Proposed international climate sections in the Pacific Arctic Ocean

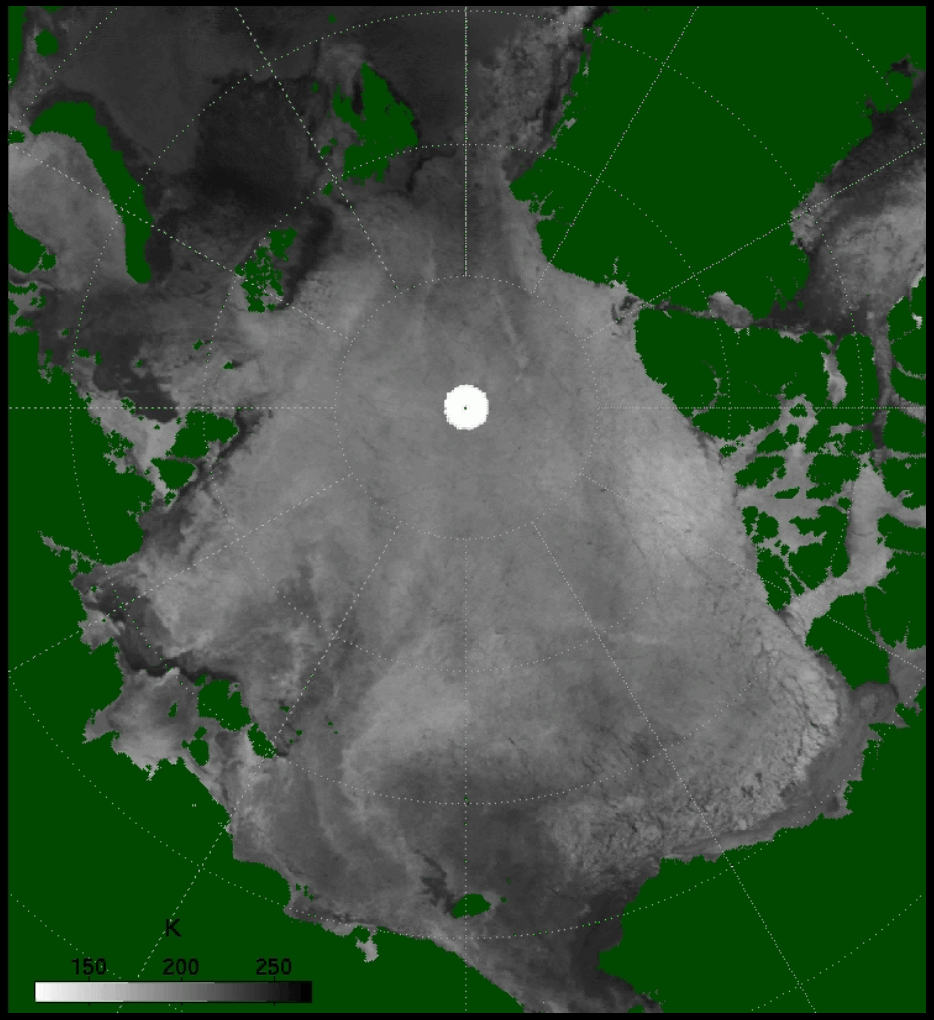
PAG meeting, April 7, 2014

Koji Shimada (Tokyo Univ. MST, IASC MWG/ Japan)

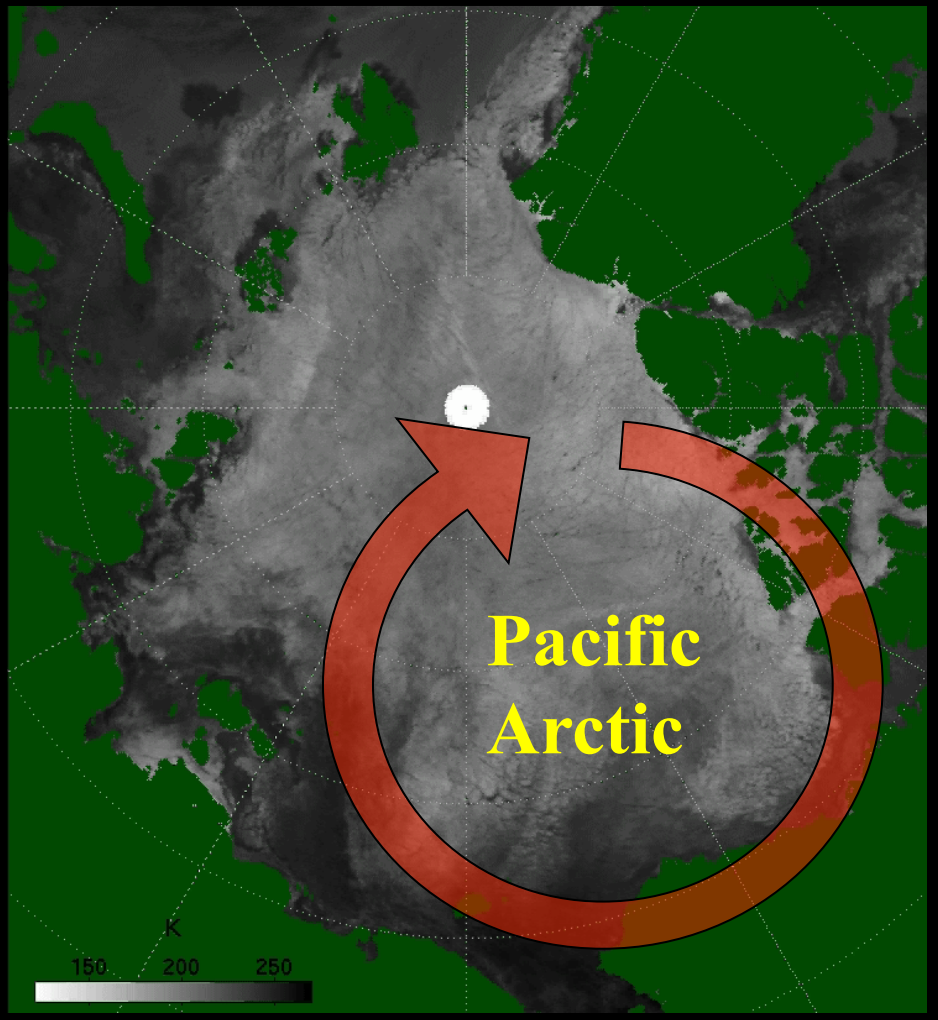
R/V Mirai in the Barrow Canyon
(one of key gateways)
Photo by Capt. David Snider (2002)

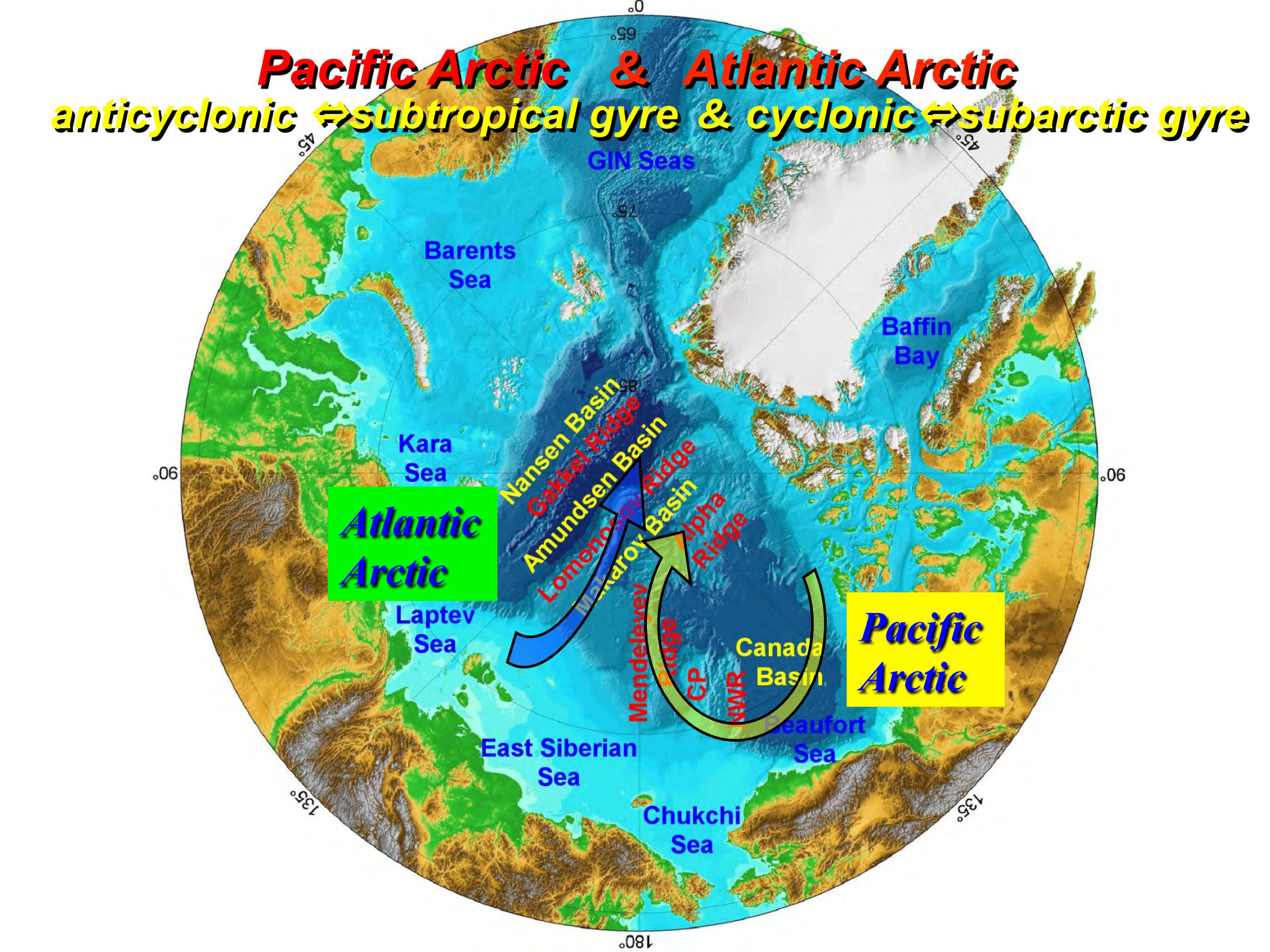

1979-1982
Pacific Waters
We now realize:
Arctic Ocean is not quiet ocean but is vigorous ocean that links to climate changes.
©NASA

Heavy Ice

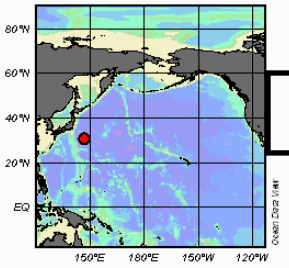


Less Ice

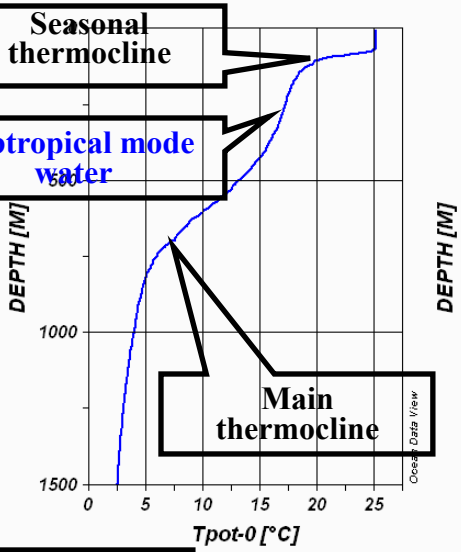


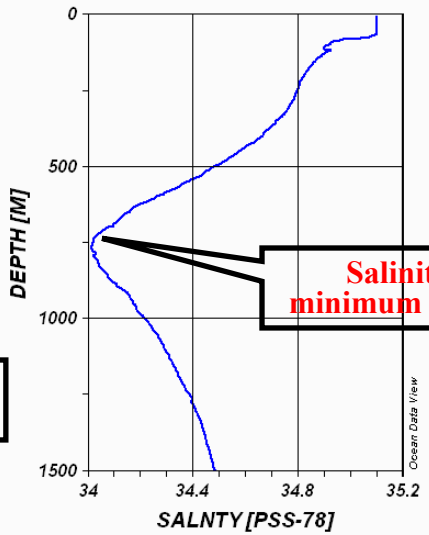

Pacific Arctic & Atlantic Arctic
anticyclonic ⇌subtropical gyre & cyclonic⇌subarctic gyre
GIN Seas
Barents Sea
Baffin Bay
Kara Sea
Nansen Basin
Gakkel Ridge
Amundsen Basin
Lomonosov Ridge
Makarov Basin
Alpha Ridge
Atlantic Arctic
Laptev Sea
Mendeleyev Ridge
CP
NWR
Canada Basin
Pacific Arctic
East Siberian Sea
Beaufort Sea
Chukchi Sea
0°
45°
90°
135°
180°

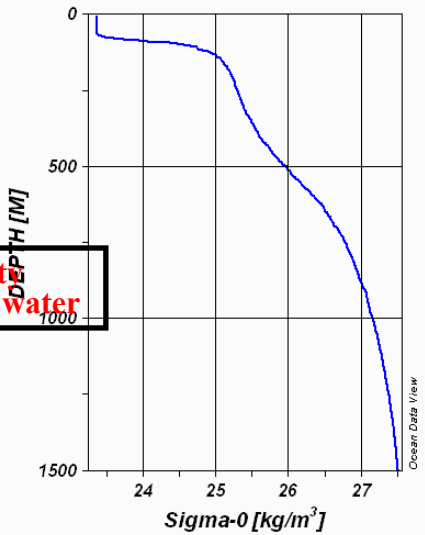
Similarities between Pacific Ocean and Arctic Ocean

