The Causes and Consequences of a Rapidly Changing Arctic

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NASA Langley Research Center
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Beaufort Se
Chukchi Sea
Shishmaref
Anchorage
Bering Sea
Bering Strait
Shishmaref
Source: cnn.com

What is the National Climate Assessment? What is the Climate Science Special Report?

- As part of its mandate, USGCRP is charged with leading a quadrennial assessment of U.S. climate: The National Climate Assessment.
- In an effort to provide a sustained assessment, the 4th National Climate Assessment will be released in two volumes.
- The CSSR is an authoritative assessment of the science of climate change in the U.S.

CSSR Stats:

63 Key Findings
3 Coordinating Lead Authors
32 Lead Authors
19 Contributing Authors

470 pages
6 Reviews
3 Review Editors
2 Leaked copies

Arctic Changes and their Effect on Alaska and the Rest of the United States

The Climate Science Special Report
U.S. Global Change Research Program

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Contributing author: J. Walsh (Univ. of Alaska)

https://science2017.globalchange.gov

Source: NASA IceBridge

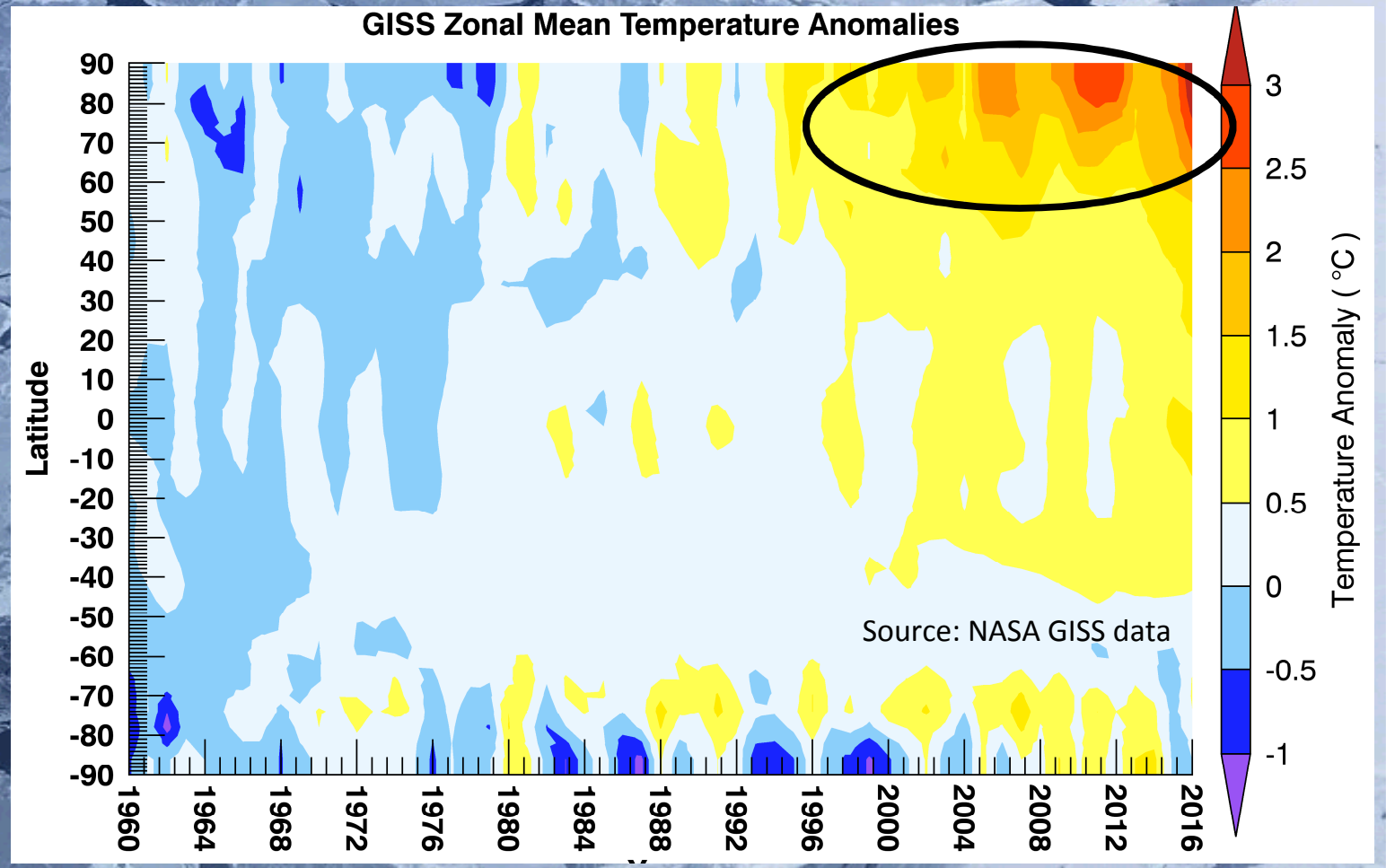
CSSR, Ch. 11 Key Finding 1:
Annual average near-surface air temperatures across Alaska and the Arctic have increased over the last 50 years at a rate more than twice as fast as the global average temperature (*very high confidence*).

Late summer and fall temperatures have changed more dramatically.

Since 1979, Utqiagvik (formally Barrow) Alaska has warmed by

- 3.8ºC in September,
- 6.6ºC in October, and
- 5.5ºC in November,

(greater than 1ºC per decade.)



CSSR, Ch. 11, Key Finding 2: Rising Alaskan permafrost temperatures are causing permafrost to thaw and become more discontinuous; this process releases additional carbon dioxide and methane, resulting in an amplifying feedback and additional warming (*high confidence*). The overall magnitude of the permafrost–carbon feedback is uncertain; however, it is clear that these emissions have the potential to compromise the ability to limit global temperature increases.

Trends in permafrost temperatures range from 0.2 to 0.7ºC per decade.

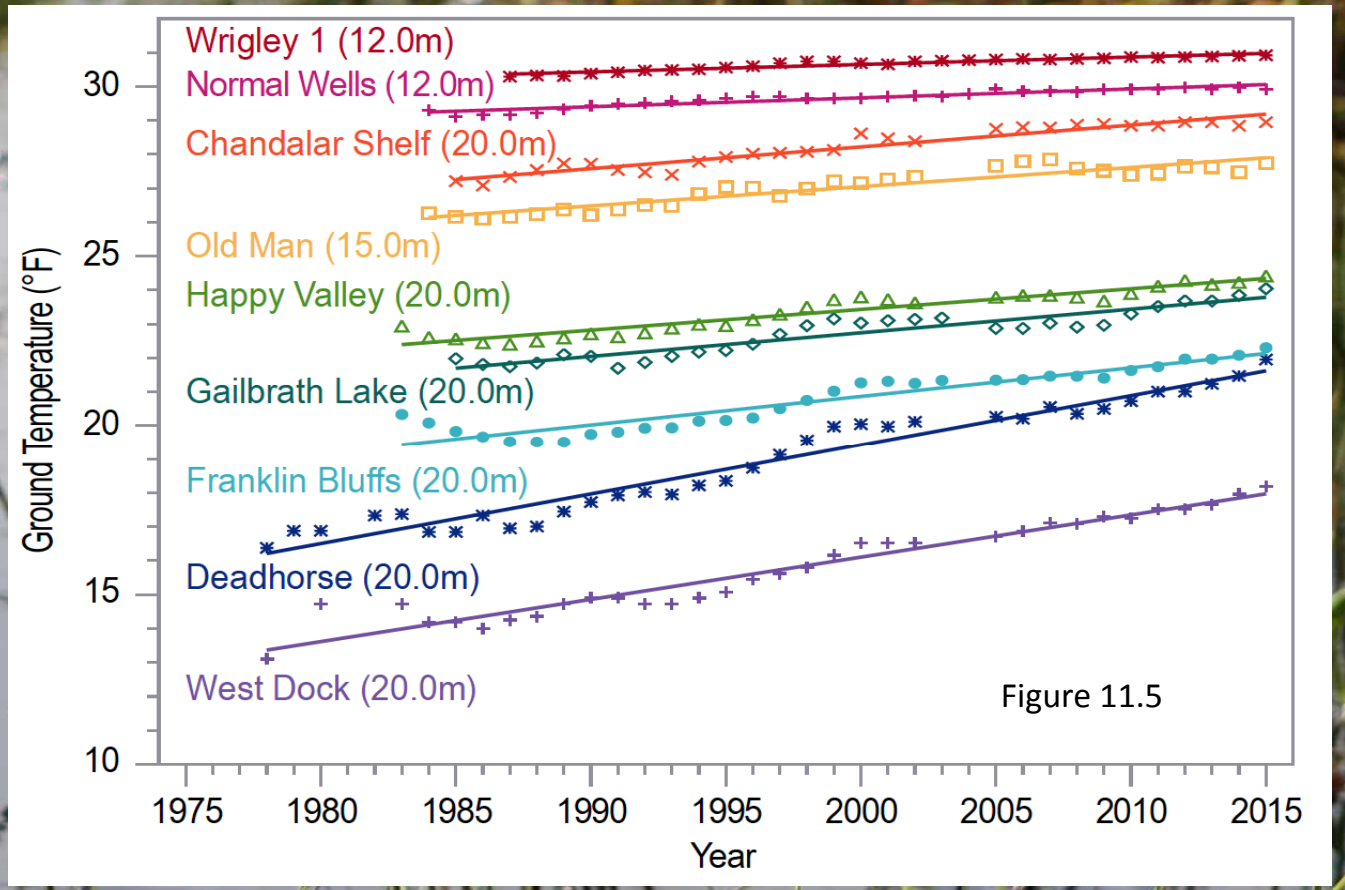
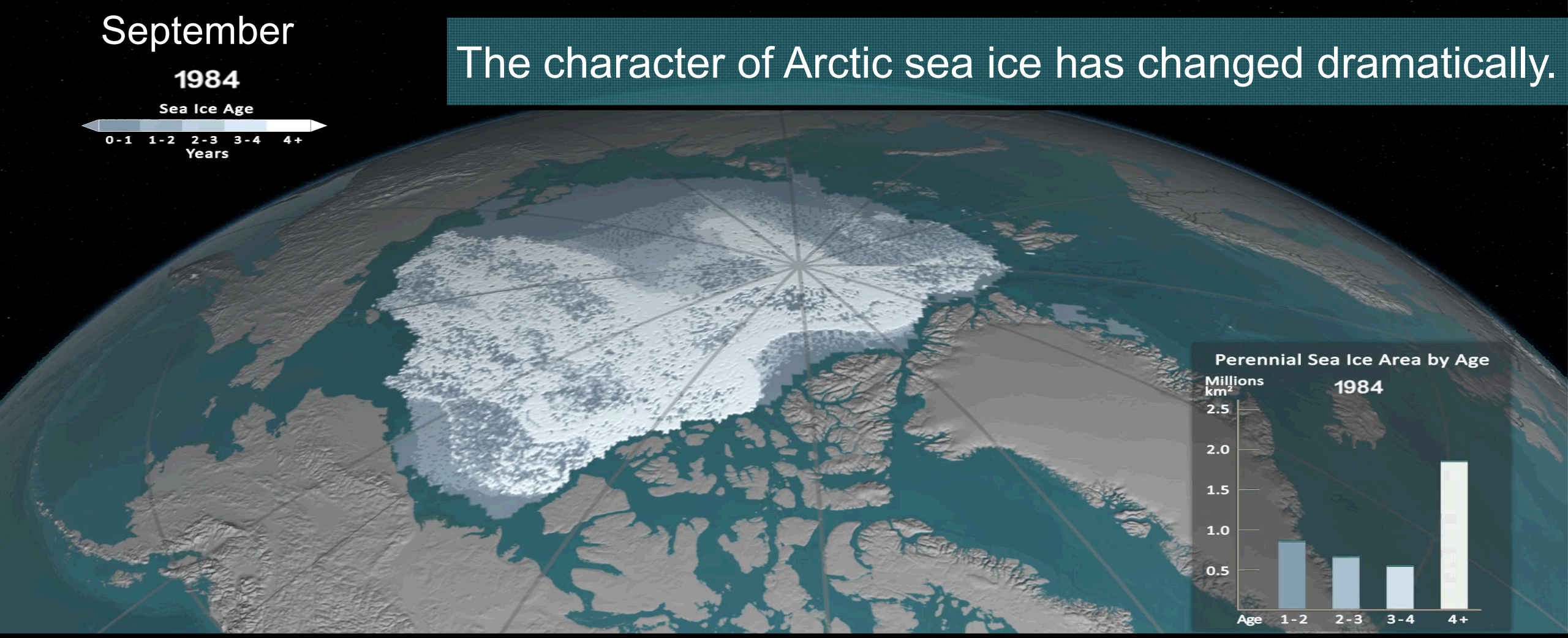


