Climate Crises and Restoration of the Arctic Ice

Presented by

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Guadalupe Regional Group of the LPC of the Sierra Club

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Securethefuture2100.org

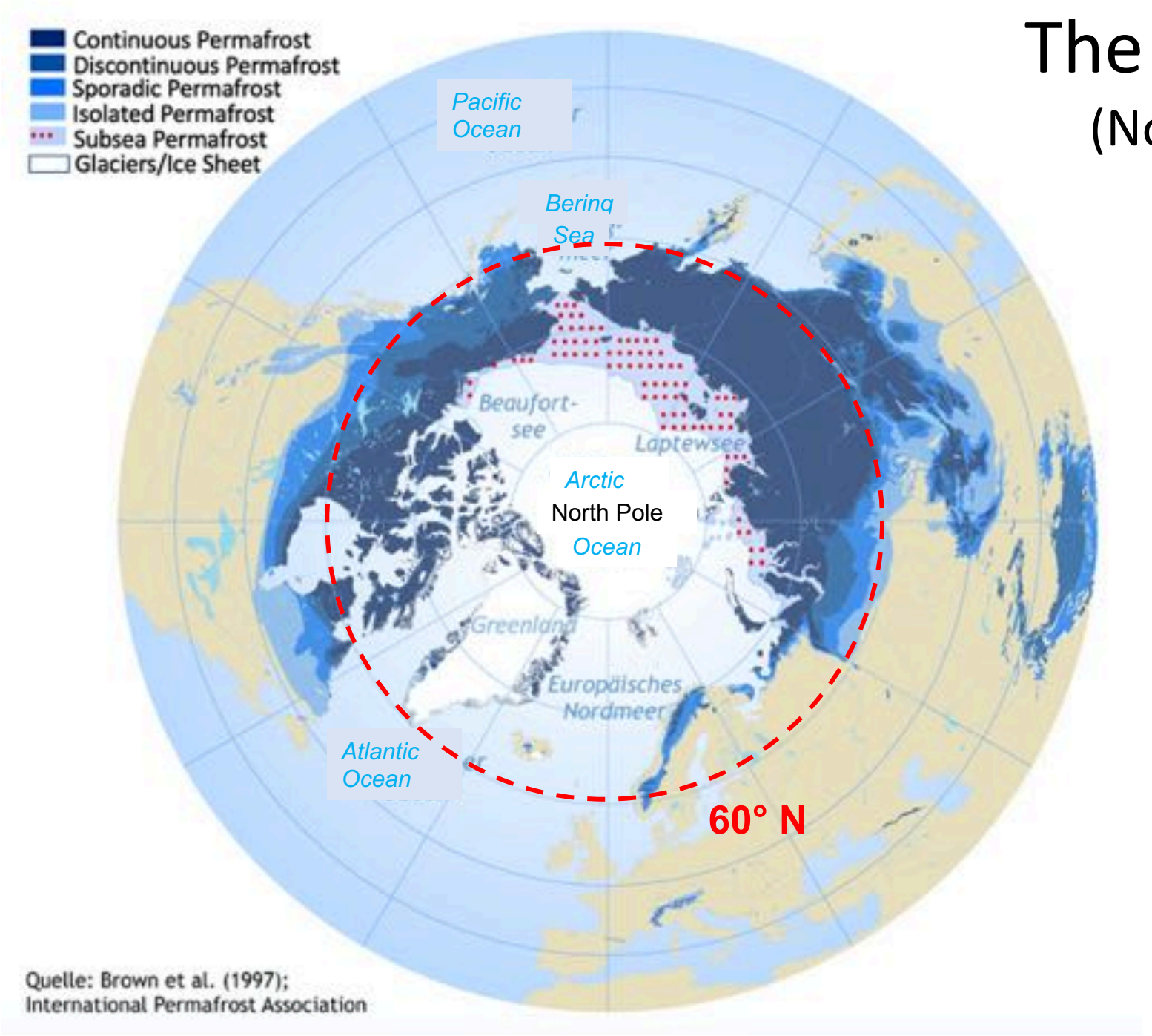
Climate Crises and Restoration of the Arctic Ice

- The Arctic region
- The Arctic: near a tipping point
- Why is the Arctic sea ice disappearing
- How it impacts the ocean, land, atmosphere
- How it impacts the worlds people, society, and security
- The cost of doing nothing
- The need for an international program to restore the Arctic sea ice
- Potential restoration methods

Photo courtesy of Peter Prokosch

The Arctic Region

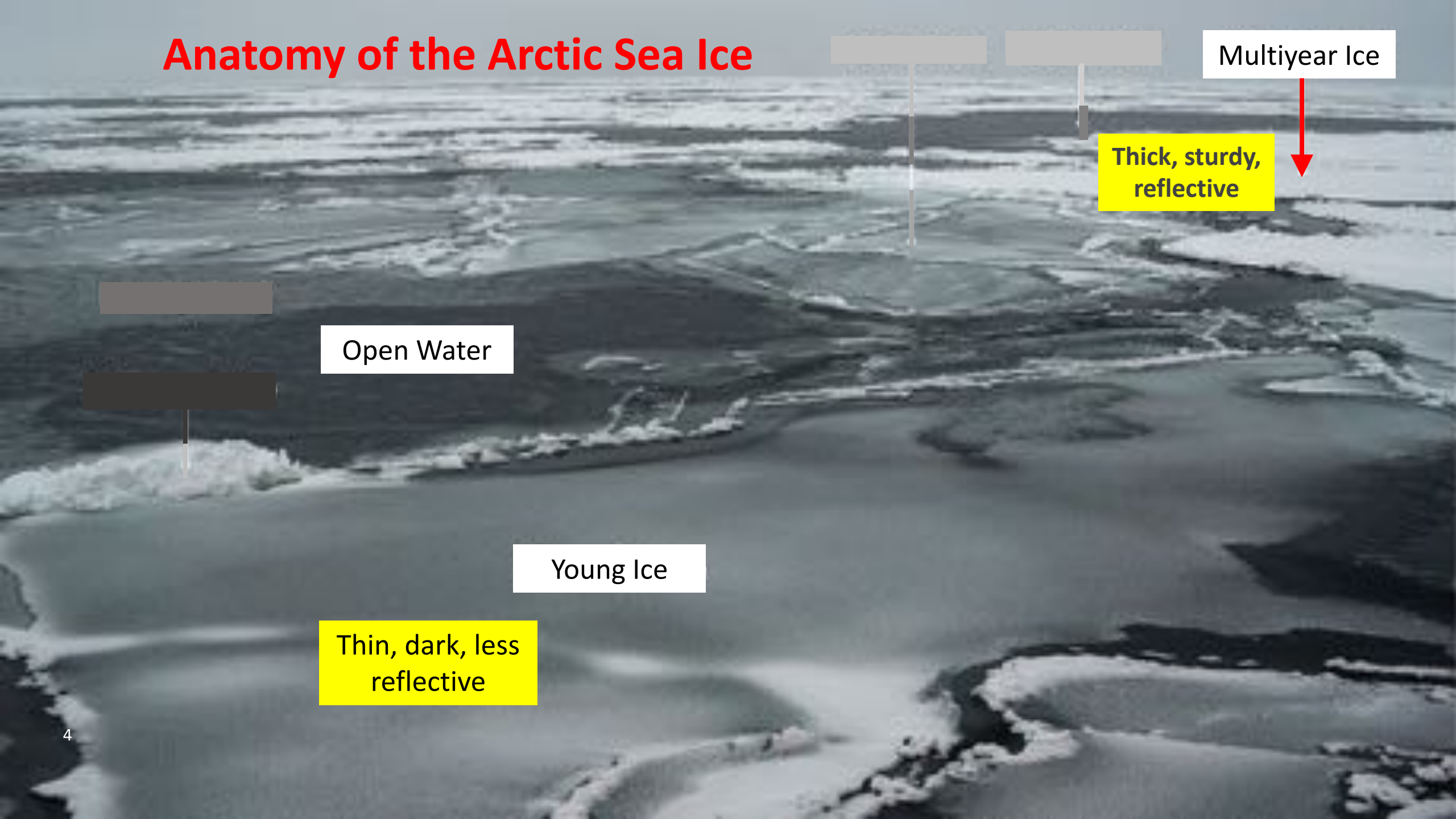
(North of 60°N Lat)



Quelle: Brown et al. (1997);
International Permafrost Association

Larger NP, etc
ID land mass

Anatomy of the Arctic Sea Ice



The Arctic is Close to a Tipping Point

- The Arctic is warming twice as fast as the global average temperature.
- The continued loss of Arctic Sea Ice is accelerating global warming.
- Reaching the tipping point of a total ice-free summer will result in a global cascade of drastic climate-related events.

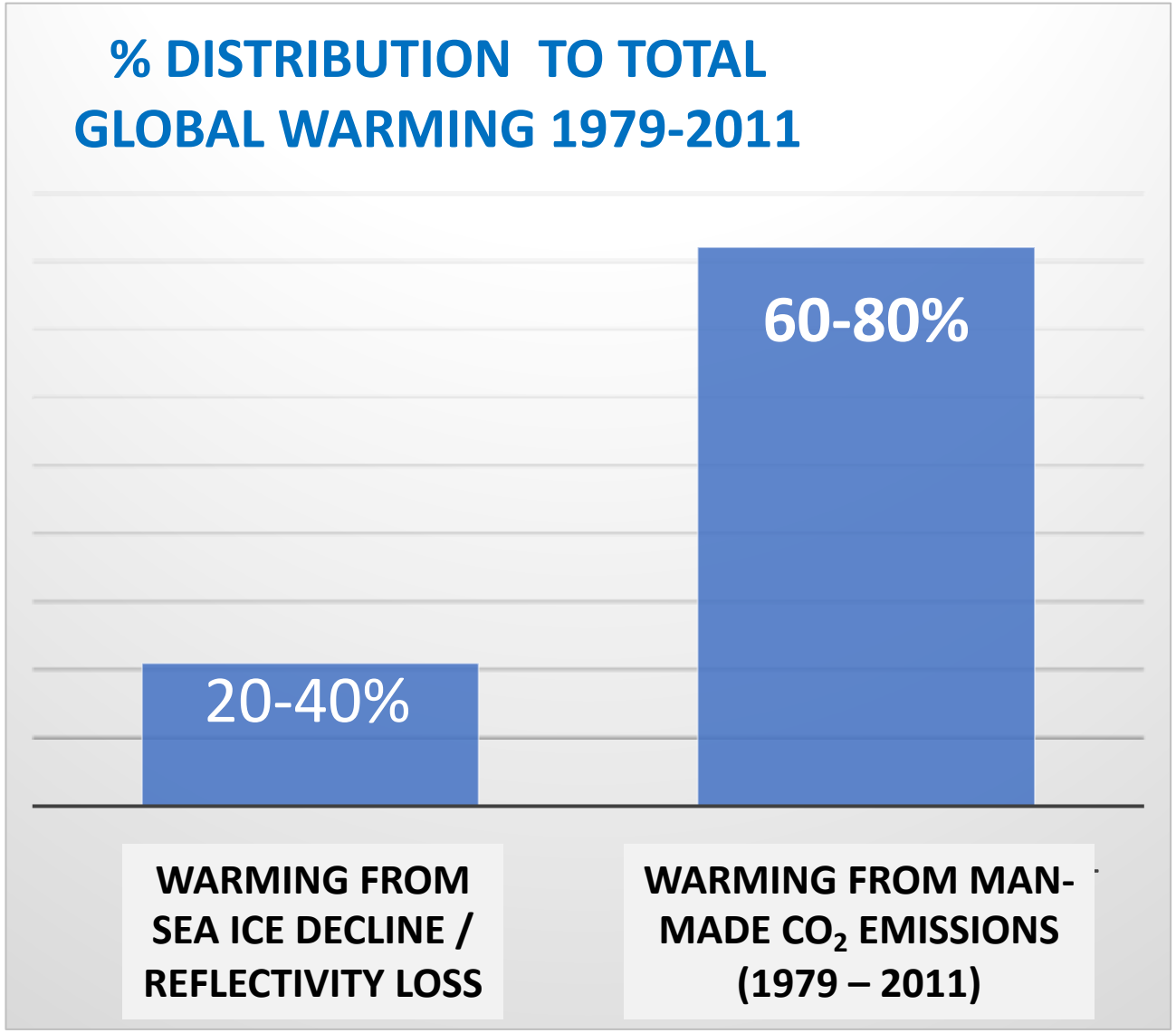
RESTORATION OF ARCTIC SEA ICE IS ESSENTIAL TO PREVENT A GLOBAL CLIMATE CRISIS

- The window for action is quickly closing
- By applying restoration technology, we can prevent the Arctic sea ice from total loss
- This will buy us time to eliminate greenhouse gas emissions and slow down climate change
- An international program will be needed to accomplish this effort

We Need To ASK…

The government of the United States to implement a comprehensive, broad, international program of STRATEGIC RESEARCH & DEVELOPMENT, the *National Arctic Ice Restoration Initiative (NAIRI)* with the objective of RESTORING THE ARCTIC SEA ICE

LOSS OF SEA ICE: IMPACT TO GLOBAL WARMING



Arctic ice-free summers will further increase global warming

- **Three times more that warming from current Loss of Arctic Ice**

Reference: Pistone, etal, *Radiative Heating of an Ice-Free Arctic Ocean*, AGU 10.1029/2019GL082914

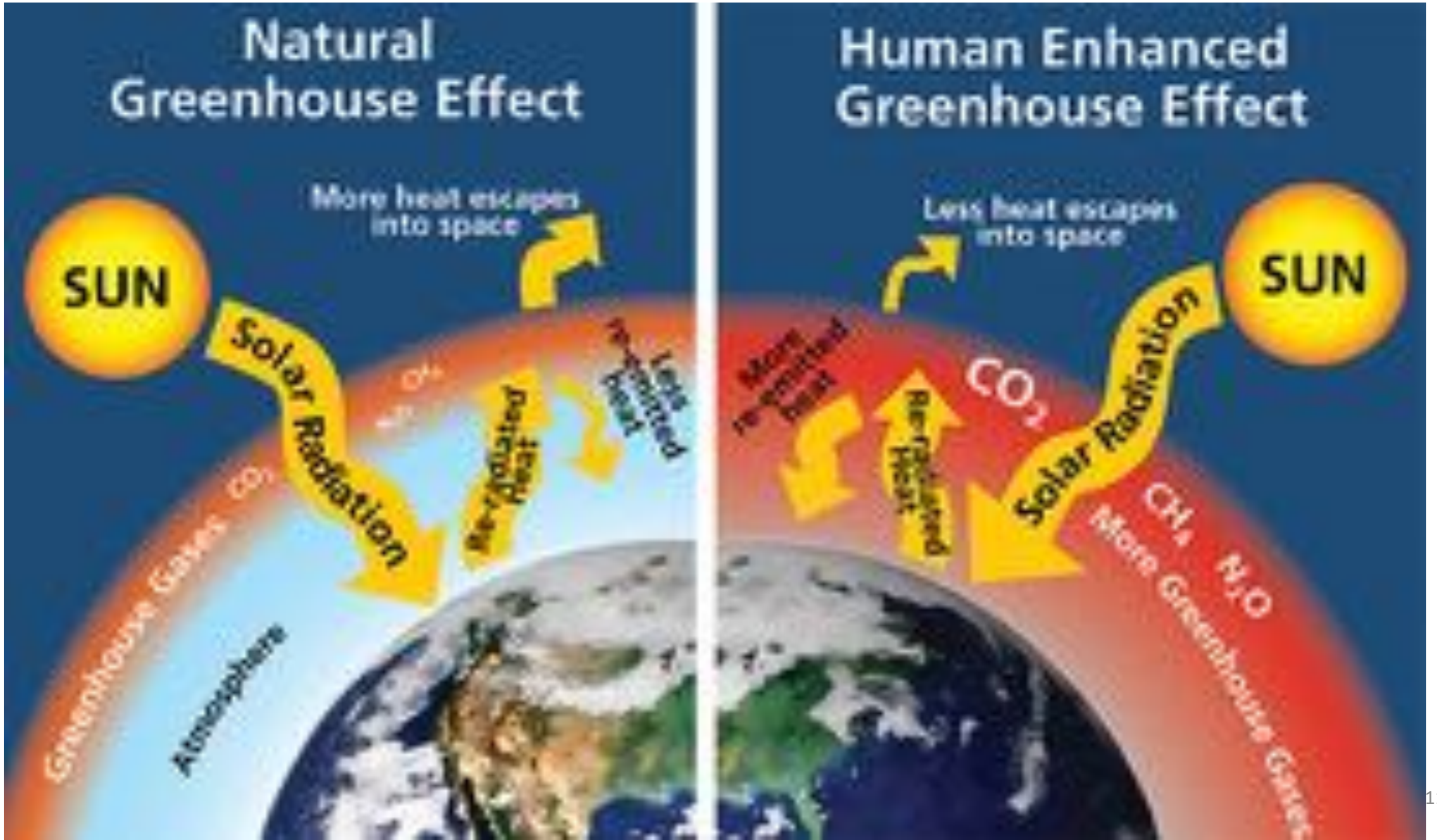
WHY IS ARCTIC SEA-ICE DISAPPEARING?