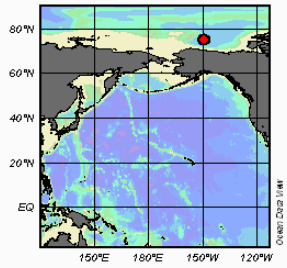


30.692°N, 147.403°E
WHP P10
November 4, 1993

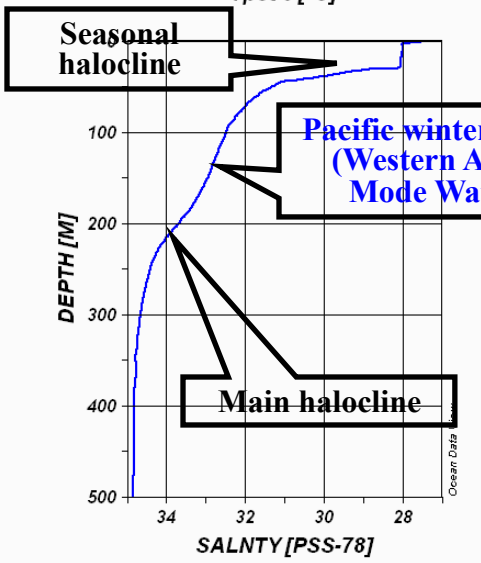


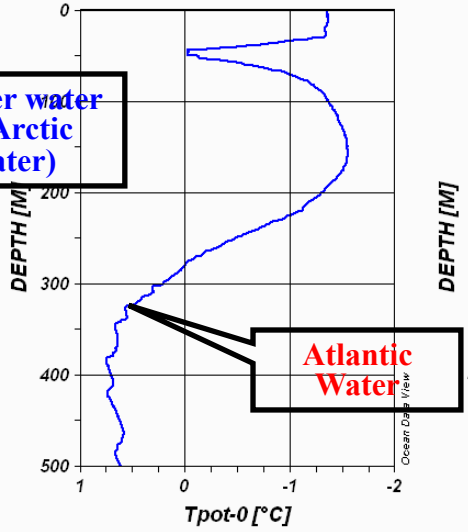


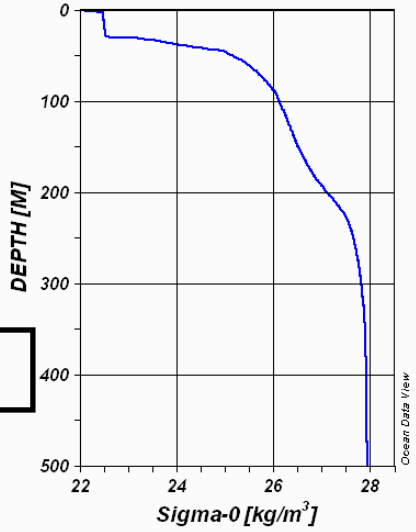




74.666°N, 156.005°W
Louis S. St-Laurent
August 15, 2003

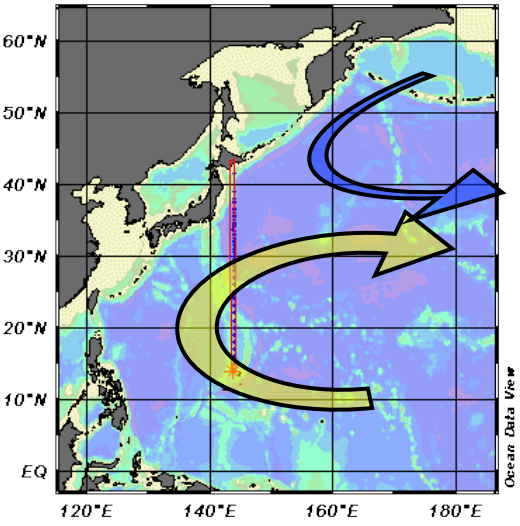


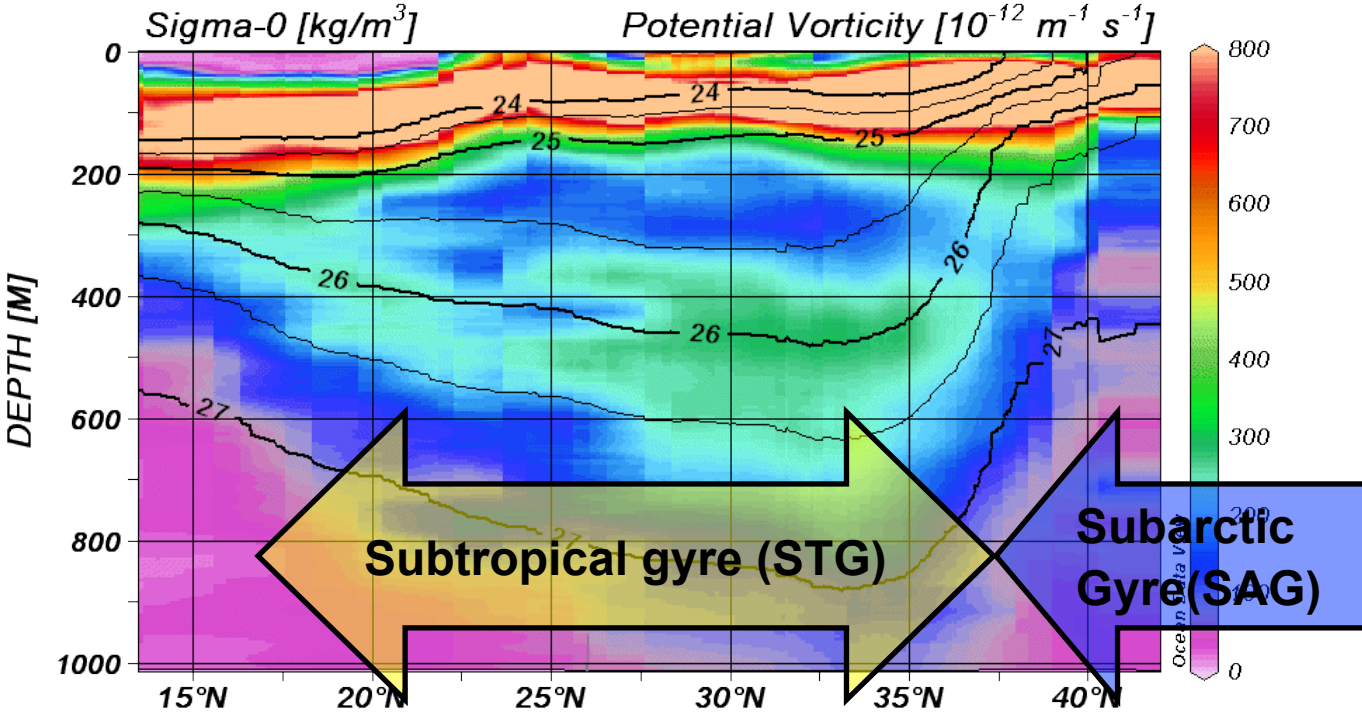




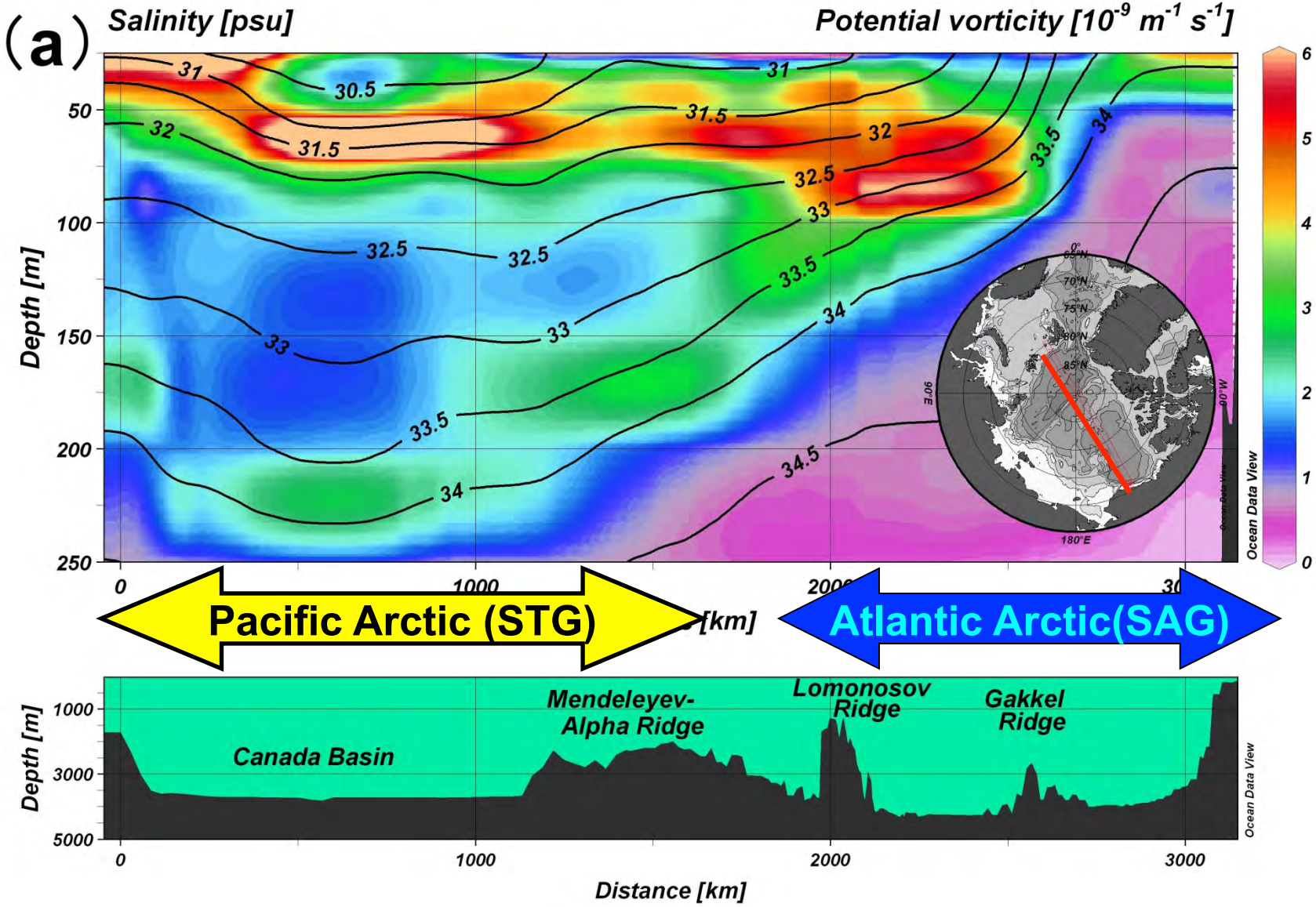
