Spreading of Polar and Atlantic Water Masses into the inner Nordic Seas

Analyses of hydrographic measurements from Argo floats and Seagilders

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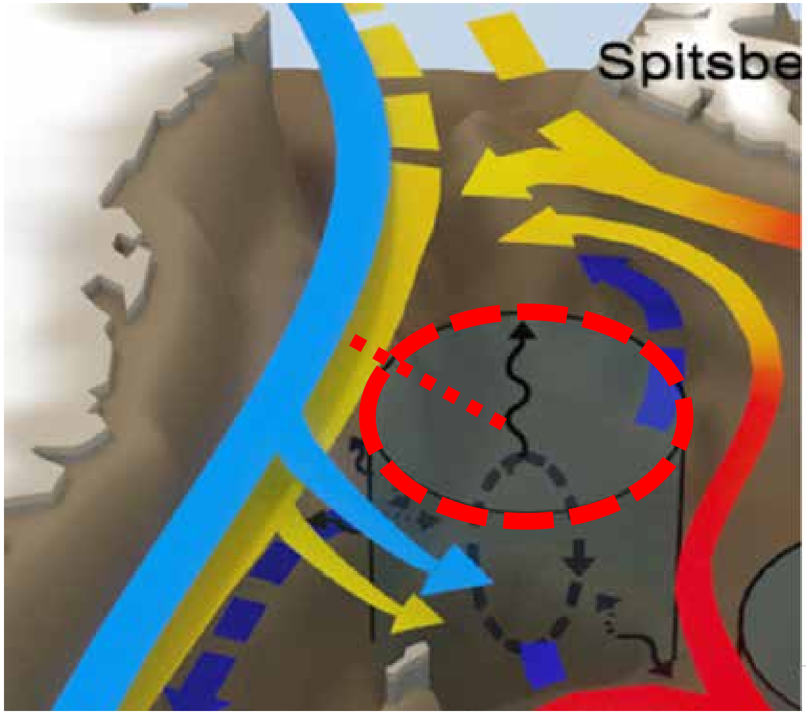
Outline of the following..

I.
Large scale:
Interannual to longer-term variability of salinity/freshwater in the Greenland Sea Basin

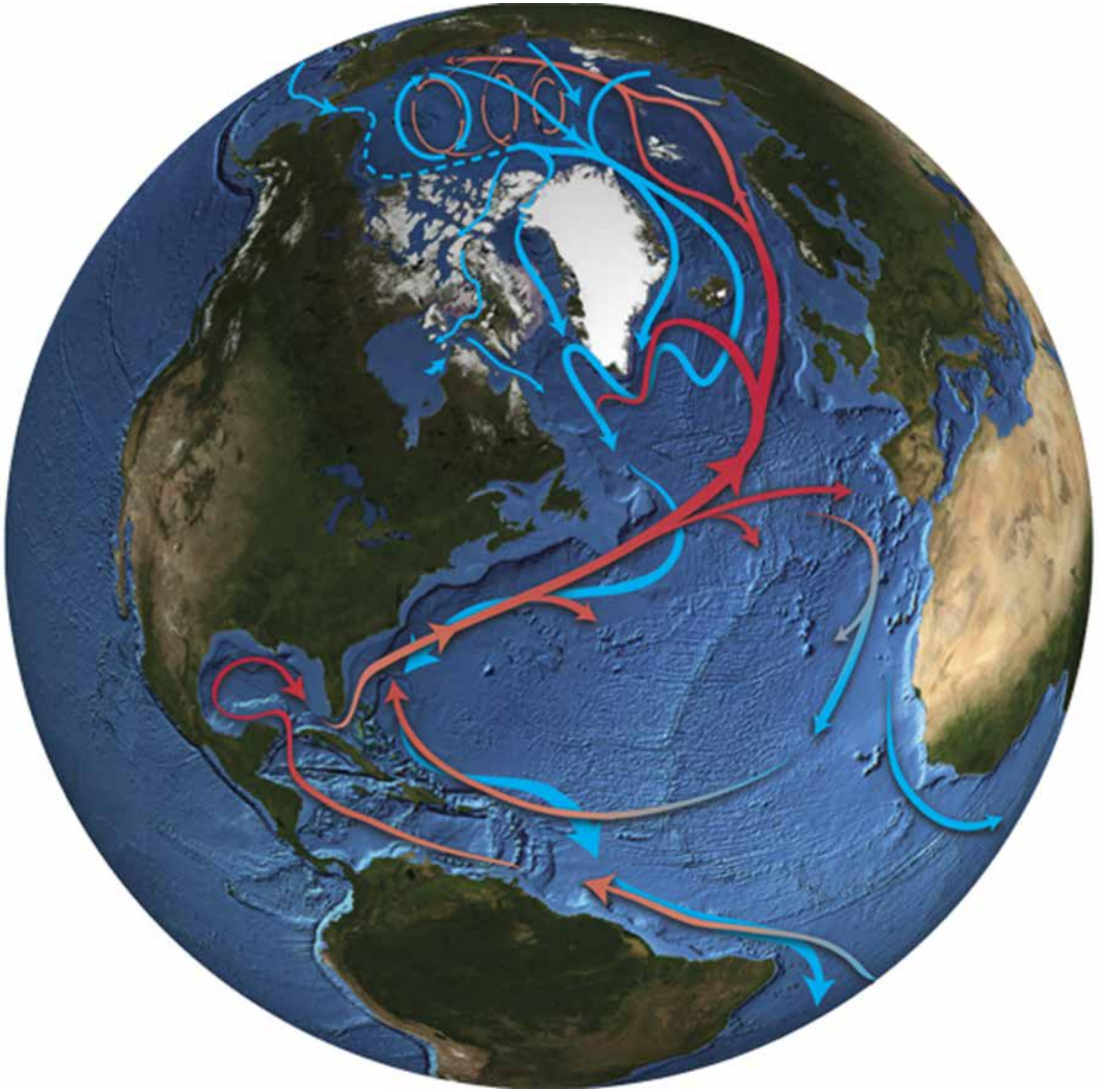
Data: measurements with Argo floats



II.
Mesoscale:
Intrusion of freshwater from the ice edge/East Greenland Current to the inner Greenland Sea Basin

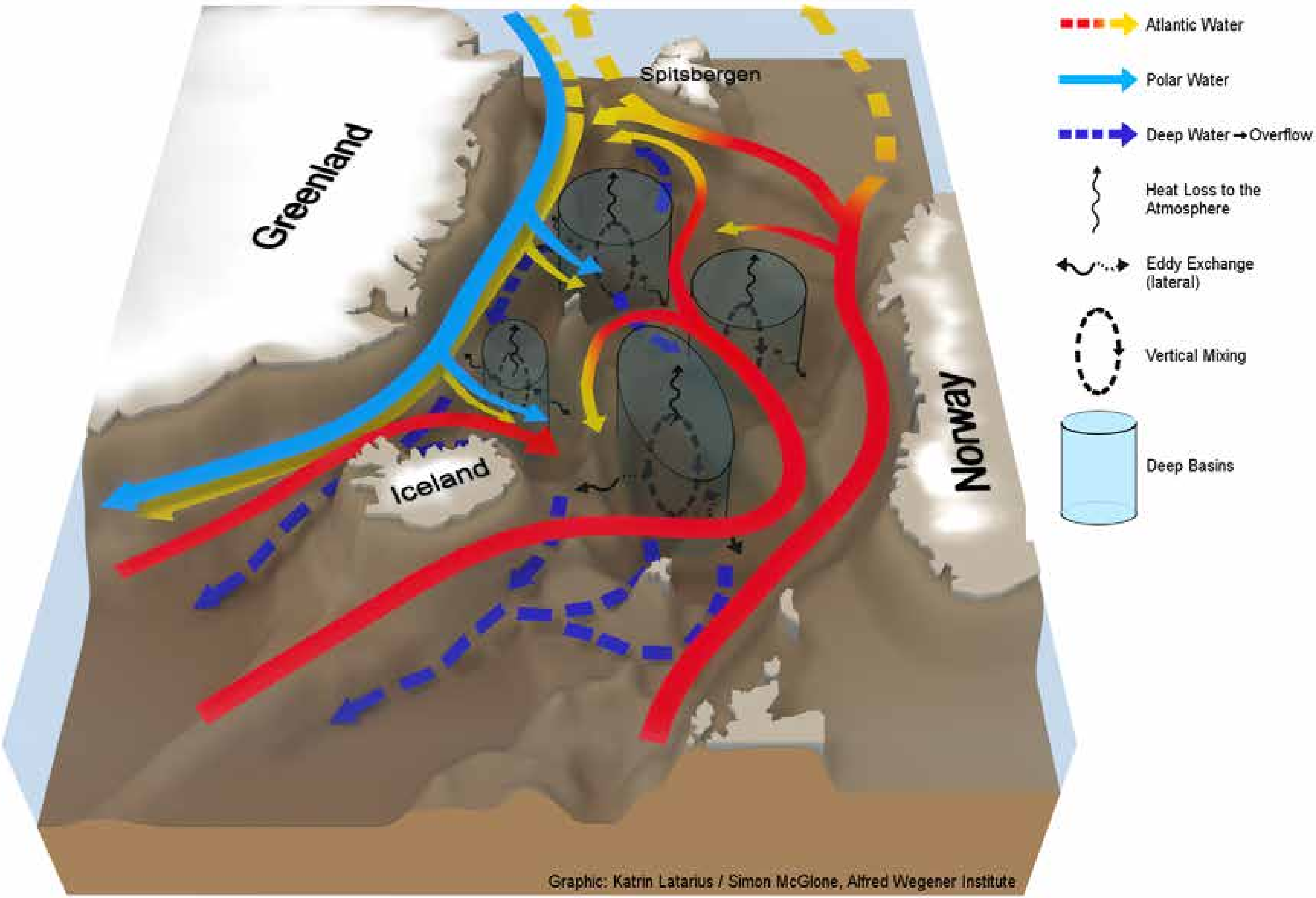
Data: high resolution Seaglider sections

