

Variability and future projections of Arctic sea ice thickness

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AGCI Polar Amplification Workshop

The background of the slide is a dark, atmospheric photograph of sea ice. In the lower-left foreground, a satellite or icebreaker is visible, partially obscured by ice floes. The rest of the image shows a vast expanse of broken ice floes under a dark sky. The text is overlaid on this image.

1) Changes in pan-Arctic sea ice thickness and volume show significant regional variability on the interannual time-scale

2) Greatest sea ice thickness variability over the East Siberian Sea – represented in both the CESM Large Ensemble and PIOMAS

3) Predicting the timing and magnitude of future sea ice volume losses remains uncertain due to the large internal variability

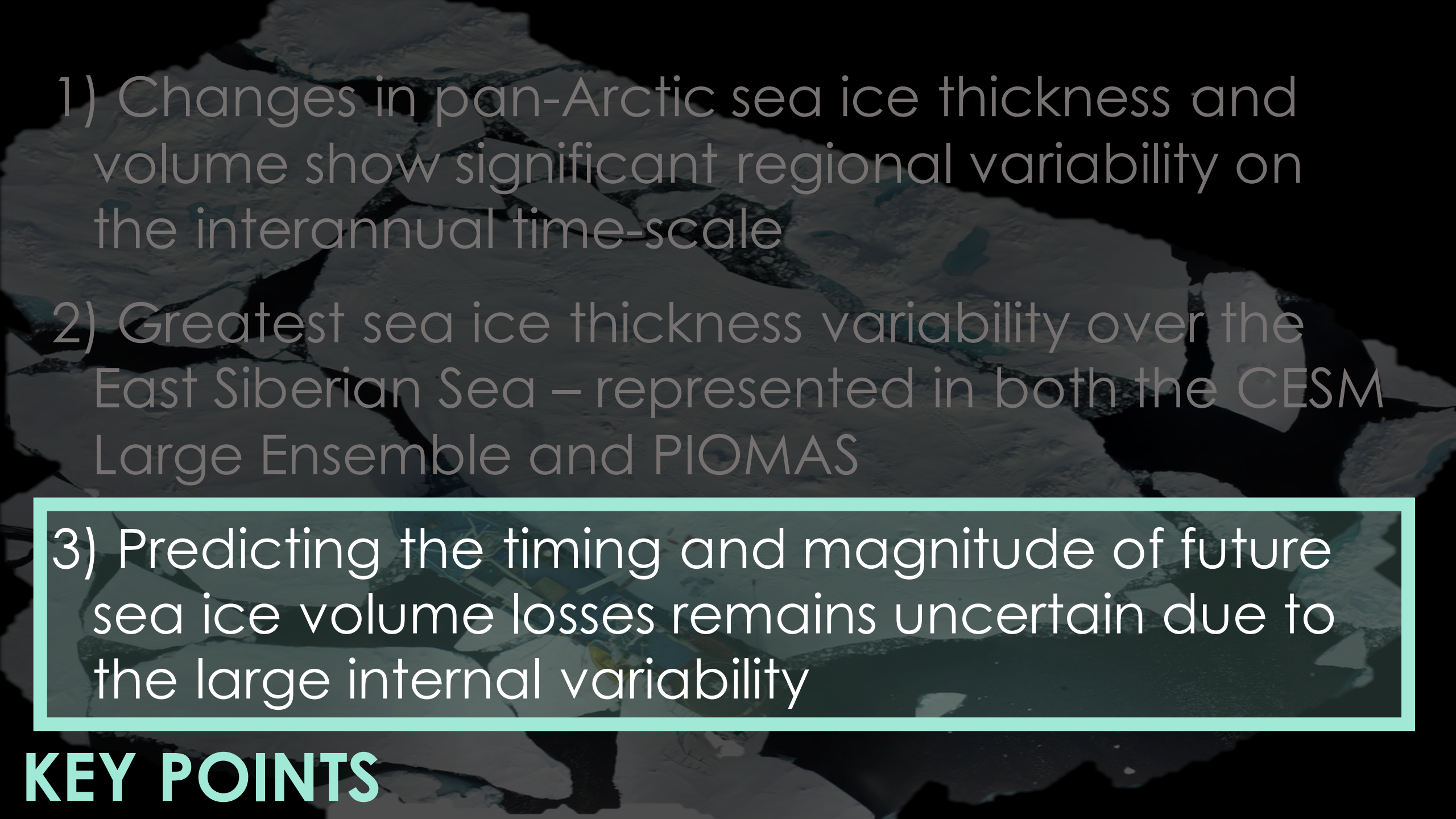
KEY POINTS

1) Changes in pan-Arctic sea ice thickness and volume show significant regional variability on the interannual time-scale

2) Greatest sea ice thickness variability over the East Siberian Sea – represented in both the CESM Large Ensemble and PIOMAS

3) Predicting the timing and magnitude of future sea ice volume losses remains uncertain due to the large internal variability

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- 1) Changes in pan-Arctic sea ice thickness and volume show significant regional variability on the interannual time-scale
 - 2) Greatest sea ice thickness variability over the East Siberian Sea – represented in both the CESM Large Ensemble and PIOMAS
 - 3) Predicting the timing and magnitude of future sea ice volume losses remains uncertain due to the large internal variability

KEY POINTS

Changing Sea Ice Thickness

A map of the Arctic region showing various shipping routes and research focus areas. The routes are color-coded: red for the Northwest Passage, green for the Northeast Passage, and blue for the trans-Arctic routes. The map also labels the Arctic Ocean, Barents Sea, Kara Sea, Laptev Sea, East Siberian Sea, Chukchi Sea, and Greenland Sea.

MELIA ET AL., 2016

“Sea ice Decline and 21st
century trans-Arctic
shipping routes”

POST ET AL., 2013

“Ecological consequences
of sea-ice decline”

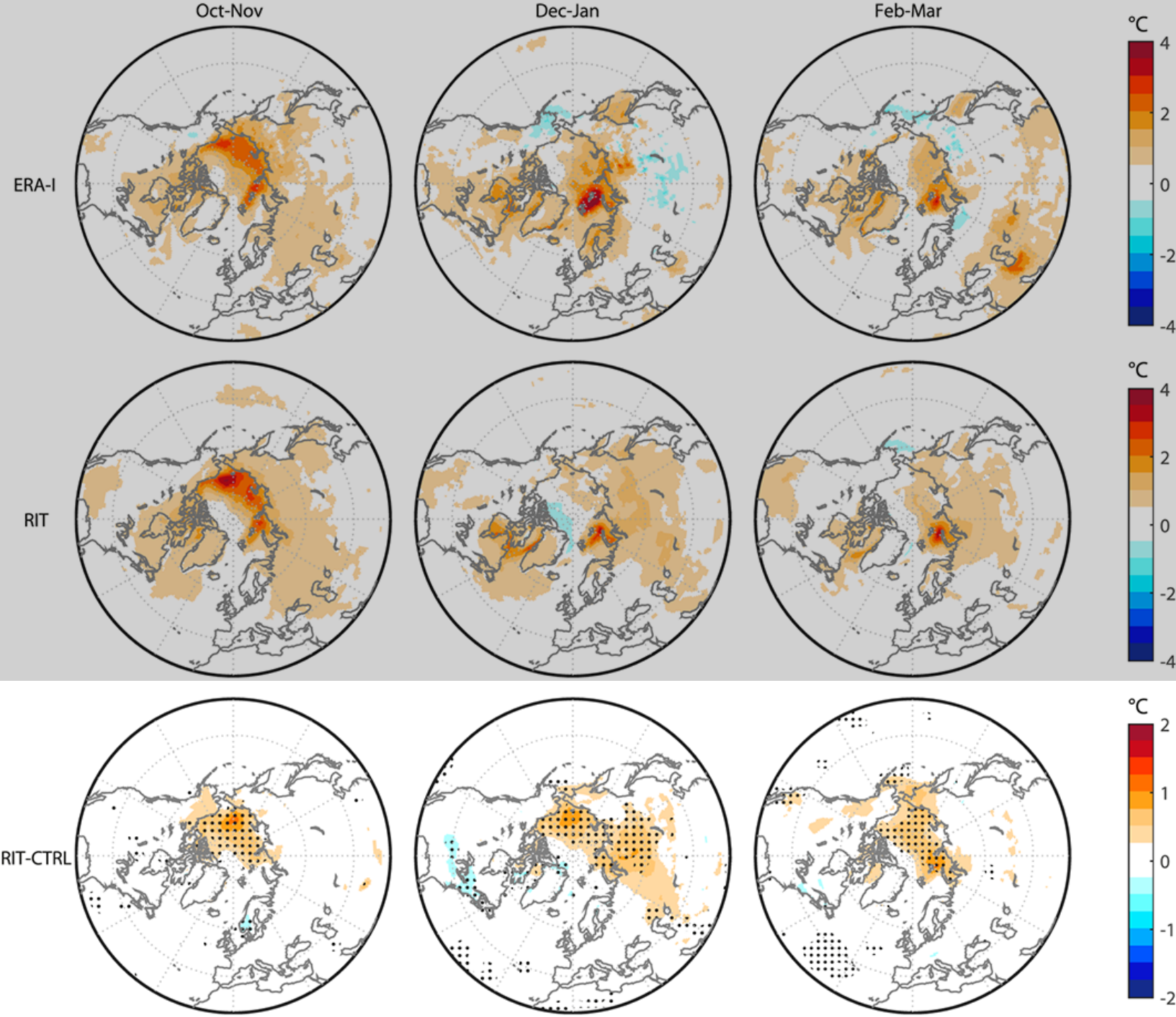
PIZZOLATO ET AL., 2016

“The influence of declining sea
ice on shipping activity in the
Canadian Arctic”

LANG ET AL., 2016

“Sea ice thickness and recent
Arctic warming”

Lang et al., 2016

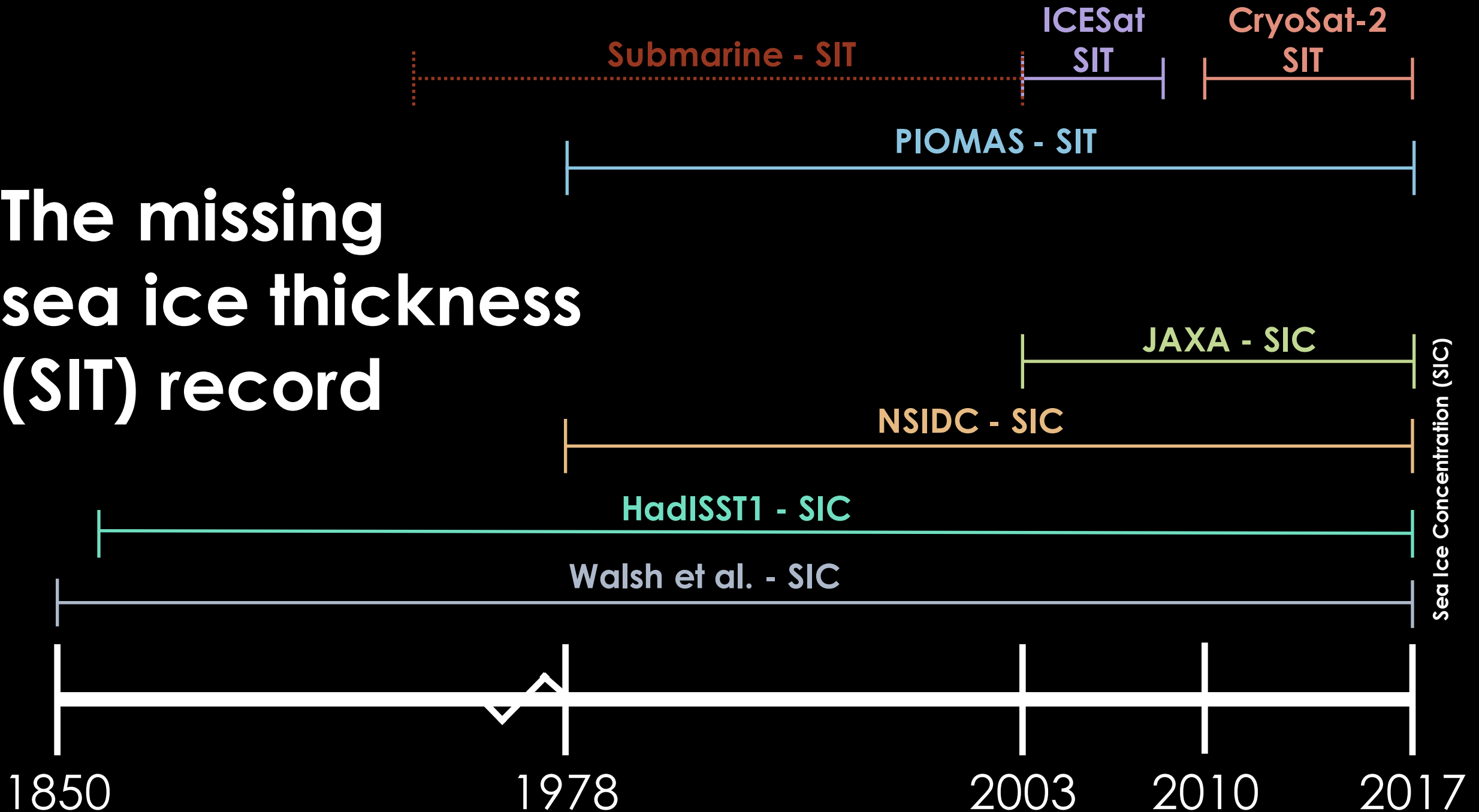


Surface warming from SIT

Sea ice thickness observations

A map of the Arctic region is shown in the background. The landmasses are outlined in a dark green color. The sea ice is represented by a color gradient, with darker blue/purple indicating thinner ice and red indicating thicker ice. The text "Sea ice thickness observations" is overlaid in a large, white, sans-serif font.

The missing sea ice thickness (SIT) record



Modeled sea ice thickness

Satellite sea ice thickness

ICESat
SIT

CryoSat-2
SIT

PIOMAS - SIT

JAXA - SIC

NSIDC - SIC

HadISST1 - SIC

Walsh et al. - SIC

Sea Ice Concentration (SIC)

