Pacific-Atlantic seesaw and the Bering Strait

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Facts about Bering Strait:

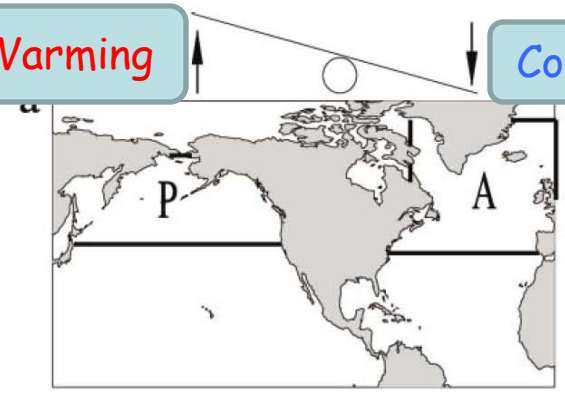
Present: Bering Strait is a narrow (~150 km) and shallow (~50 m) pathway connecting the Pacific and the Arctic between Alaska and Siberia.

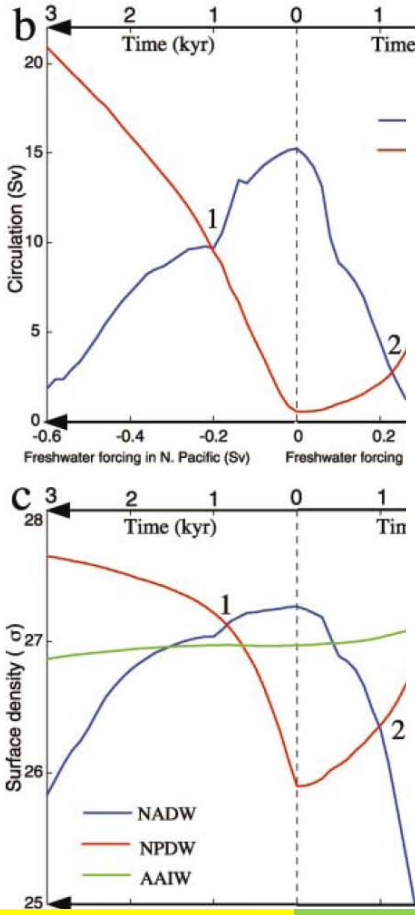
On average, about 0.8 Sv fresher North Pacific water flows through this strait into the Arctic, subsequently into the North Atlantic.