The Nordic Seas – where Polar and Atlantic water masses meet



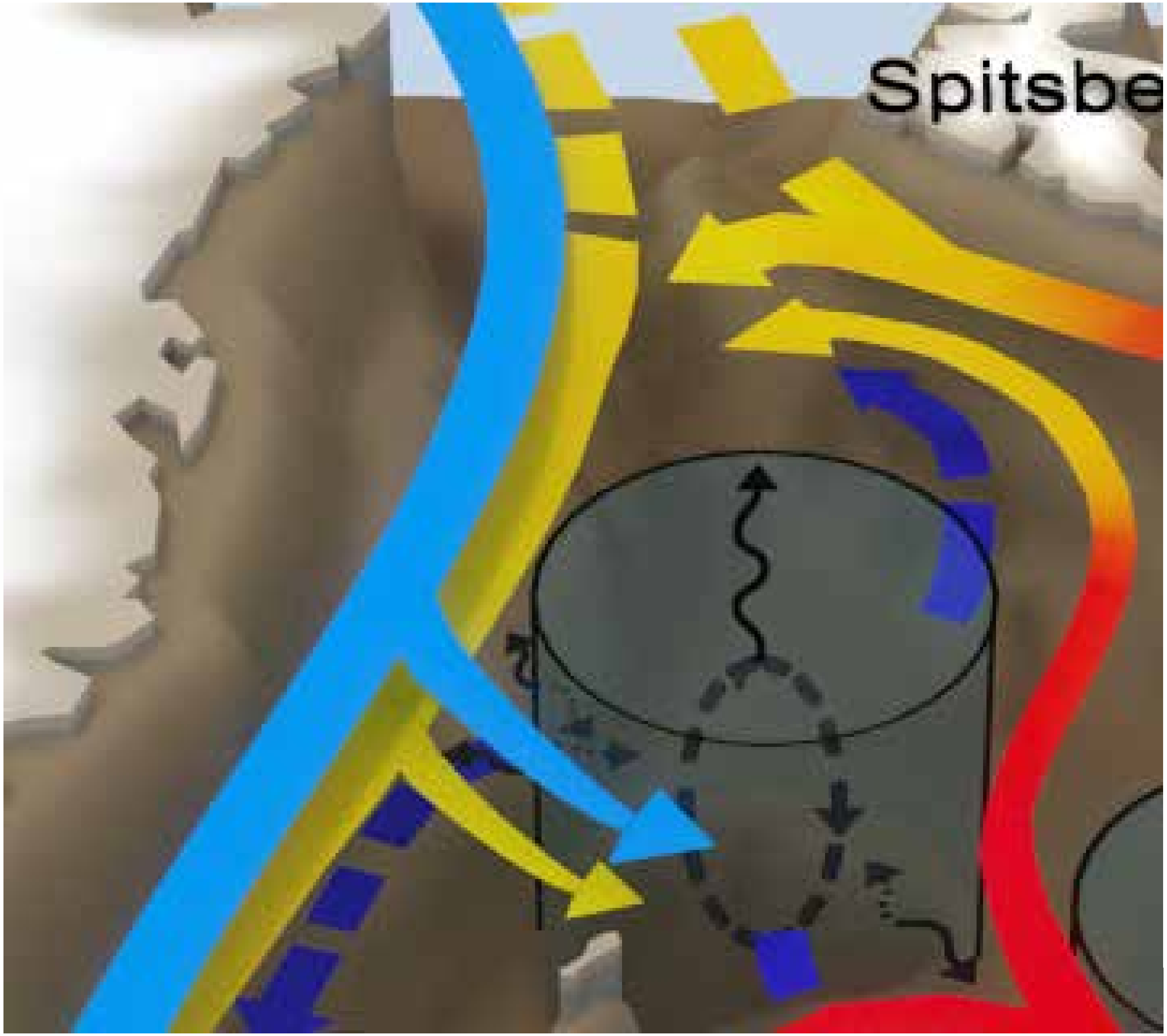
E.P. Oberlander, WHOI

The Nordic Seas – Schematic of the system

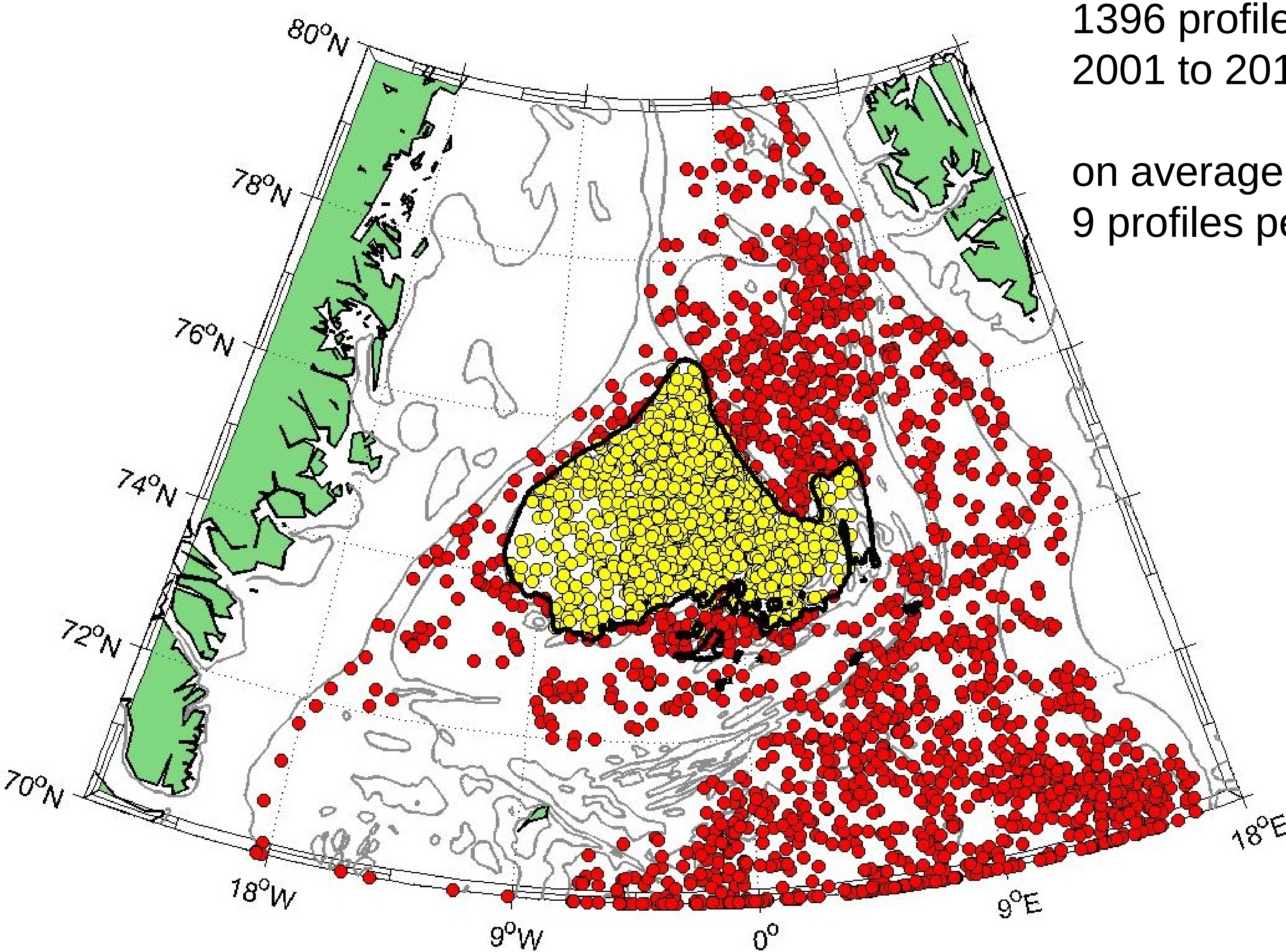


Latarius & Quadfasel, submitted to DSR 2015

The Nordic Seas – Focus on the Greenland Sea



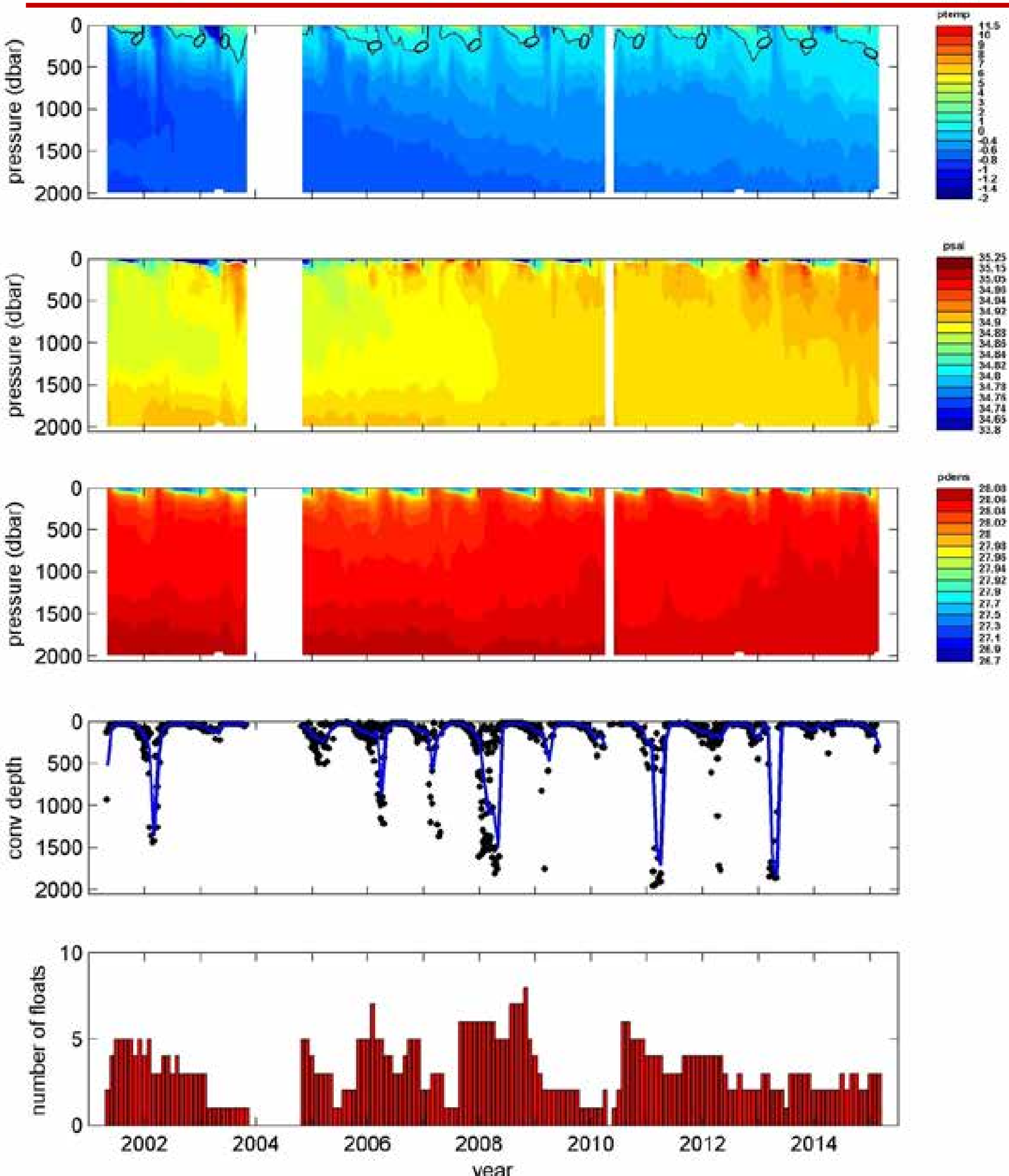
Argo float measurements in the northwestern Nordic Seas