Figure 11.5

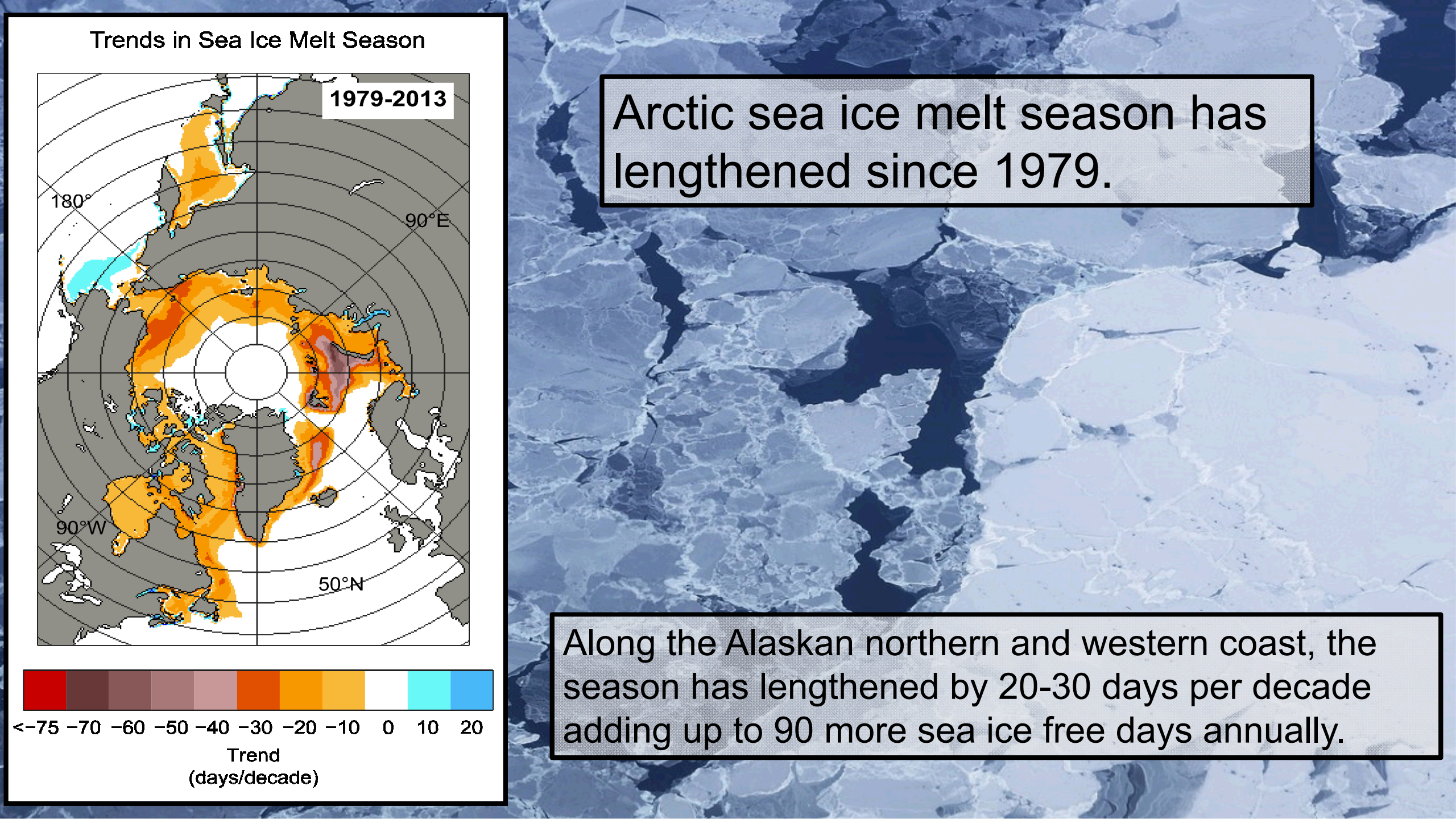
Methane Bubbles

Source: NASA ABoVE

The character of Arctic sea ice has changed dramatically.

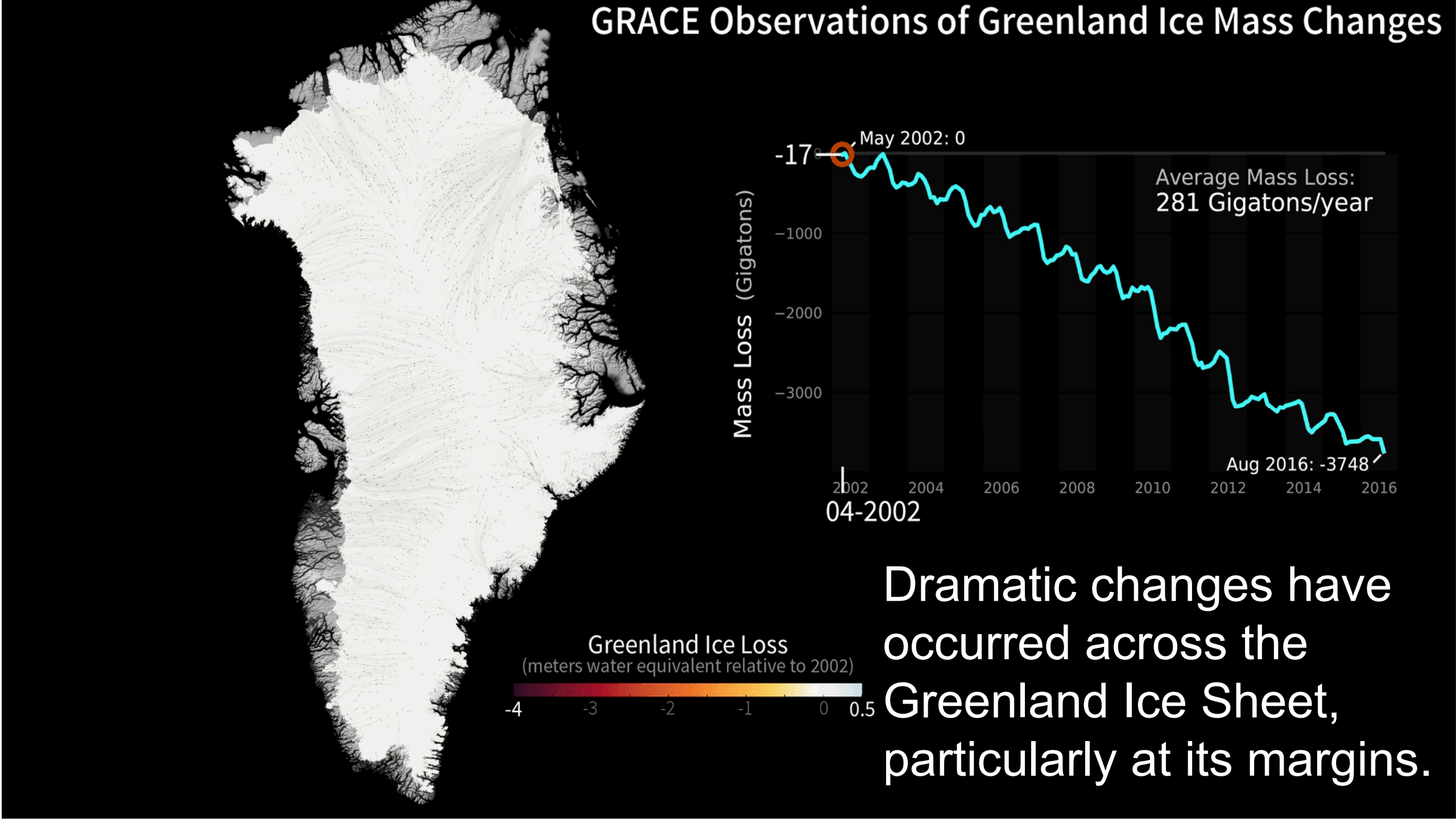


CSSR, Ch. 11 Key Finding 3:
Arctic land and sea ice loss observed in the last three decades continues, in some cases accelerating (*very high confidence*)….Arctic-wide ice loss is expected to continue through the 21st century, very likely resulting in nearly sea ice-free late summers by the 2040s (very high confidence).



Arctic sea ice melt season has lengthened since 1979.

Along the Alaskan northern and western coast, the season has lengthened by 20-30 days per decade adding up to 90 more sea ice free days annually.


GRACE Observations of Greenland Ice Mass Changes
May 2002: 0
-17
Average Mass Loss:
281 Gigatons/year
Mass Loss (Gigatons)
−1000
−2000
−3000
Aug 2016: -3748
2002
2004
2006
2008
2010
2012
2014
2016
04-2002
Greenland Ice Loss
(meters water equivalent relative to 2002)
-4
-3
-2
-1
0
0.5
Dramatic changes have occurred across the Greenland Ice Sheet, particularly at its margins.