Sverdrup (Sv) ≡ 10^6 m^3s^{-1} or 1 million cubic meters per second

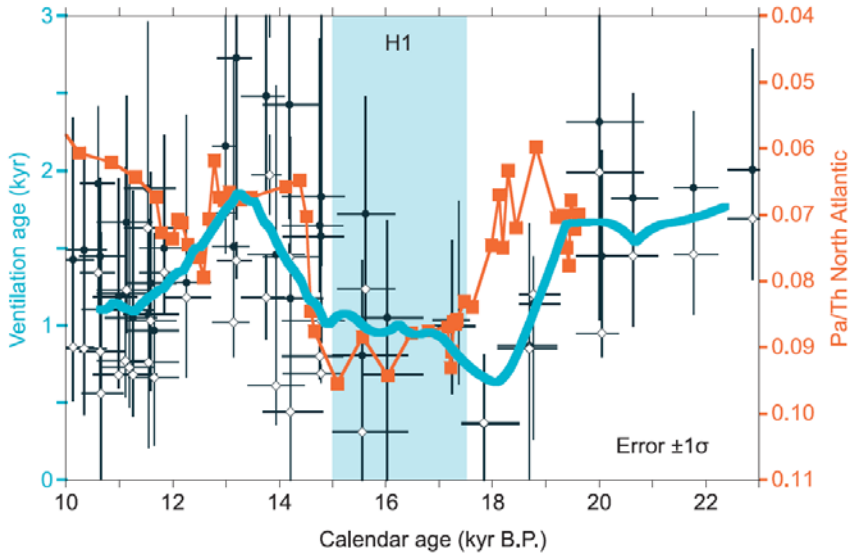
Warming

Cooling

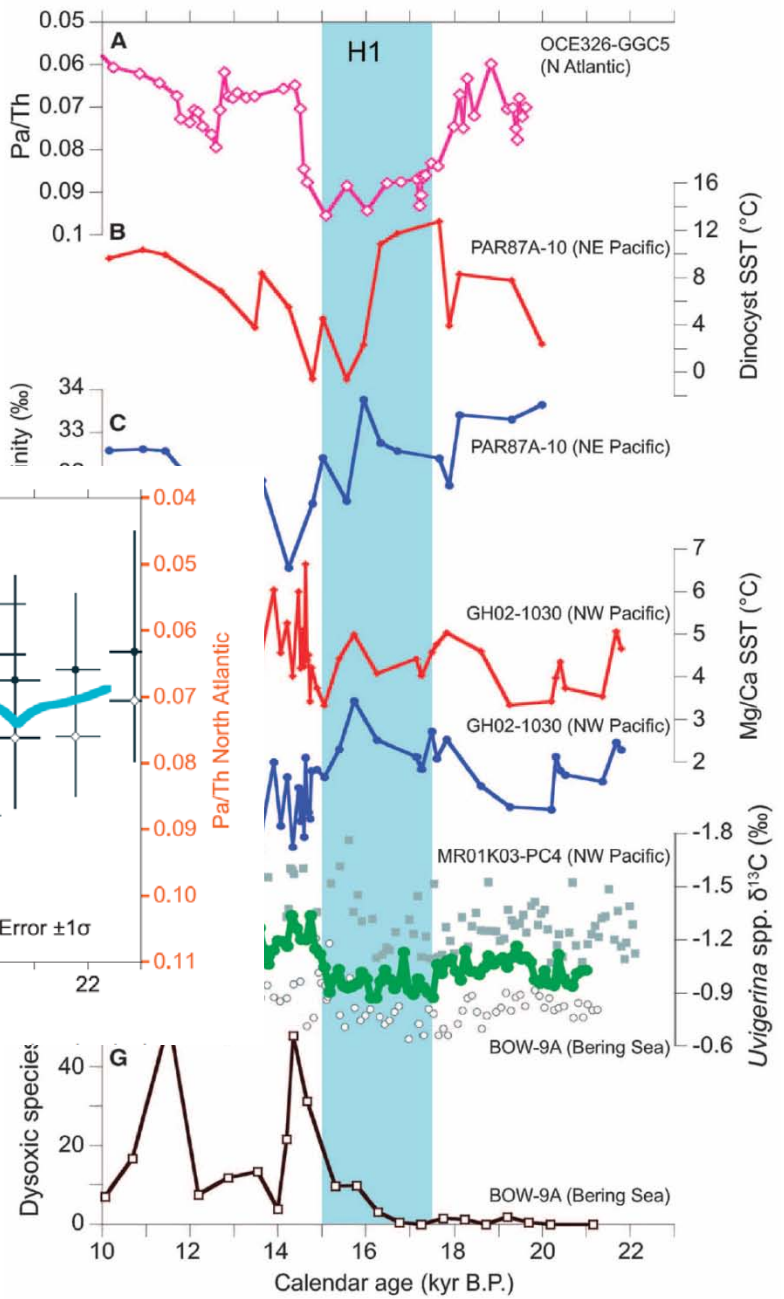




Saenko, et al. 2004

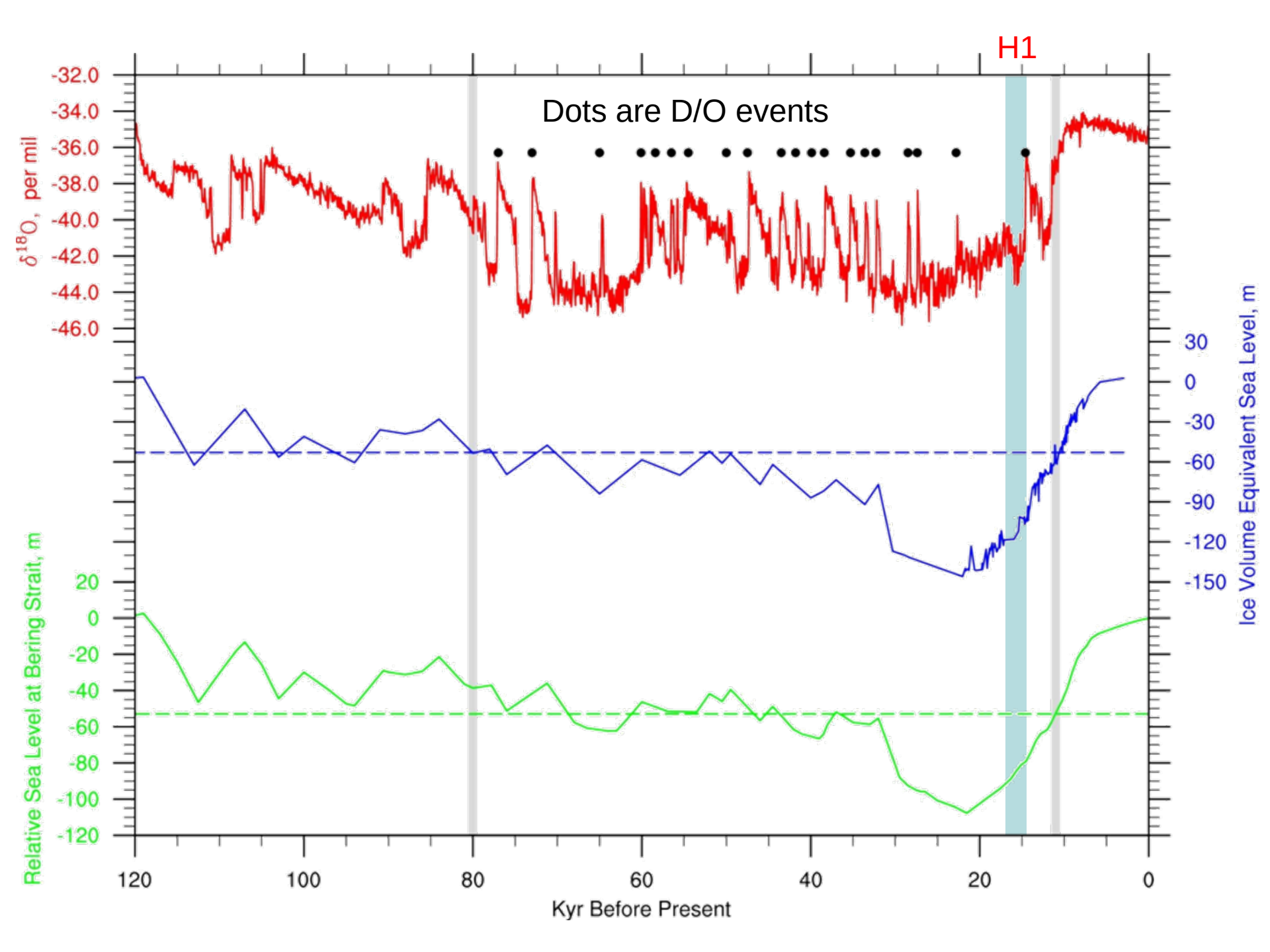


Okazaki et al., 2010



FW forcing NP

FW forcing NA


H1
Dots are D/O events
-32.0
-34.0
-36.0
-38.0
-40.0
-42.0
-44.0
-46.0
δ18O, per mil
30
0
-30
-60
-90
-120
-150
Ice Volume Equivalent Sea Level, m
20
0
-20
-40
-60
-80
-100
-120
Relative Sea Level at Bering Strait, m
120
100
80
60
40
20
0
Kyr Before Present

Model and Experiments:

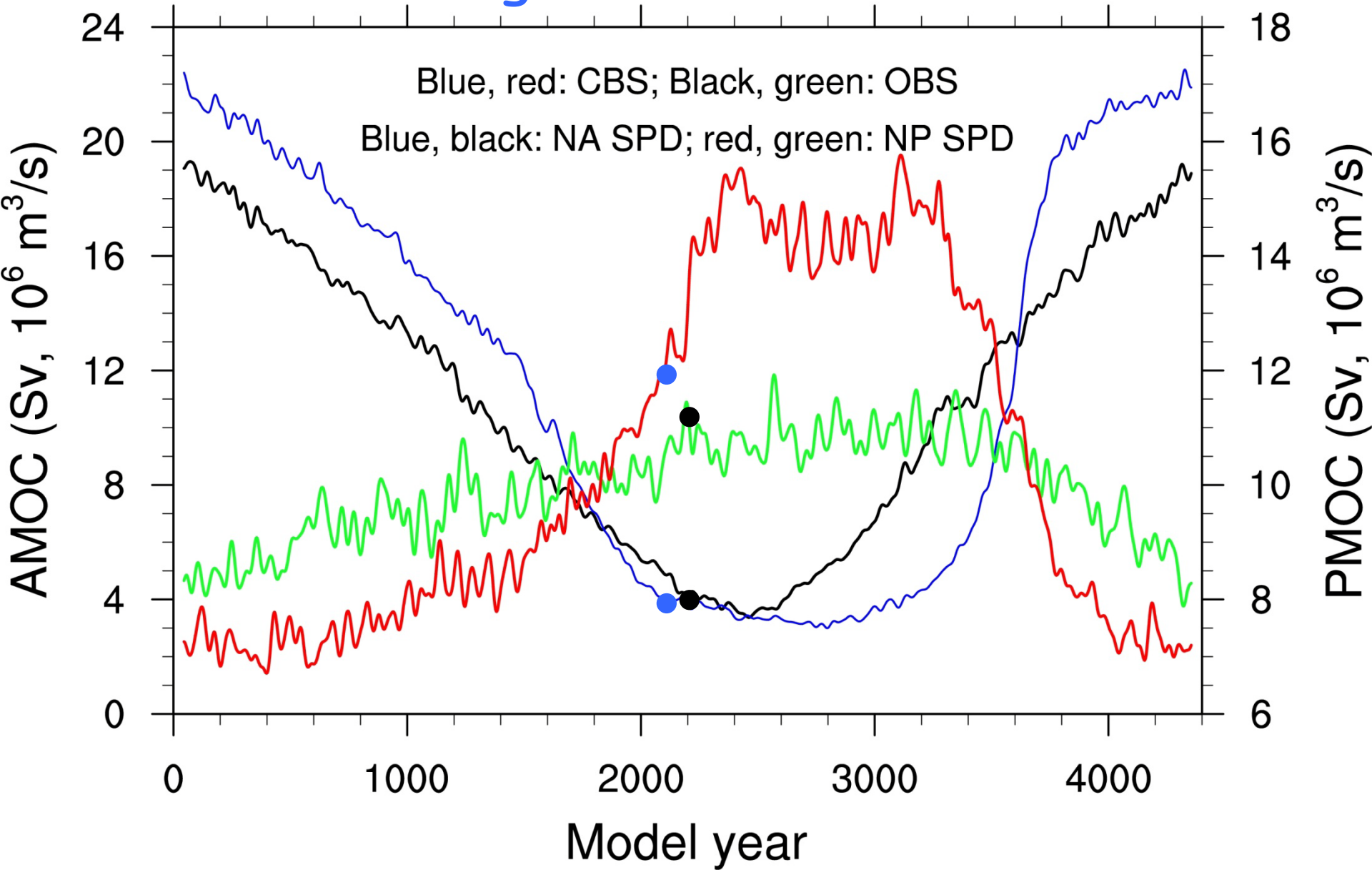
Here we use the National Center for Atmospheric Research Community Climate System Model version 3.

Atmospheric model (CAM3): T42 (2.8 degree), 26 hybrid levels
Land model (CLM3): T42
Ocean model (POP): 1 degree, 40 levels
Sea ice model (CSIM5): 1 degree

Climate boundary condition: present day

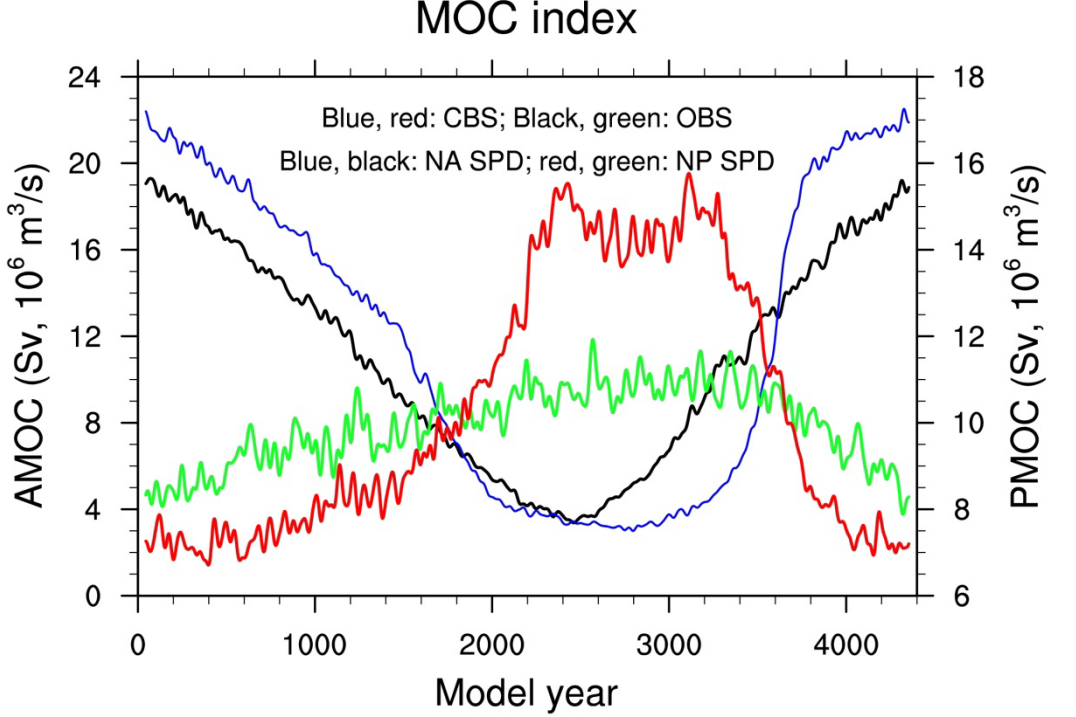
Experiments:
Two experiments are carried out with everything identical, except one with an open Bering Strait (OBS) and the other with a closed one (CBS). Following Rahmstorf et al. (2005), the freshwater forcing is added uniformly in the Atlantic between 20 and 50^{o}N at an initial rate of 0.0002 Sv (200m^{3}/s), with a linear annual increment of 0.0002 Sv. Note: it takes 500 model years for the freshwater forcing to increase by 0.1 Sv.

