Comparison of NADW in a basin-scale model to observations

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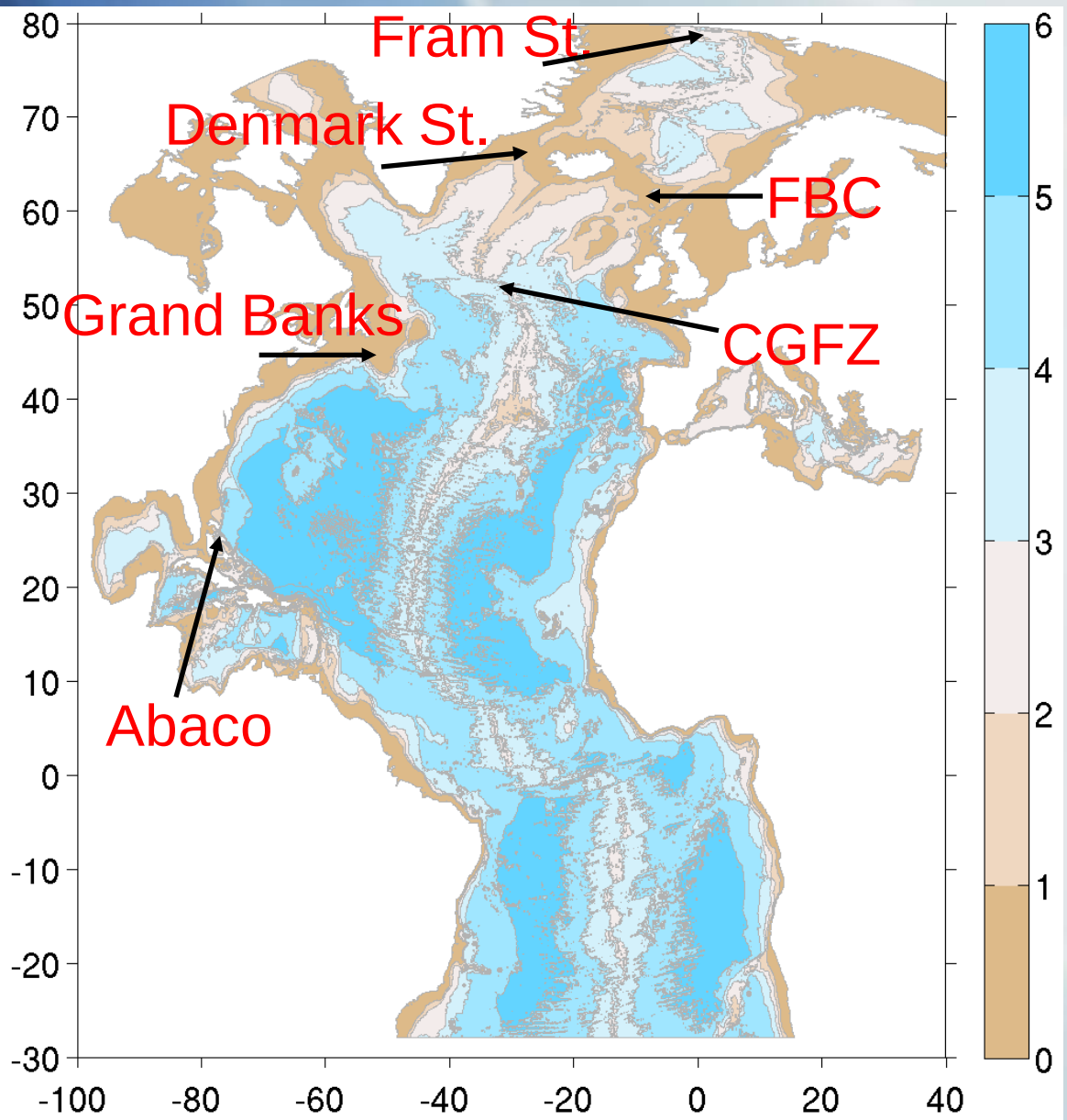
Many thanks to Alan Wallcraft, Pat Hogan, Joe Metzger (NRL)

- Layer Ocean Model (LOM) workshop Miami, June 1 2009 -

Outline

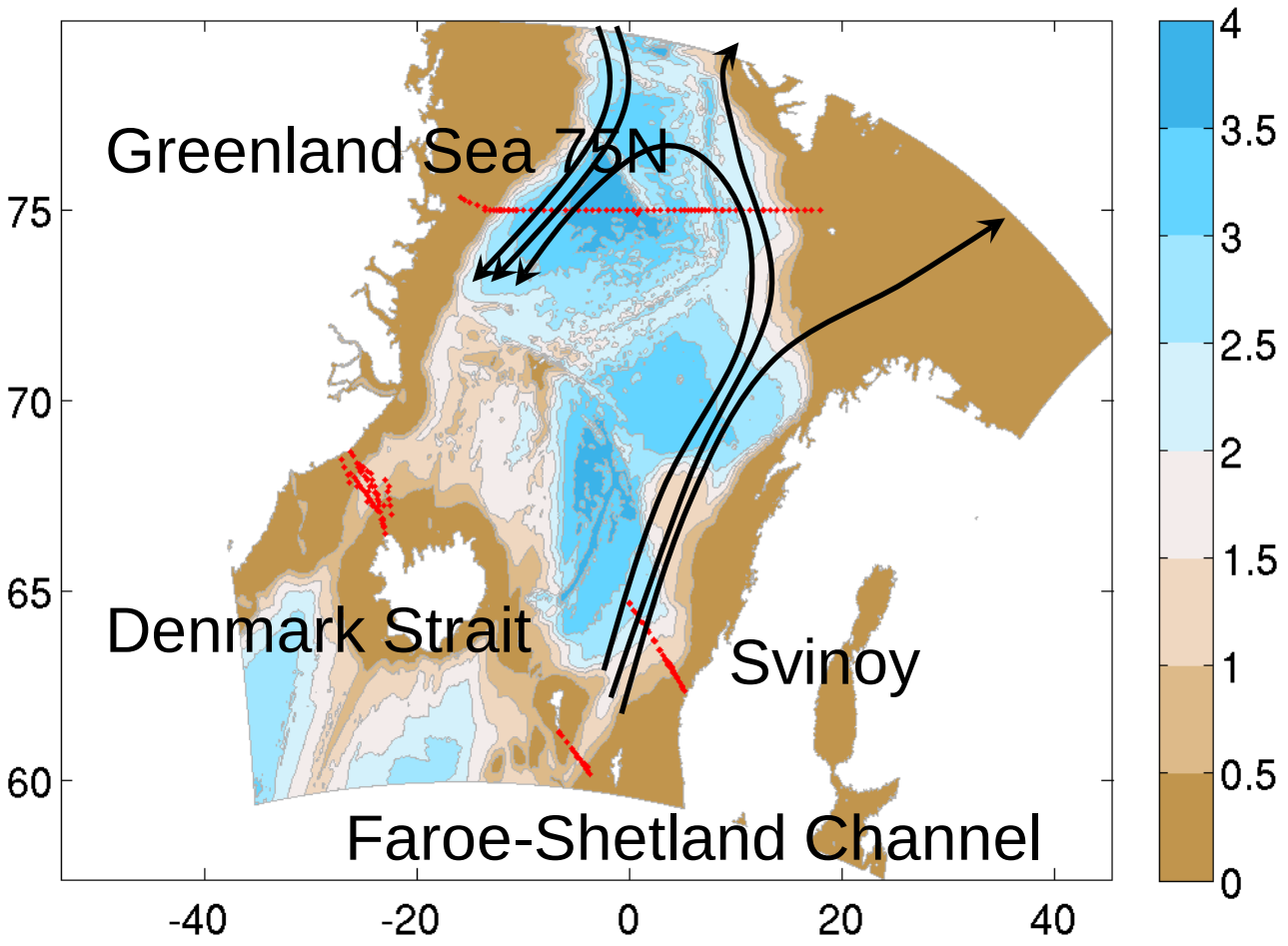
- Model configurations
- North of Greenland-Scotland Ridge
- Subpolar North Atlantic
- Around the Grand Banks
- Subtropical North Atlantic
- Summary (discussions)

1. Model configurations



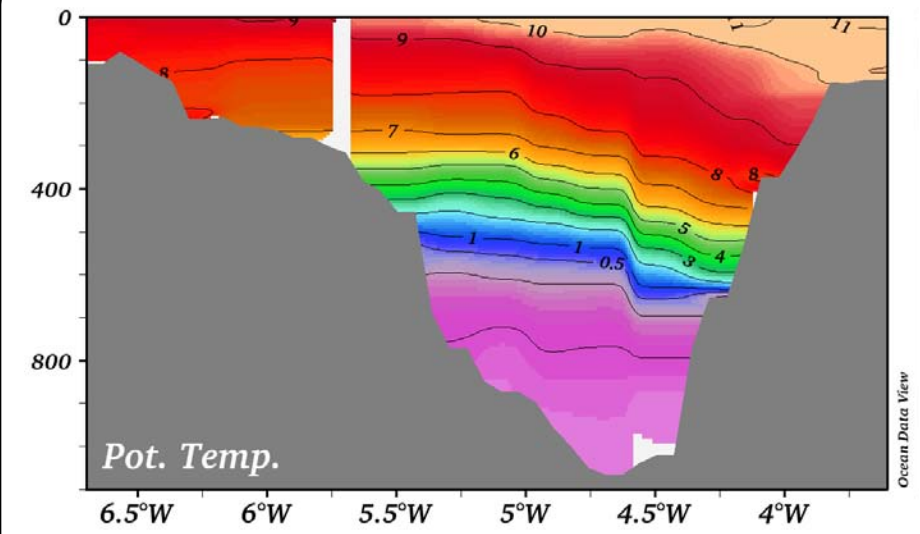
- Domain 28S-80N, T/S relaxation near boundaries, no inflow/outflow
- Initialized T/S from GDEM3 (July) and zero velocities
- Monthly mean wind & buoyancy forcing (ERA40)
- Single thermobaric reference (T, S of 3C, 35)
- 28-layer (σ_2) with no varying target densities
- KPP mixing (Ri_c=0.45, BL_{max}=1200m)
- Entrainment mixing for outflow (Xu et al. 2006)
- A=25; C_D= 0.003
- 15-year run (year 11_15)

