Sea icescape and Antarctic marine ecosystem productivity in the CESM2

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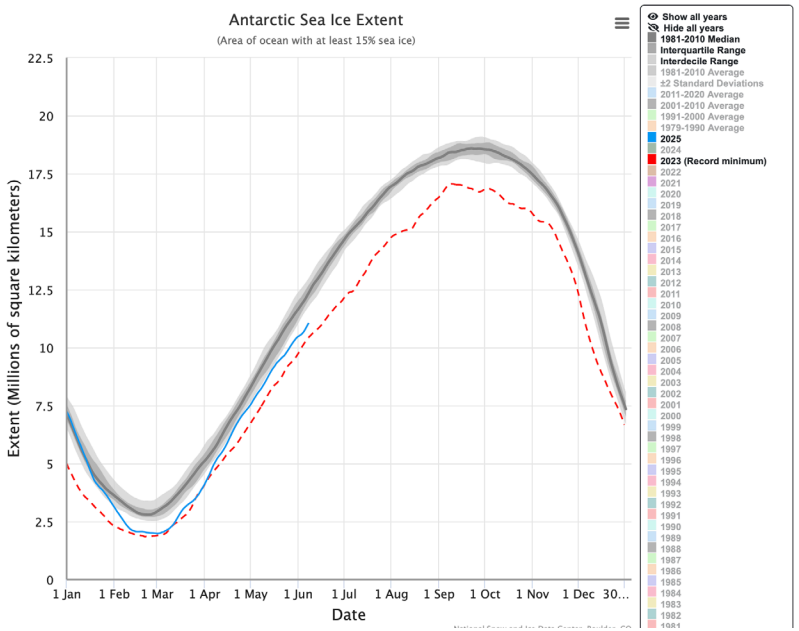
Overview

Antarctic Sea Ice
Sea icescape in marine ecosystems
Polynyas: biological hotspots in the ice
Sea ice and net primary productivity in a changing climate
Wrap up and other workshop presentations for more!

Antarctic Sea Ice

Antarctic Sea Ice & Southern Ocean
Global players in climate mitigation, sea levels, ecosystems



Ocean heat and carbon uptake:

~43% of the anthropogenic carbon

~83% of the heat taken up by the world's oceans

estimated value of $180 billion per year

Global sea level rise:

Antarctica's floating ice shelves buttress land ice sheets

Sea ice production near the Antarctic coast protects some ice shelves from penetration and melt by warm CDW

Antarctic ecosystems:

unique, endemic, highly productive and highly sea -ice dependent ecosystems

Icescape: sea ice in marine ecosystems

Sea ice - seasonal infrastructure

Light

Nutrients

Temperature

Image: British Antarctic Survey
(https://www.nbcnews.com/id/wbna6398305)

Habitat

(hunting, hiding, nursery, pinniped day-care, housing)

Many “ecosystem services” provided by sea ice are at relatively small scales

How important are polynyas for the Antarctic ecosystem?