Burning fossil fuels amplify the greenhouse effect, increasing the melting of the ice

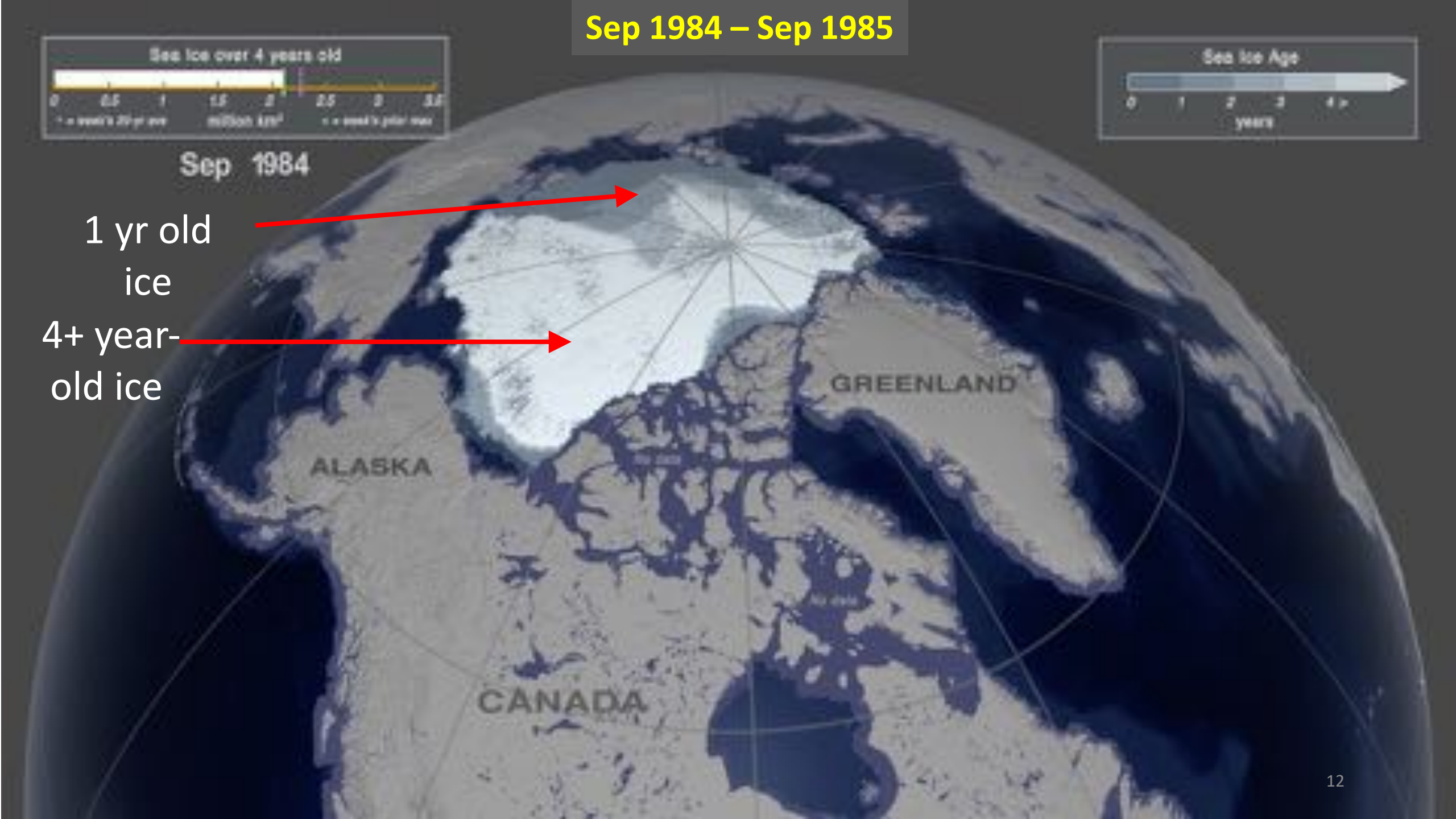
Ice-melt is further accelerated as the Arctic atmosphere and ocean heat up

GREENHOUSE EFFECT

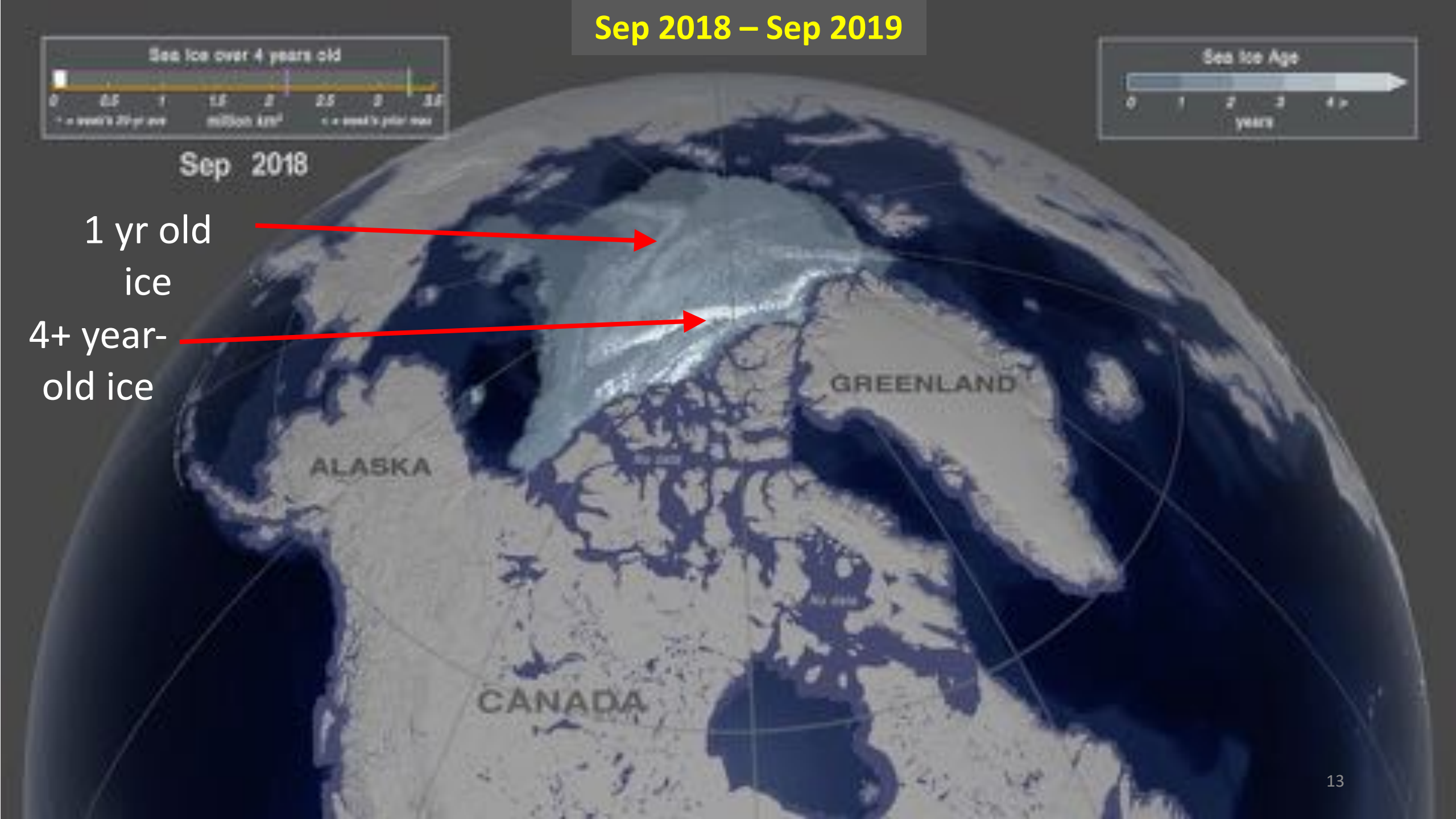
GREENHOUSE EFFECT



Sep 1984 – Sep 1985



Sep 2018 – Sep 2019

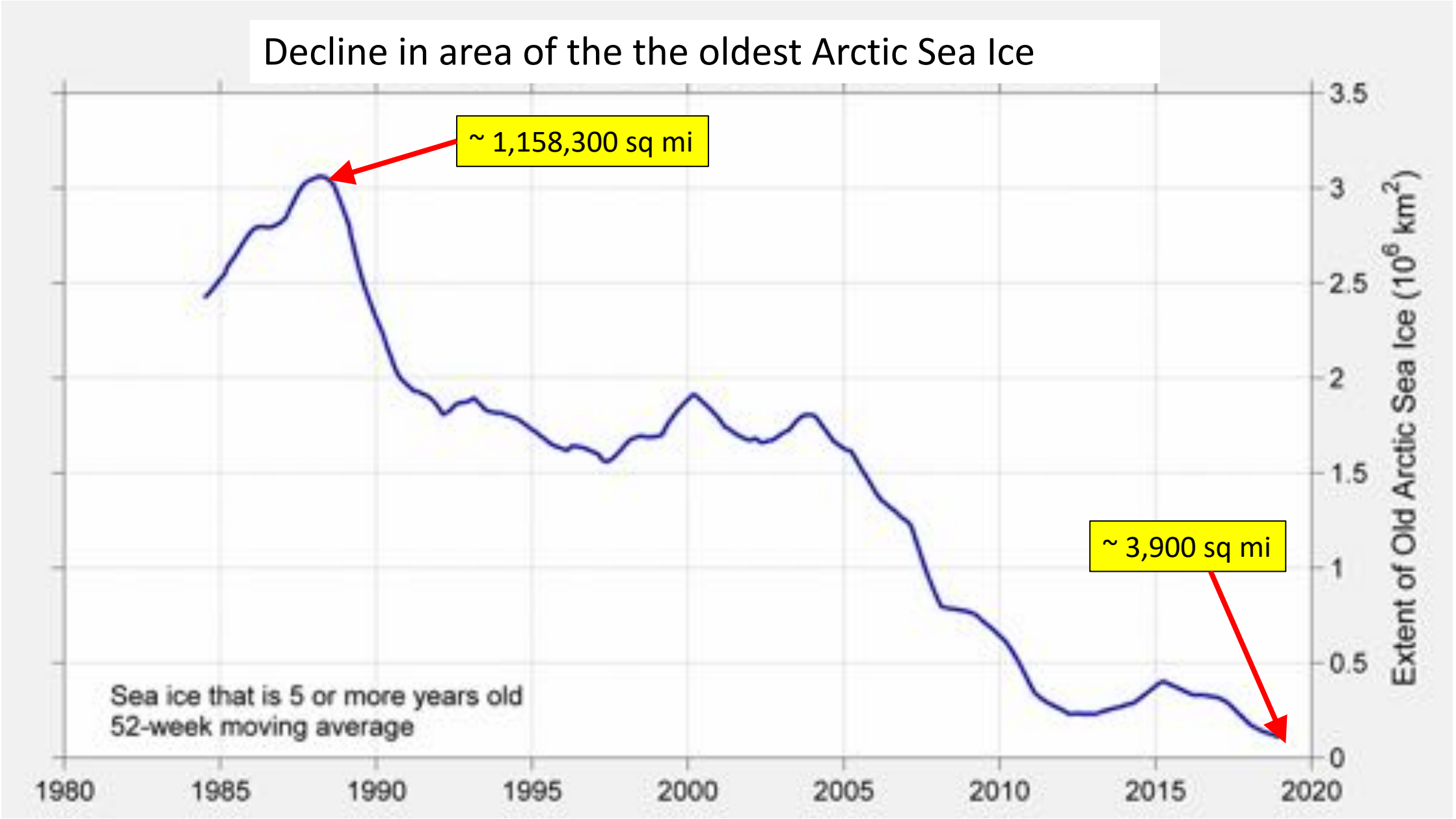


SEA ICE MINIMUM
Sep 1984

SEA ICE MINIMUM
Sep 2019

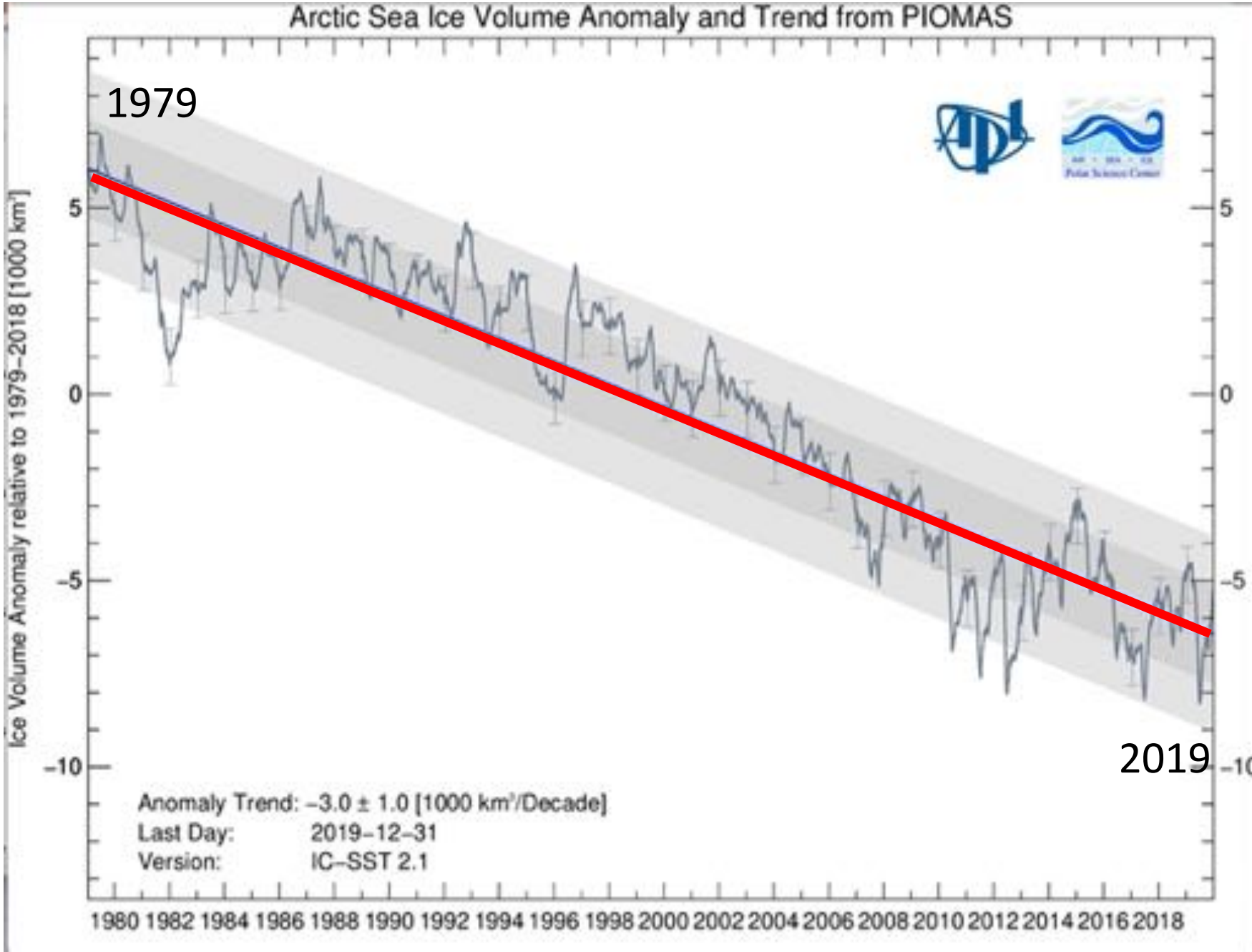

Before 2018, the Arctic's oldest and thickest sea ice was never observed breaking up.
….but it happened twice in 2018!

Decline in area of the the oldest Arctic Sea Ice



Heading in 10 years to an ice-free Arctic summer

2019:
Second greatest loss in average sea ice volume since 1979
(75% loss over 50 yrs)



THE ARCTIC IN CRISIS

Over the last 40 years:

50%

LOSS IN ICE THICKNESS Since 1970's

50%

LOSS IN AREA COVERAGE Since 1980

75%

LOSS IN VOLUME Since 1980

Sources: http://nsidc.org/data/seaice_index/
http://psc.apl.uw.edu/research/projects/arctic-sea-ice-volume-anomaly/
http://www.the-cryosphere.net/9/269/2015/tc-9-269-2015.html

ARCTIC BASECAMP
@ARCTICBASECAMP

RESTORATION OF THE ARCTIC SEA ICE

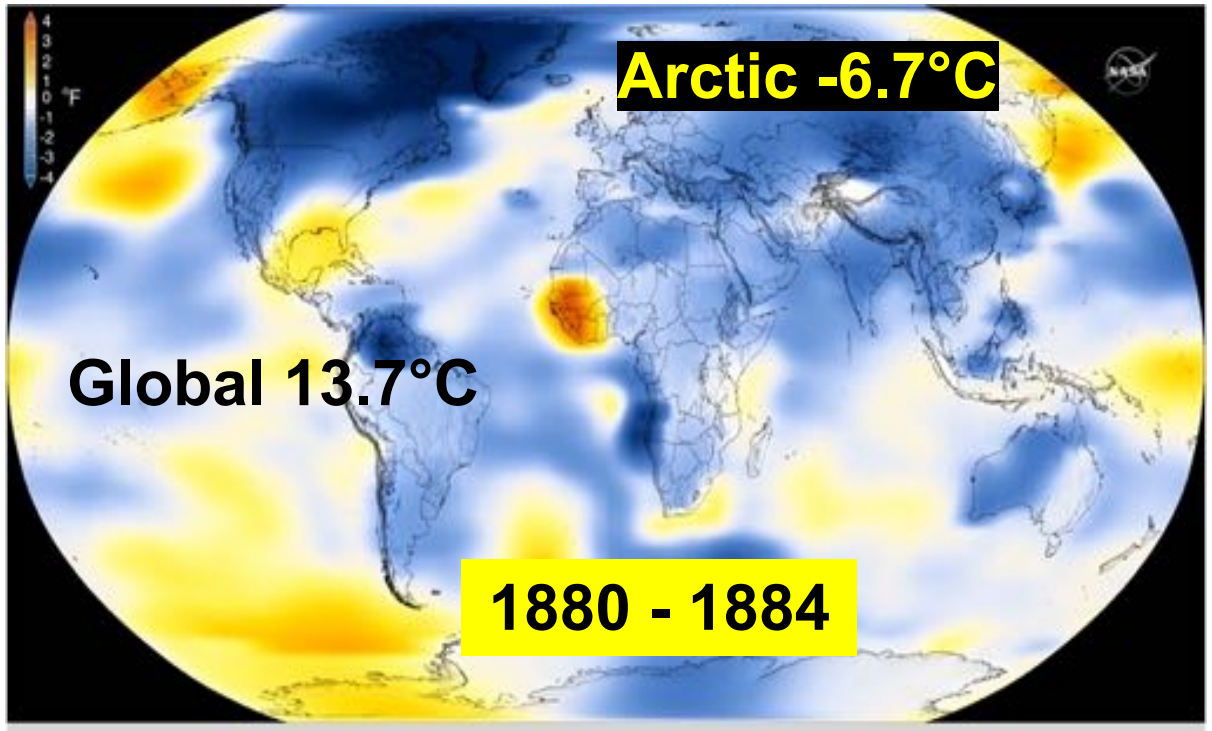
IS NEEDED IN CONCERT WITH

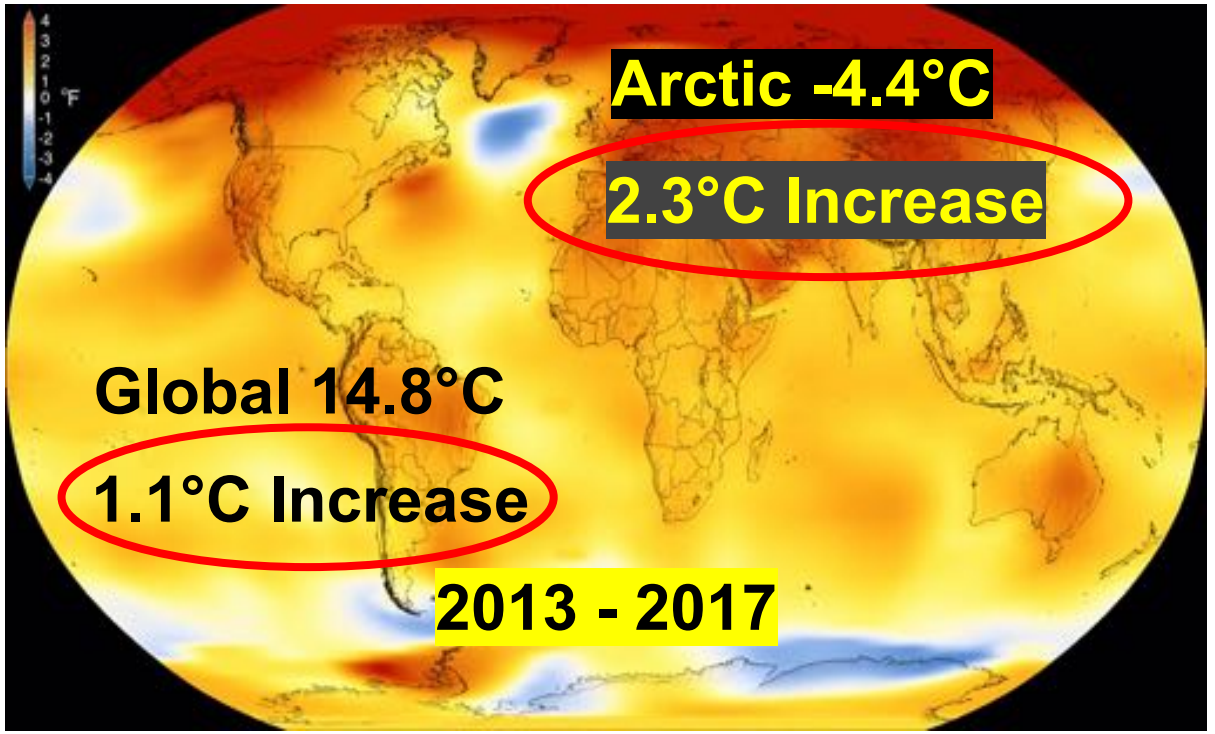
THE ELIMINATION OF FOSSIL FUELS

Arctic sea ice restoration will be applied to a limited area – just the ice

...this process will not have unintended consequences affecting a wider geographical area