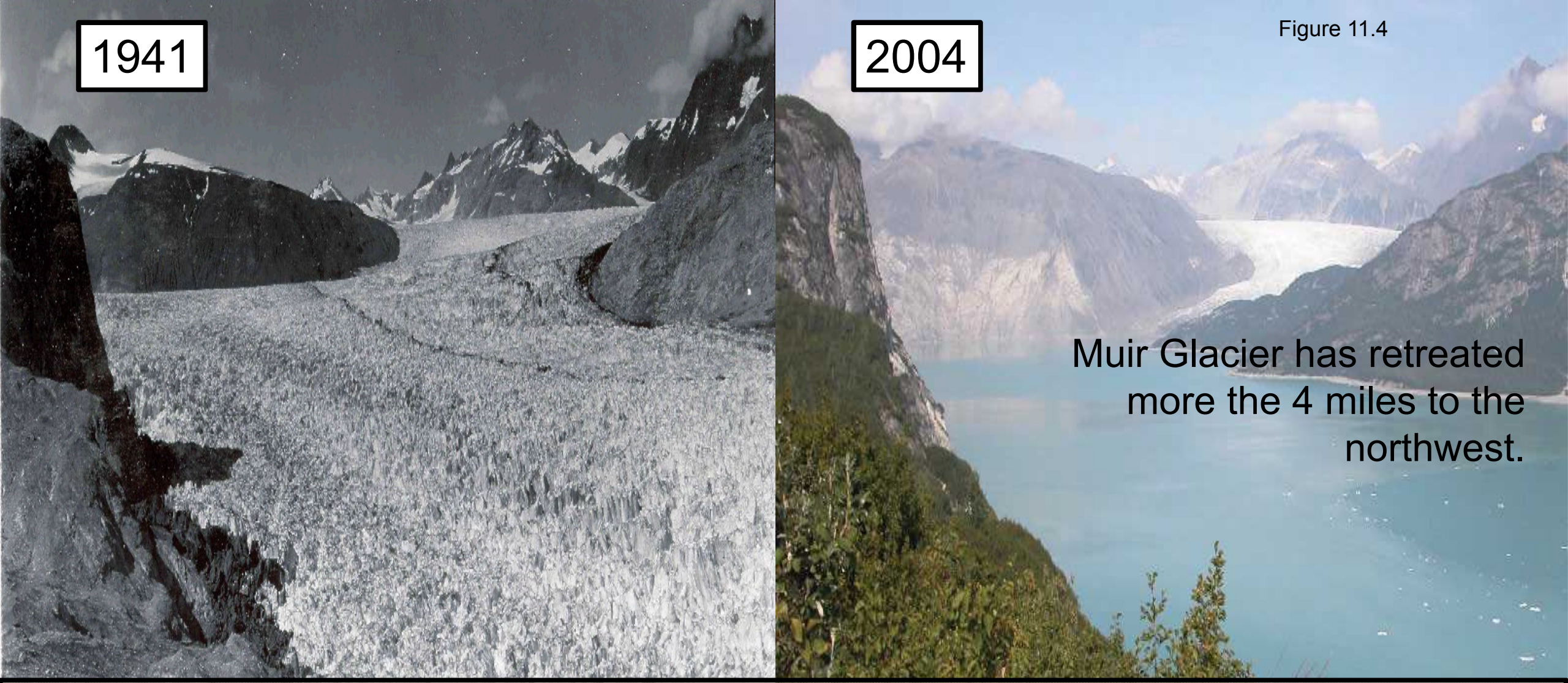
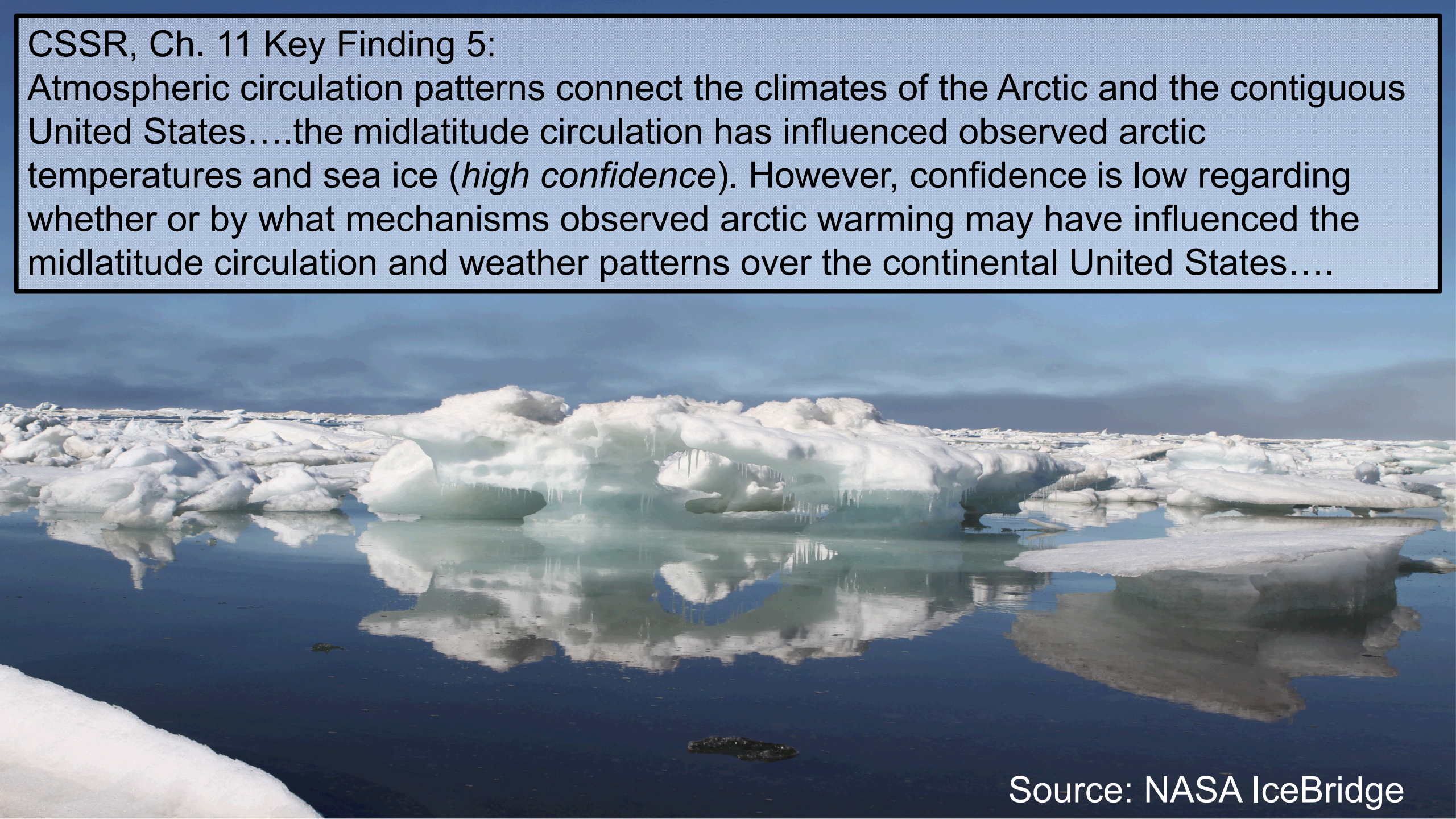


Figure 11.4

CSSR, Ch. 11 Key Finding 4:
It is very likely that human activities have contributed to observed arctic surface temperature warming, sea ice loss, glacier mass loss, and Northern Hemisphere snow extent decline (*high confidence*).

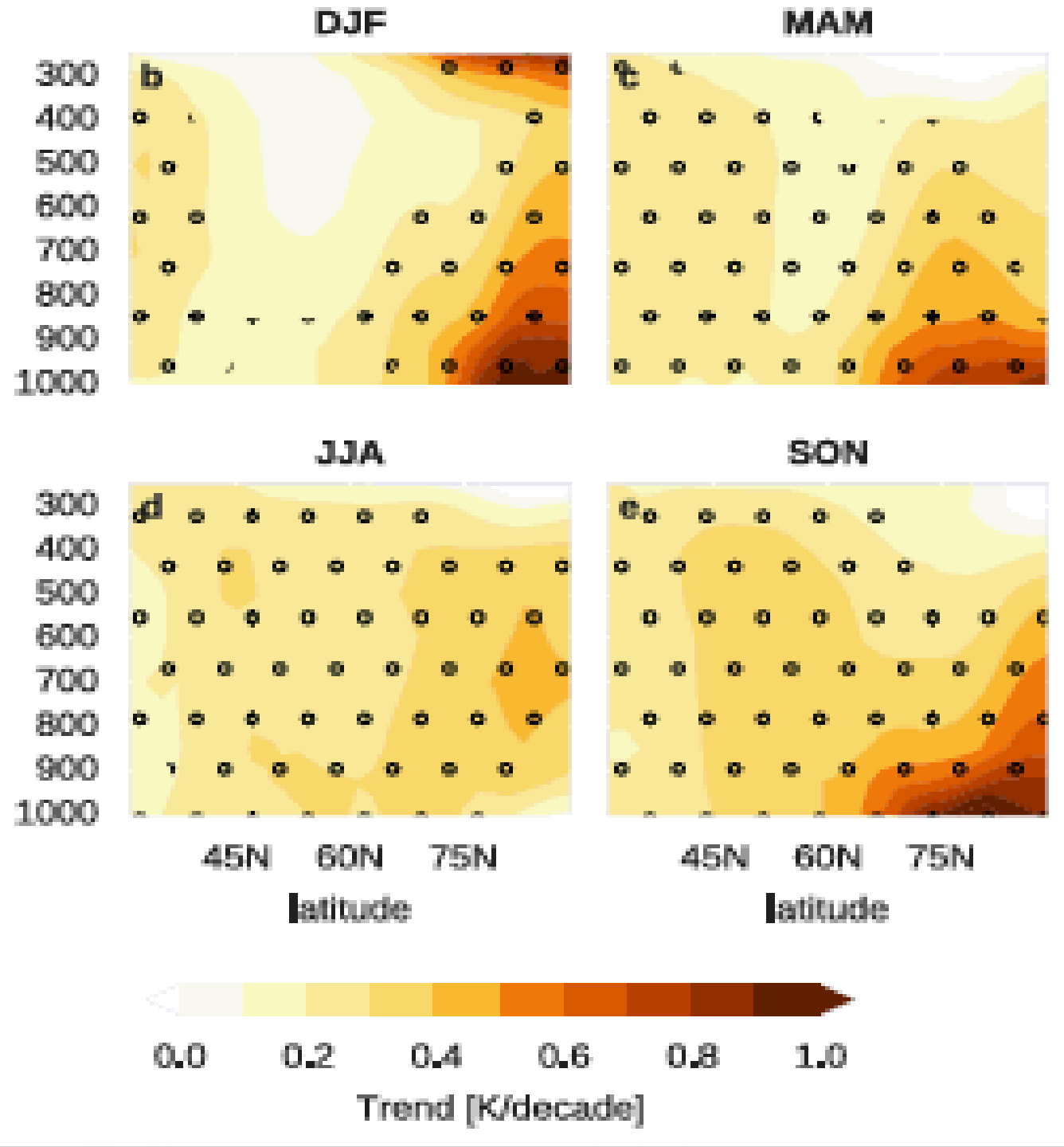
CSSR, Ch. 11 Key Finding 5:
Atmospheric circulation patterns connect the climates of the Arctic and the contiguous United States….the midlatitude circulation has influenced observed arctic temperatures and sea ice (*high confidence*). However, confidence is low regarding whether or by what mechanisms observed arctic warming may have influenced the midlatitude circulation and weather patterns over the continental United States….