Pacific Ocean

Potential Vorticity:
$Q=f/g*N^2$

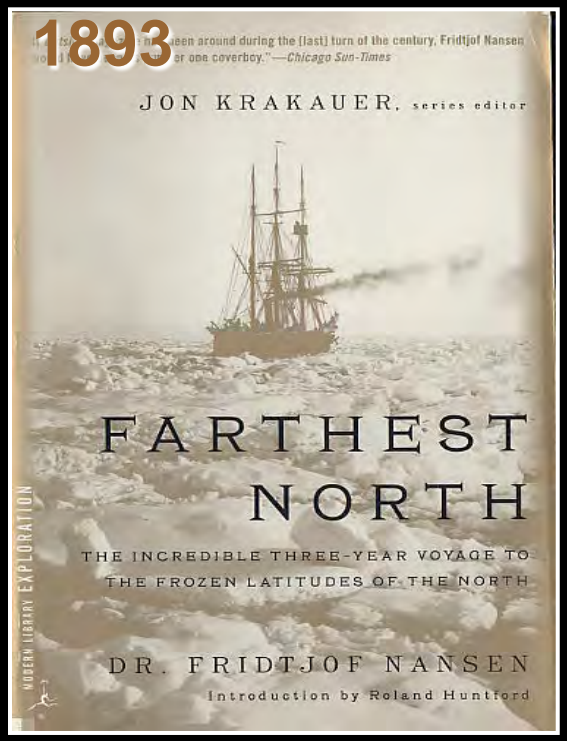




Arctic Ocean

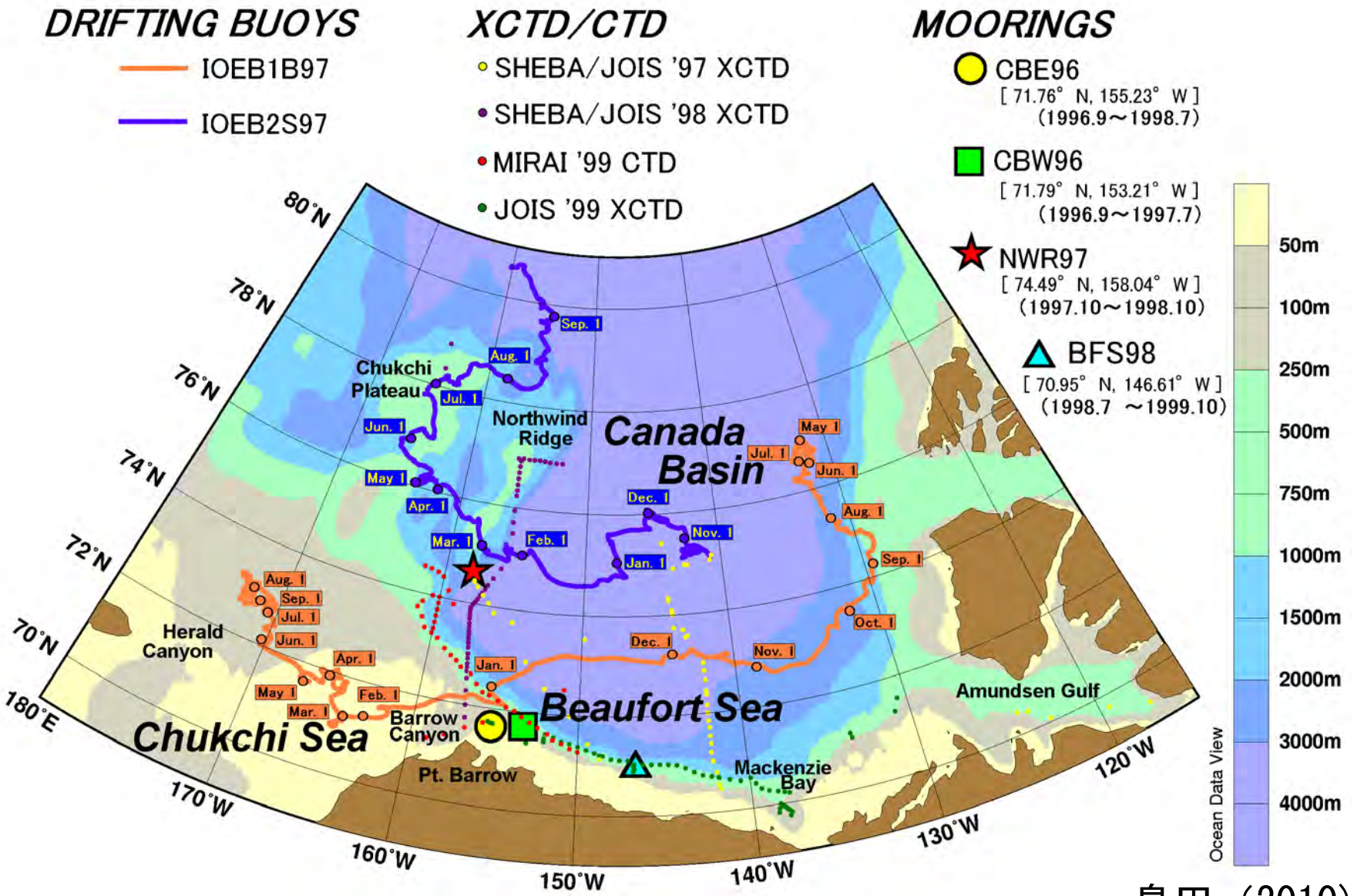


Changes in the Arctic Ocean



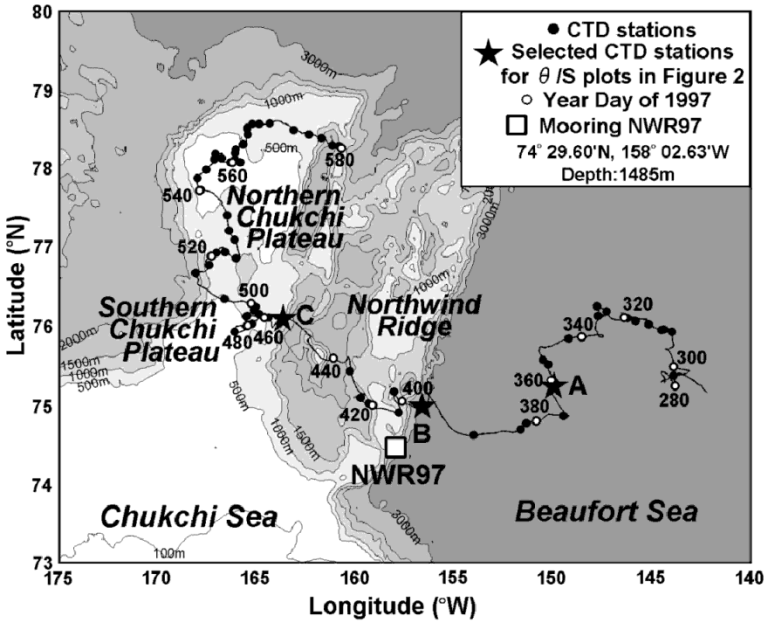
SHEBA 1997-1998

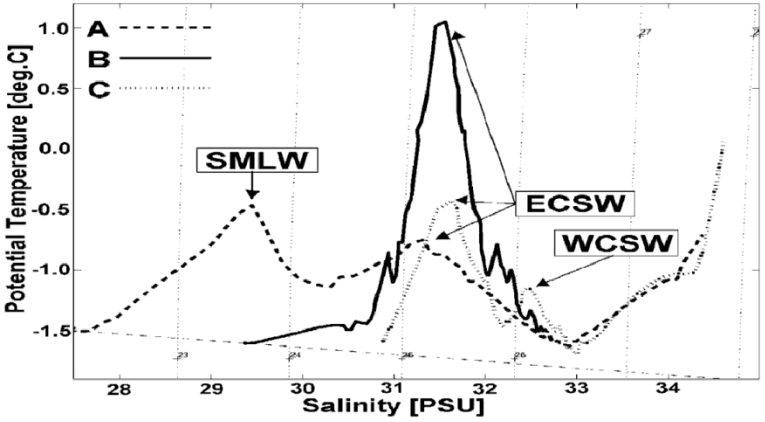
SHEBA／ARM 1997-1998

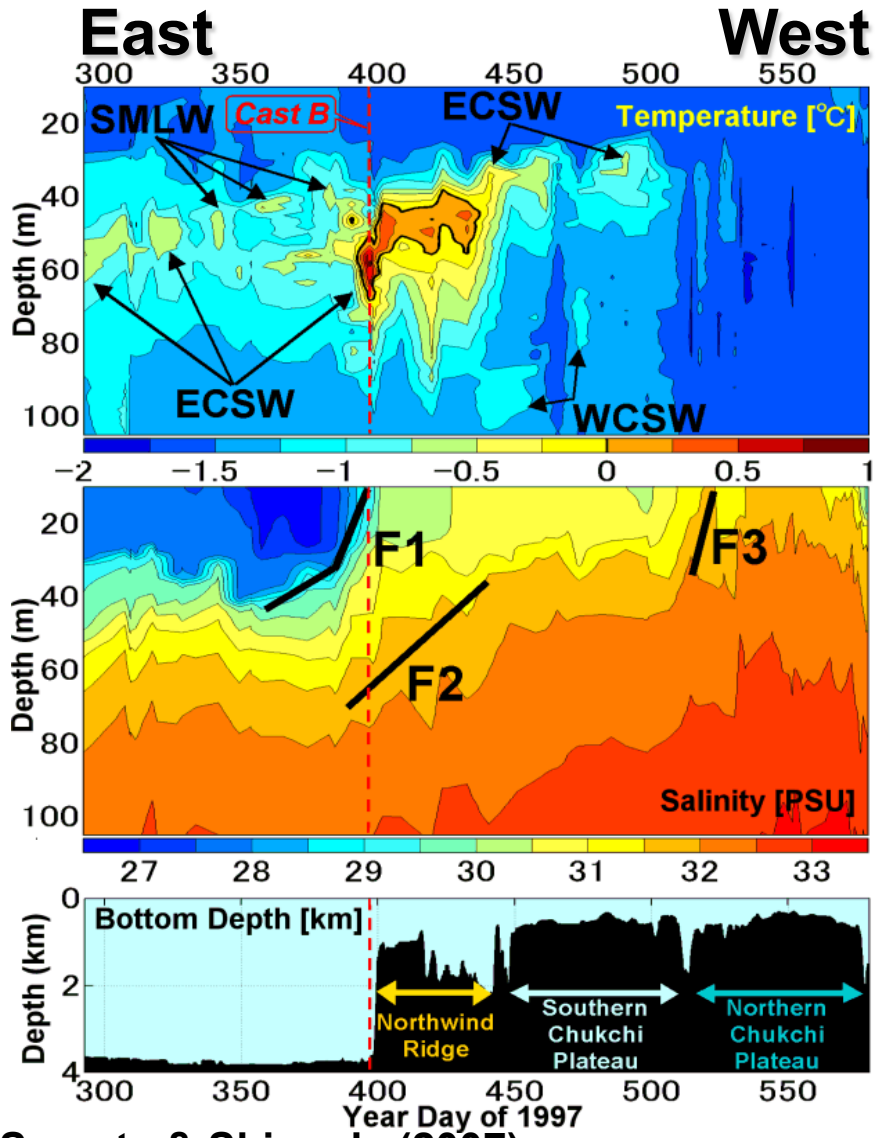


島田 (2010)

Major pathways of Pacific Summer Waters were identified.