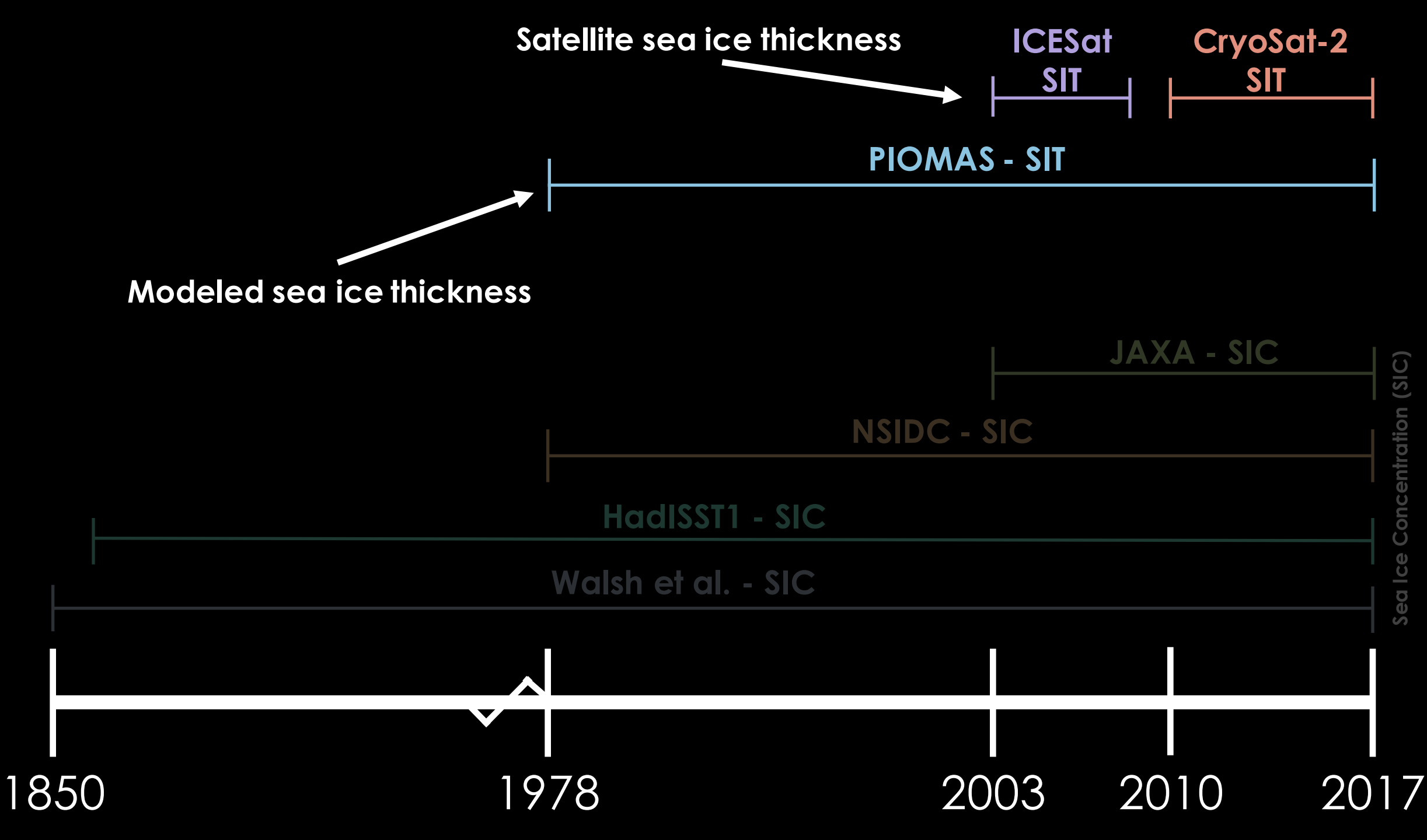
1850

1978

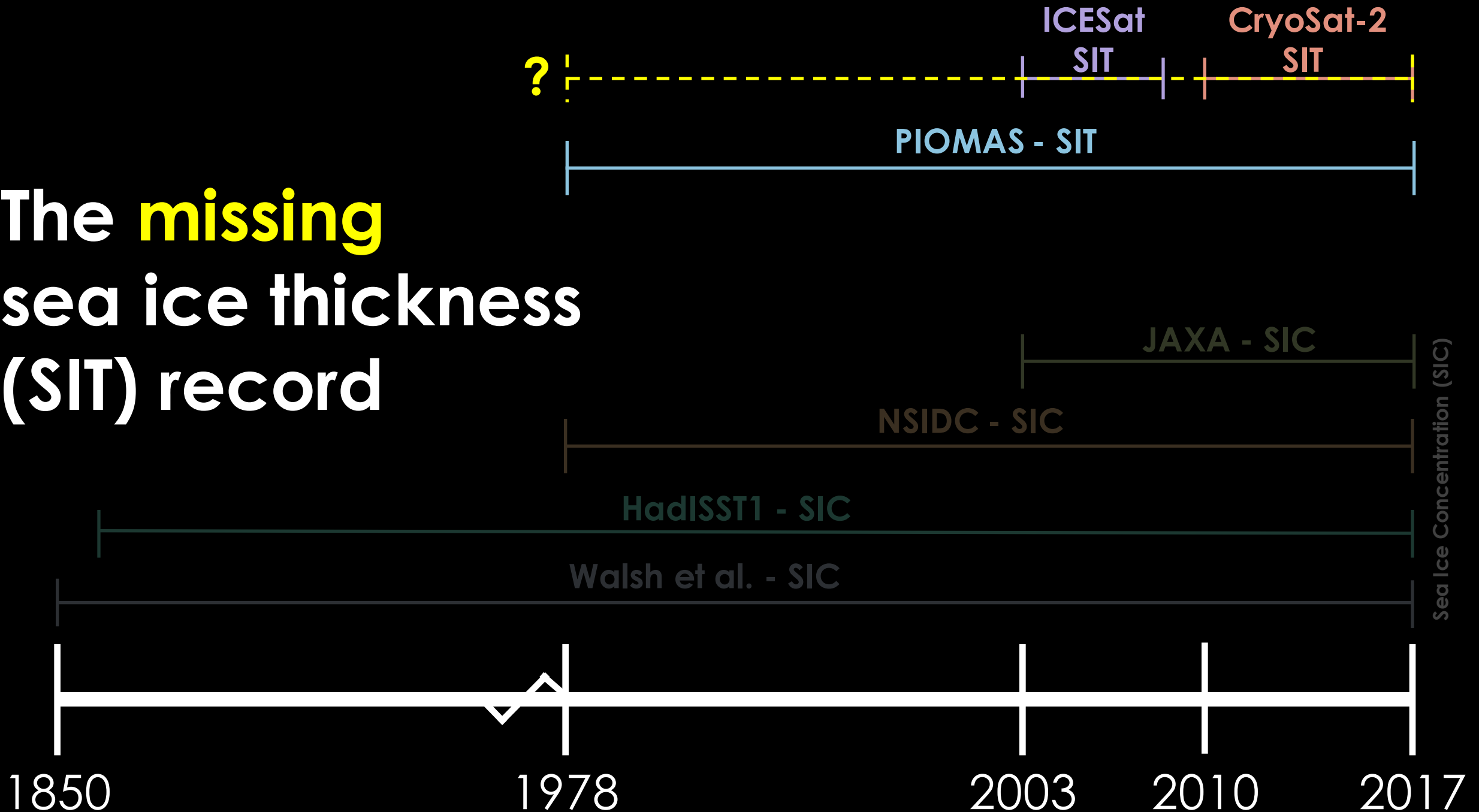
2003

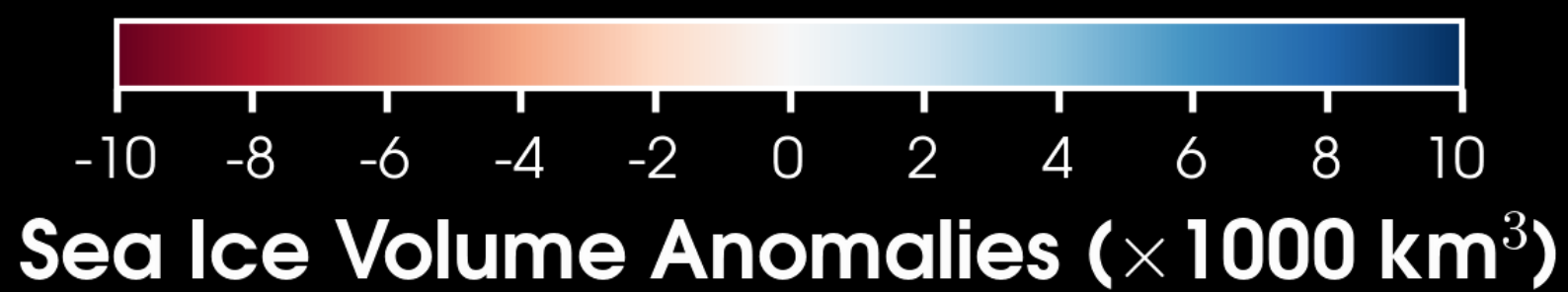
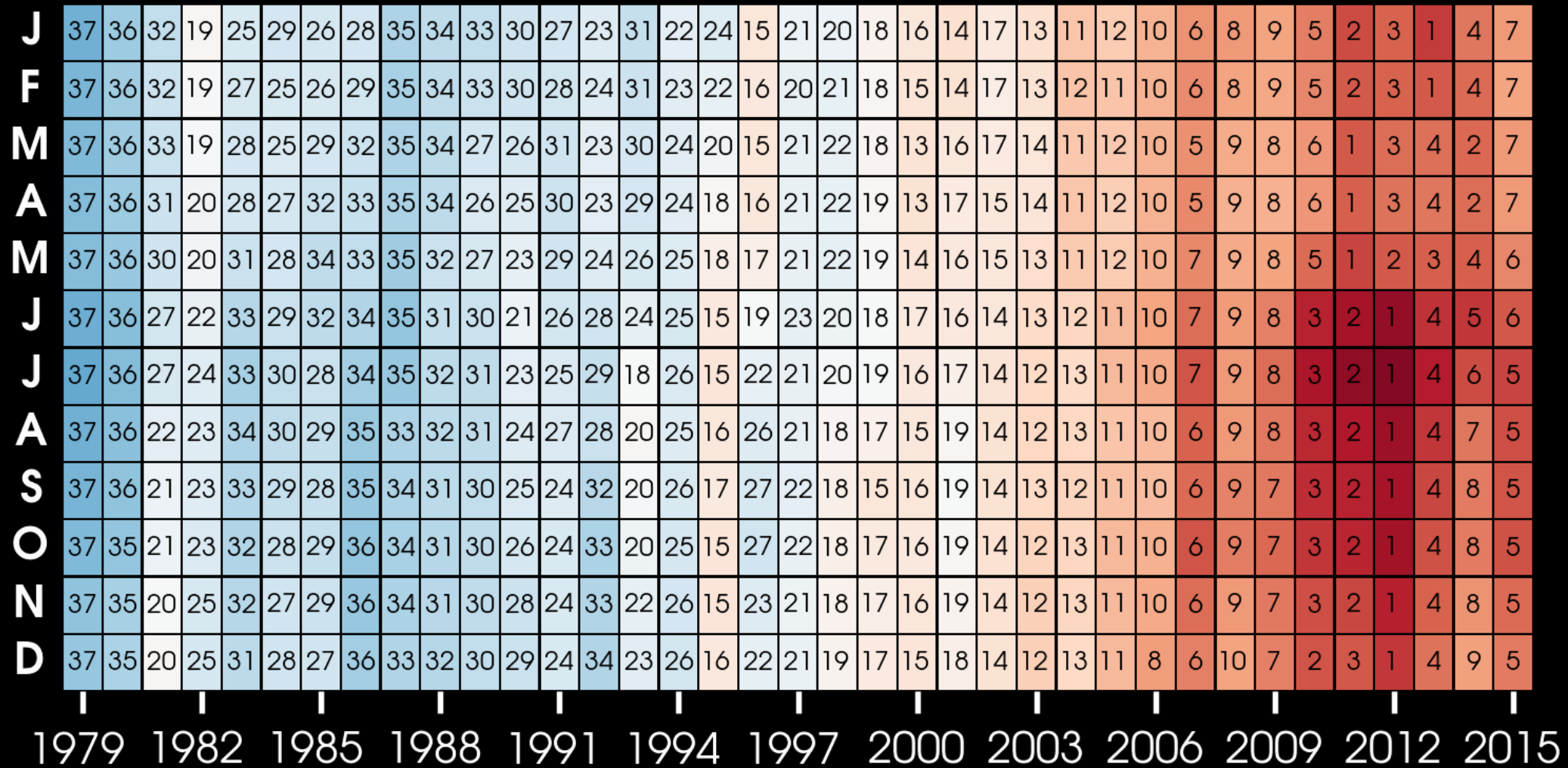
2010

2017

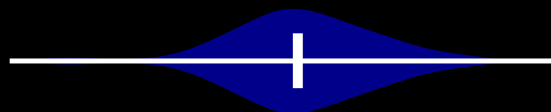


The **missing** sea ice thickness (SIT) record





Submarine
(1986-1994)



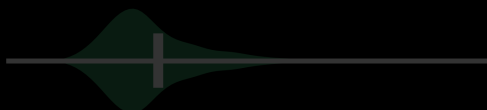
PIOMAS



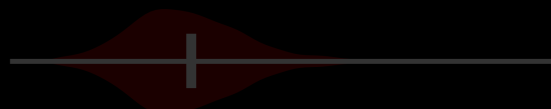
ICESat-J
(2004-2009)



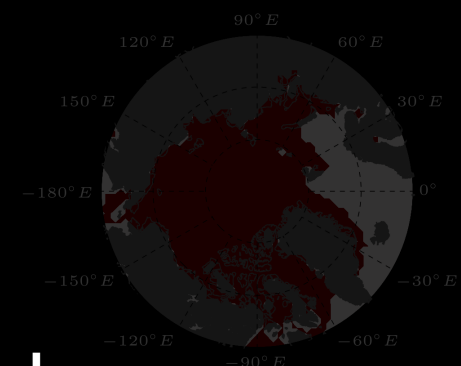
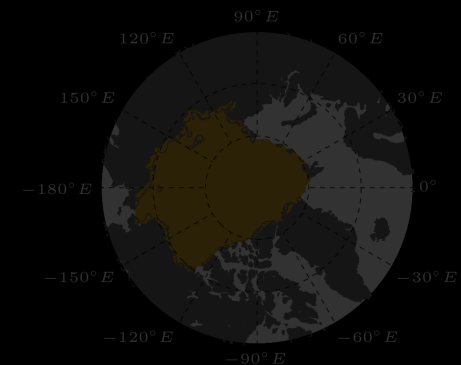
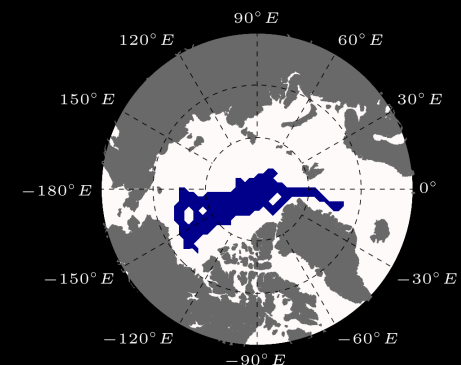
PIOMAS



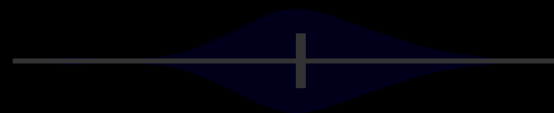
CryoSat-2
(2011-2015)



PIOMAS



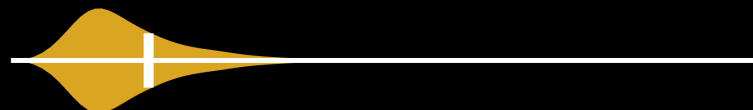
Submarine
(1986-1994)



PIOMAS



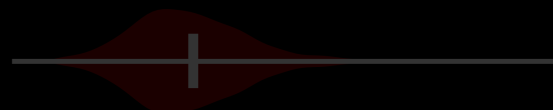
ICESat-J
(2004-2009)



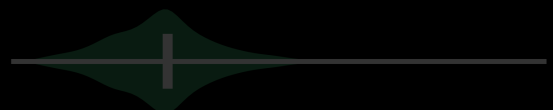
PIOMAS



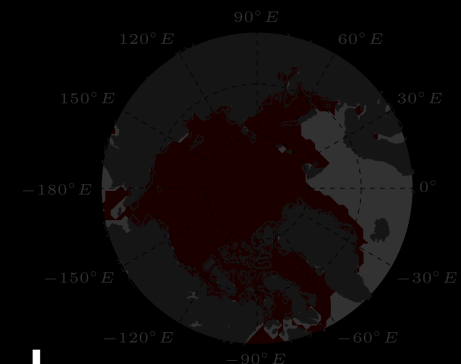
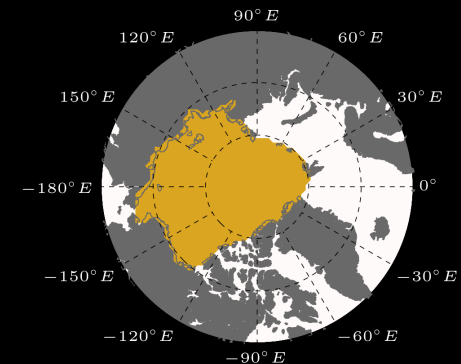
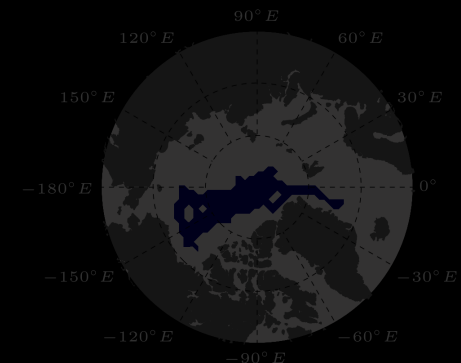
CryoSat-2
(2011-2015)



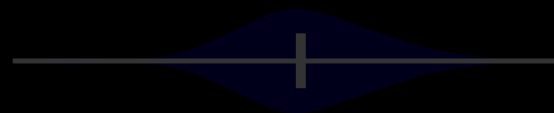
PIOMAS



0 1 2 3 4 5 6 7 8 9
Thickness (m)



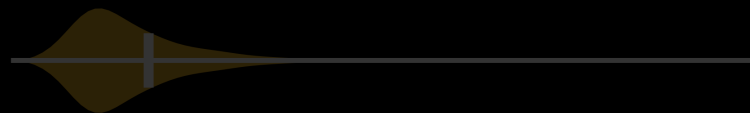
Submarine
(1986-1994)



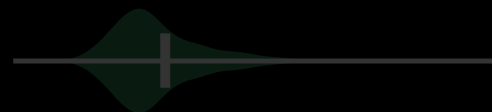
PIOMAS



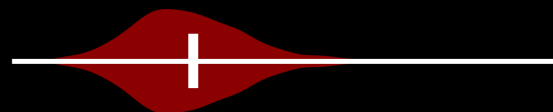
ICESat-J
(2004-2009)



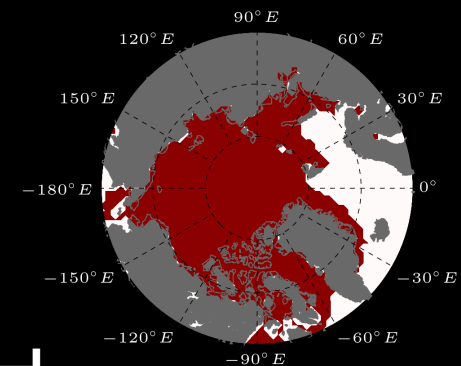
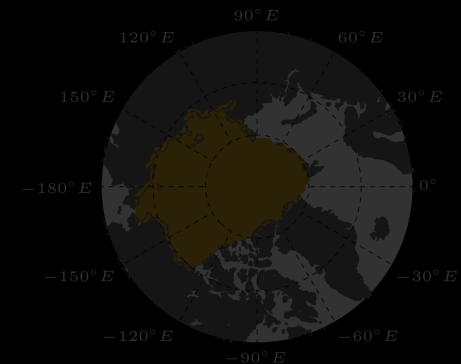
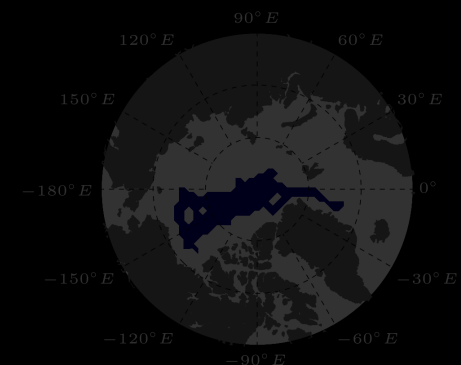
PIOMAS



CryoSat-2
(2011-2015)

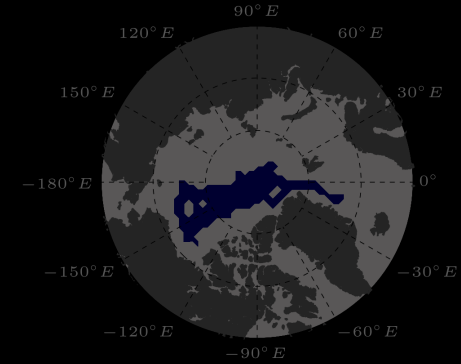
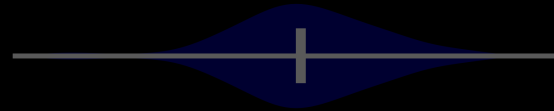


PIOMAS



Submarine
(1986-1994)

PIOMAS

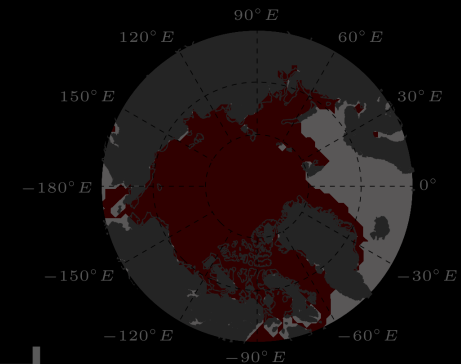
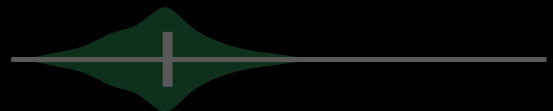
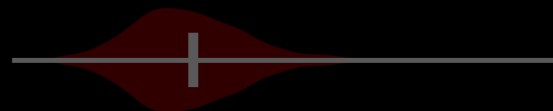


PIOMAS {
ICESat-J
(2003-2009)
PIOMAS

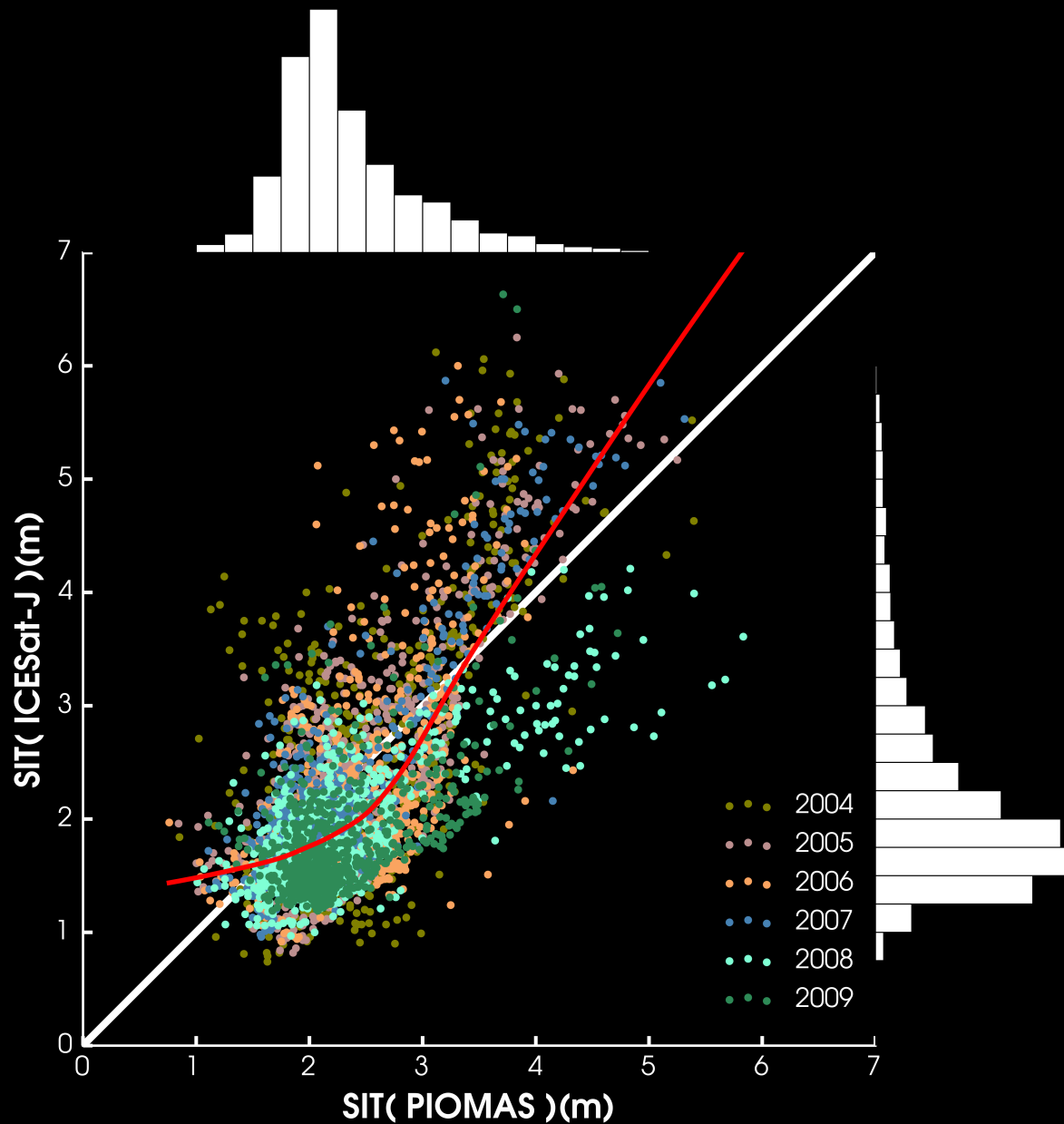
Overestimates thin ice
Underestimates thick ice

CryoSat-2
(2011-2015)

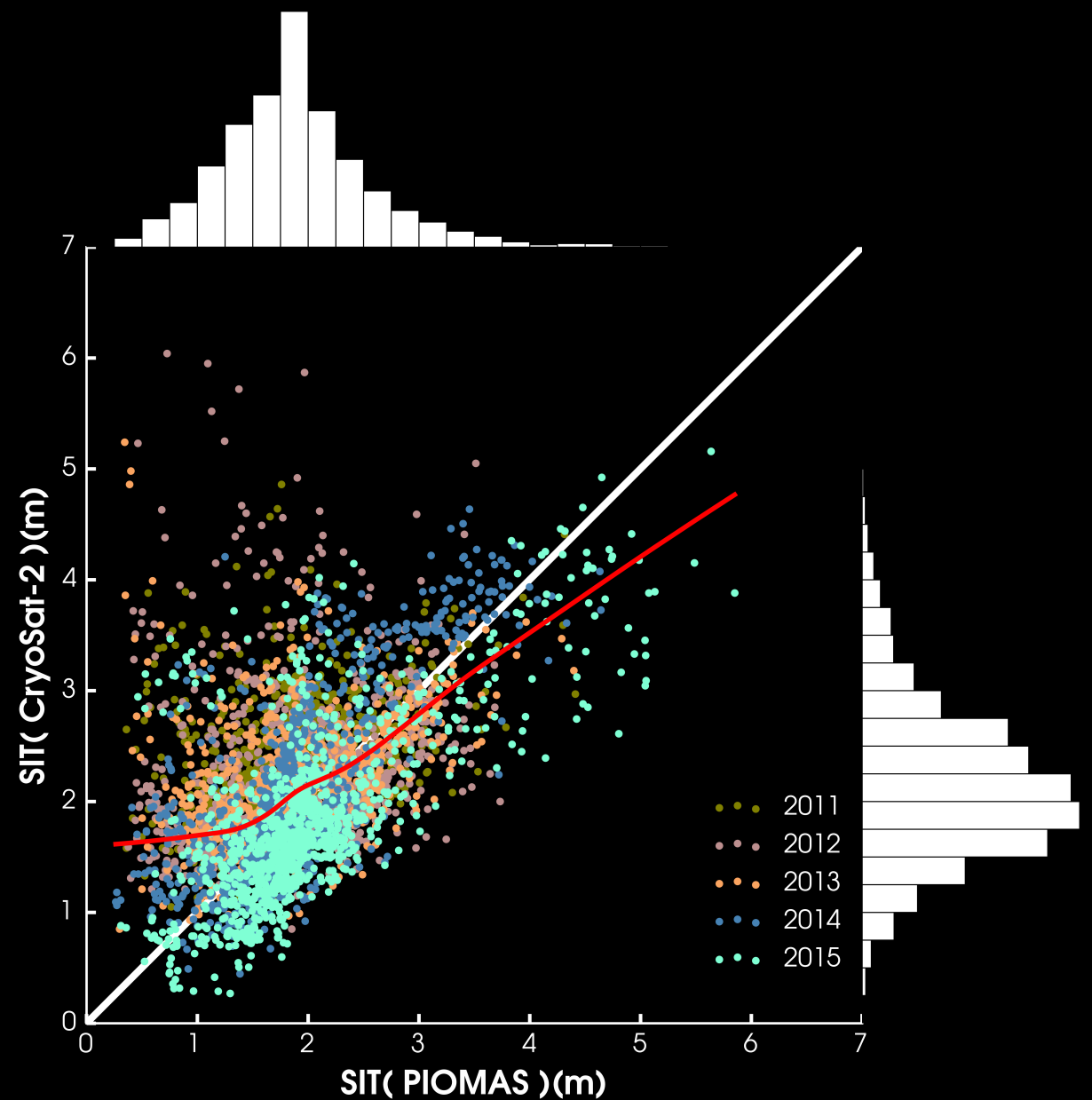
PIOMAS



PIOMAS vs. ICESat-J



PIOMAS vs. CryoSat-2

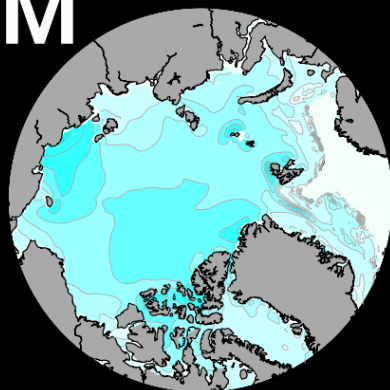


A map of the Arctic region, including parts of North America, Europe, and Asia, overlaid with a color-coded contour plot representing sea ice thickness variability. The colors range from dark purple (low variability) to bright yellow (high variability). High variability is concentrated in the central Arctic Ocean and along the northern coasts of North America and Eurasia. The text "Regional sea ice thickness variability" is superimposed in large white font across the center of the map.