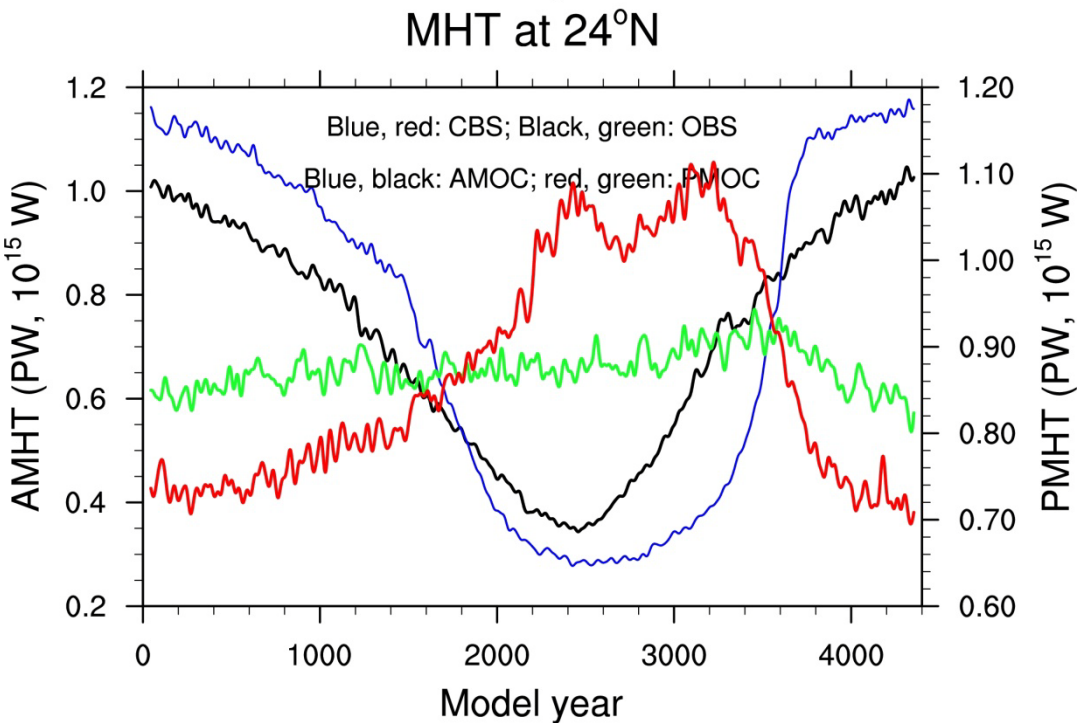
Simulated AMOC, PMOC response to FW forcing in North Atlantic



MOC and MHT

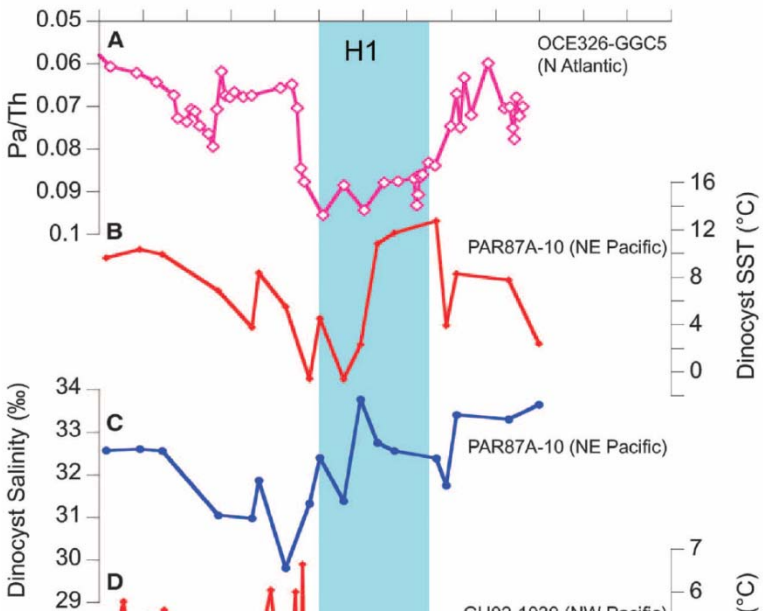
The Meridional heat transport increases from about 0.7 PW (10^{15}W) to a maximum over 1.1 PW in the closed Bering Strait simulation, but only from about 0.86 PW to 0.92 PW in the open Bering Strait simulation.

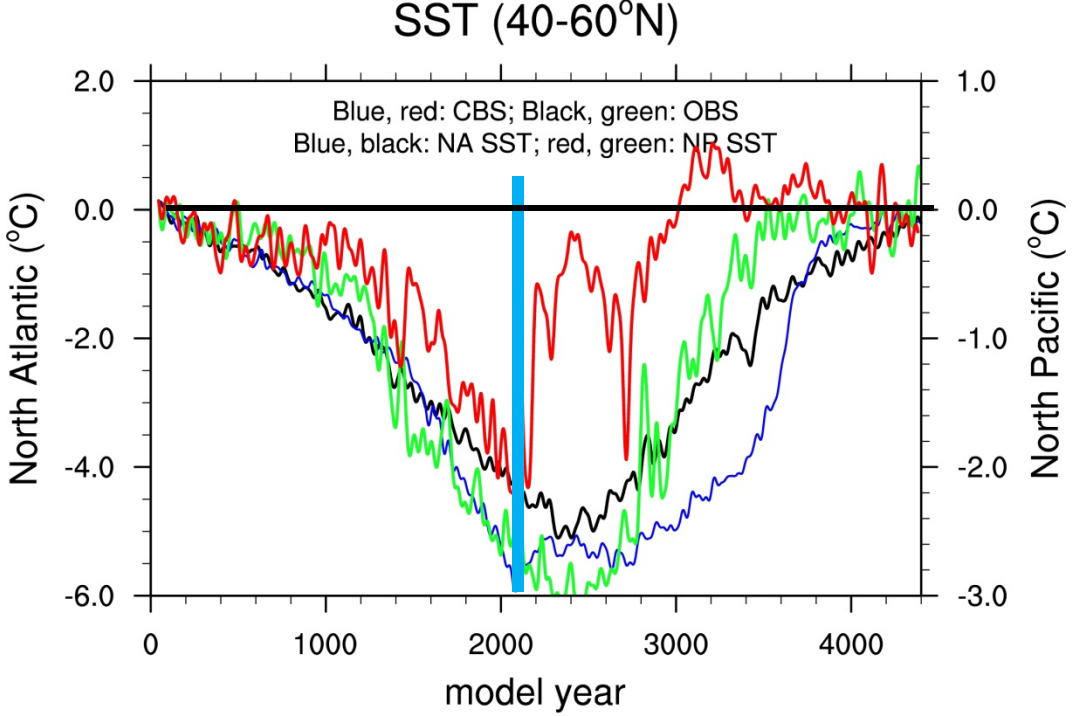


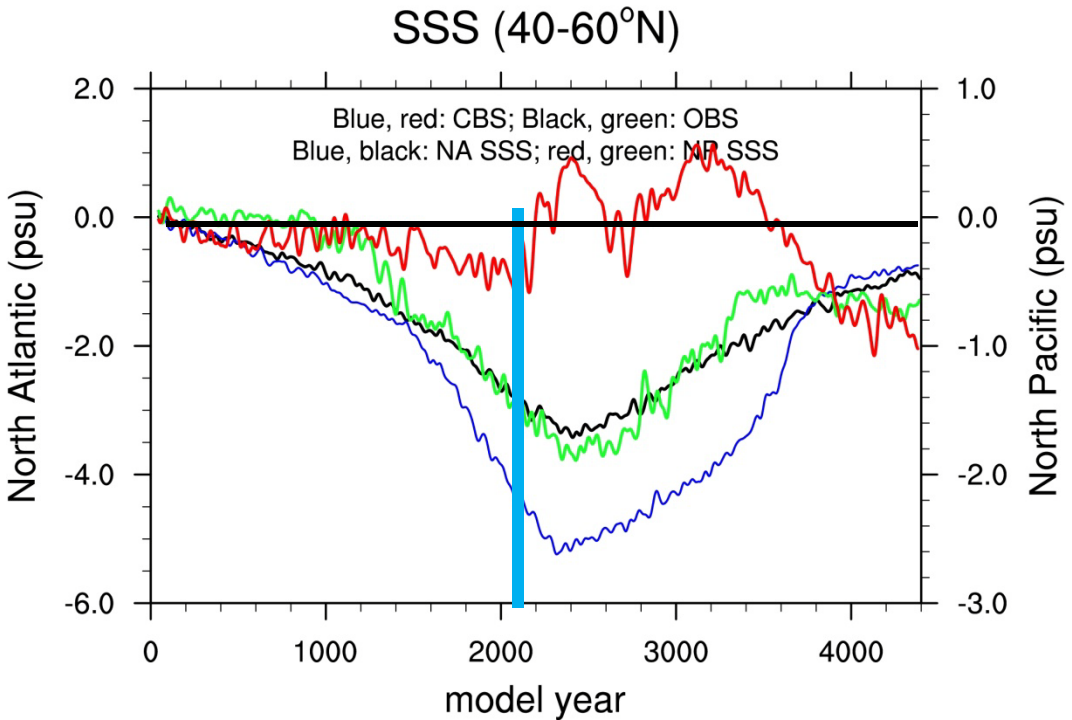


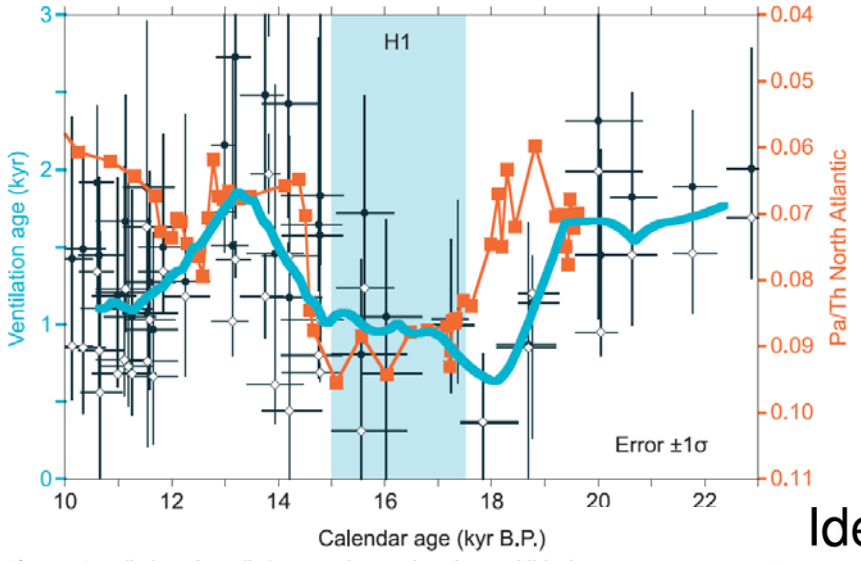
Changes of the SST and SSS in the North Pacific and North Atlantic Oceans