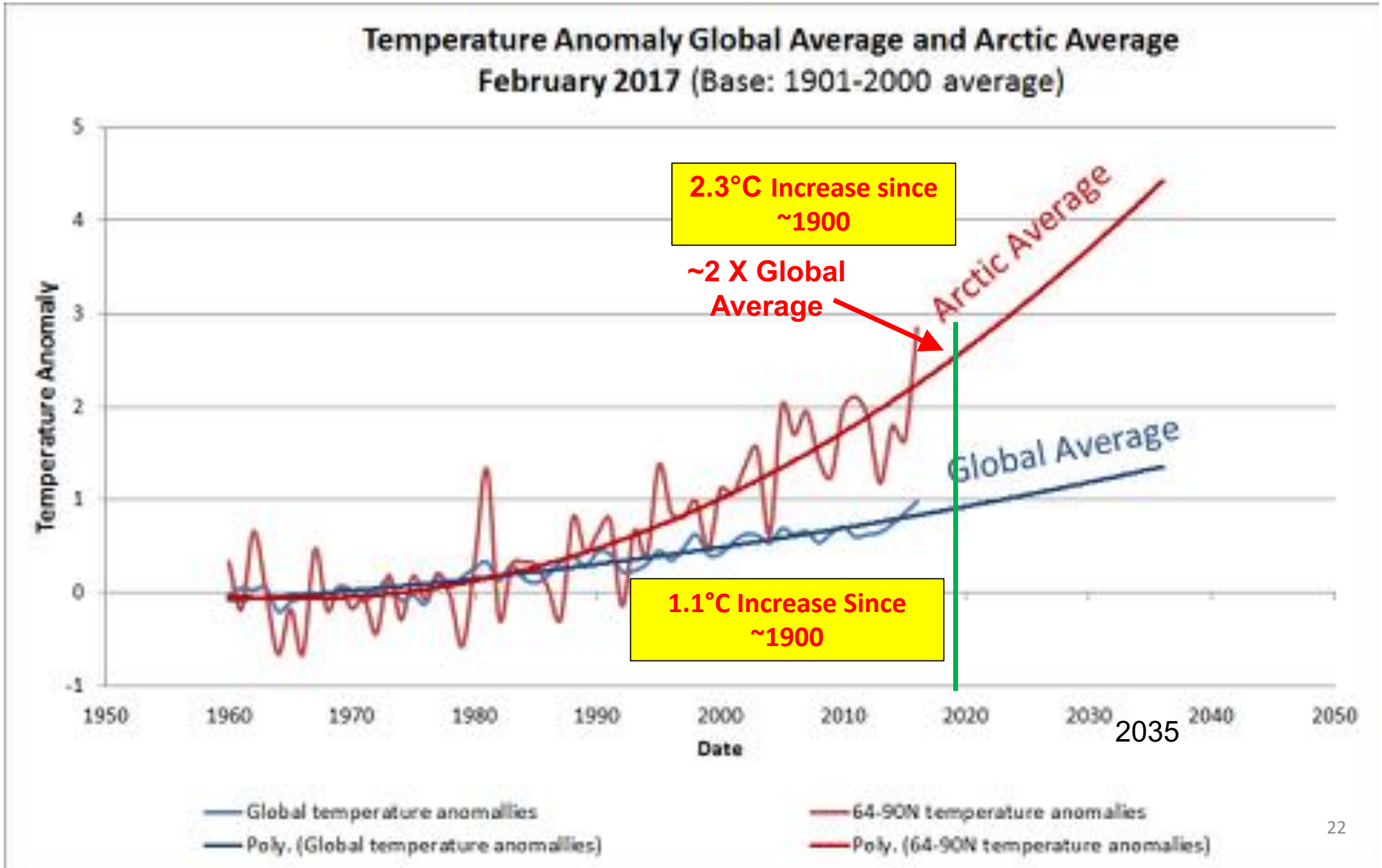
Arctic Warming 2X Faster than Average World Temperature - Arctic Amplification -





Surface Temperature Since 1880's

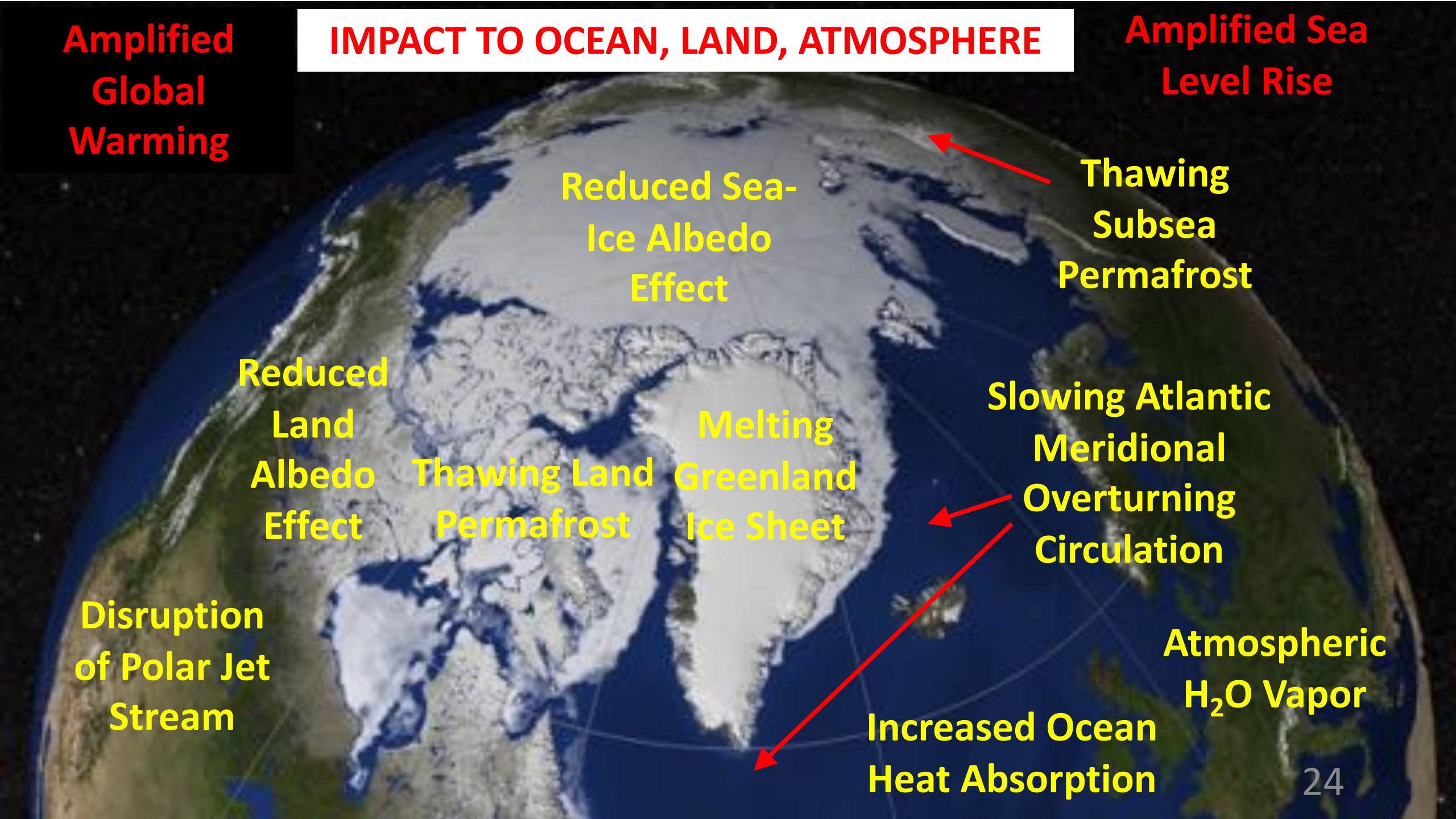
Arctic - Areas north of 60° N Lat
Baseline – Average 1951 to 1980


Temperature Anomaly Global Average and Arctic Average
February 2017 (Base: 1901-2000 average)
2.3°C Increase since ~1900
~2 X Global Average
Arctic Average
Global Average
1.1°C Increase Since ~1900
2035
Temperature Anomaly
Date
5
4
3
2
1
0
-1
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Global temperature anomalies
Poly. (Global temperature anomalies)
64-90N temperature anomalies
Poly. (64-90N temperature anomalies)

THE LOSS OF ARCTIC SEA-ICE AMPLIFIES

- RISING ARCTIC OCEAN TEMPERATURE
- RISING ARCTIC ATMOSPHERIC TEMPERATURE
- GLOBAL WARMING
- SEA LEVEL RISE
- CHANGES OF GLOBAL WEATHER PATERNS AND CLIMATE

IMPACT TO OCEAN, LAND, ATMOSPHERE



REDUCED ALBEDO EFFECT

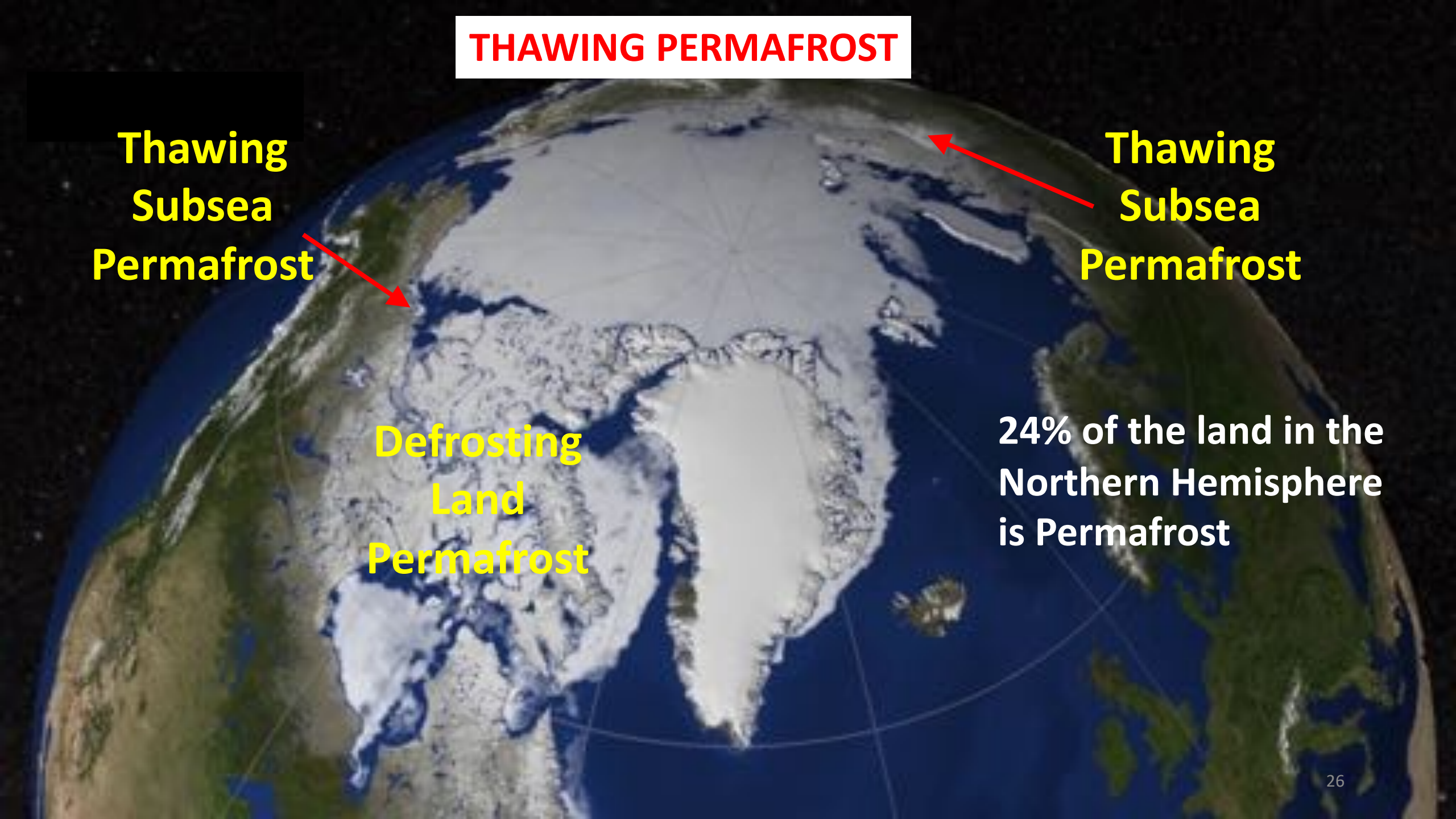
Arctic sea ice is rapidly disappearing

Open Arctic Ocean absorbs more energy from the sun

Heat is then transferred to the atmosphere and land

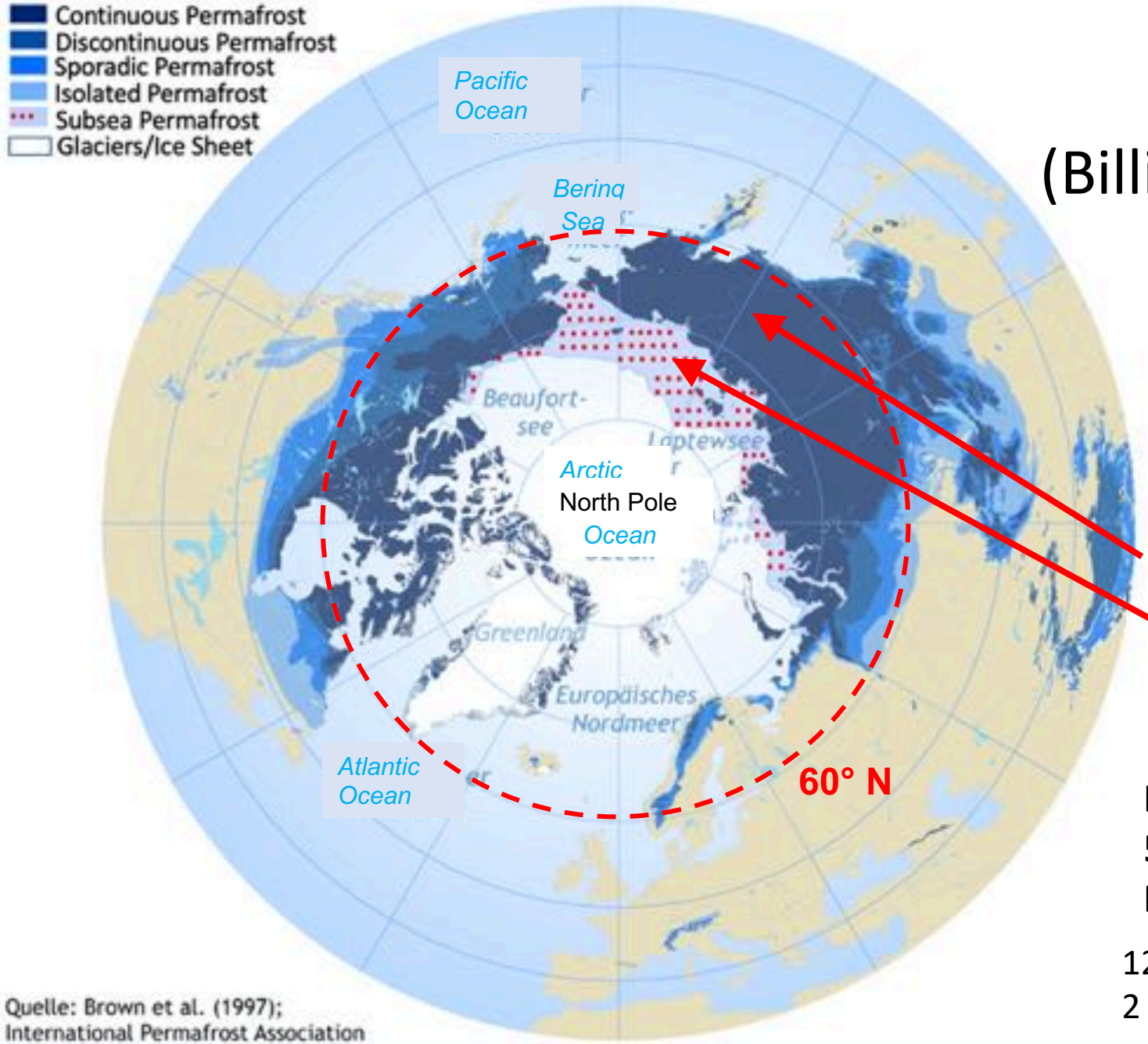
Arctic temperatures then rise twice as fast as the rest of the planet - Arctic Amplification