Greenland Sea Basin:
1396 profiles
2001 to 2015

on average:
9 profiles per month

Time series of hydrography – Greenland Sea Basin 2001 to 2015

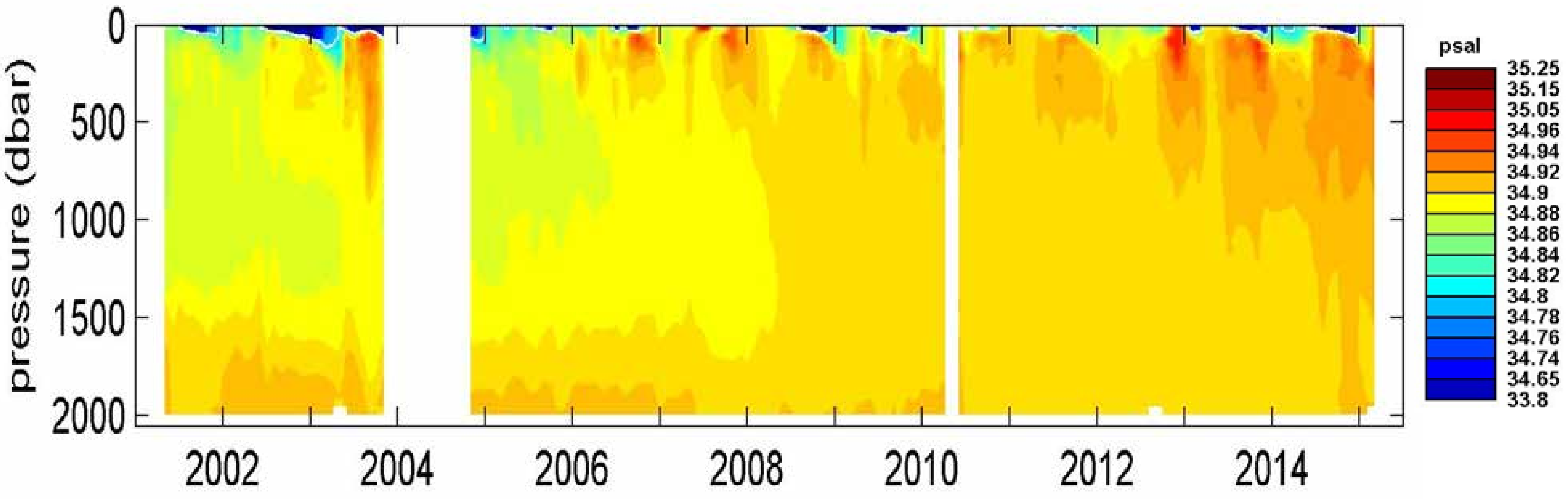


Increasing temperature and salinity in the time span of observations.

Interannual variability of convection depth.

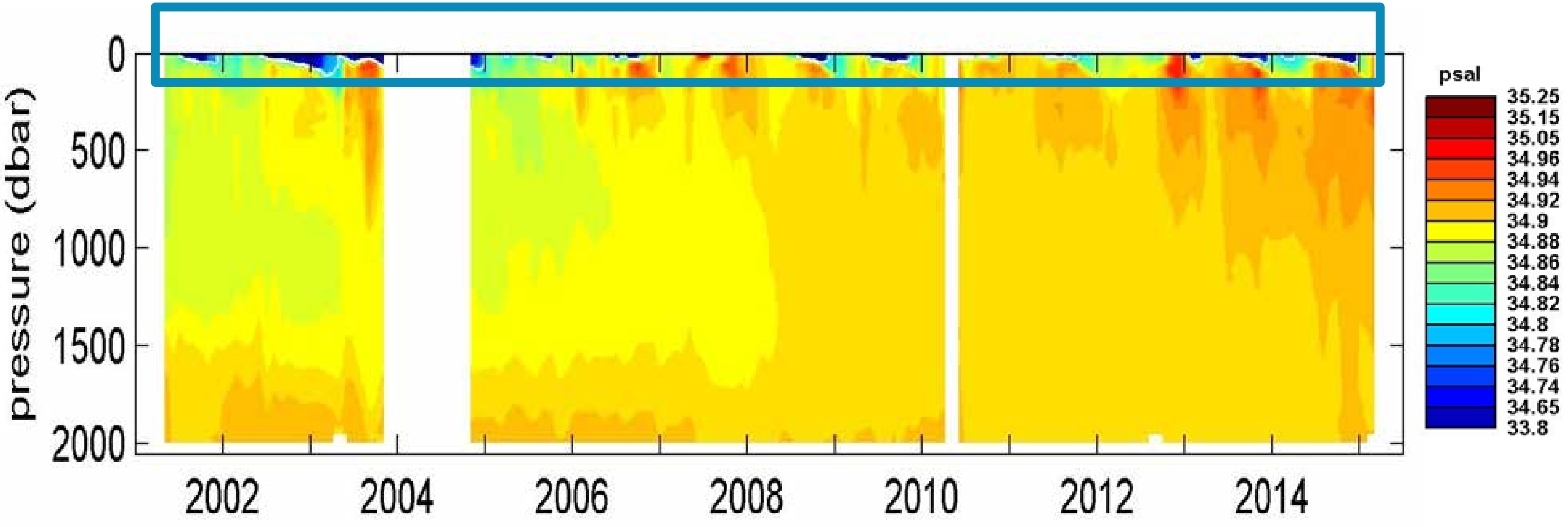
Increasing T and S in the Atlantic inflow to the Nordic Seas:
Faroe-Scotland-Channel:
T: + until 2003
(2005/06 still high)
S: + 1996-2006
Propagation with the circulation around the Nordic Seas; 3 to 4 years later in Fram Strait
(Holliday et al., 2008)