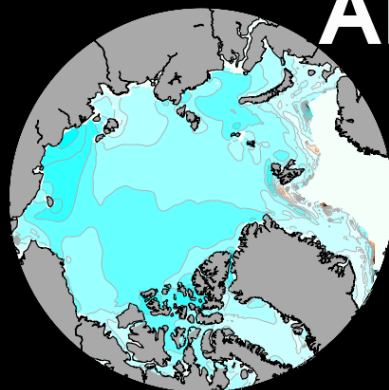
Regional sea ice thickness variability

TRENDS

JFM



AMJ



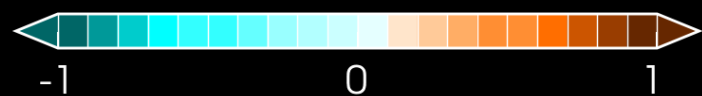
JAS



OND



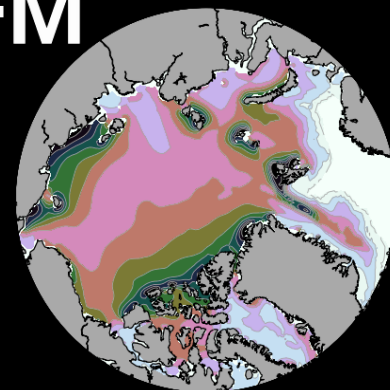
1979-2015



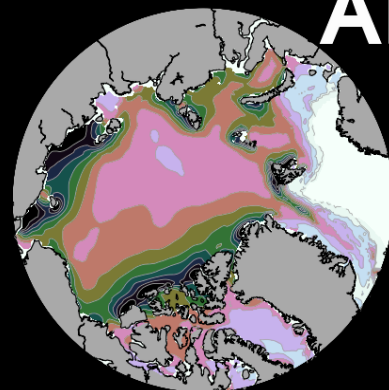
SIT(m decade⁻¹)

STD

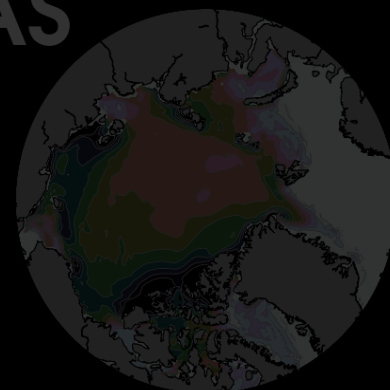
JFM



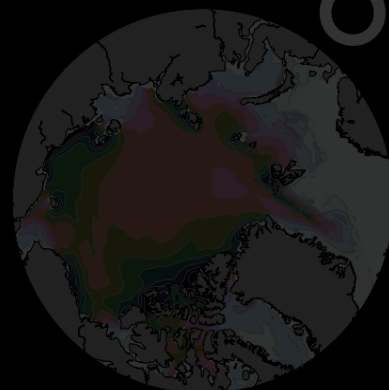
AMJ



JAS



OND



1979-2015



meters

TRENDS

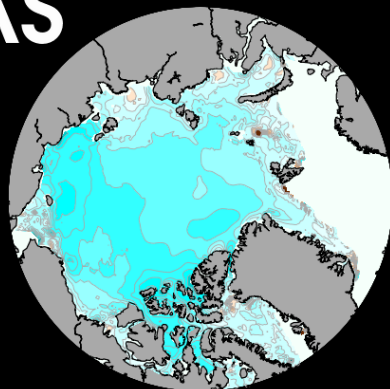
JFM



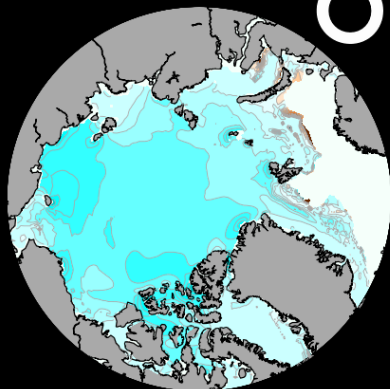
AMJ



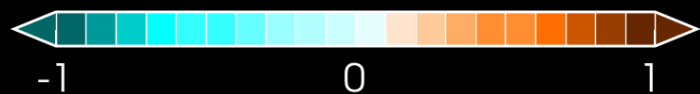
JAS



OND



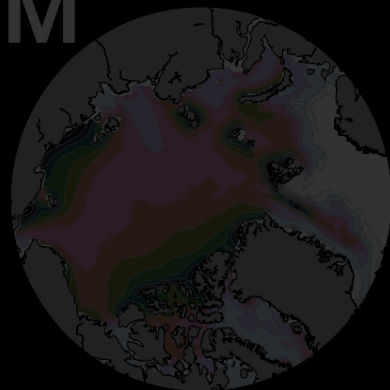
1979-2015



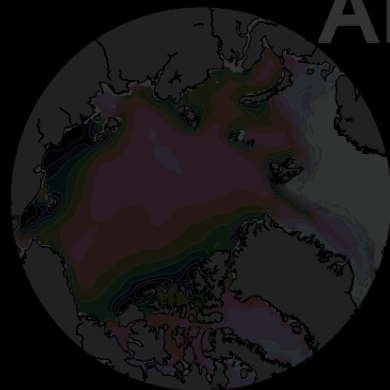
SIT(m decade⁻¹)

STD

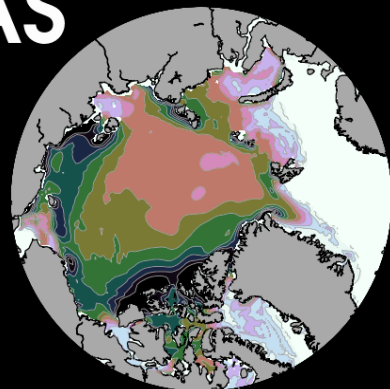
JFM



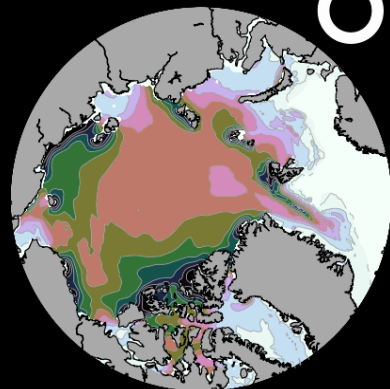
AMJ



JAS



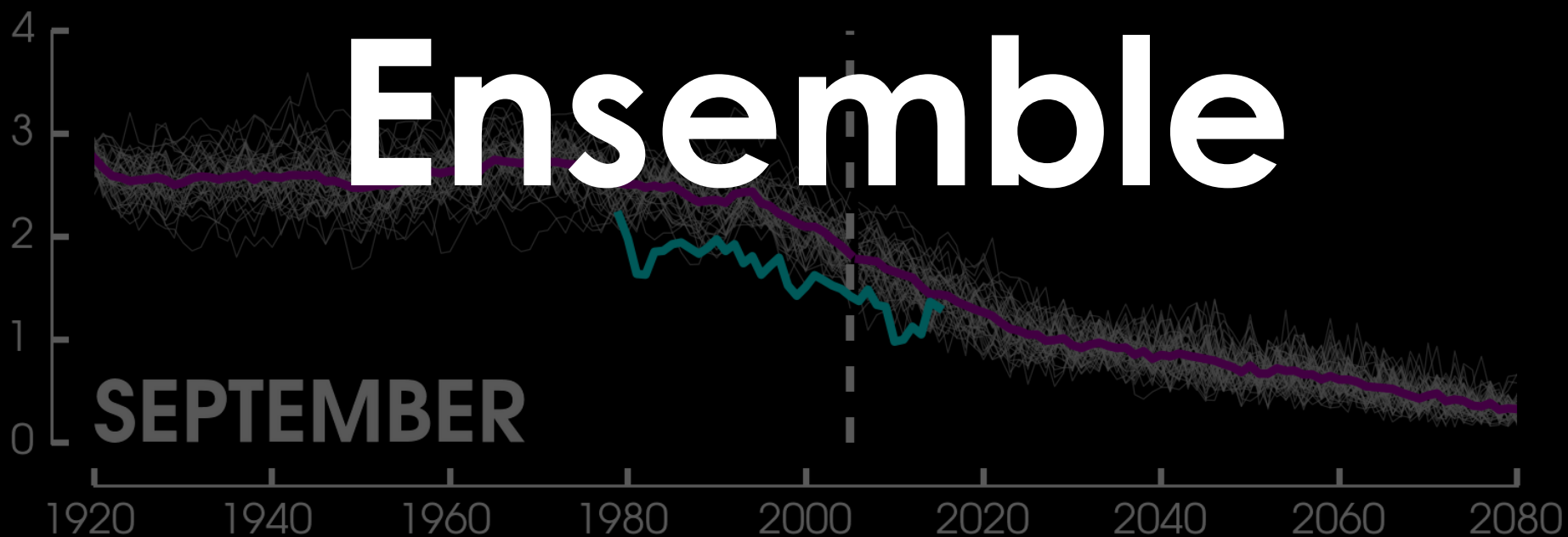
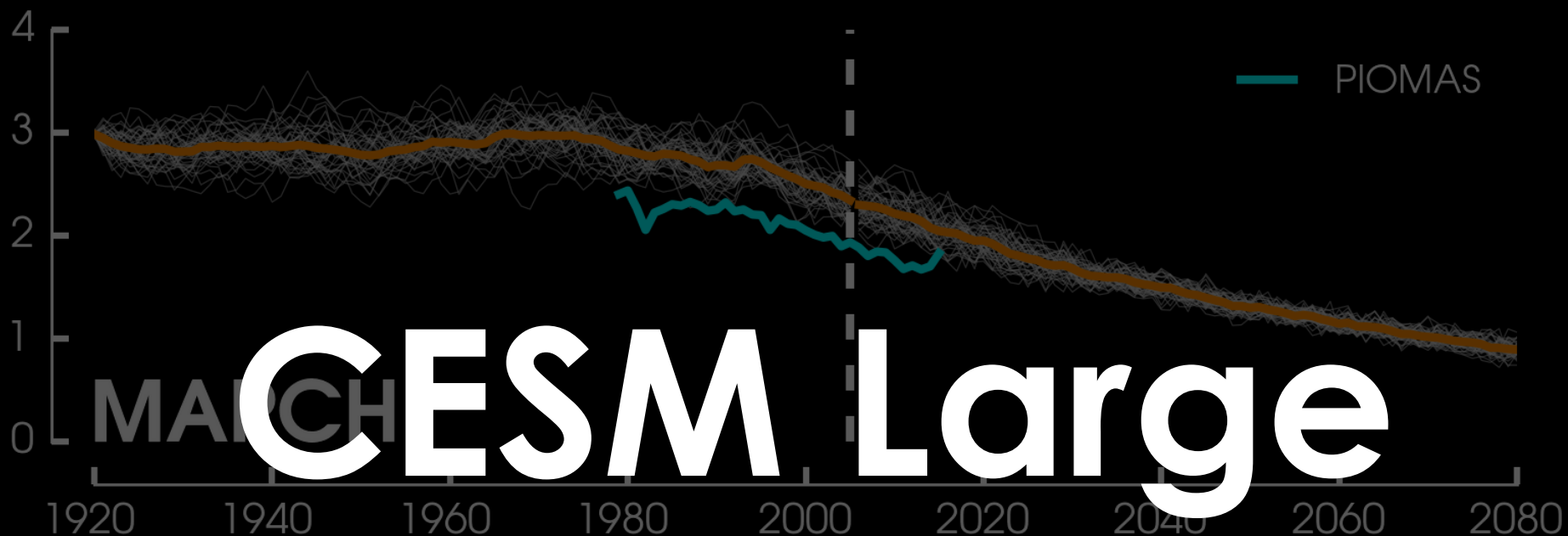
OND

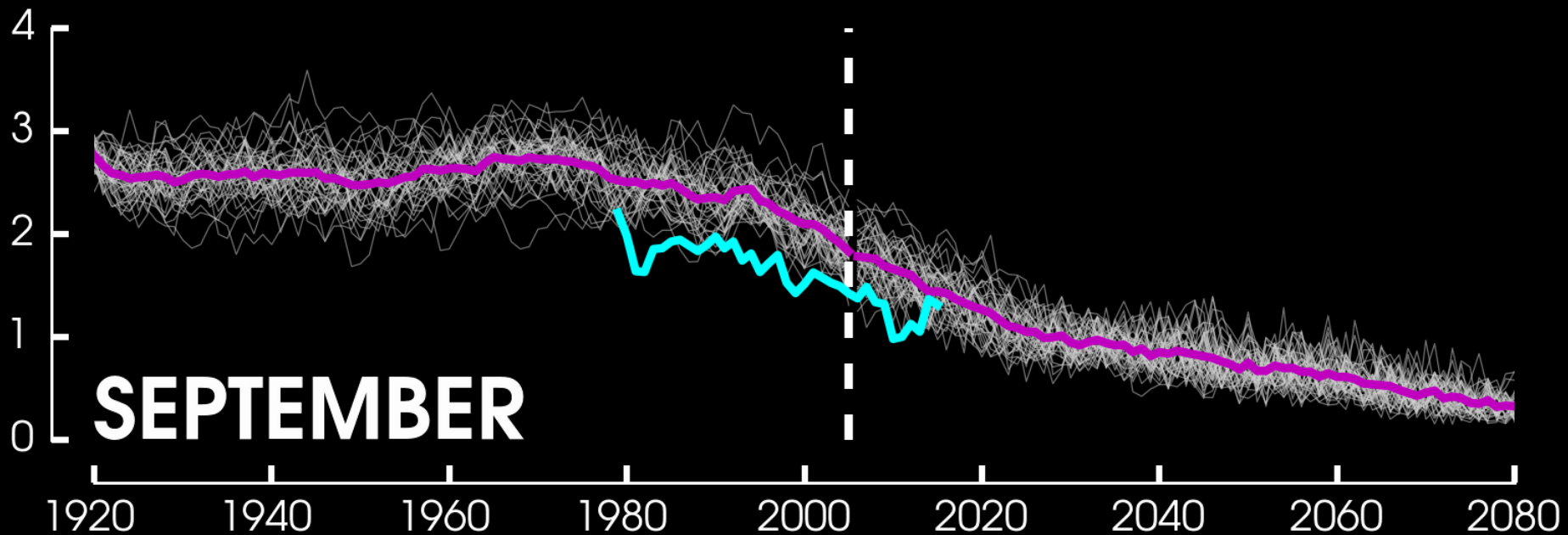
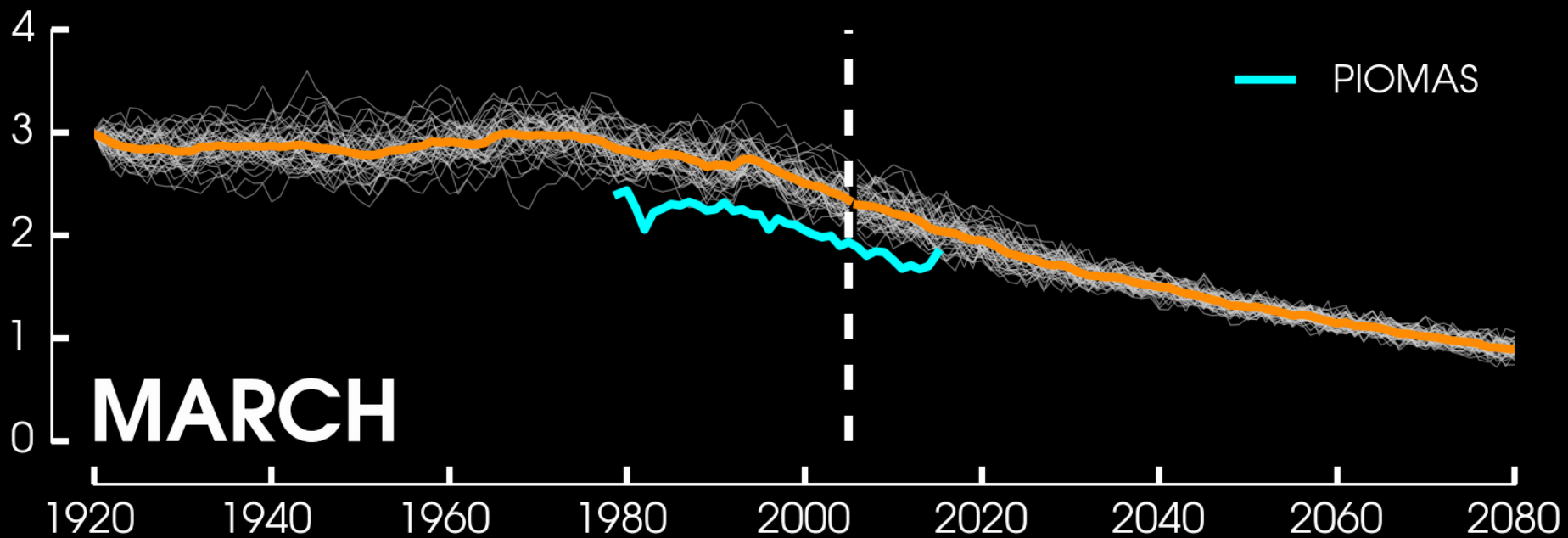


1979-2015

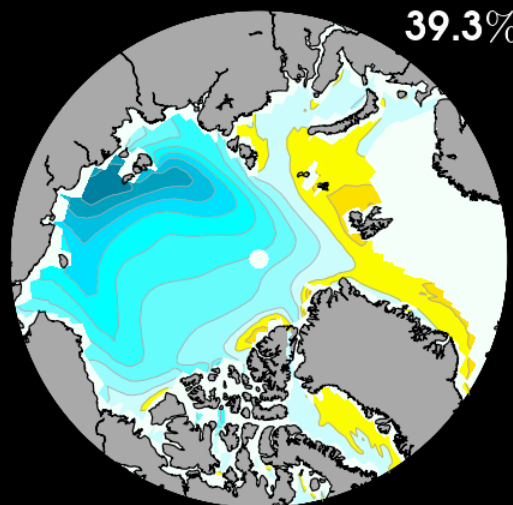


meters





EOF1



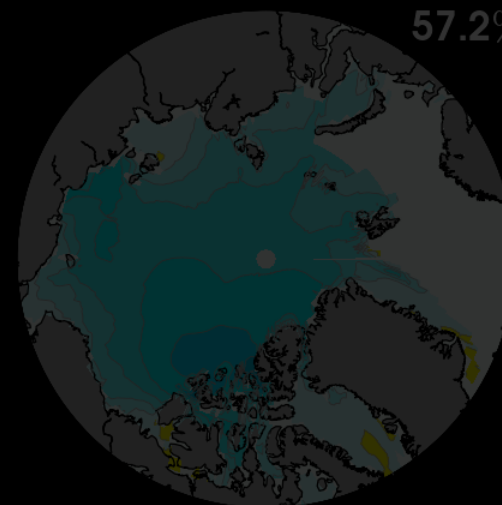
39.3%

1920-2005



53.3%

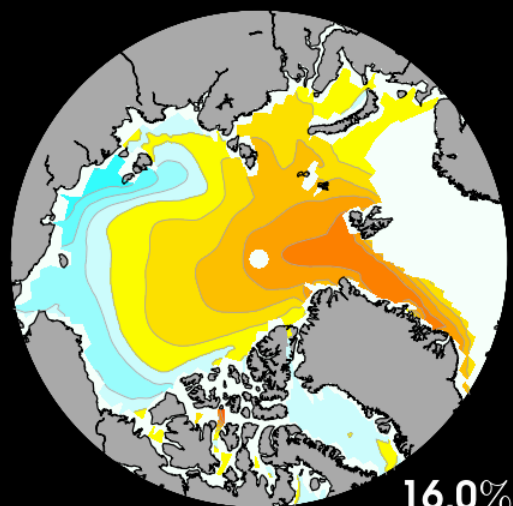
1979-2015



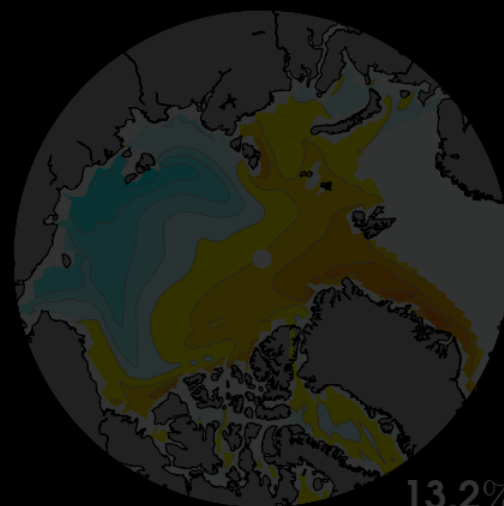
57.2%

PIOMAS

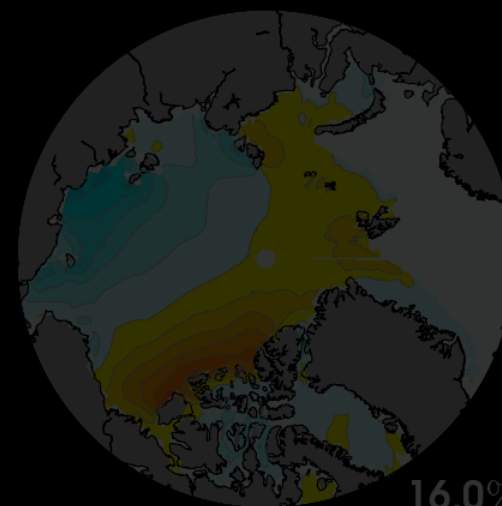
EOF2



16.0%



13.2%



16.0%



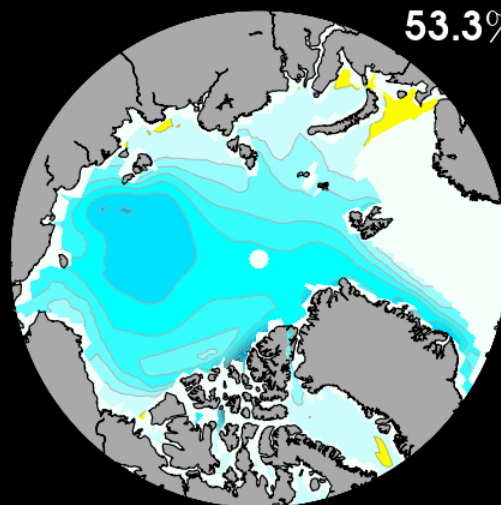
m

EOF1



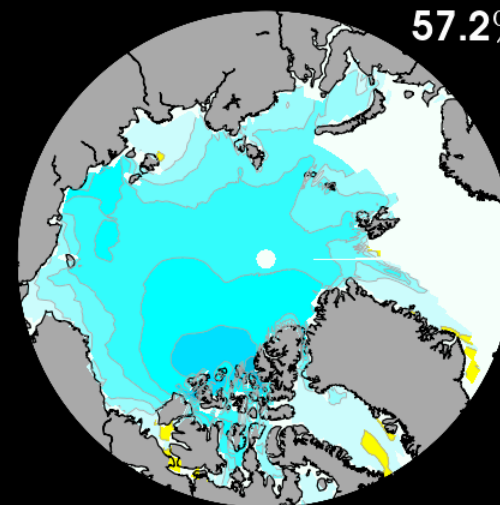
39.3%

1920-2005



53.3%

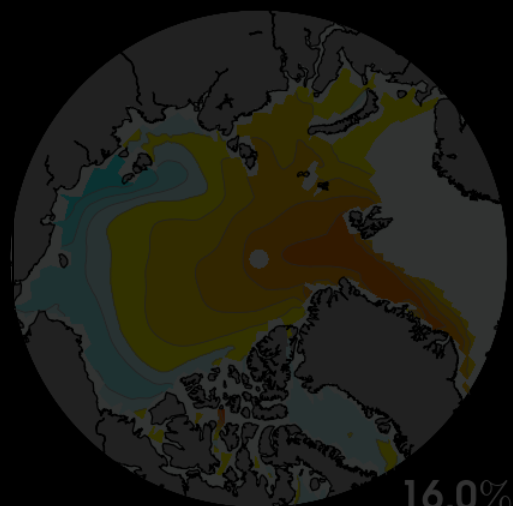
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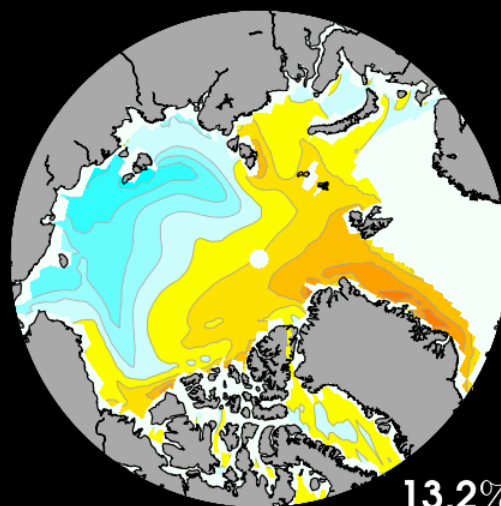
57.2%