THAWING PERMAFROST



Global Stored Organic Carbon

(Billion Tons in CO_2 equivalent)



Quelle: Brown et al. (1997); International Permafrost Association

Oceans = 139,460

Atmosphere = 3,200

Plants = 2,020

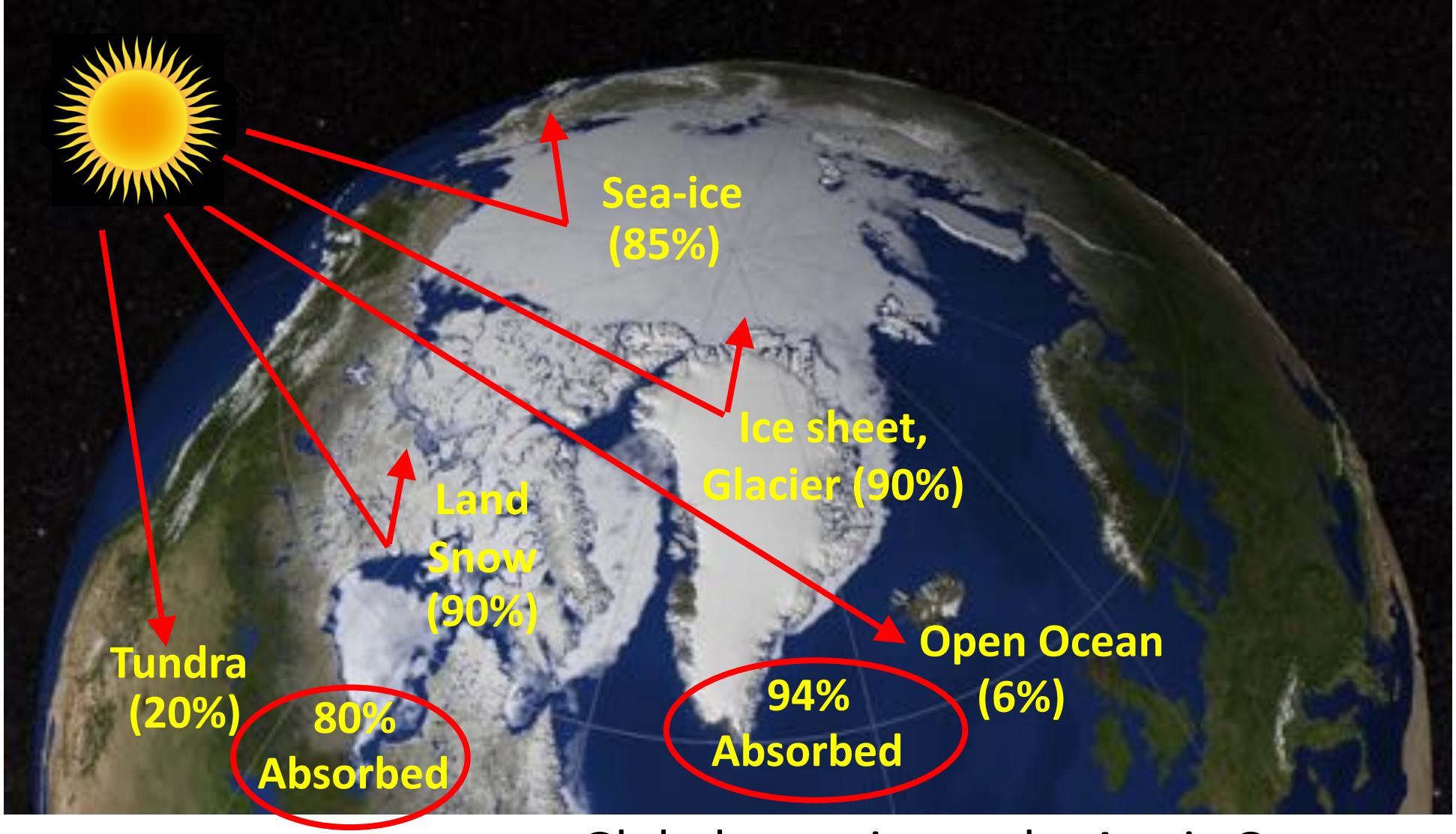
Soil (minus Permafrost) = 2,200

Permafrost = 6,240

Subsea Permafrost= 400 BT Methane (86 x more potent than CO_2 over 20 yrs = 34,400 BT CO_2)

Depth of thawing could increase by 30-50% by the year 2080 (United Nations Environmental Program)

120 ML mercury in Permafrost
2 x that of total in soil, oceans, atmosphere



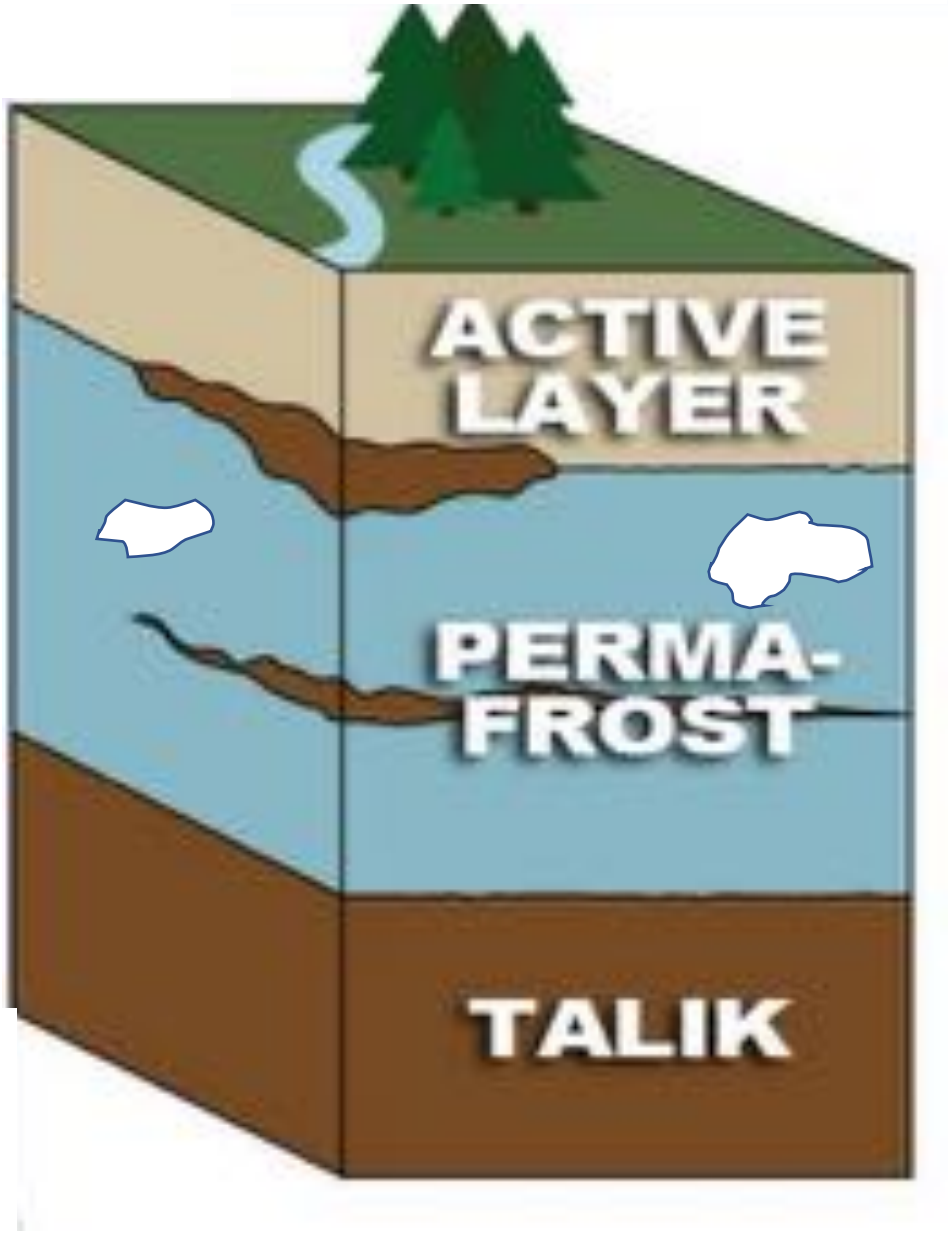
SEA-ICE, OPEN OCEAN & LAND ALBEDO EFFECT

- Global warming melts Arctic Ocean sea-ice, land snow
- White reflective surfaces turn to dark heat-absorbing surfaces

THAWING PERMAFROST

Land Permafrost

- 10.5 million km^2 in Northern Hemisphere
- Formed when ground remains frozen: since last ice age
- CO_2 is produced with microbial decomposition under aerobic conditions
- Methane is produced under anaerobic conditions (in mud or stagnant water)

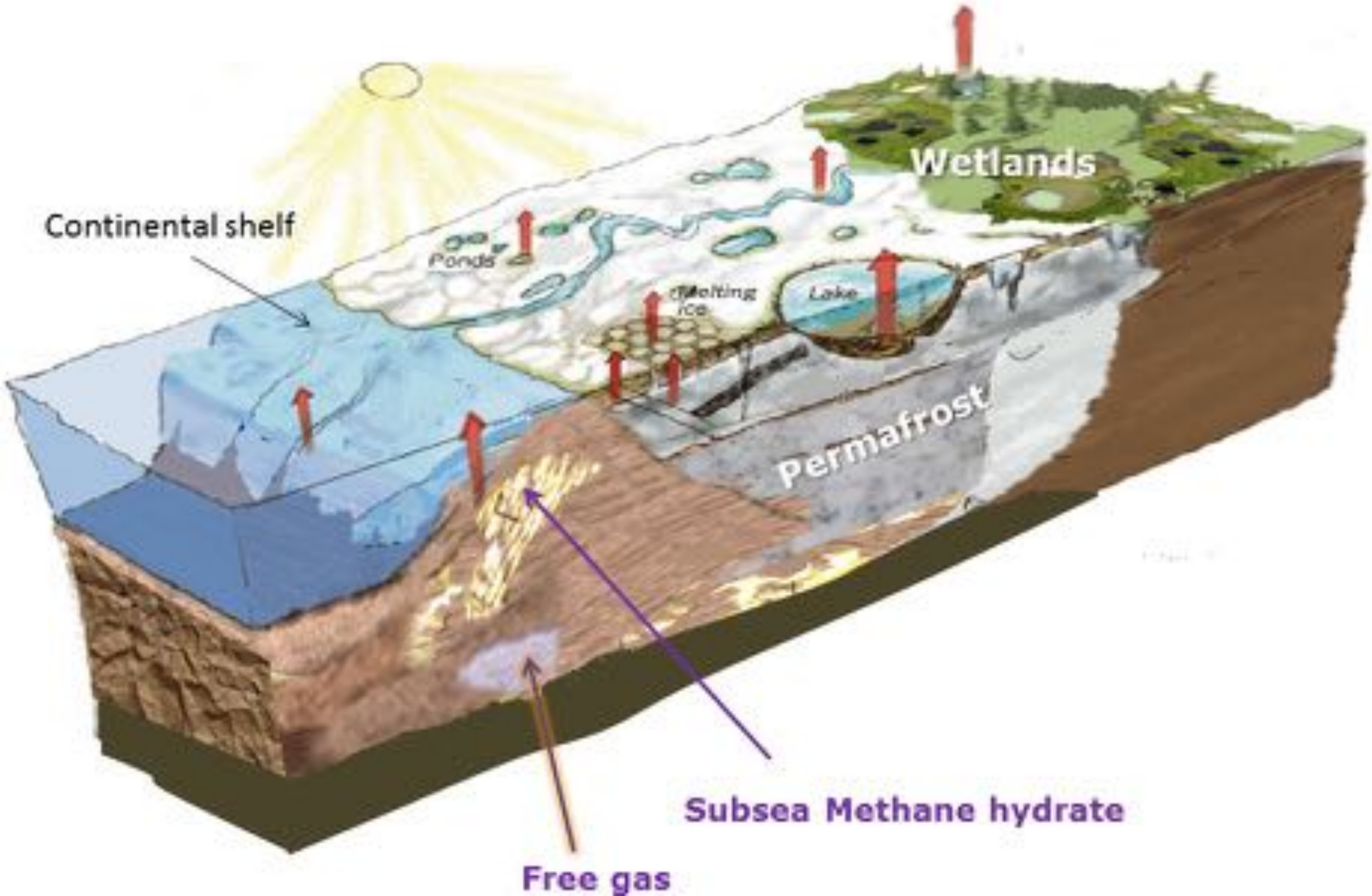


Organic material freezes and thaws each year producing methane and CO_2
< 1m thick

Organic Material
Ice
Remains Frozen

Unfrozen layers underneath or sometimes within permafrost layer

Arctic Sources of CO_2 and Methane



Threat From Deteriorating Arctic Ocean Continental Shelf

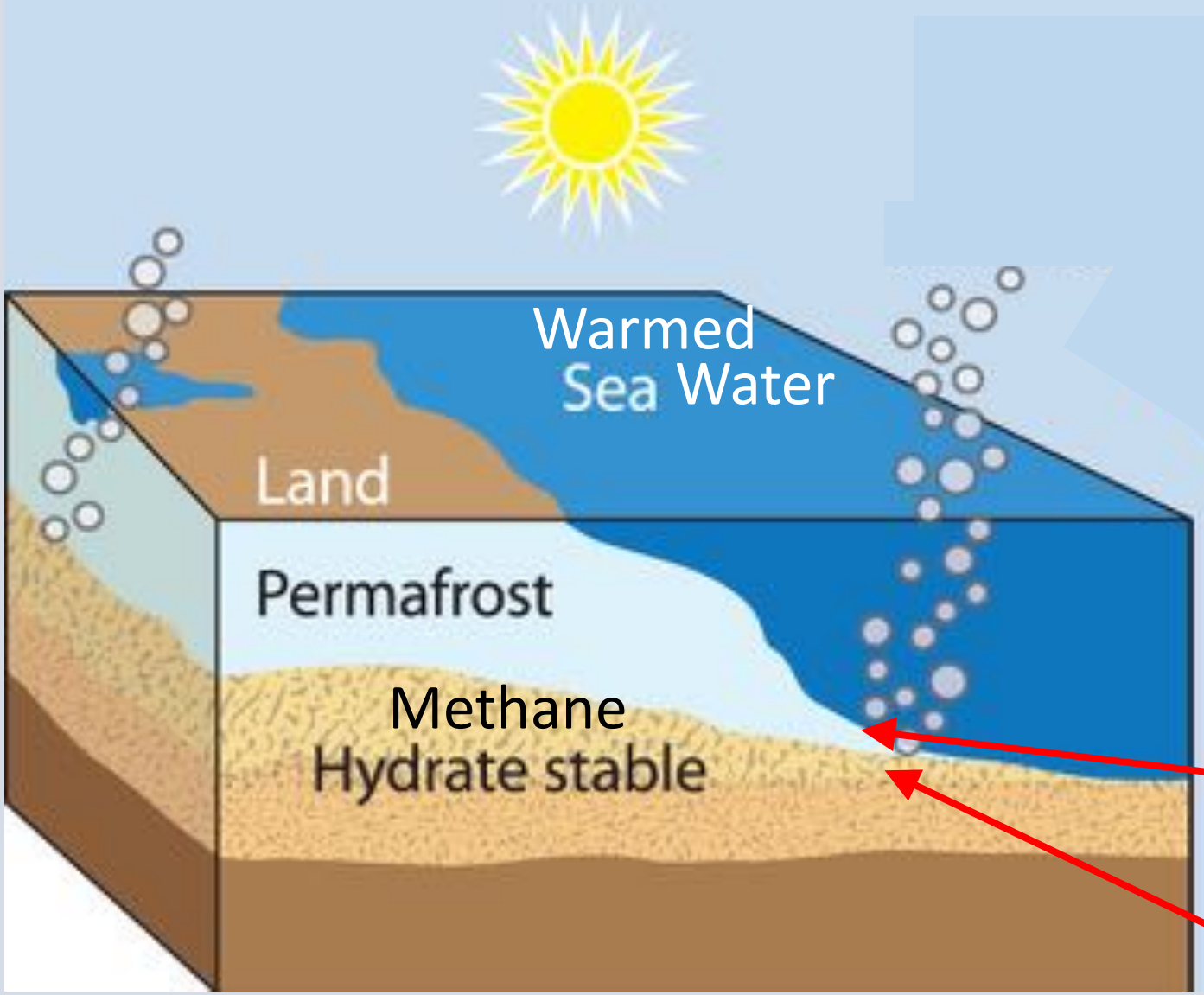
400 Billion tons of Methane is Estimated to be Stored in Arctic Ocean Continental Shelf

Methane's half life in the atmosphere is 7 yrs but is 84 x more potent as a greenhouse gas over a 20 yr period than CO_2

Potential of a 50 Billion ton release of Methane over 10 yrs

- 0.2 - 0.4°C increase in global temperatures within ~10 yrs
- 0.6°C within ~25 yrs

SUB-SEABED PERMAFROST ON Continental Shelf
- Release of Frozen Methane Hydrate -



Thawed subsea permafrost warms frozen methane hydrate beneath

Frozen methane hydrate melts with potential release of massive amounts of methane

Source: University of Alaska - Fairbanks/INE, 2007

RAPID THAWING PERMAFROST

- Thermokarst Lakes -

Maximum thaw depths for Thermokarst lakes has already exceeded what was expected by 2090.