Focus on salinity time series from the Greenland Sea



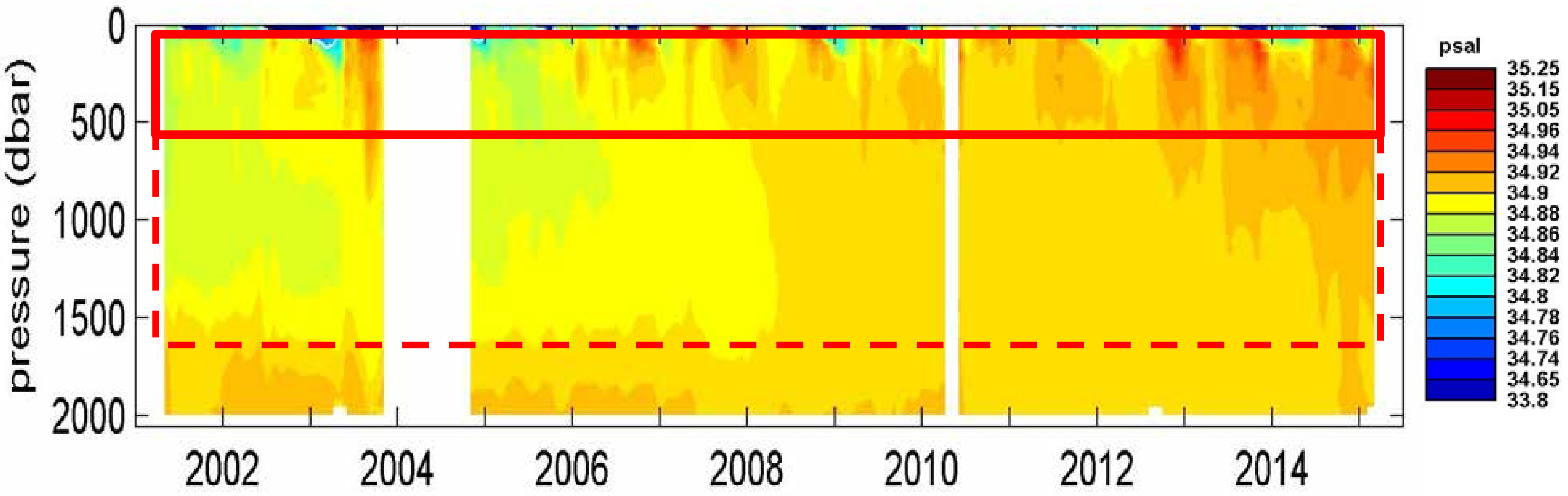
From surface to great depths

freshwater in the surface layer



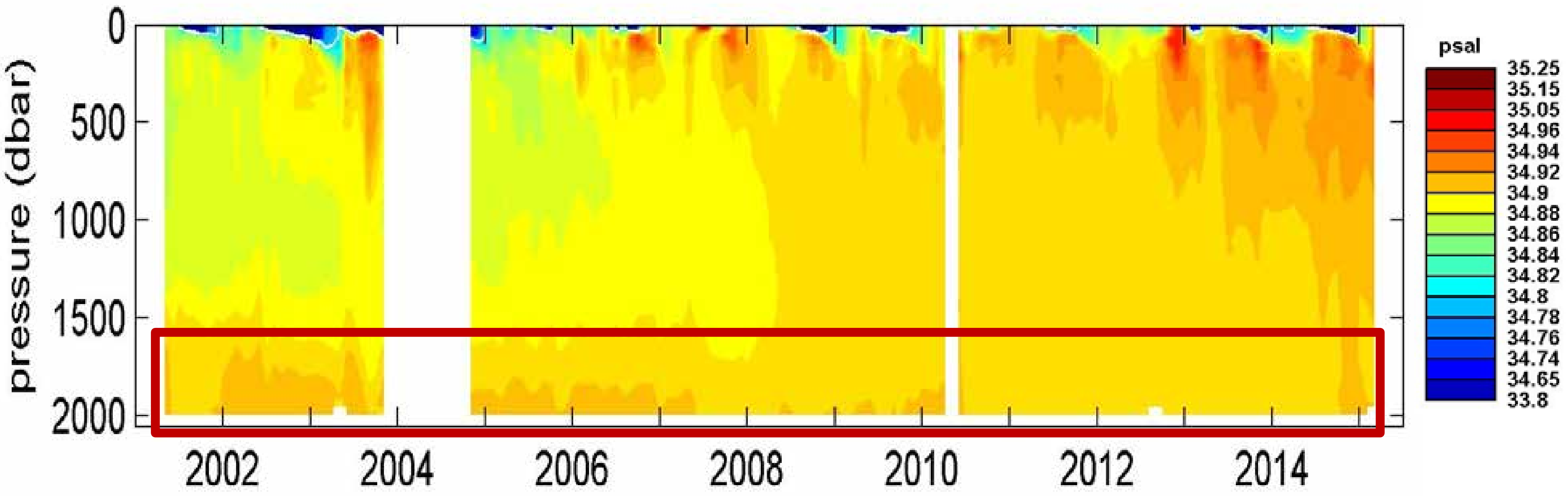
From surface to great depths

salinity changes in the Atlantic layer



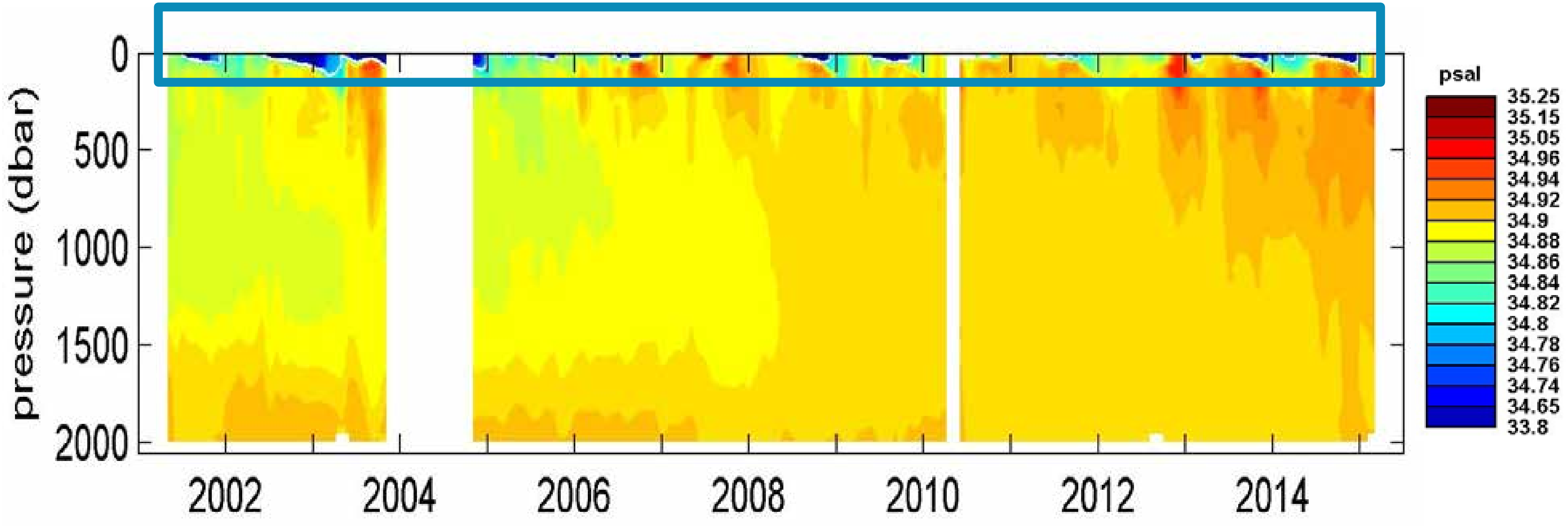
spreading in the vertical forced by convection