Okazaki et al., 2010



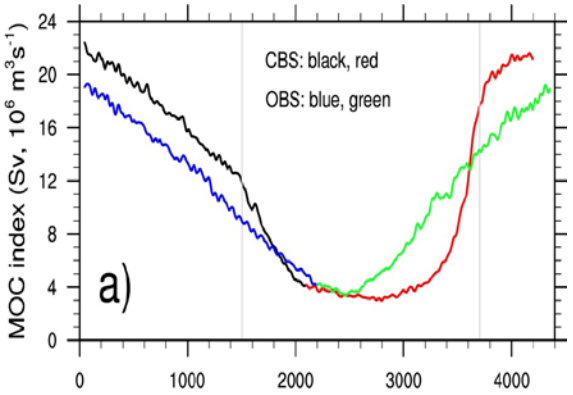


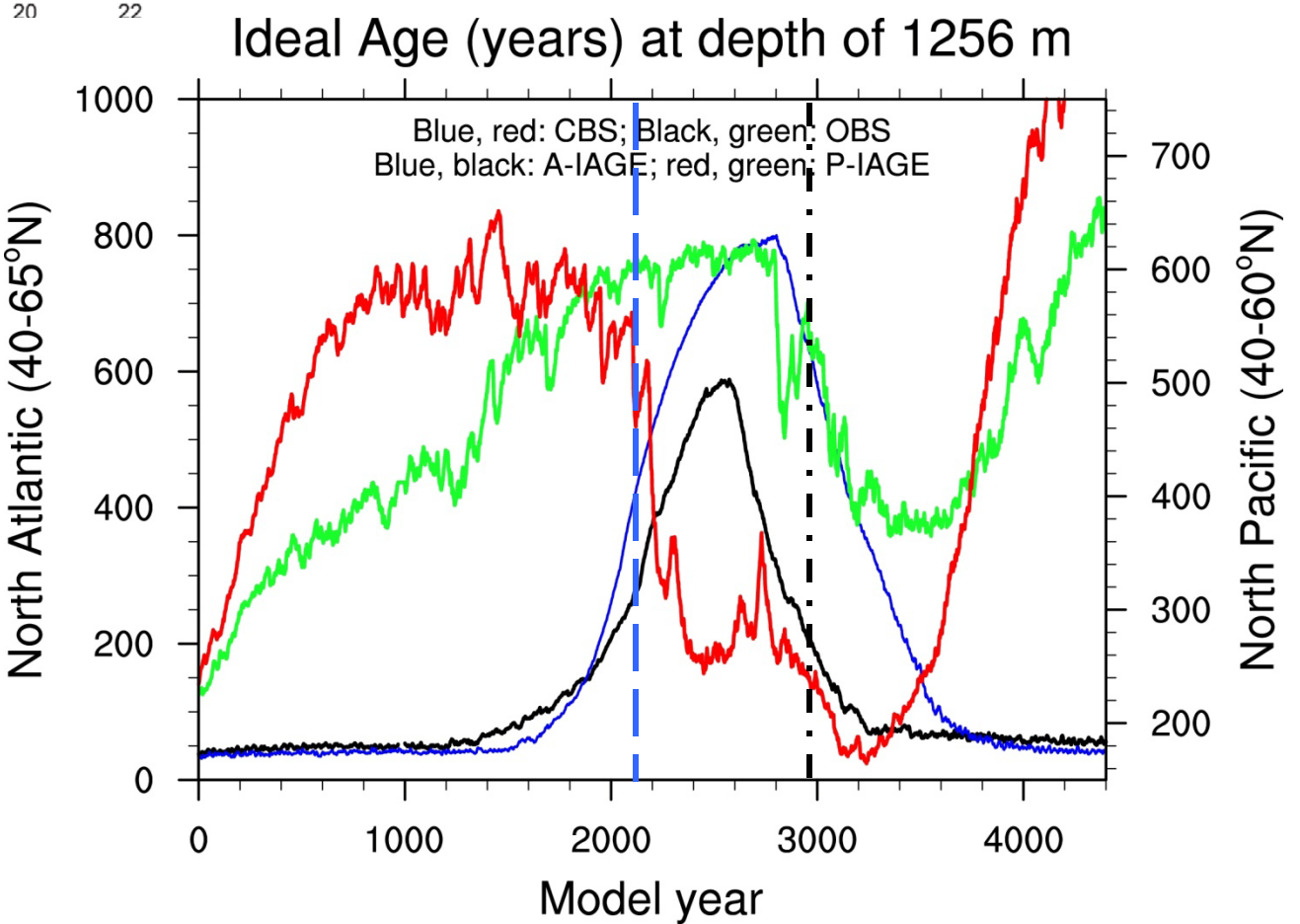




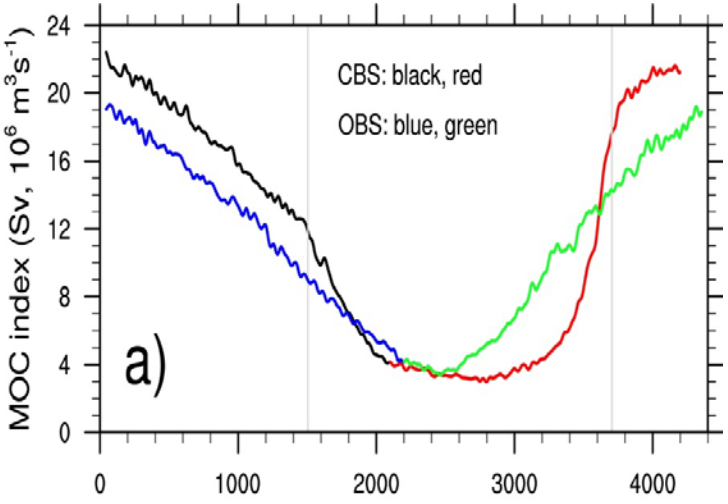
Pa/Th ratio as a proxy for the AMOC strength in the North Atlantic