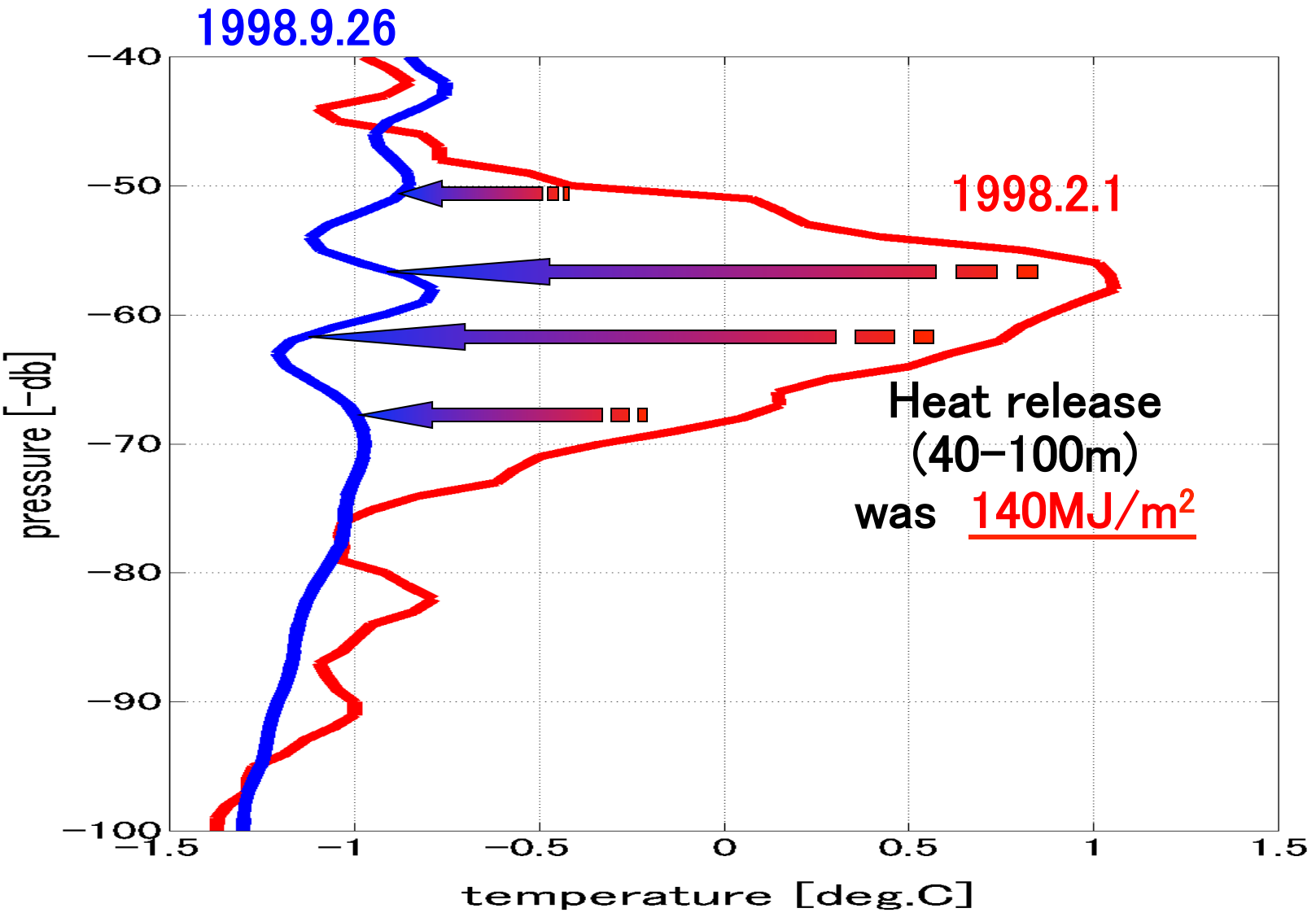


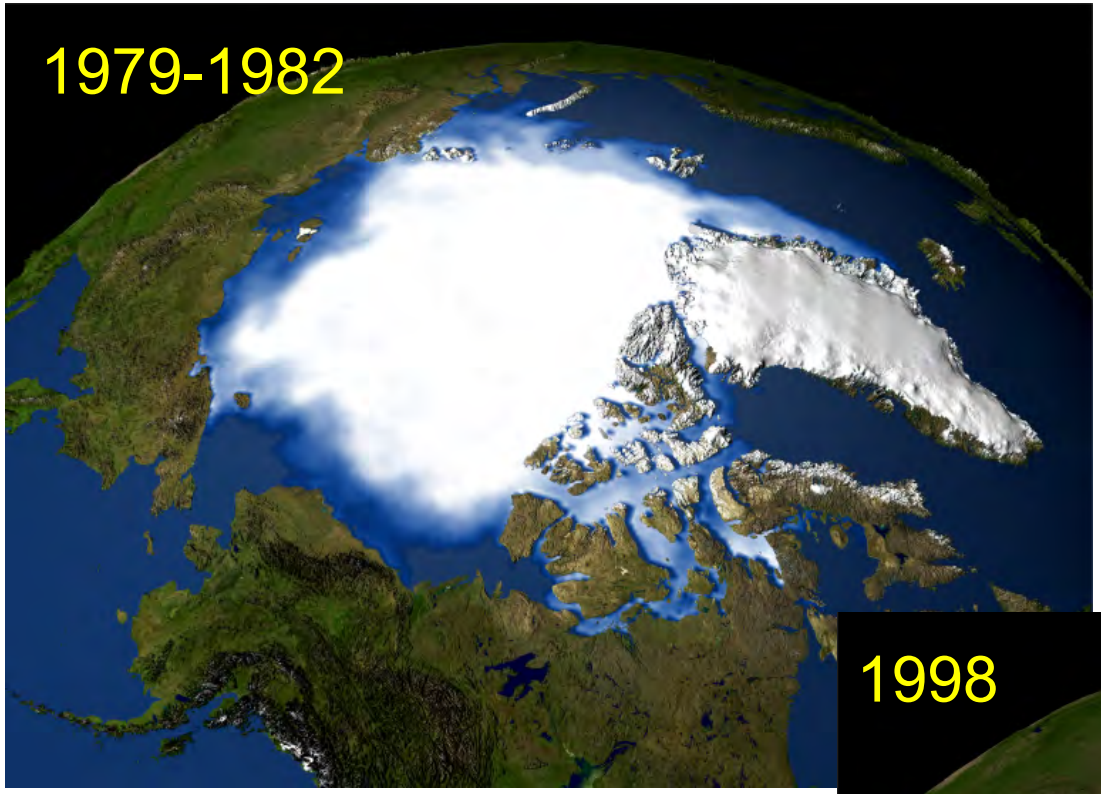




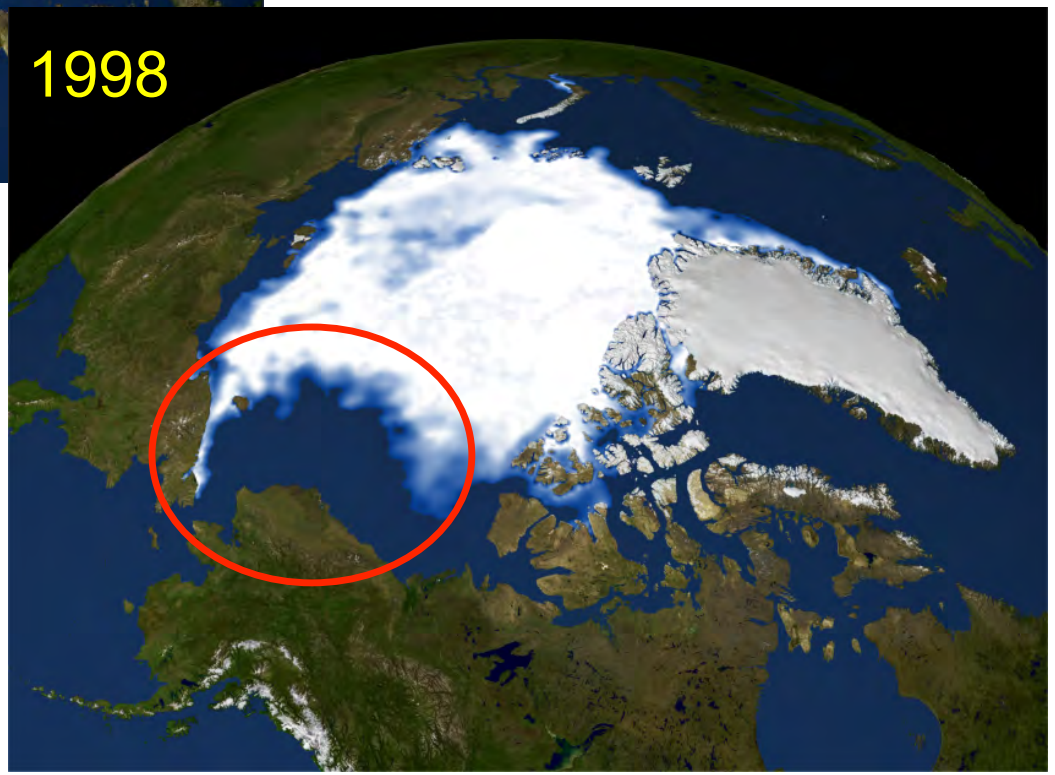
Shimada et al. (2001)、Sumata & Shimada (2007)

Heat release from ocean to sea ice during SHEBA in the Northwind Ridge area

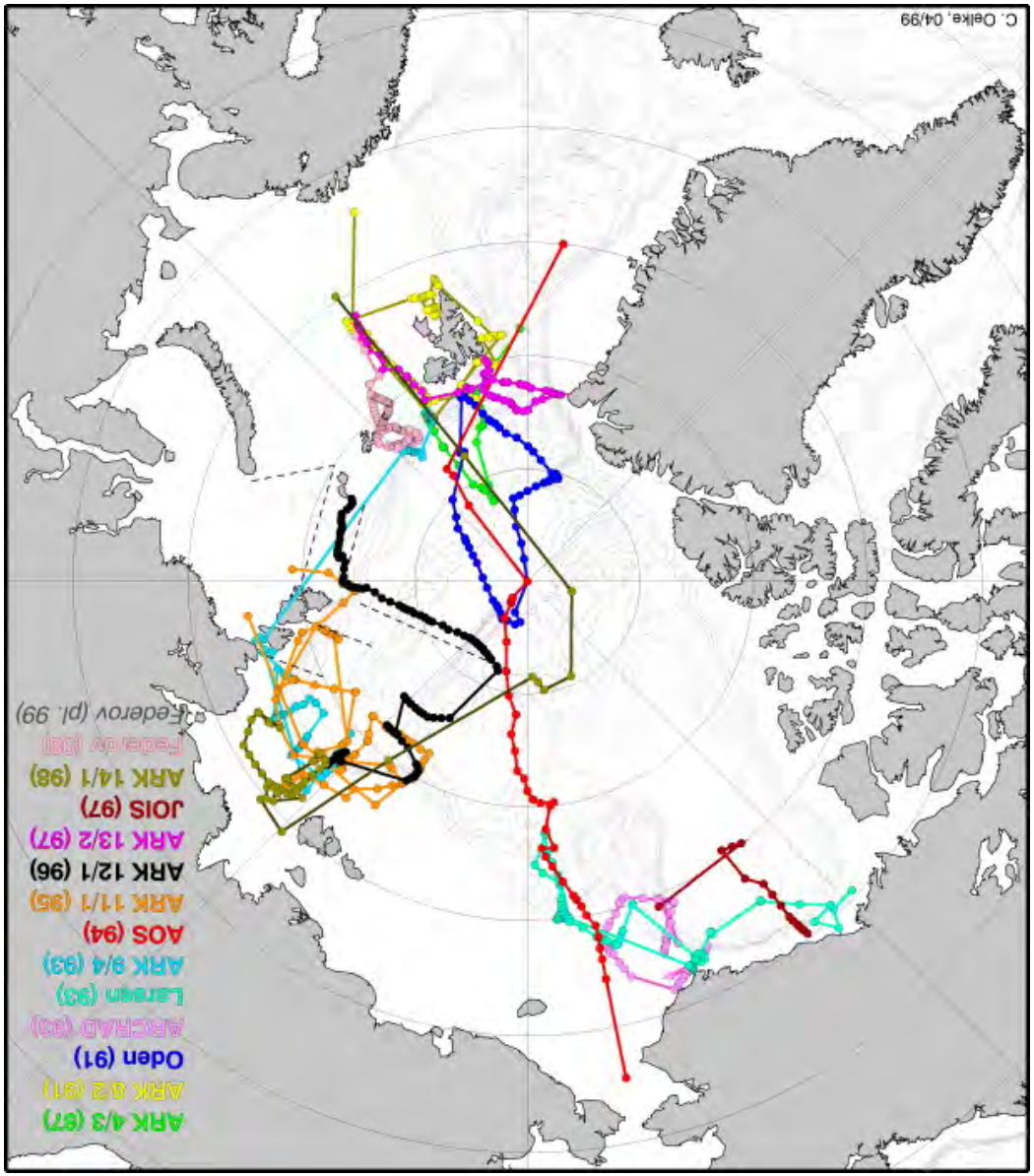




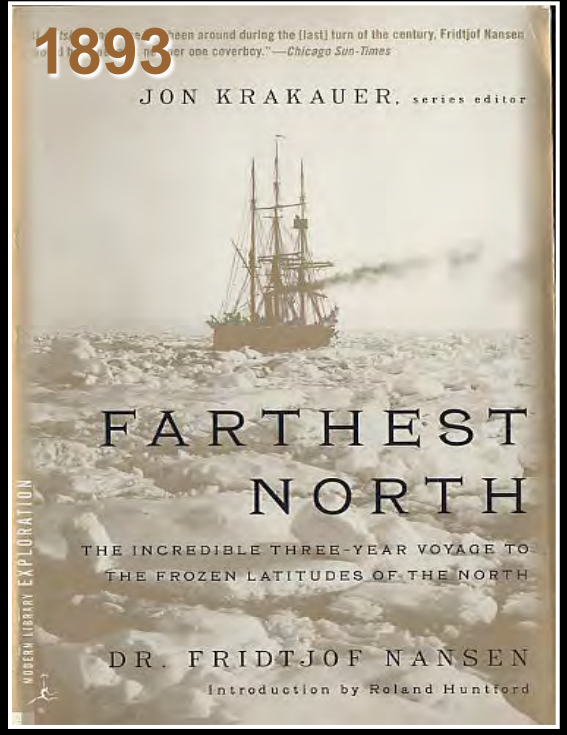
Ocean controled the sea ice reduction in the Pacific Sector