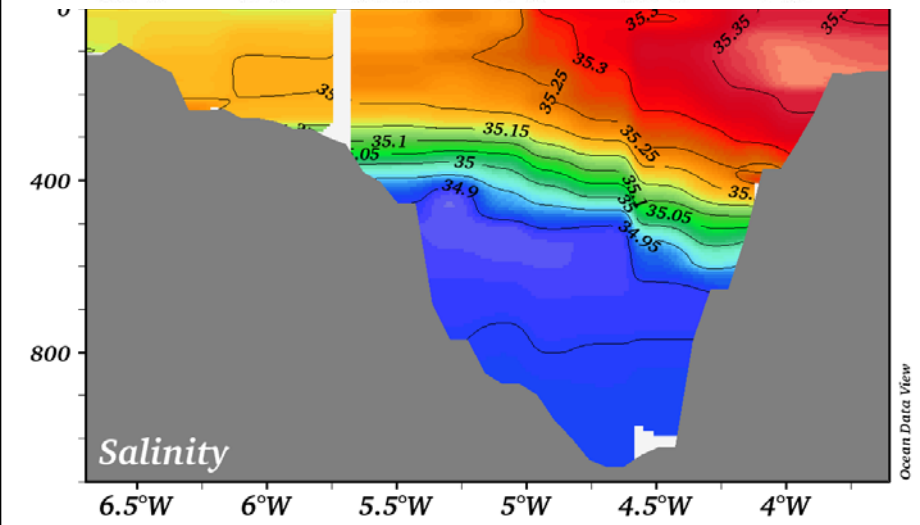
2. North of GIS - Outflow source

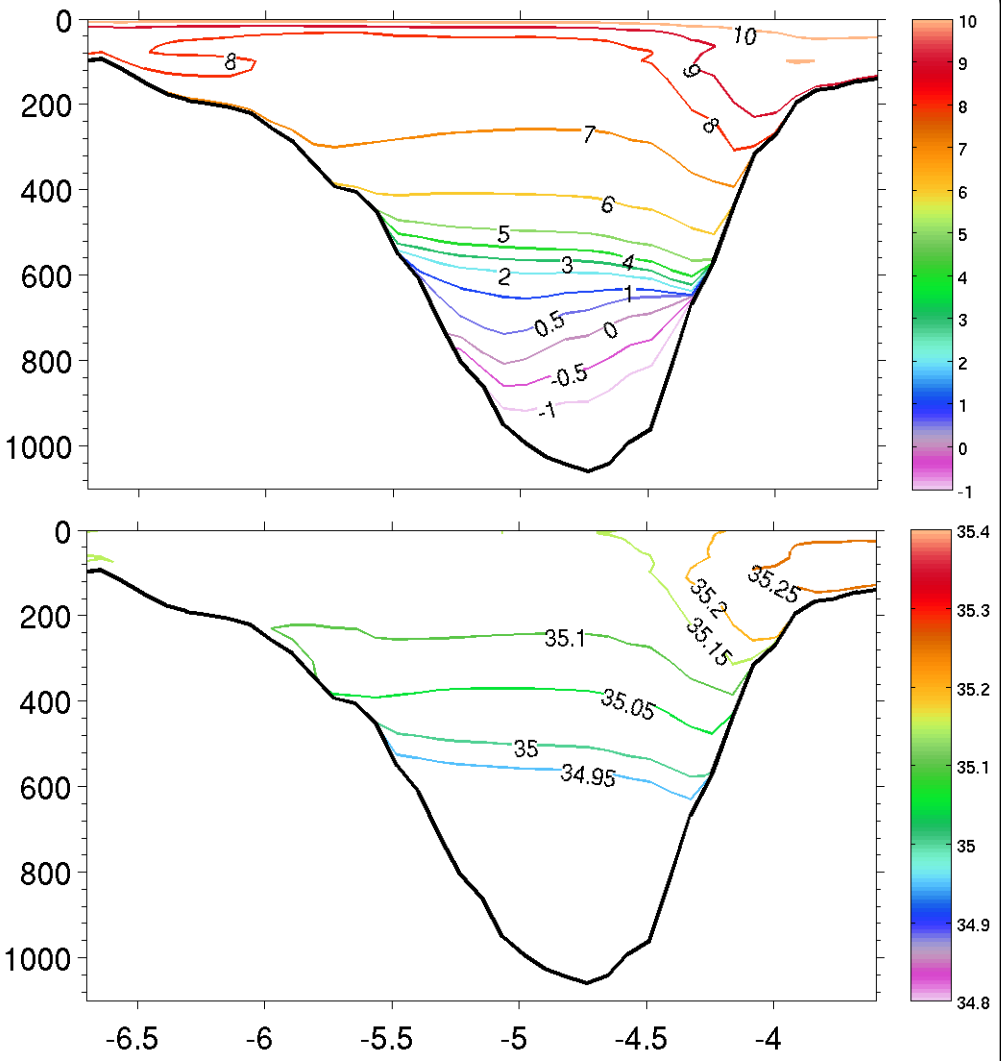


Three routes for Atlantic inflow water in the Arctic Mediterranean (Mauritzen, DSR 1996)