PIOMAS

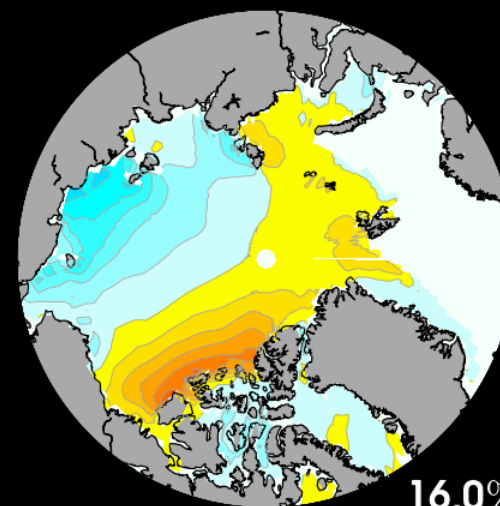
EOF2



16.0%



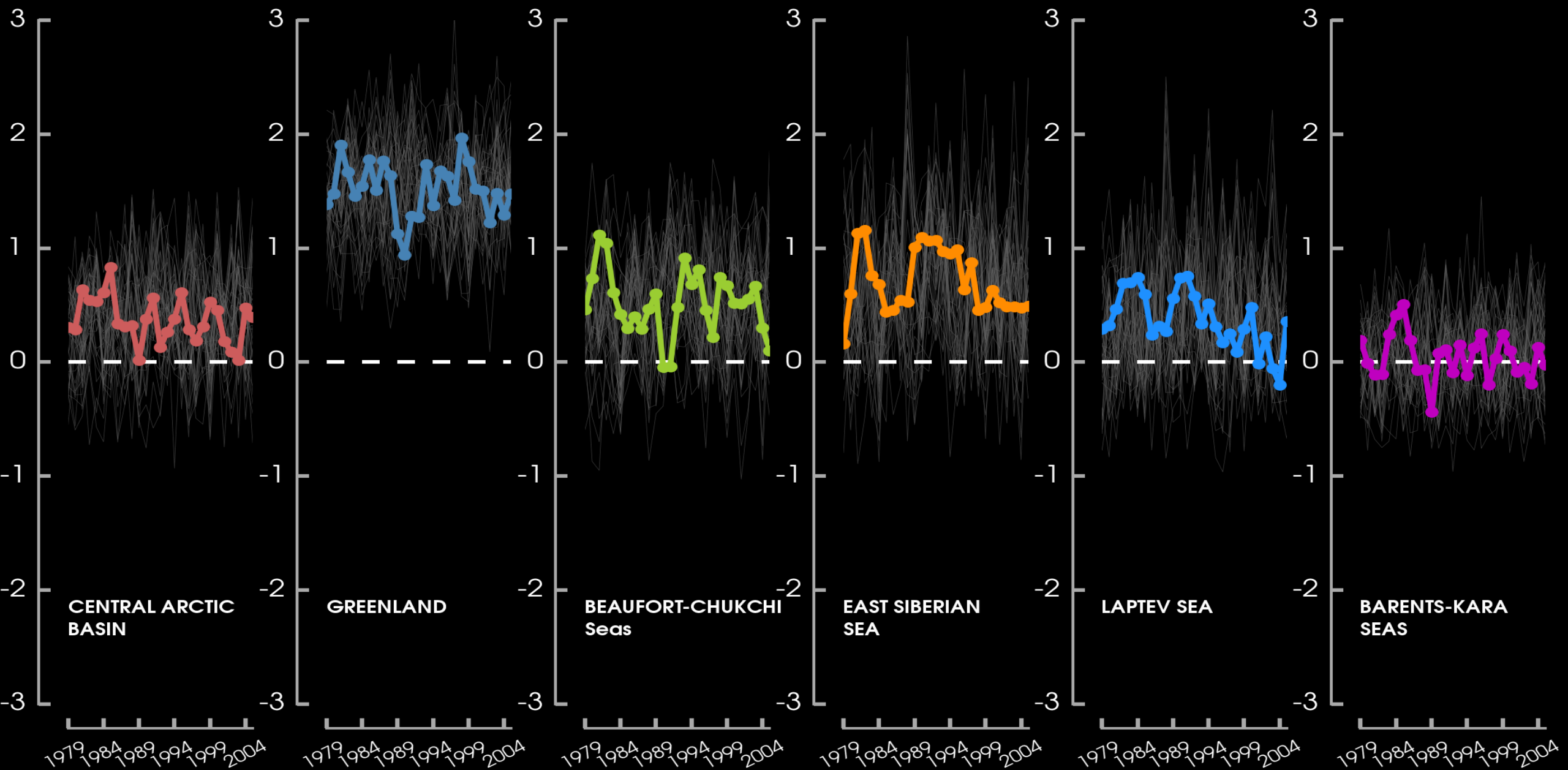
13.2%



16.0%

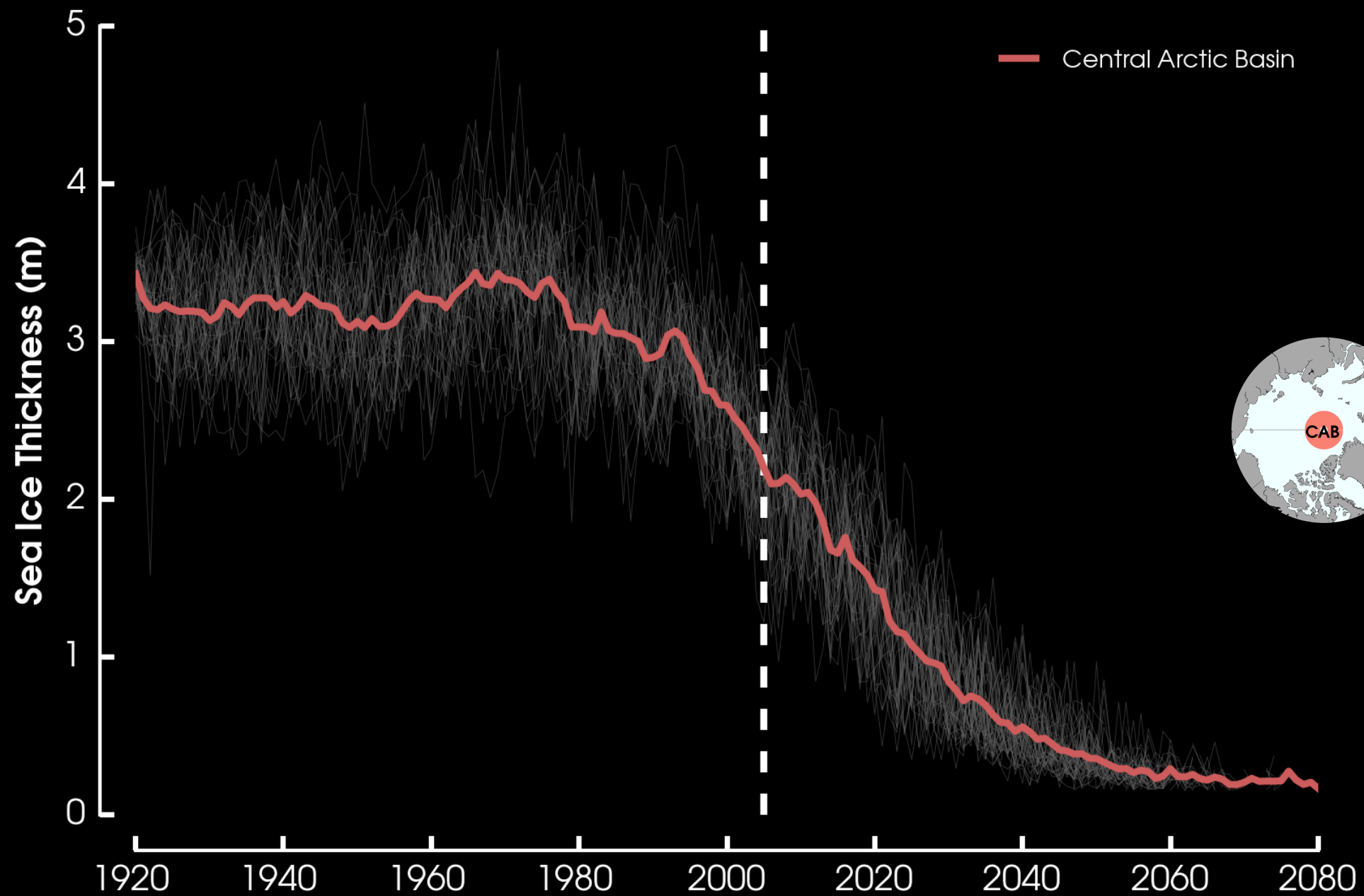


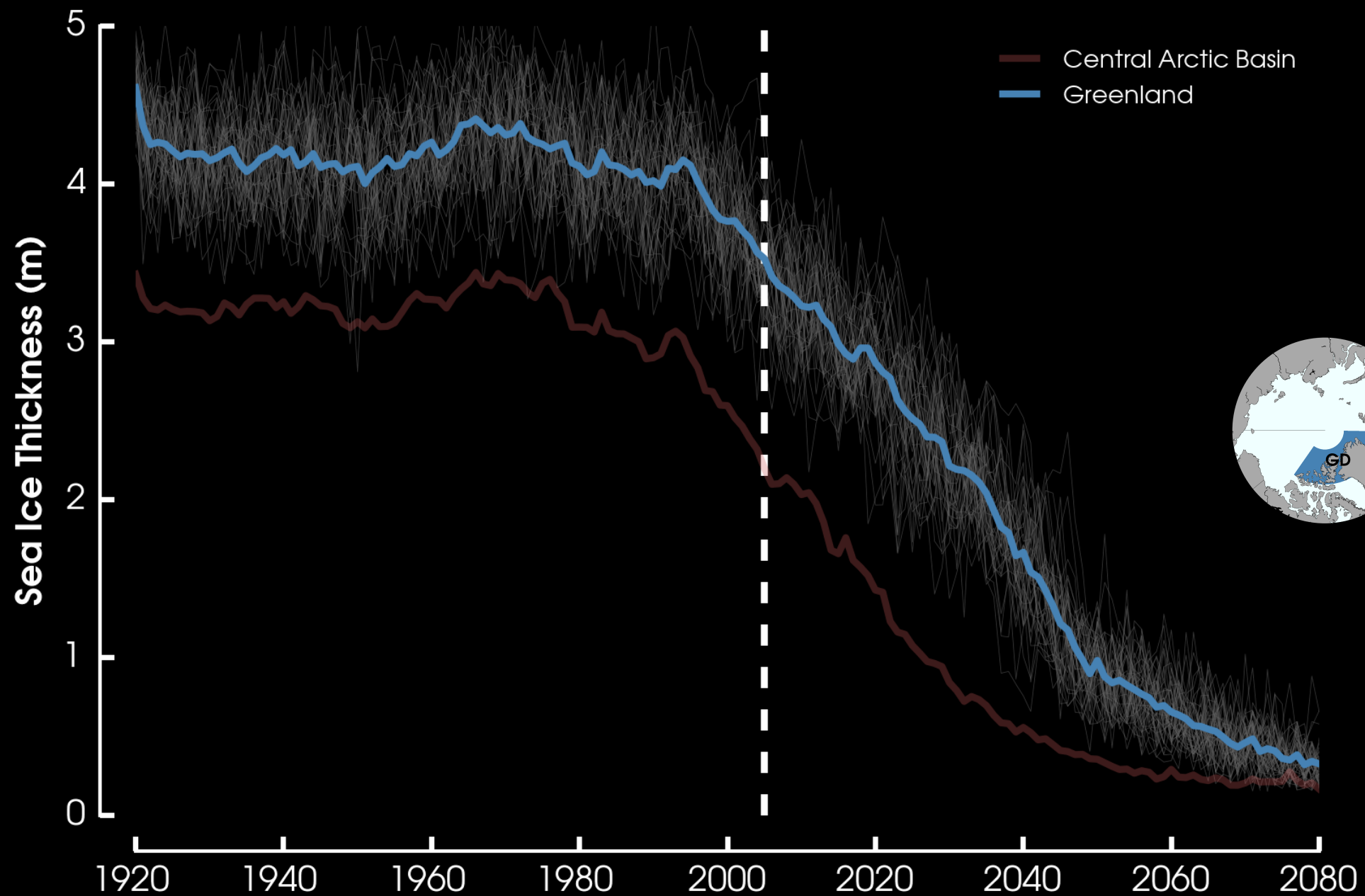
m

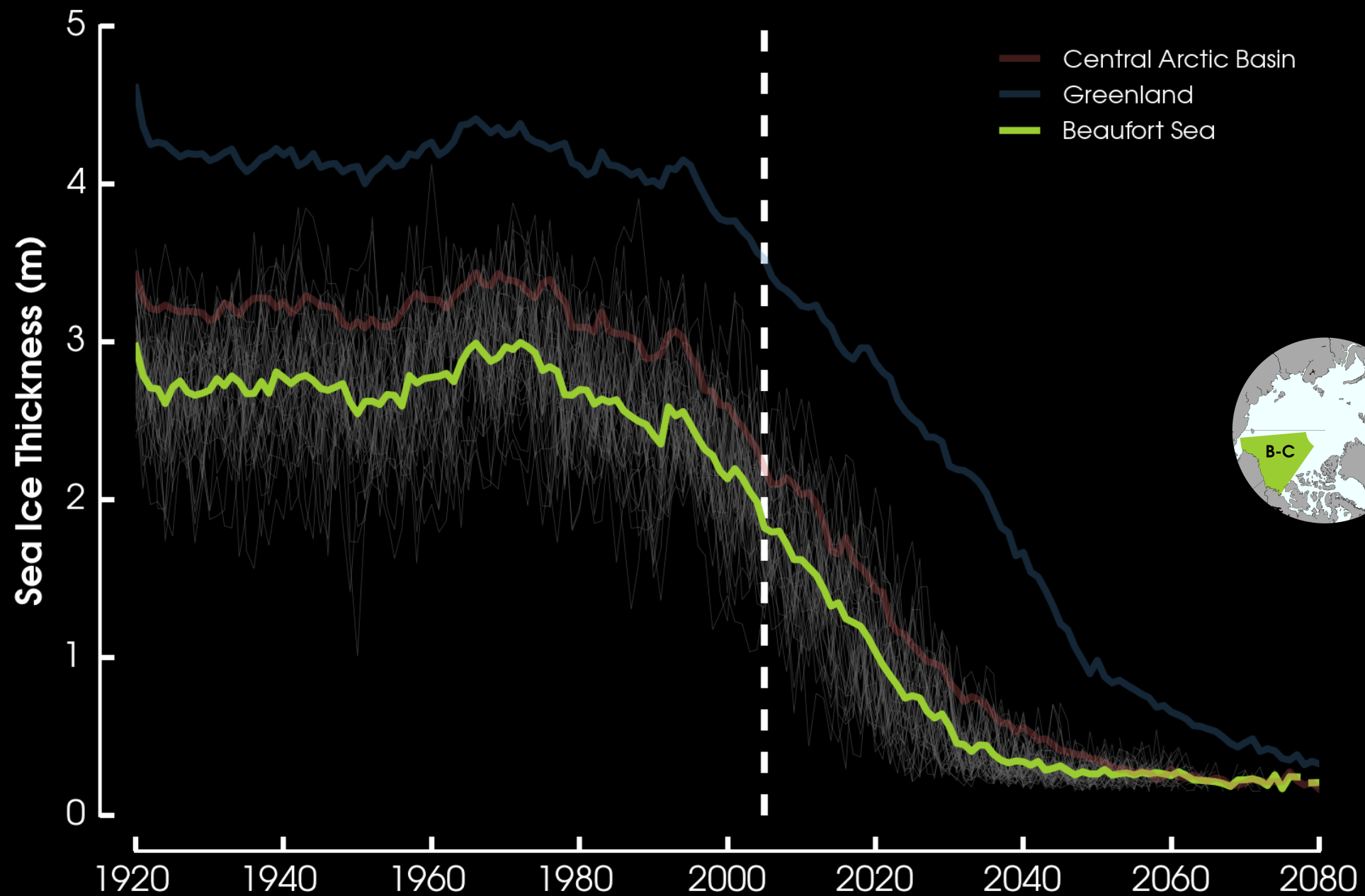


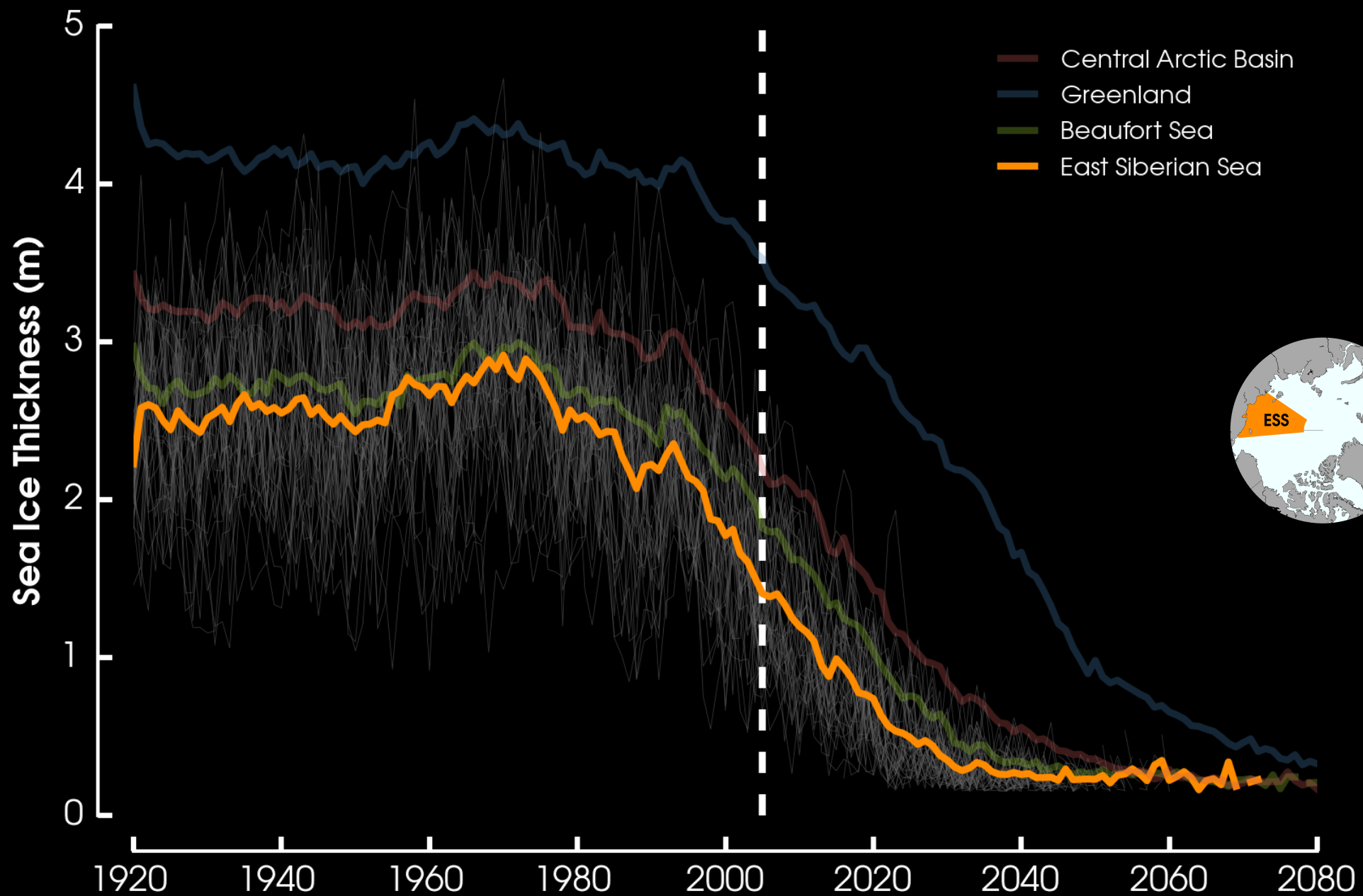
Future projections of sea ice thickness

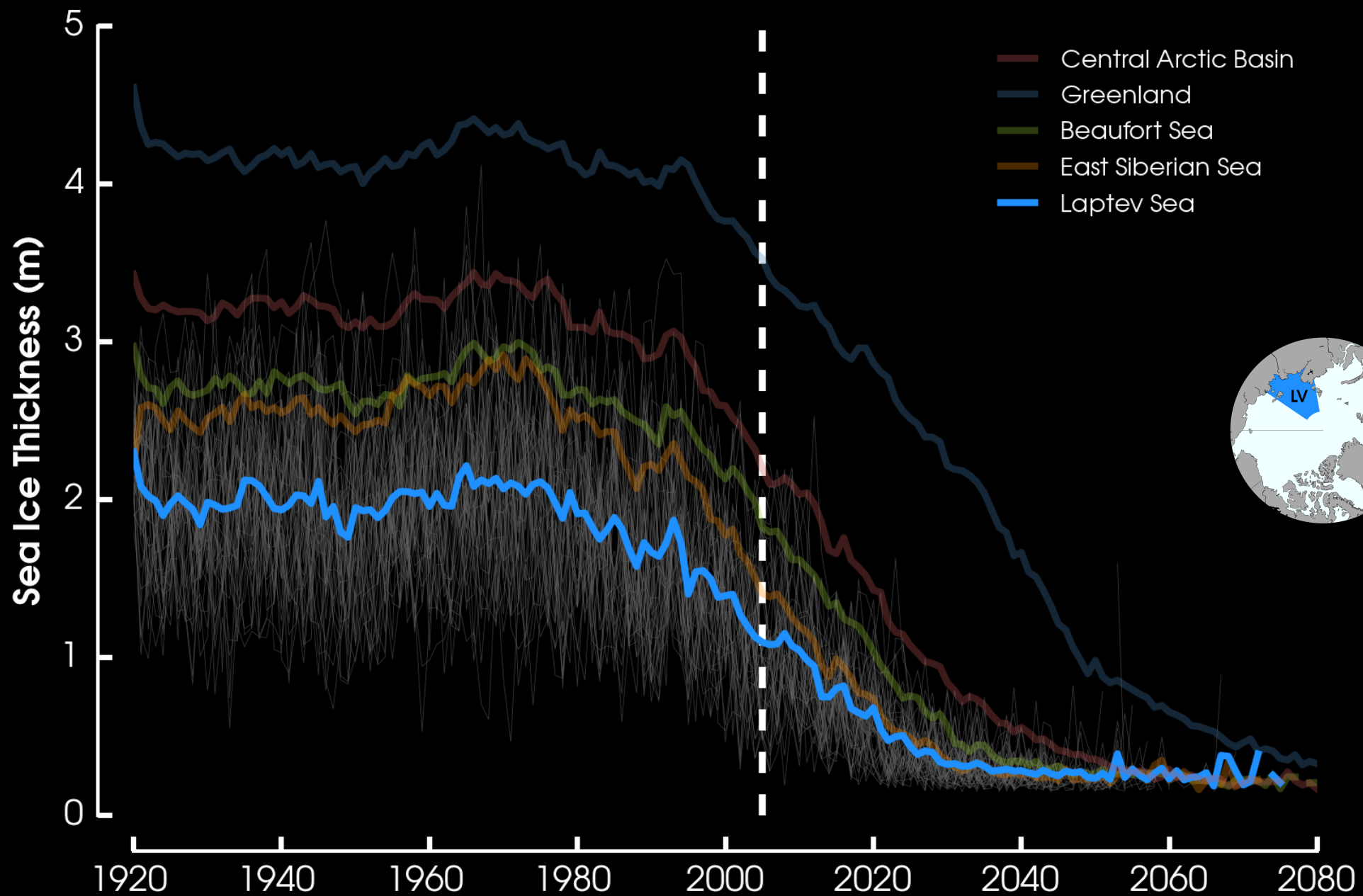
A map of the Arctic region is visible in the background, overlaid with a color-coded projection of sea ice thickness. The colors range from dark purple to light blue, indicating varying levels of ice thickness. The map shows the Arctic Ocean and surrounding landmasses, with the ice thickness projections concentrated in the central and peripheral areas of the Arctic.