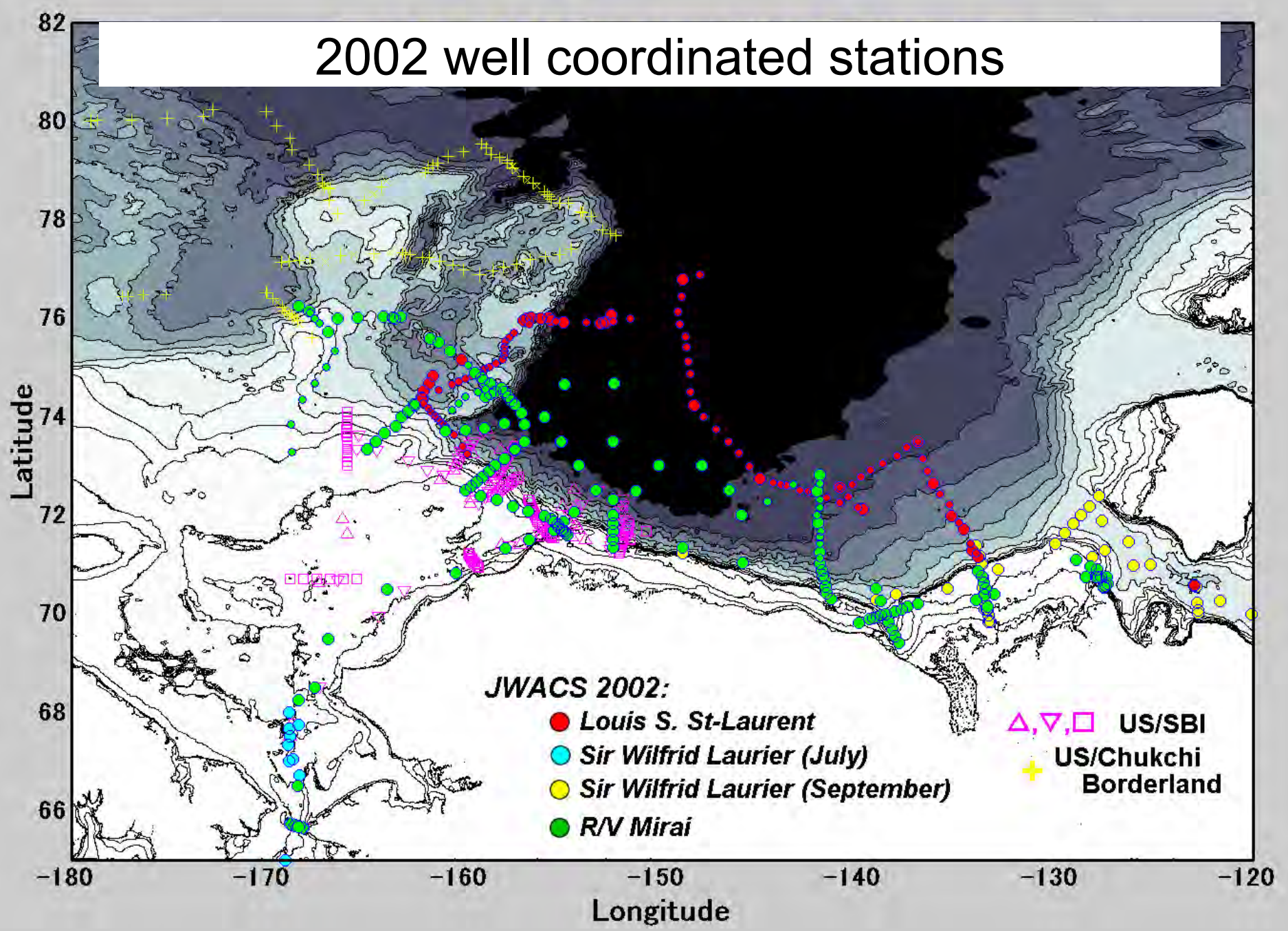
CTD stations in 1990s from ACSYS HP

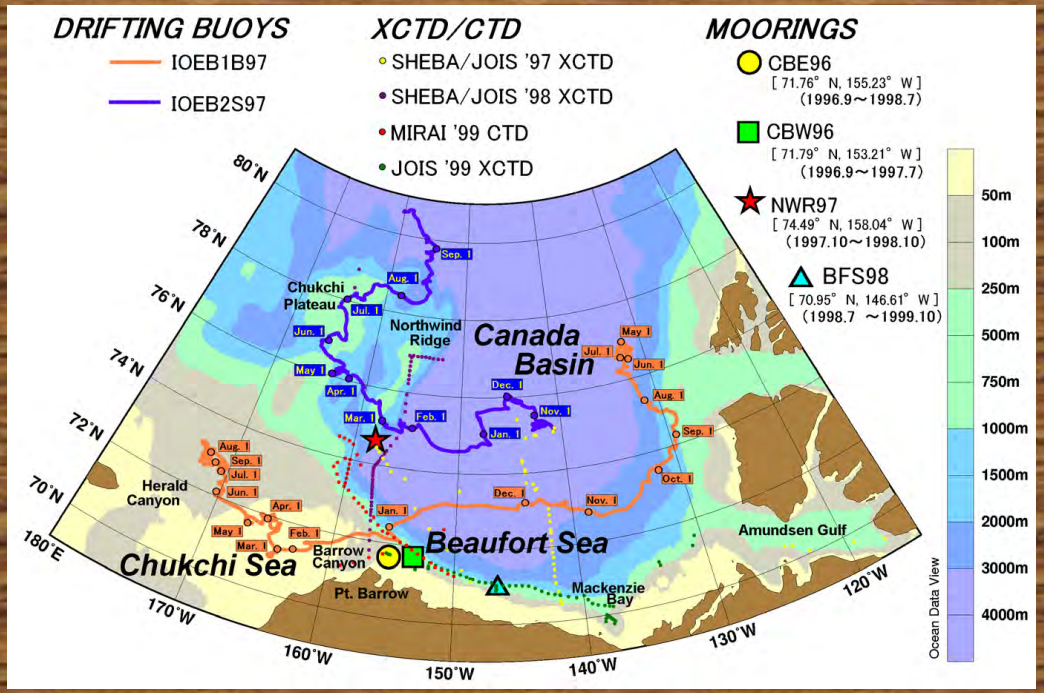


Changes in the Arctic Ocean

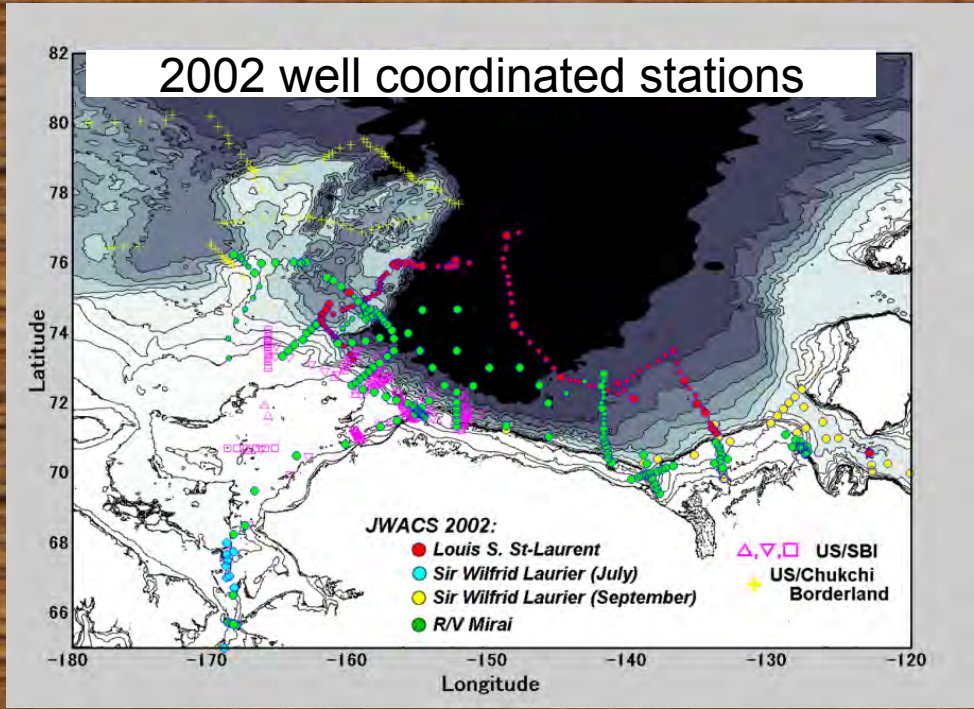


2002 well coordinated stations




DRIFTING BUOYS
IOEB1B97
IOEB2S97
XCTD/CTD
SHEBA/JOIS '97 XCTD
SHEBA/JOIS '98 XCTD
MIRAI '99 CTD
JOIS '99 XCTD
MOORINGS
CBE96
[71.76° N, 155.23° W]
(1996.9～1998.7)
CBW96
[71.79° N, 153.21° W]
(1996.9～1997.7)
NWR97
[74.49° N, 158.04° W]
(1997.10～1998.10)
BFS98
[70.95° N, 146.61° W]
(1998.7 ～1999.10)
Chukchi Plateau
Northwind Ridge
Canada Basin
Herald Canyon
Chukchi Sea
Barrow Canyon
Pt. Barrow
Beaufort Sea
Mackenzie Bay
Amundsen Gulf
80°N
78°N
76°N
74°N
72°N
70°N
180°E
170°W
160°W
150°W
140°W
130°W
120°W
50m
100m
250m
500m
750m
1000m
1500m
2000m
3000m
4000m
Ocean Data View

+


2002 well coordinated stations
Latitude
Longitude
82
80
78
76
74
72
70
68
66
-180
-170
-160
-150
-140
-130
-120
JWACS 2002:
Louis S. St-Laurent
Sir Wilfrid Laurier (July)
Sir Wilfrid Laurier (September)
R/V Mirai
△,▽,□ US/SBI
US/Chukchi Borderland

=

IPY2007-2008

80°N

70°N

180°E

160°W

140°W

120°W

Complete observatory

in the Pacific Arctic Ocean

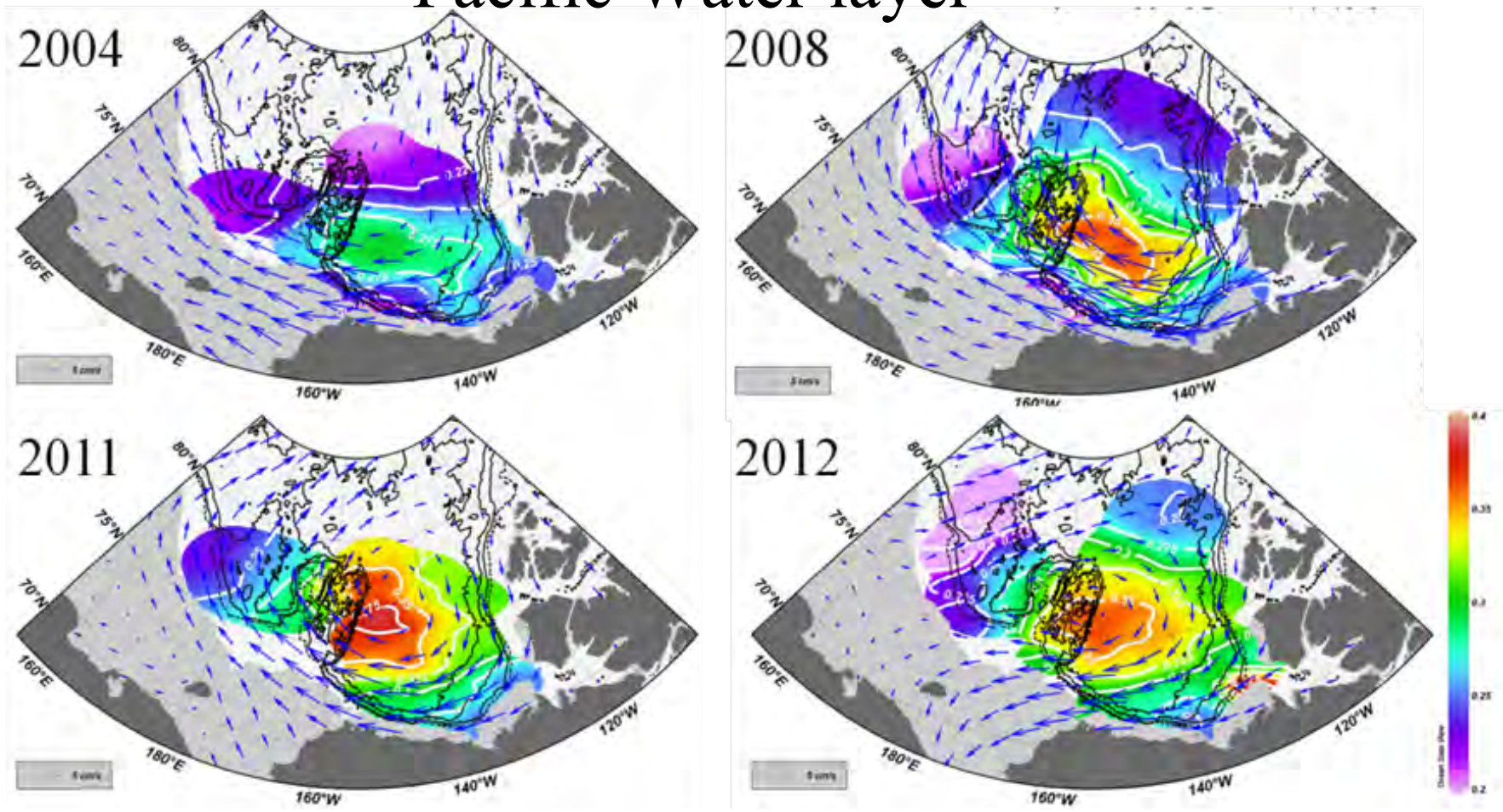
2010~

Araon and Louis S. St-Laurent covered the full span of the Pacific Sector of the Arctic O

Araon & LSSL 2011-2012

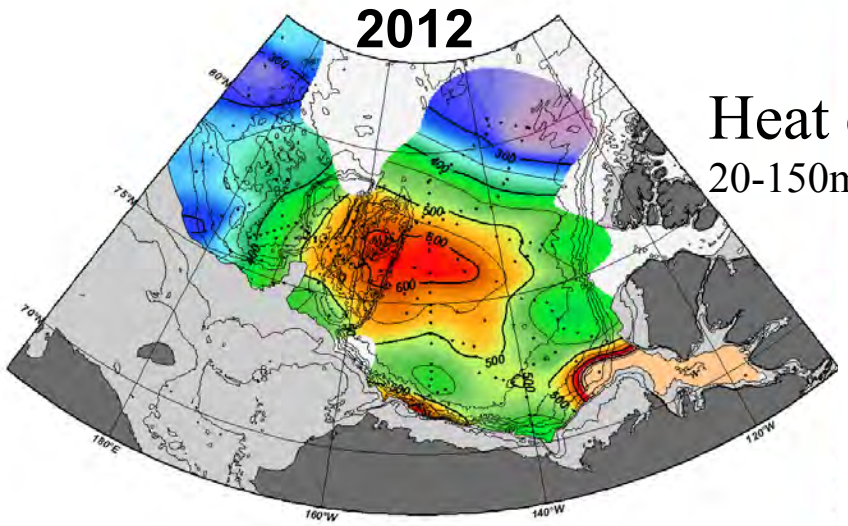

KOPRI
Korea Polar Research Institute
ARAON
아라온
KOPRI
2012 Araon Arctic Cruise
1st Aug. - 10th Sept
82°19'N

Sea ice motion and ocean circulation of Pacific Water layer

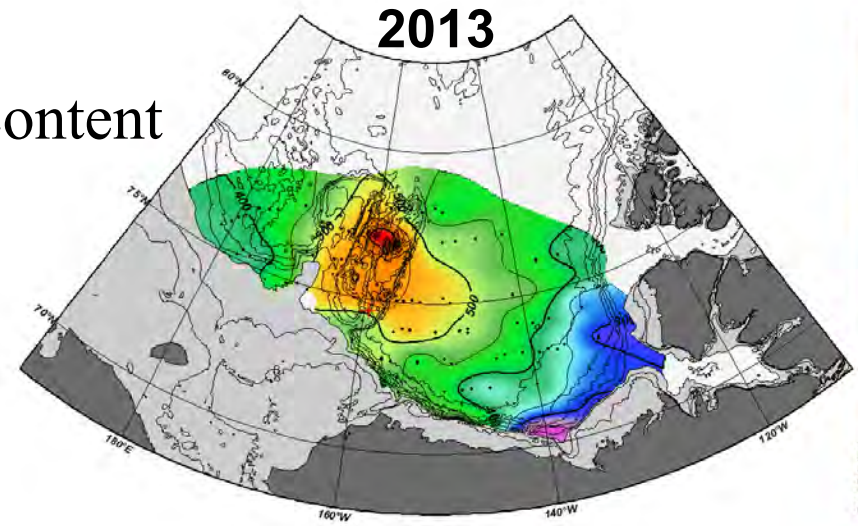


Background color: dynamic height at 100dar relative to 800bdar (Oceanic Beaufort Gyre)
Black vectors: average sea ice motion vectors for November – April.