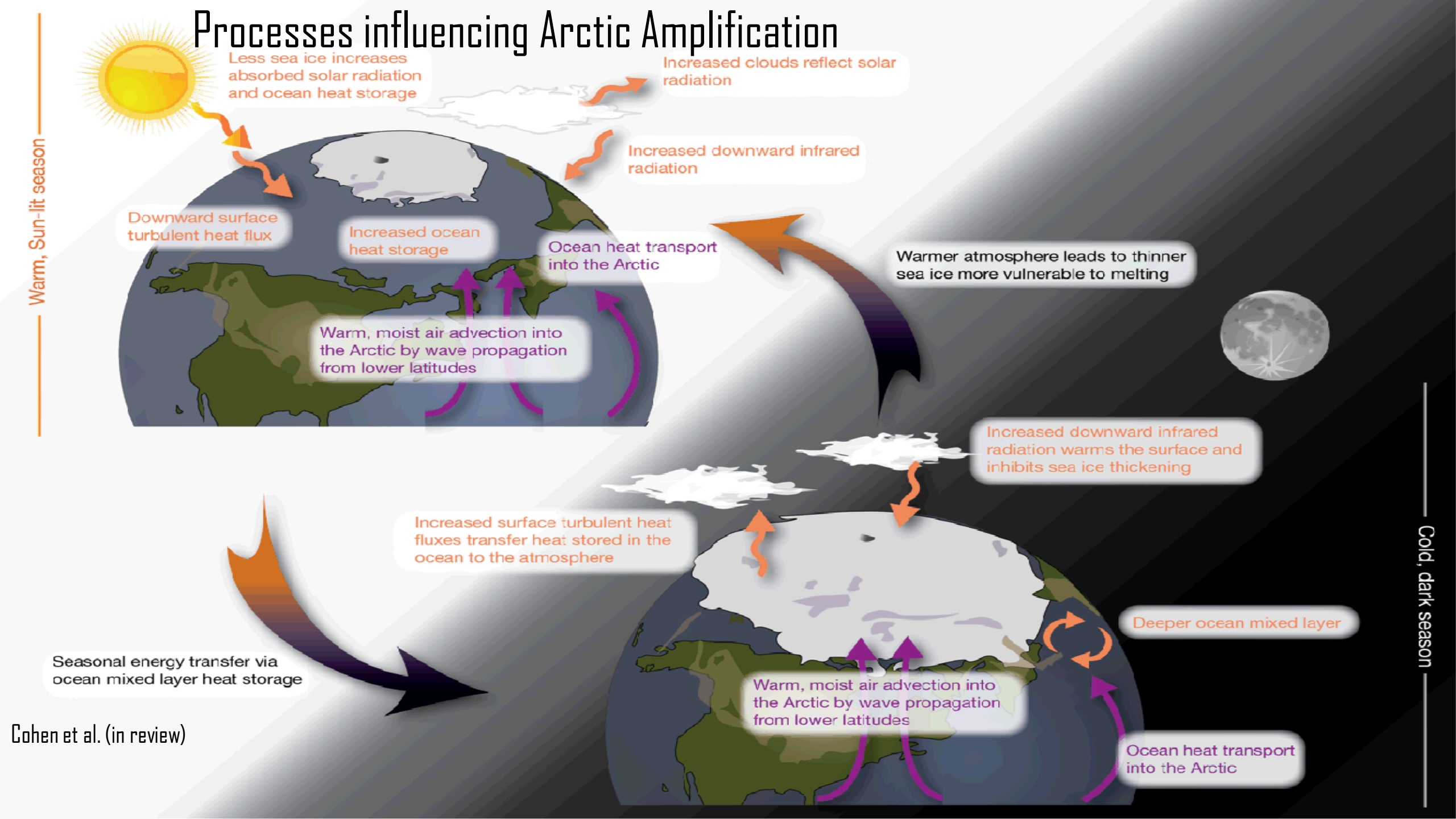
Source: NASA IceBridge

Nature of Arctic Amplification

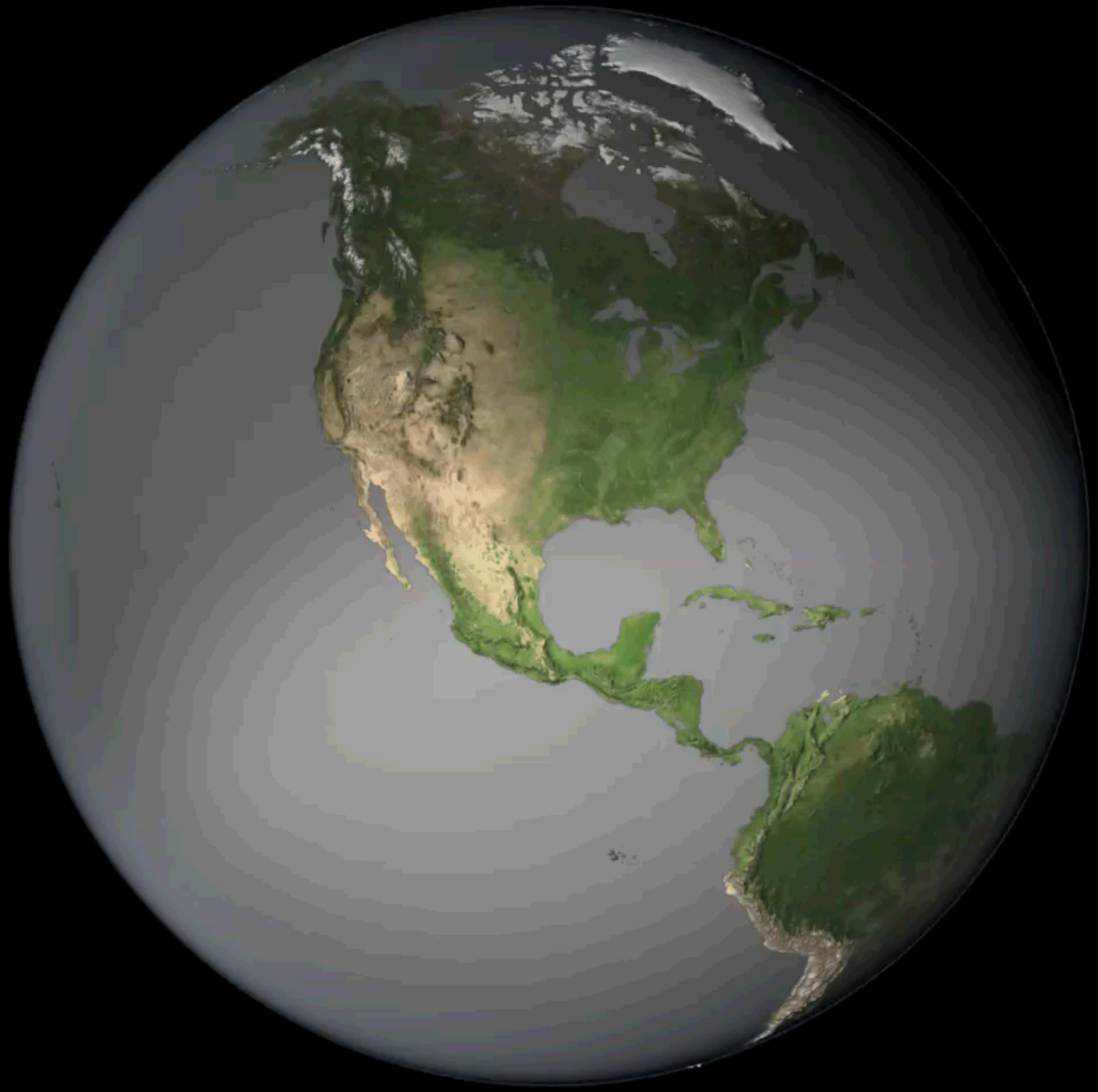
- Arctic Amplification Defined: Arctic warms more given the same CO_2 forcing
- Arctic warming focused at the surface.
- Arctic warming strongest in fall and winter.

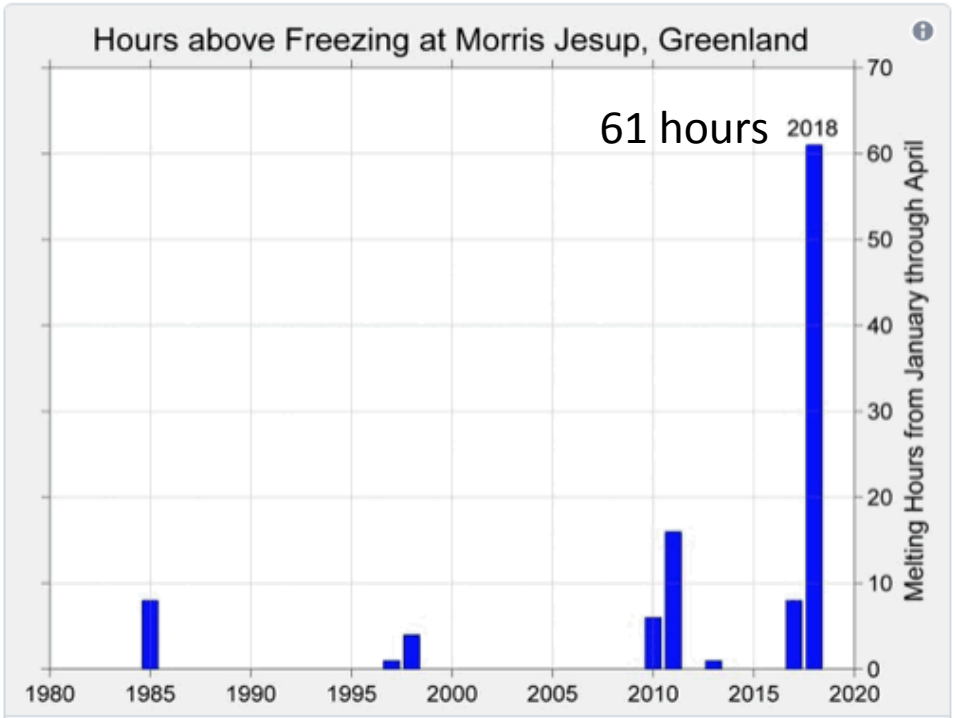


Processes influencing Arctic Amplification



Cohen et al. (in review)