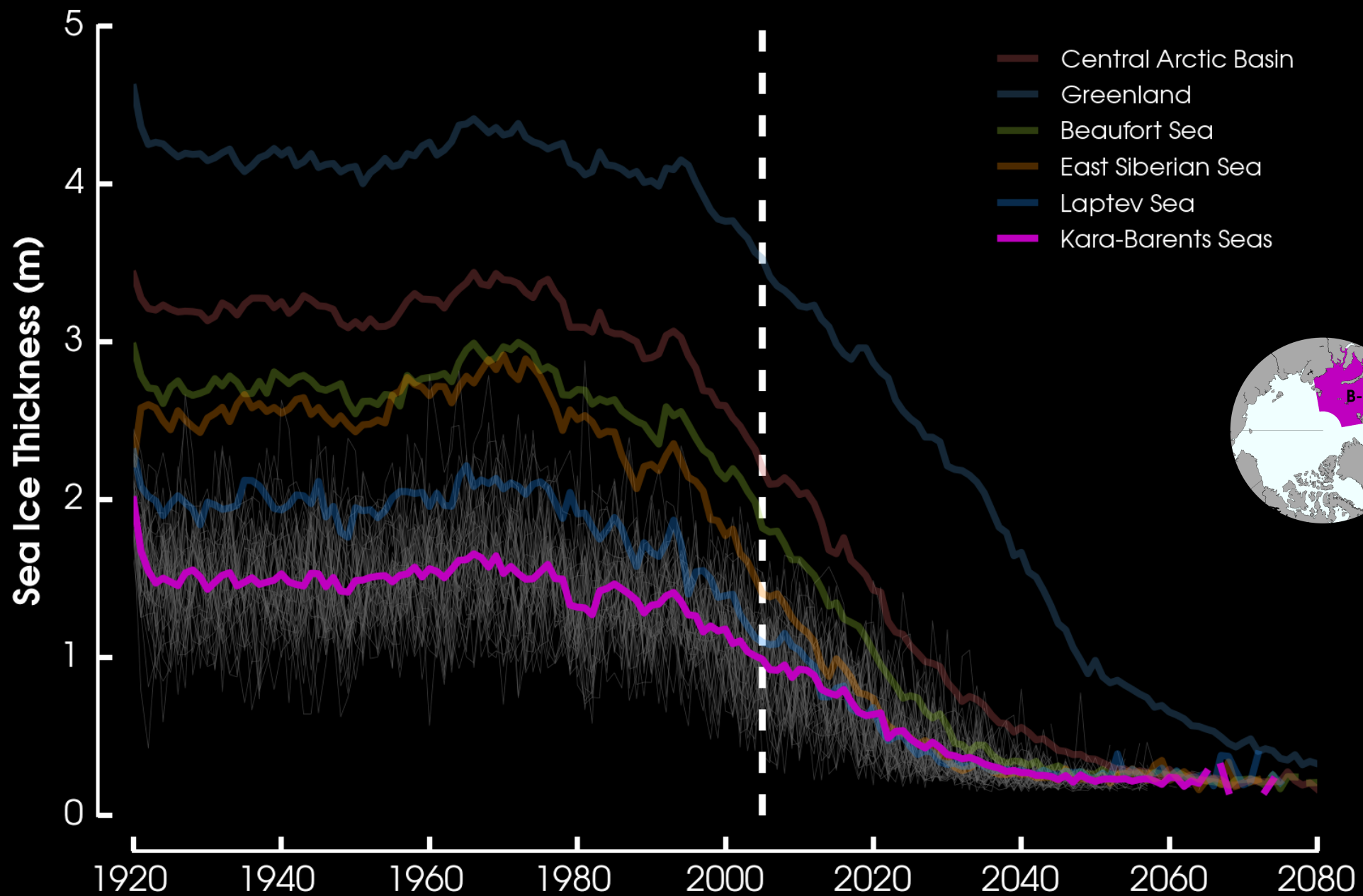




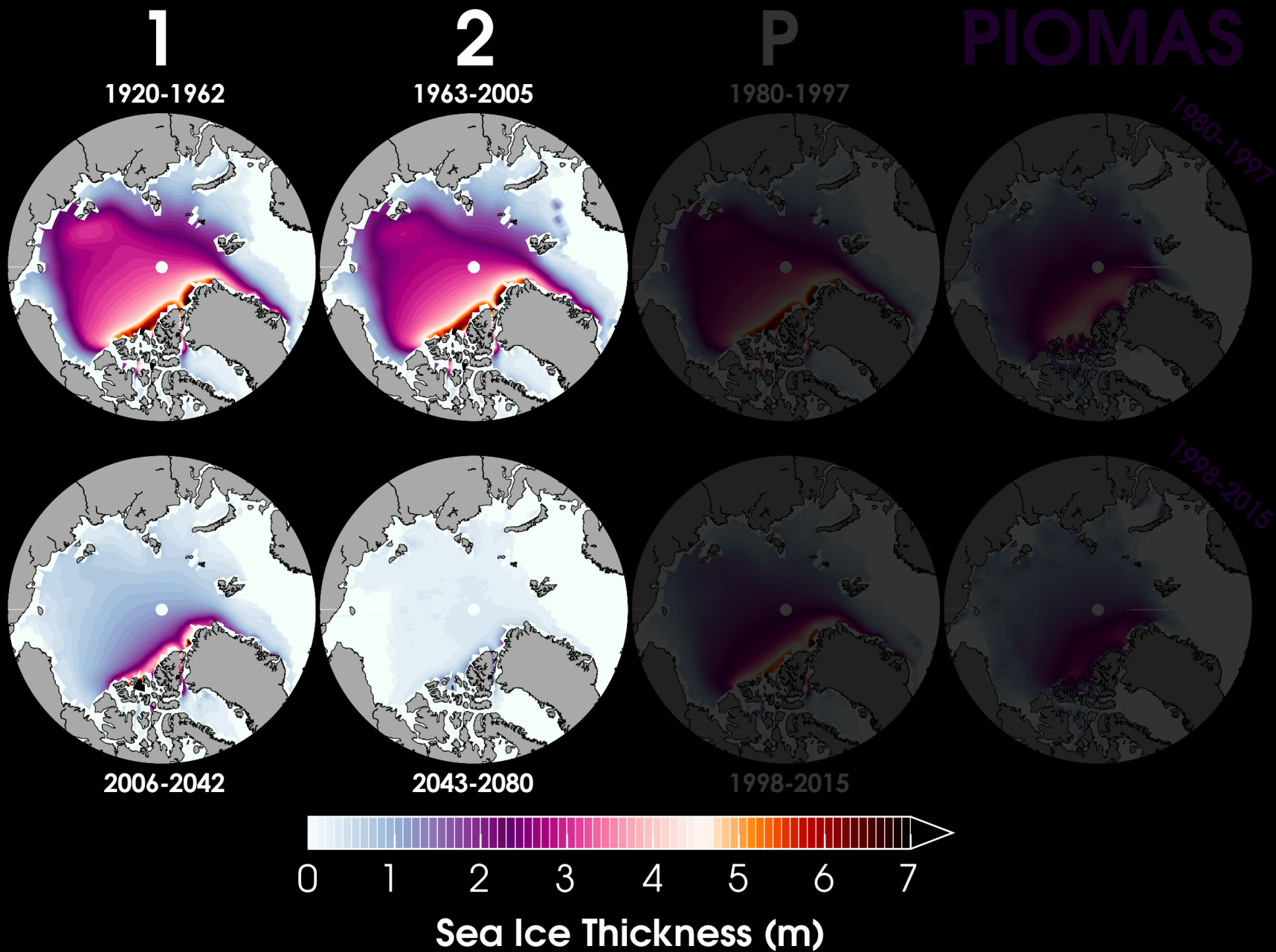








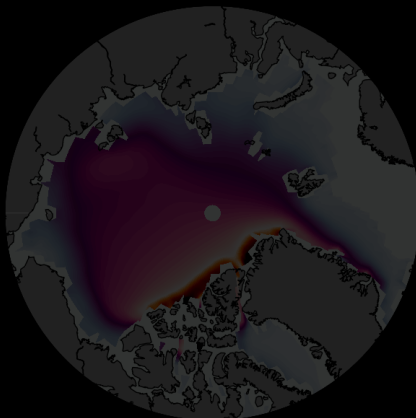
RCP8.5 Historical



Historical
RCP8.5

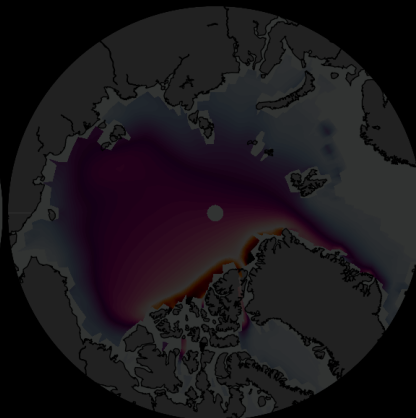
1

1920-1962



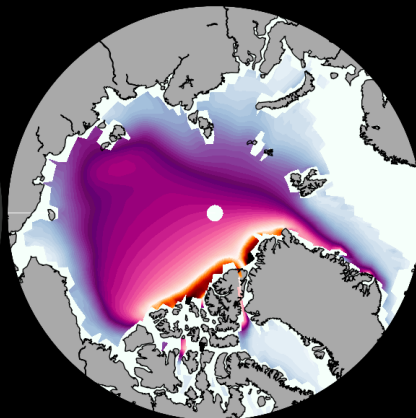
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1963-2005



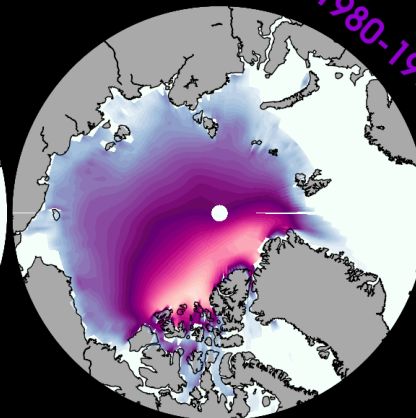
P

1980-1997

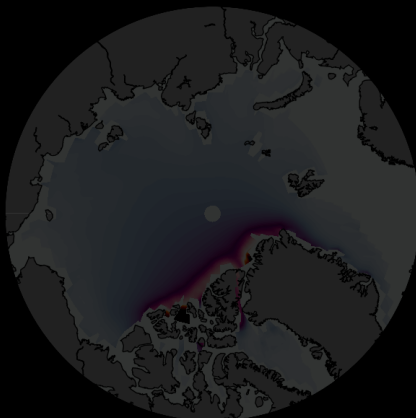


PIOMAS

1980-1997



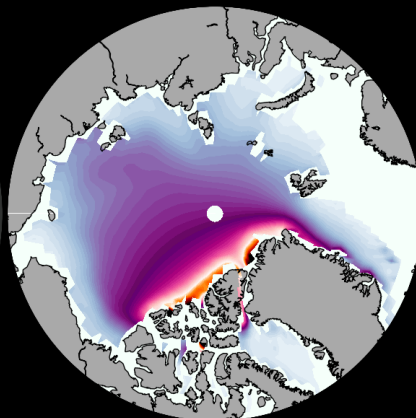
2006-2042



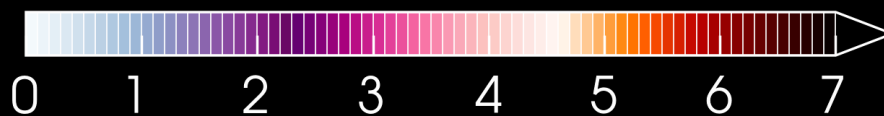
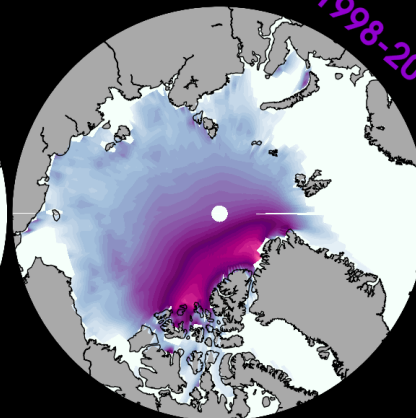
2043-2080



1998-2015

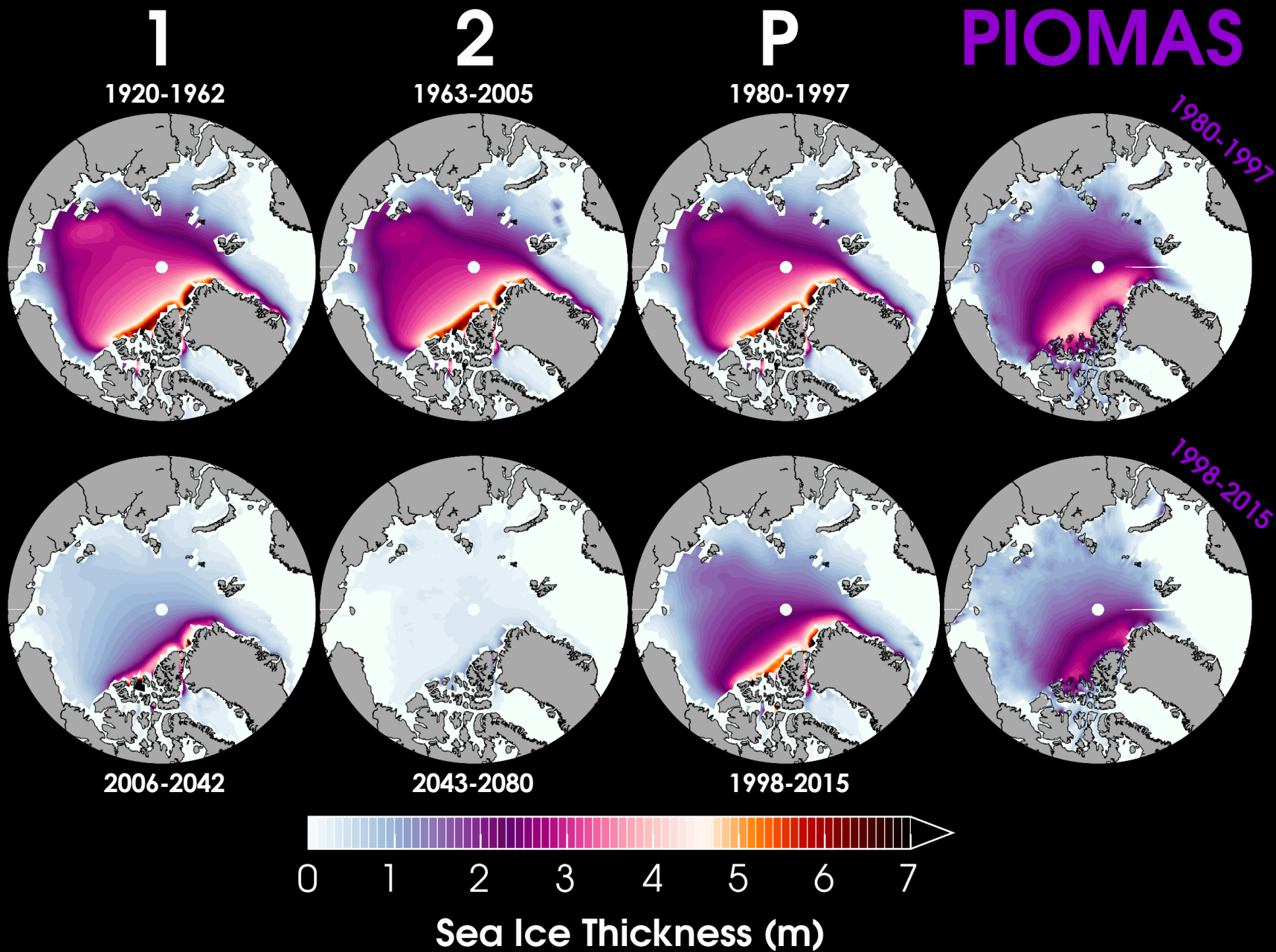


1998-2015

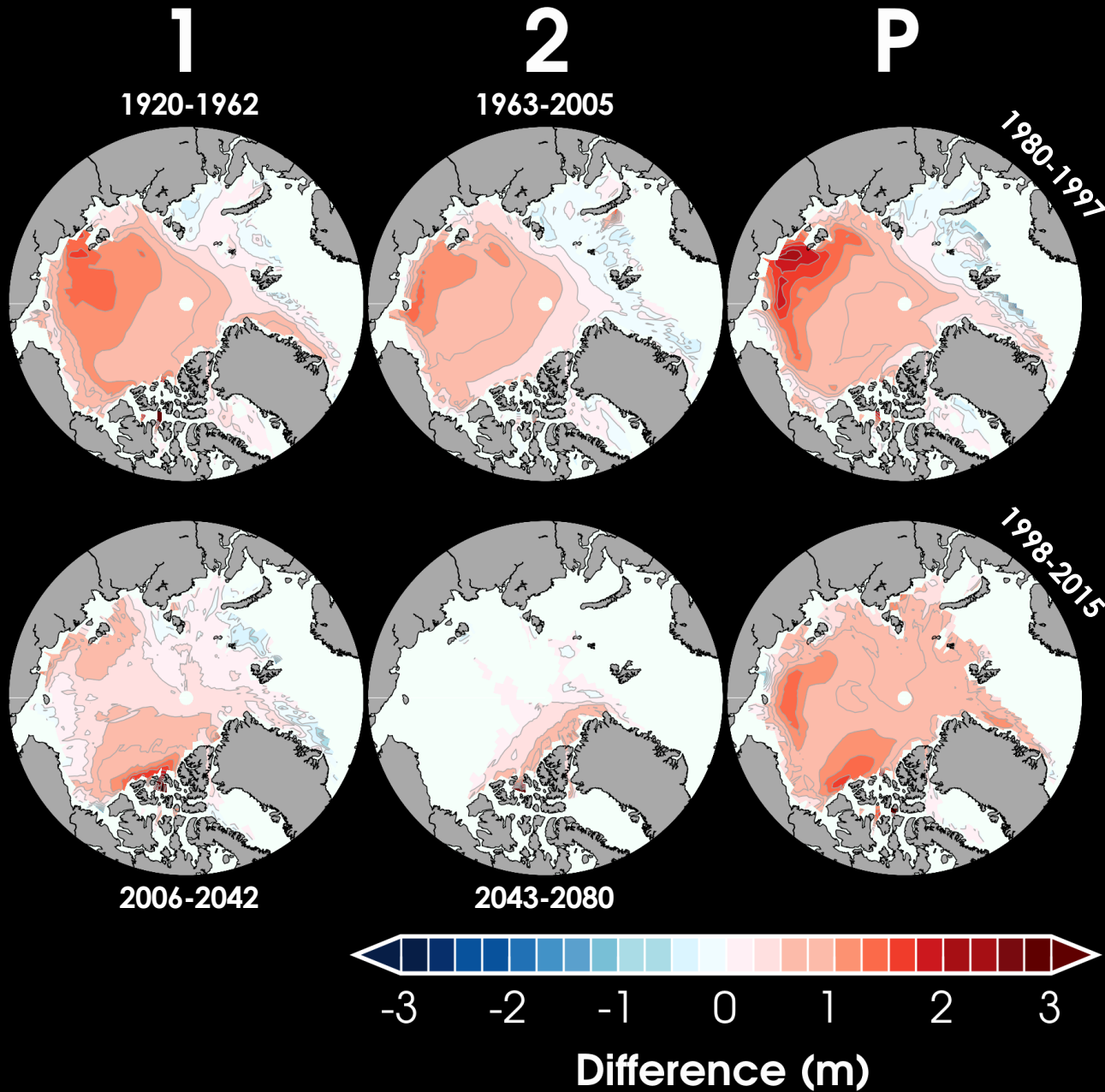


Sea Ice Thickness (m)