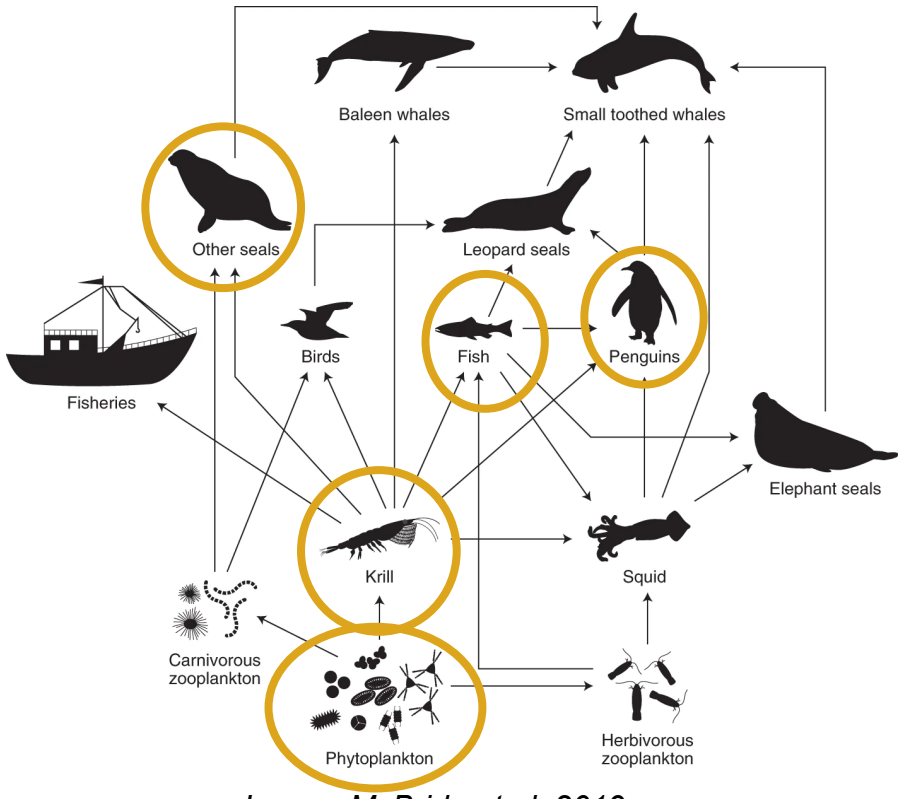


Image: McBride et al. 2019

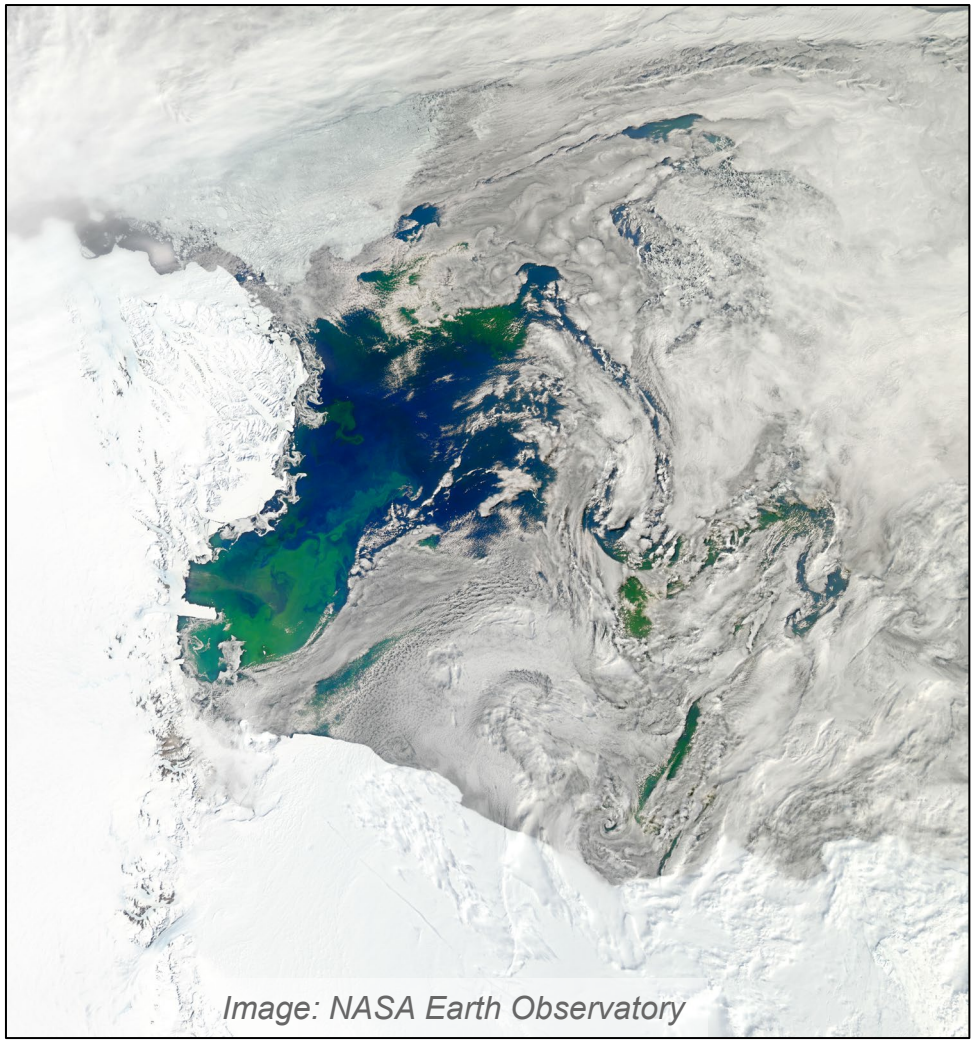
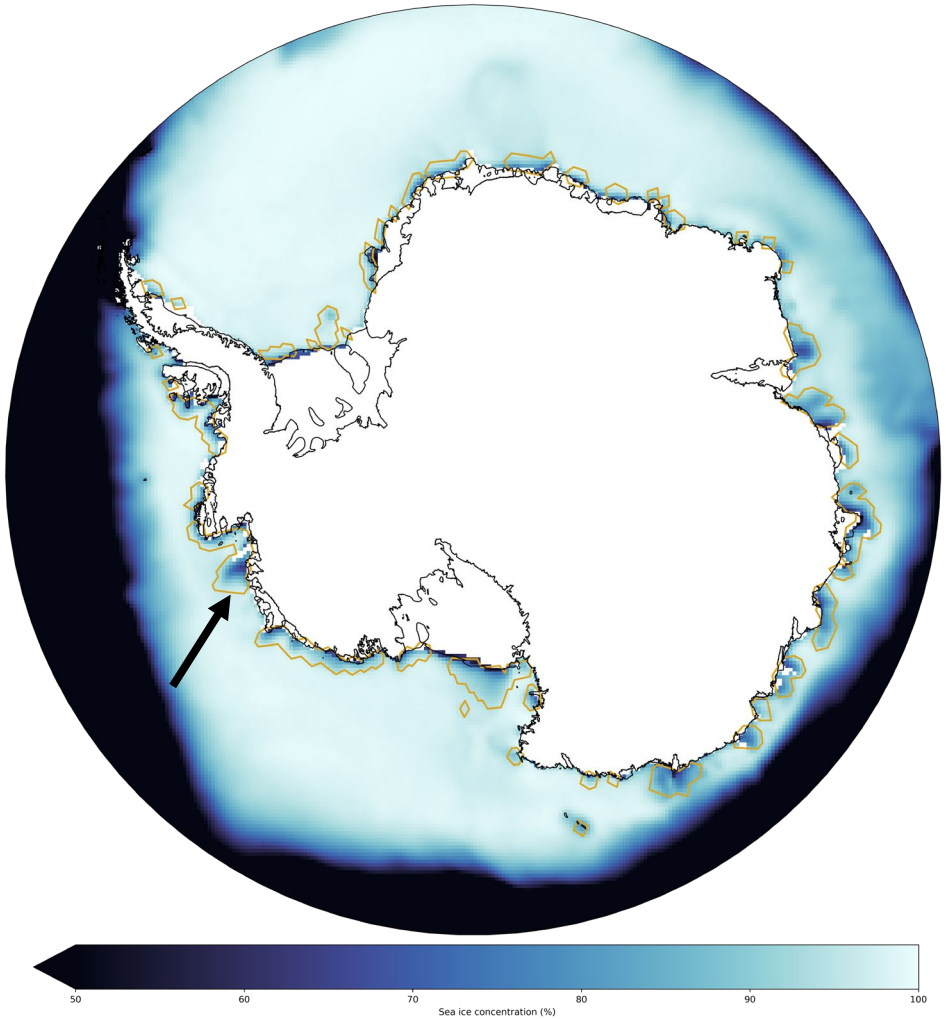


Image: NASA Earth Observatory

Polynyas generally occur in the same locations over time.

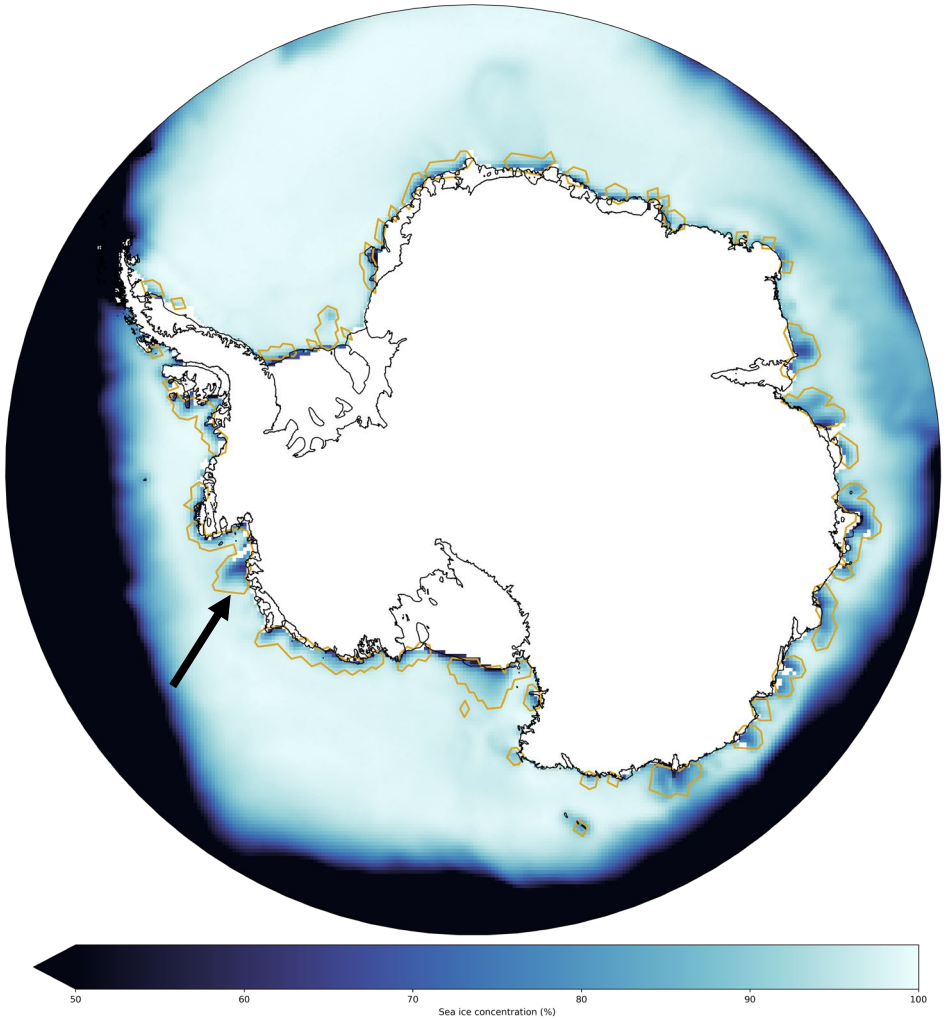
1979-2020 Winter average sea ice concentration



Data: NSIDC CDR satellite data

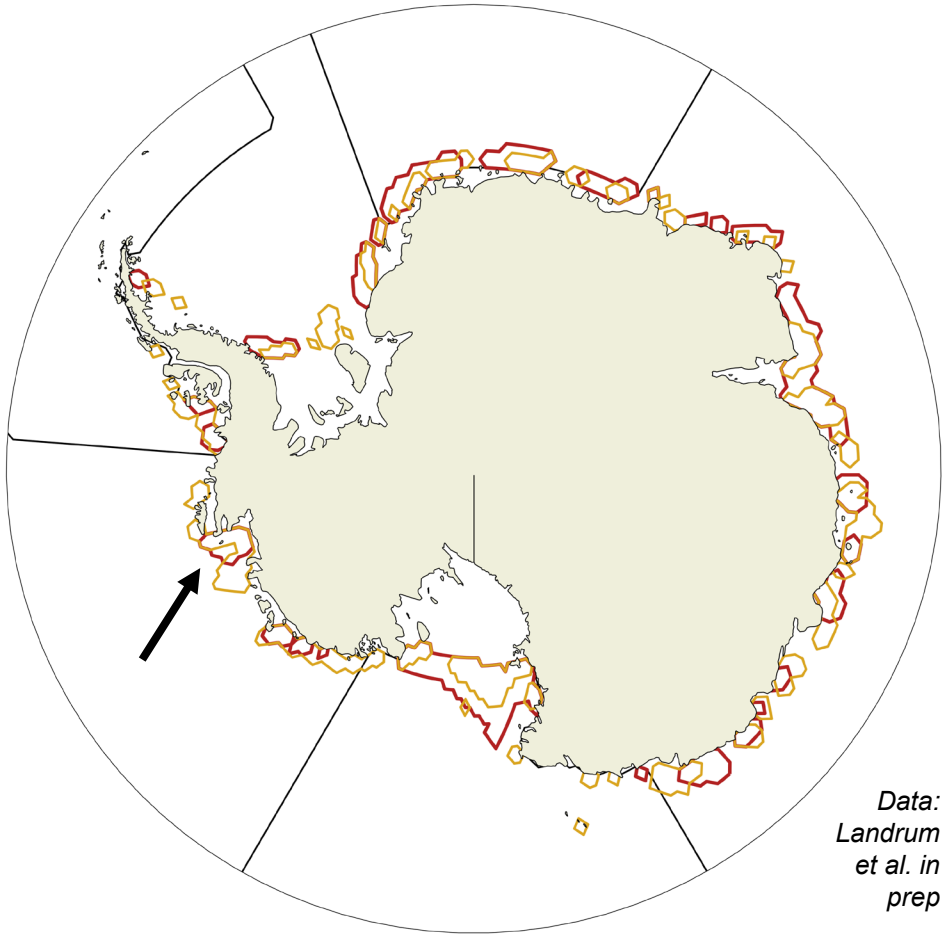
Satellite and model polynyas regions generally match well.