From surface to great depths

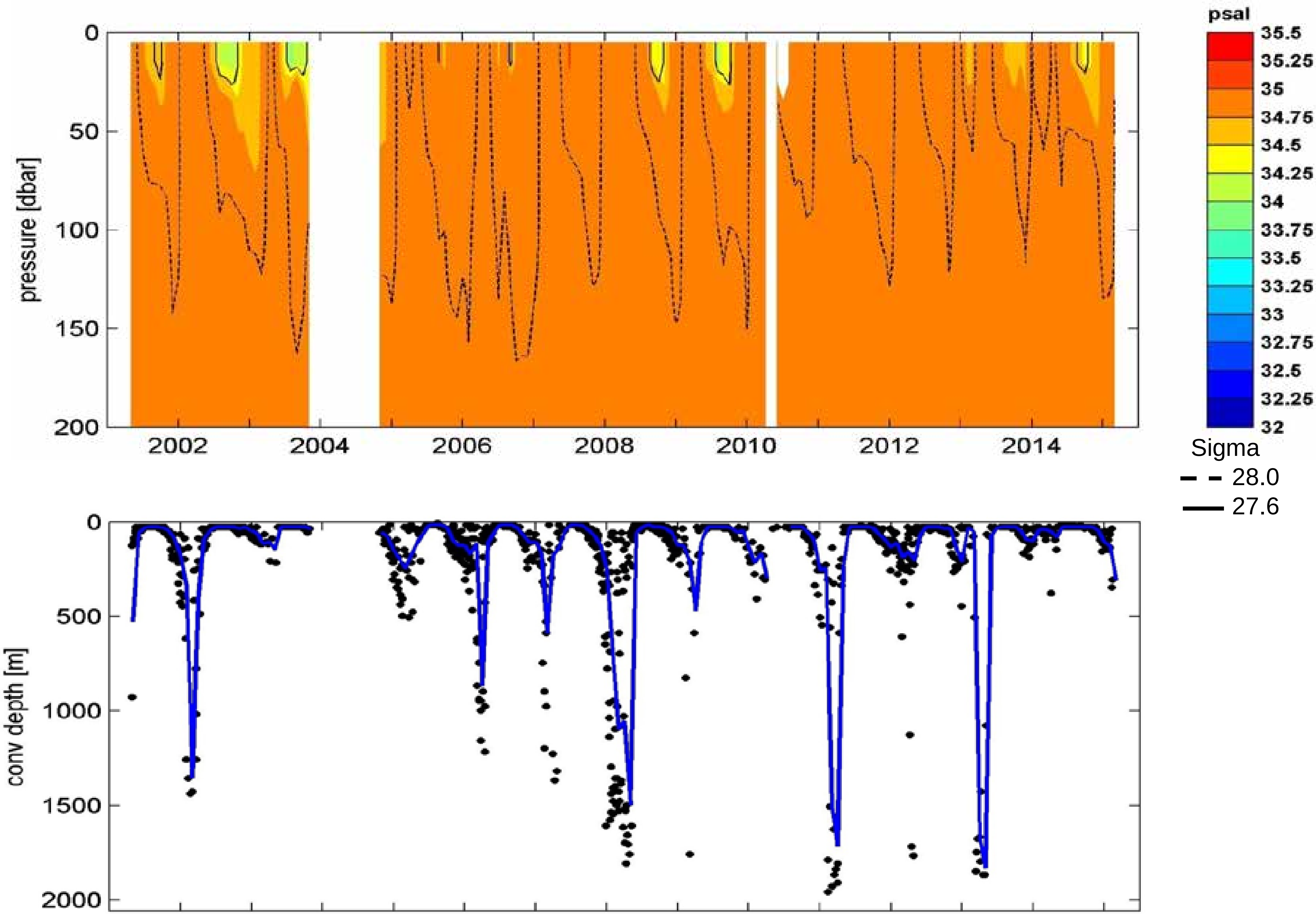


salinity increase from below

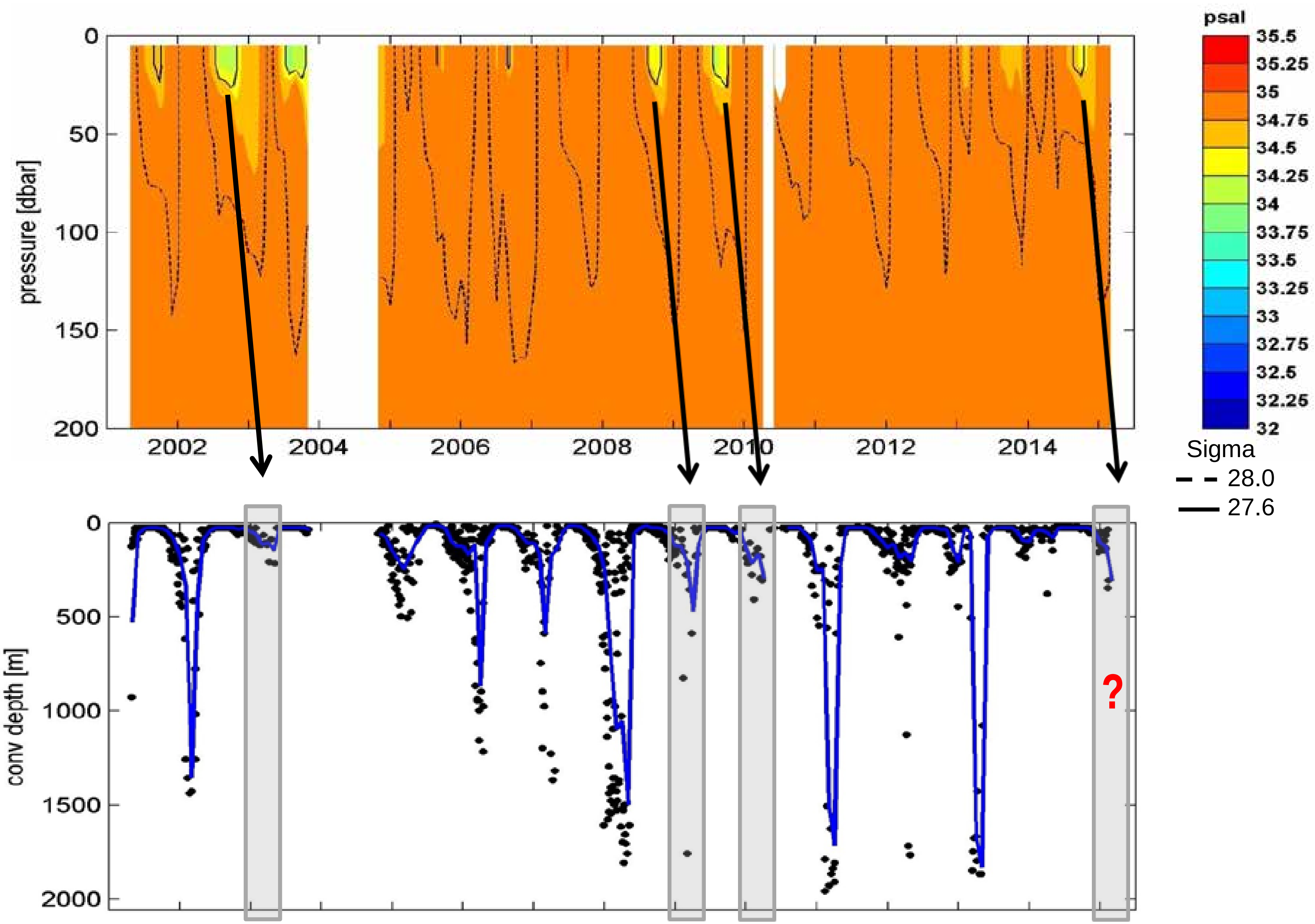
freshwater in the surface layer:



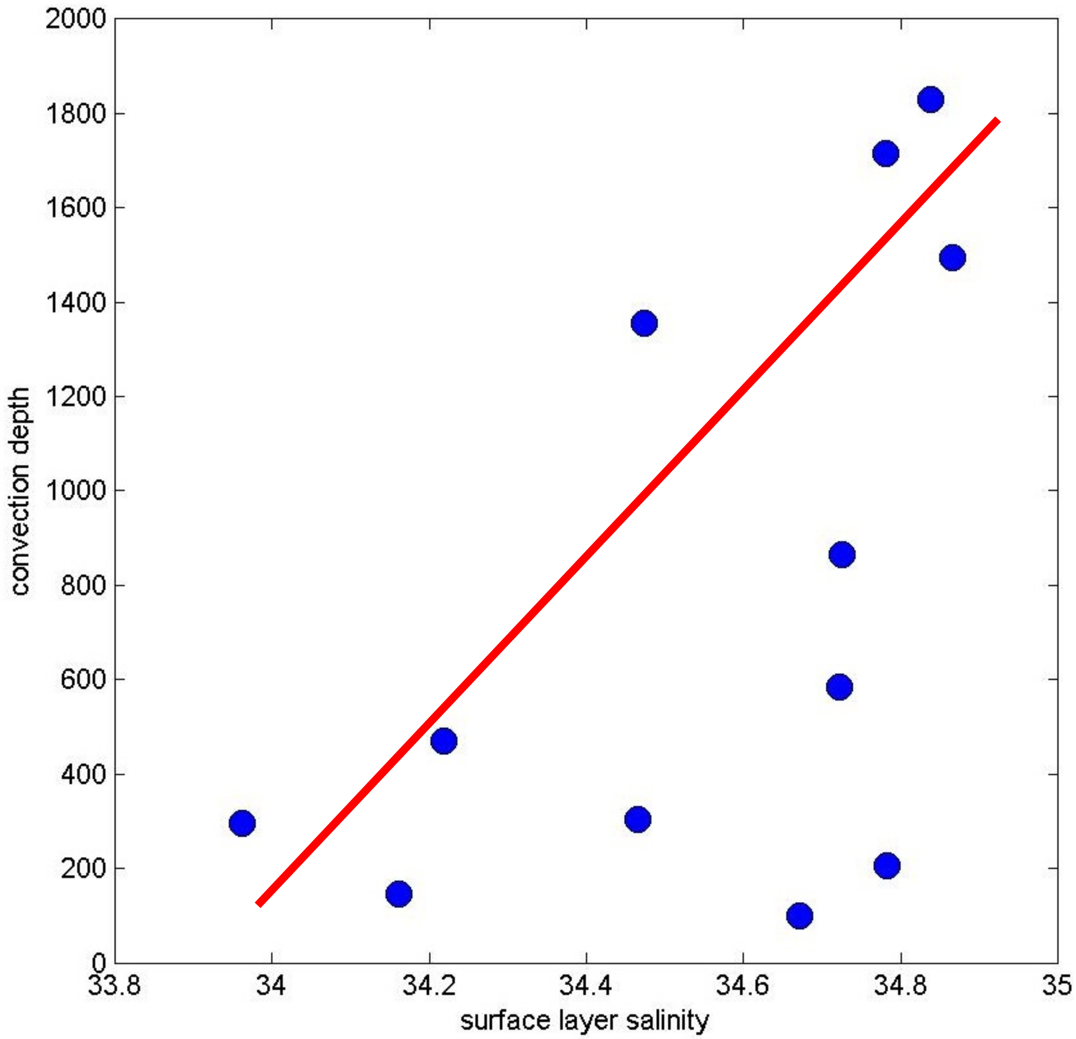
freshwater in the surface layer:



freshwater in the surface layer:



freshwater in the surface layer: summary



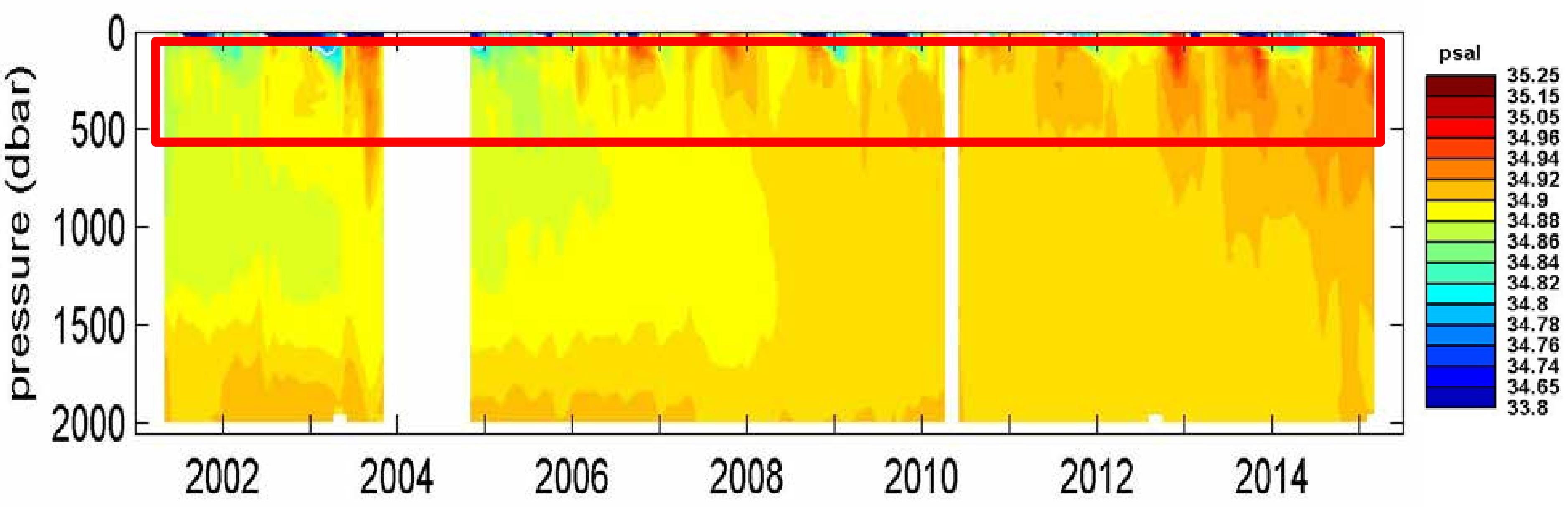
Relation between surface salinity
and convection depth

but also heat loss to the atmosphere,
wind field, stratification below the surface layer influence the convection depth