2.1 Faroe-Shetland Channel



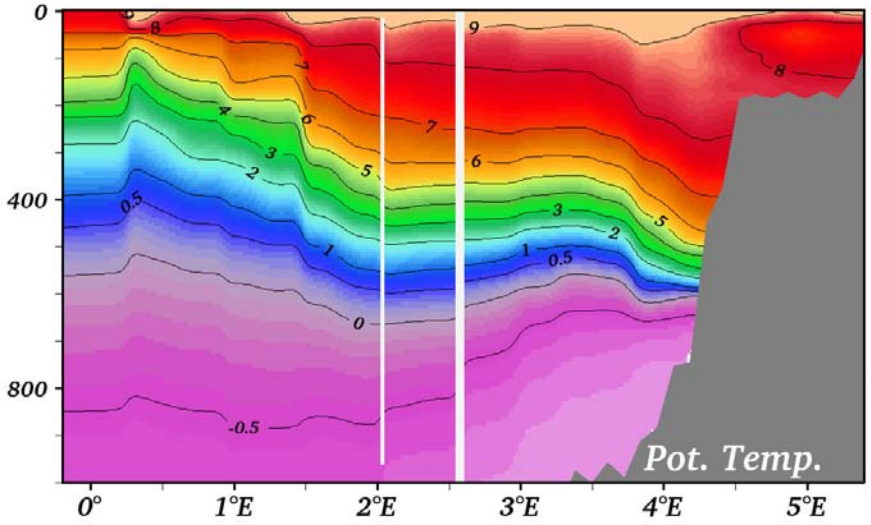


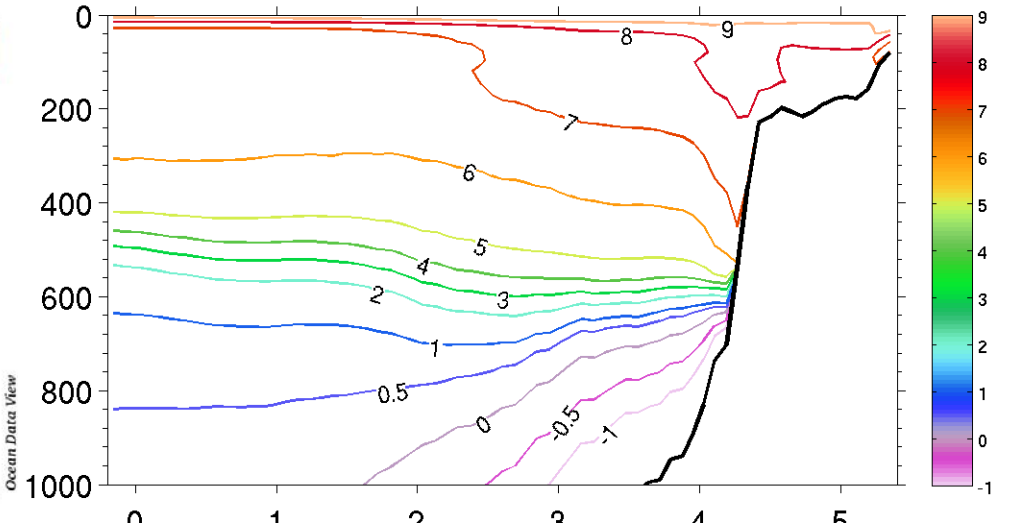


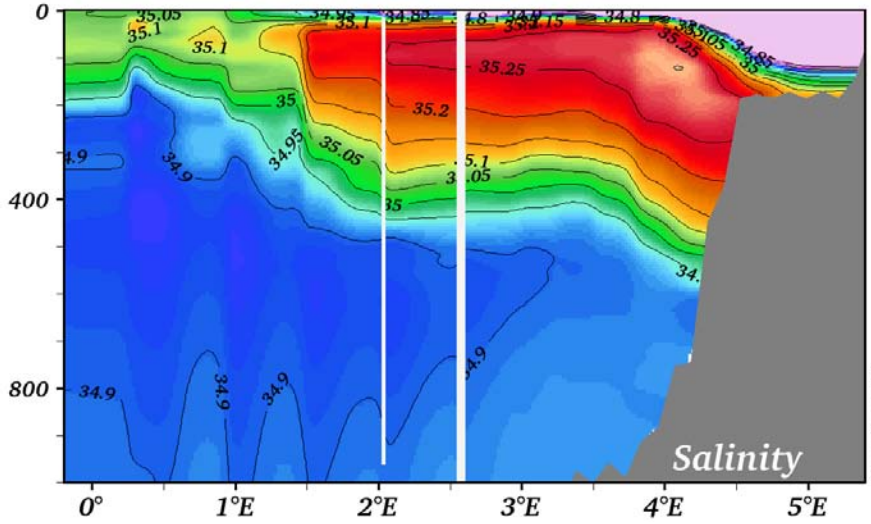
Observation

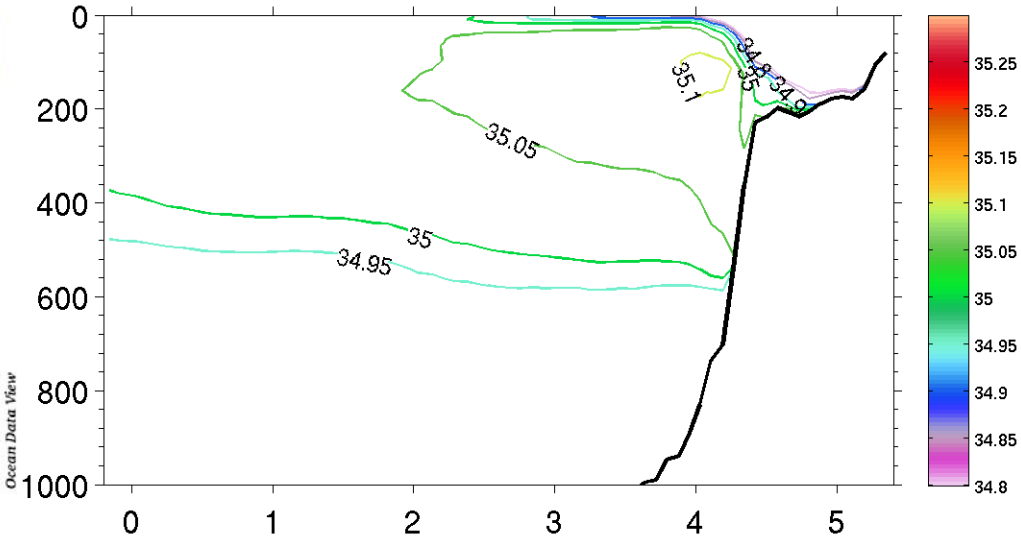
Model

2.2 Svinoy





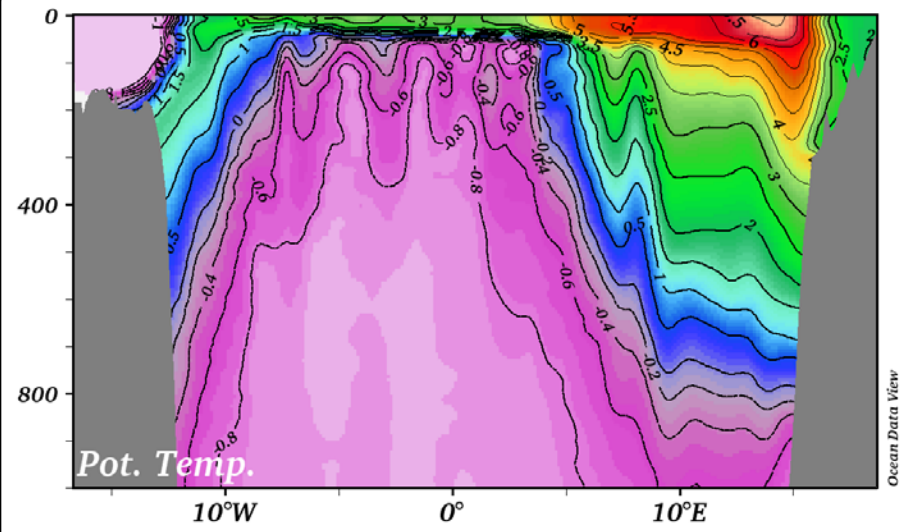


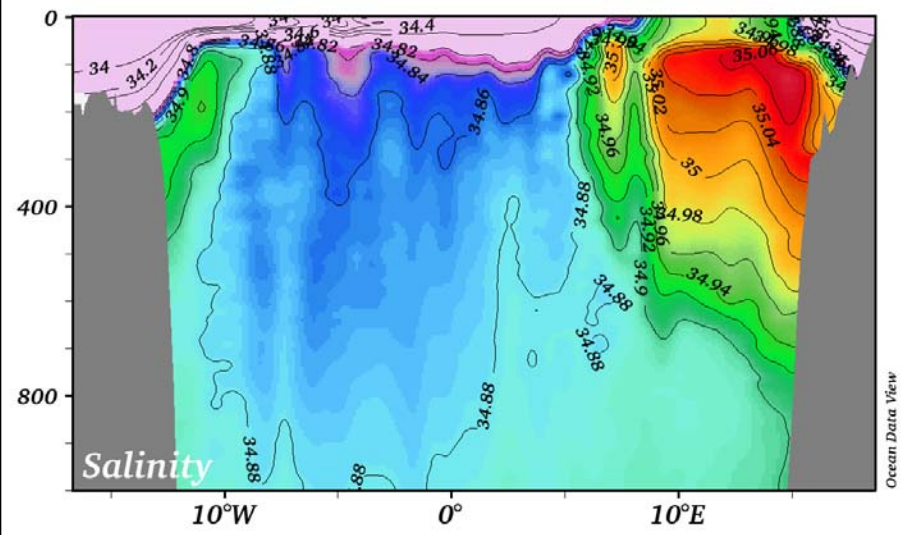


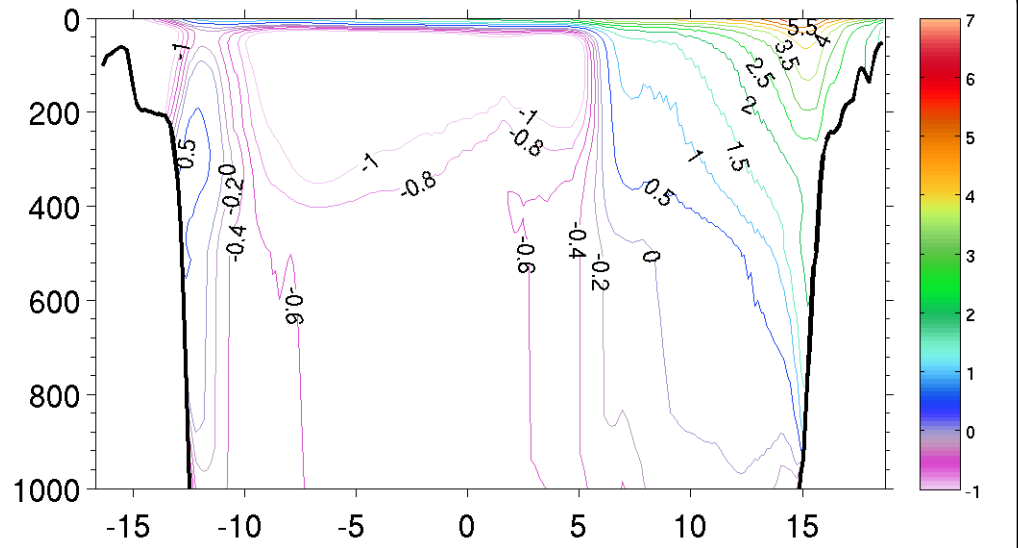
Observation

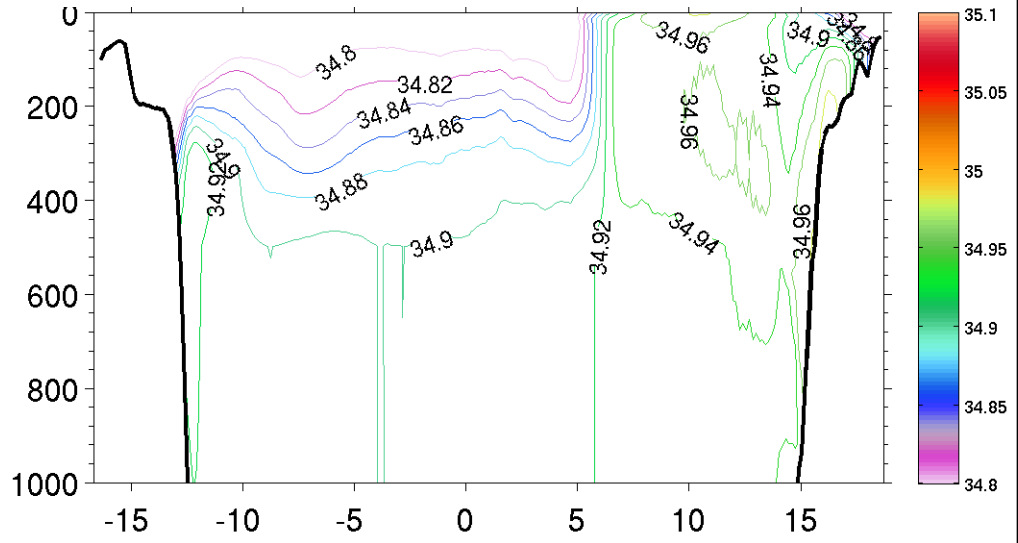
Model

2.3 Greenland Sea @75N





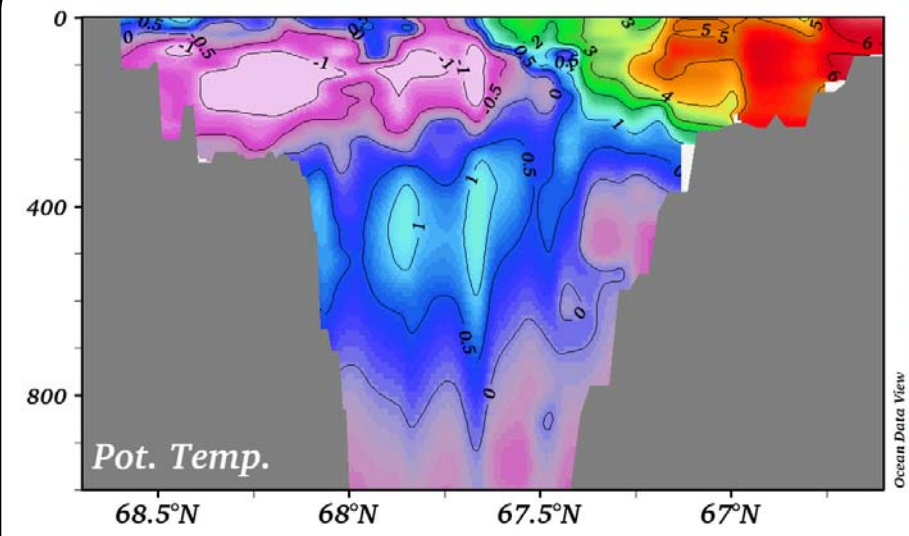


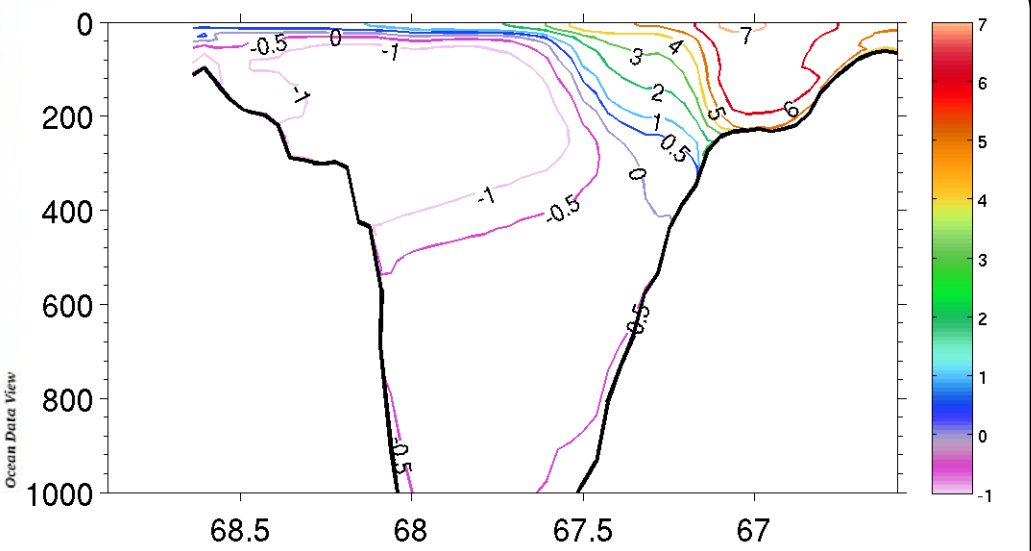


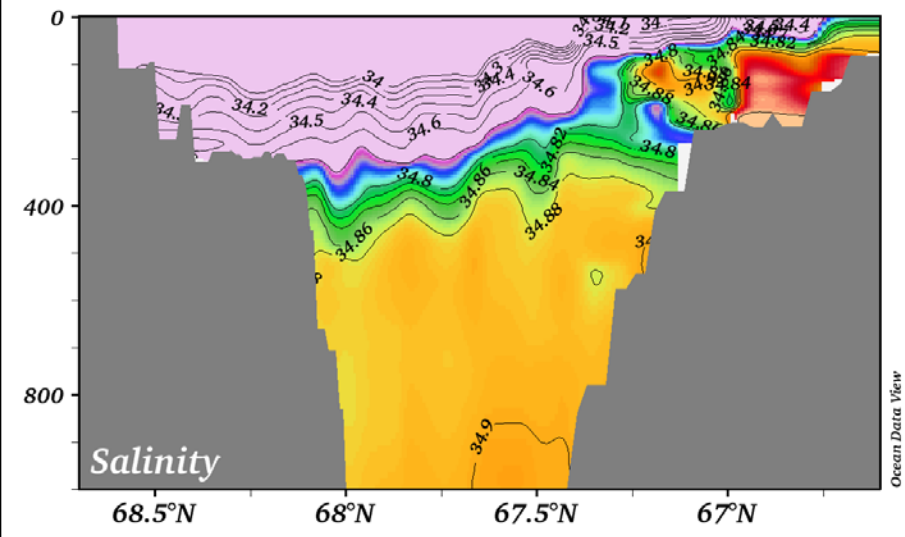
Observation

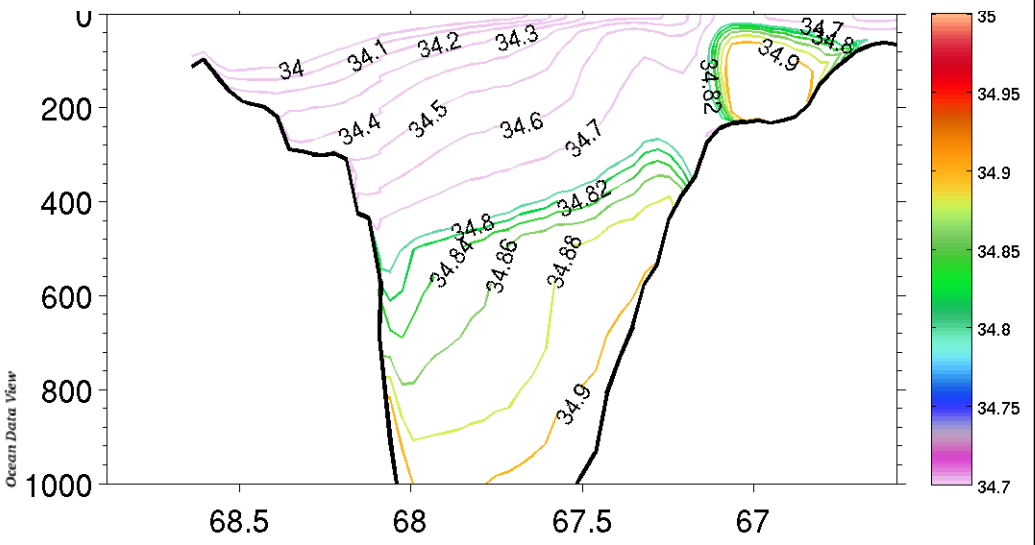
Model

2.4 Upstream of the Denmark Strait