1979-2020 Winter average sea ice concentration



Data: NSIDC CDR satellite data

1979-2020 “typical” polynyas
(identified >10% of the year)



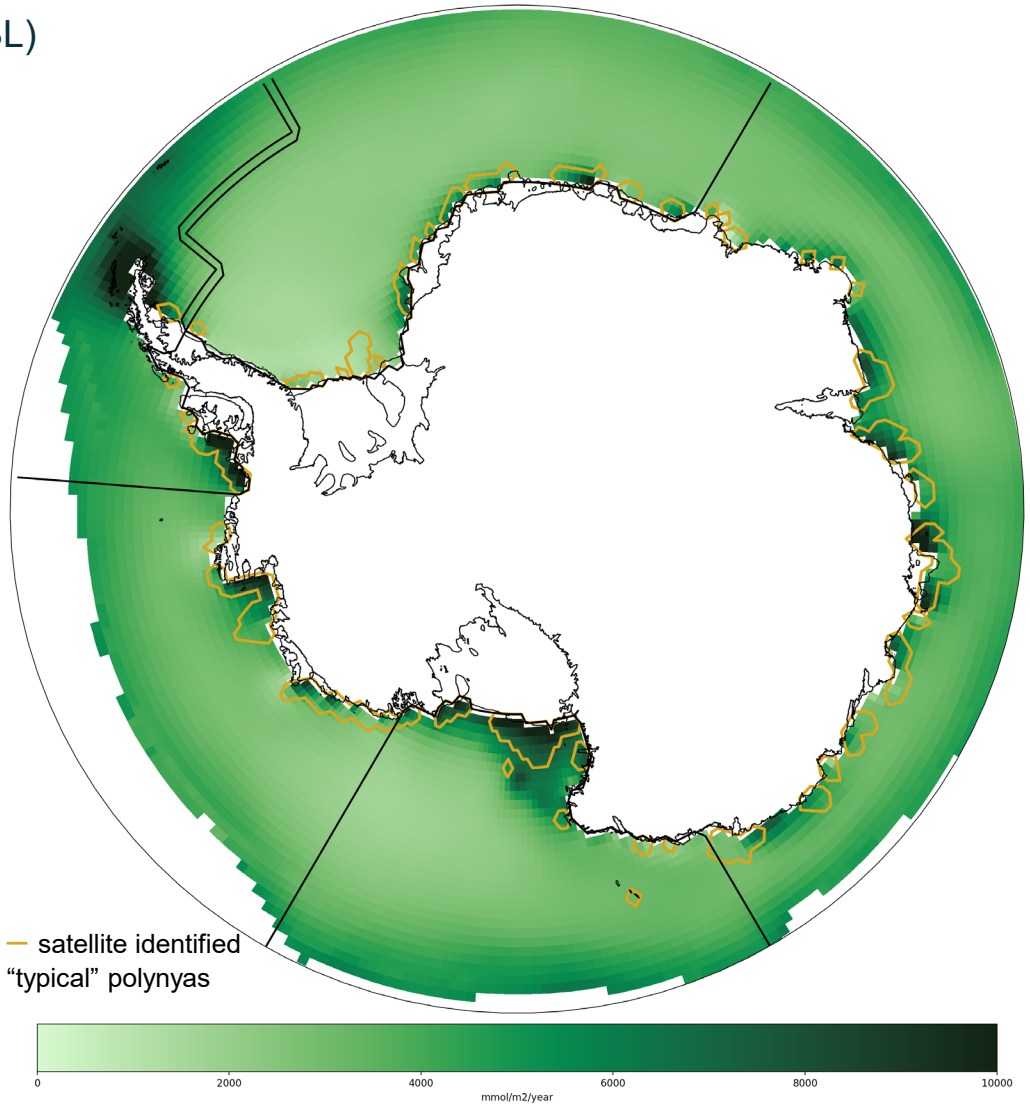
Data: Landrum et al. in prep

satellite (85% SIC threshold)

CESM hindcast (0.4m SIT threshold)

Net Primary Productivity (NPP)

DATA SOURCE:
MODEL (CESM2-MARBL)



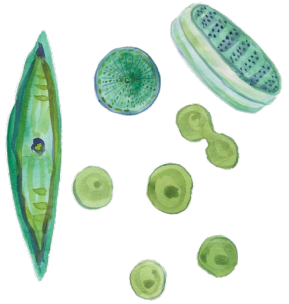
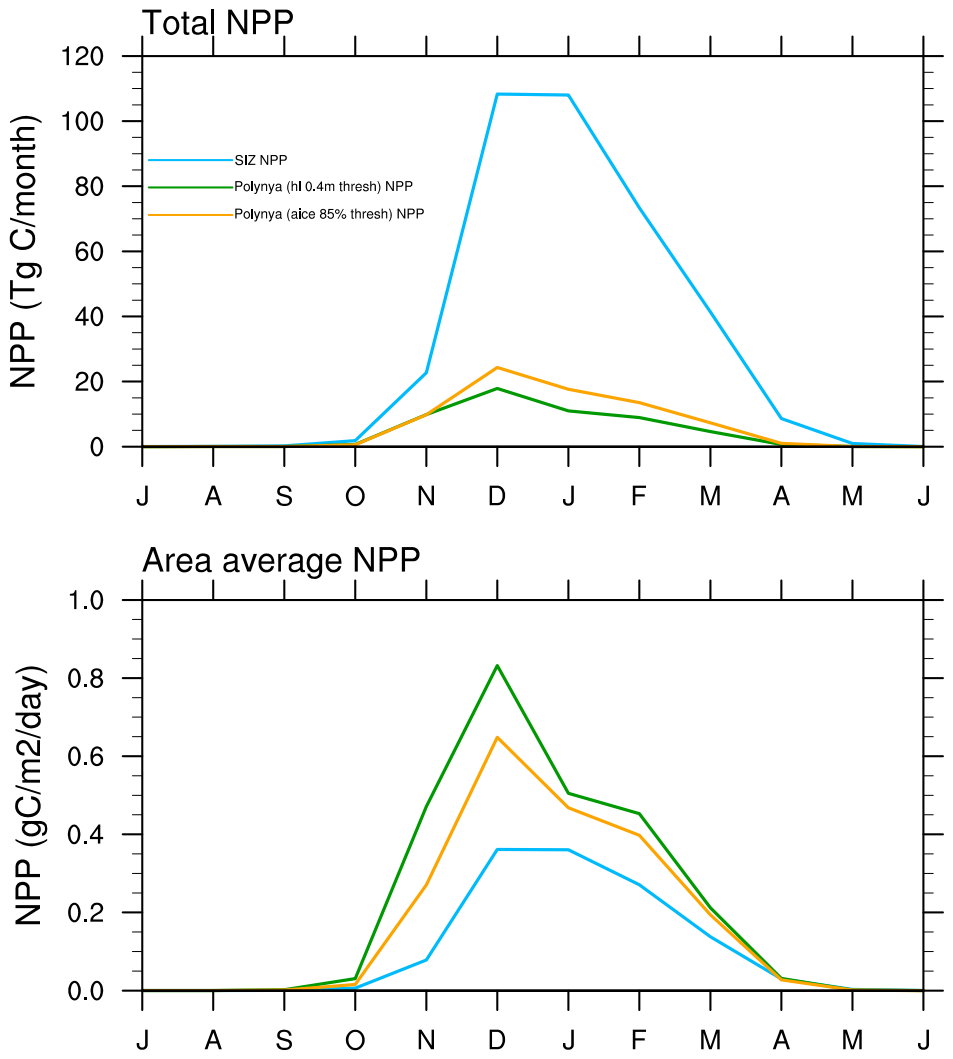


