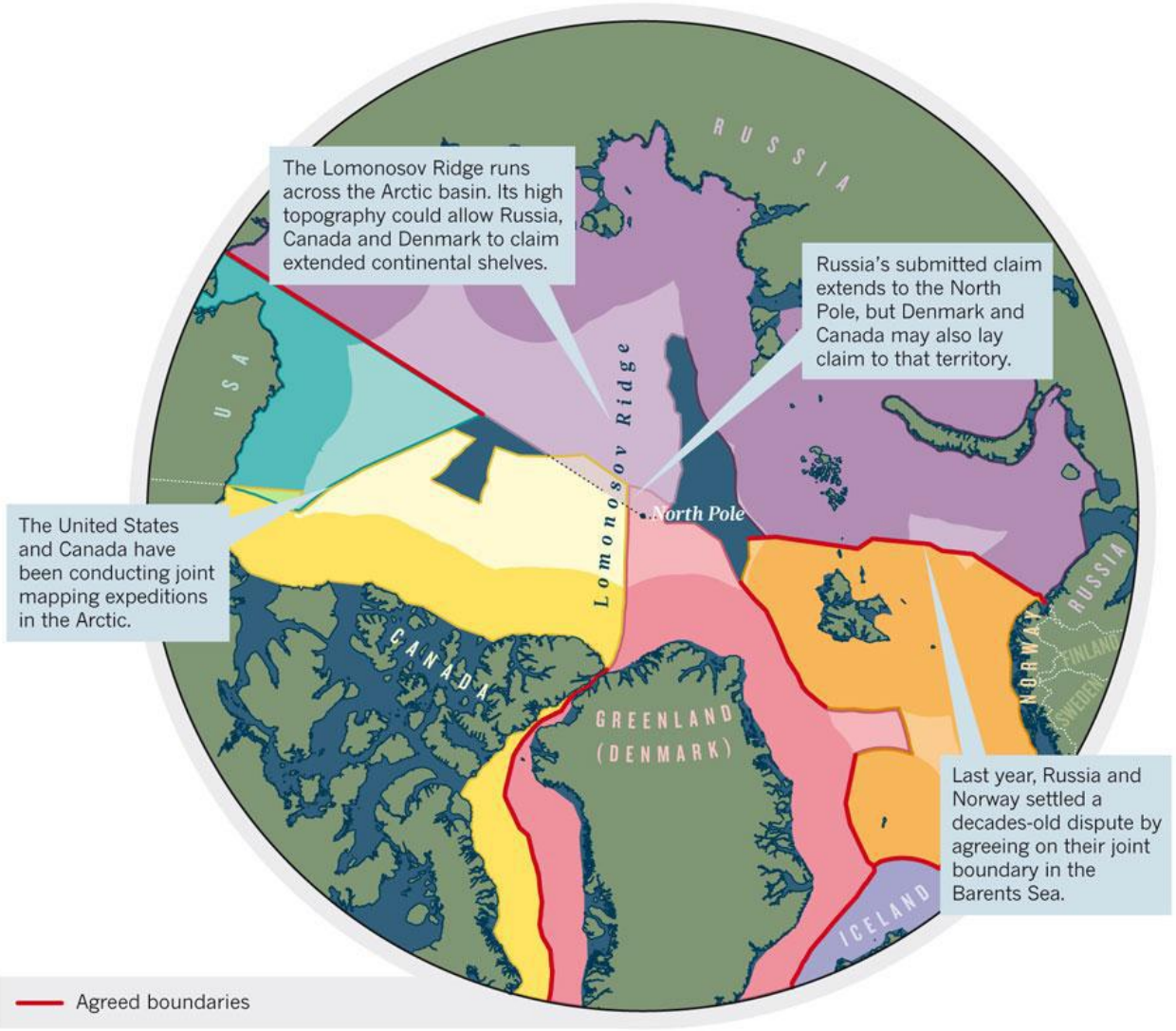
* Data based on the *Arctic Marine Synthesis: Atlas of the Chukchi and Beaufort Seas* and SkyTruth's Gulf of Mexico oil spill database. Map created June 3, 2010.