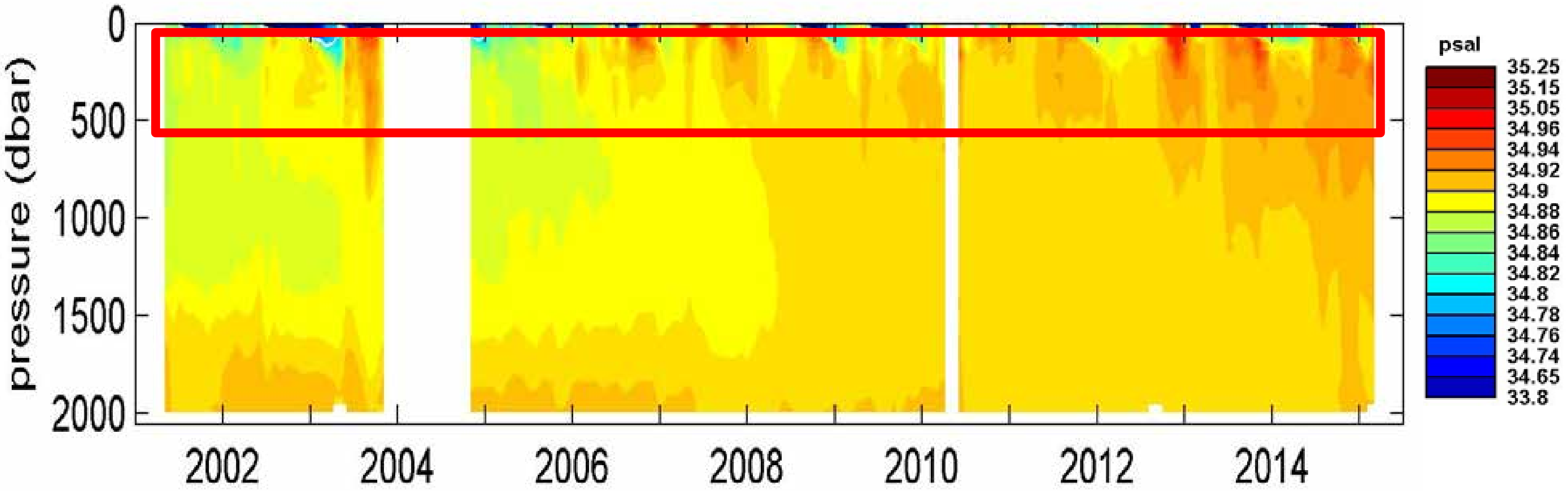
Another open question:
Where is the variability of freshwater in the surface layer coming from

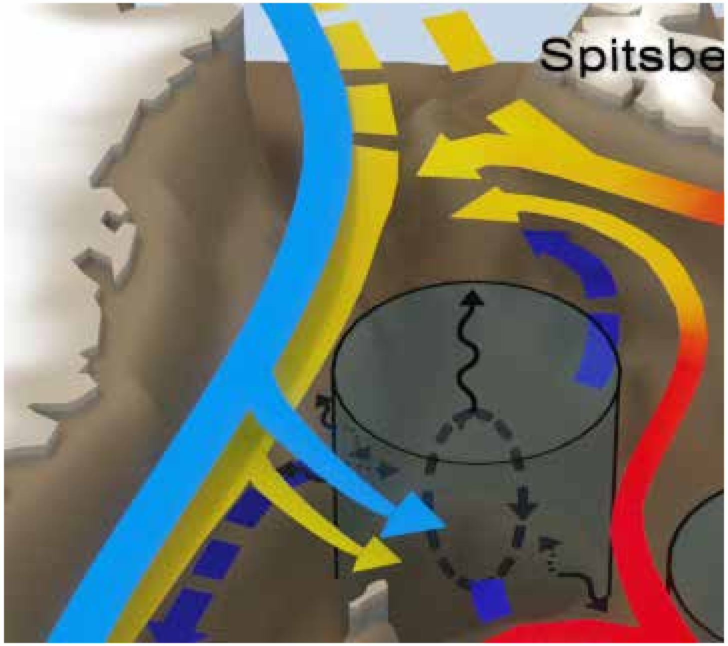
Sources of freshwater:
Liquid outflow from the Arctic Ocean (via Fram Strait)
Ice melt, locally and remote

salinity changes in the Atlantic layer



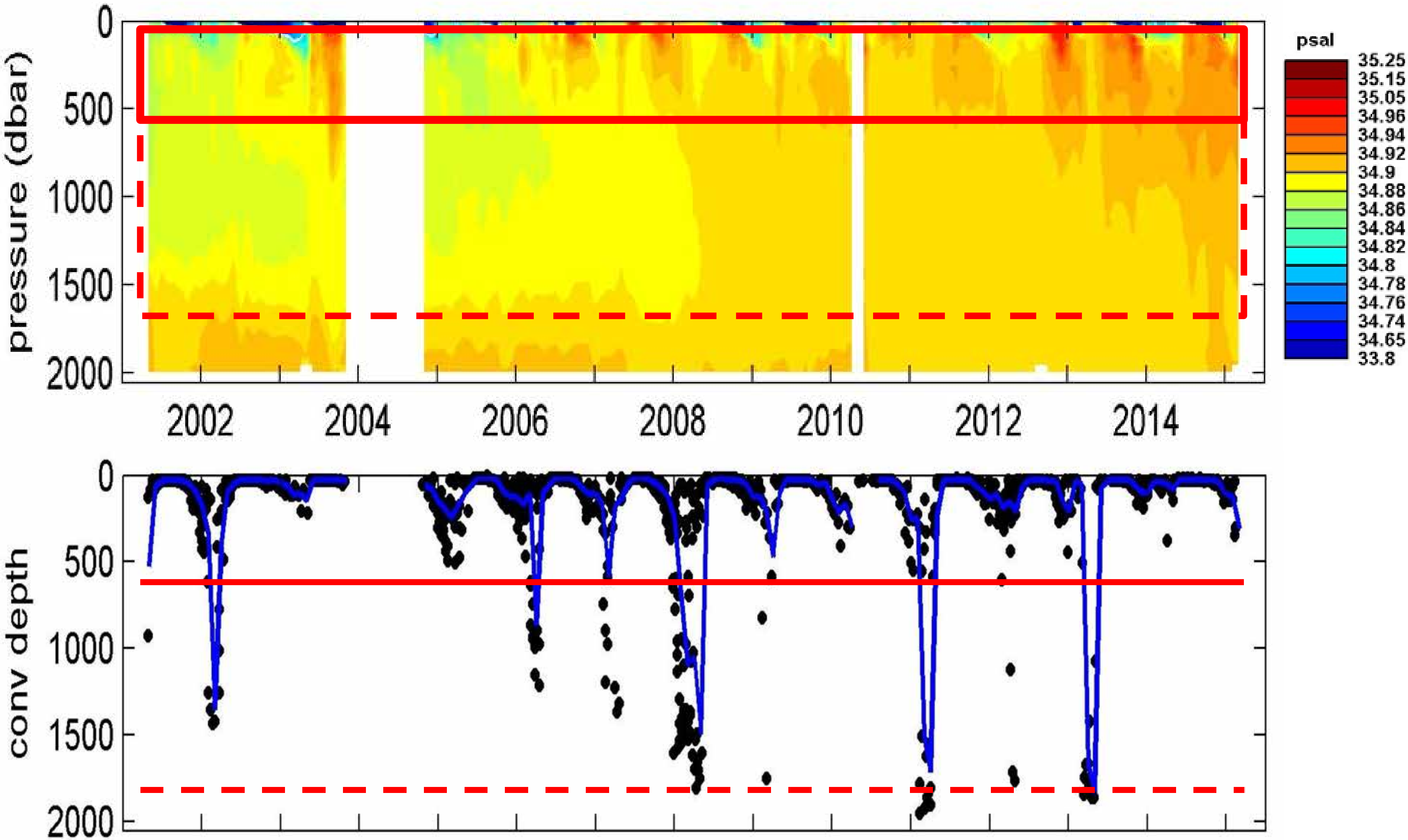
salinity changes in the Atlantic layer



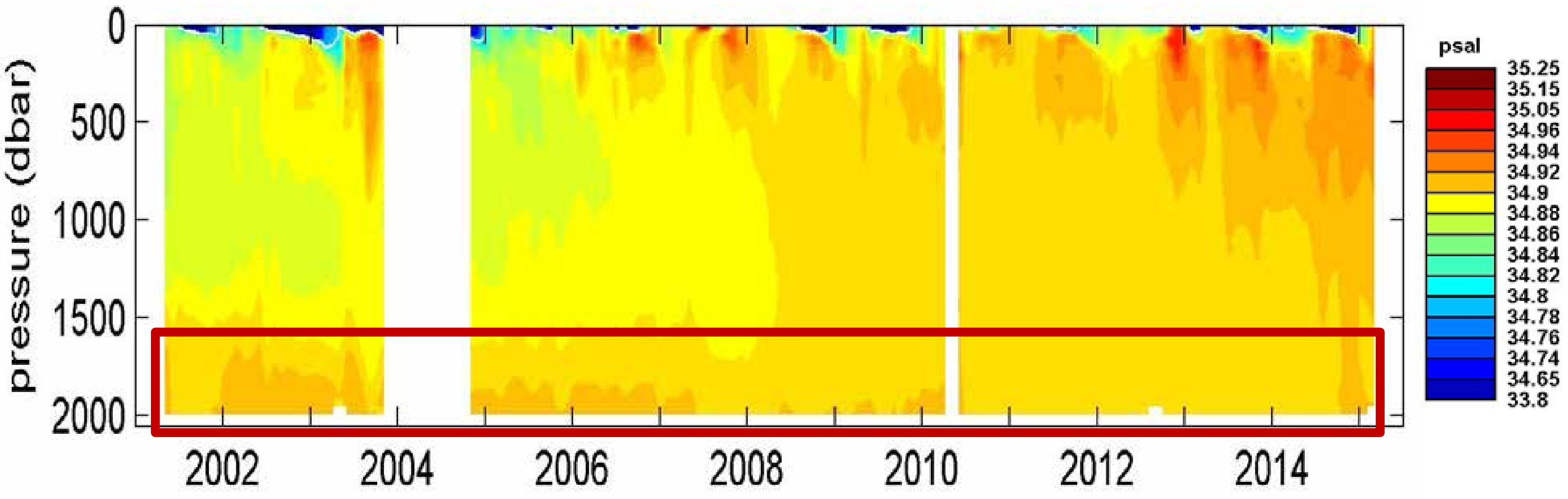


Lateral input of Atlantic Water is concentrated in 50 to 600 m (Latarius, 2013)