Robert Rohde
@rarohde

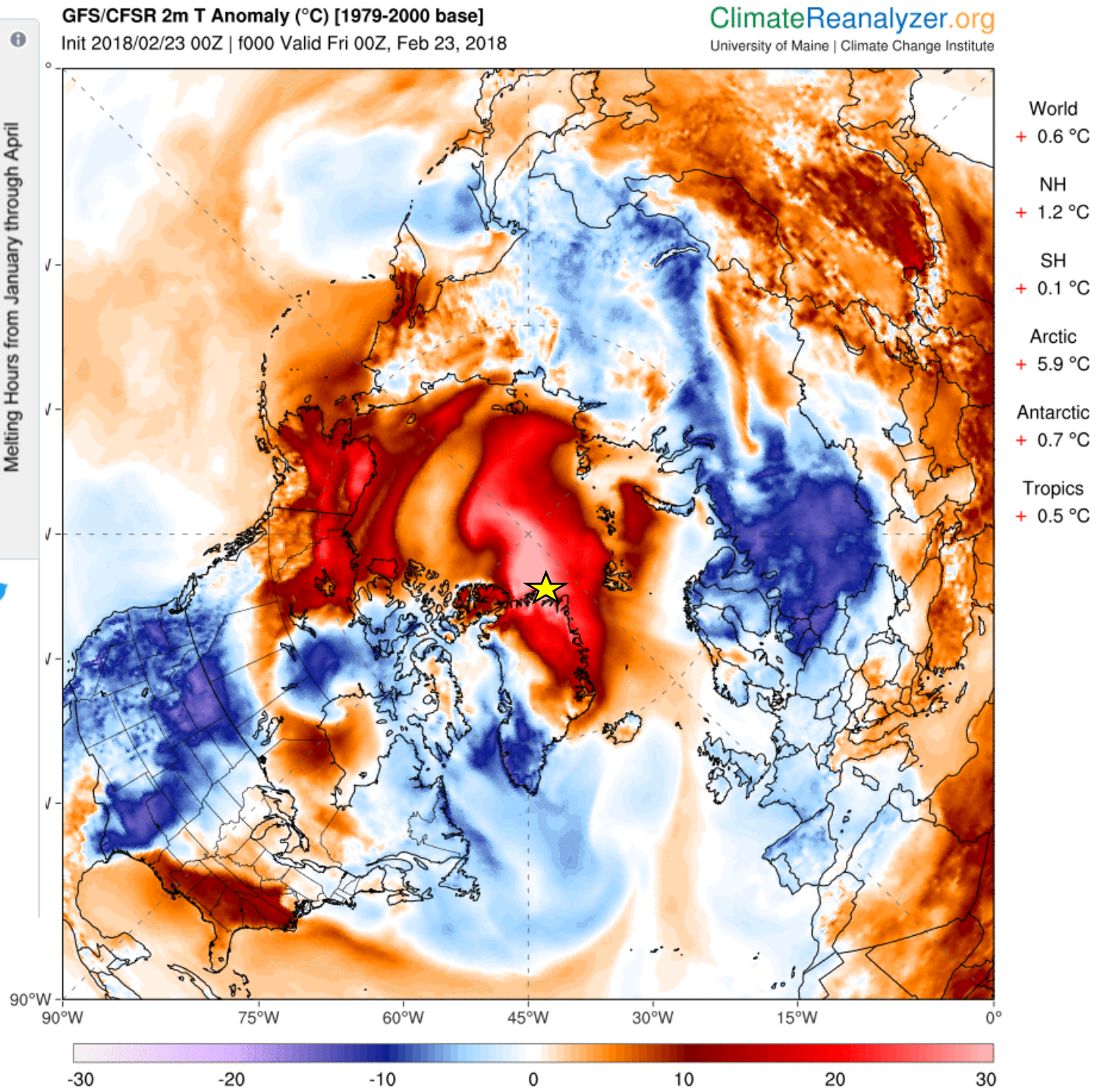
Replying to @rarohde

In 2018, there have already been 61 hours above freezing at Cape Morris Jesup, Greenland.

The previous record was 16 hours before the end of April in 2011.

8:02 PM - Feb 25, 2018

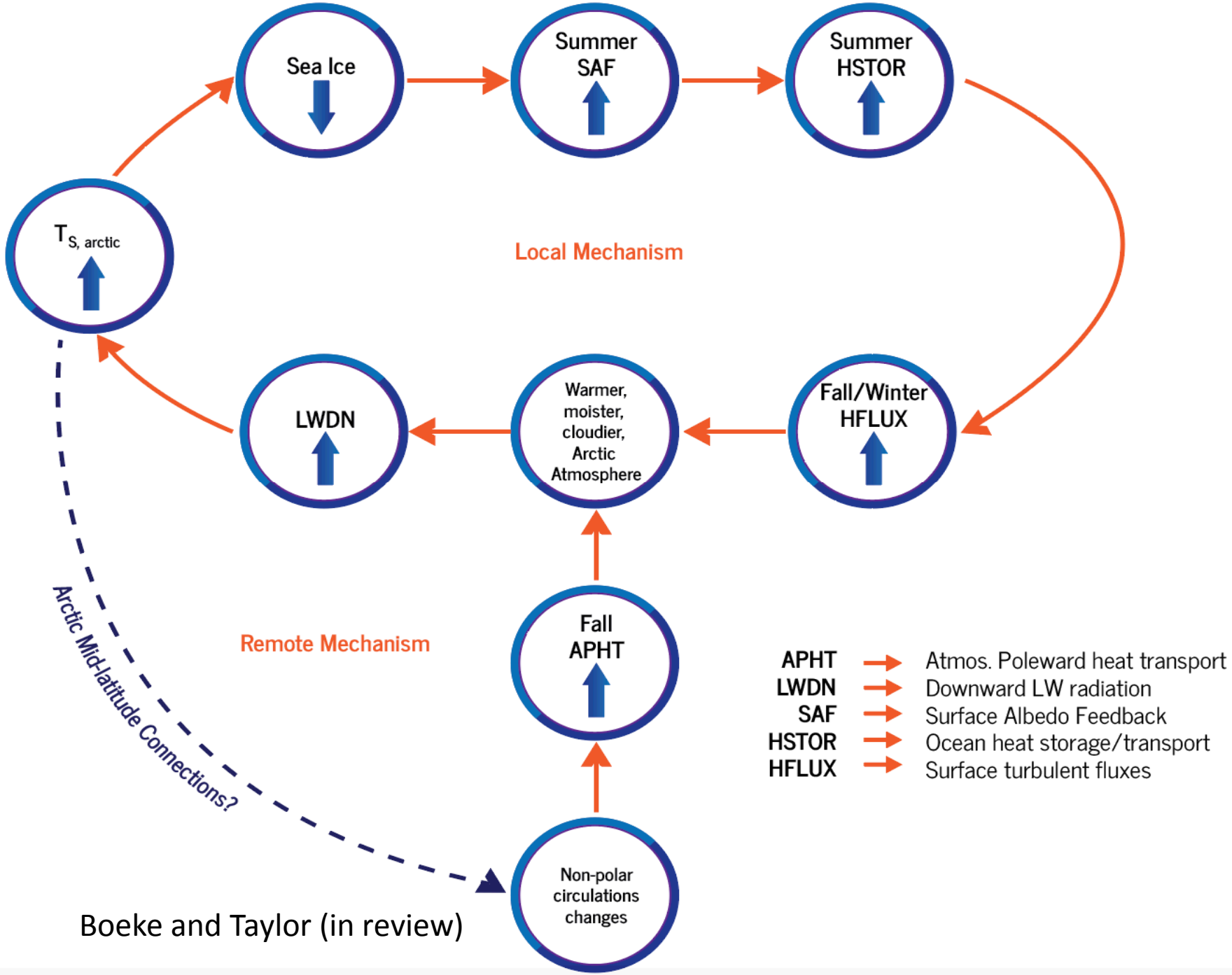
157 180 people are talking about this



Source:https://www.theweathernetwork.com/

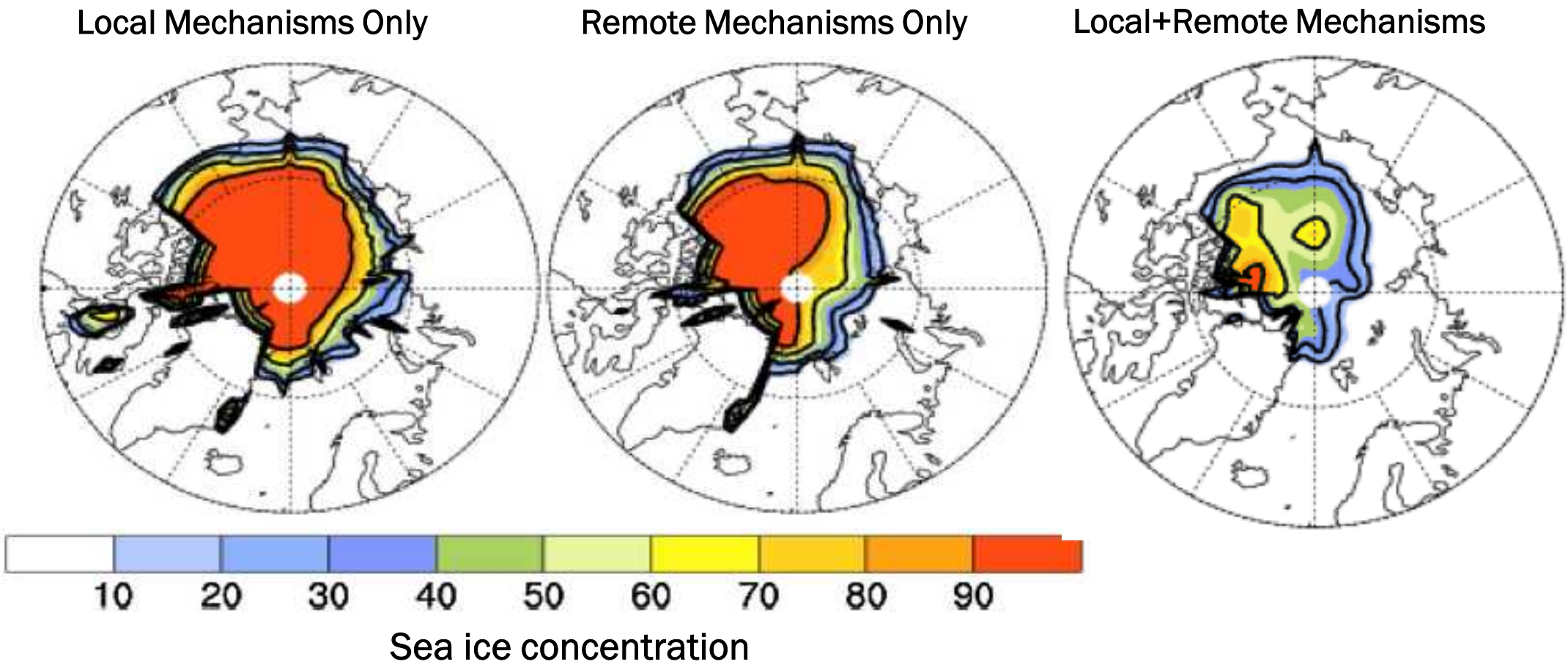
A complete picture of Arctic Amplification?

LWDN is the dominant term contributed to Arctic Amplification and integrates the local and remote mechanisms.