Yoshizawa et al., (2014)



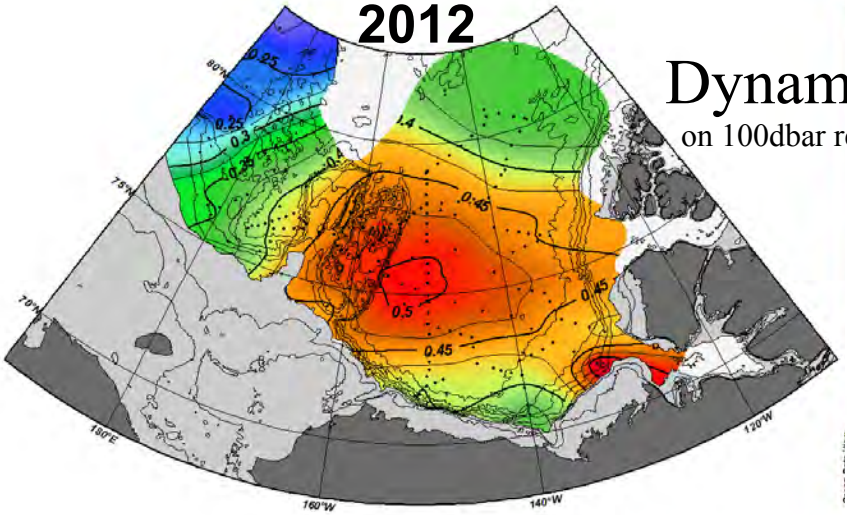
Heat content
20-150m



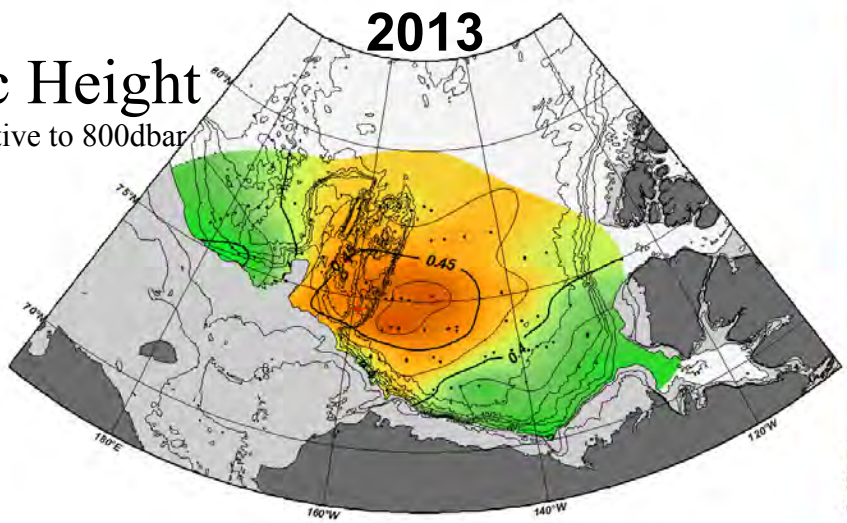
2013:

upper ocean heat decrease→ formation of sea ice enhanced

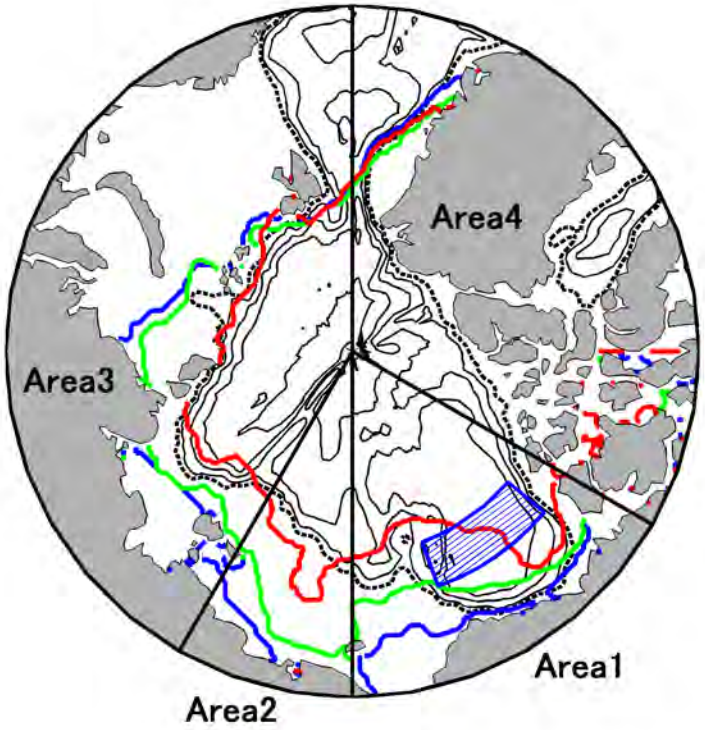
→thickness of first year ice increase→sea ice survive by the end of summer

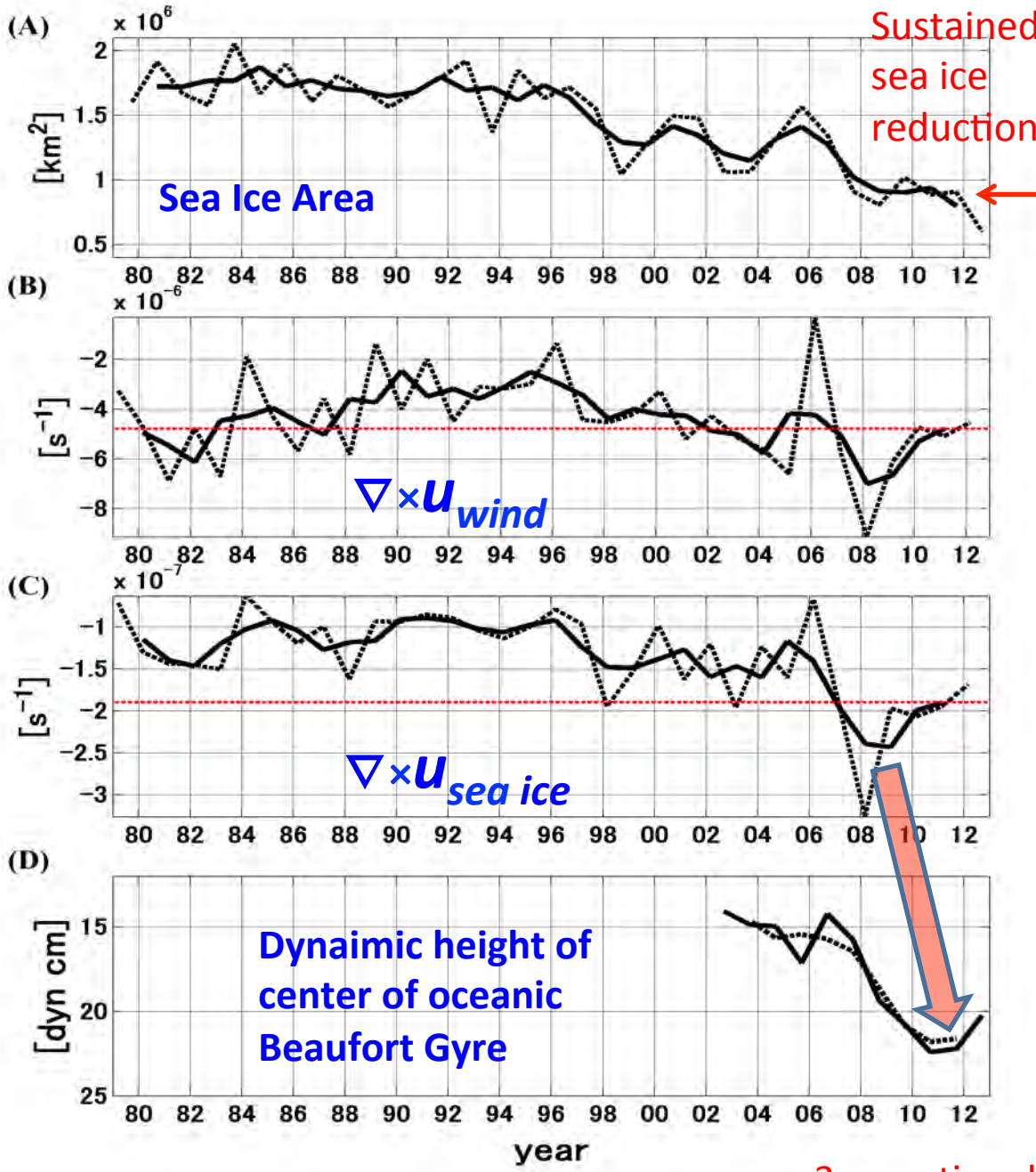


Dynamic Height
on 100dbar relative to 800dbar



Upper ocean circulation was weakened in 2013

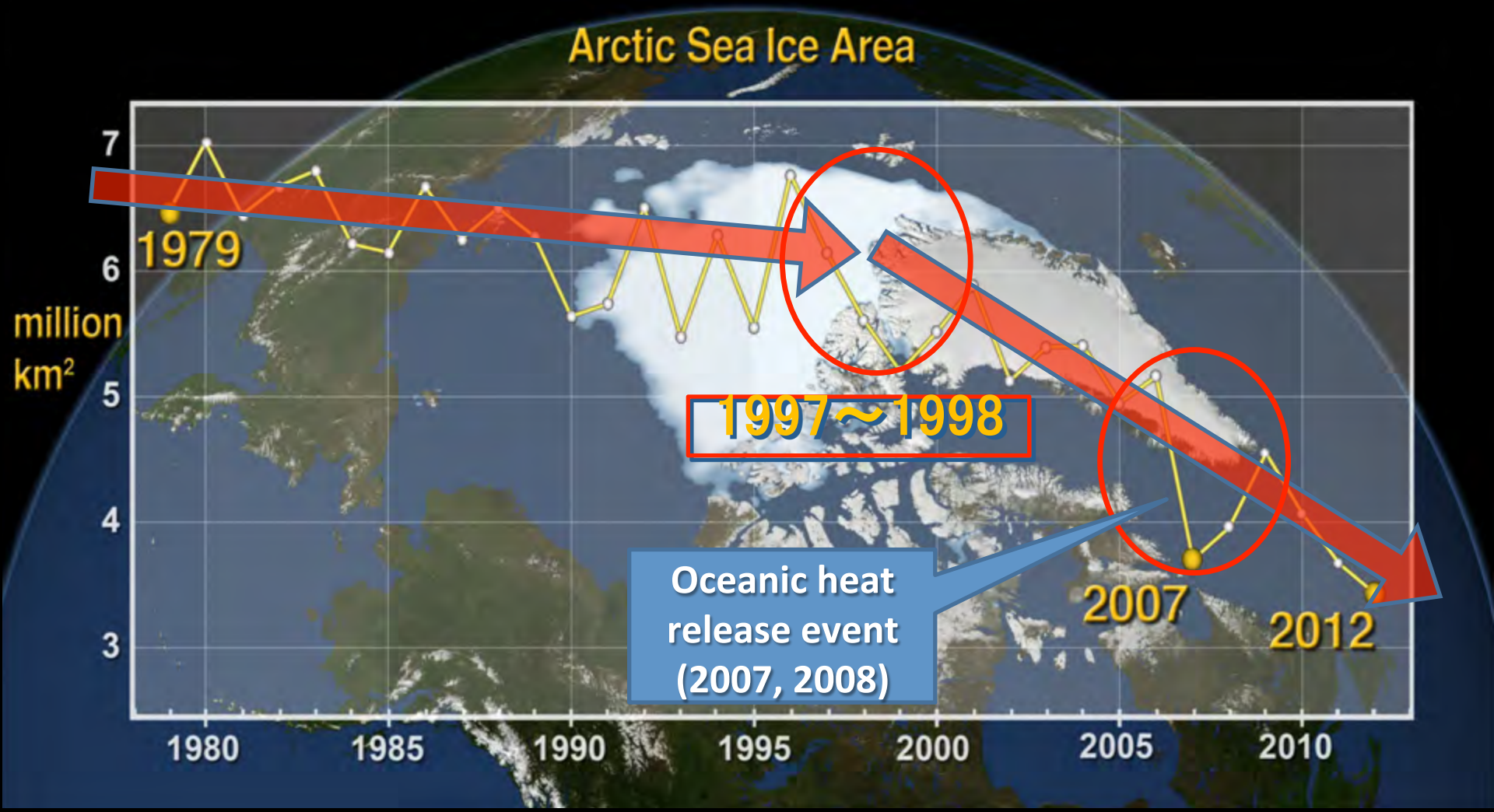




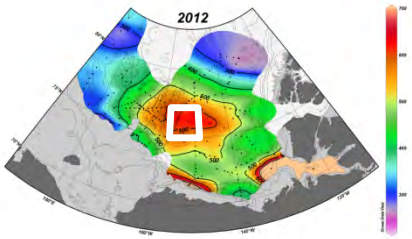
Upper ocean response delayed about 3 years relative to the surface forcings (wind or sea ice motion).