- 15m in last 50 yrs

Methane from Thermokarst Lakes not factored into existing global climate models


Thermokarst Lakes
Canadian High Arctic

Consequences of Permafrost Thaw to Infrastructure

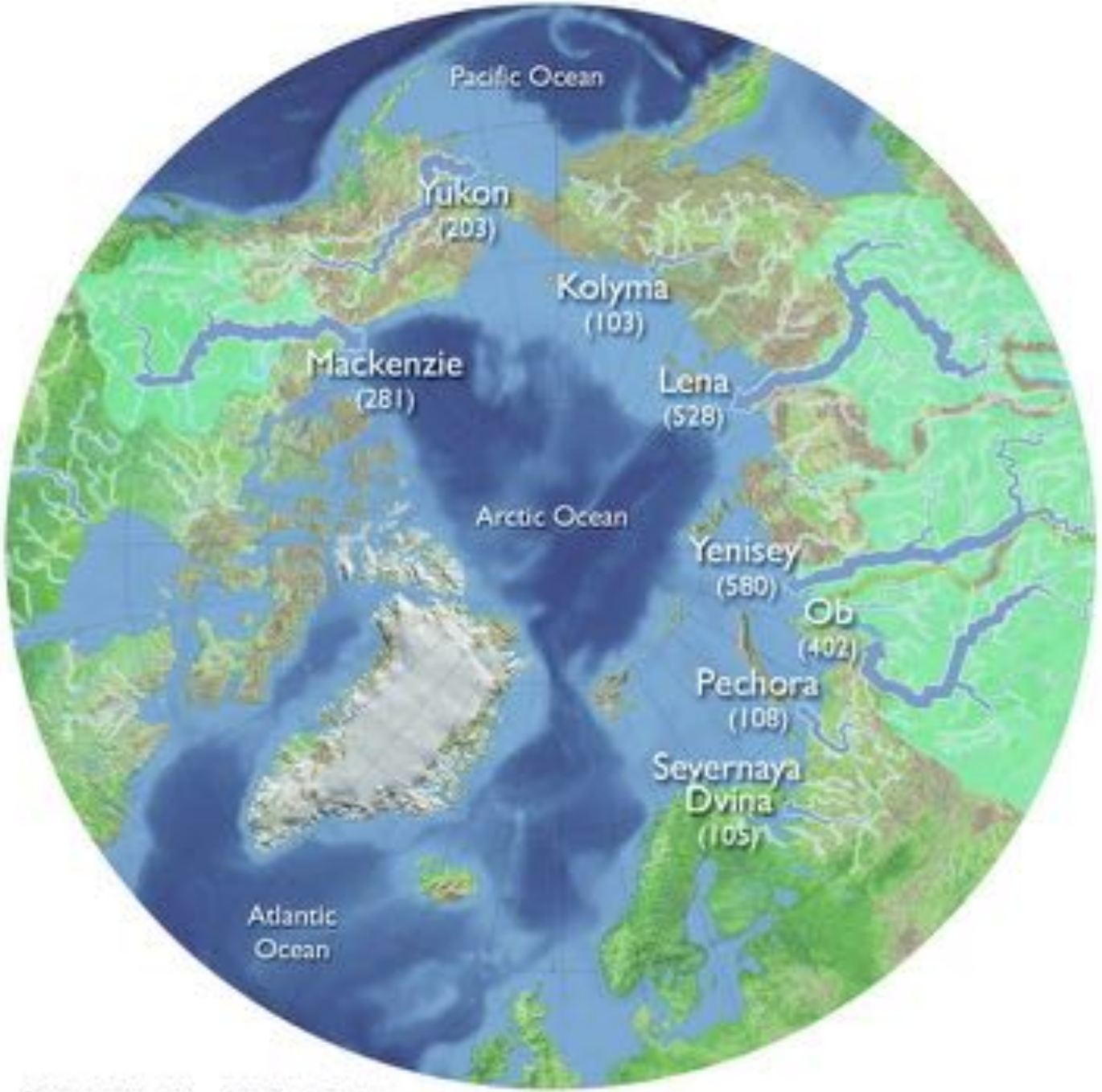
Aprox 70 percent of infrastructure in the global Arctic region is built on permafrost.

Consequences of Permafrost Thaw to Infrastructure

Damage could cost 100's of billions

Consequences of Permafrost Thaw to Infrastructure

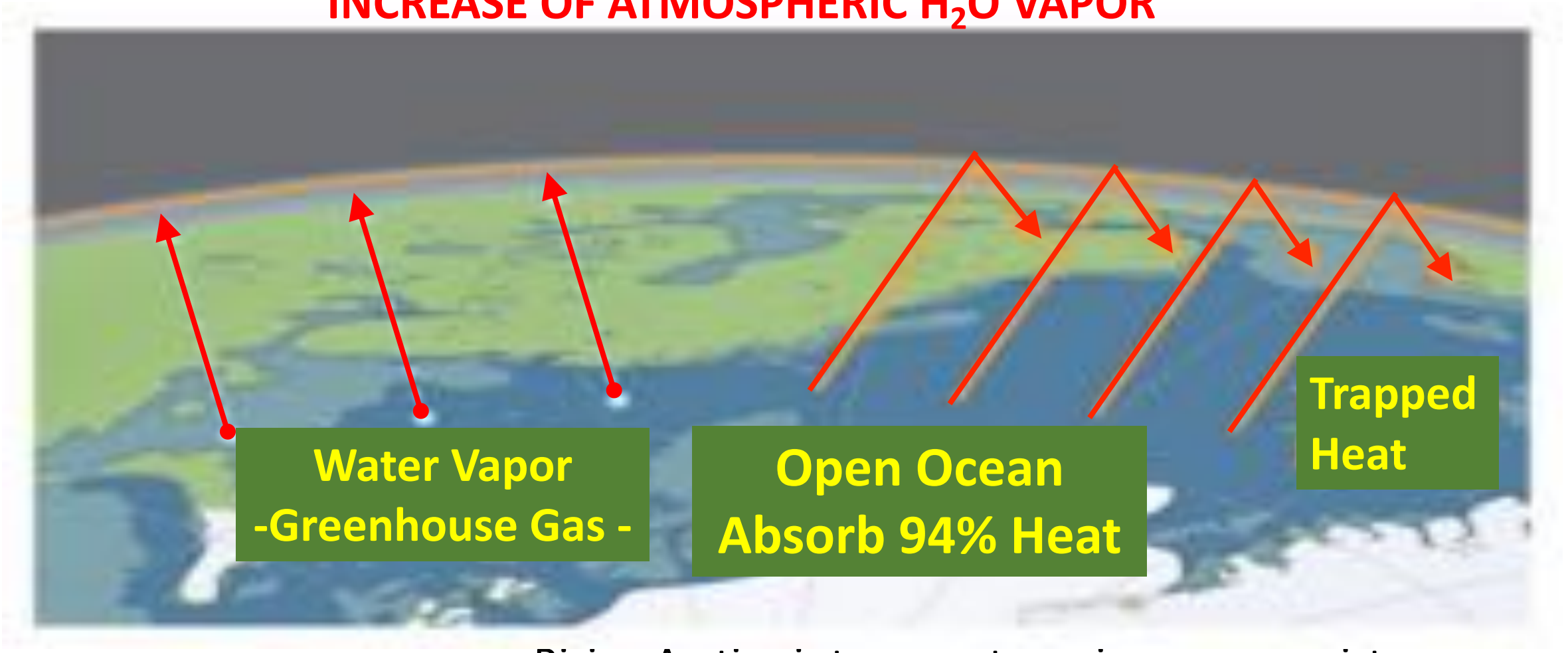
Designing, construction, and maintenance of infrastructure in the Arctic is and will be a technical, engineering, and economic challenge



WARMING ARCTIC RIVERS

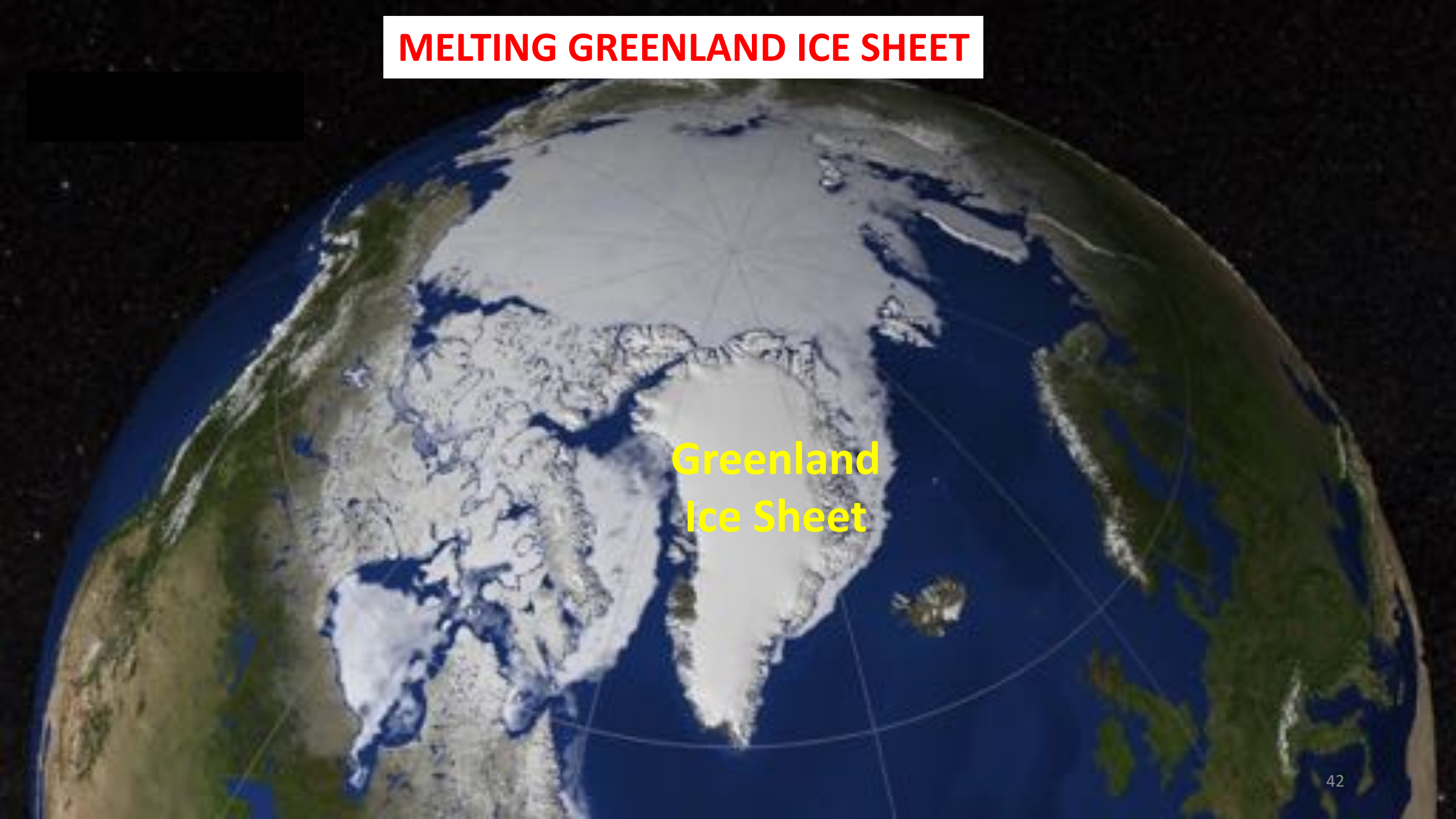
- Eight major river basins in the Arctic
- Runoff and snow melt from waterways flow through warmer land
- Warmed land increases temperature of large north-flowing rivers in Canada and Siberia
- Outflow provides additional heat to Arctic Ocean

INCREASE OF ATMOSPHERIC H_2O VAPOR



- Rising Arctic air temperatures increases moisture content of regional atmosphere
- Resulting water vapor, a greenhouse gas, traps outgoing heat (long-wave radiation) – further heating Arctic region

MELTING GREENLAND ICE SHEET



GREENLAND ICE SHEET

- 2,900,000 km^3 of Ice
- Melting 7 x faster than the 1990s
  - 50% from warming ocean
  - 50% from warming atmosphere
- **~50 melt events at Summit Reseach Station in past 10,000 years.**
  - **4 events in past 7 yrs.**

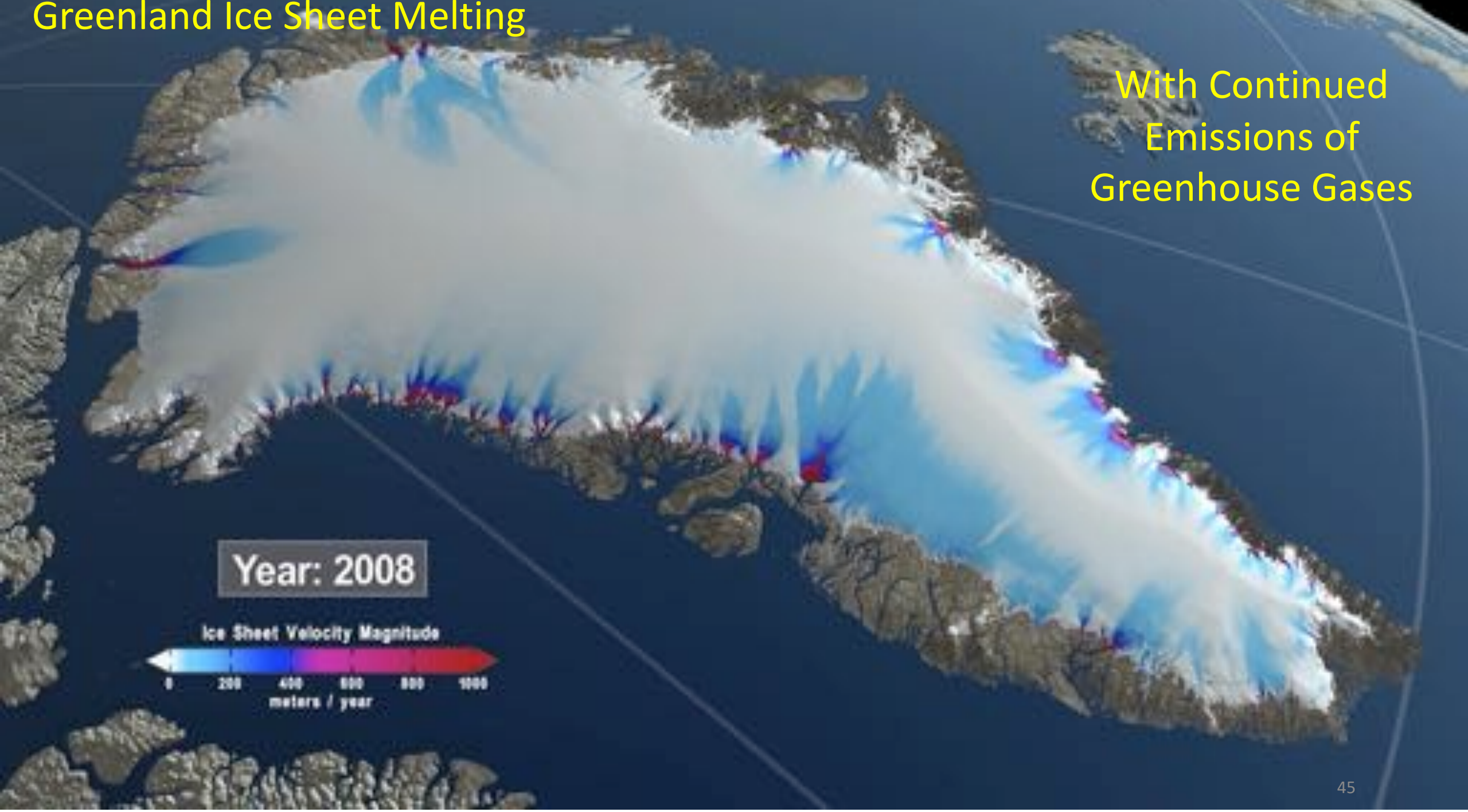
Southern Greenland

Greenland Glaciers

- As Greenland's ice sheet flows to it's shore it continues as glaciers or rivers of ice.
- There are approximately 200 glaciers on Greenland and 28 that are monitored are shrinking.

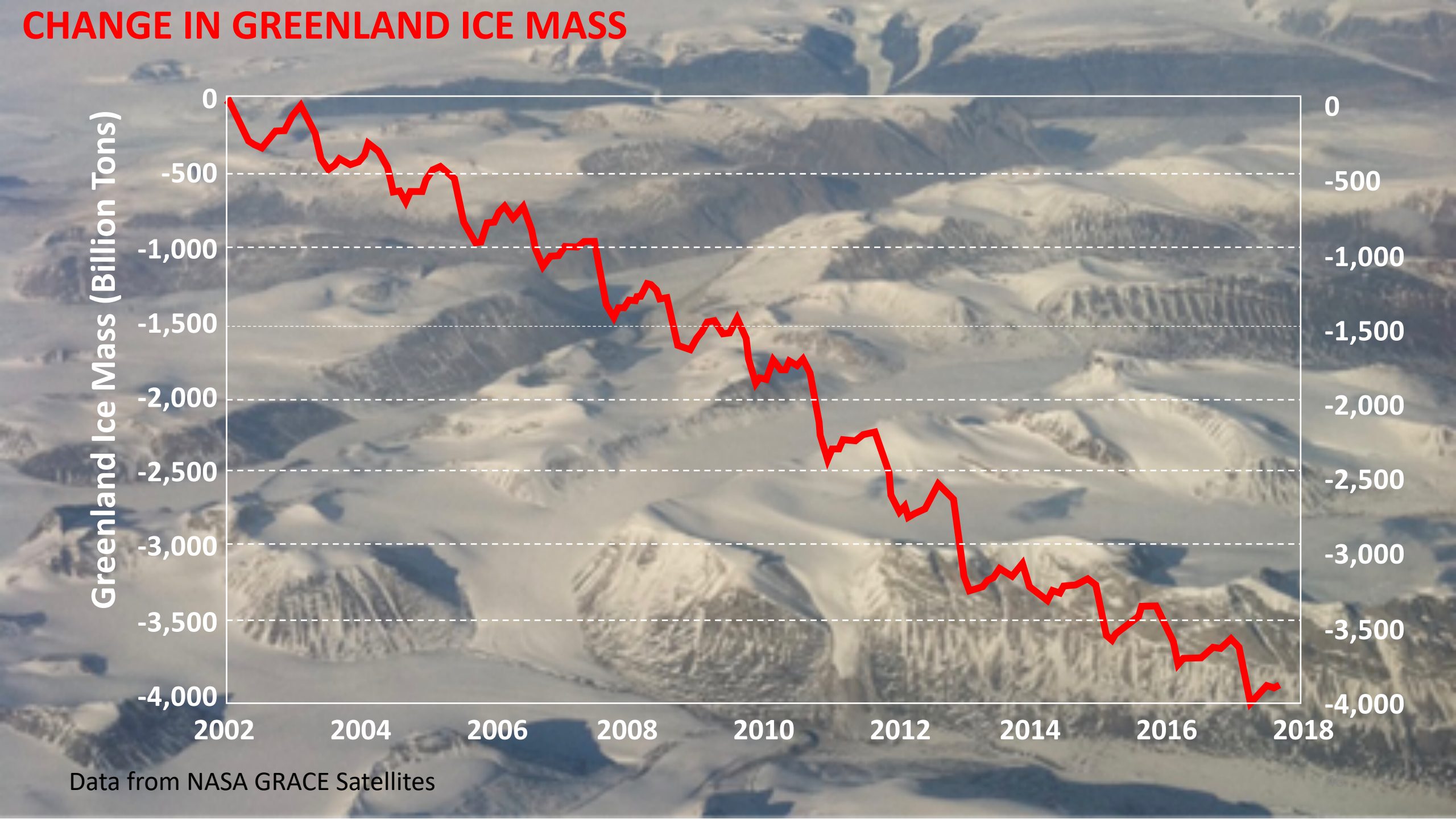
Southern Greenland

Greenland Ice Sheet Melting



With Continued Emissions of Greenhouse Gases

CHANGE IN GREENLAND ICE MASS



Data from NASA GRACE Satellites

MELTING GREENLAND ICE SHEET

Greenland Rivers

- Meltwater creates a 18 meter deep canyon in the polar ice sheet
  - Drains down to base of ice sheet or flows over edge into sea