Illustration: Kristen Krumhardt

Data from
DuVivier et al. (in prep)

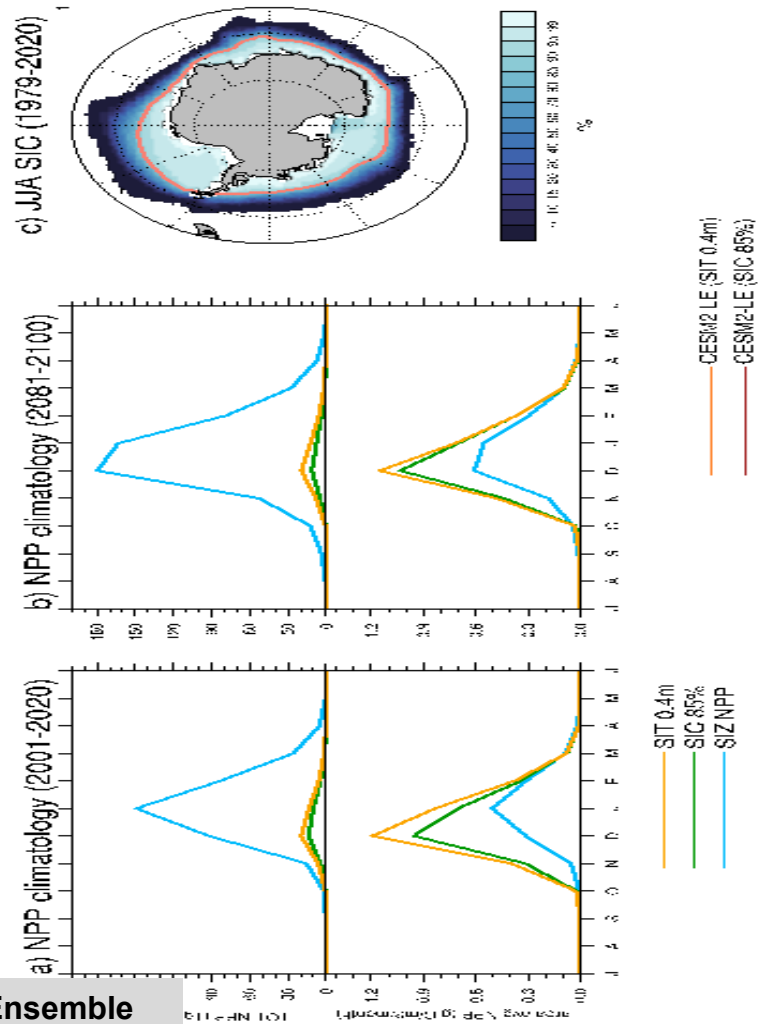
NPP in polynyas

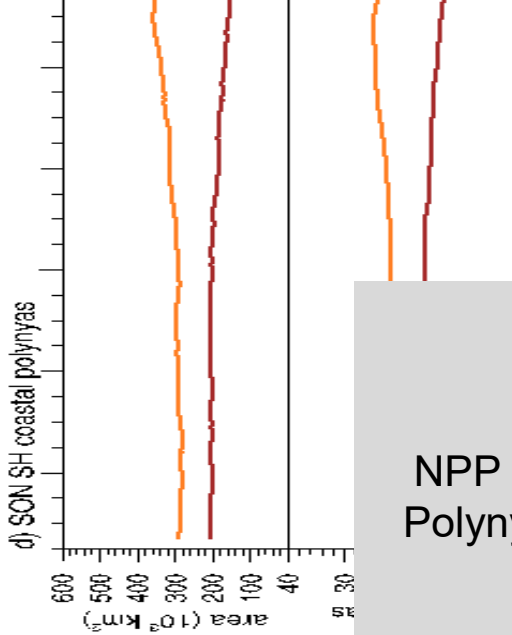


NPP within polynyas
~2x as high as within the sea ice zone
~10% of the area (polynyas) contributes ~18% of the total NPP

CESM2 Forced Ocean Sea Ice hindcast (FOSI)

CESM2 NPP and polynyas





CESM2 Large Ensemble

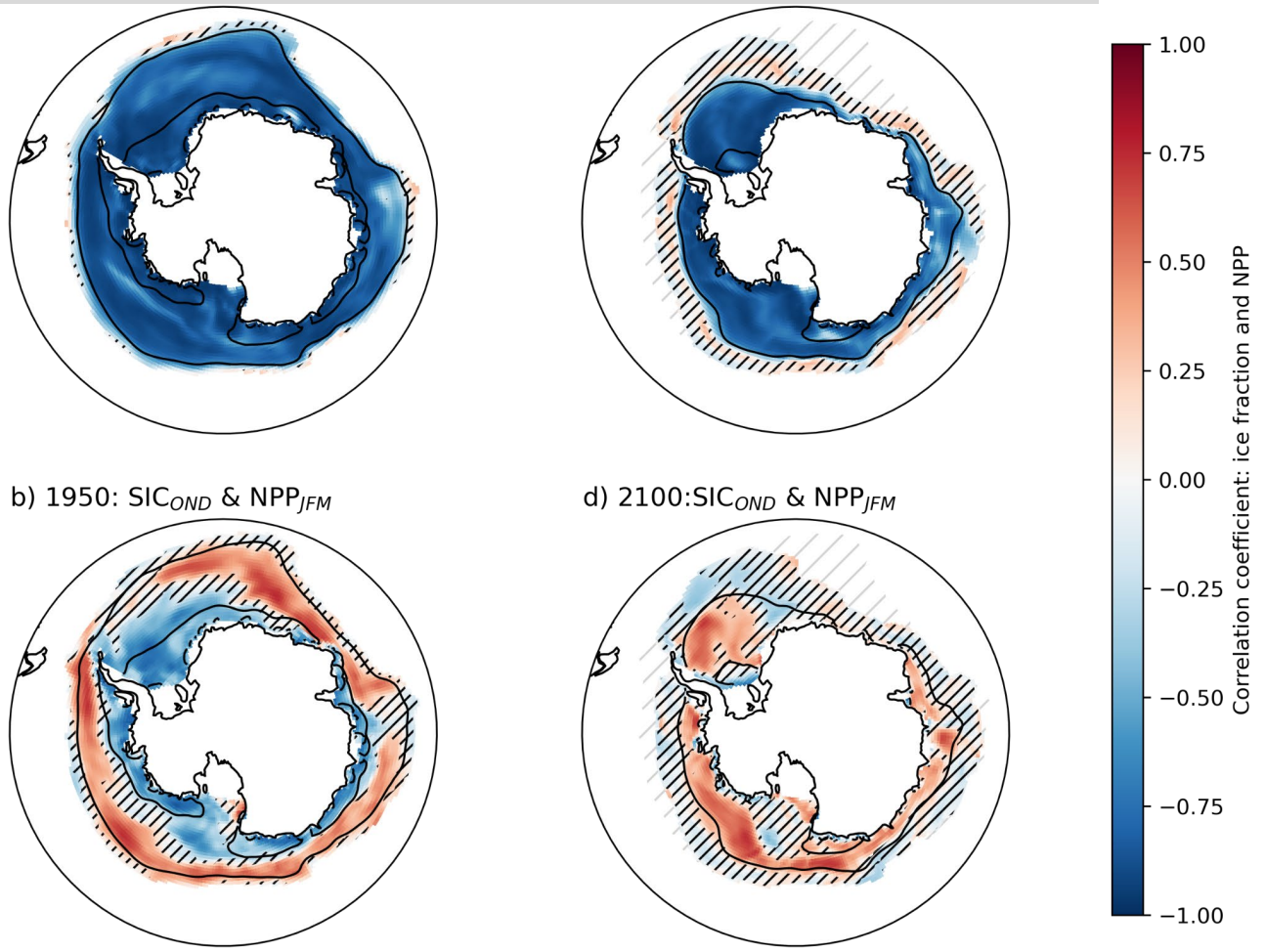
NPP, polynyas in a changing climate

NPP within polynyas relatively unchanged (21st C)
Polynya-NPP contributing less to total sea ice zone (SIZ) NPP at end of the 21st C
Polynya area decreasing
SIZ NPP peaking earlier