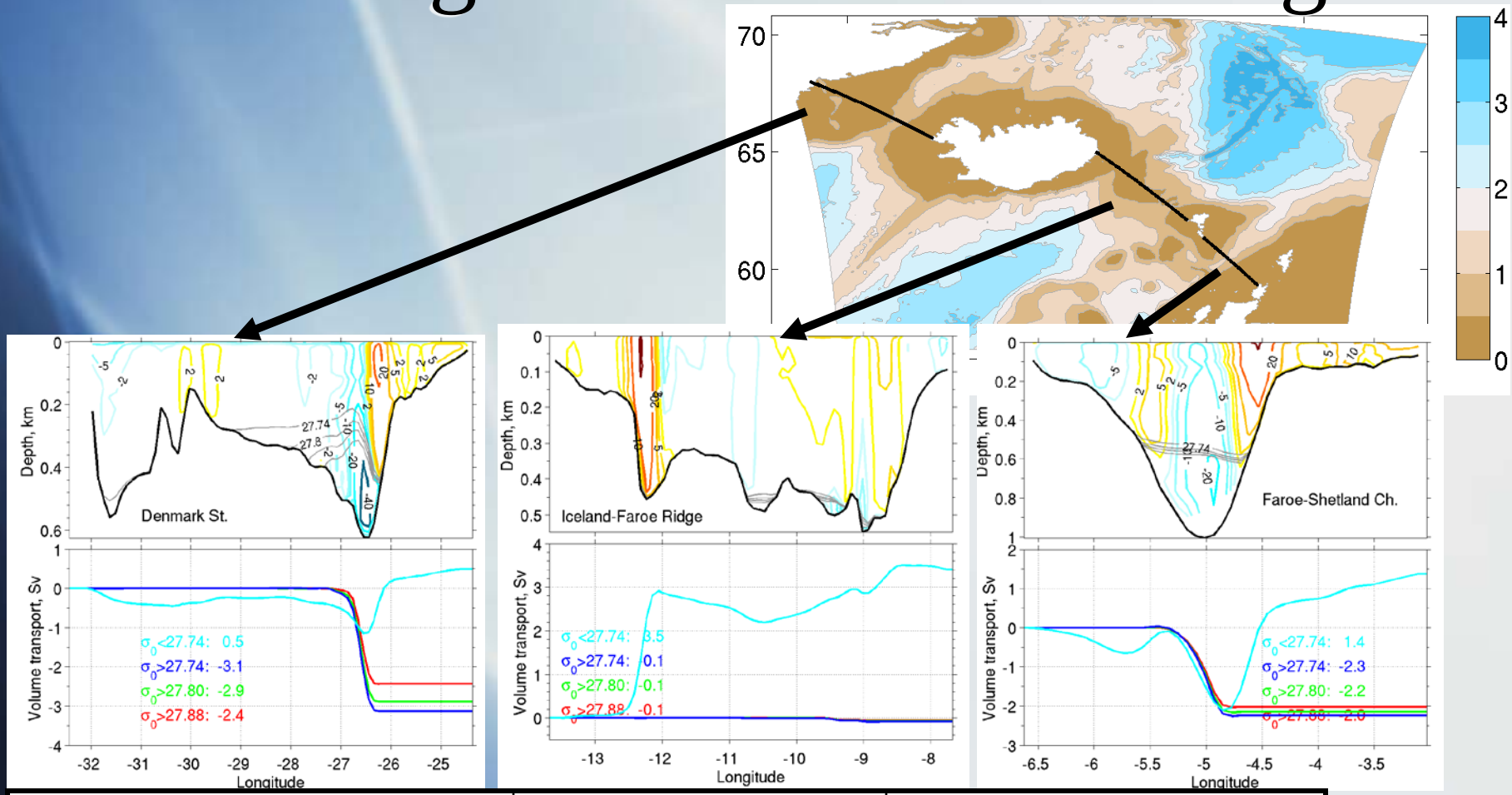




Observation

Model

Exchange across the GIS Ridge



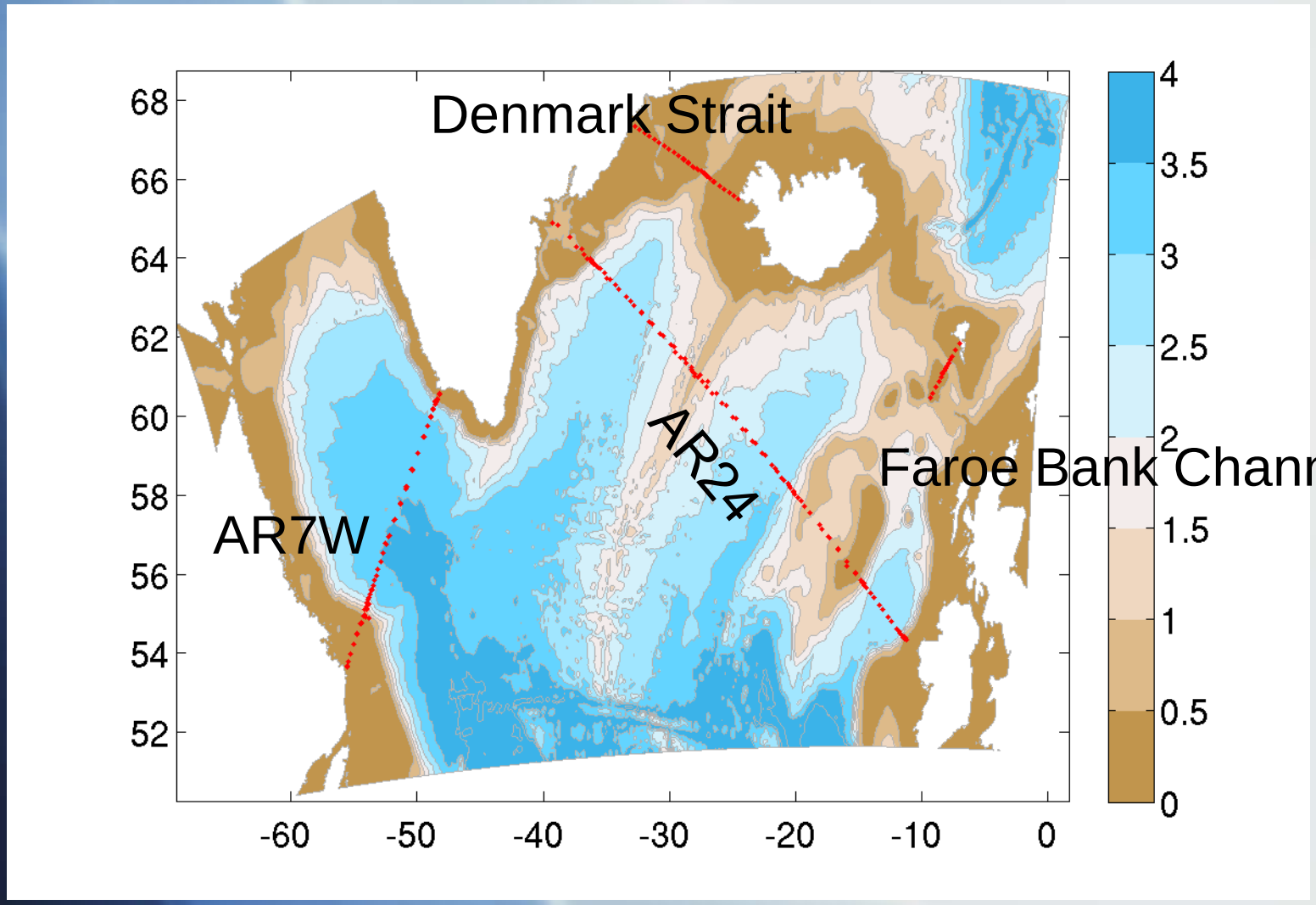
-1[-1], +1.5[1]	+3.5 [+3.3]	+1.4 [3.7]	upper
-2.9 [-3]	-0.1 [-1]	-2.1 [-2]	lower

*[Hansen & Osterhus 00]

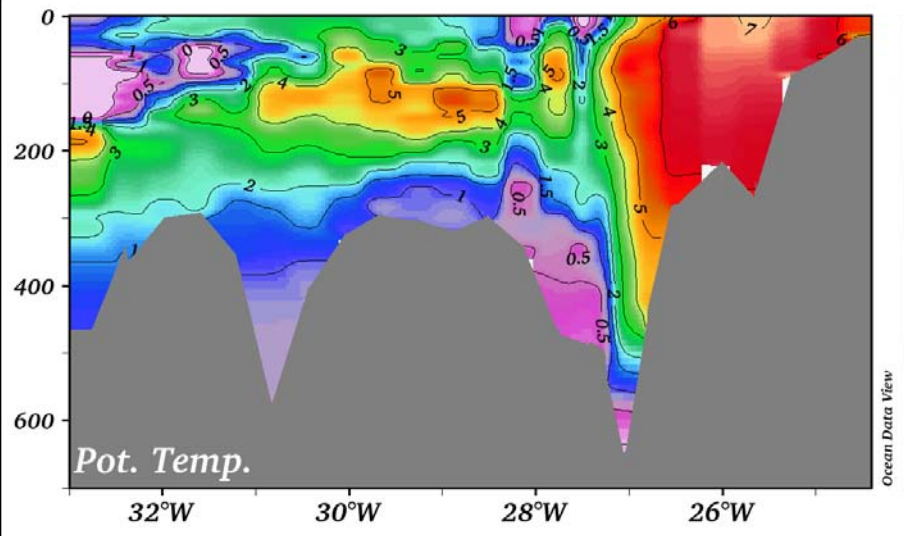
Issues for north of GIS

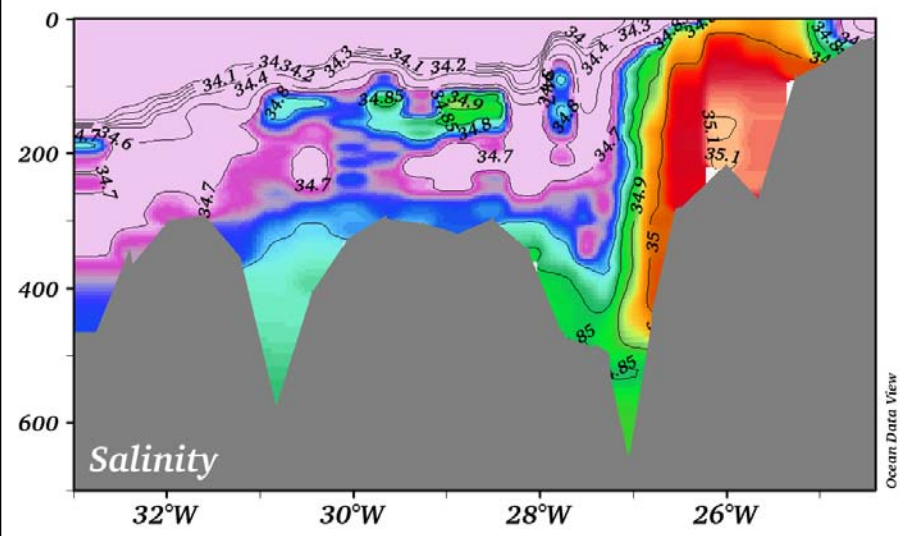
- The inflow water salinity through the FSC is about 0.1~0.2 psu lower than observation; its mean volume transport is only ~40% of observed.
- The deep convection in the Greenland Sea is not represented well.
- The DSOW salinity is also about 0.1psu lower than observed, mainly due to thicker than observed surface cold/fresh layer along the East Greenland coast.