Historical RCP8.5



RCP8.5 Historical



Large ensemble spread over the East Siberian Sea

Reduction in future ensemble spread with increased surface warming

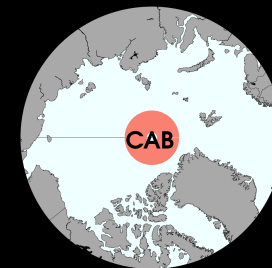
Ensemble Number

JFM

AMJ

JAS

OND

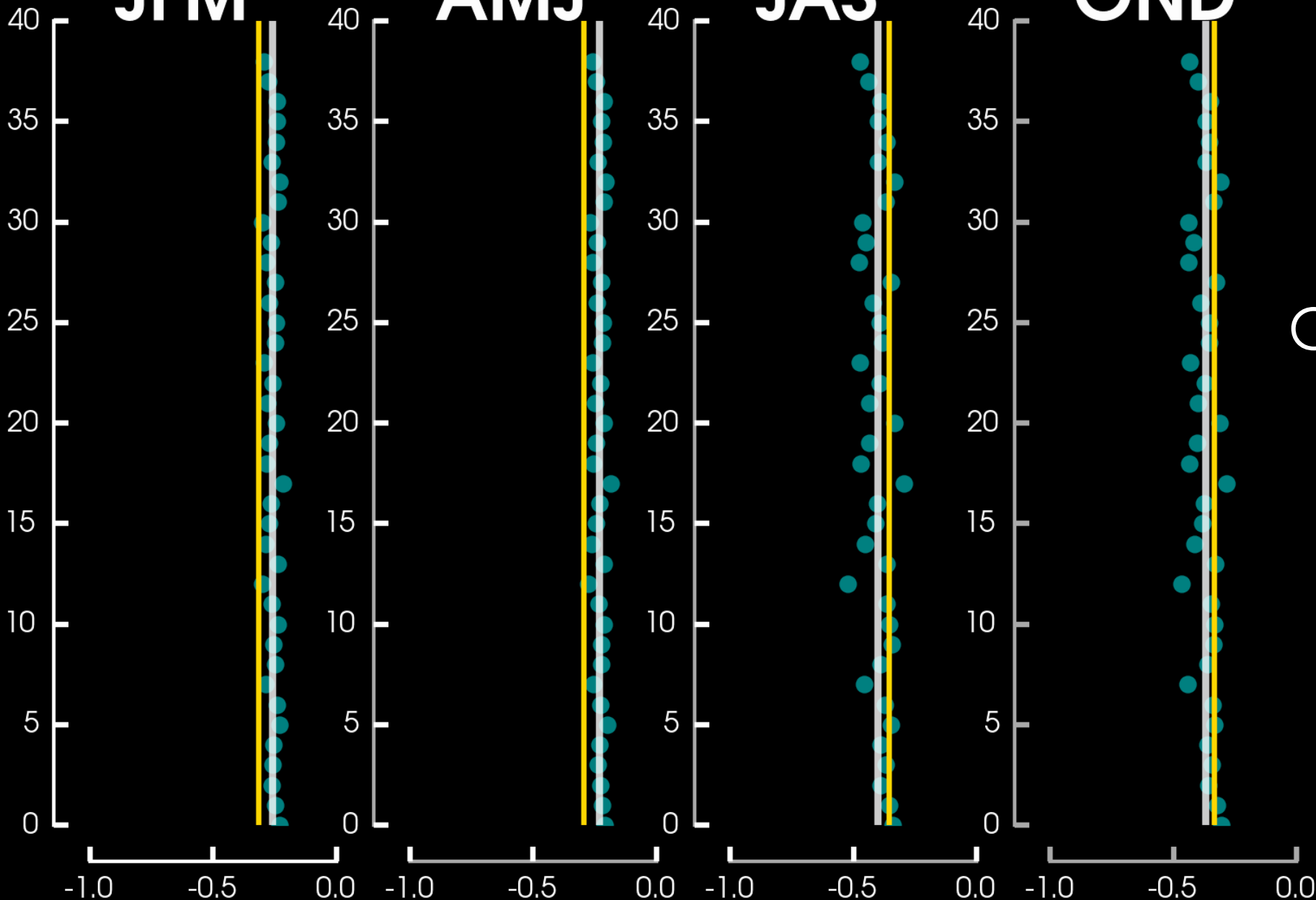


Central Arctic
Basin

Trend



LENS (2006-2080)
PIOMAS (1979-2015)



Ensemble Number

JFM

AMJ

JAS

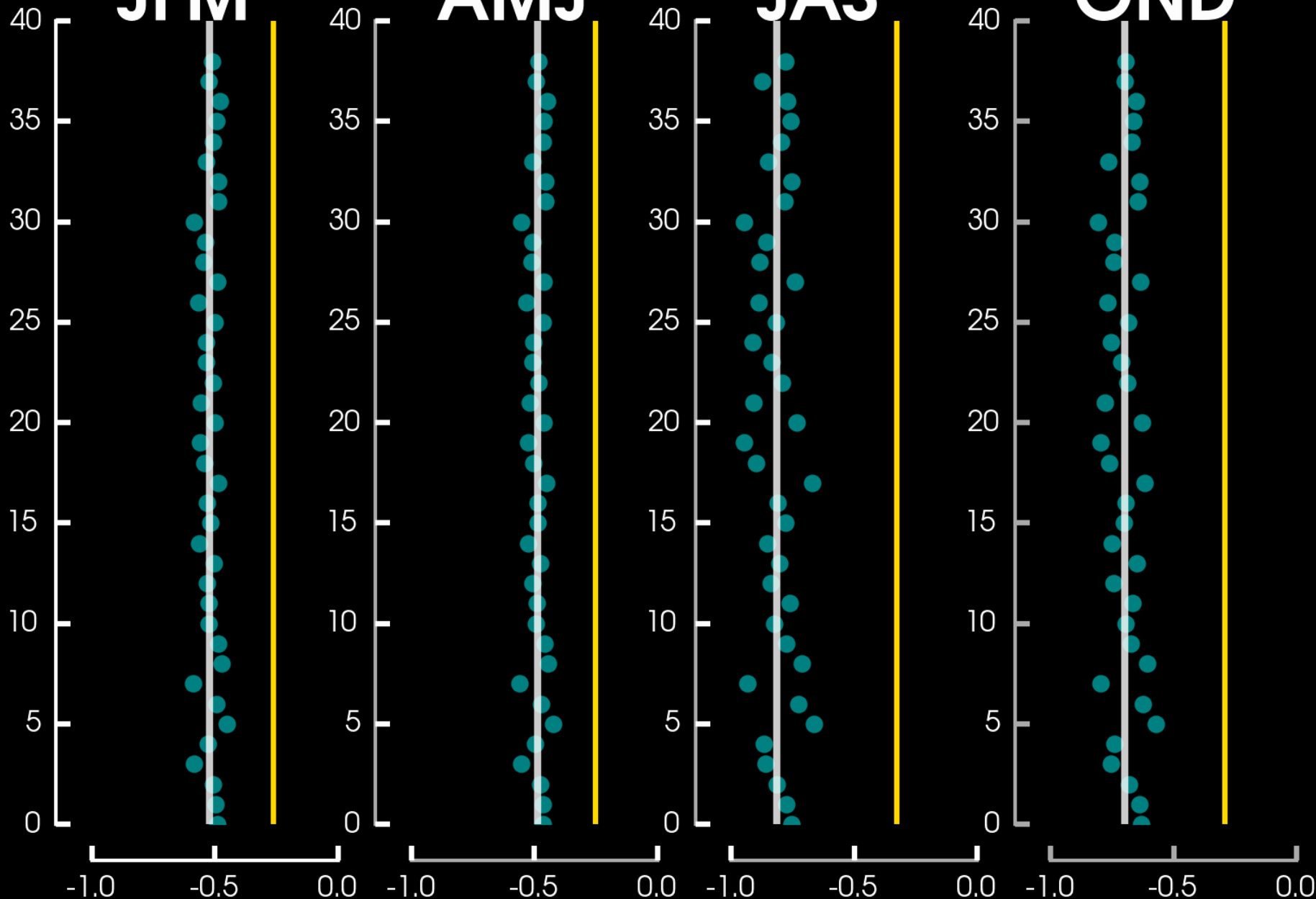
OND



Coastal
Greenland

← Trend

LENS (2006-2080)
PIOMAS (1979-2015)



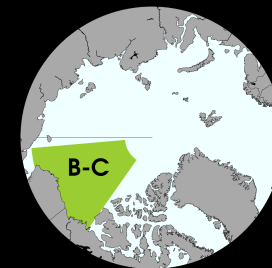
Ensemble Number

JFM

AMJ

JAS

OND

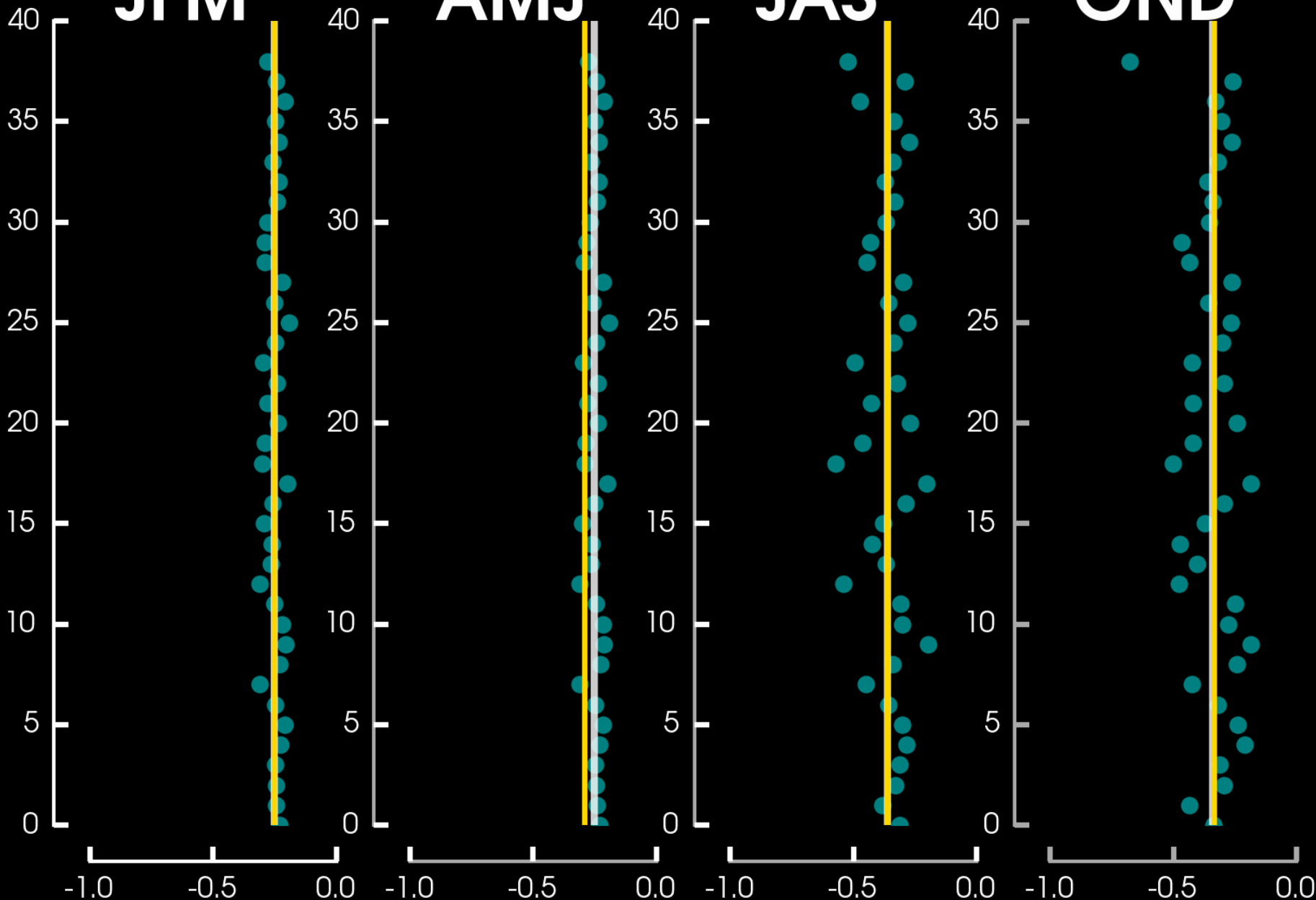


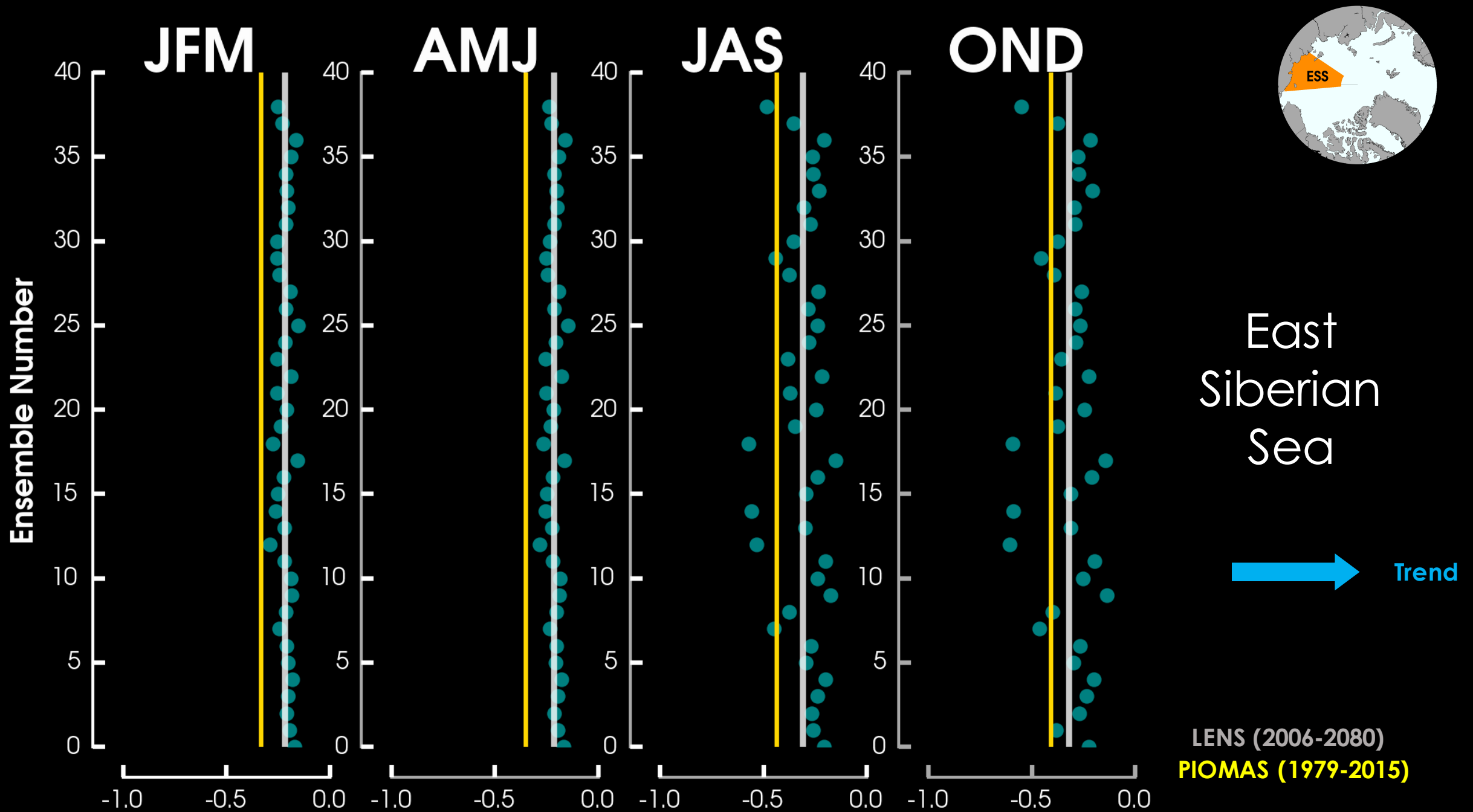
Beaufort-
Chukchi
Seas



Trend

LENS (2006-2080)
PIOMAS (1979-2015)





Ensemble Number

JFM

AMJ

JAS

OND

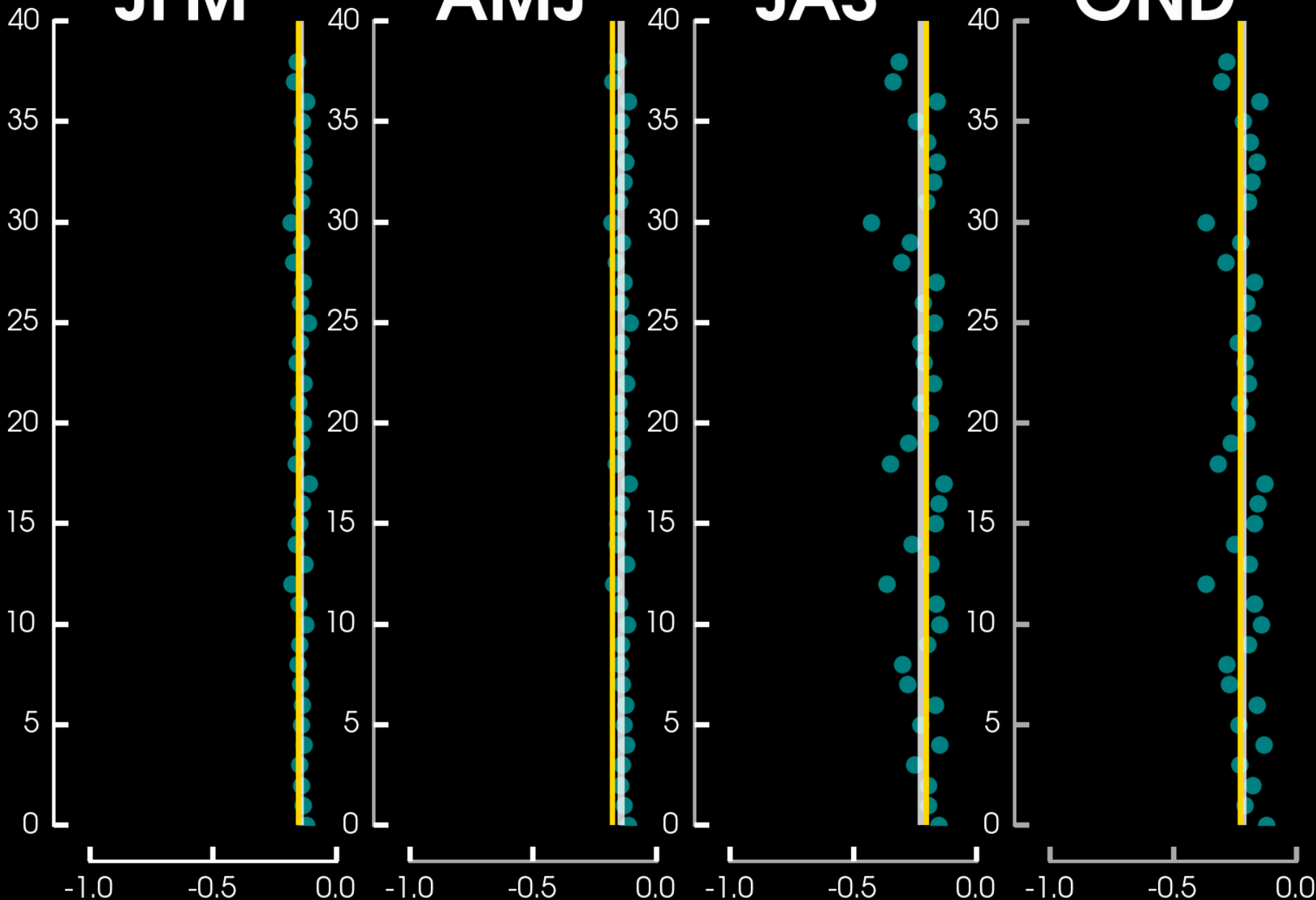


Laptev
Sea



Trend

LENS (2006-2080)
PIOMAS (1979-2015)



Ensemble Number

JFM

AMJ

JAS

OND

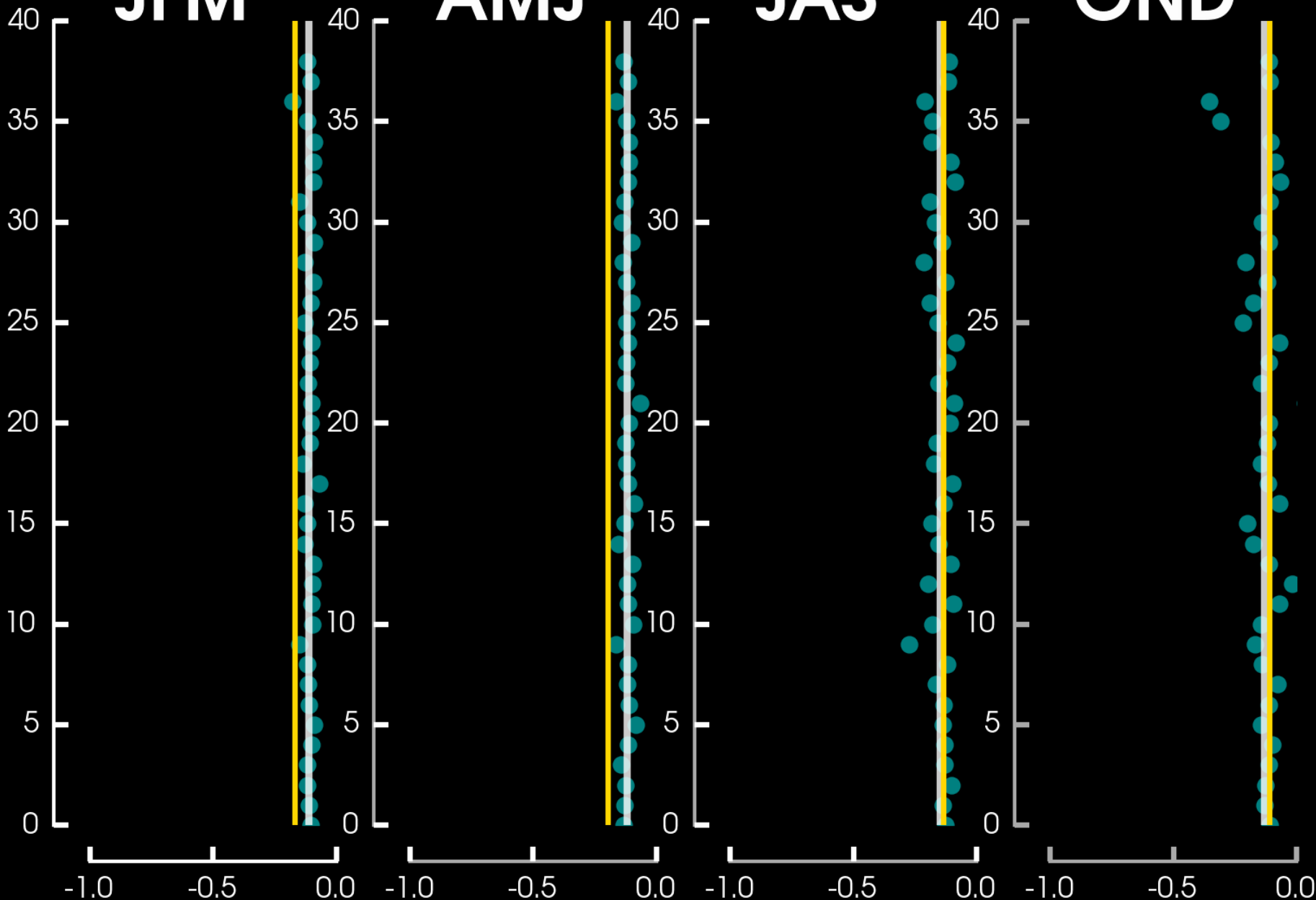


Kara-
Barents
Seas

Trend



LENS (2006-2080)
PIOMAS (1979-2015)



Improves our understanding of regional variability of Arctic sea ice thickness

Demonstrates significance of internal variability on Arctic climate system (sea ice)

Highlights need for additional pan-Arctic sea ice thickness remote sensing observations