Antarctic sea ice and marine productivity in a changing climate

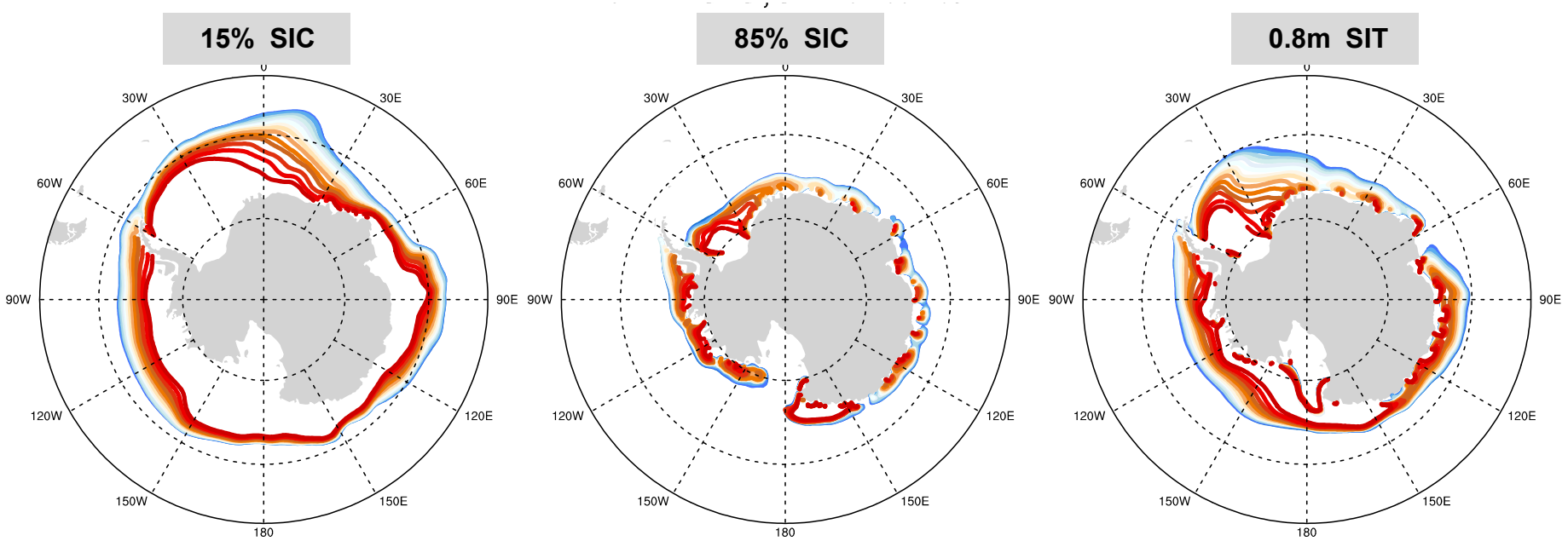
Sea Ice Concentration (SIC):NPP Correlations

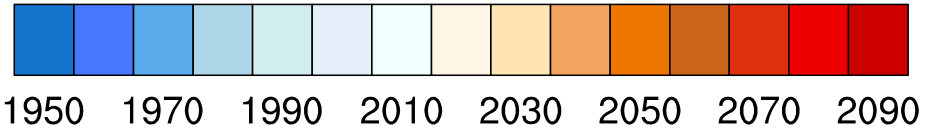
	1950	2100
OND SIC: OND NPP		
OND SIC: JFM NPP	b) 1950: SIC_{OND} & NPP_{JFM}	d) 2100:SIC_{OND} & NPP_{JFM}



CESM2 Large Ensemble

Changing sea ice concentrations (SIC) and thicknesses (SIT)

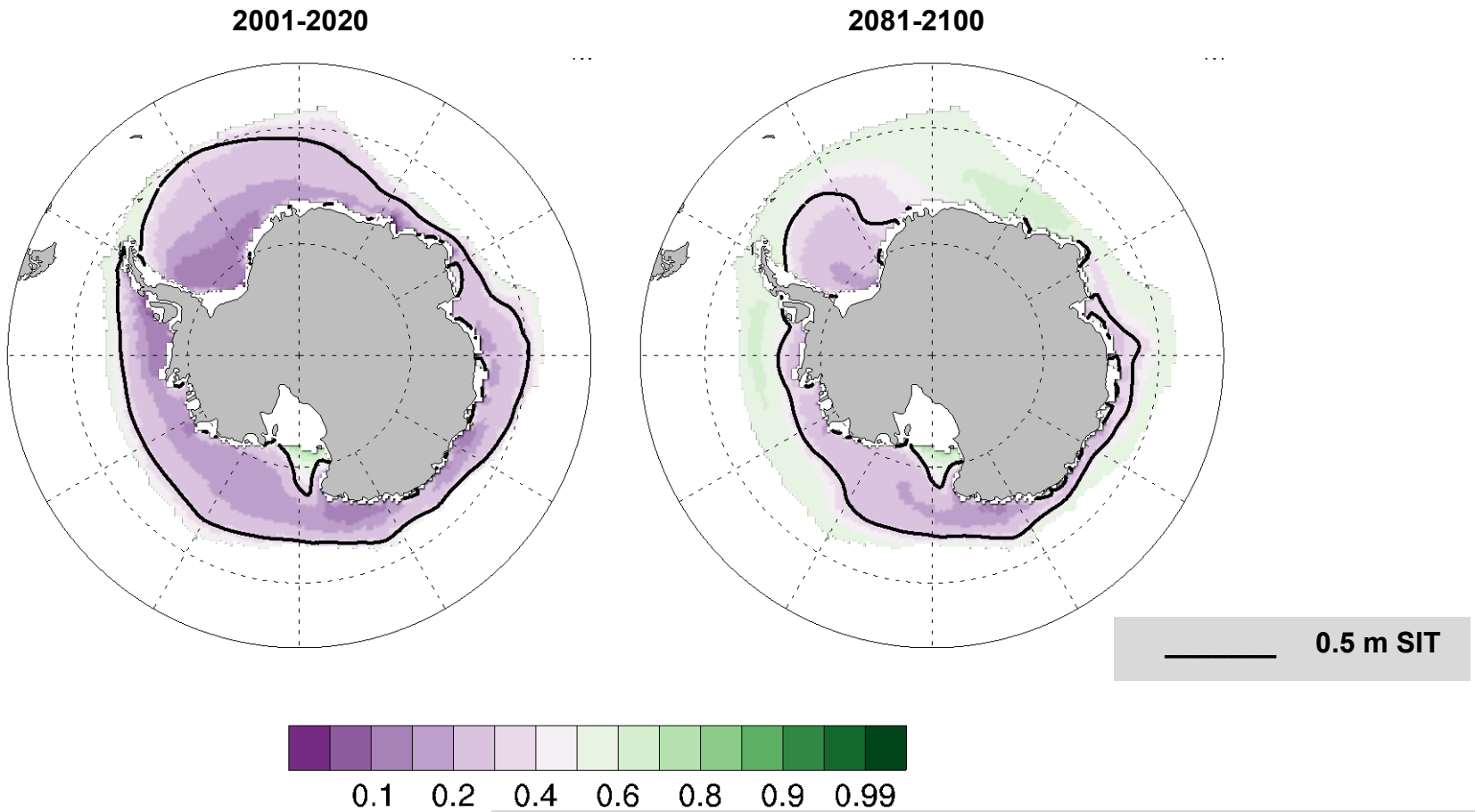




CESM2 Large Ensemble

Sea ice edge (15% SIC) & sea ice thickness (Weddell Sea) retreating faster than pack ice (85% SIC)