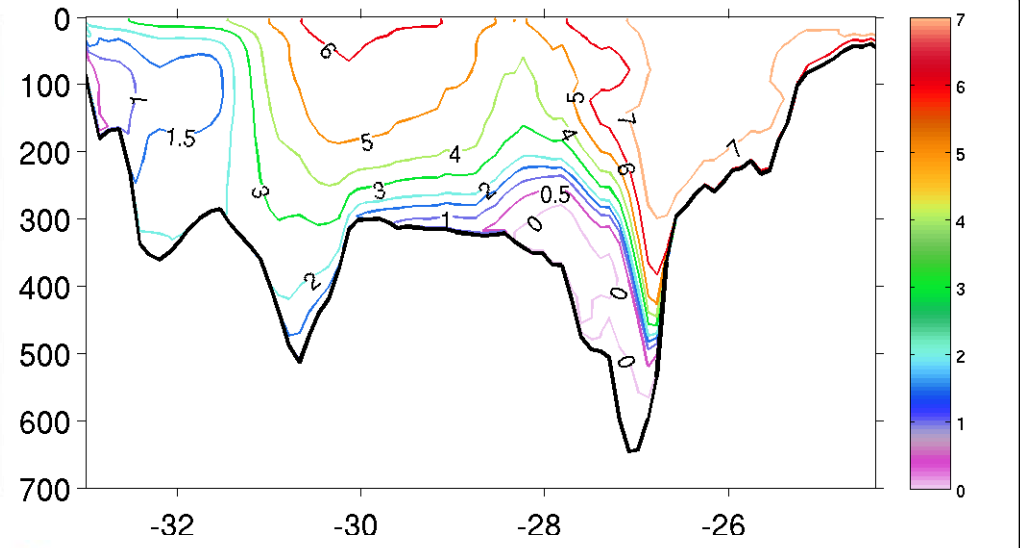
3. Subpolar North Atlantic

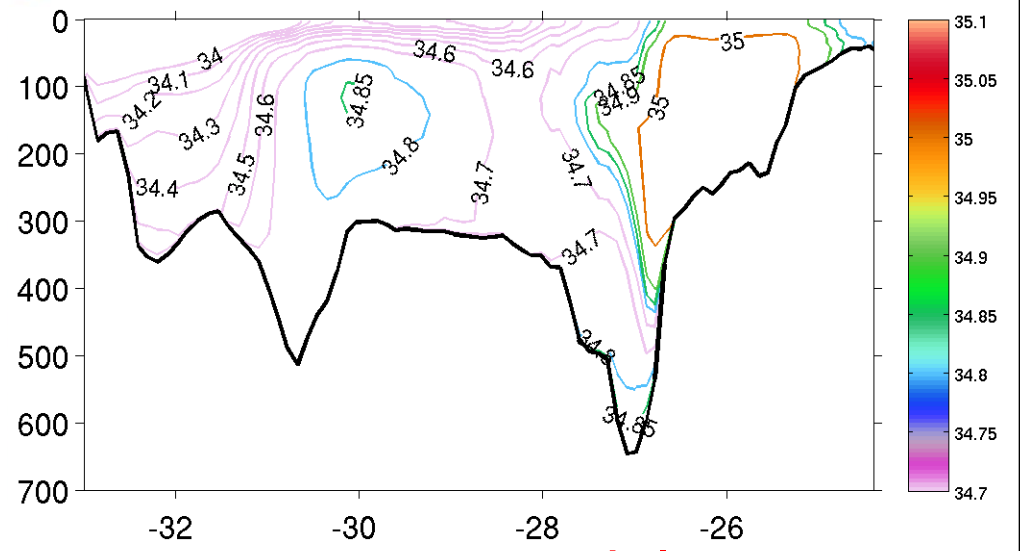


The Denmark Strait





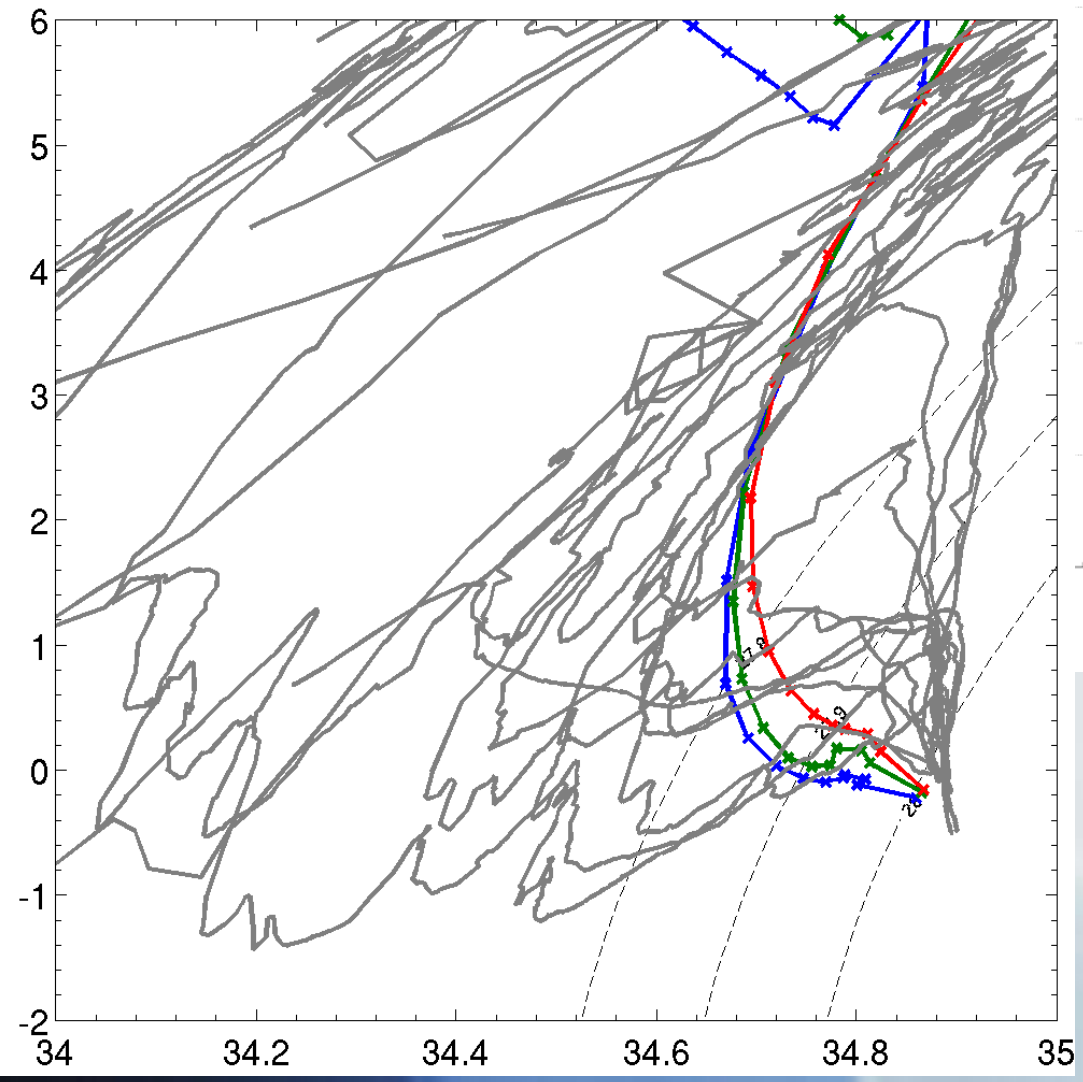


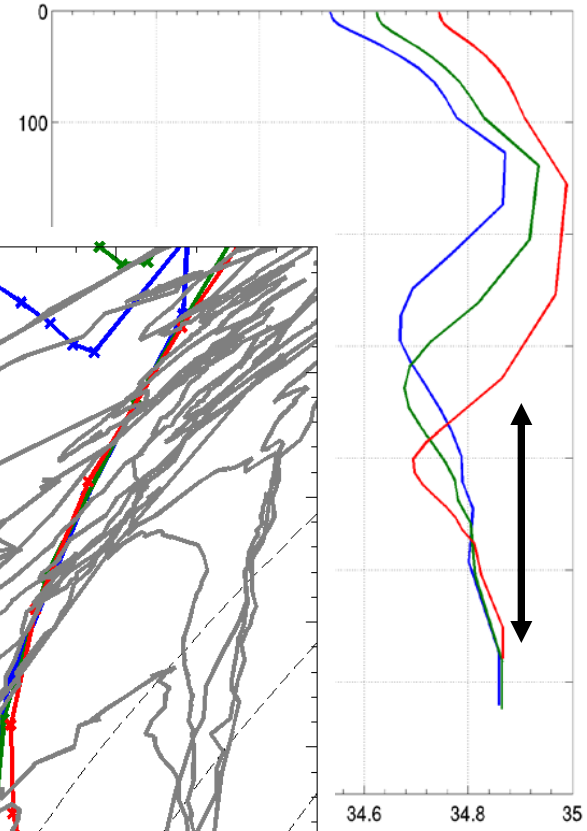


Observation

Model

A closer view

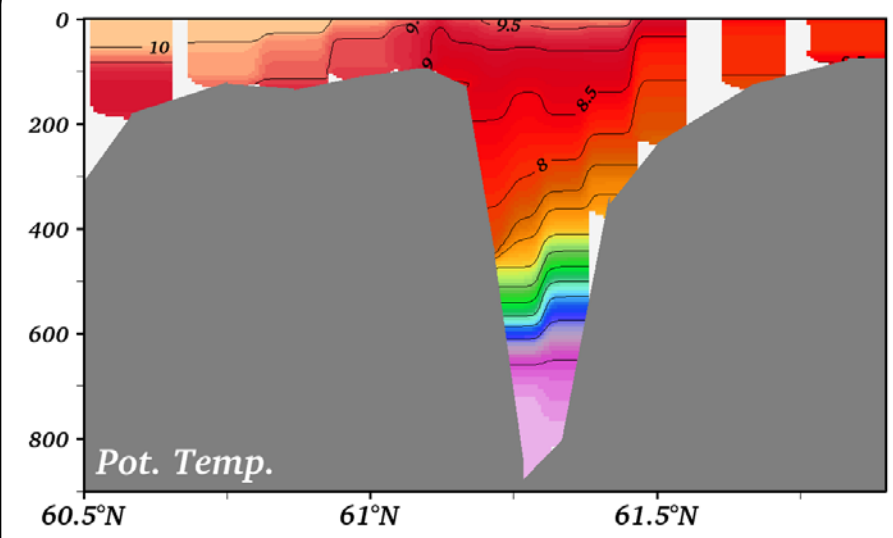


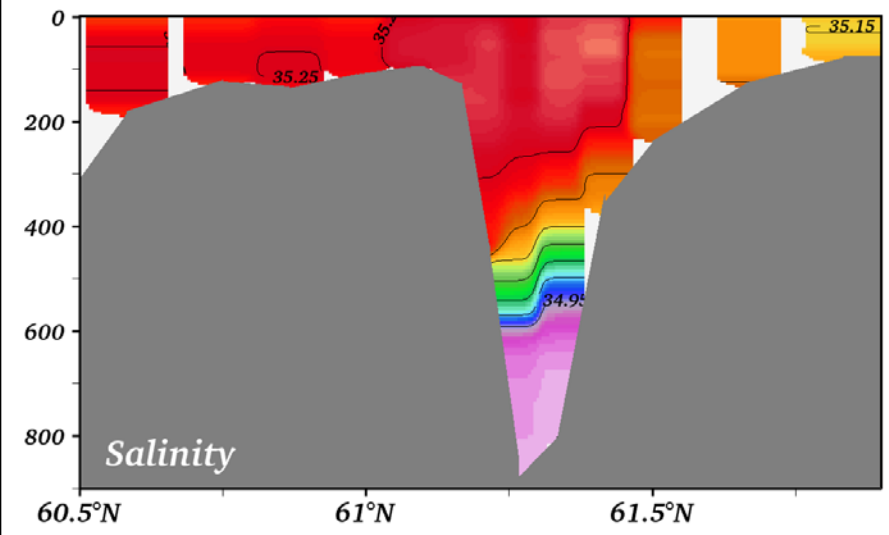


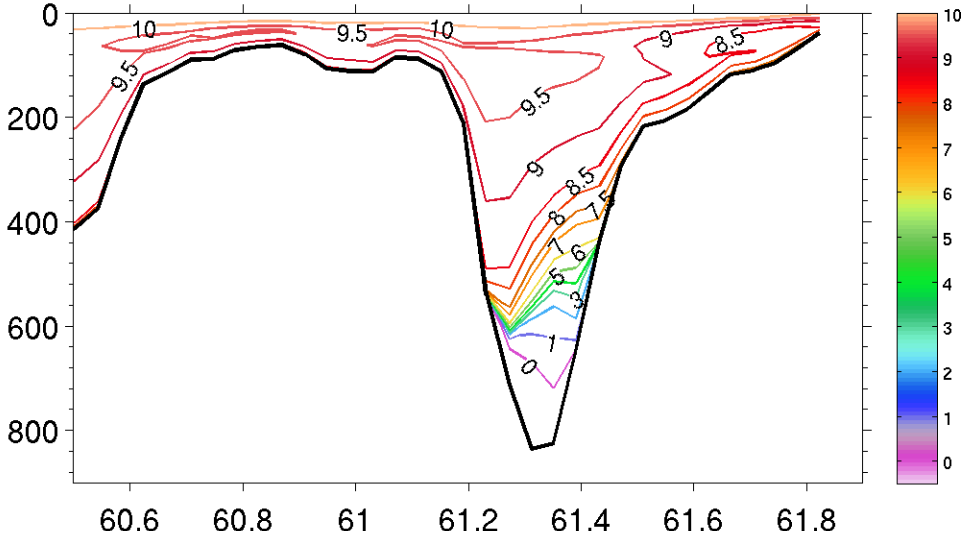
QuickTime™ and a
decompressor
are needed to see this picture.