Boeke and Taylor (in review)

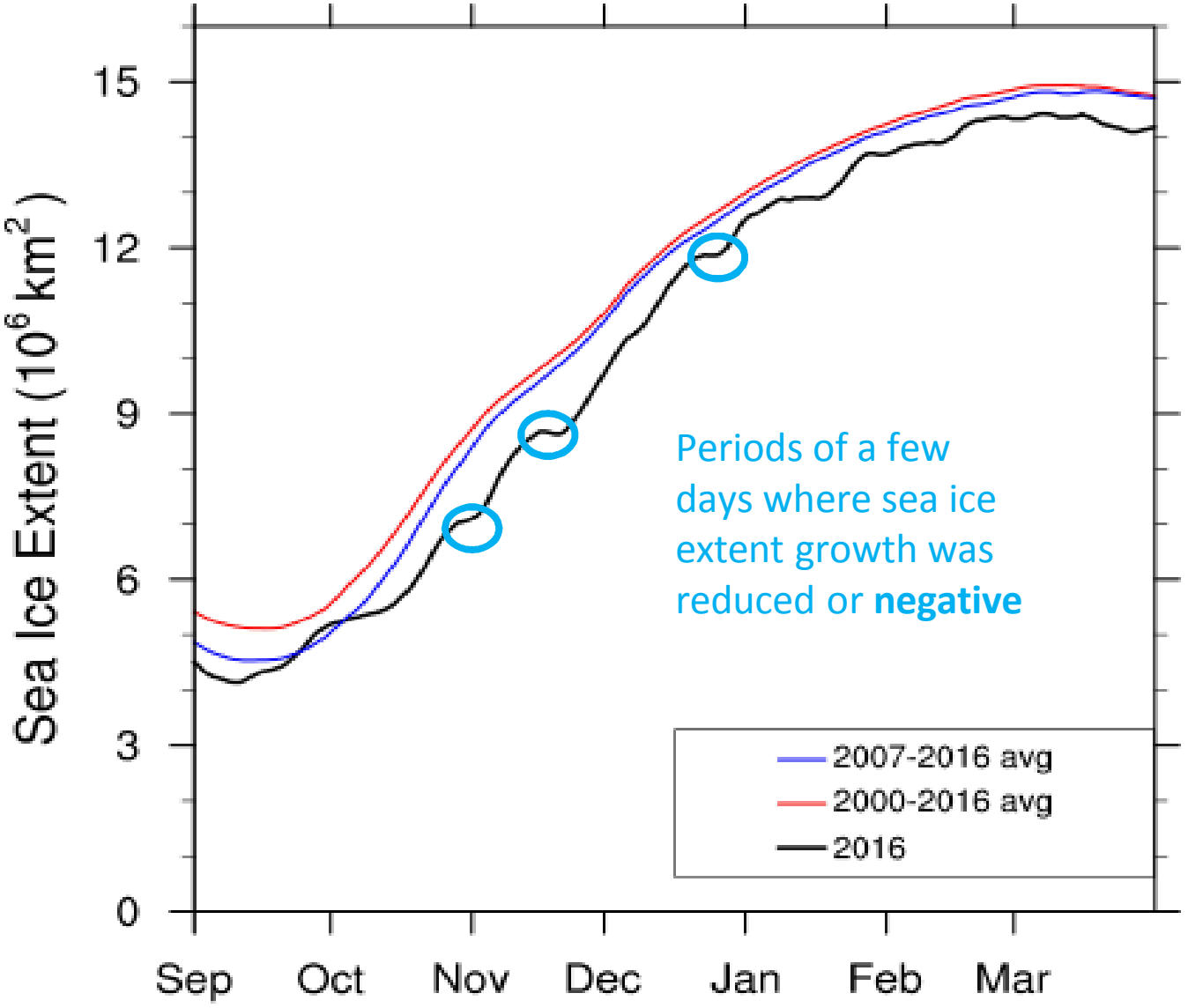
Are the interactions between local and remote mechanisms most important?



Yoshimori et al. 2017

2016-17 Arctic Sea Ice Growth Season

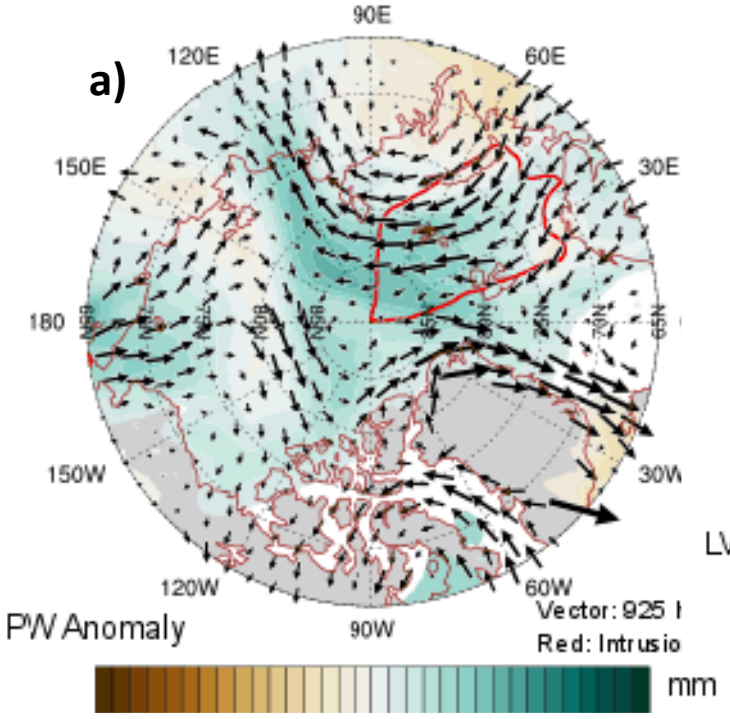
2016-17 also exhibited low sea ice extent from October-March, well below recent averages, contributing to one of the lowest end of season Arctic sea ice volume on record.

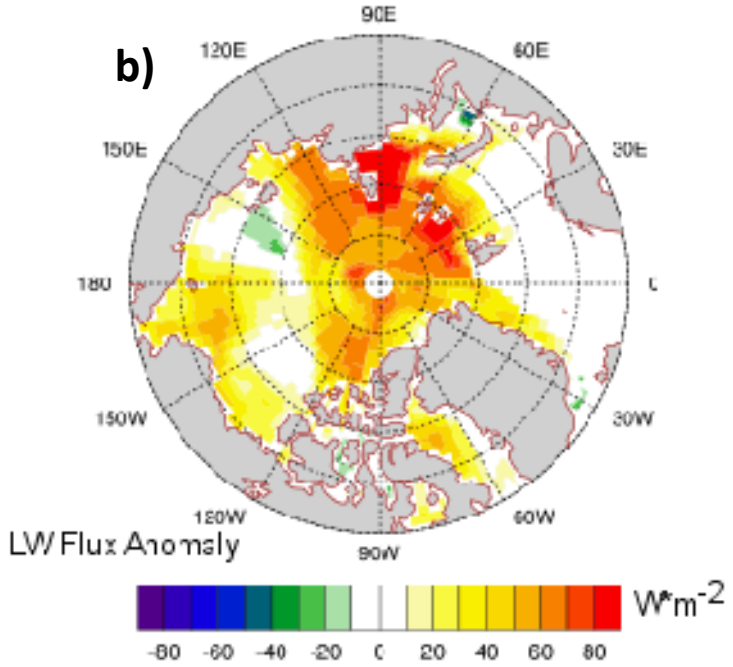


Hegyi and Taylor (2018; GRL): The Unprecedented 2016–2017 Arctic Sea Ice Growth Season: The Crucial Role of Atmospheric Rivers and Longwave Fluxes

November 17, 2016

Presence of a moisture intrusion



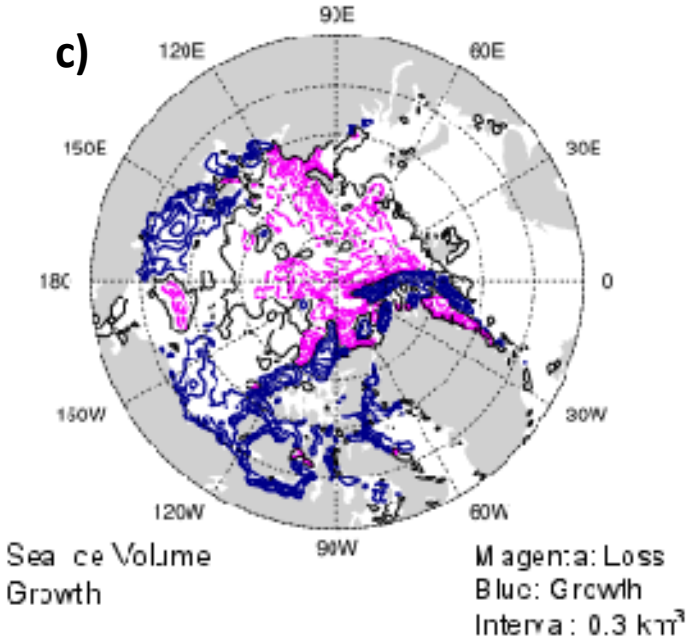


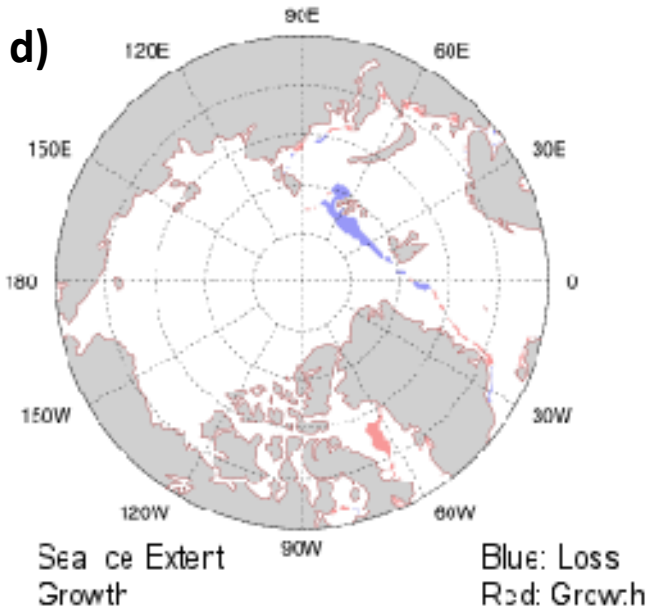
Increased downwelling LW fluxes

November 17, 2016

a) Anomalous PW (shading), 925 hPa winds (vectors), and area of moisture intrusion (red contour)
b) Anomalous downwelling LW flux anomaly
c) Sea ice volume growth
d) Sea ice extent retreat