- Greenland ice loss alone could add **0.3 to 1 meter to global sea level rise by 2100**

Image courtesy of Ian Joughin, University of Washington

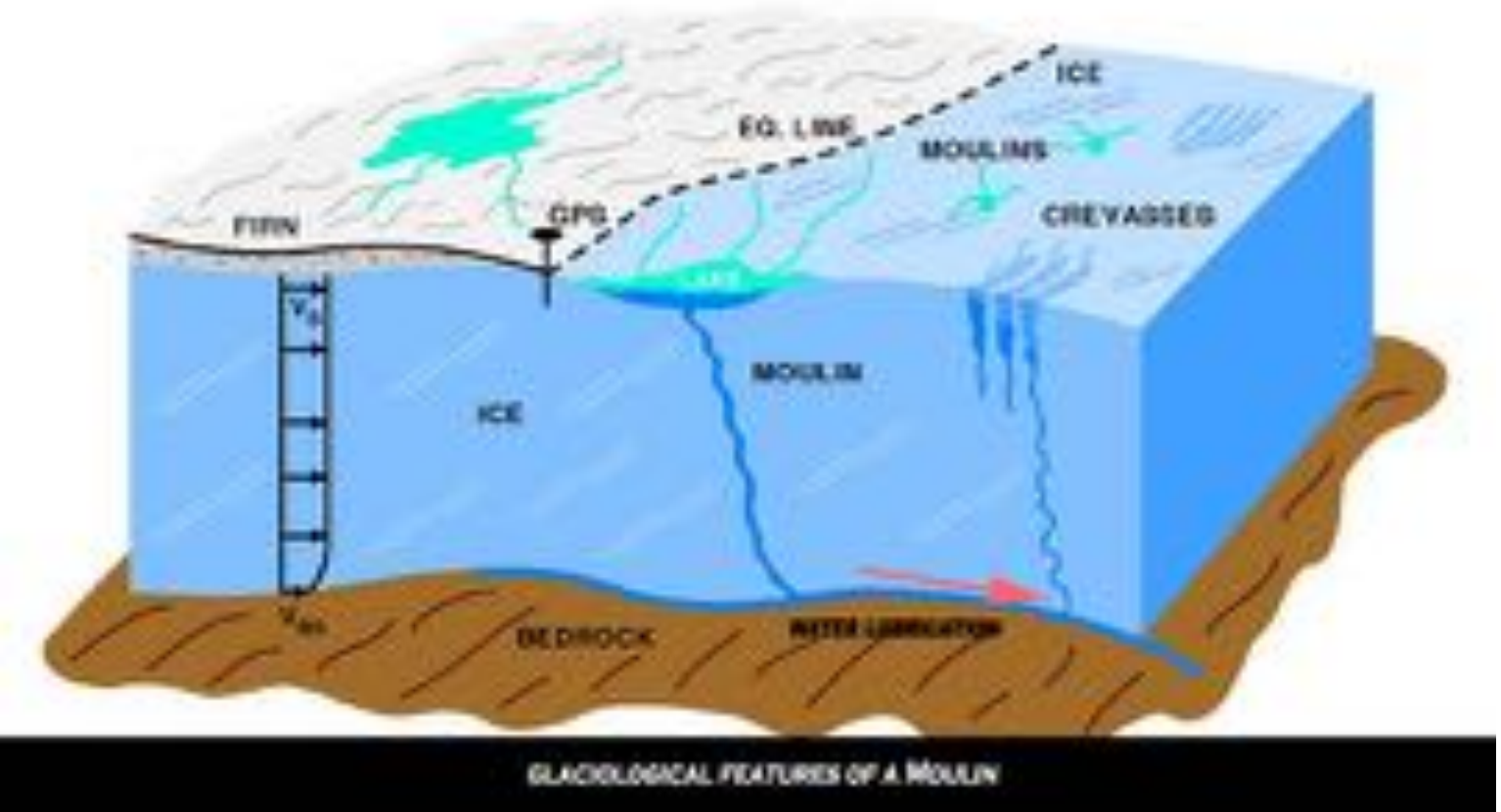
MELTING GREENLAND ICE SHEET

Record 197 billion tons of ice lost to the ocean

July 2019

MELTING GREENLAND ICE SHEET

- Melt water flowing down Moulins from the surface to the base of the ice sheet / glacier
- Up to 100s of meters deep



GLACIOLOGICAL FEATURES OF A MOULIN

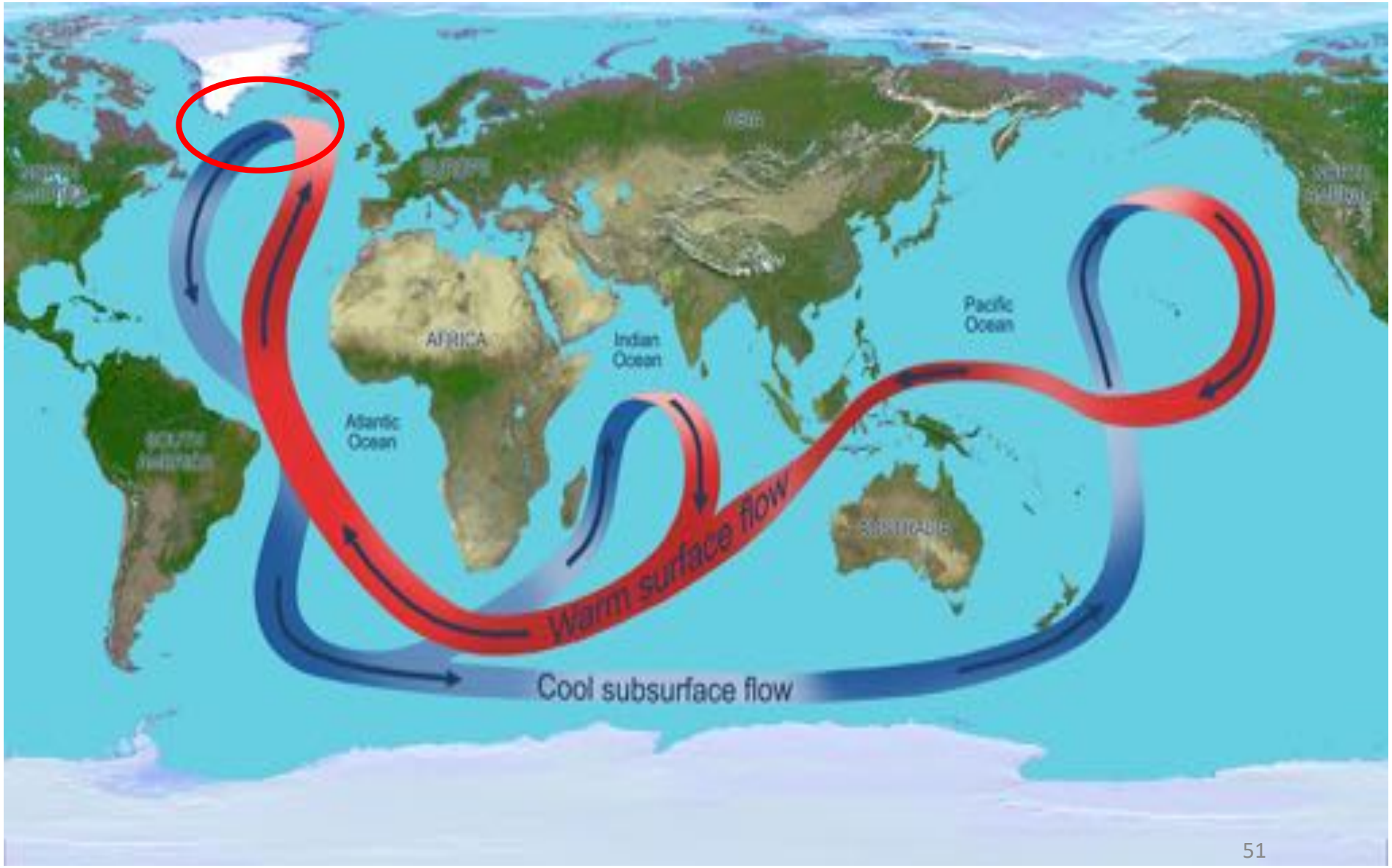
PHOTO COURTESY: ROGER BRAITHWAITE, UNIVERSITY OF MANCHESTER

MELTING WATER FLOWING INTO A HUGE MOULIN IN THE GREENLAND ICE SHEET


Northwest Greenland
June 13, 2019

Slowing Atlantic Meridional Overturning Circulation (AMOC)

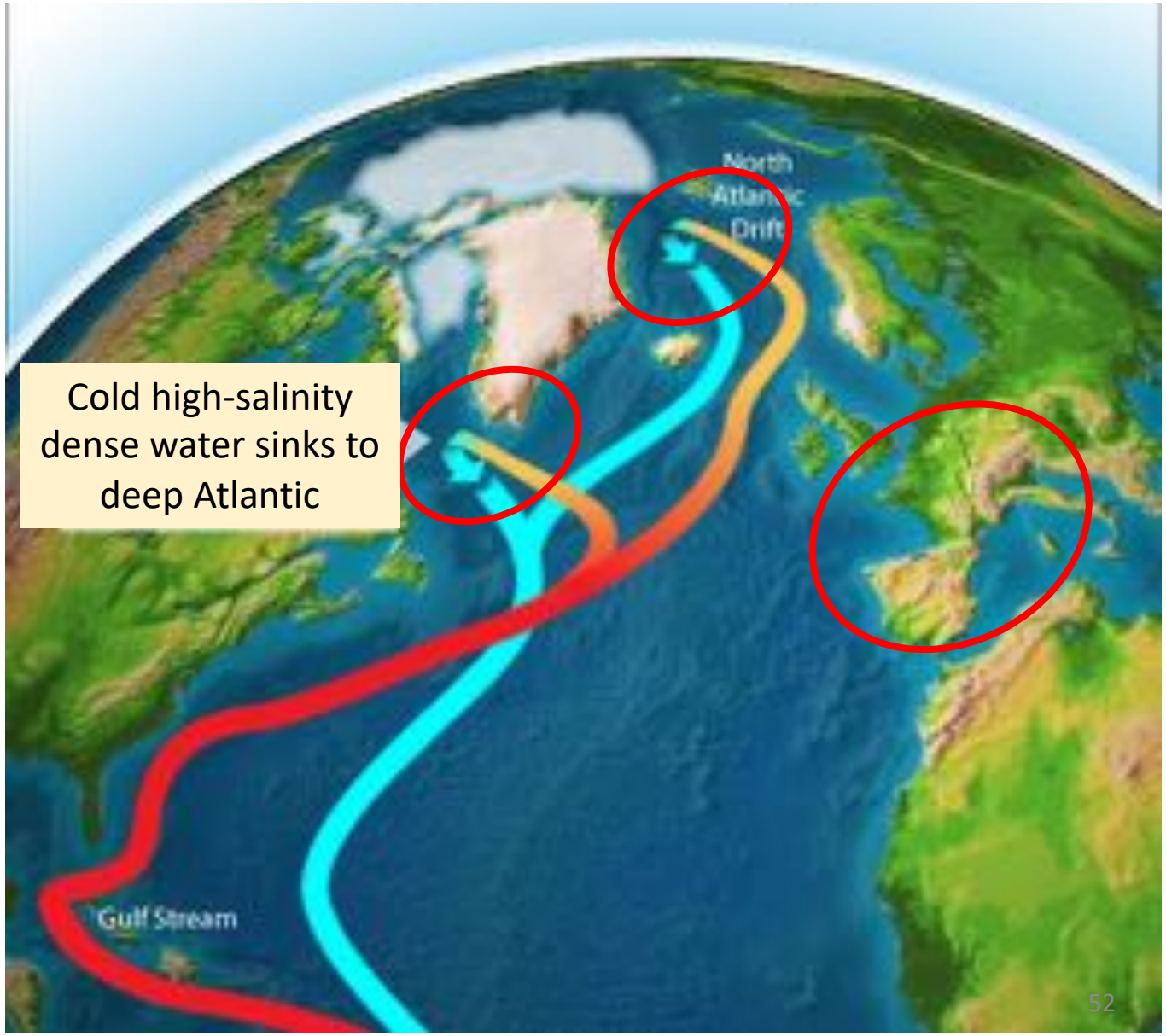
Ocean currents driven by the cooling of the Arctic waters which Sinks in North Atlantic



Slowing Atlantic Meridional Overturning Circulation (AMOC)

The Gulf Stream transports heat from tropics:

- Major contributor to maintaining temperature of US East coast and Europe



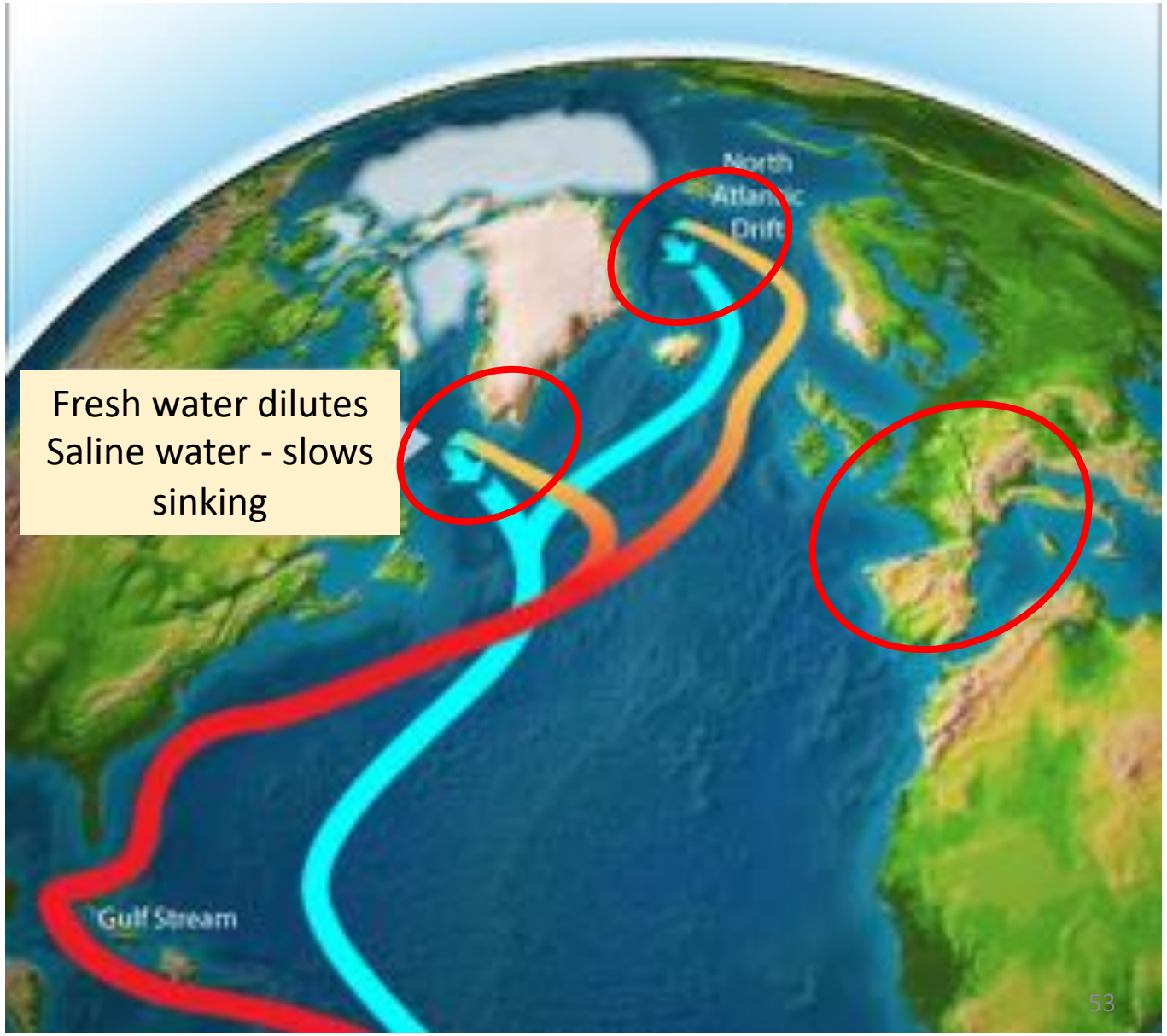
Slowing Atlantic Meridional Overturning Circulation (AMOC)

With Arctic warming and Greenland warming:

Fresh water flowing off Greenland slows sinking :

- Slows global ocean circulation
- Weakest in 1,600 years

Impacts weather in US East coast and Europe.