Yoshizawa et al., (2014)

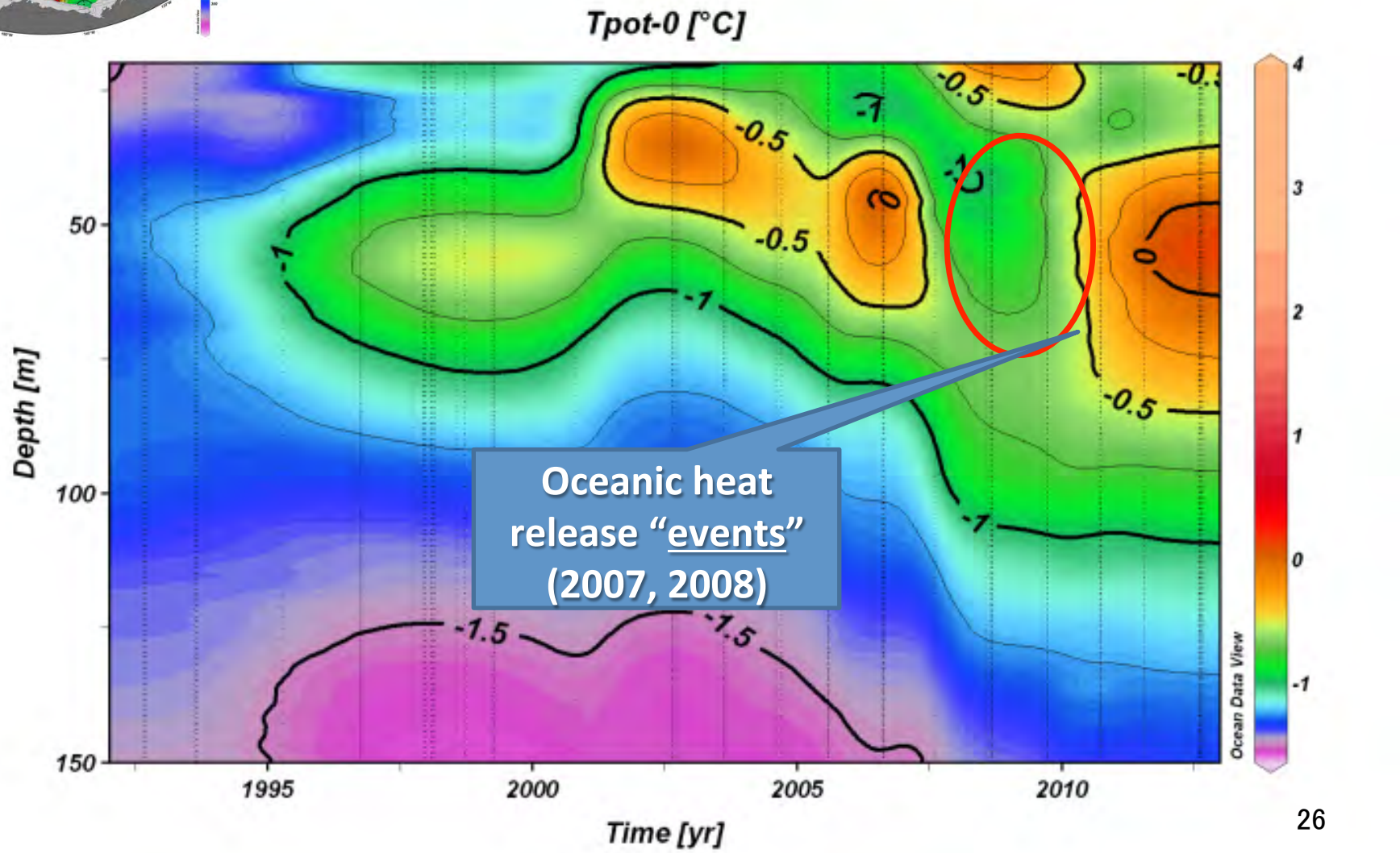
Sea ice extent : 1979～2012



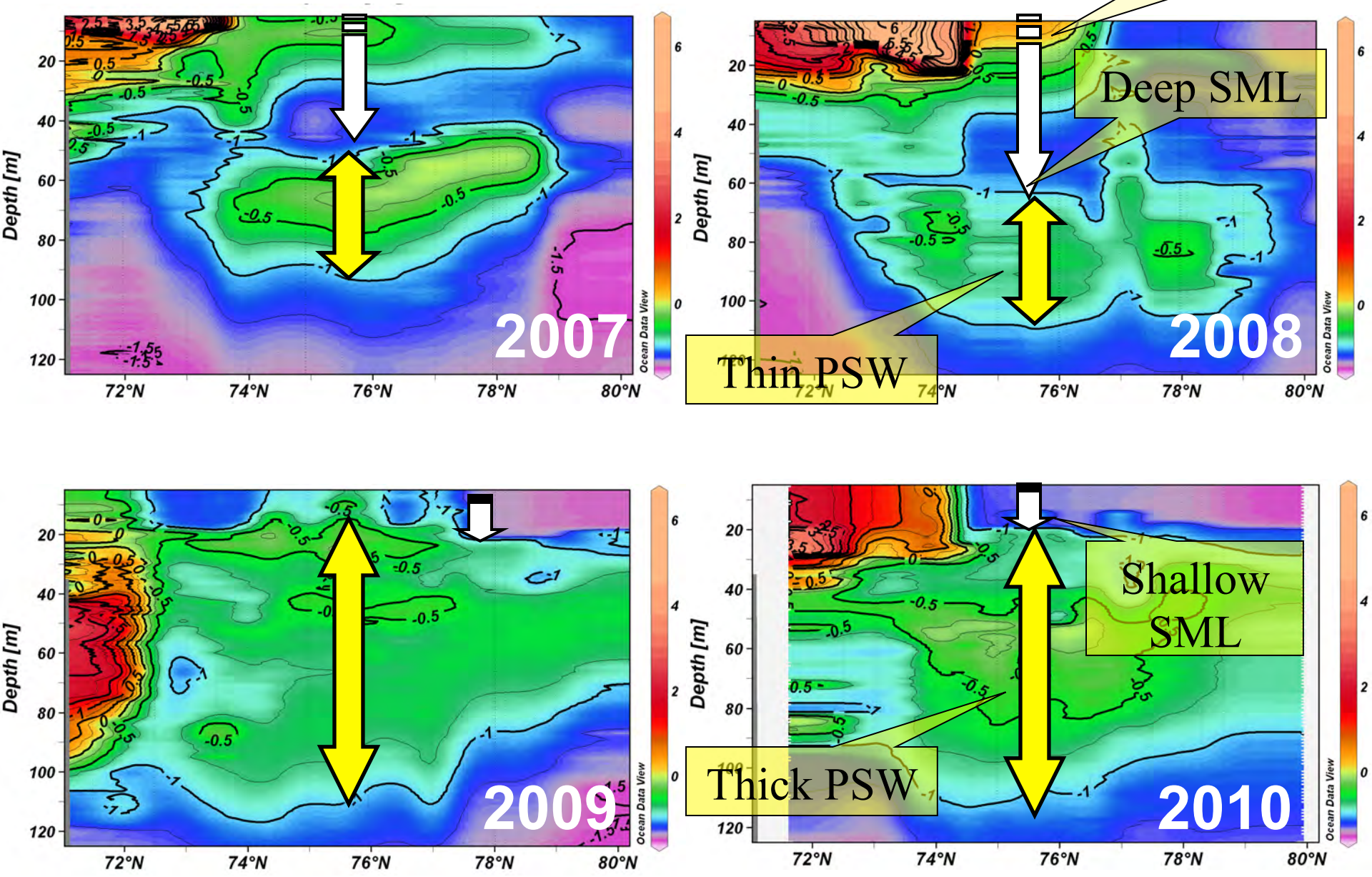
Time series of temperature on the Northwindridge

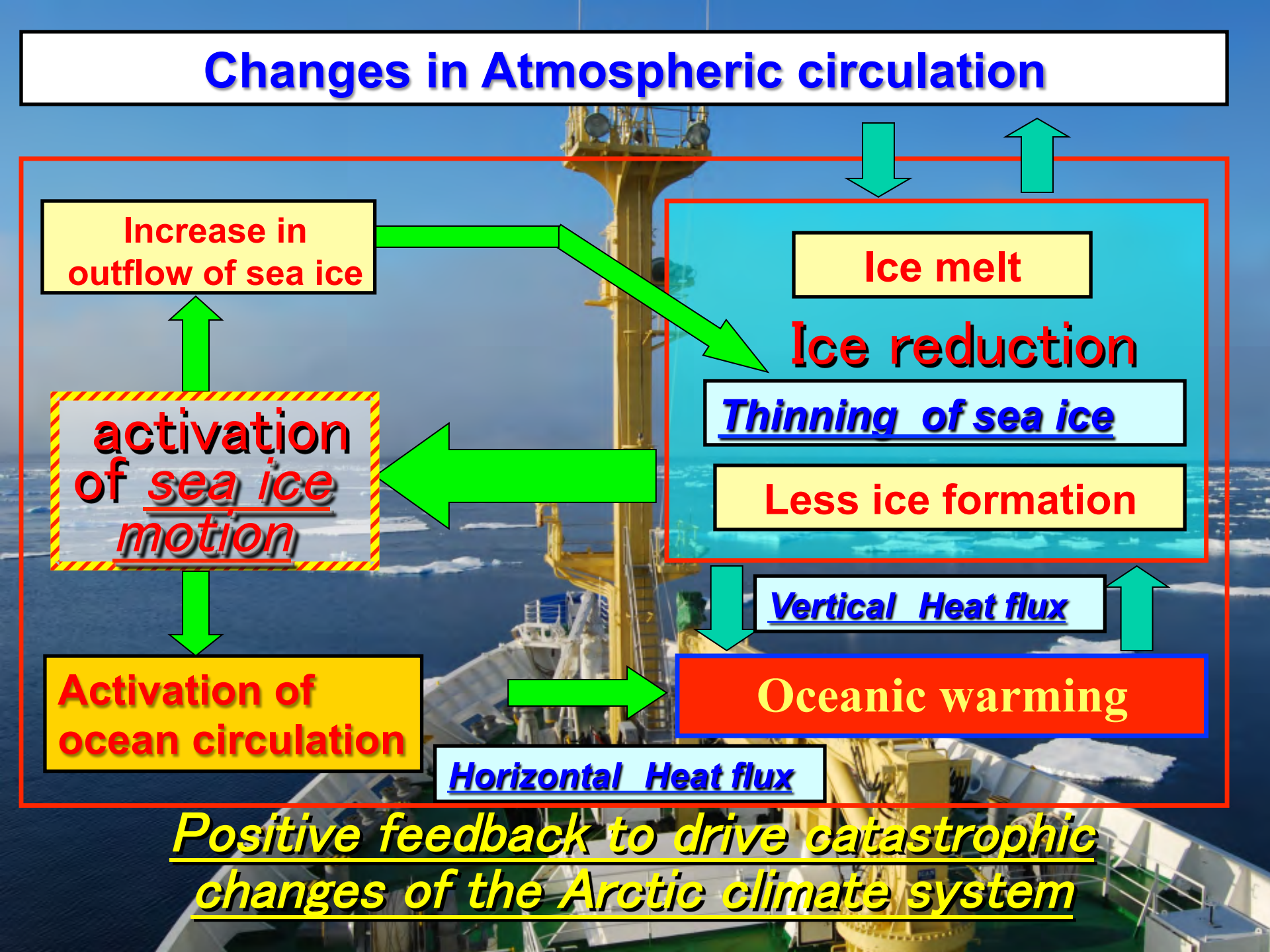


Heat release “event”.