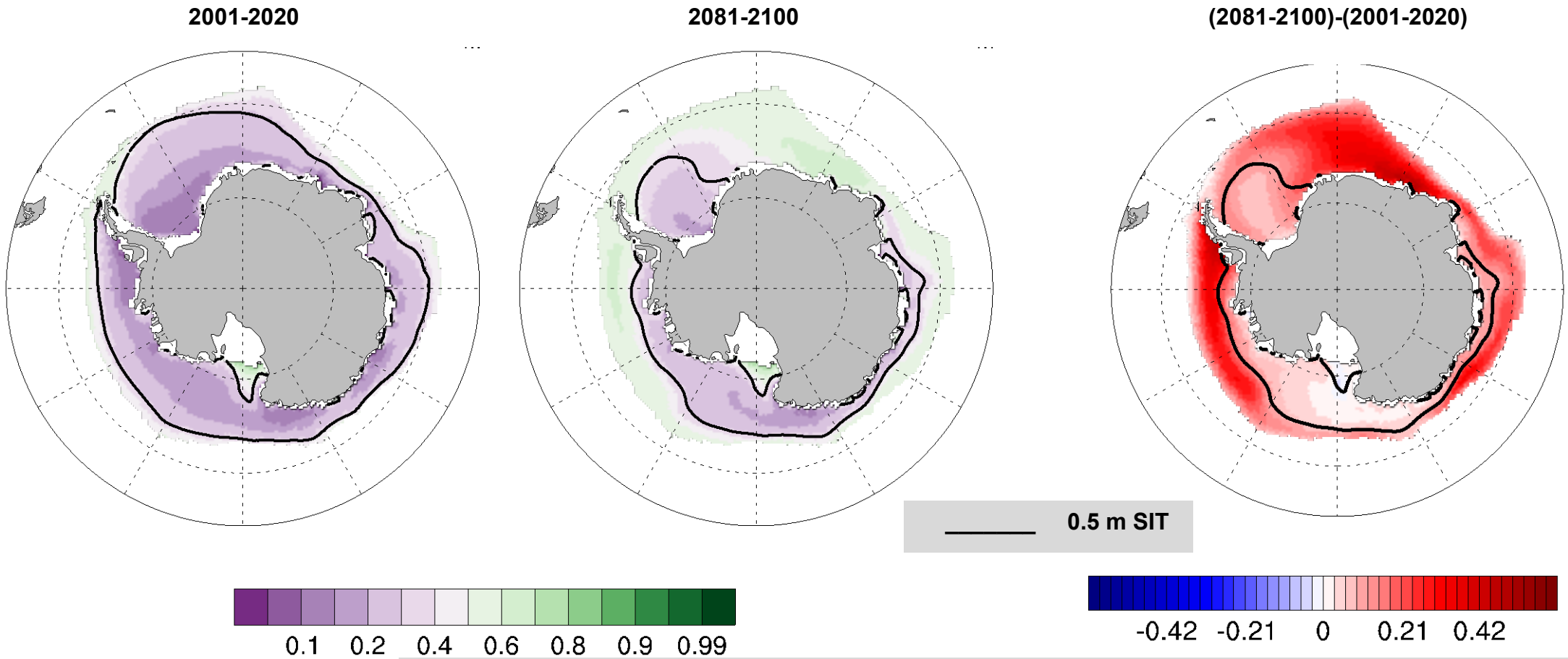
Spring (OND) Light Limitation



CESM2 Large Ensemble

Changes in spring light limitation: changes in concentrations and thicknesses

Spring (OND) Light Limitation



CESM2 Large Ensemble

Changes in spring light limitation: changes in concentrations and thicknesses

Summary

Antarctic sea icescape and ecosystems in the CESM2

CESM2 simulates polynya-like features

Polynyas are“hot spots” of productivity

NPP in polynyas remains high but smaller contribution to SH NPP (polynya areas decreasing & NPP in the sea ice zone increasing)

Negative relationships between OND SIC & OND NPP

Positive relationships between OND SICs & JFM NPP
except where both SICs & SITs are high

SIC & SIT influencing bloom timing, magnitude

Other related CESM presentations:
Posters (Alice DuVivier; Kristen Krumhardt)
Oral presentations (Courtney Payne)

Thank you for your attention!