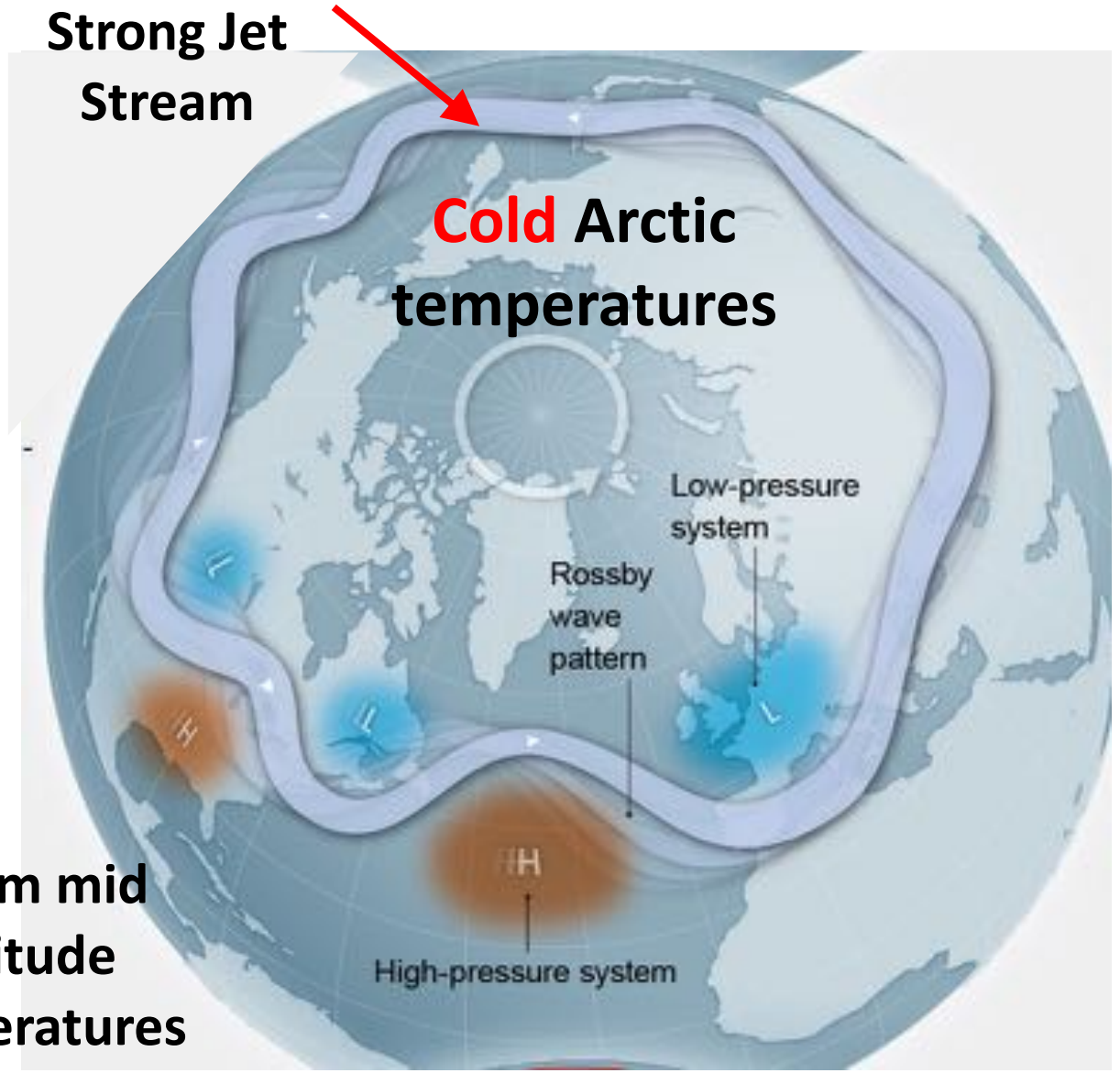


ARCTIC OSCILLATION
- SUMMER POLAR JET STREAM -

Large difference in temperature between mid latitudes and Arctic

Jet stream confines:

- **Arctic air to arctic**
- **Mid latitude air to mid latitude**



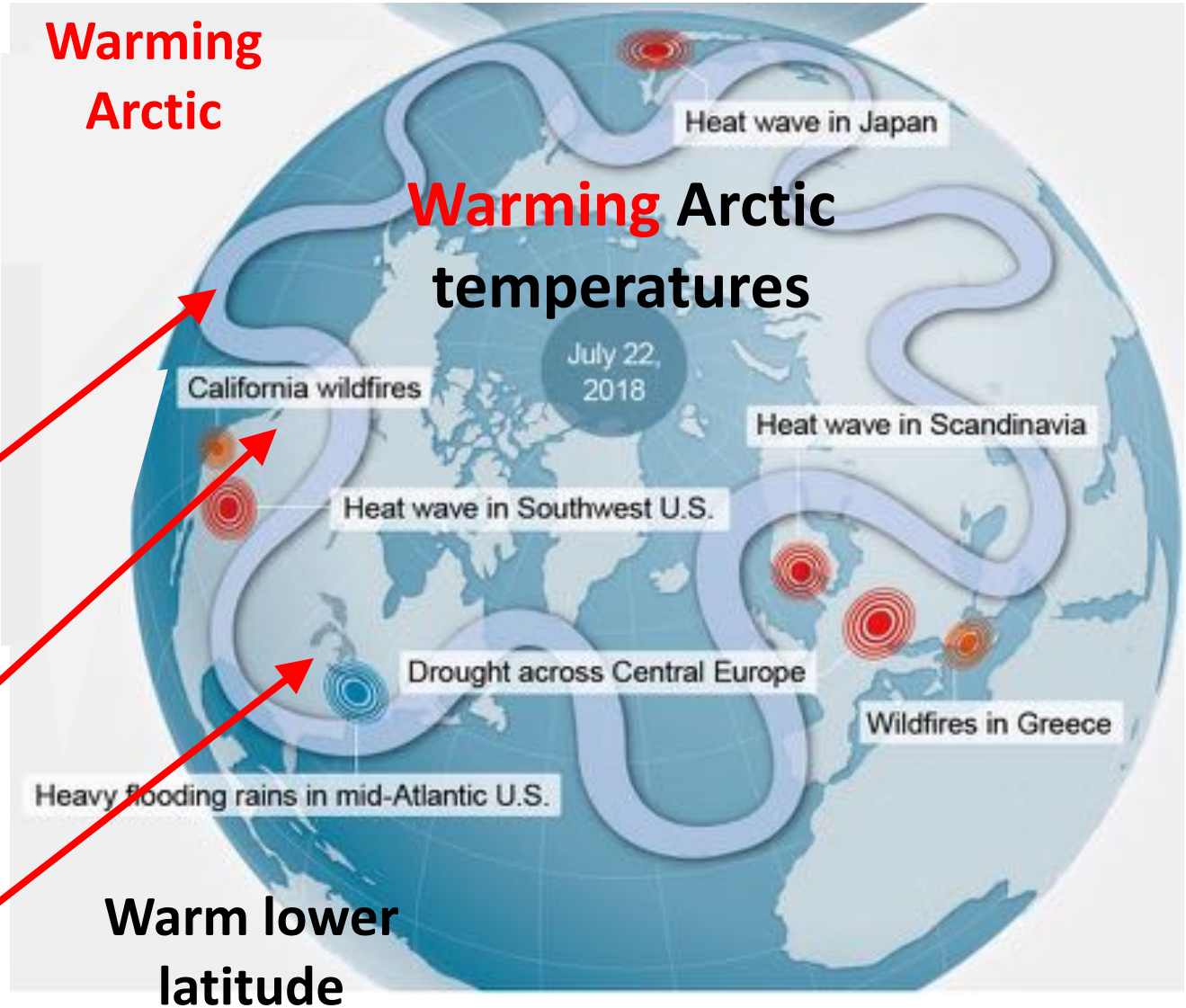
ARCTIC OSCILLATION
- DISRUPTION OF POLAR JET STREAM -

Decrease difference in temperature between mid latitudes and Arctic as the Arctic warms,

The jet stream weakens and becomes loopier

Warm mid latitude air pushes into Arctic

Cold Arctic air pushes into mid latitudes

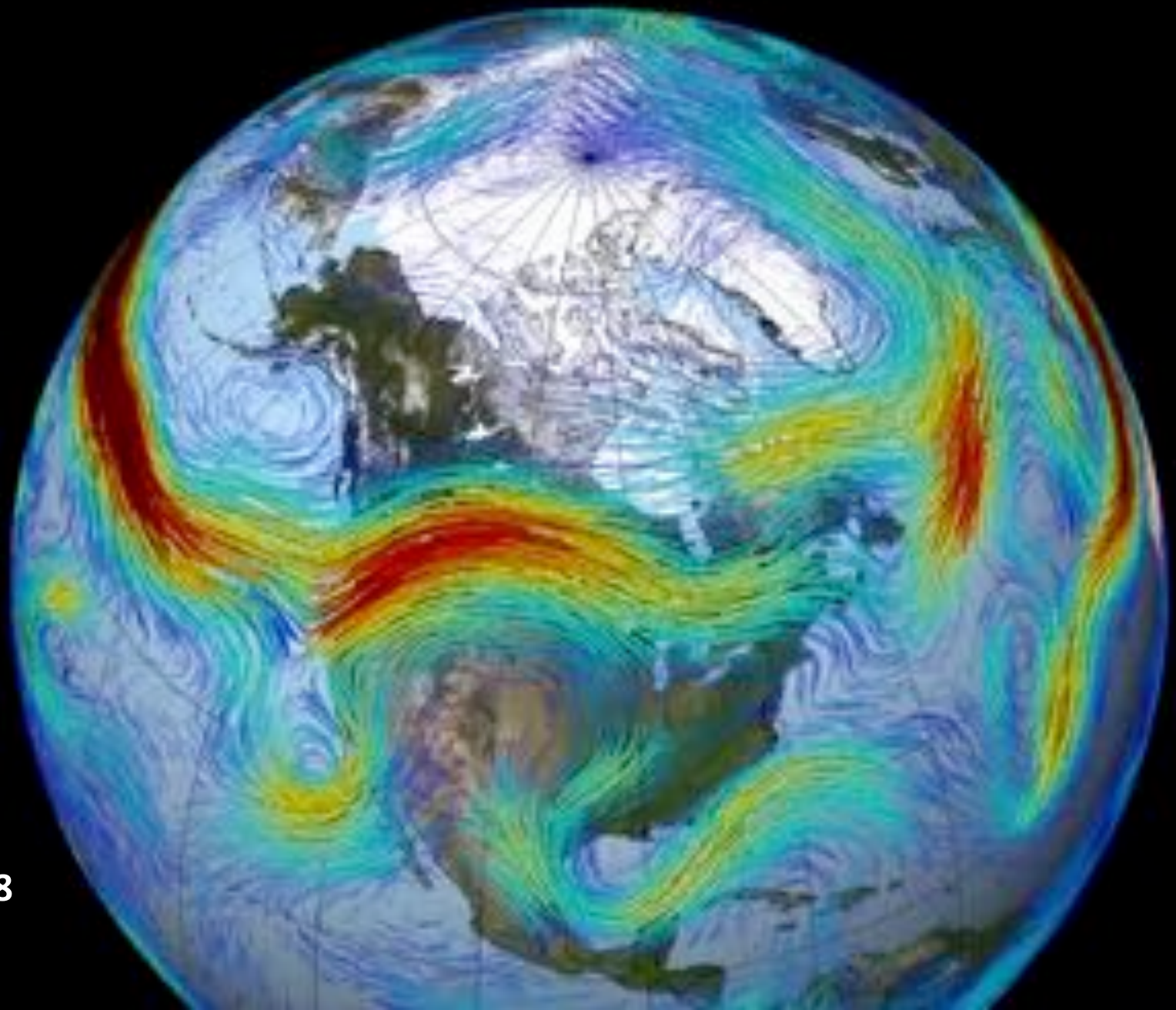


Warm lower latitude temperatures

More severe and unpredictable weather

Disruption becoming prevalent in winter

POLAR JET STREAM



10 June – 8 July 1988


Amplified Global Warming
DISAPPEARING ARCTIC SEA ICE
IMPACTS TO WORLDS PEOPLE, SOCIETY, AND SECURITY
Amplified Sea-Level Rise

AMPLIFIED GLOBAL WARMING

Modification of Storms & Weather Extremes. Changes in:

- Intensity
- Frequency
- Longevity
- Timing
- Geographical Distribution
- Precipitation type (snow, rain, hail)

- Any one of these changes could have an impact on the capability of a nation to feed itself and survive.

- A WATER CRISES FOR 3 BILLION -

10 major river basins fed by Himalayan Glaciers and supplemented by monsoons, snow melt and ground water provide food, water, and energy for
3 billion people in 12 nations: 40% of the world's population.

Global warming augmented by Arctic warming is already causing glacier retreat, reduction of ground water, and changes to the timing and intensity of storms and monsoons:

- 1/3 of glaciers will be melted by 2050 with increased flooding
- 2/3 will be melted by 2100 with increased water shortages
- Weather is becoming unpredictable for food production

China controls the head-waters of 3 major river basis that also serve India, Pakistan, Bangladesh:
sets up a scenario for conflict over water rights.

- Three of these nations have nuclear capability

SEA LEVEL RISE - US

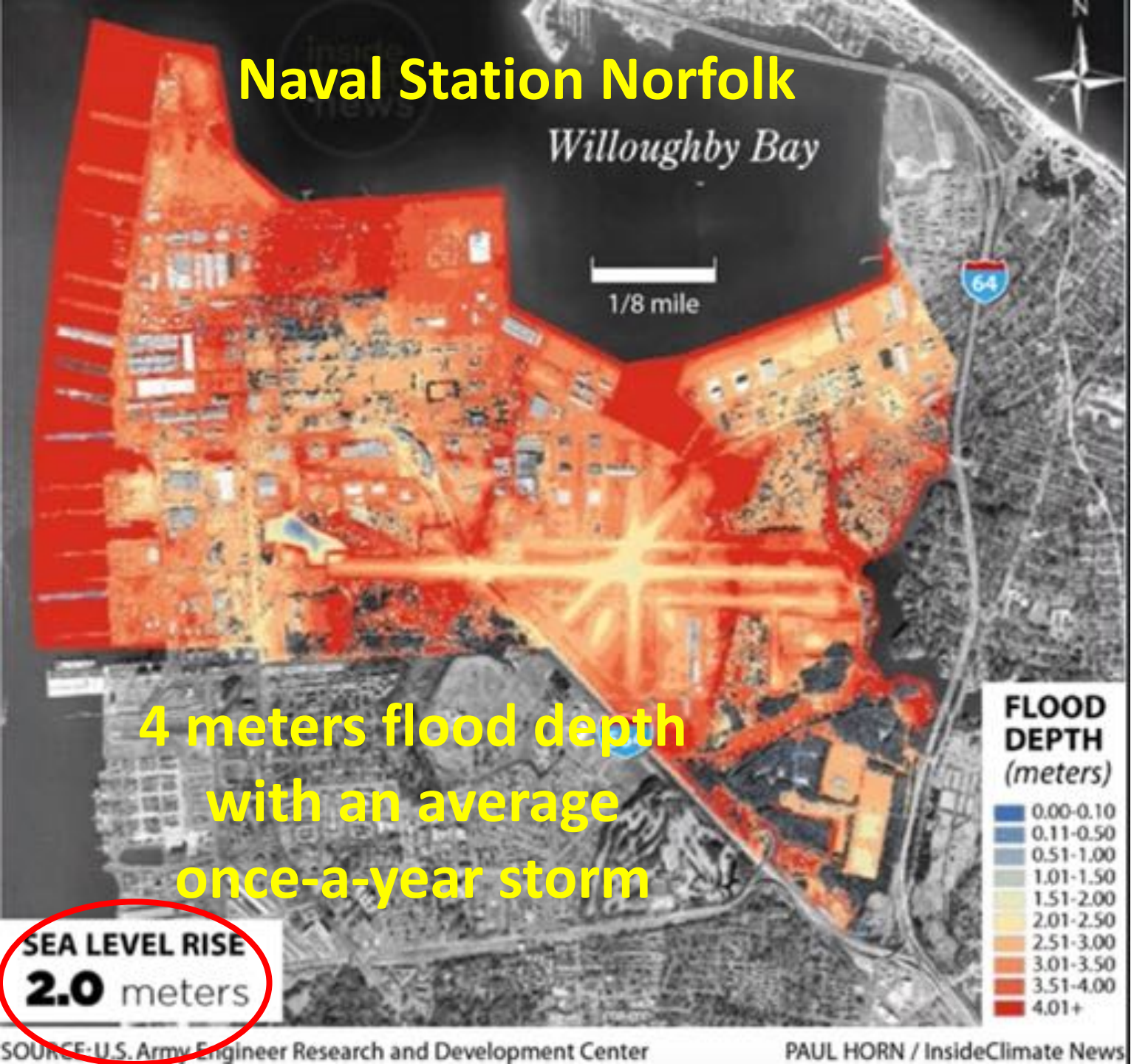
King Tide in South Florida

- 12 million people on coastline live within 9ft of sea level

Miami	New York City
New Orleans	San Diego
San Francisco Bay Area	Other Cities of the Eastern Sea-Board and Gulf States

https://www.wlrn.org/post/what-new-sea-level-rise-projections-mean-florida-keys#stream/0

SEA LEVEL RISE
- US MILITARY BASES -



128 domestic and international US Military Bases are threatened by sea level rise – Naval Station Norfolk included

SEA LEVEL RISE – INTERNATIONAL

- By 2050 - Up to 340 million projected to be below annual flood levels
- By 2100 – It's Over 500 million
- Migration of 100s of millions in-land or to attempt to migrate to neighboring countries.
- Setting for conflict within or between nations

Bangladesh	South East Asia
India	China
Pakistan	African Coastal Nations
Vietnam	Pacific Island Nations

ARCTIC GEOPOLITICS: ADVANTAGES OF OUR ADVERSARIES

Russia and China are extending their influence to control and exploit the Arctic

Russia has the worlds largest icebreaker fleet with 40 including nuclear

China has 2 with plans for a nuclear

US has 2

GLOBAL INFRASTRUCTURE AT RISK

- Fresh Water Supply
- Agriculture
- Energy
- Spread of Tropical Vector Borne Diseases
- Transportation
- Ecosystem

IMPACTS TO WORLDS PEOPLE, SOCIETY, AND SECURITY

THE COST OF DOING NOTHING

- From 2016 through 2018 climate-related disasters cost the world $650 billion
- By 2100 the global cost could be in the 100's of Trillions
- **It is economically beneficial to rectify the problem than simply suffer the fate of man-made climate change.**