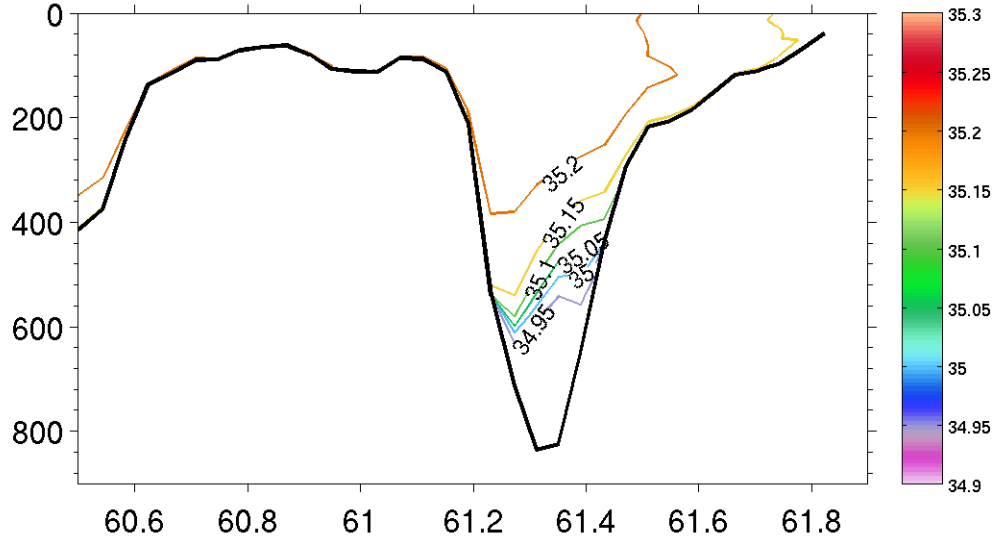
Girton & Sandford
JPO 2003

Faroe Bank Channel





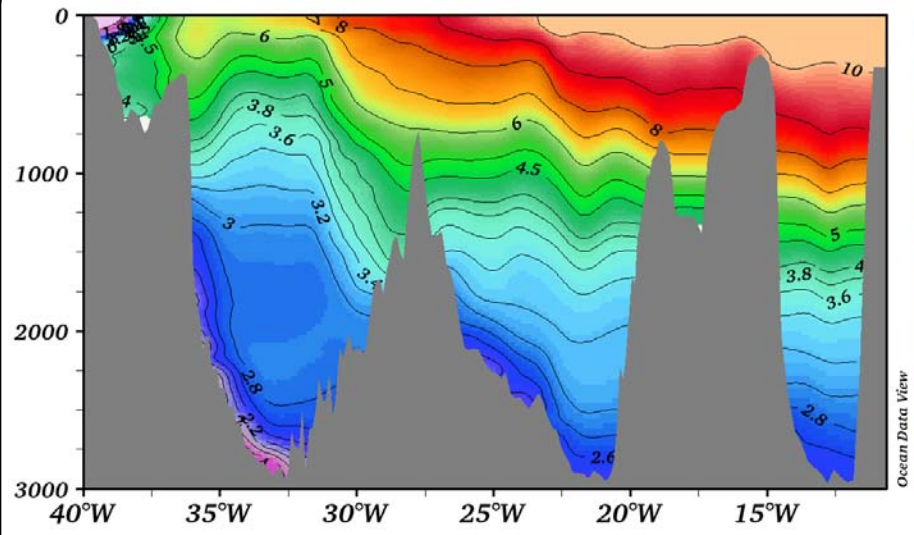


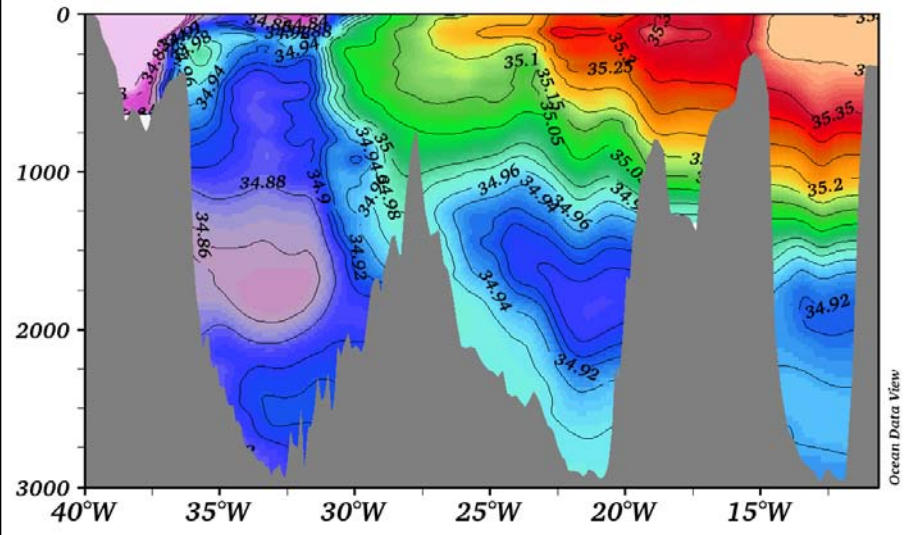


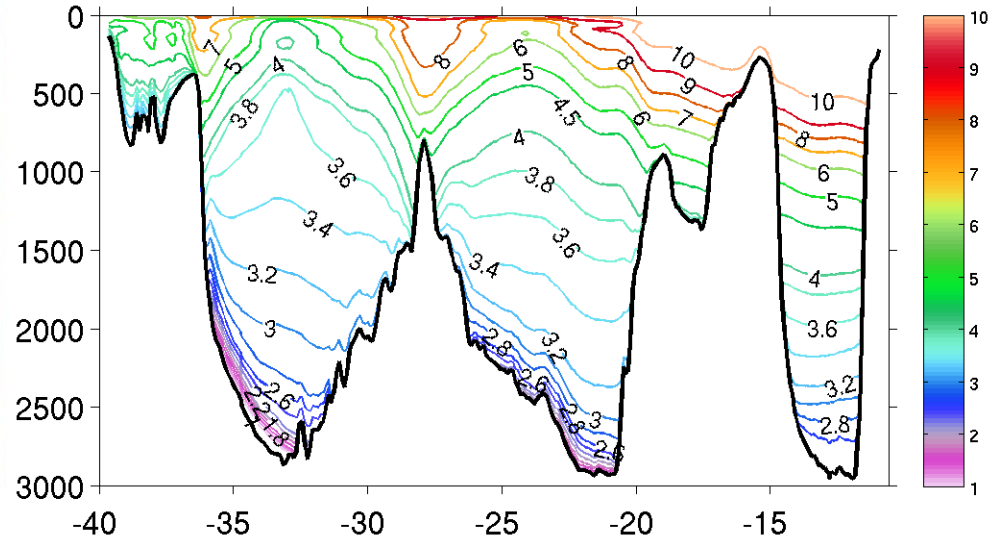
Observation

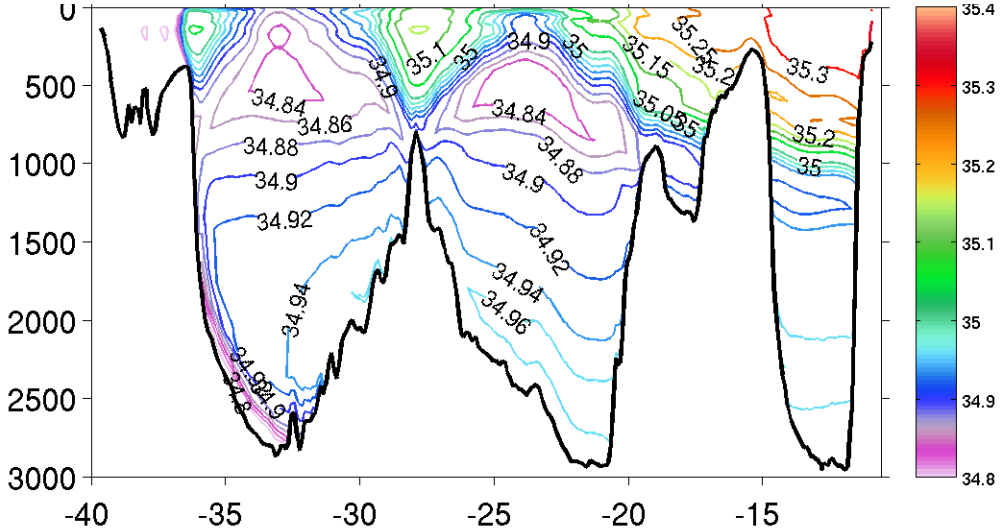
Model

WOCE AR24





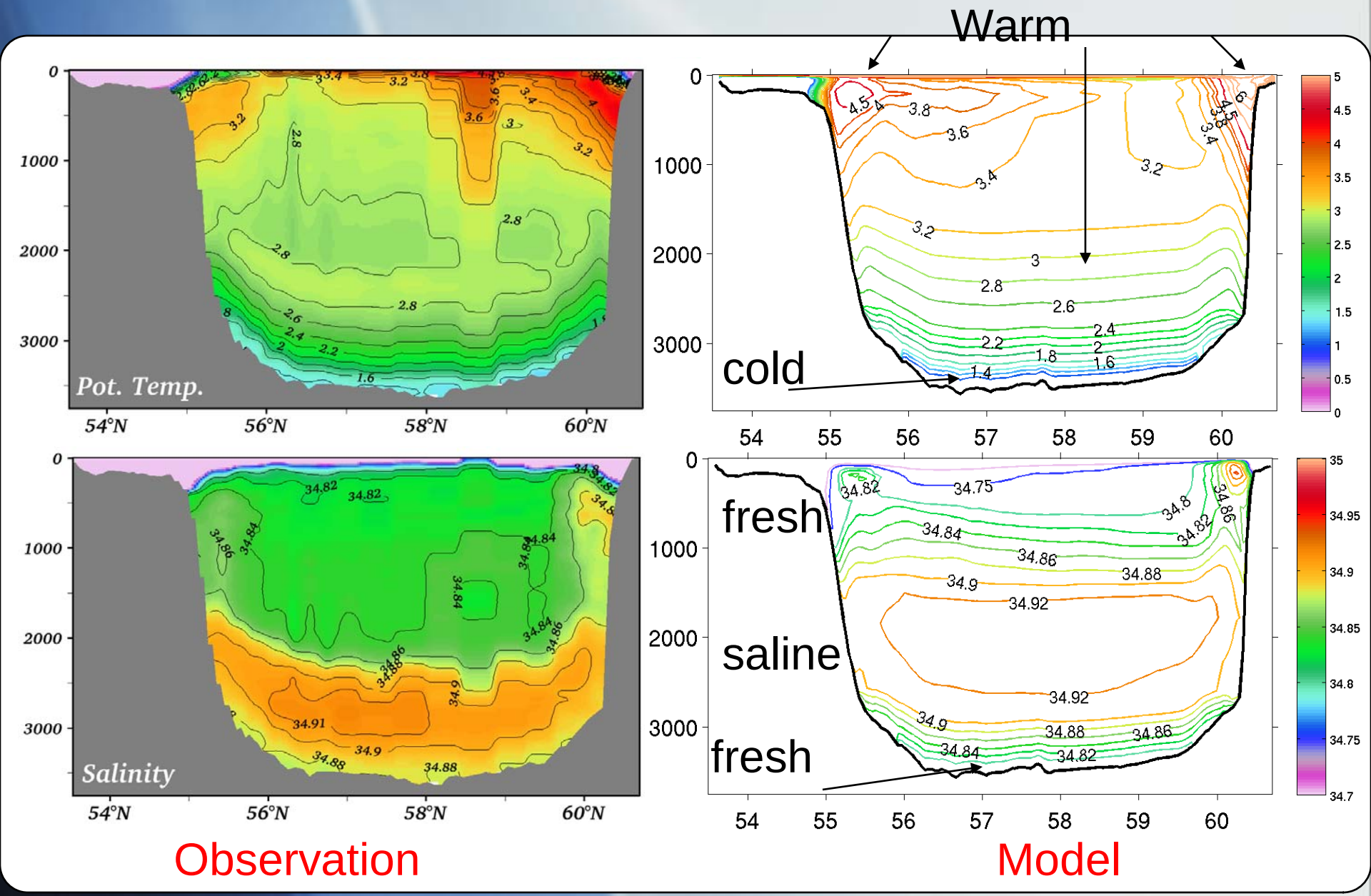




Observation

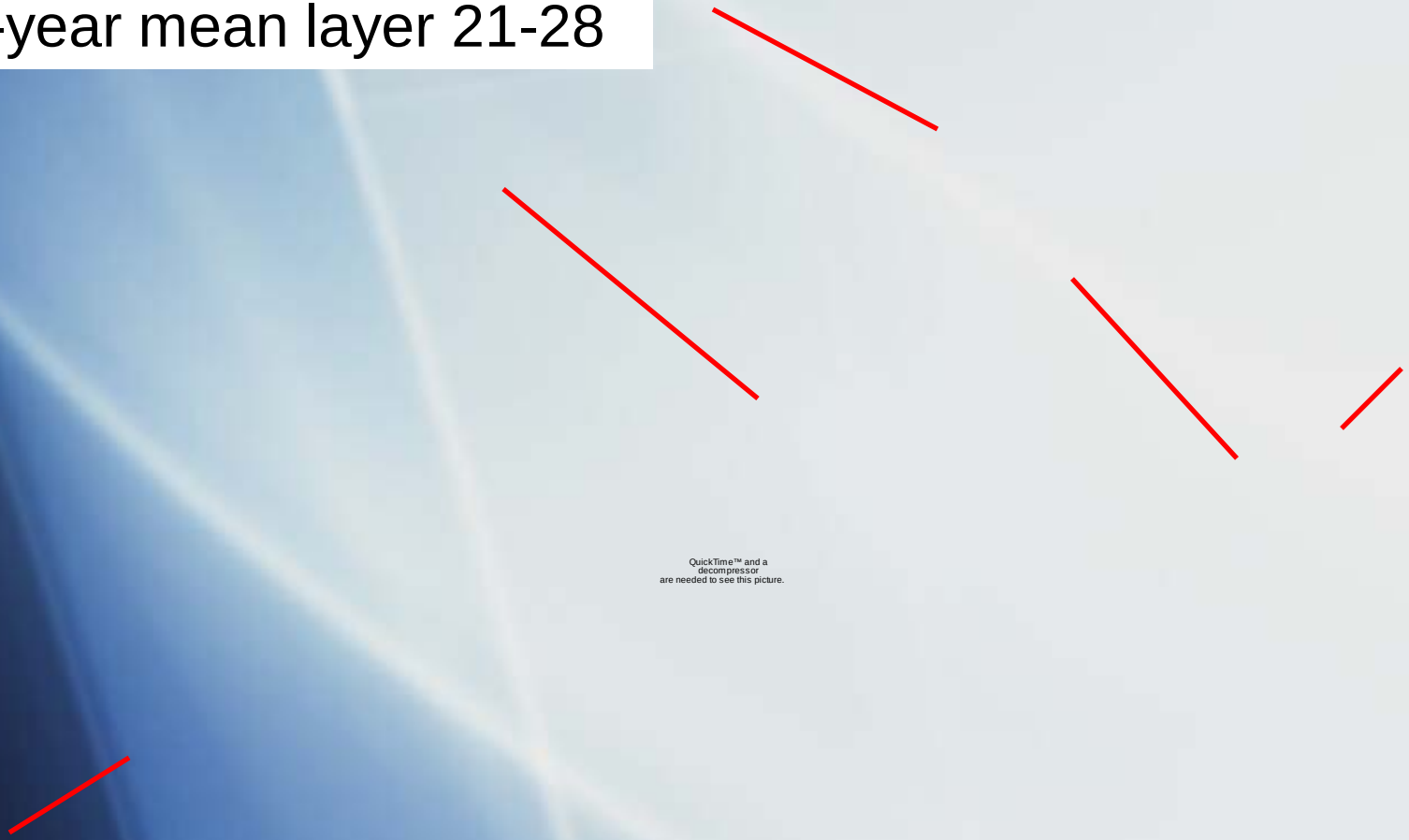
Model

WOCE AR7W


Warm
Pot. Temp.
cold
Salinity
fresh
saline
fresh
0
1000
2000
3000
54°N
56°N
58°N
60°N
54
55
56
57
58
59
60
Observation
Model