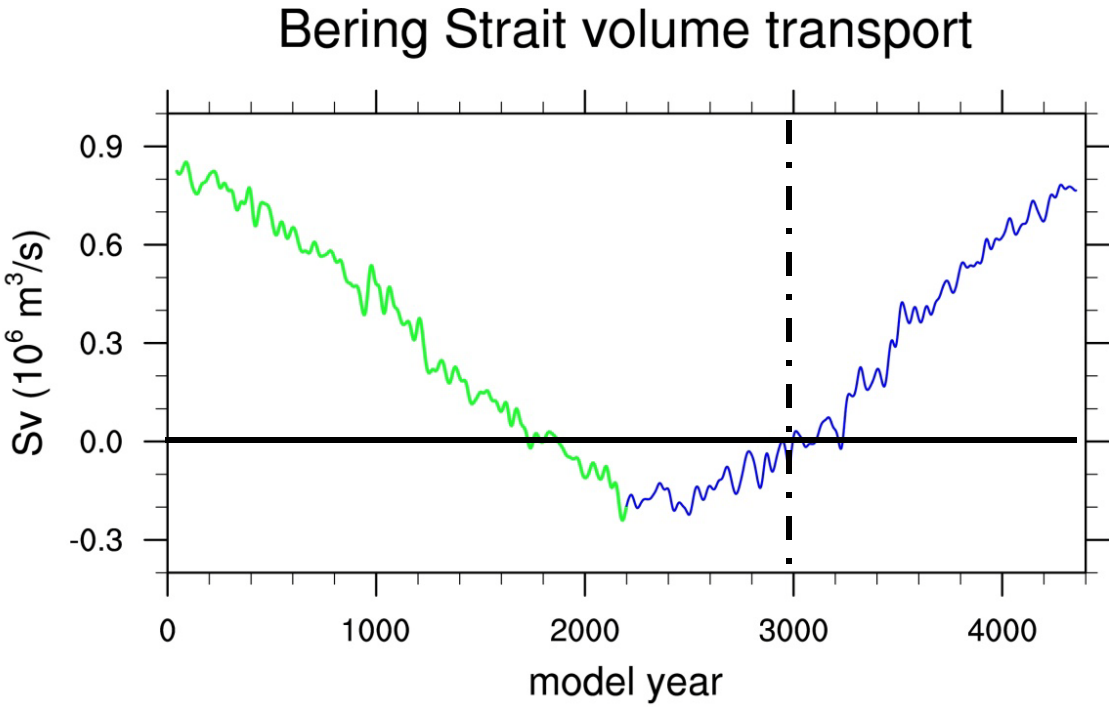
Okazaki et al., 2010

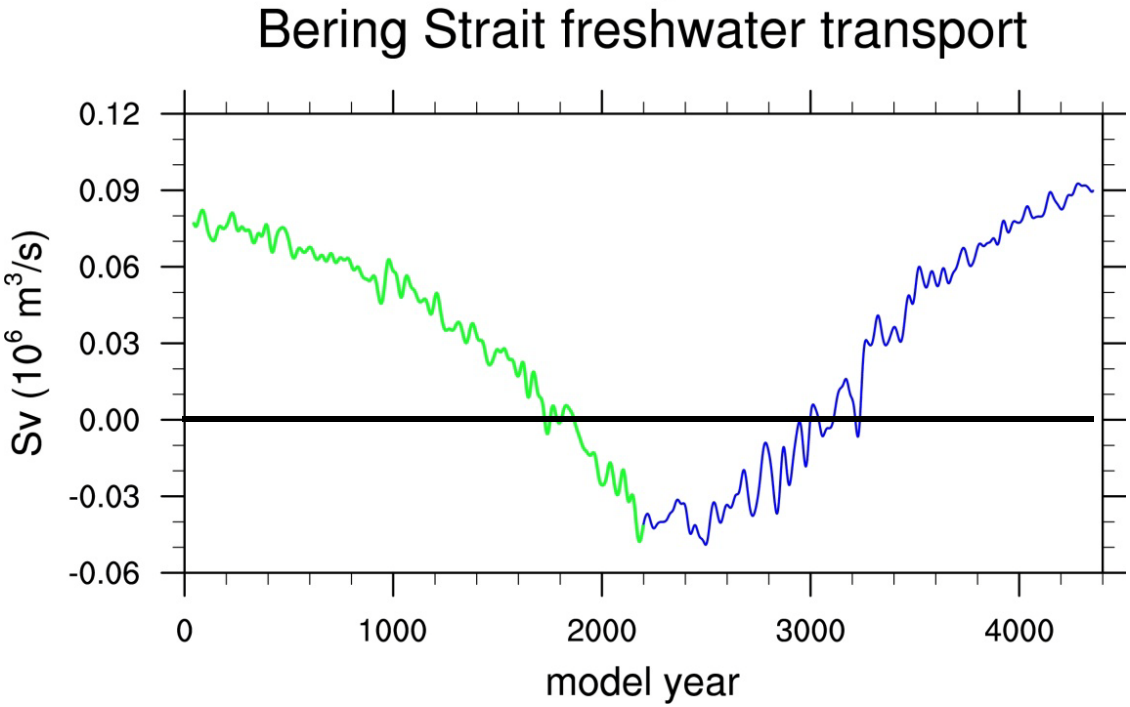




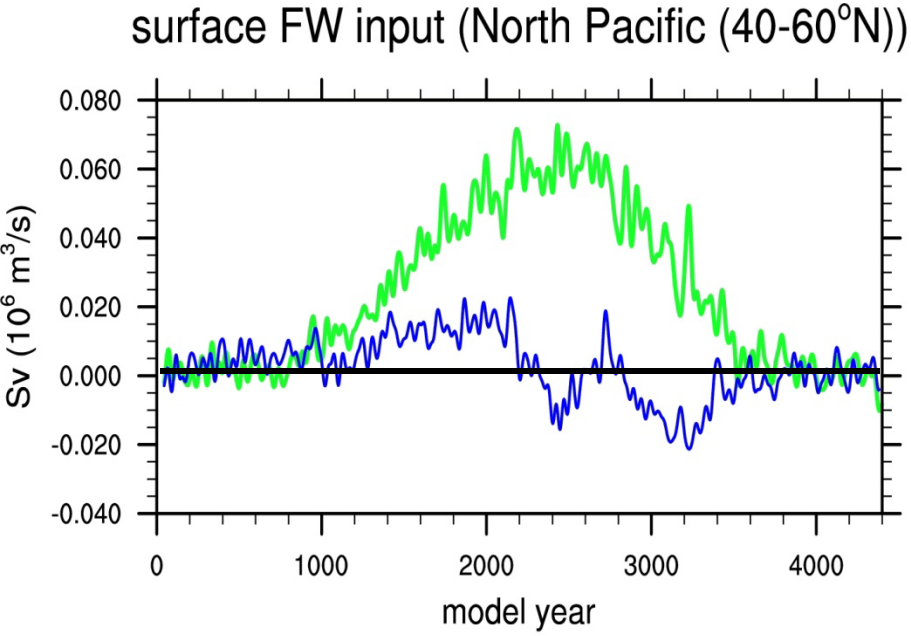
What happened at the Bering Strait?