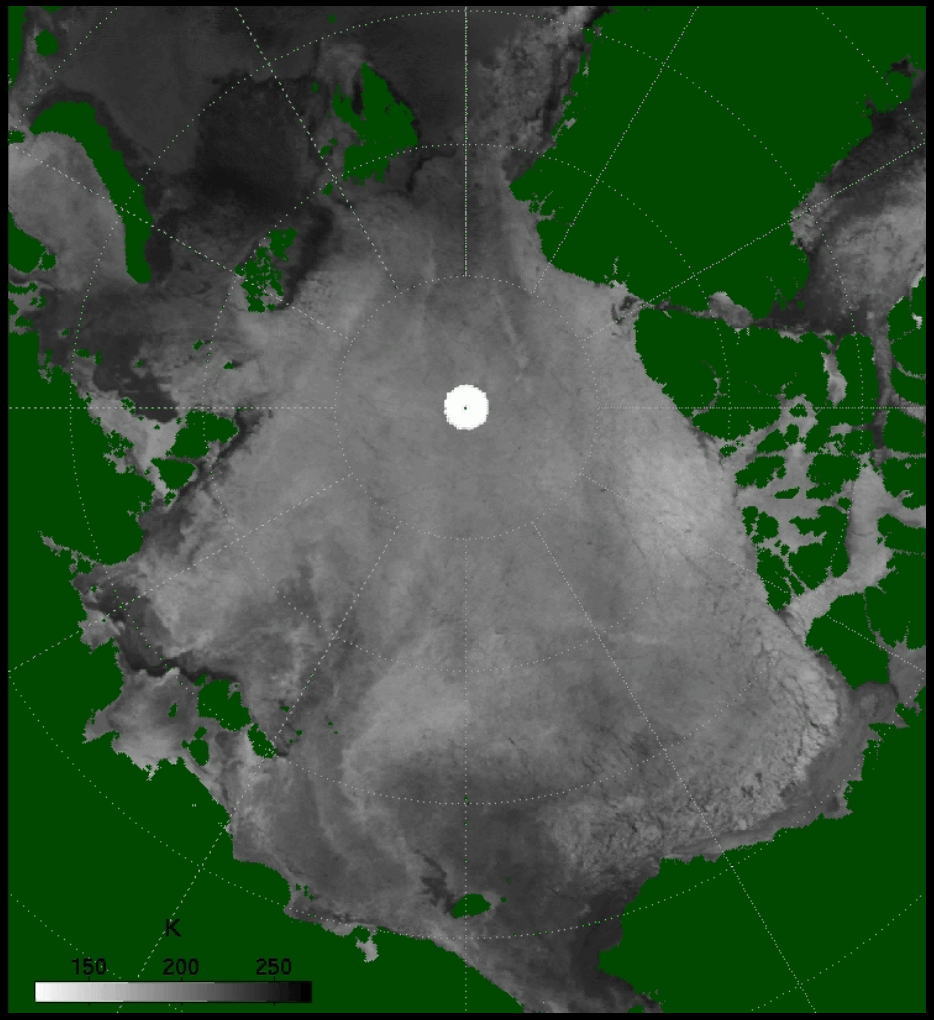


Changes in temperature along 150W

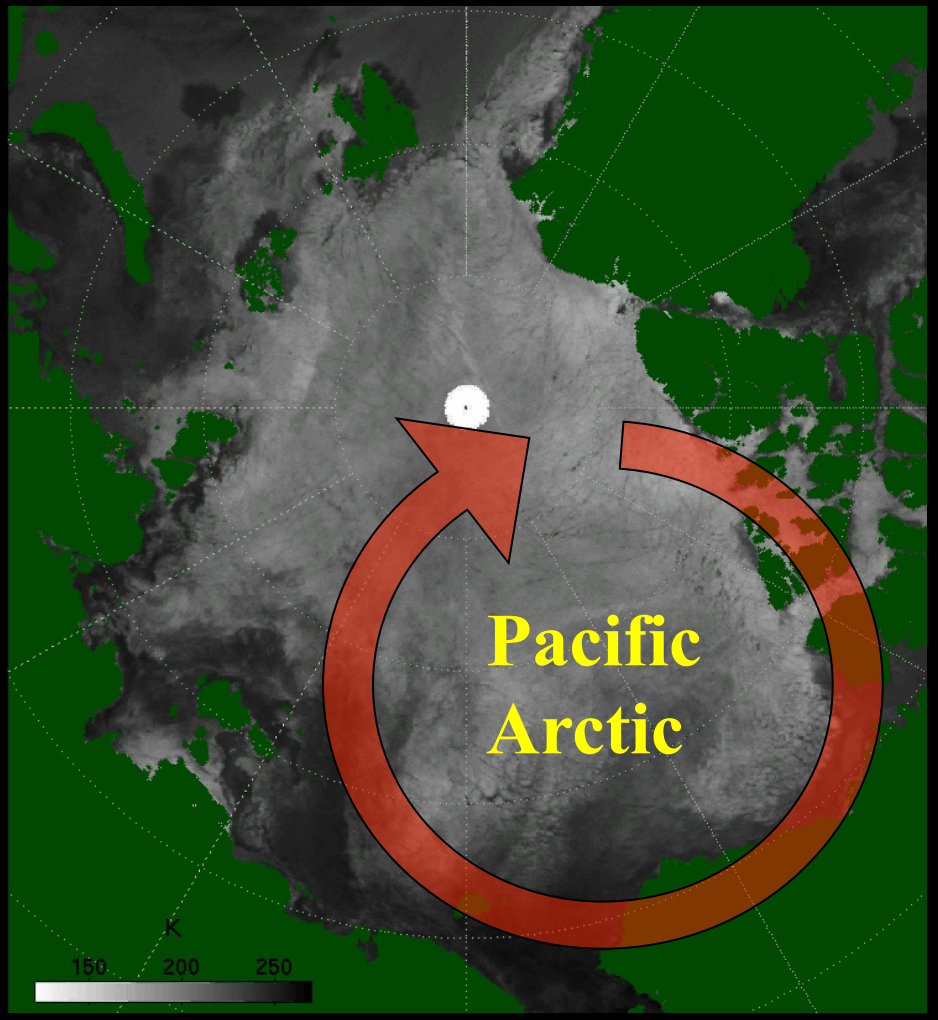


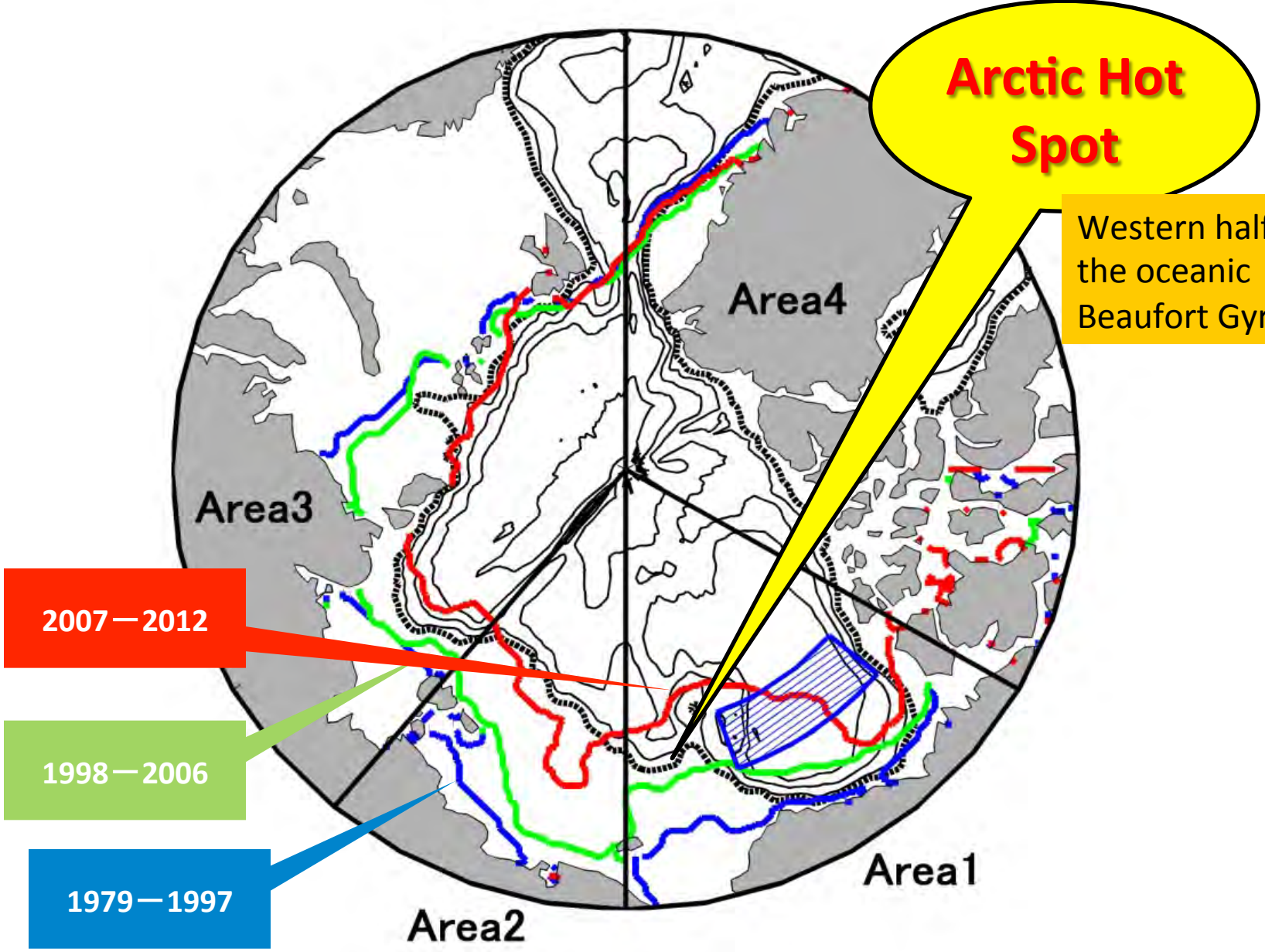

Changes in Atmospheric circulation
Increase in outflow of sea ice
Ice melt
Ice reduction
Thinning of sea ice
Less ice formation
activation of sea ice motion
Vertical Heat flux
Activation of ocean circulation
Oceanic warming
Horizontal Heat flux
Positive feedback to drive catastrophic changes of the Arctic climate system

Heavy Ice



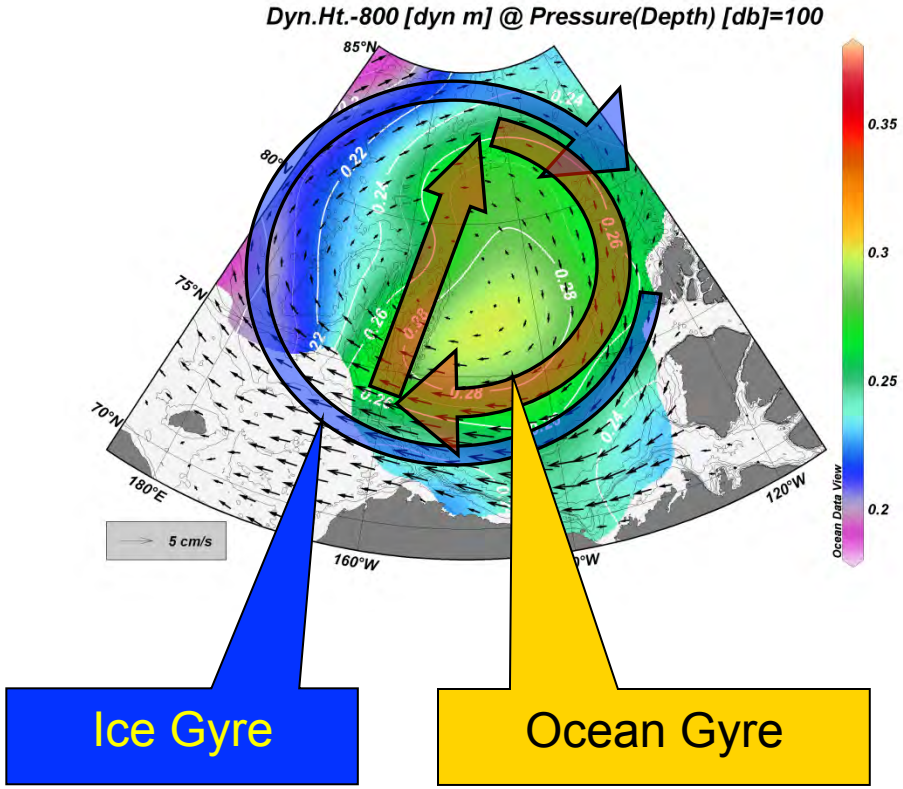
Less Ice

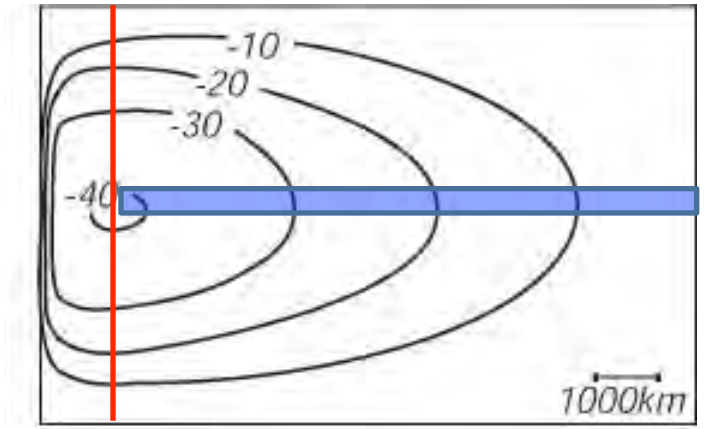




Ice edge in September

Yoshizawa et al., (2014)





β-plane

スベルトラップ輸送を計算

This is principal “Oceanic Beaufort Gyre” established by surface forcing and wave dynamics.
It is different from Beaufort High and Beaufort Ice Gyre.

Sumata & Shimada (2007)

Proposed international Pacific Arctic climate monitoring sections

Background color: dynamic height at 100dar relative to 800bdar from Mirai and Louis S. St-Laurent 2008 cruises (Oceanic Beaufort Gyre)

Black vectors: average sea ice motion vectors for Nov. 2007- Apr. 2008 (Sea Ice Beaufort Gyre)

Simbols: Mooring array in 2012-2013 (TUMSAT/KOPRI/NIPR & WHOI)