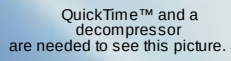
Deep circulation

5-year mean layer 21-28



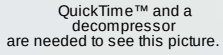
Outflow at sill

Denmark Strait



Obs: 2.9 Sv for >27.80
(Dickson Brown, 1994)

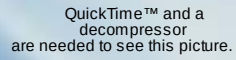
Faroe Bank Channel



Obs: 1.9 Sv for >27.80
(Hansen and Osterhus, 2007)

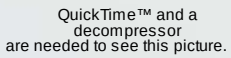
Downstream of the overflow sill

Angmagssalik line



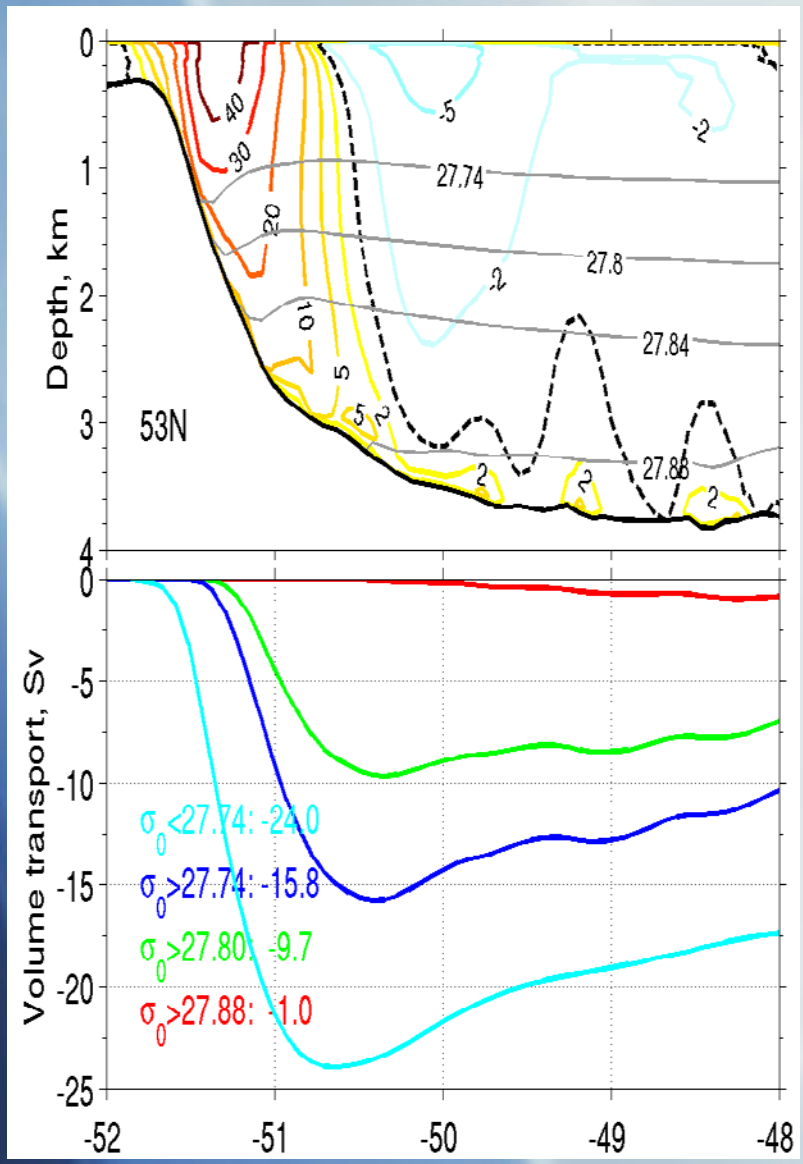
10.7 Sv Dickson and Brown, 1994; 7.3 Sv Dickson et al 2008; 9.0 Sv by Sauders 2001

Southeast of Iceland



3.2 Sv southeast of Iceland, Saunders, 1996

the Labrador Sea (53N)



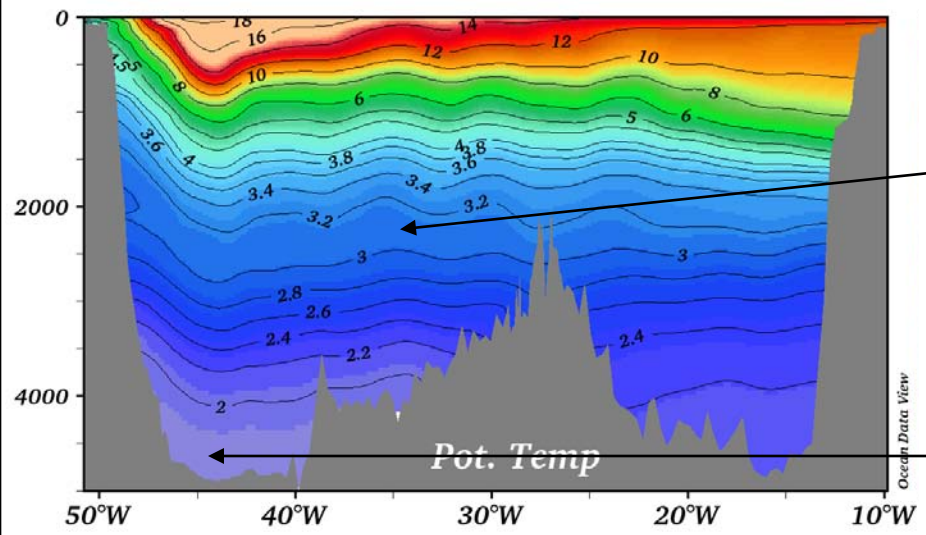
Issues in Subpolar NA

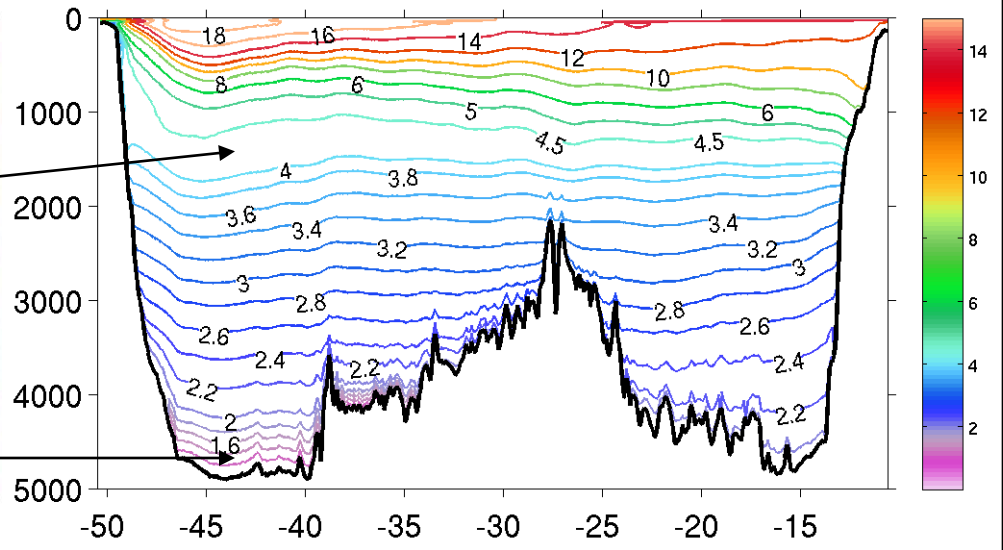
- The net volume transport of DSOW does not increase, even thought the density is decreased significantly via mixing with ambient water.
- The modeled ISOW has about correct TS properties from FBC to southeast of the Iceland. It has no contribution from cold entrainment (LSW and AABW), however, and the flow at southern channel of CGFZ is eastward.
- The deep convection in the Labrador Sea (formation of LSW) is poorly represented. The convection is much shallower than observation.