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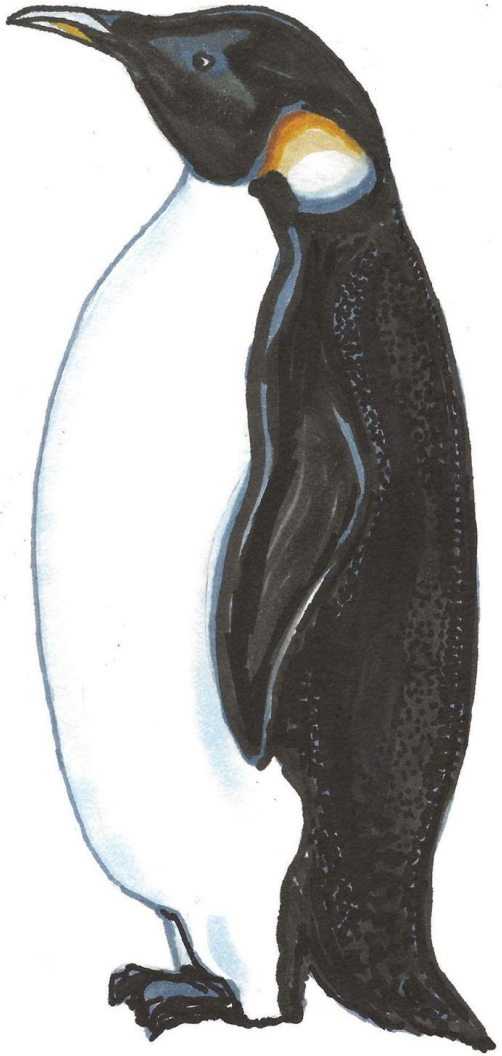
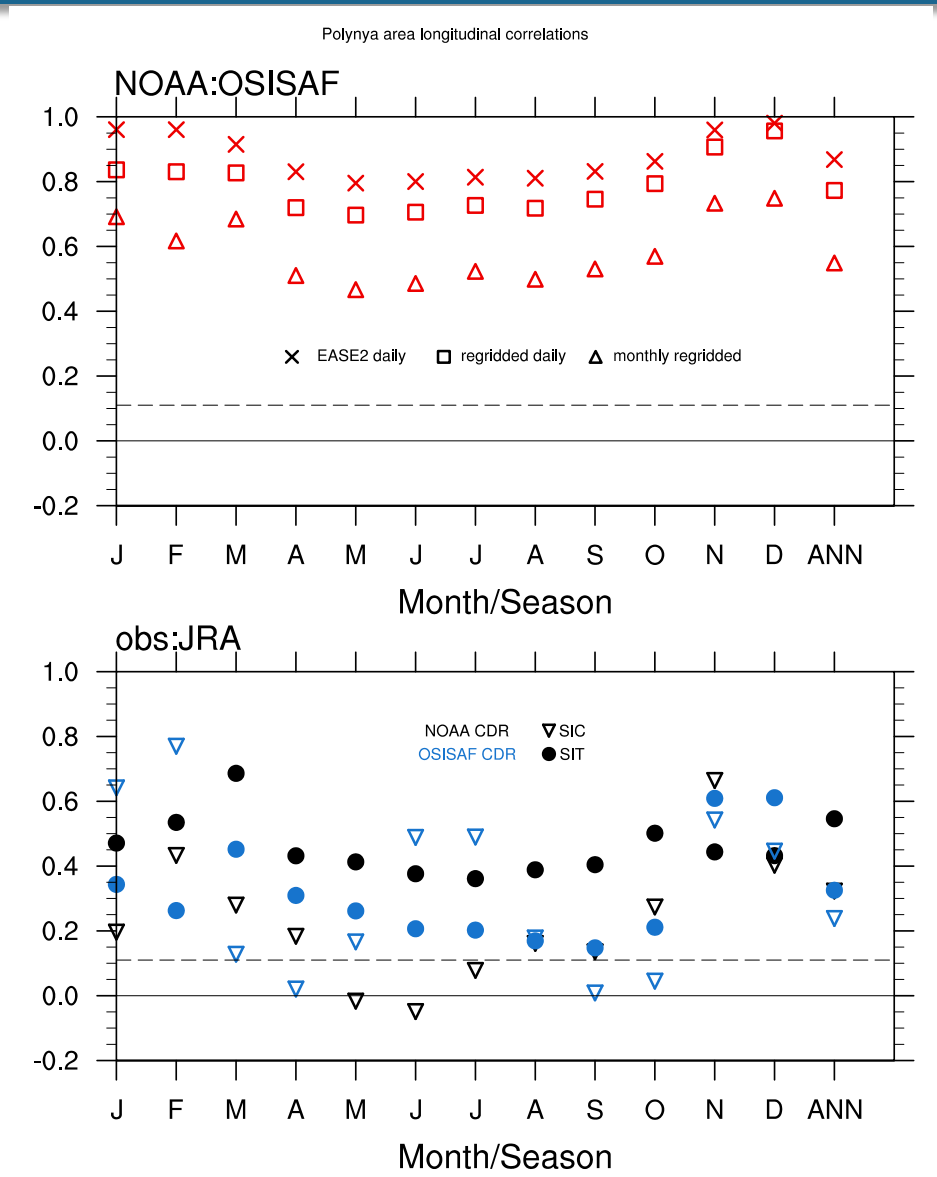
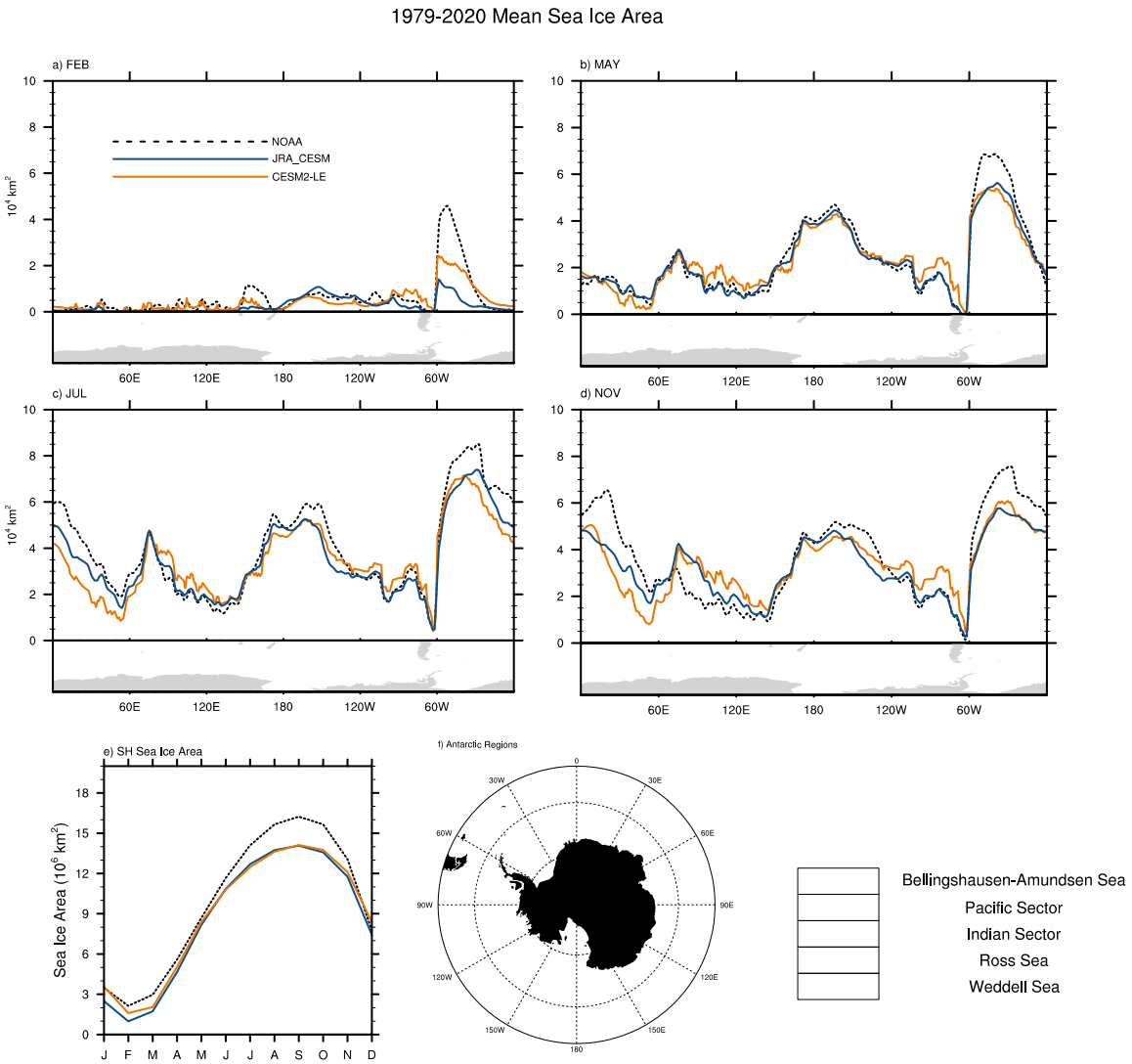
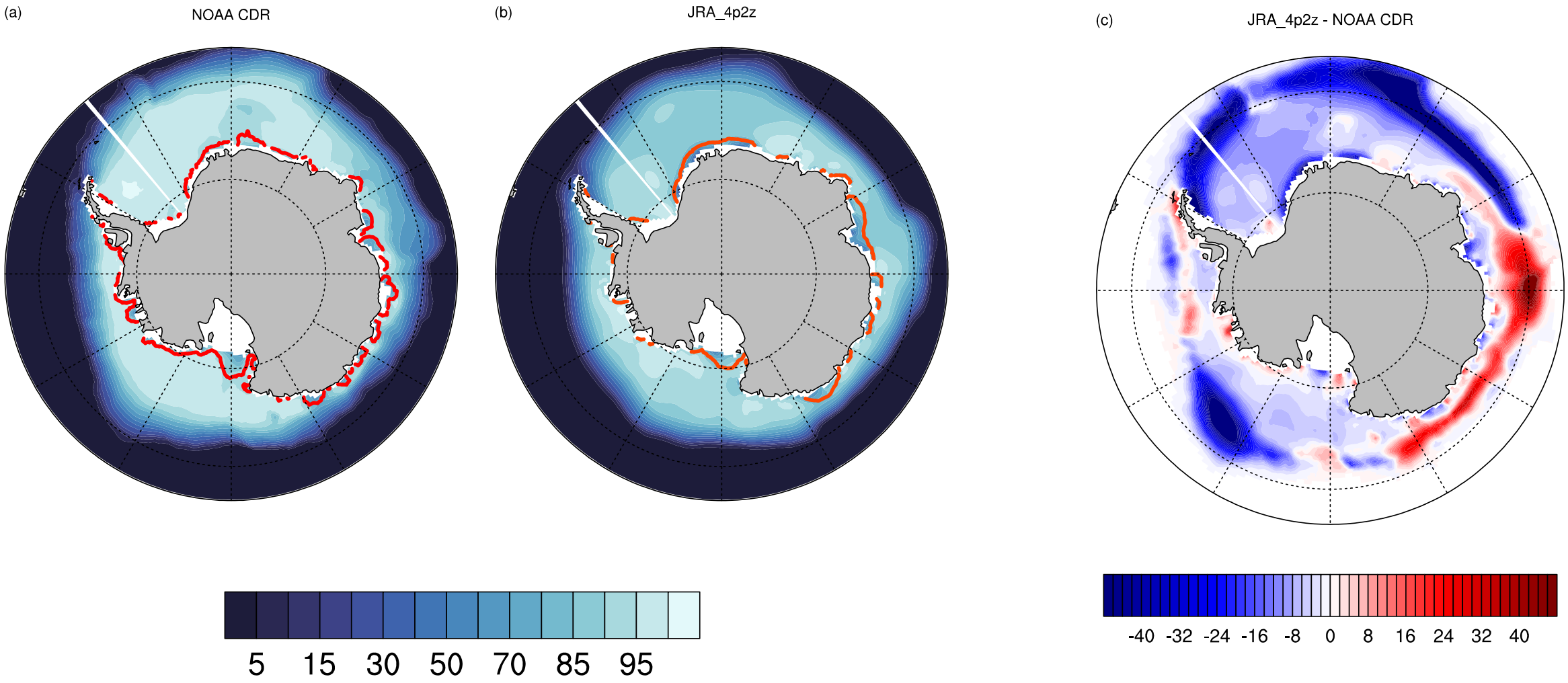