Sea ice volume loss



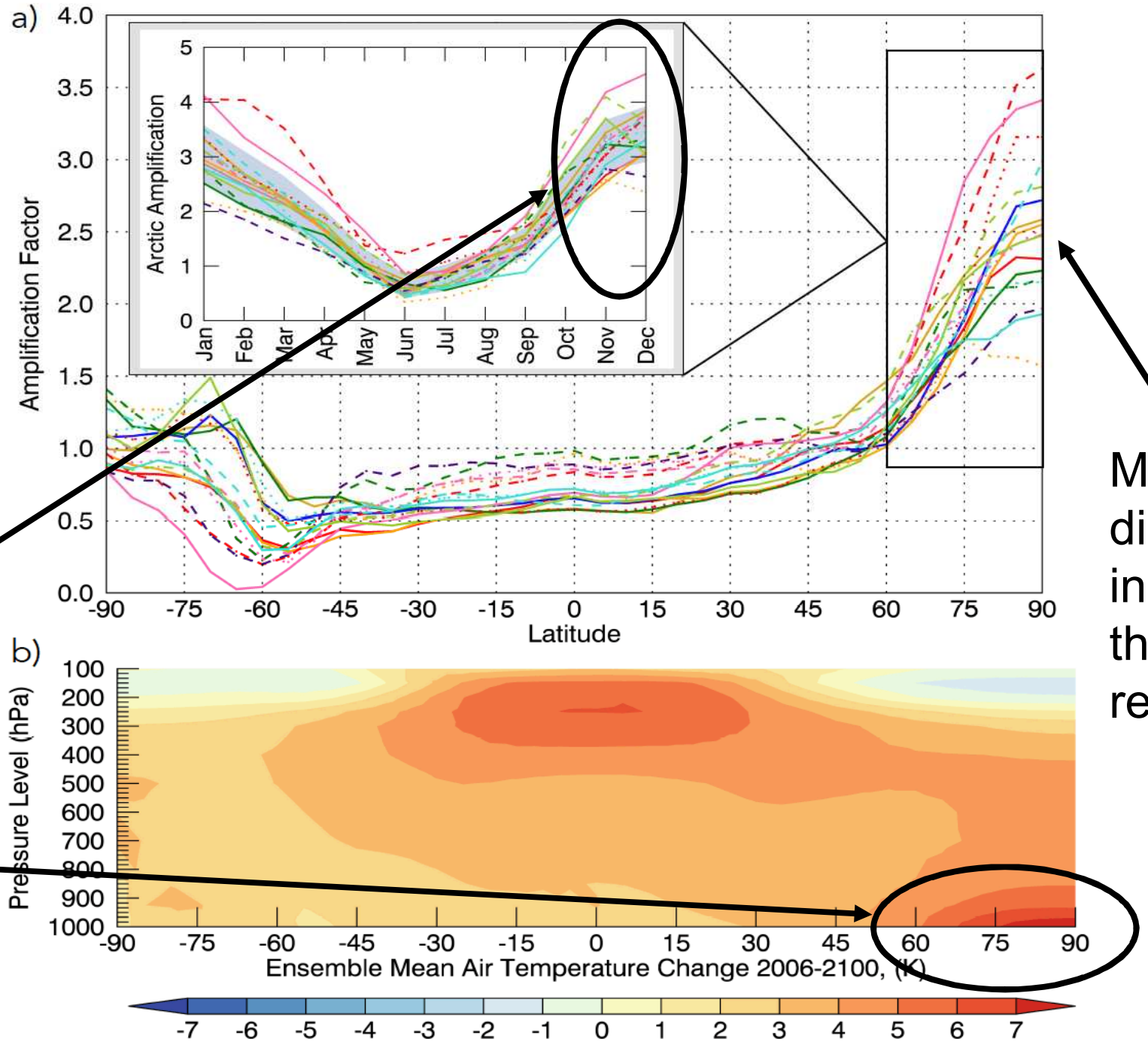


Sea ice extent retreat

Arctic Temperature Response (RCP 8.5)

Most warming in fall/winter

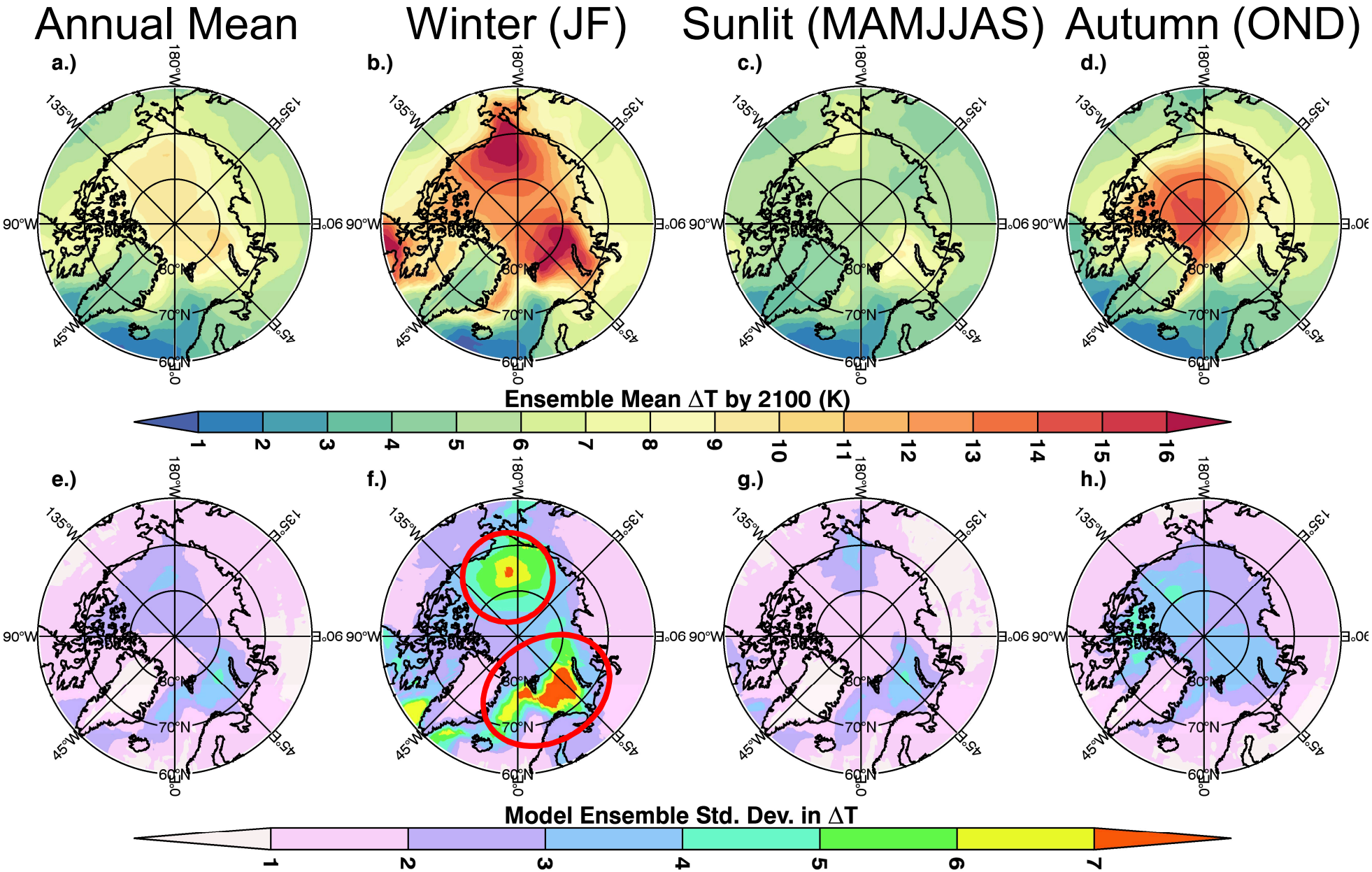
Bottom heavy warming profile



More model disagreement in the Arctic than any other region

Projected Arctic Surface Temperature Warming (RCP8.5)

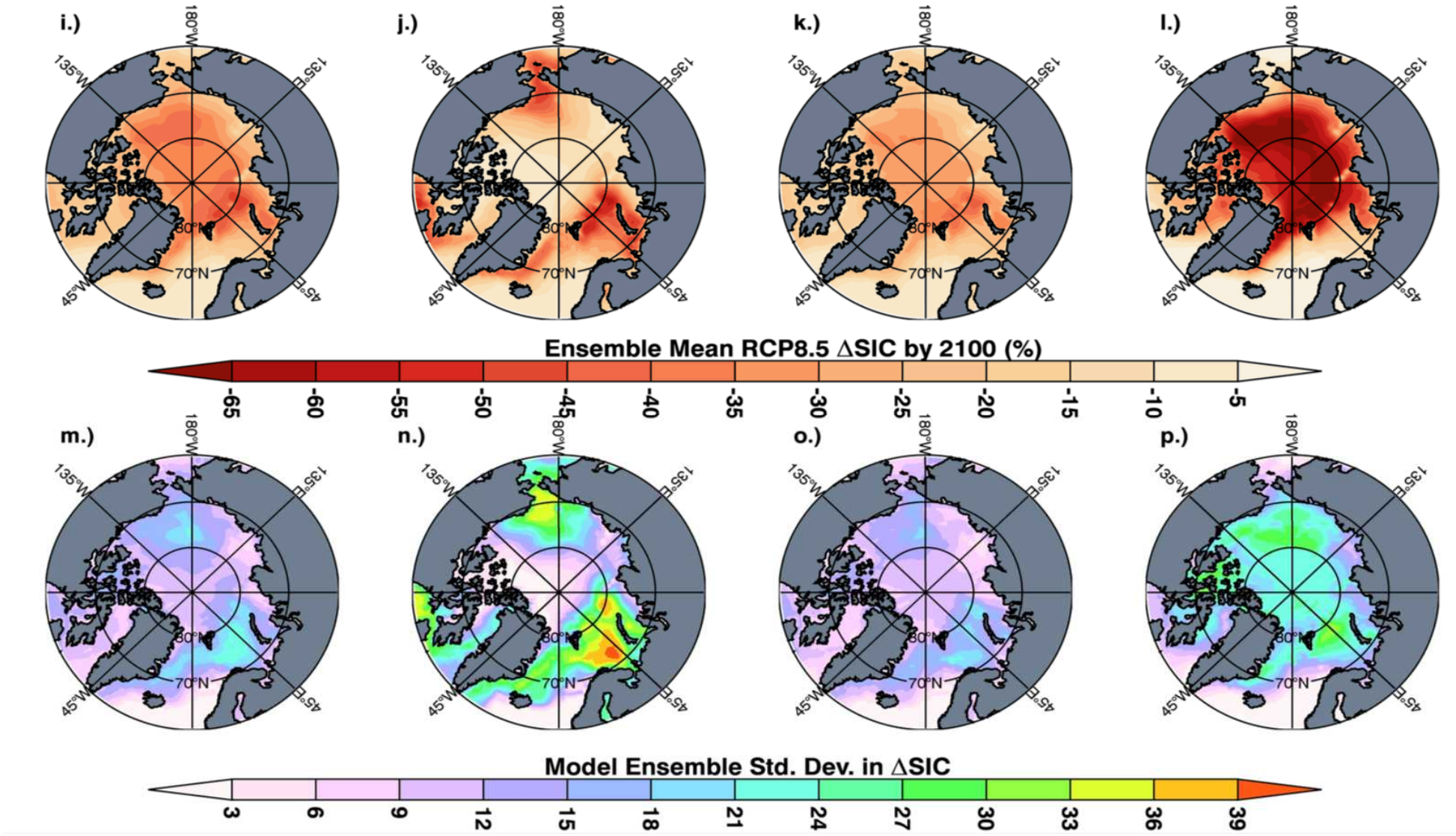
Largest differences between CMIP5 models occur in fall and winter in the Barents-Kara Seas and the Chukchi-Beaufort Seas regions.