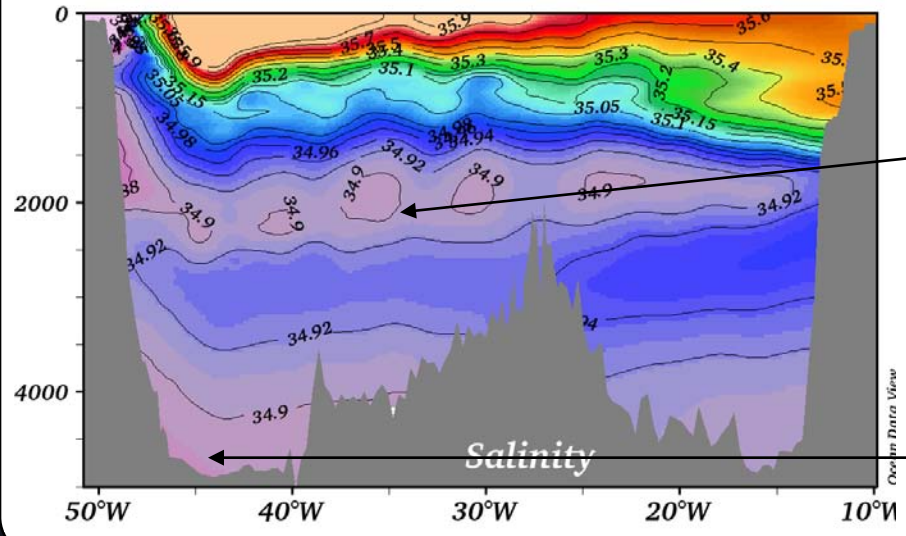
4. Around the Grand Banks

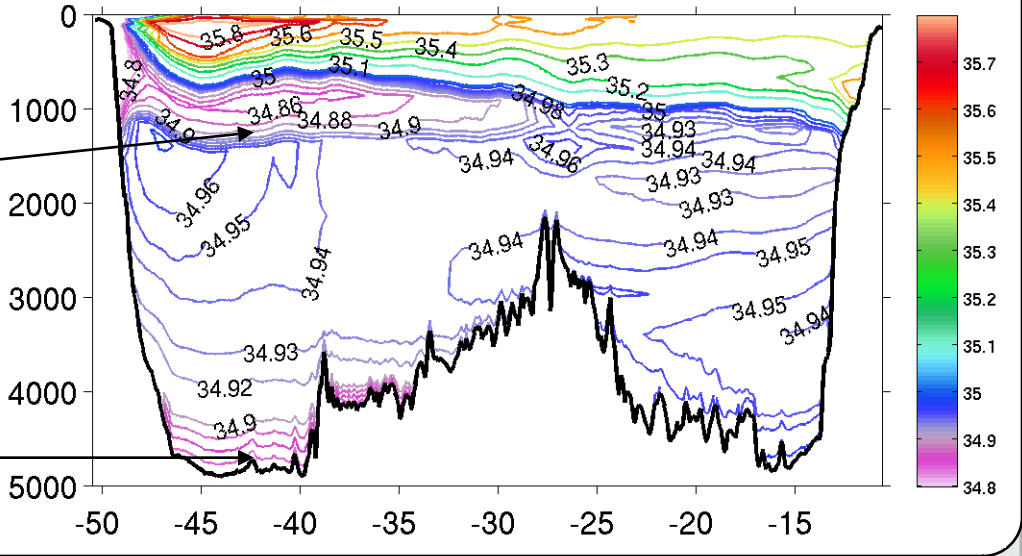
ACM6/AR19

T/S AR19


Pot. Temp
50°W
40°W
30°W
20°W
10°W
Ocean Data View

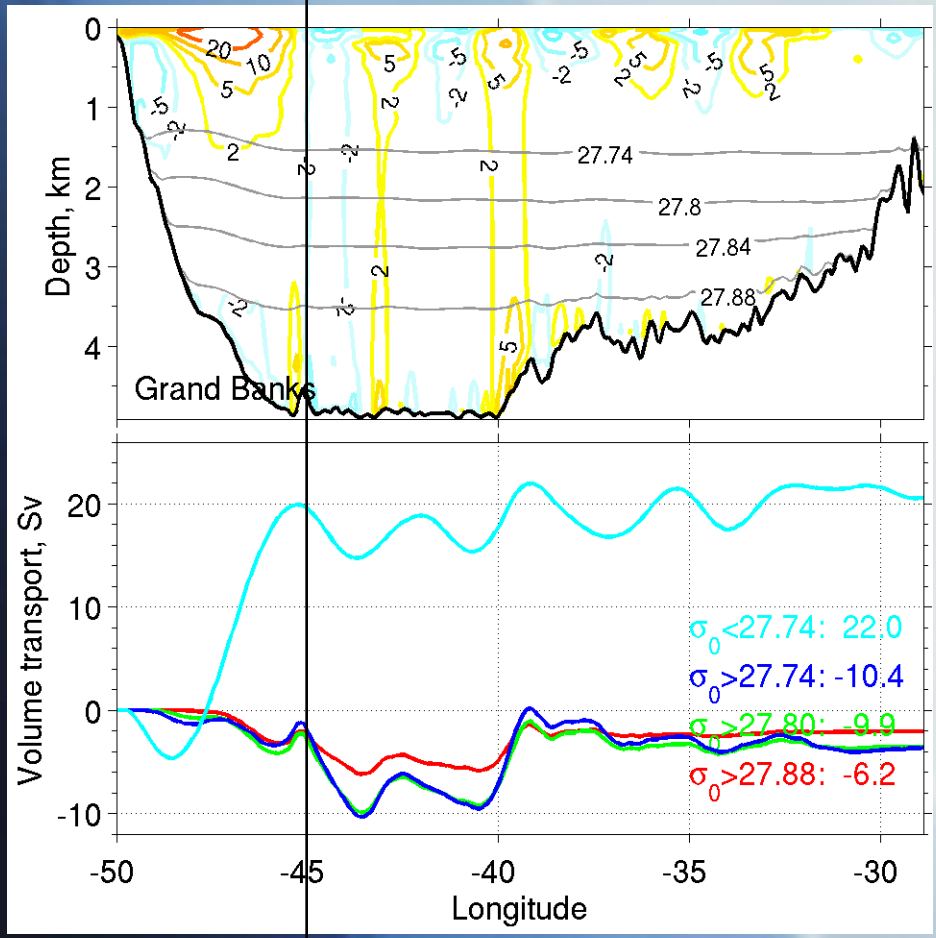



Salinity
50°W
40°W
30°W
20°W
10°W
Ocean Data View



Velocity/volume transport

Zonal section ~43N



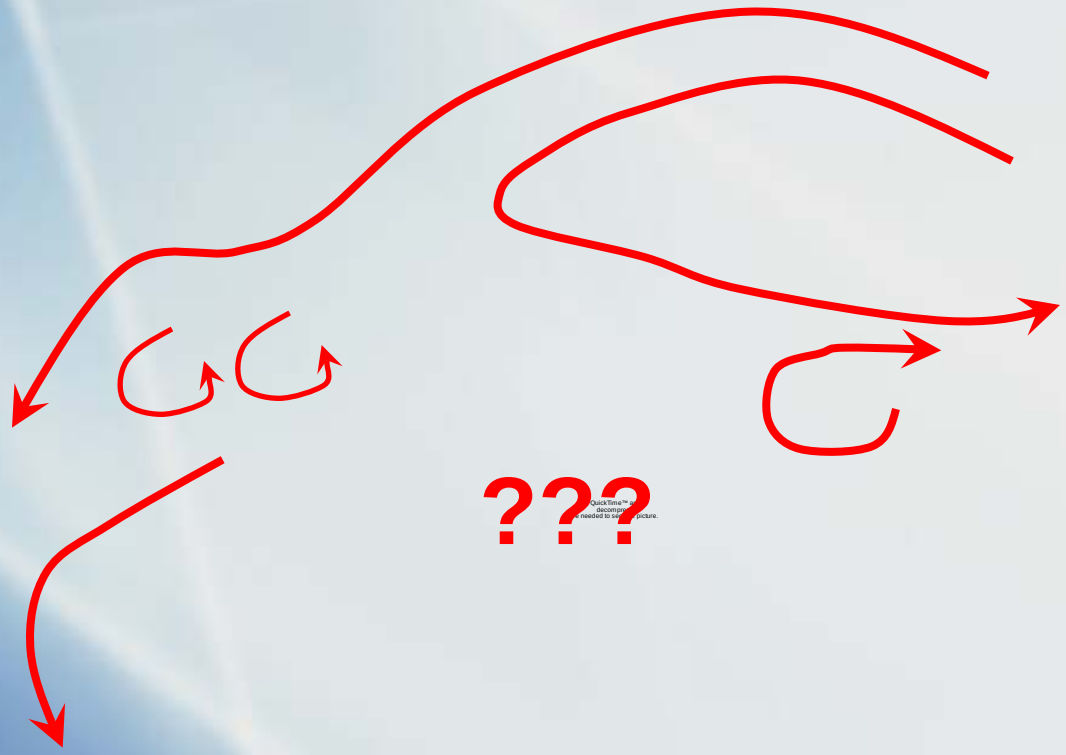
ACM-6 mooring

Schott, JPO 2004

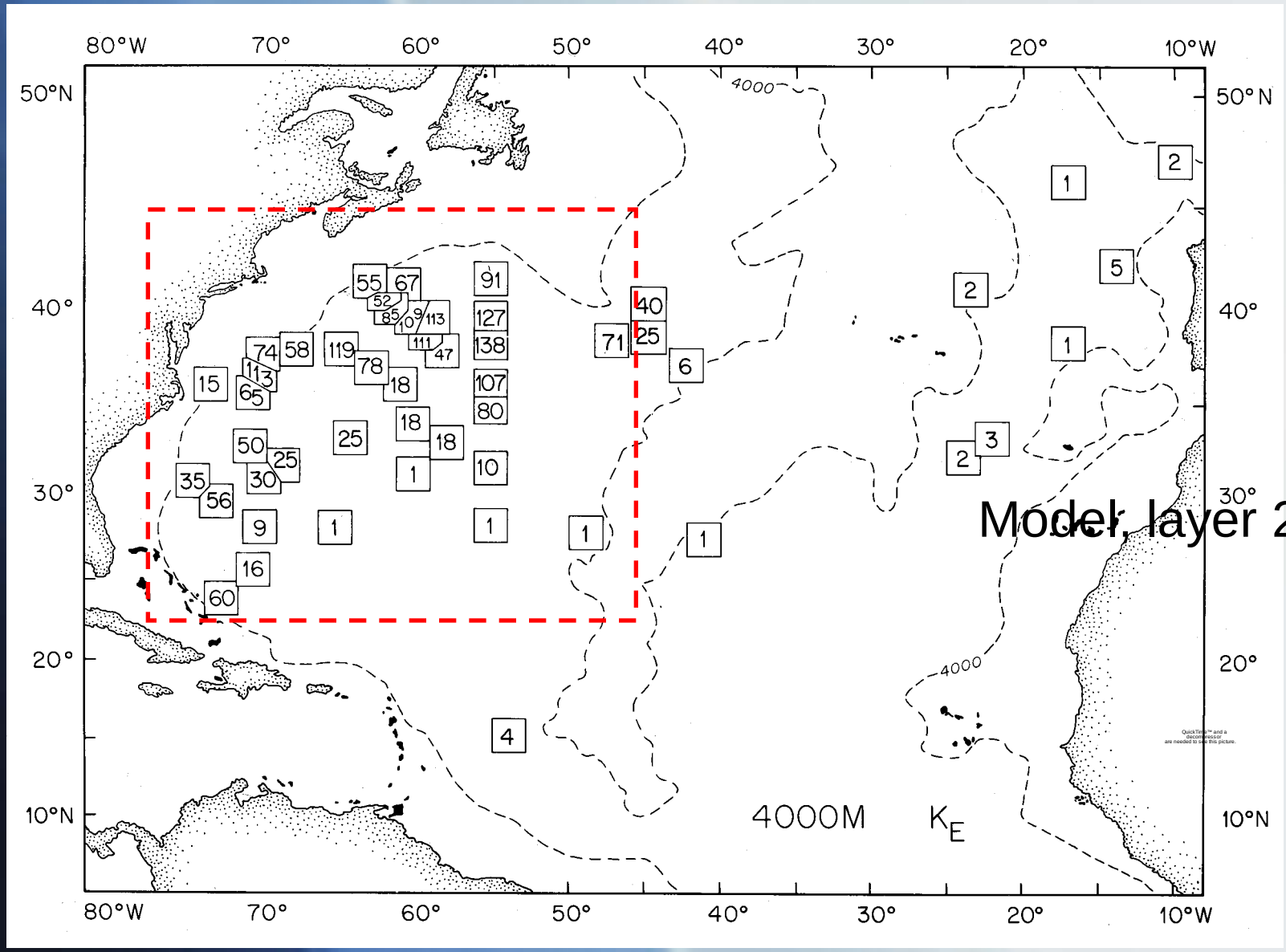
Issues around GB

- Weaker volume transport of both DWBC and northward North Atlantic current (gyre)
- Water mass issues similar to that in AR7W/AR24; and not contribution of AABW in the eastern Basin.

5. Subtropic North Atlantic

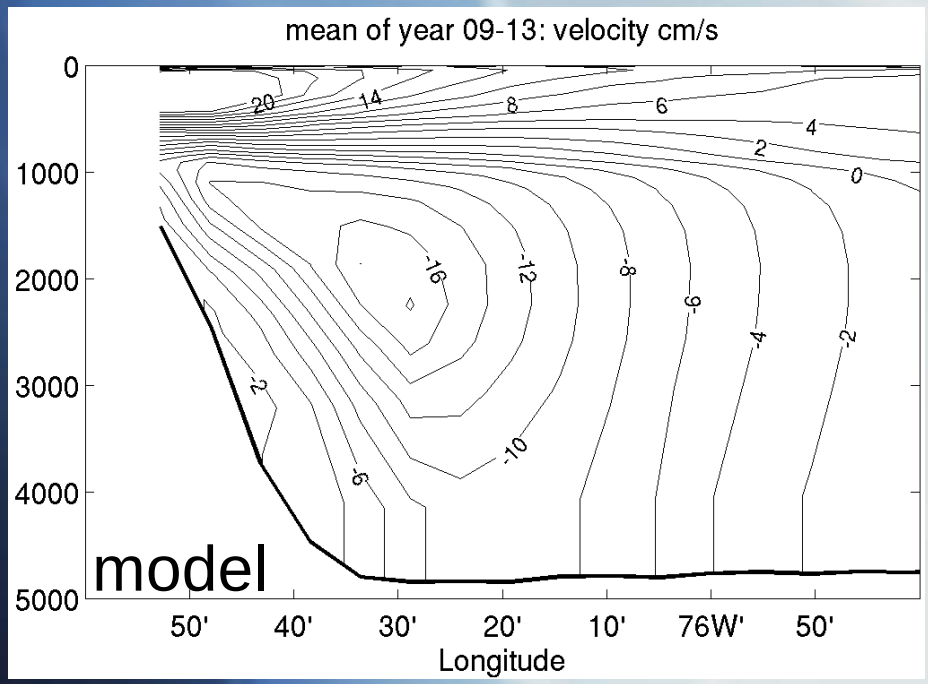


EKE @ ~4000m



Model layer 24

DWBC @26.5N (Abaco)



QuickTime™ and a decompressor are needed to see this picture.

LADCP

QuickTime™ and a decompressor are needed to see this picture.

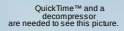
QuickTime™ and a decompressor are needed to see this picture.

15
10
5

Mooring 04-05

Mooring: Lee et al (1990)

Quantitatively …



Accumulated volume transport below 1000m from the coast (77W)

Vertical profile of volume transport from coast to about 72W (solid) and 71W (dash)

Summarize

- An 1st step toward semi-realistic simulation of NADW in high-resolution large scale model. Many issues:
- Weaker meridional flow between subtropic and subpolar, both in upper layer and lower layer
- No AABW contribution to the north, LSW formation
- The fresh Atlantic surface water
- Gulf Stream extension (vertical/horizontal)

- NADW is a combination of the Northern overflow (ISOW and DSOW), LSW, and AABW. The overflow also entrains shallow Atlantic surface water (near the sill).