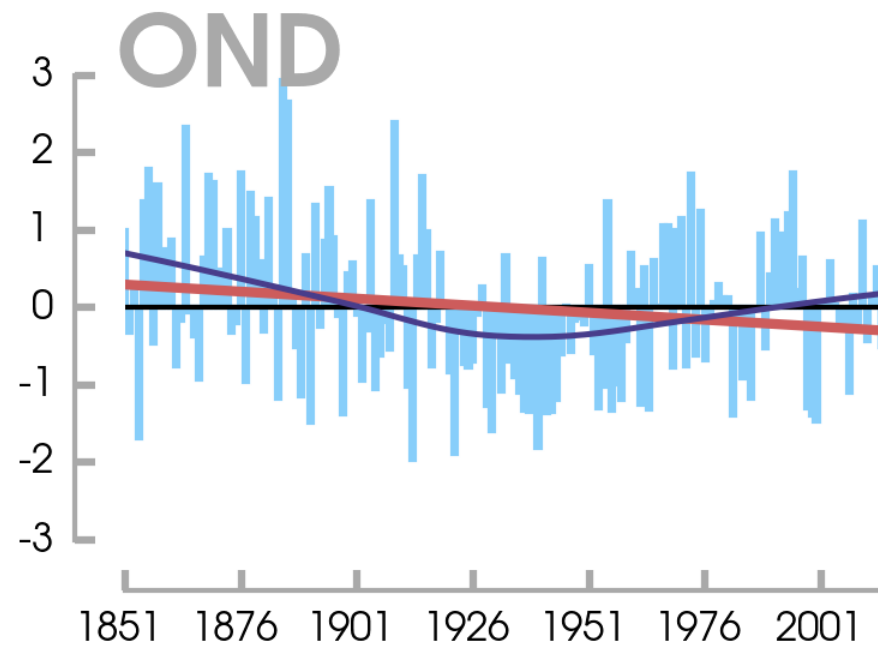
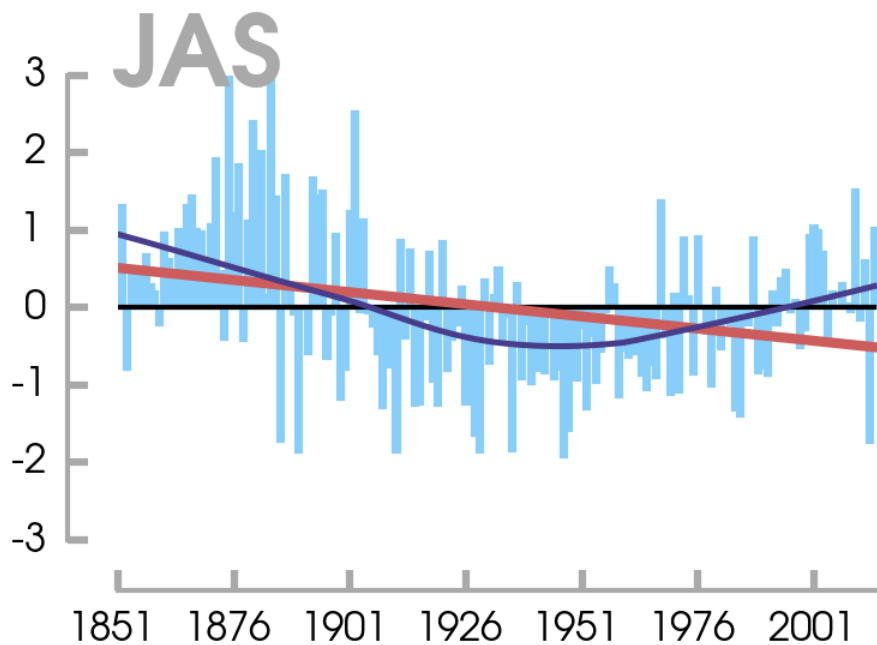
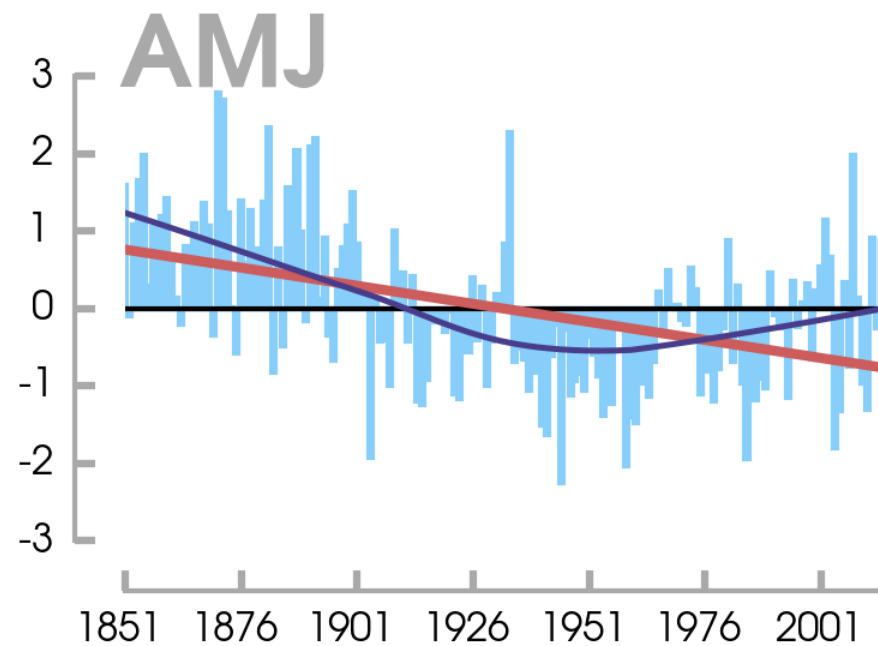
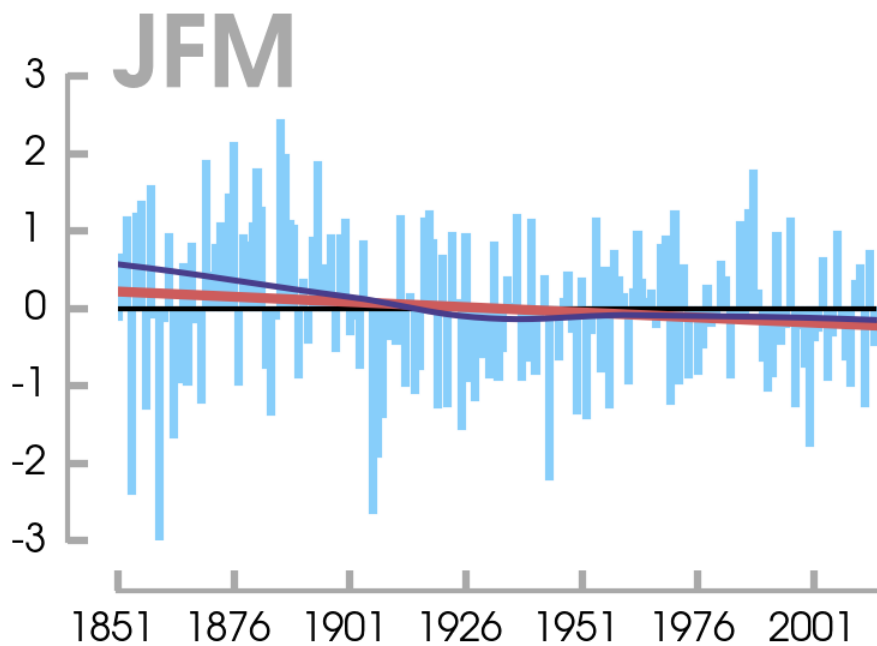
SIGNIFICANCE

Improves our understanding of regional variability of Arctic sea ice thickness

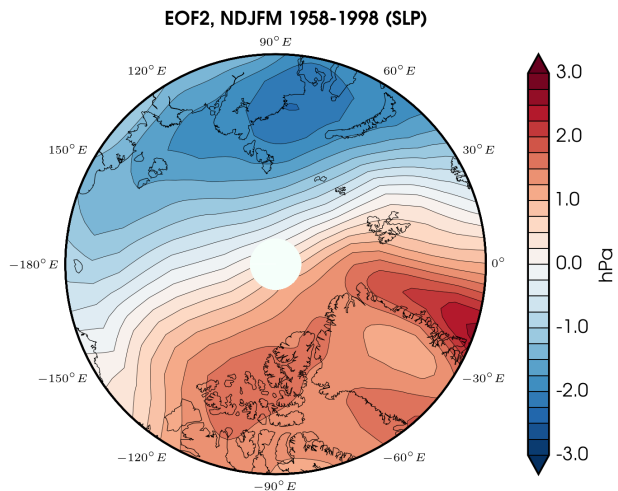
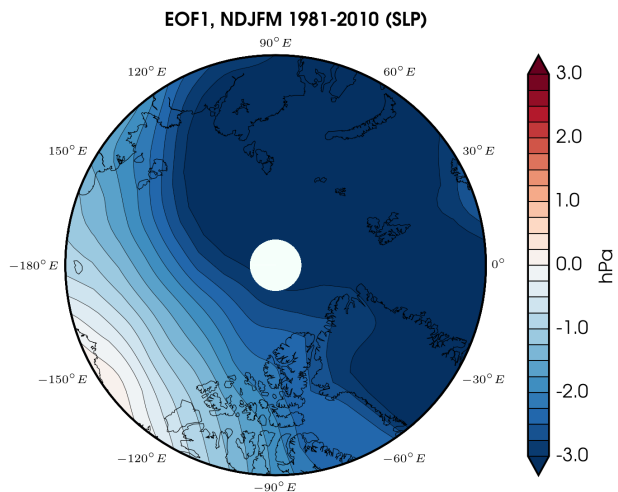
Demonstrates significance of internal variability on Arctic climate system (sea ice)

Highlights need for additional pan-Arctic sea ice thickness remote sensing observations