Boeke and Taylor (in revision)

Projected Arctic Sea Ice Loss (RCP8.5)

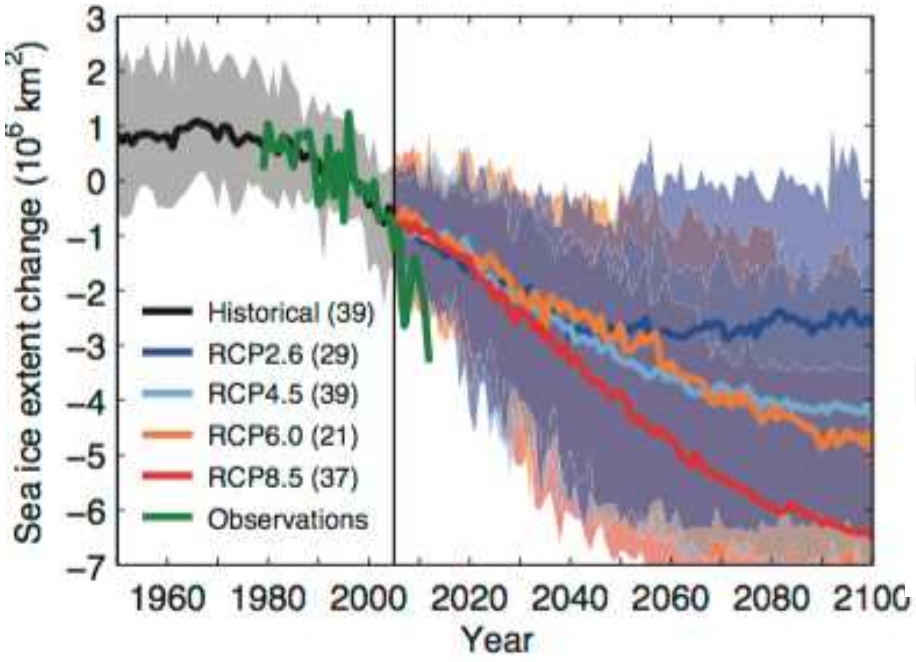
Largest differences between CMIP5 models occur in fall and winter in the Barents-Kara Seas and the Chukchi-Beaufort Seas regions.



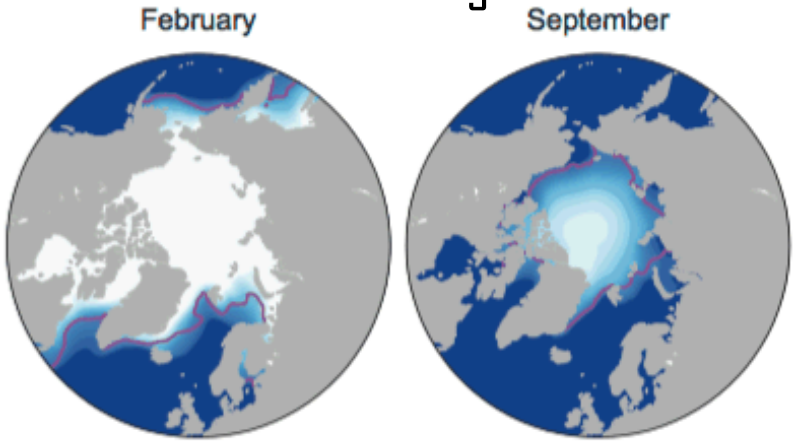
Boeke and Taylor (in revision)

Projected Arctic Sea Ice Loss (RCP4.5 vs. RCP8.5)

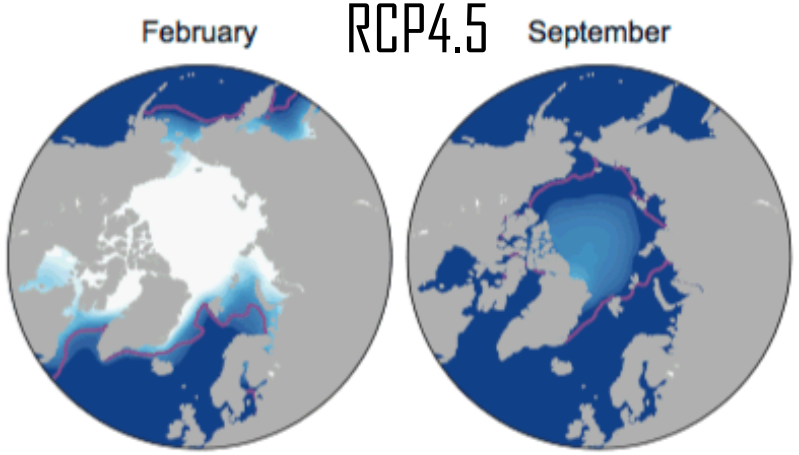
September Arctic Sea Ice Projections



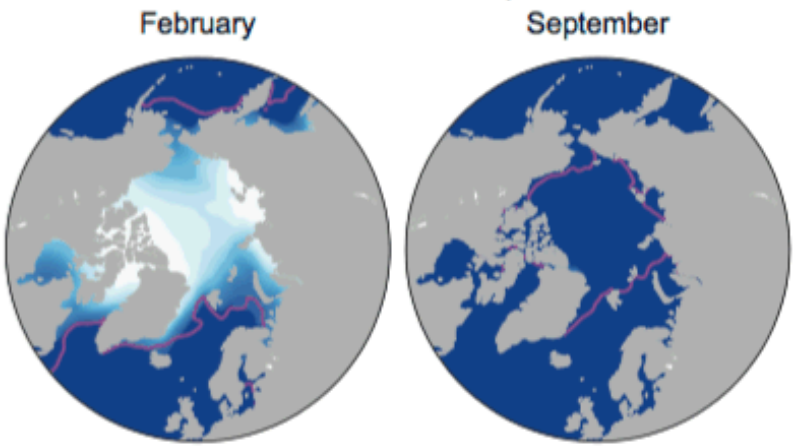
1985-2005 Average

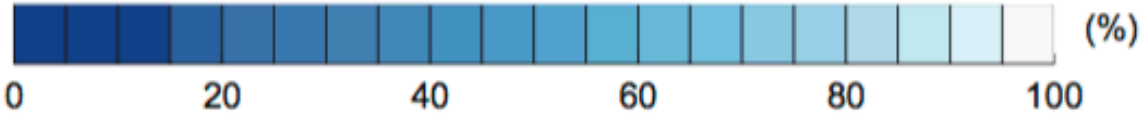


2081-2100 Average, RCP4.5



2081-2100 Average, RCP8.5





In recent decades, Alaskan wildfire activity has increased in both boreal forest and in the Arctic tundra.

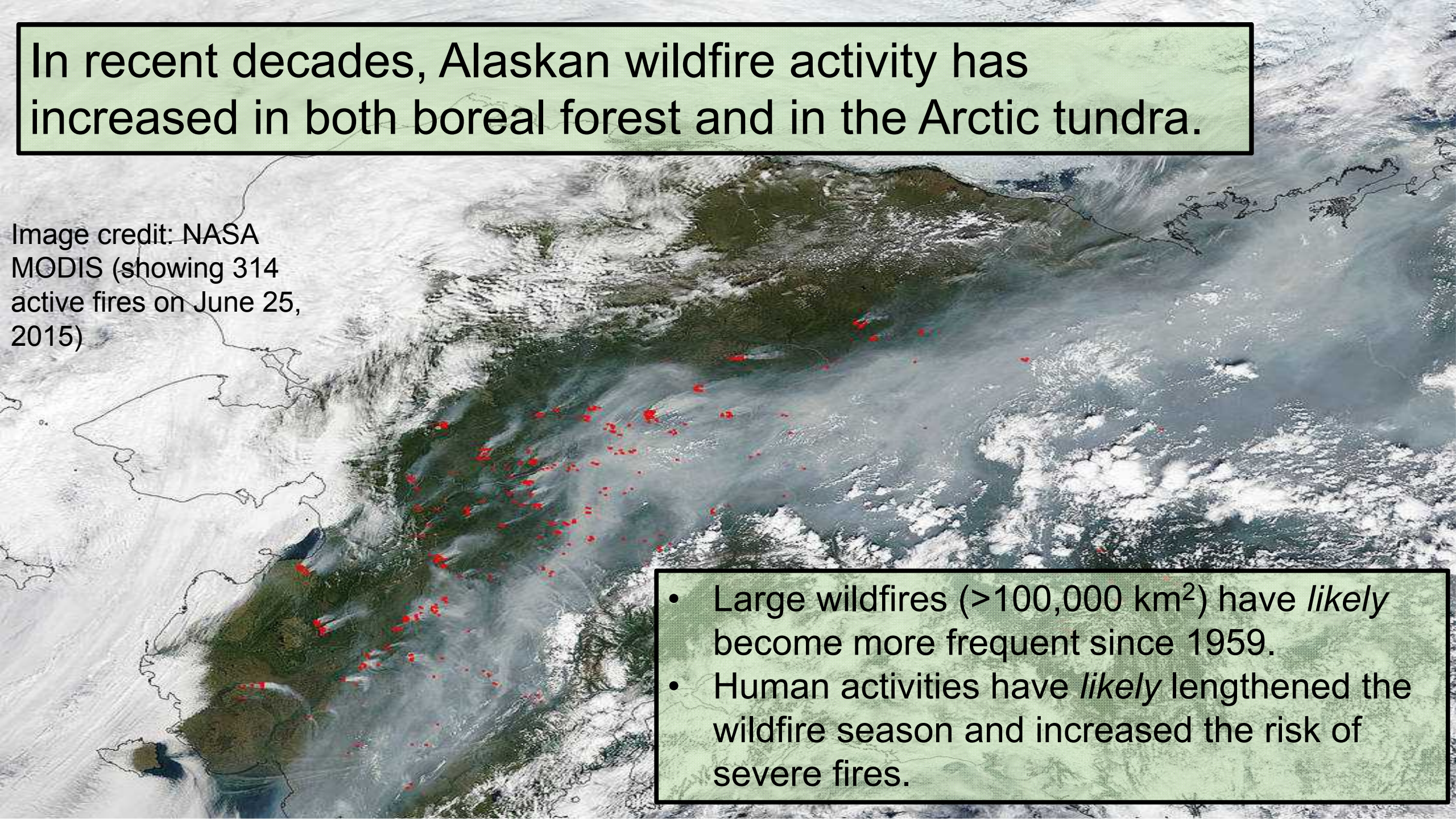


Image credit: NASA MODIS (showing 314 active fires on June 25, 2015)

- Large wildfires (>100,000 km^2) have *likely* become more frequent since 1959.
- Human activities have *likely* lengthened the wildfire season and increased the risk of severe fires.

A plethora of opportunities and challenges in a changing Arctic…

Source: NASA IceBridge

Thank you.

patrick.c.taylor@nasa.gov

https://science2017.globalchange.gov/chapter/11/

Questions?

Source: NASA IceBridge