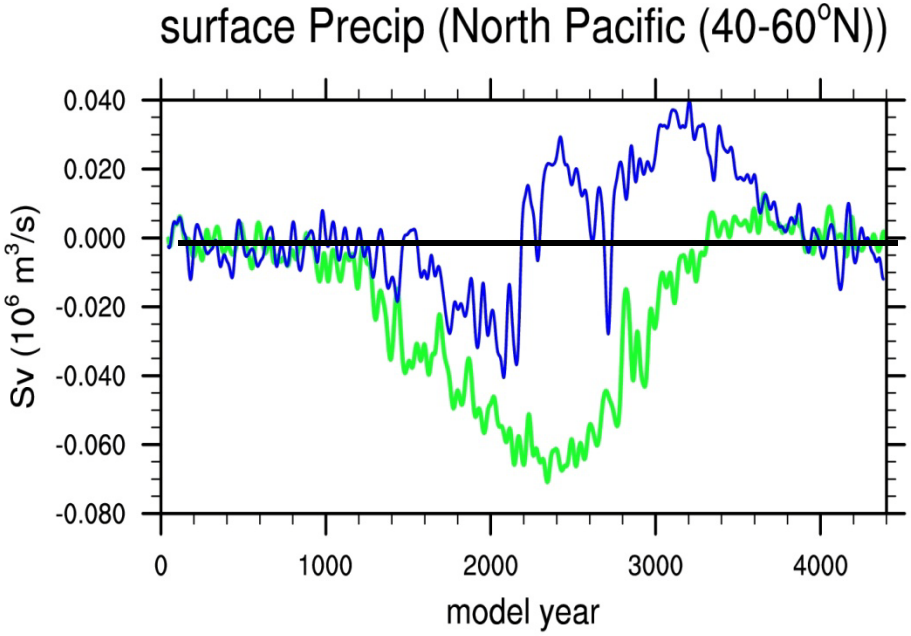


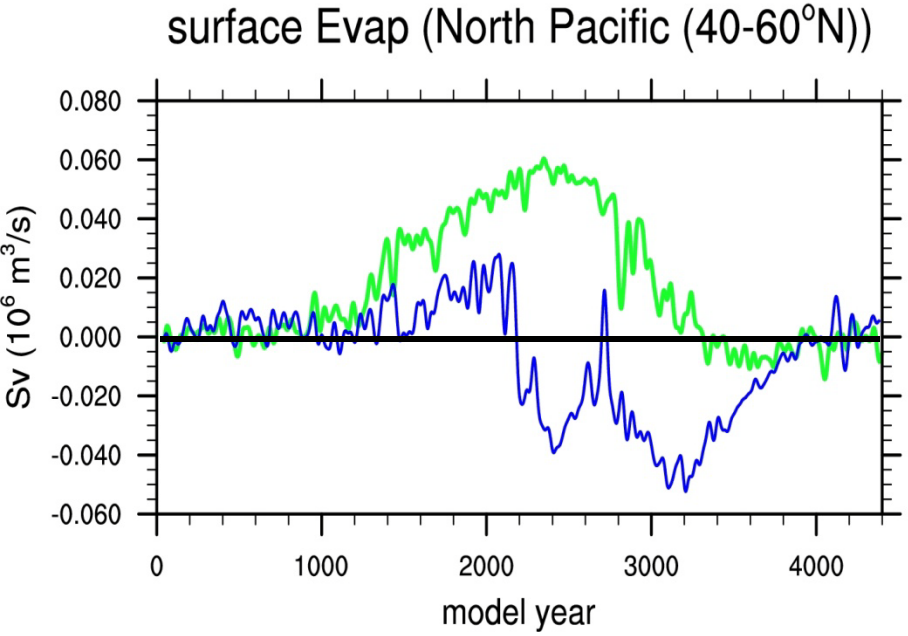


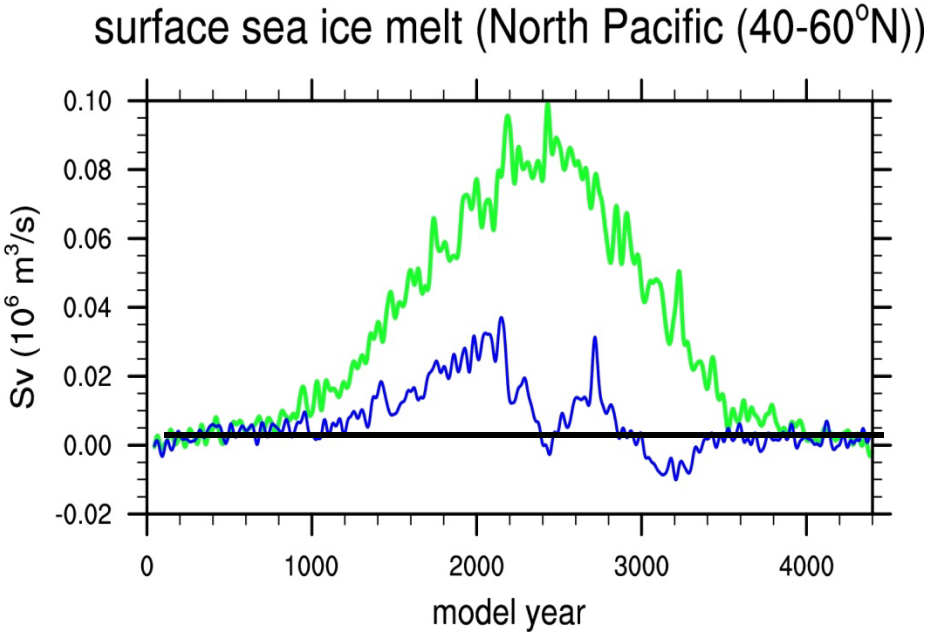


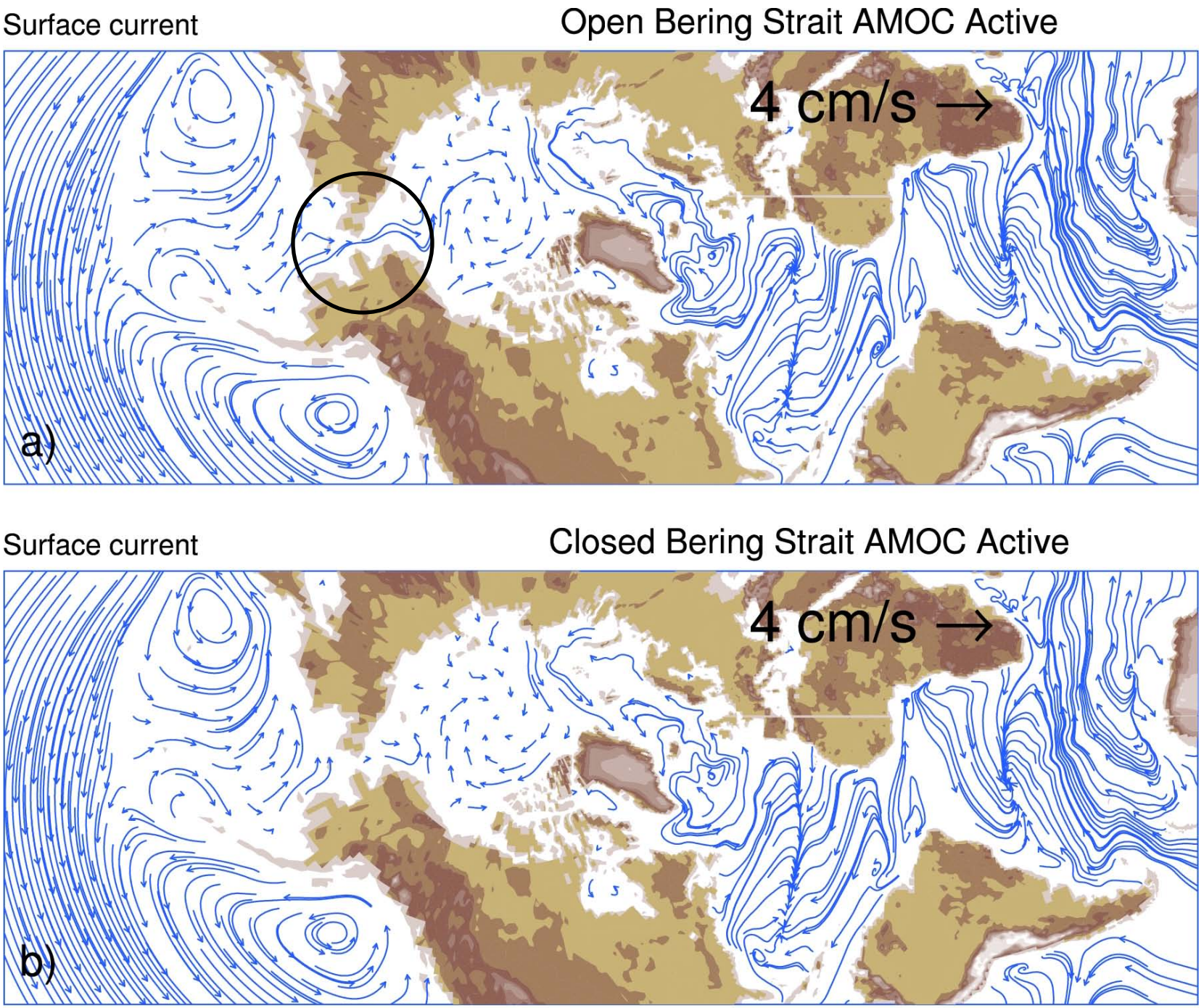
Changes of the surface freshwater fluxes