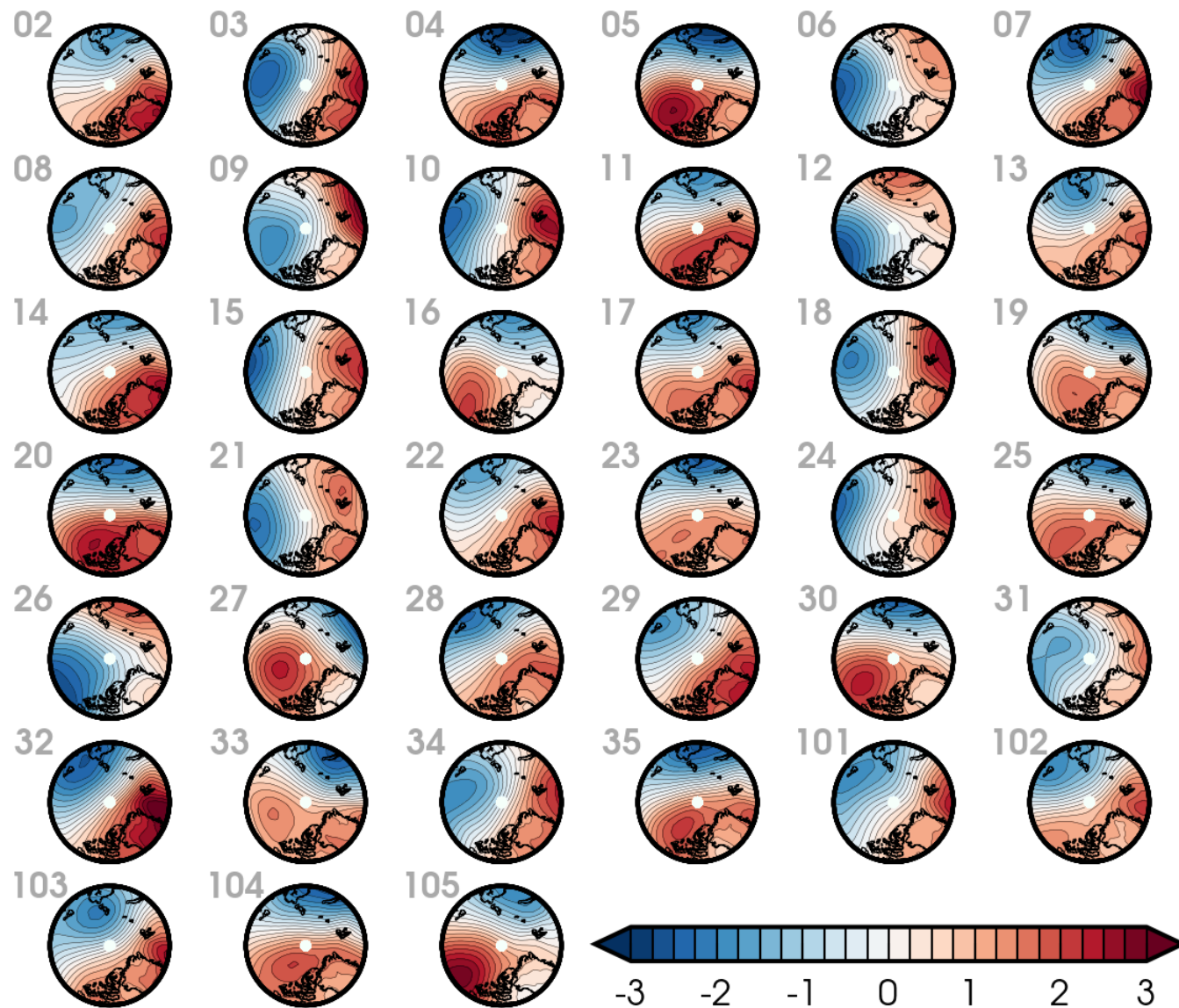
V2C - Arctic Dipole



LENS - Arctic Dipole

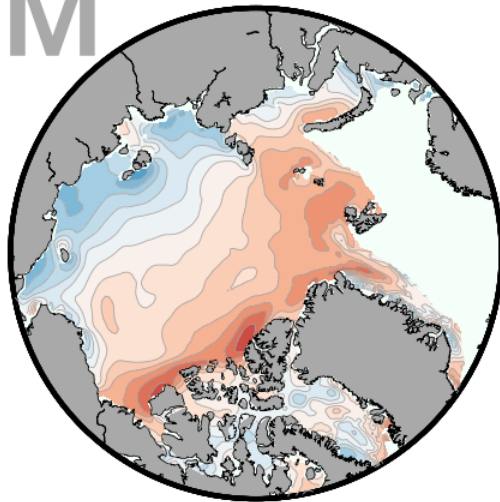


EOF2, NDJFM 1981-2010 (SLP) – LENS

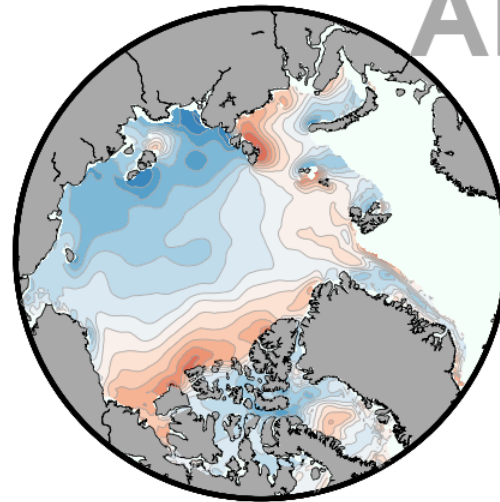


AO : SIT correlations

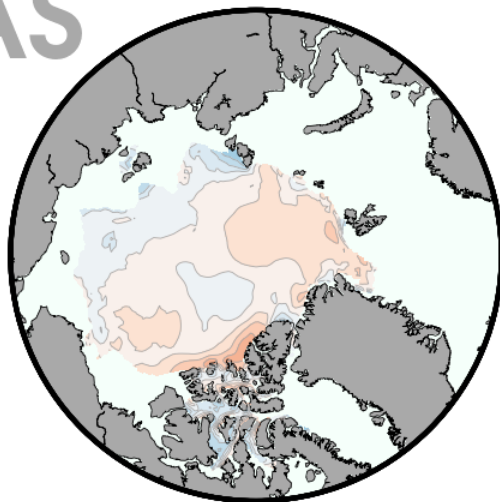
JFM



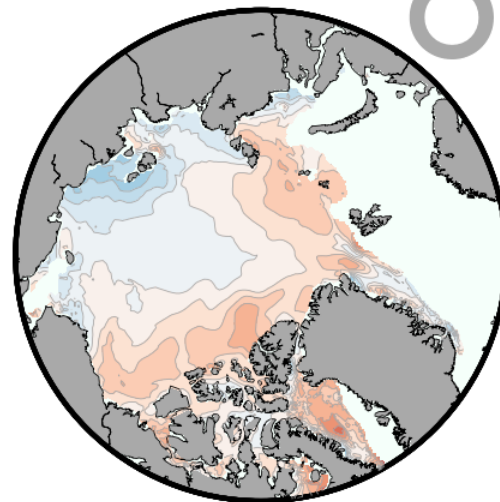
AMJ



JAS



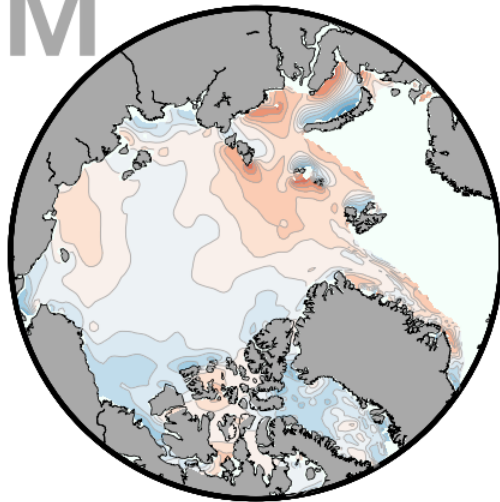
OND



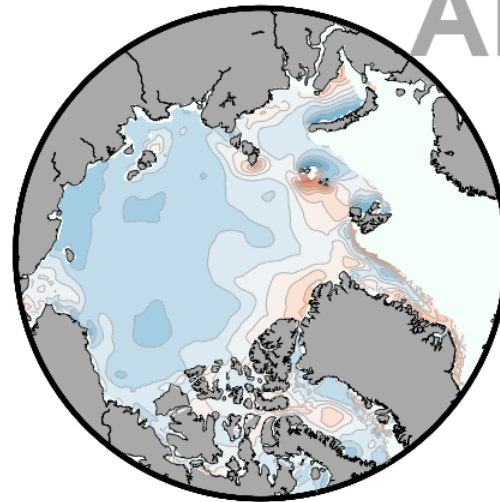
Correlation Coefficient

AD : SLT correlations

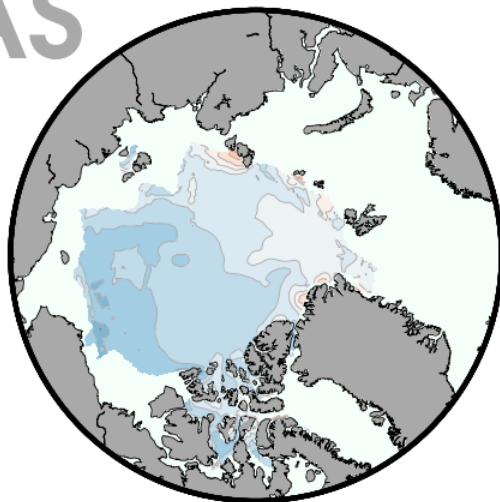
JFM



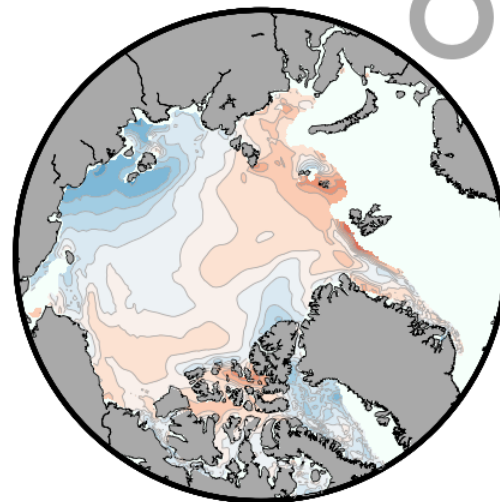
AMJ



JAS

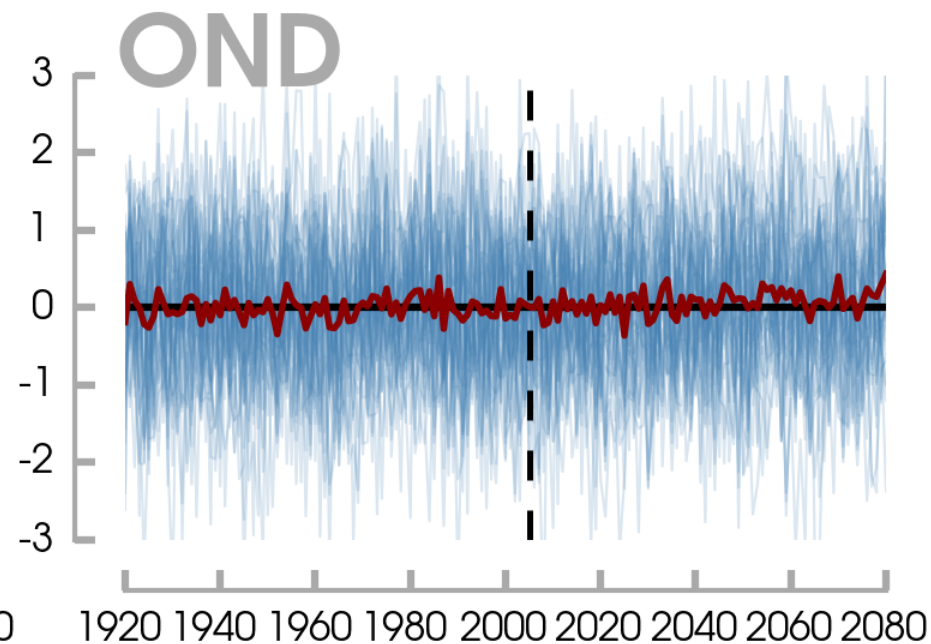
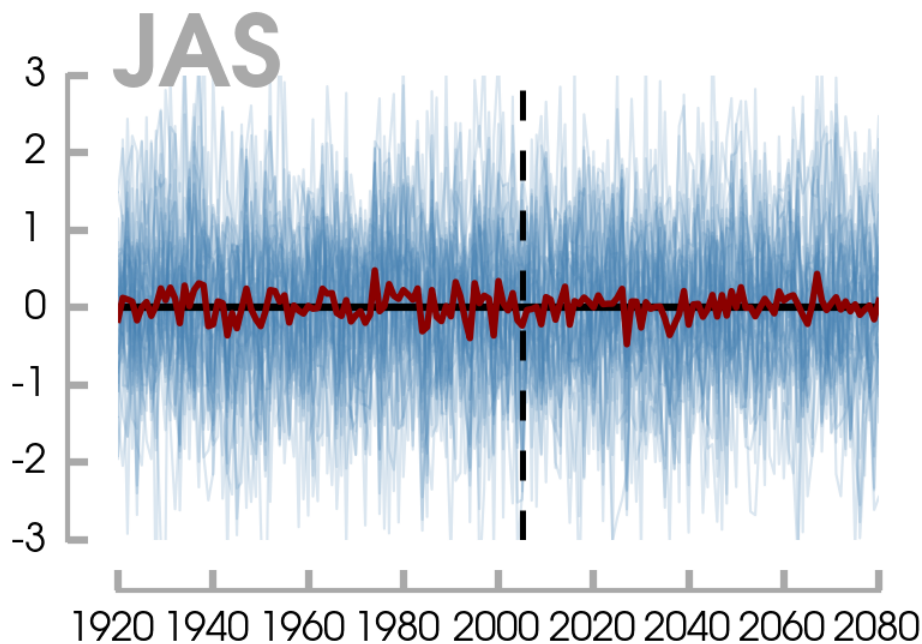
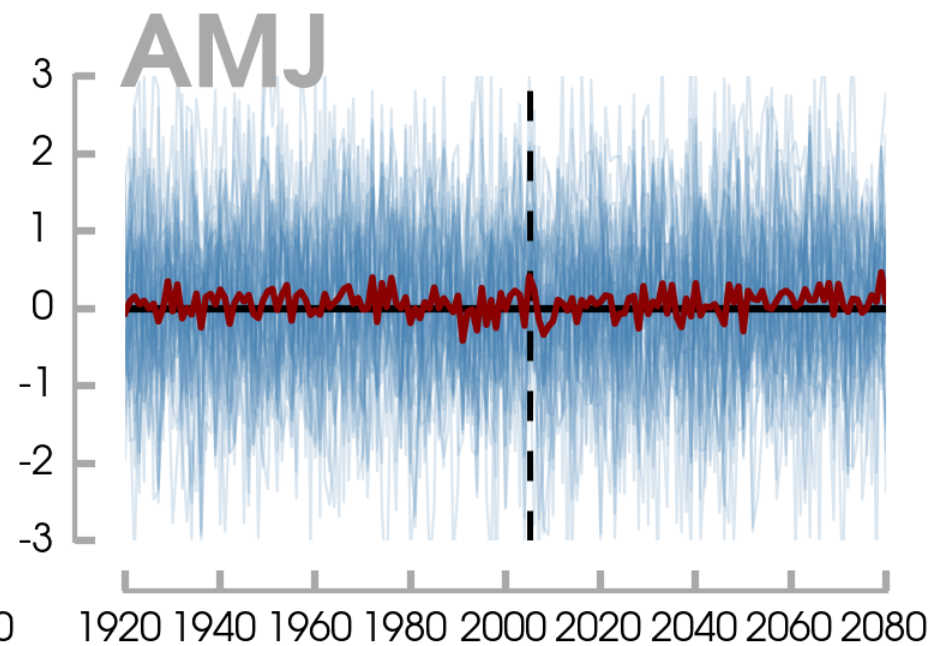
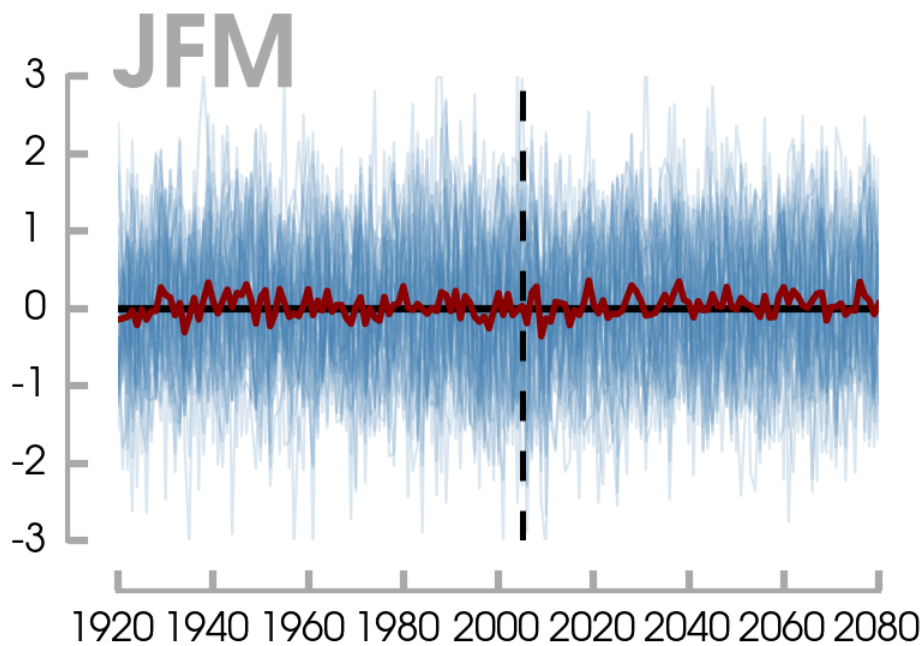


OND

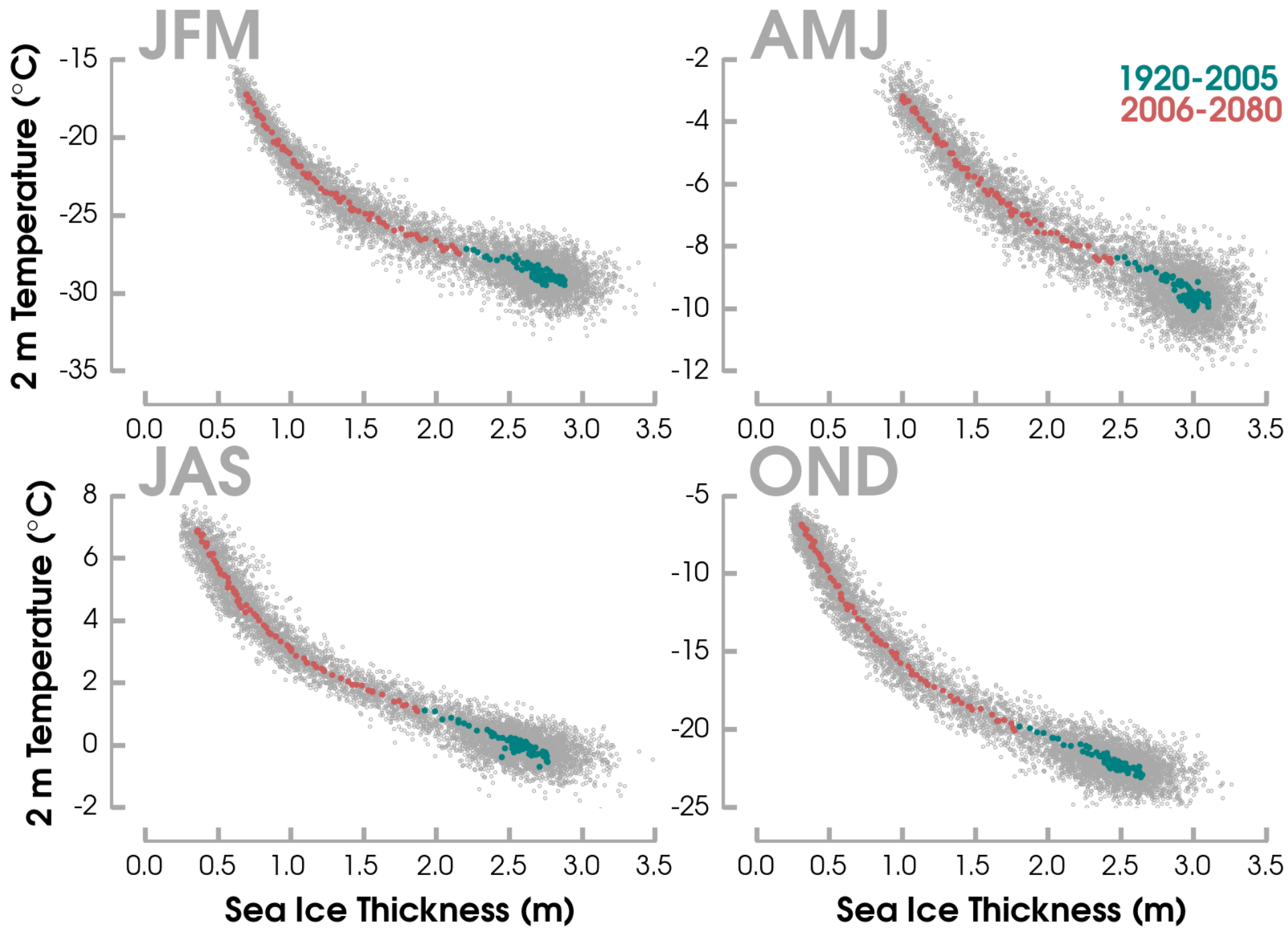


Correlation Coefficient

LENS - Arctic Dipole



LENS SIT - T (2 m)



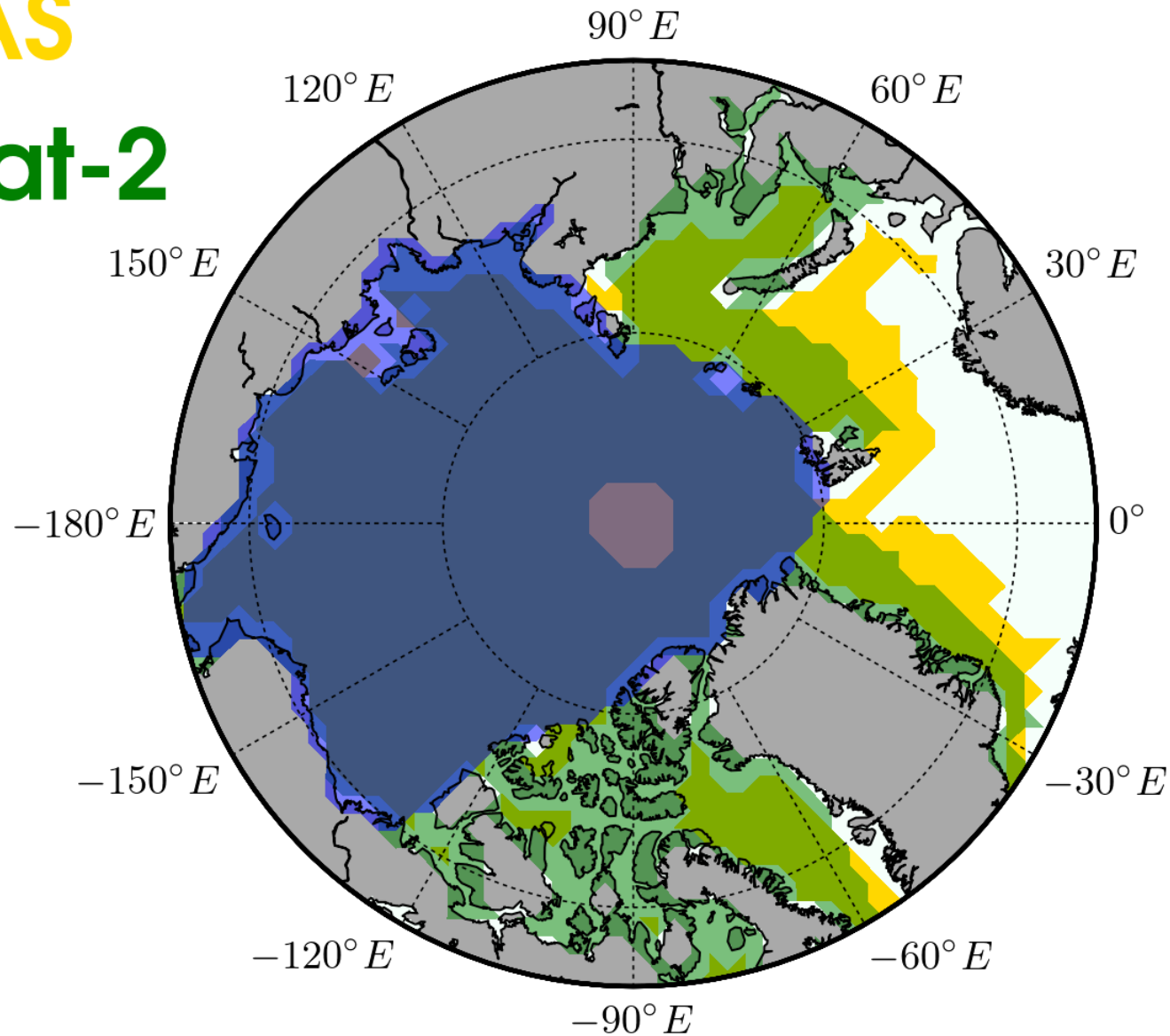
SLT Spatial Grids

Grid Domains, 100 km EASE

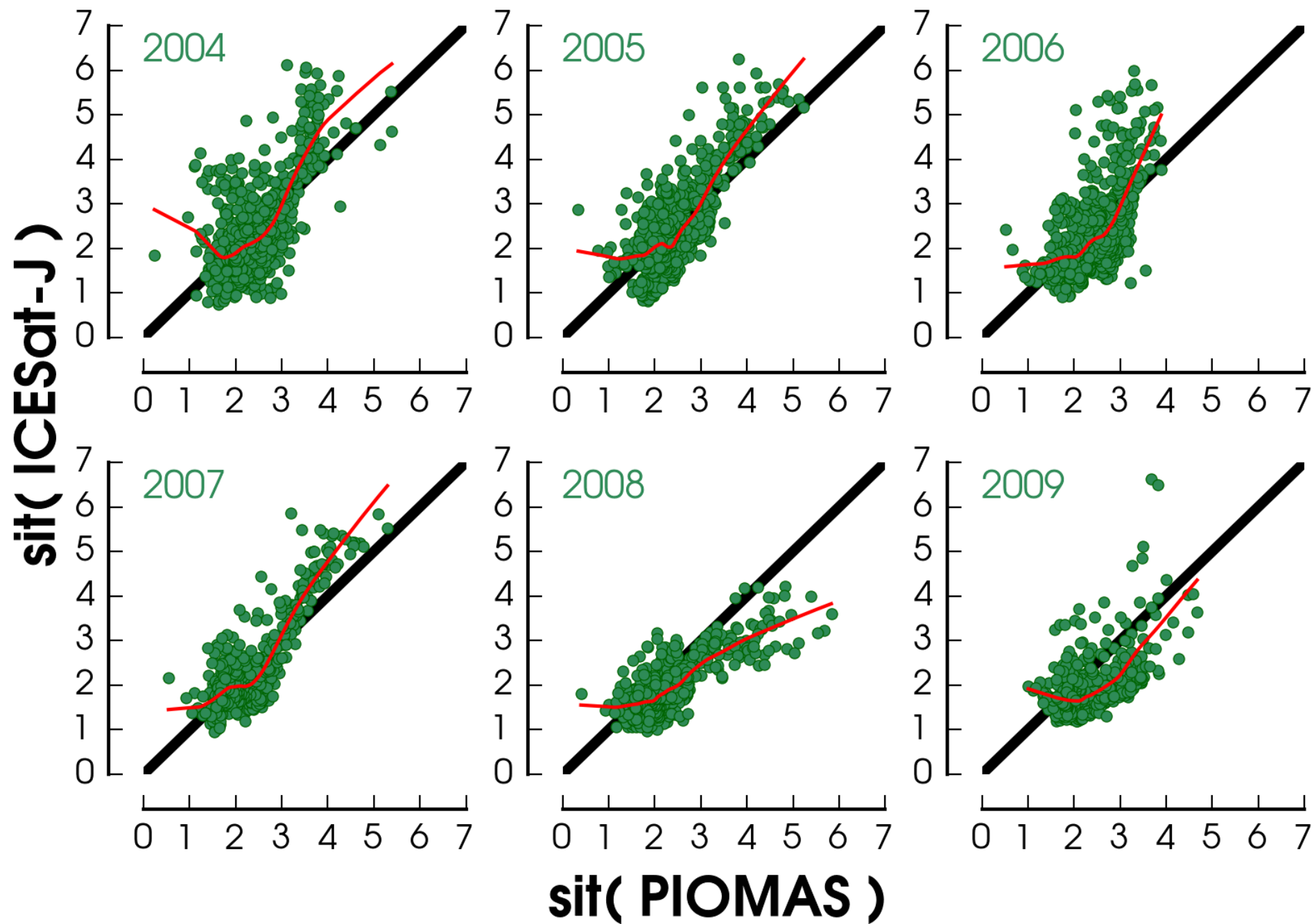
PIOMAS

CryoSat-2

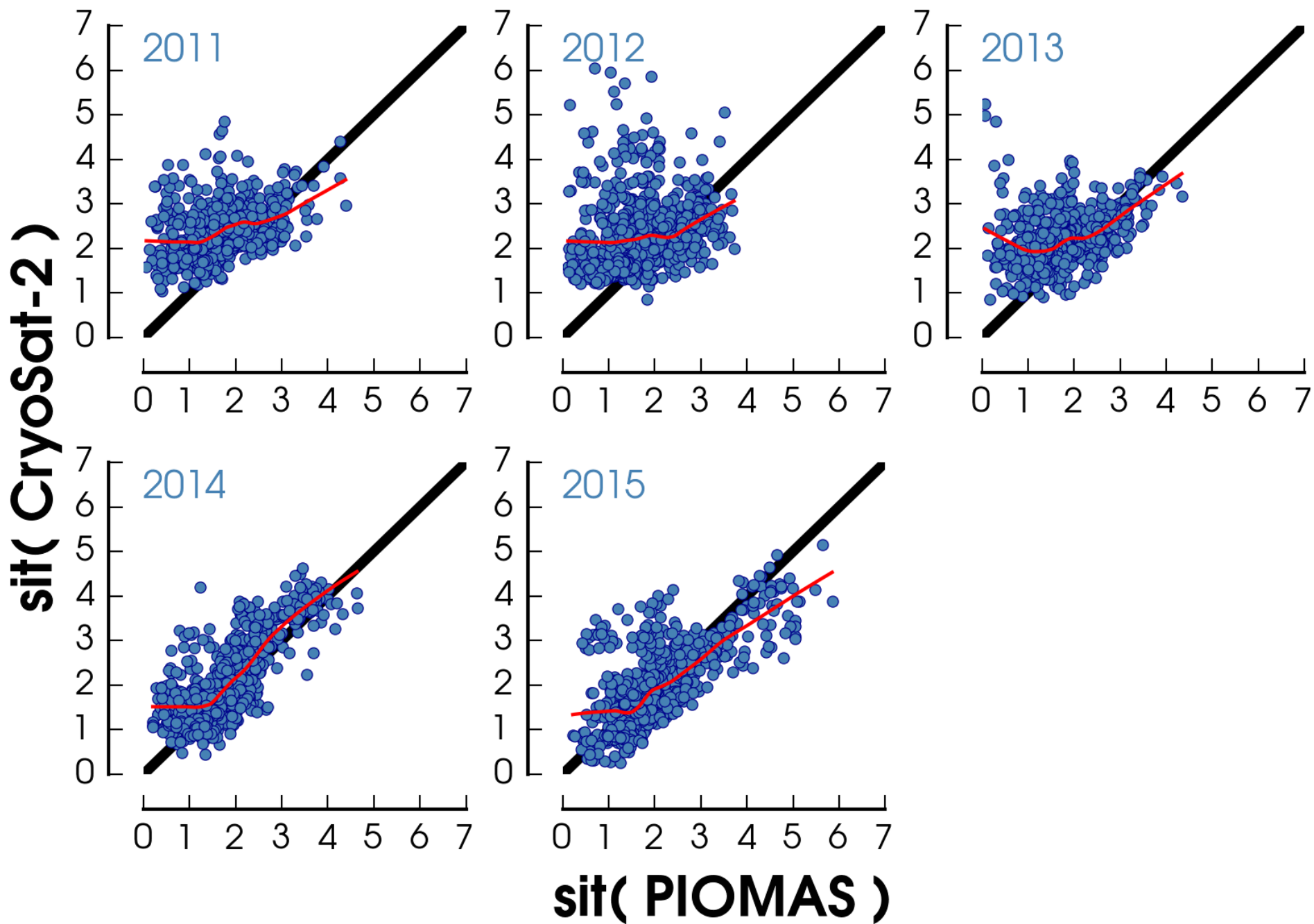
ICESat



SIT - ICESat-j

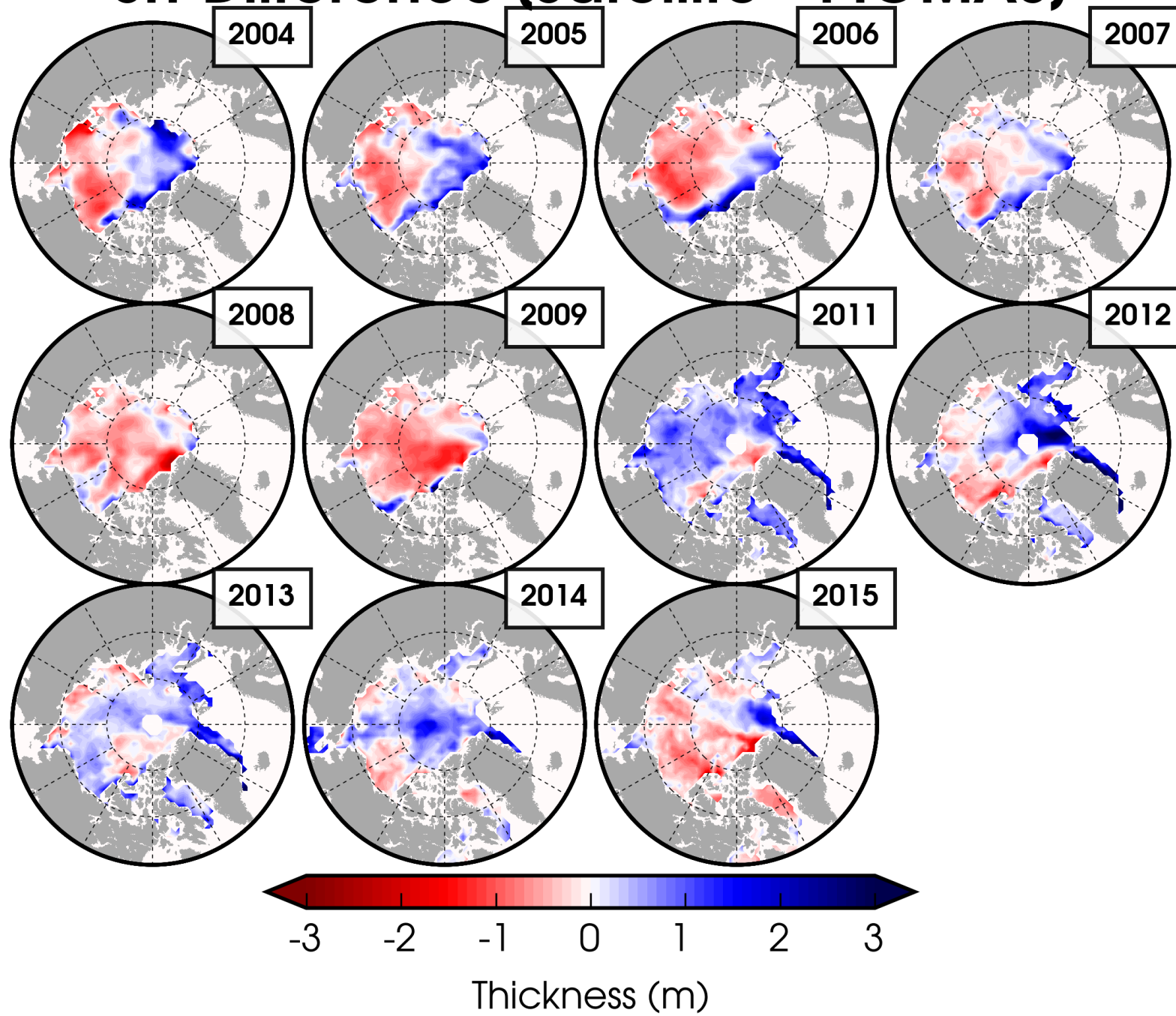


SLT - Cryosat-2



SIT Comparison

SIT Difference (Satellite - PIOMAS)



SLT Comparison