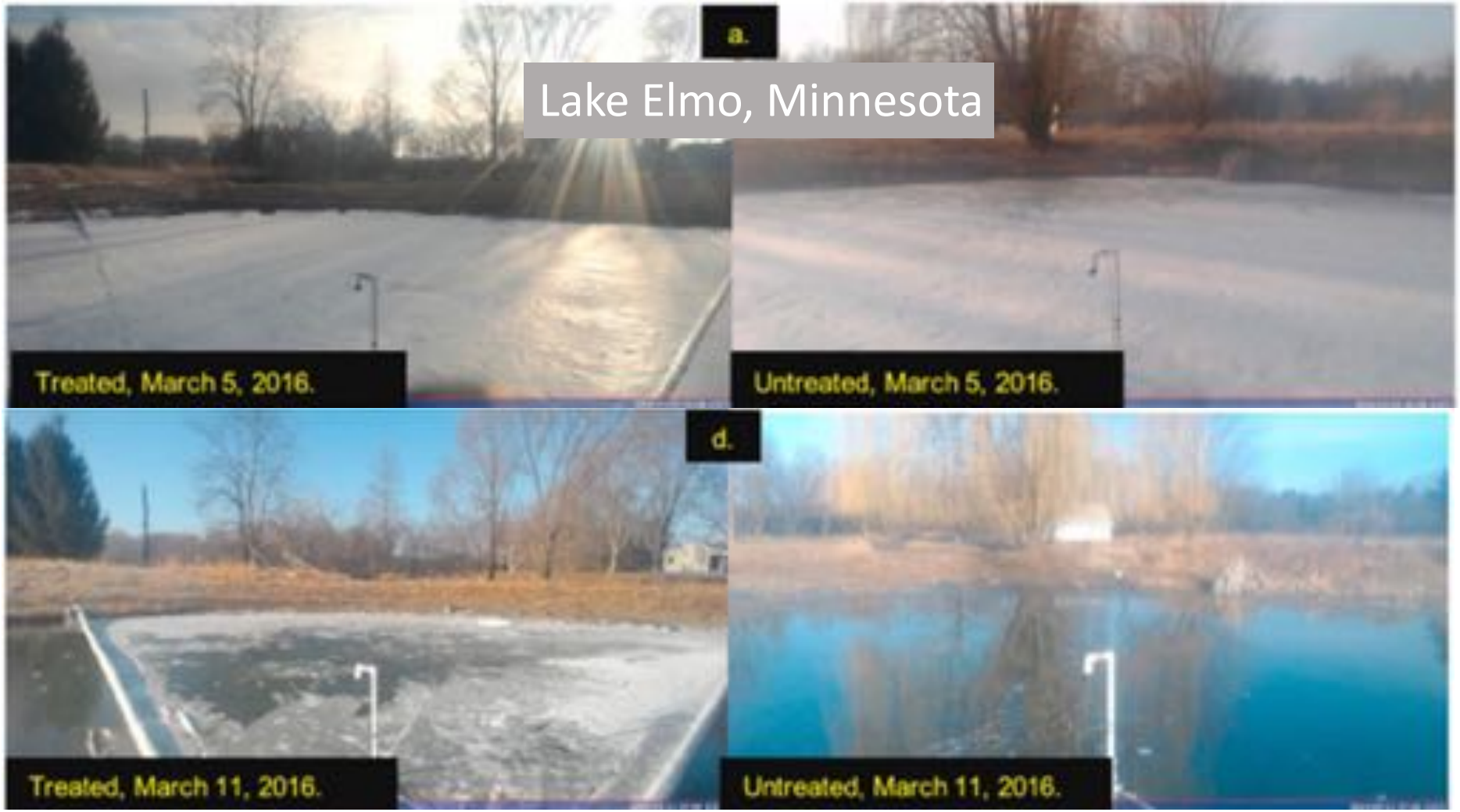
We Need To ASK…

The government of the United States to implement a comprehensive, broad, international program of STRATEGIC RESEARCH & DEVELOPMENT, the *National Arctic Ice Restoration Initiative (NAIRI)* with the objective of RESTORING THE ARCTIC SEA ICE

National Arctic Ice Restoration Initiative (NAIRI)
- A Strategic International R & D Program -

Potential Restoration Methods

- Small Spheres (microspheres) spread on the ice to increase reflectivity (albedo)
- Flooding ice with cold sea water to Thicken the sea ice
- Just a Start – Others to be ID with Proposals



Microspheres Spread on Ice - ice911.org -

Test done at Lake Elmo, MN

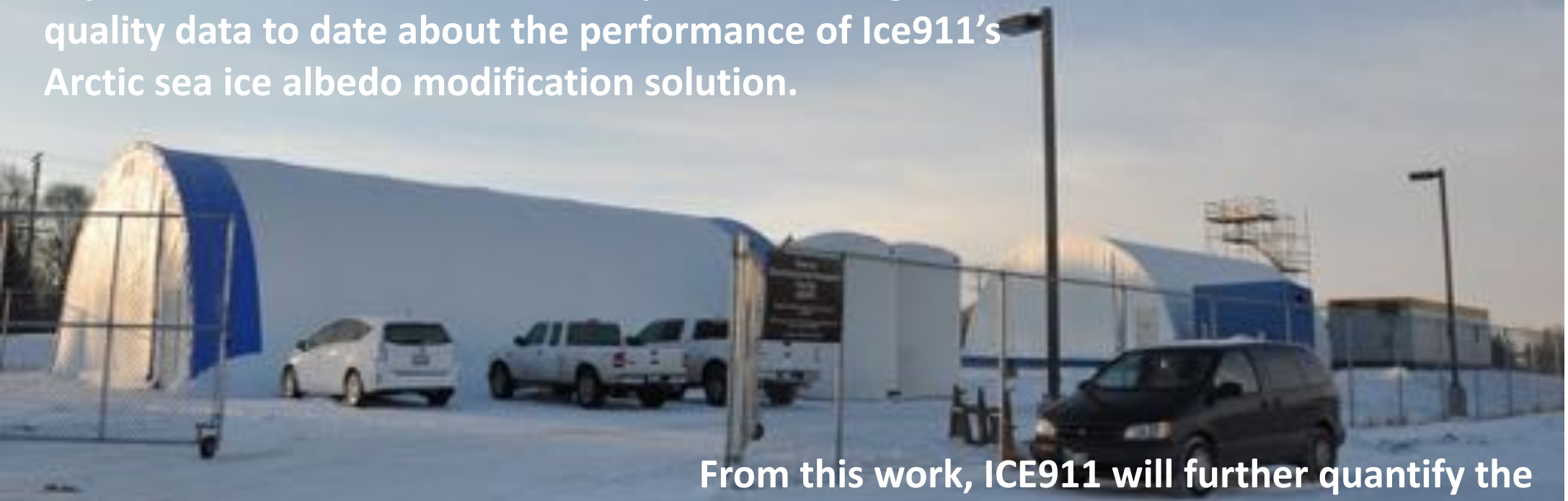
Toxicology studies show that there are no effects on several species of ocean fish.

From publication at ice911.org, *Increasing Arctic Sea Ice Albedo Using Localized Reversible Geoengineering.* AGU100

Microspheres Spread on Ice - ice911 -

On Jan 31, 2020 Ice911 Research announced that they will begin testing on sea ice in February utilizing the University of Manitoba's Sea-ice Environmental Research Facility (SERF) in Winnipeg, Canada.

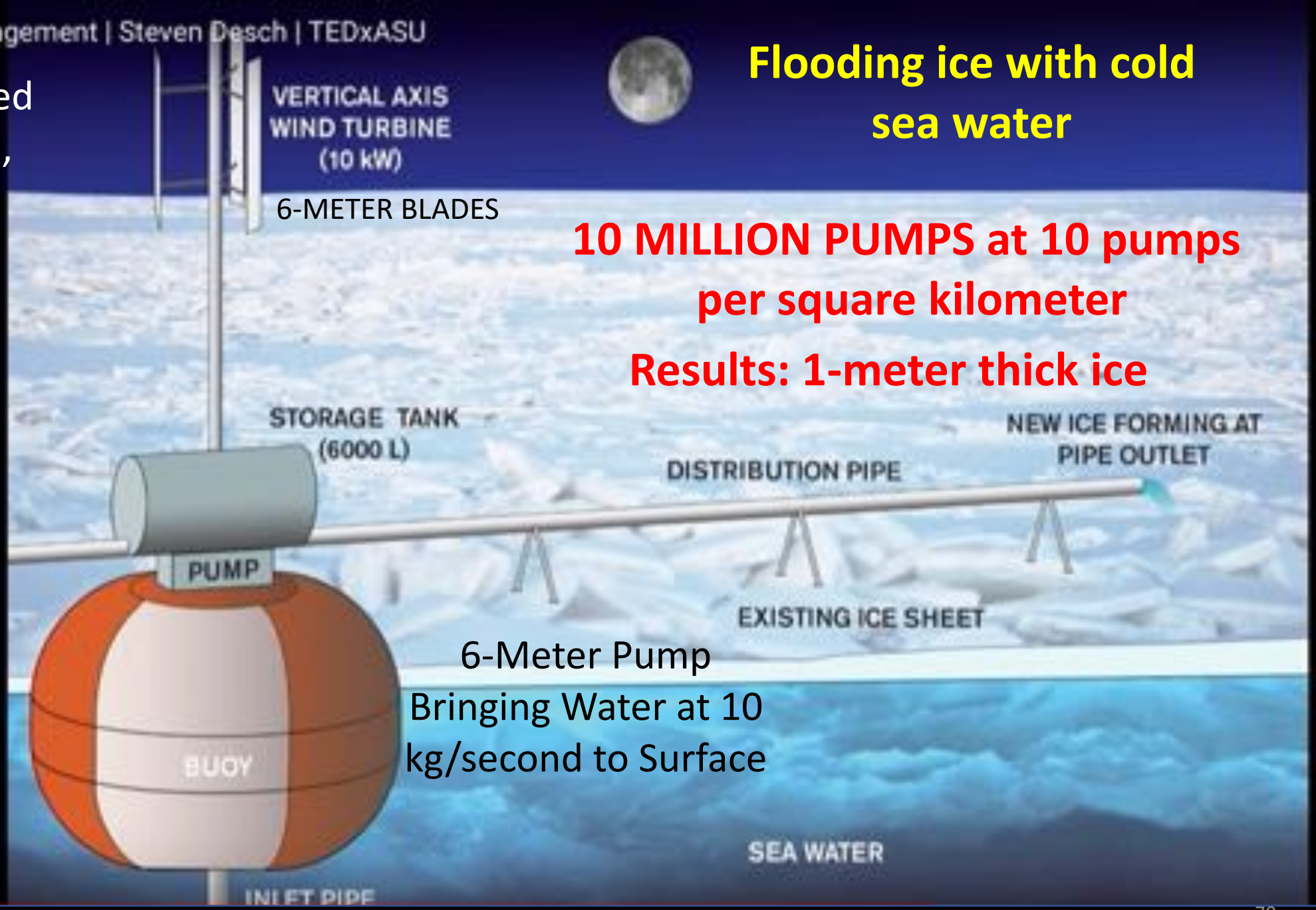
Under rigorously controlled conditions in a contained experimental site, these tests will provide the highest quality data to date about the performance of Ice911's Arctic sea ice albedo modification solution.

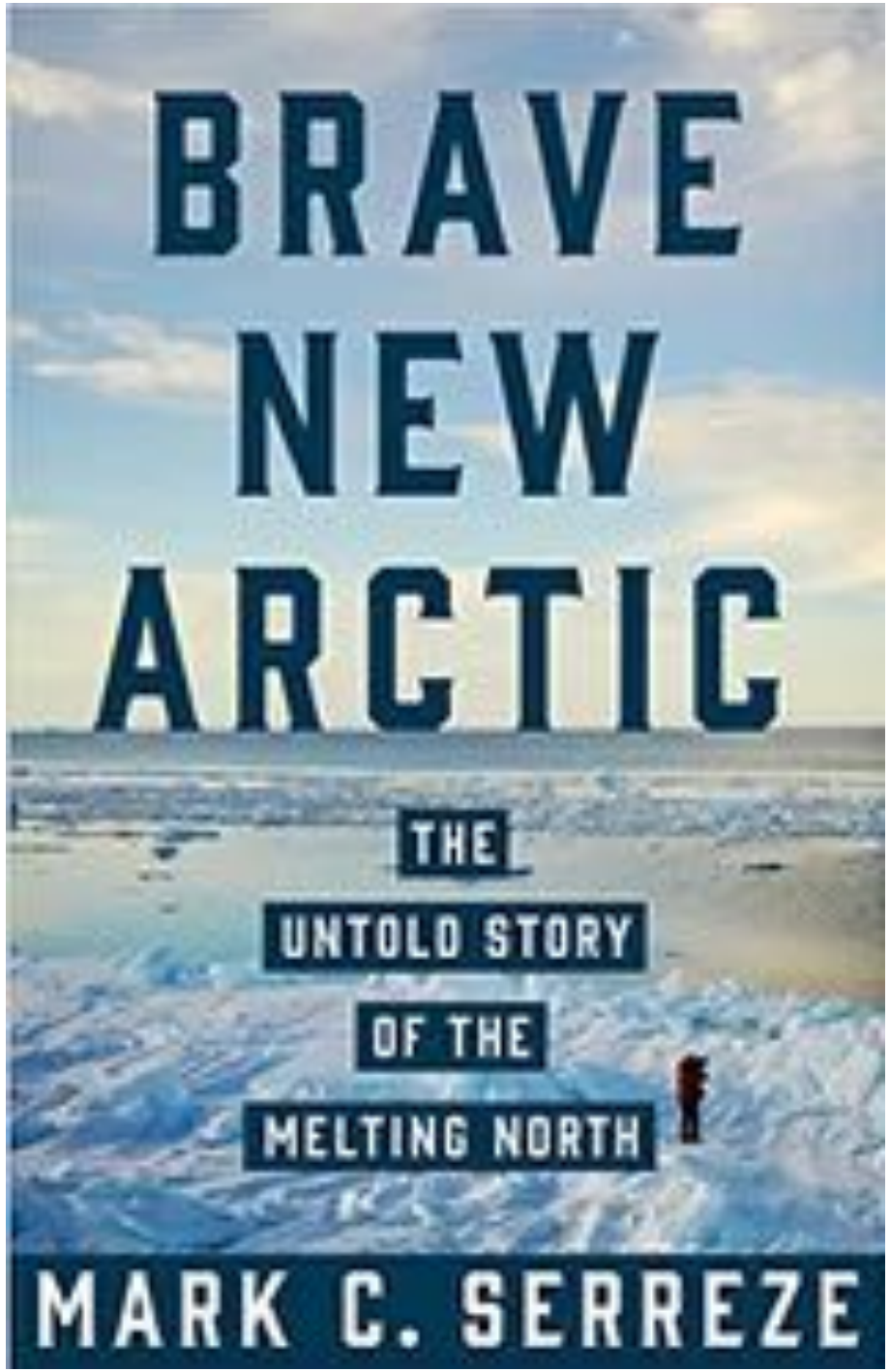


The Sea-ice Environmental Research Facility (SERF) in Winnipeg, Canada. Photo credit: Dr. Fei Wang.

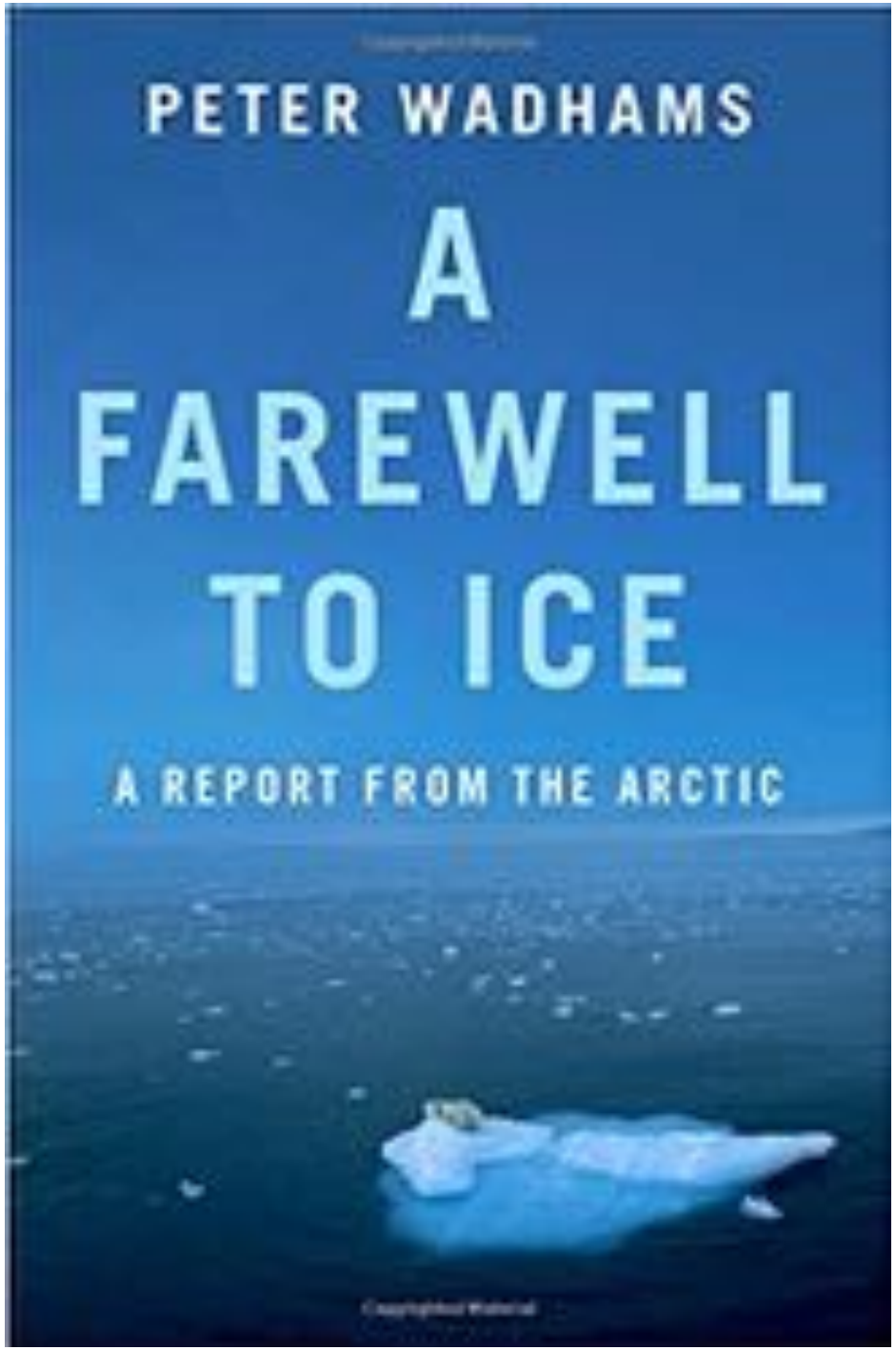
From this work, ICE911 will further quantify the albedo-enhancing effect of its approach under various conditions, and its effect on ice preservation.

Method proposed by Steve Desch, Arizona State University





Suggested Readings……



We Need To ASK…

The government of the United States to implement a comprehensive, broad, international program of STRATEGIC RESEARCH & DEVELOPMENT, the *National Arctic Ice Restoration Initiative (NAIRI)* with the objective of RESTORING THE ARCTIC SEA ICE

HOW CAN YOU HELP?
Sign Our Petition To Ask

The government of the United States to implement a comprehensive, broad, international program of STRATEGIC RESEARCH & DEVELOPMENT, the *National Arctic Ice Restoration Initiative (NAIRI)* with the objective of RESTORING THE ARCTIC SEA ICE

Securethefuture2100.org

A group of dedicated and passionate Scientists and Engineers with ranging fields of expertise with the objective of providing elected officials and their staffs with unbiased judgements on issues related to Climate Change.

Stanley Farkas, Ph.D., Gary Latshaw, Ph.D., Philip Russell, Ph.D., Anthony Strawa, Ph.D., Steve Zornetzer, Ph.D.

Climate Crises and Restoration of the Arctic Ice

Questions?

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