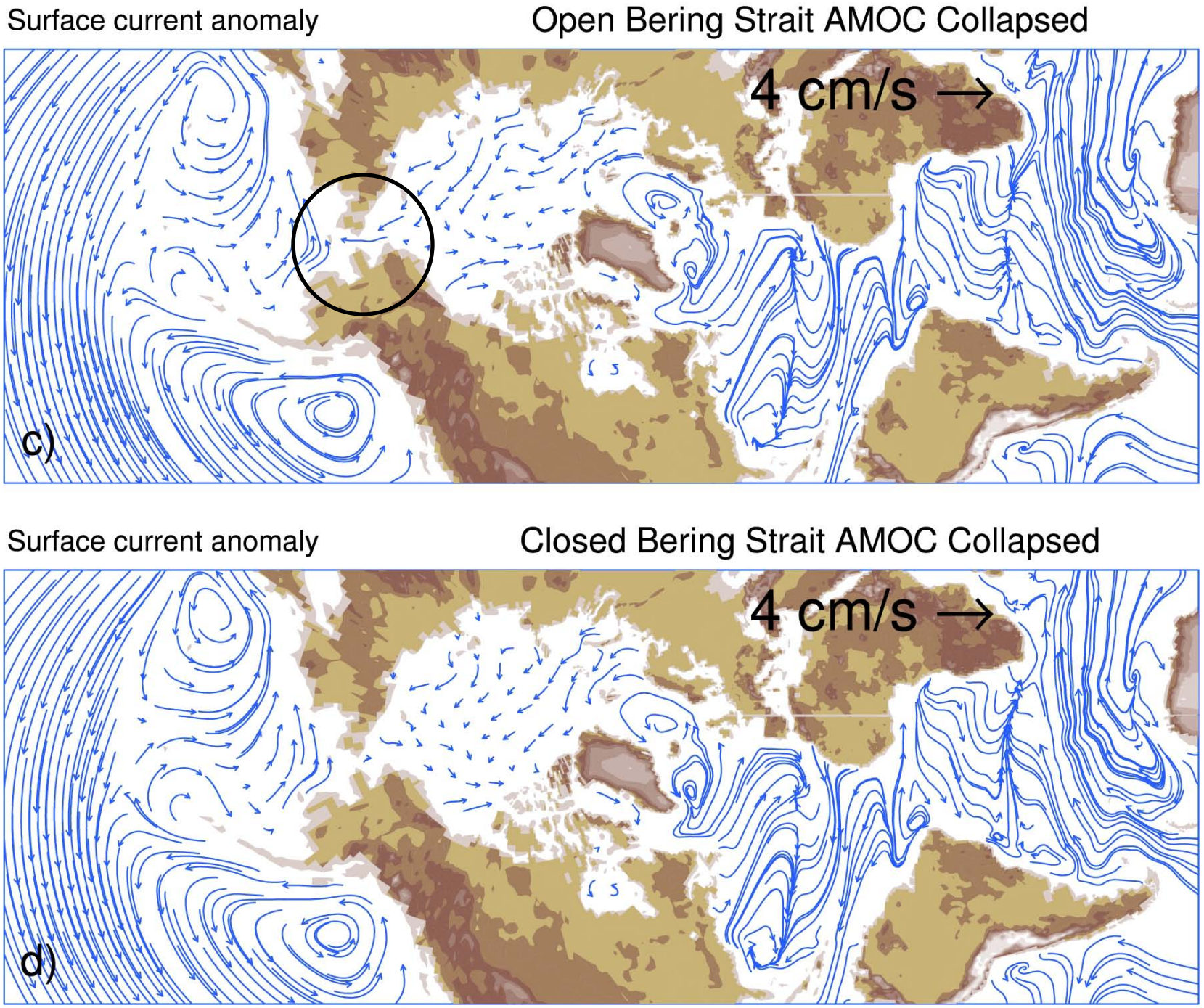


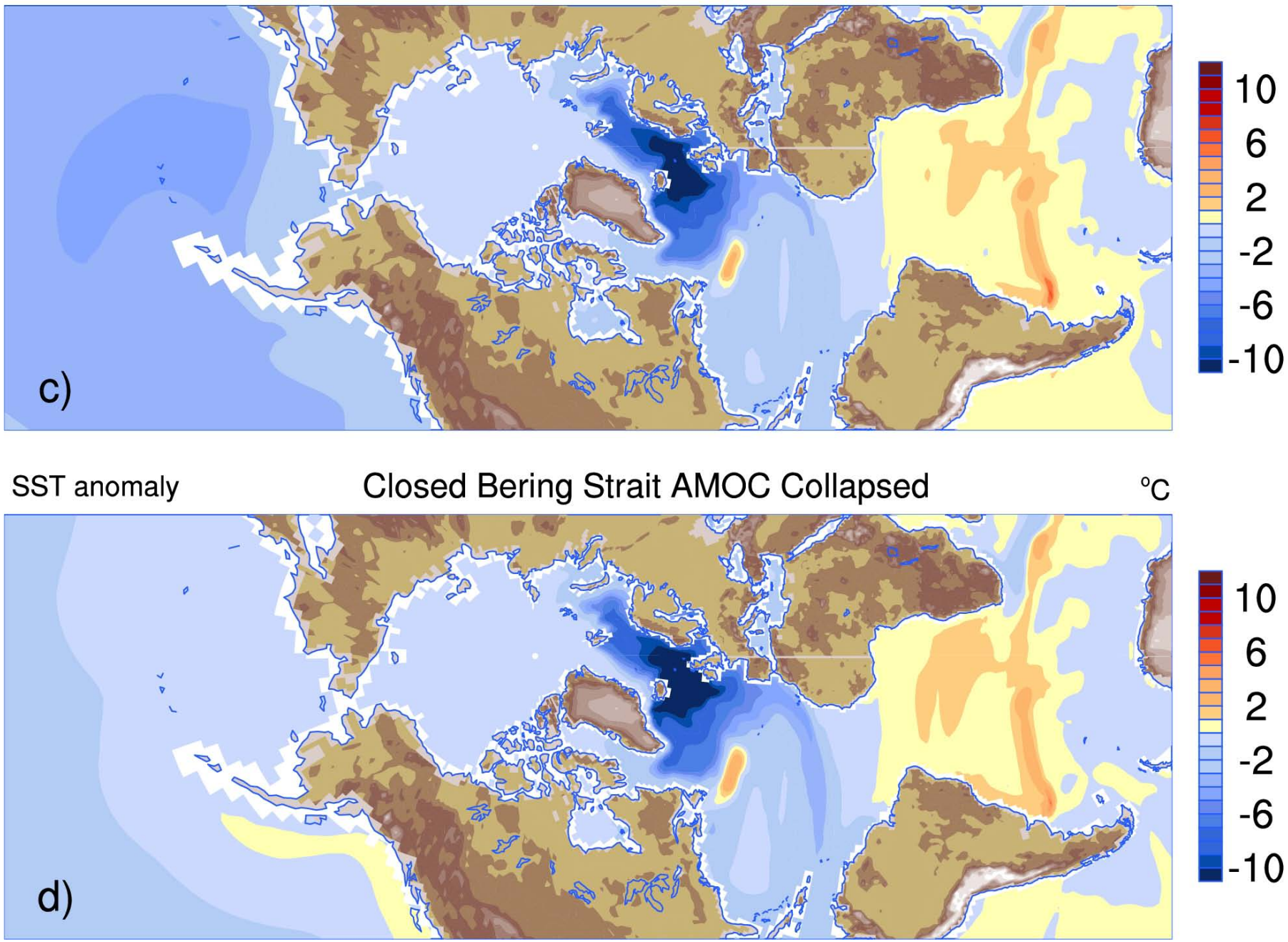


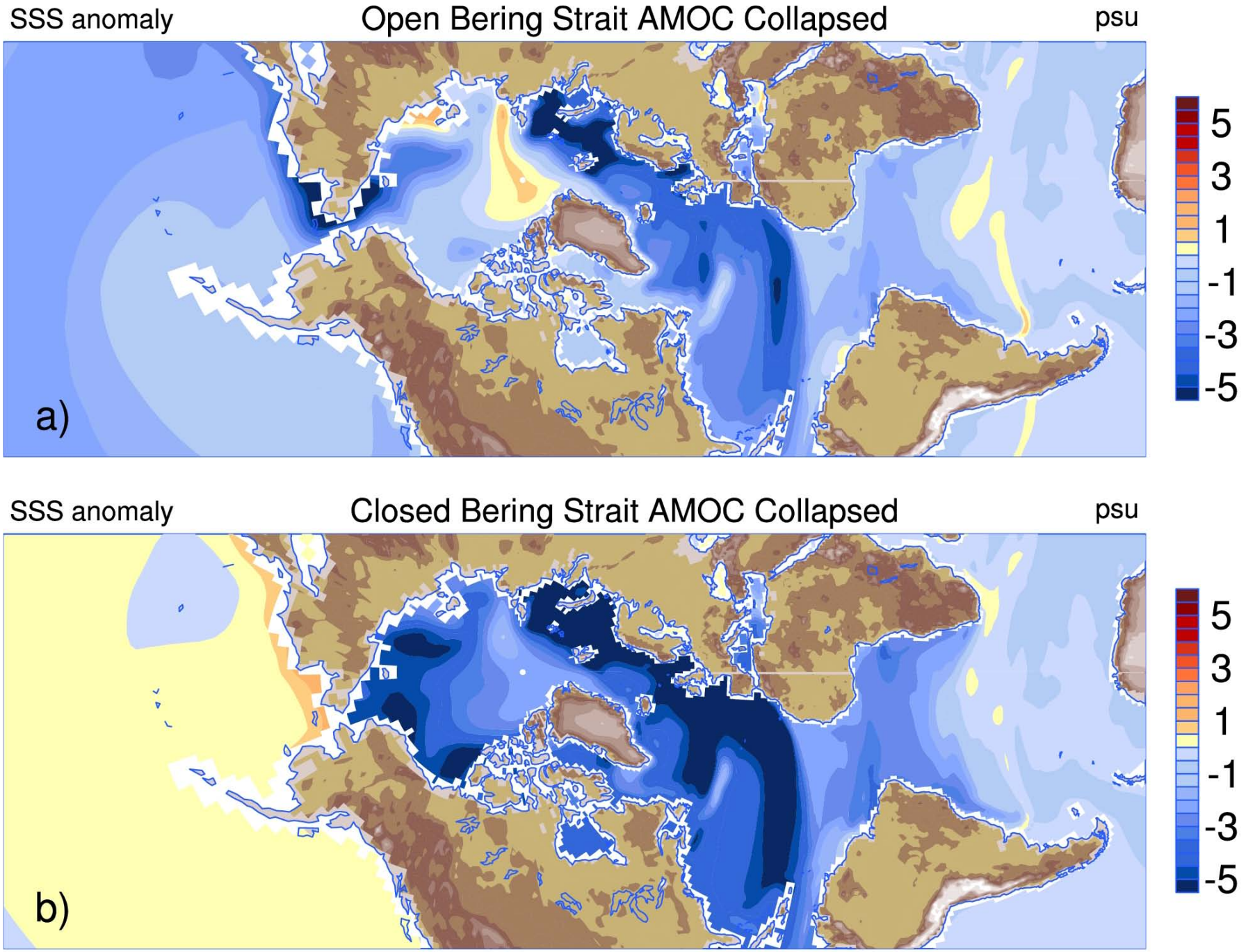


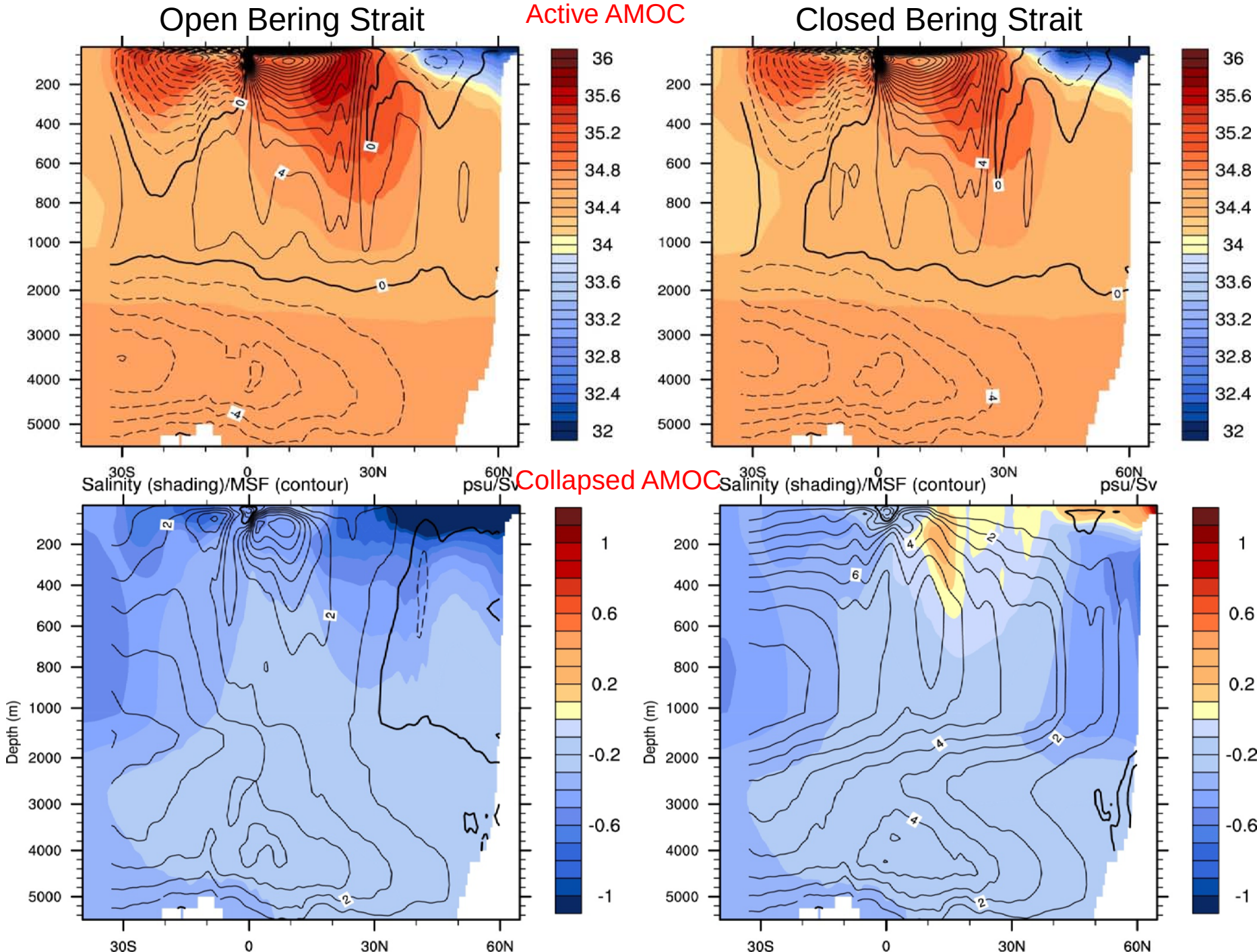



Surface current
Open Bering Strait AMOC Active
4 cm/s →
a)
Surface current
Closed Bering Strait AMOC Active
4 cm/s →
b)


Surface current anomaly
Open Bering Strait AMOC Collapsed
4 cm/s →
c)
Surface current anomaly
Closed Bering Strait AMOC Collapsed
4 cm/s →
d)


SST anomaly
Open Bering Strait AMOC Collapsed
°C
10
6
2
-2
-6
-10
c)
SST anomaly
Closed Bering Strait AMOC Collapsed
°C
10
6
2
-2
-6
-10
d)


SSS anomaly
Open Bering Strait AMOC Collapsed
psu
5
3
1
-1
-3
-5
a)
SSS anomaly
Closed Bering Strait AMOC Collapsed
psu
5
3
1
-1
-3
-5
b)


Open Bering Strait
Active AMOC
Closed Bering Strait
Collapsed AMOC
Salinity (shading)/MSF (contour)
psu/Sv
Depth (m)
30S
0
30N
60N
36
35.6
35.2
34.8
34.4
34
33.6
33.2
32.8
32.4
32
1
0.6
0.2
-0.2
-0.6
-1

Summary

Our results suggest that the Bering Strait may have played an important role in modulating the re-organization of the Atlantic and Pacific MOCs and ice age climate under land-base freshwater discharge into the North Atlantic, e.g.

i. The closing of the Bering Strait may have changed the characteristics of the ocean circulation to a state which is in favour of a MOC seesaw between the Atlantic and Pacific.

ii. Since the open Bering Strait can transport water mass in both direction depending on the AMOC strength, it intends to prevent the MOC seesaw between Atlantic and Pacific by leaking the freshwater anomaly in the North Atlantic into North Pacific.

Thank You

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To provide facility support to the wider community; and,
To apply the results to benefit society.