Application of the Law of the Sea (Article 76)



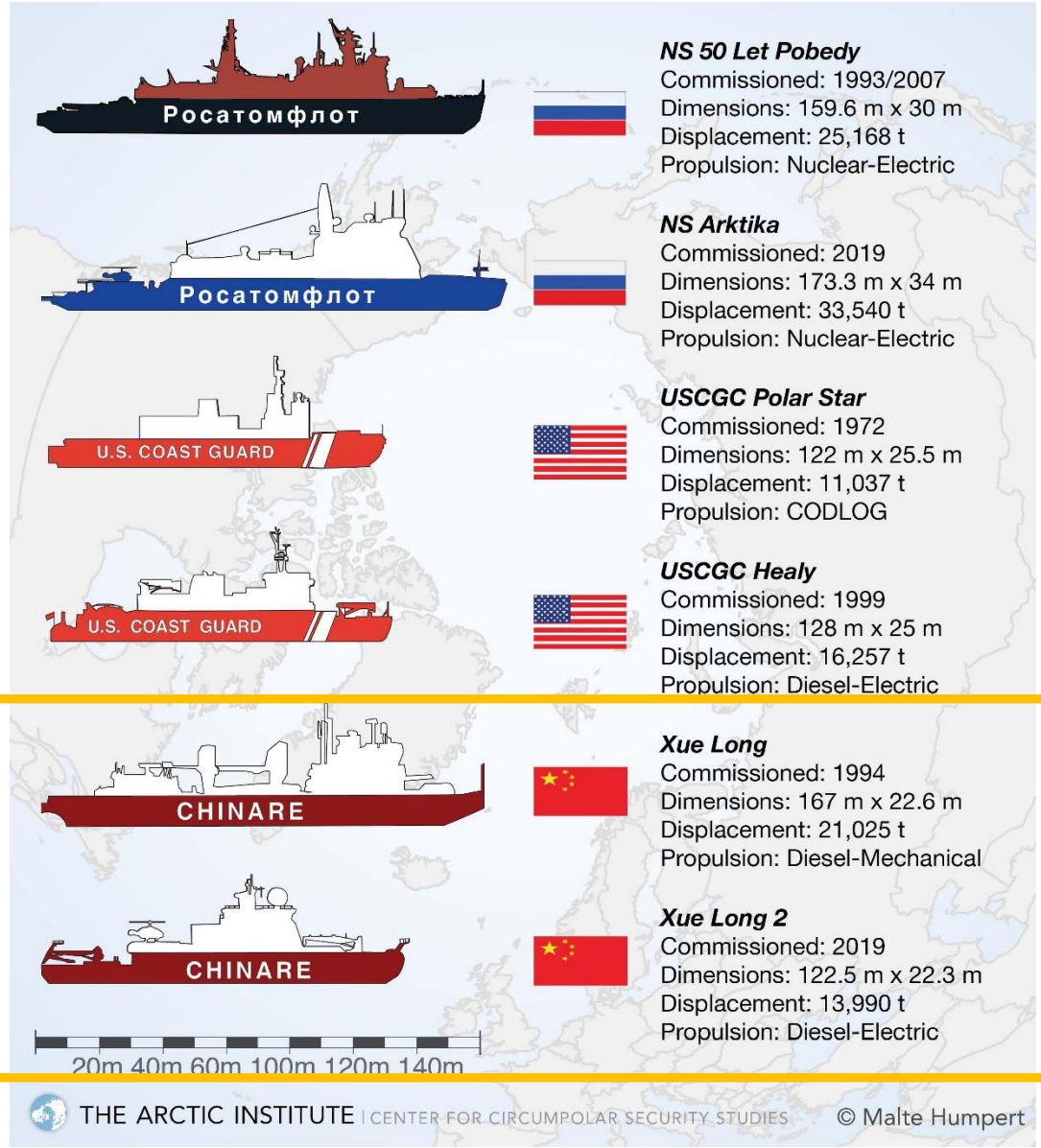
Arctic countries

Article 76 claims in the Arctic

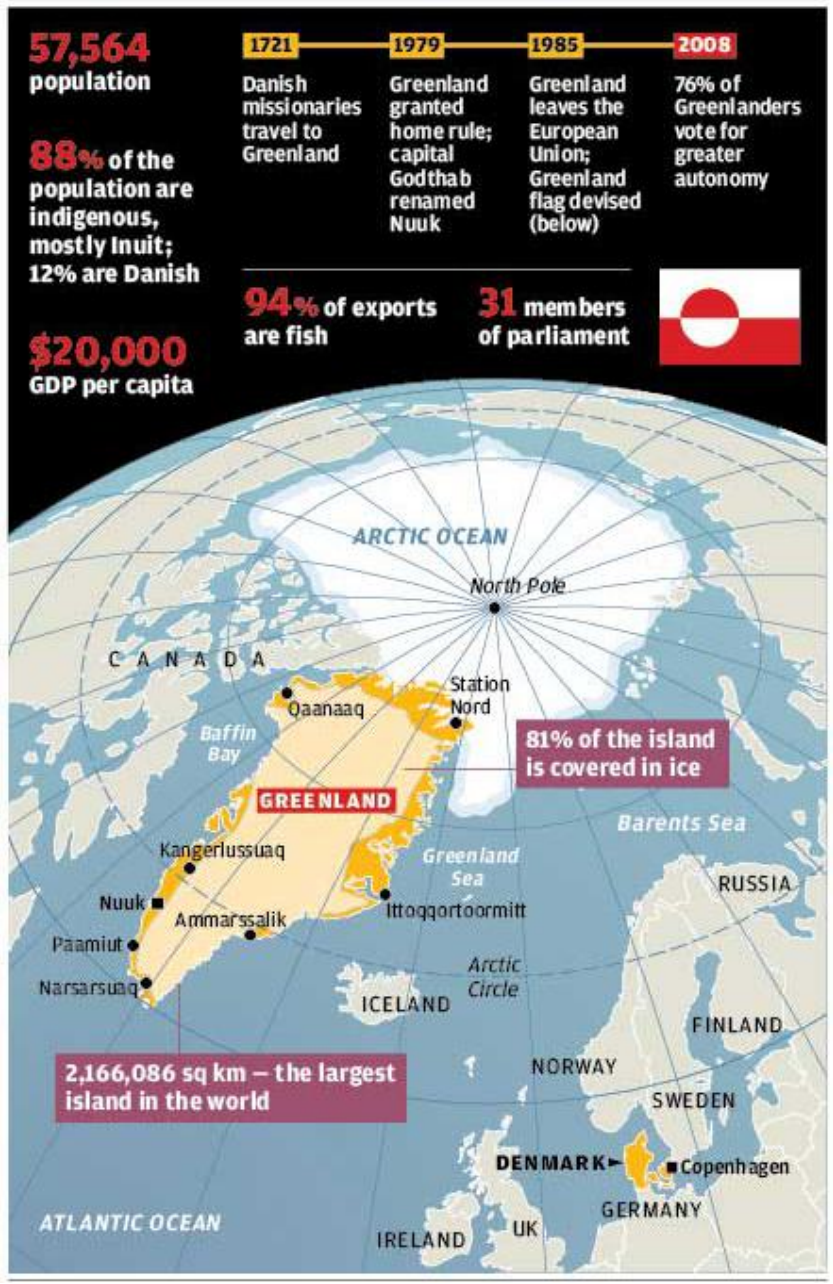


Nature, 2011

New players in the game



Unrest in the Kingdom of Denmark



Greenland is an autonomous constituent country of the Danish Realm …

Should Greenland become independent?

Just headlines …

A Russian company is pushing forward with plans to bring container shipping to the Northern Sea Route

Chinese firm withdraws bid for Greenland airport projects, reports Sermitsiaq

Insulting Canada won't help the US with its Arctic ambitions

In court and out, the Trump administration continues its push for offshore Arctic oil development

Like Denmark and Russia, Canada says its extended continental shelf includes the North Pole

For the first time ever, an Arctic Council ministerial meeting has ended without a joint declaration

Where shall we go?

- Secretary Pompeo: ramp up security, no “climate”
- China (Korea, etc): international accessibility
- Or ... focus on reducing waste (including emissions),

  create more protected areas