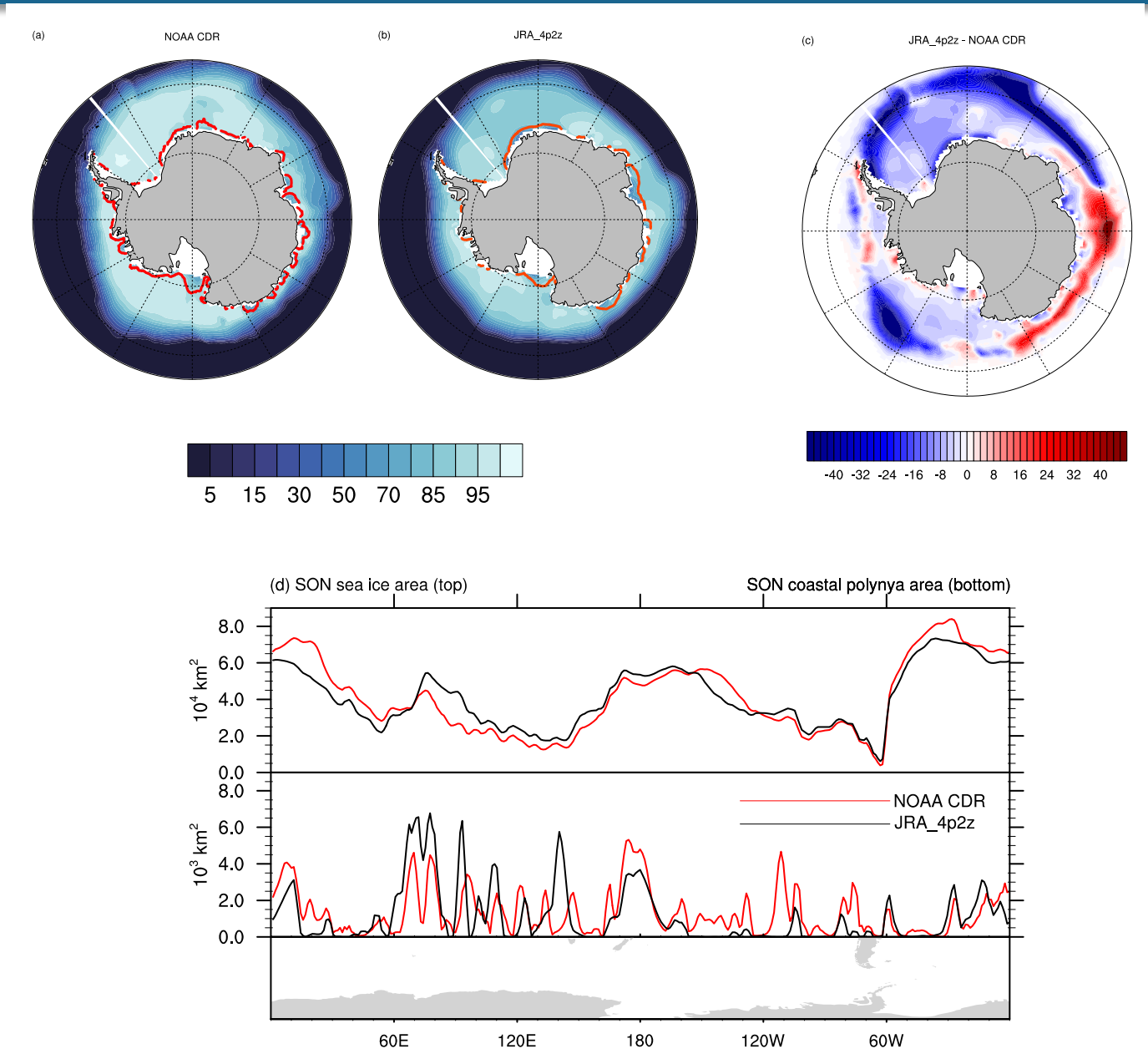
Illustration: Kristen Krumhardt

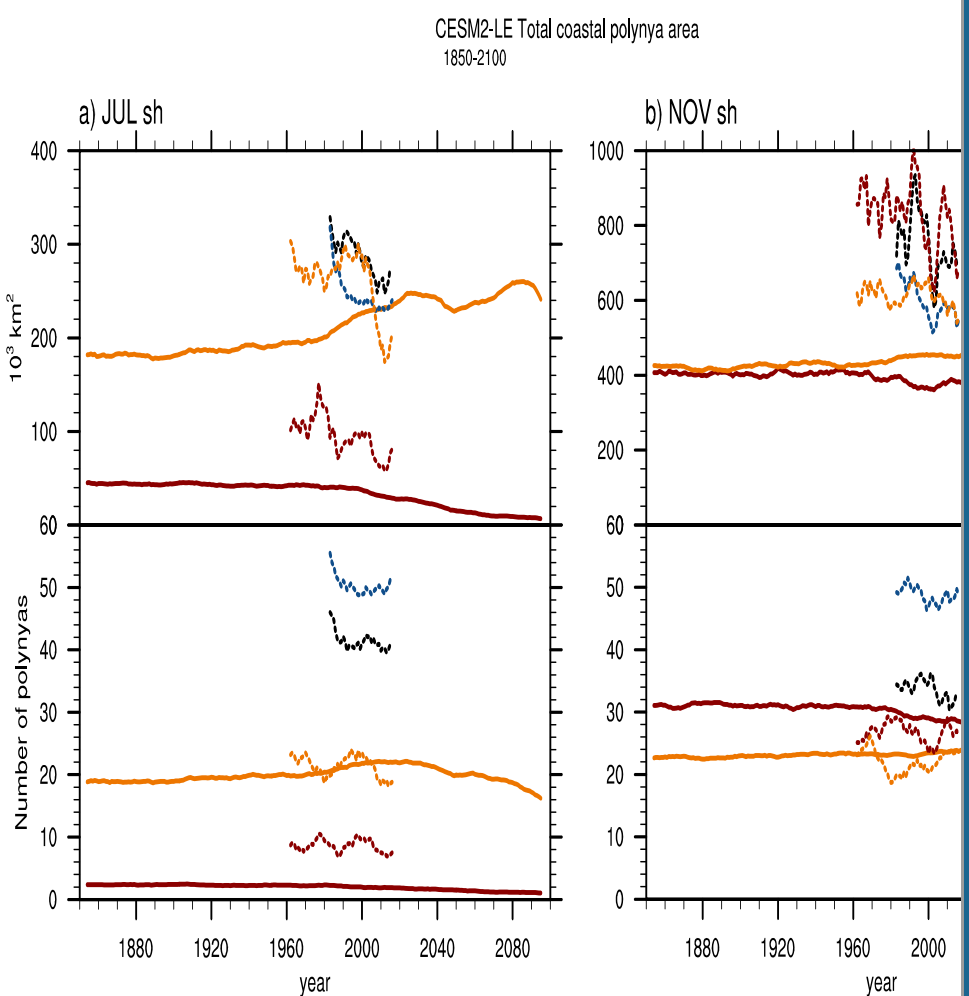

Polynya area longitudinal correlations
NOAA:OSISAF
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
EASE2 daily
regridded daily
monthly regridded
J F M A M J J A S O N D ANN
Month/Season
obs:JRA
NOAA CDR
OSISAF CDR
SIC
SIT
J F M A M J J A S O N D ANN
Month/Season


1979-2020 Mean Sea Ice Area
a) FEB
b) MAY
c) JUL
d) NOV
NOAA
JRA_CESM
CESM2-LE
10^6 km^2
60E
120E
180
120W
60W
e) SH Sea Ice Area
Sea Ice Area (10^6 km^2)
J F M A M J J A S O N D
f) Antarctic Regions
Bellingshausen-Amundsen Sea
Pacific Sector
Indian Sector
Ross Sea
Weddell Sea

CESM simulates polynya -like features




(a) NOAA CDR
(b) JRA_4p2z
(c) JRA_4p2z - NOAA CDR
5 15 30 50 70 85 95
-40 -32 -24 -16 -8 0 8 16 24 32 40
(d) SON sea ice area (top)
SON coastal polynya area (bottom)
10^4 km^2
10^3 km^2
8.0
6.0
4.0
2.0
0.0
NOAA CDR
JRA_4p2z
60E
120E
180
120W
60W


CESM2-LE Total coastal polynya area
1850-2100
a) JUL sh
b) NOV sh
10^3 km^2
Number of polynyas
year
year