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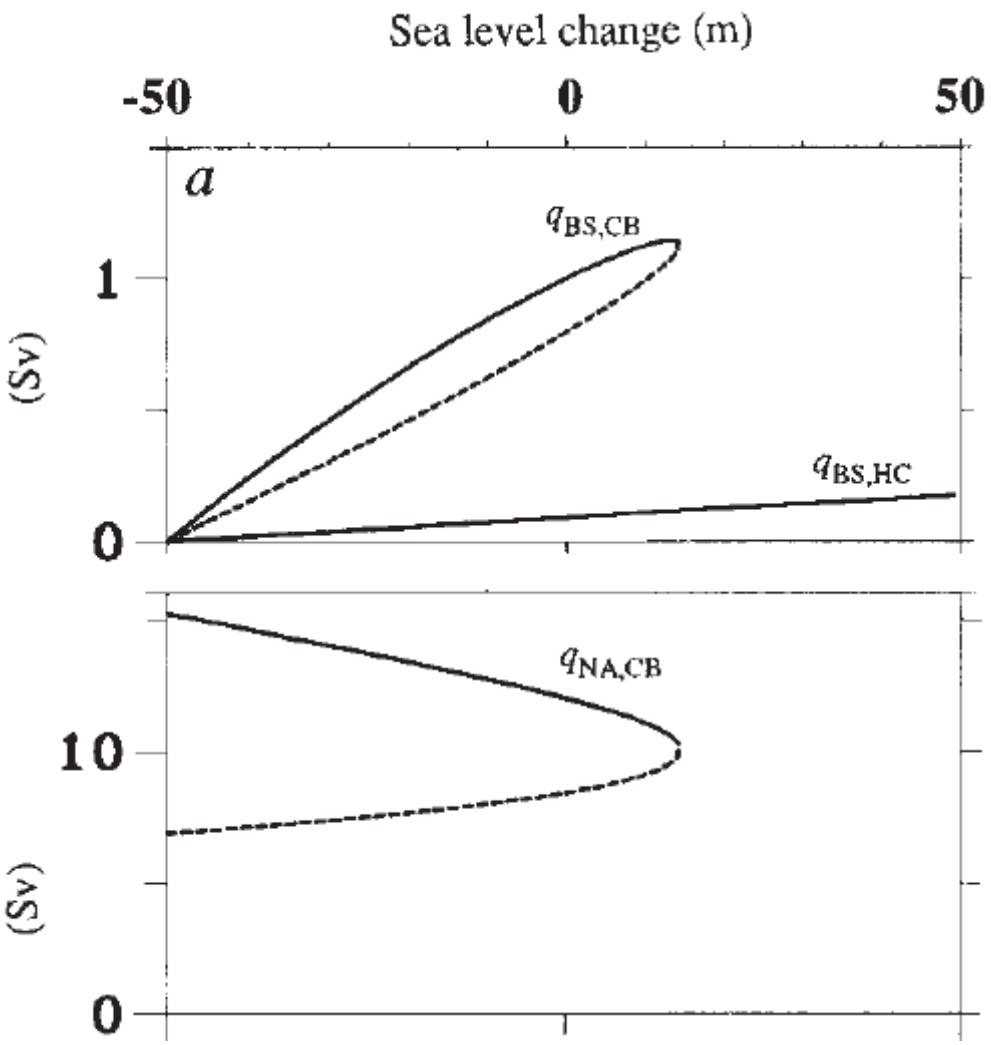
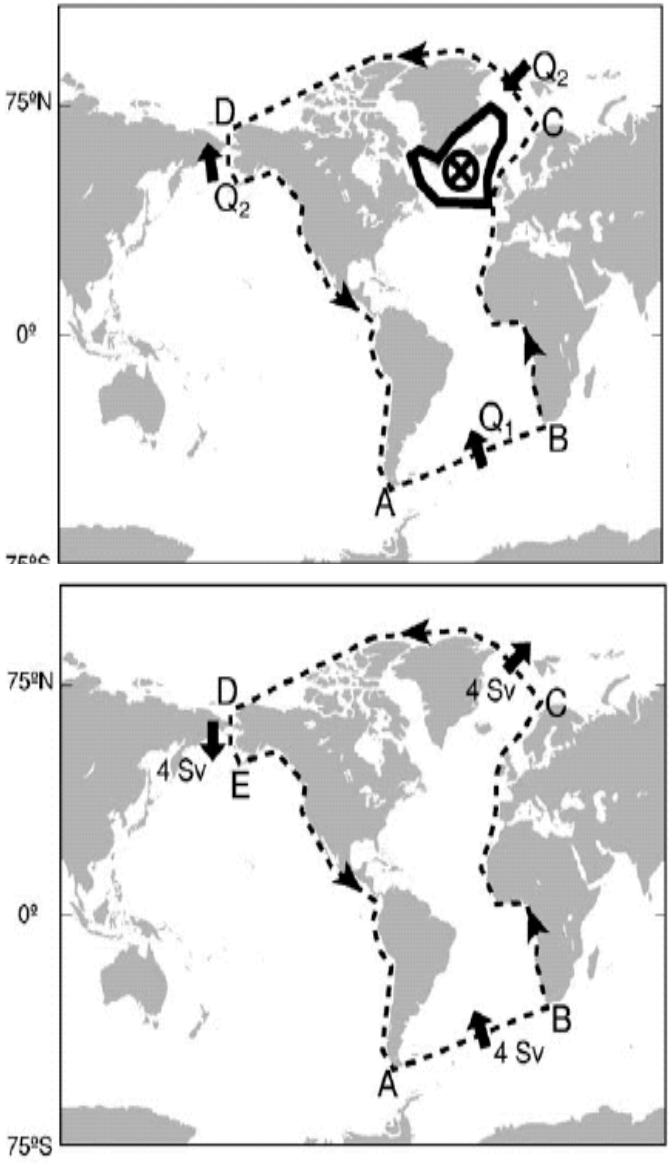
2. Why is this pathway important?



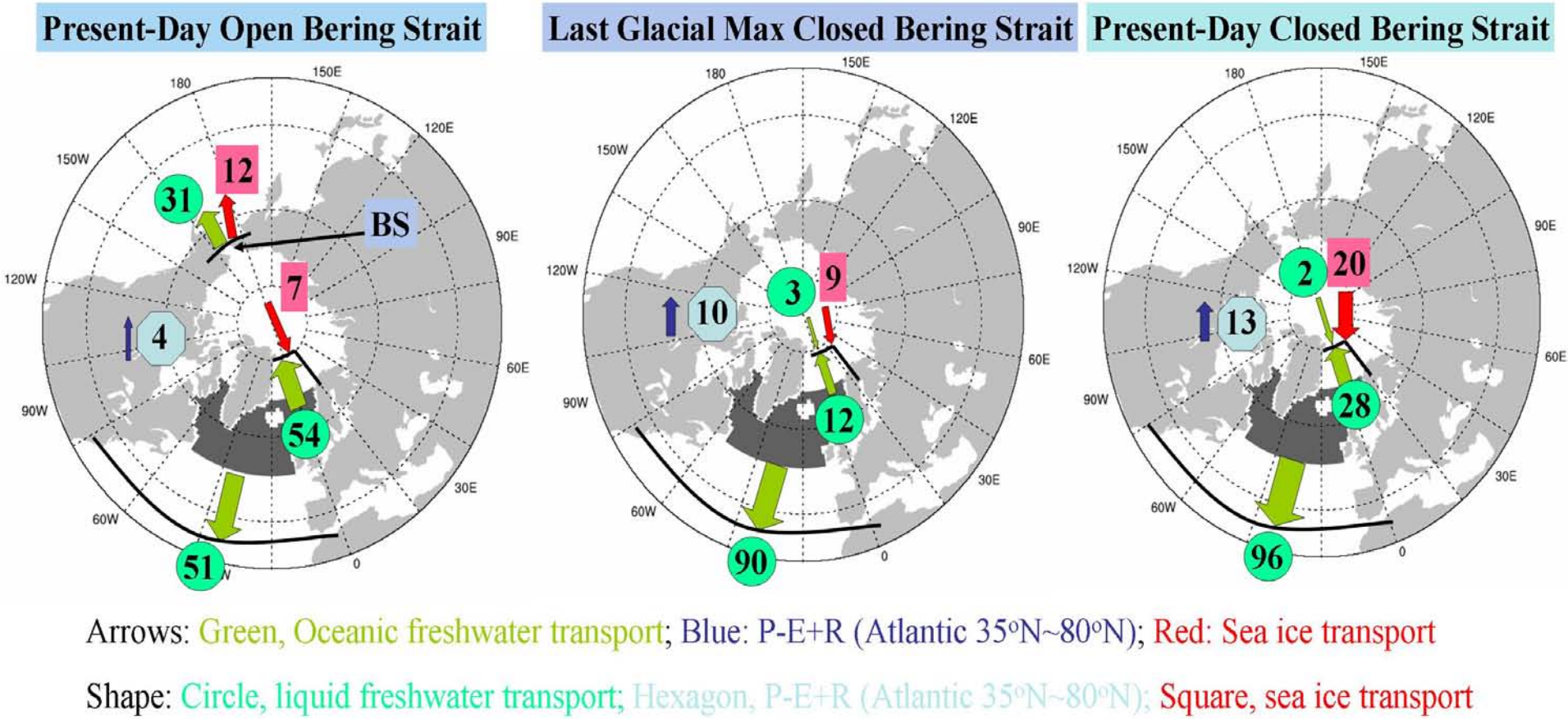
Shaffer and Bendtsen, 1994



De Boer and Nof, 2004a,b

A summary of the comparison of the present day open Bering Strait, closed Bering Strait to LGM closed Bering Strait simulation

1Sv freshwater into North Atlantic 50-70ºN for 100 yr, then this freshwater forcing is switched off.



Numbers shown in this figure are the percentage of the total freshwater added into the subpolar North Atlantic during hosing

Hu et al., GRL, 2007; Hu et al., J Clim. 2008