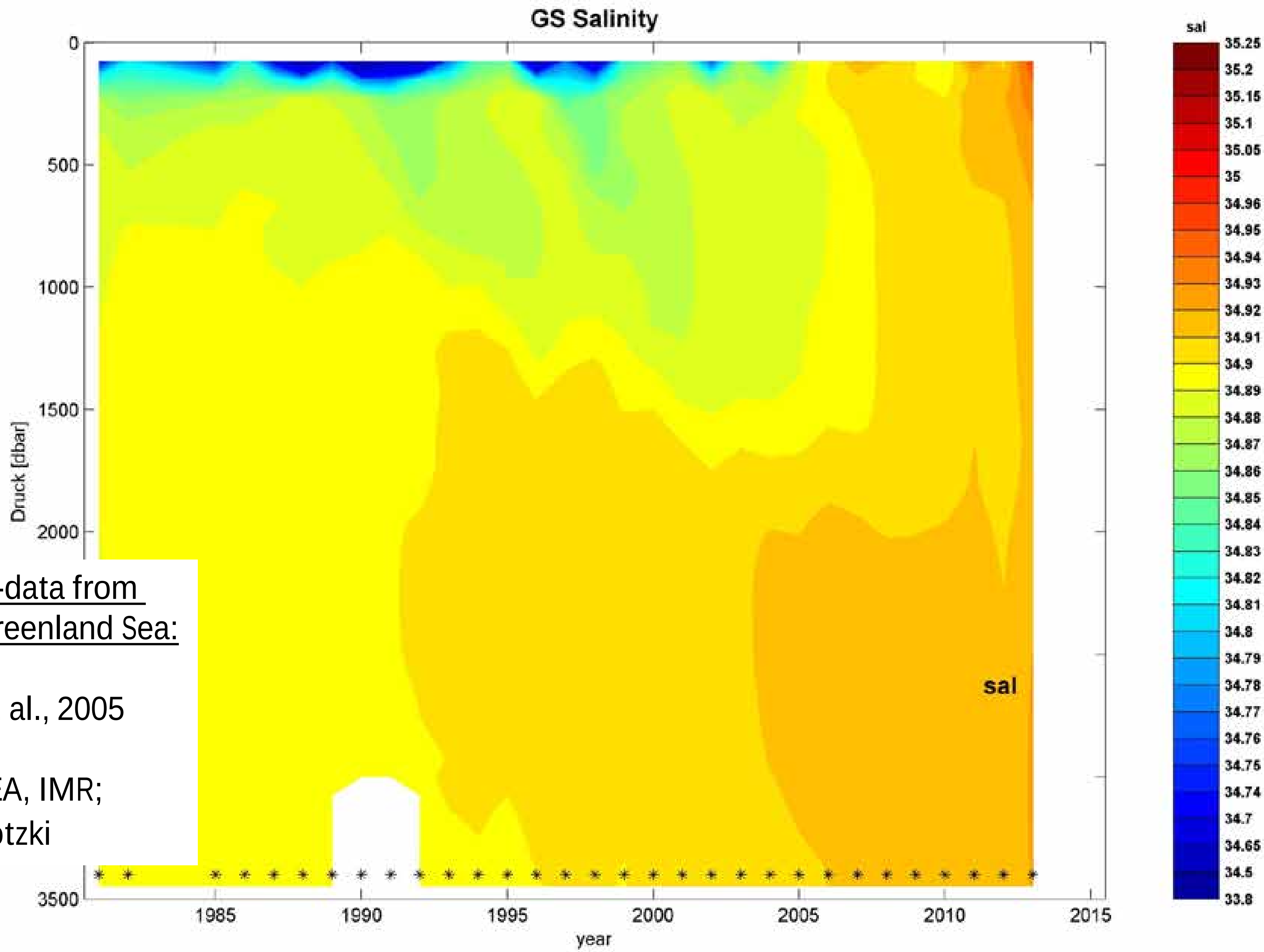
salinity changes in the Atlantic layer



salinity increase from below



salinity increase from below



Summer CTD-data from the central Greenland Sea:

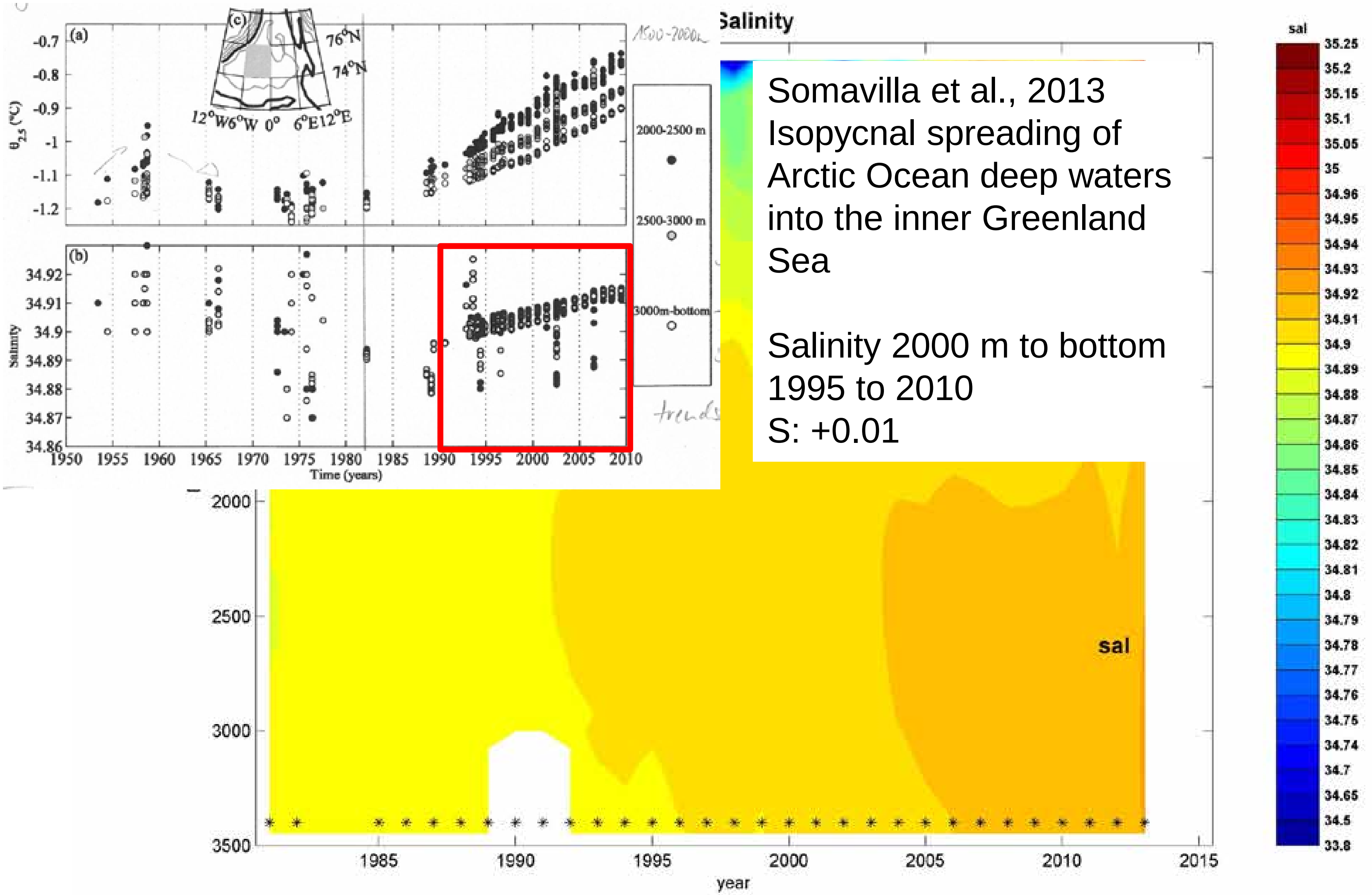
1981-2003

Karstensen et al., 2005

2004-2013

ICES, PANGAEA, IMR; Andreas Wisotzki

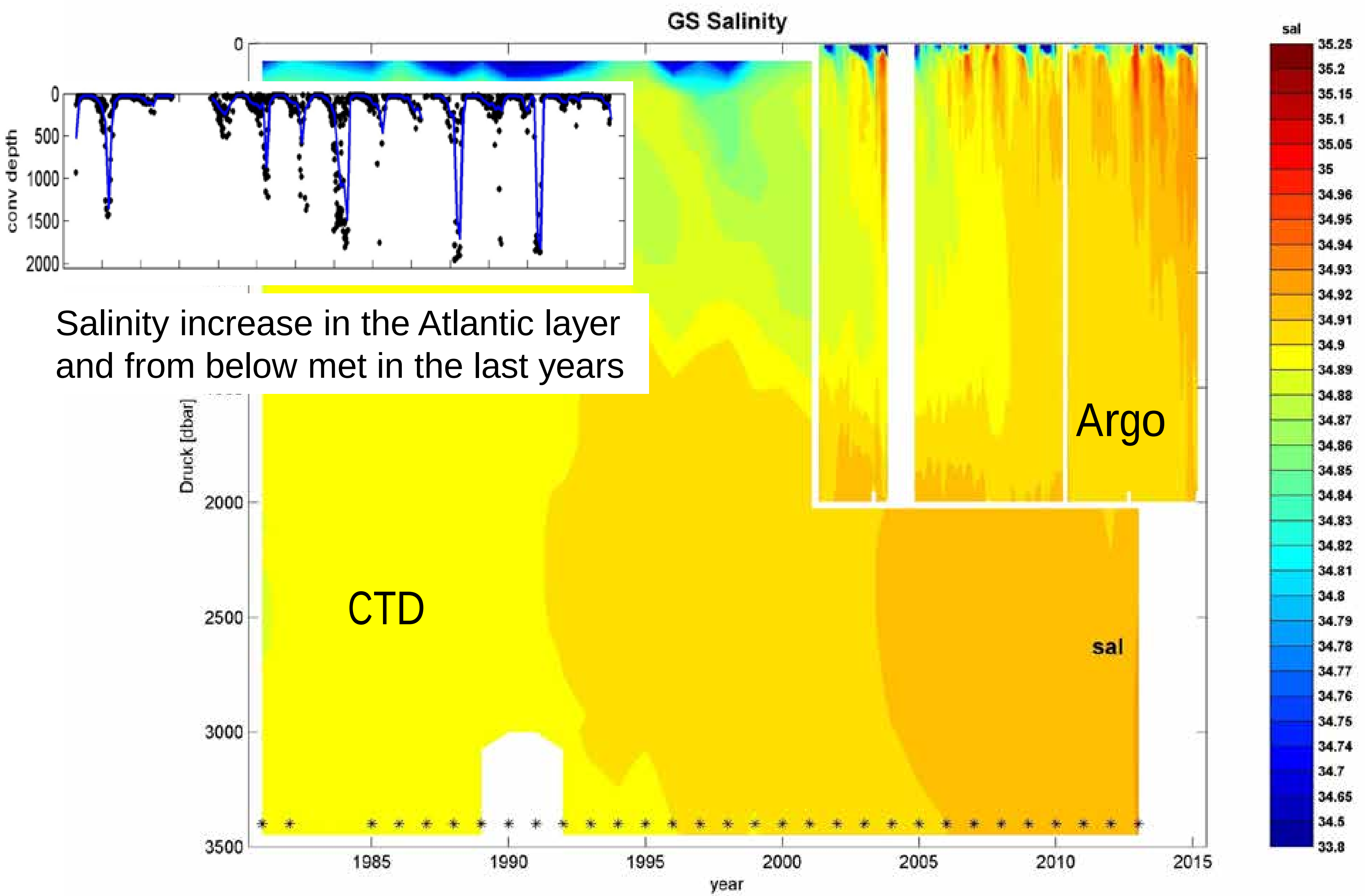
salinity increase from below



Somavilla et al., 2013
Isopycnal spreading of Arctic Ocean deep waters into the inner Greenland Sea

Salinity 2000 m to bottom
1995 to 2010
S: +0.01

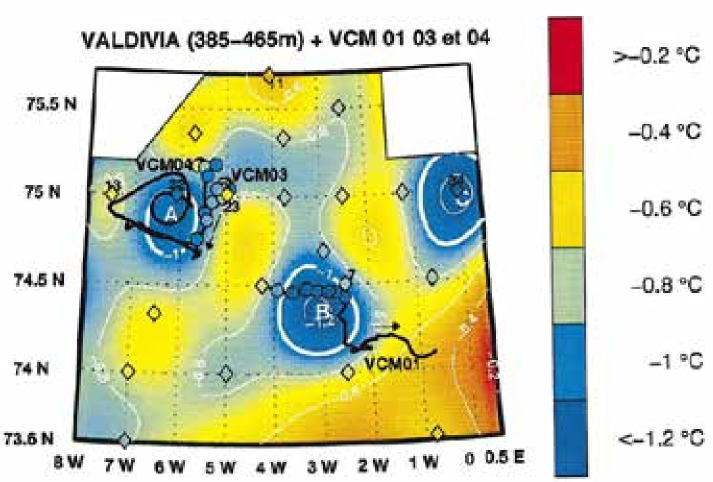
salinity increase from below



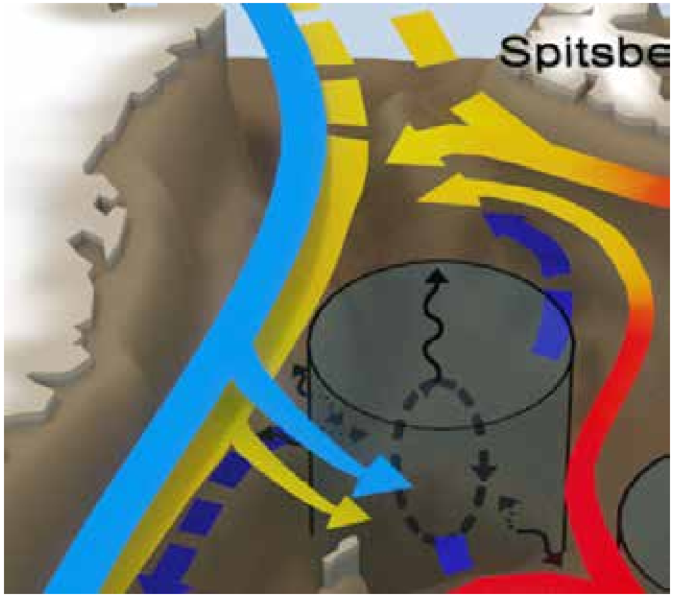
Salinity increase in the Atlantic layer and from below met in the last years

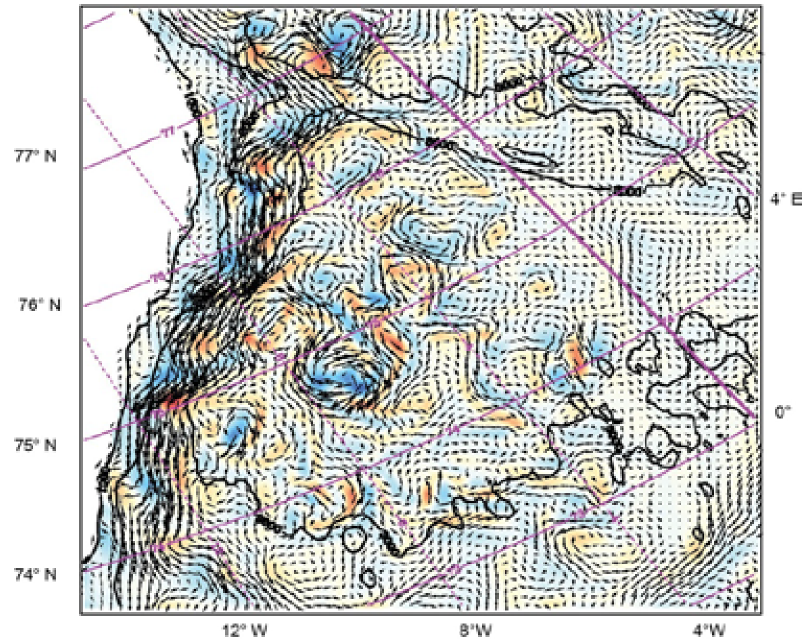
From Argo floats to gliders

from large scale to mesoscale..



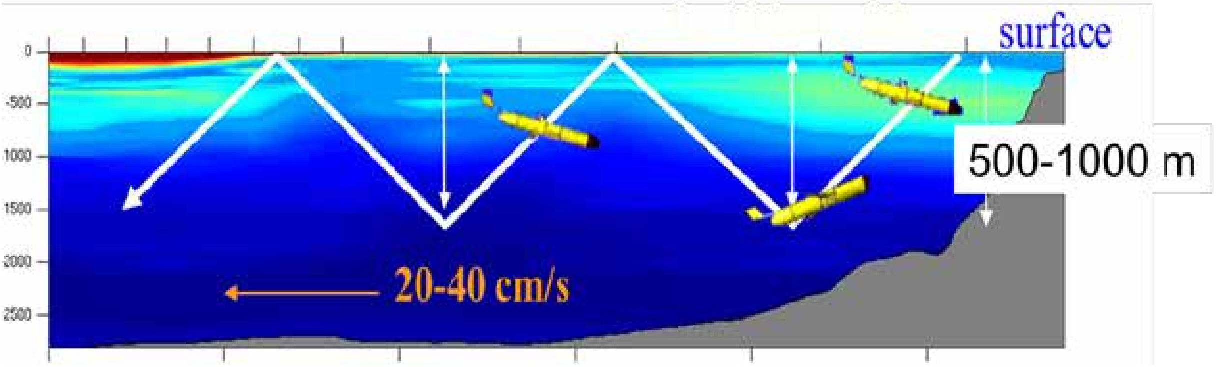
Lherminier et al., 1999:
Pot. T 420m, CTD

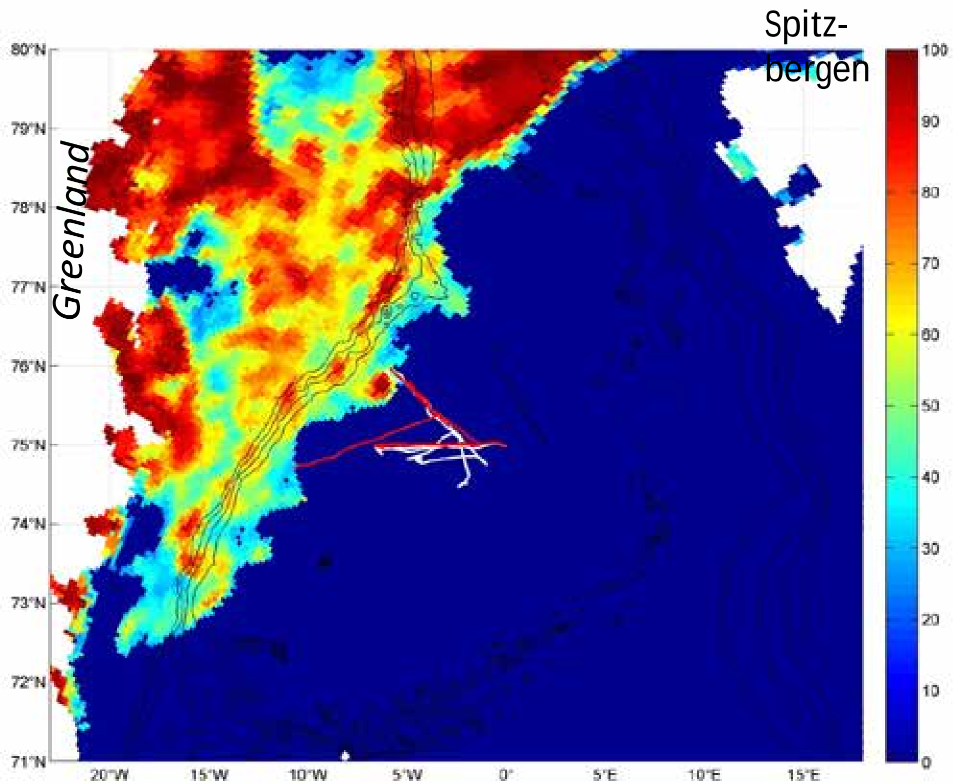


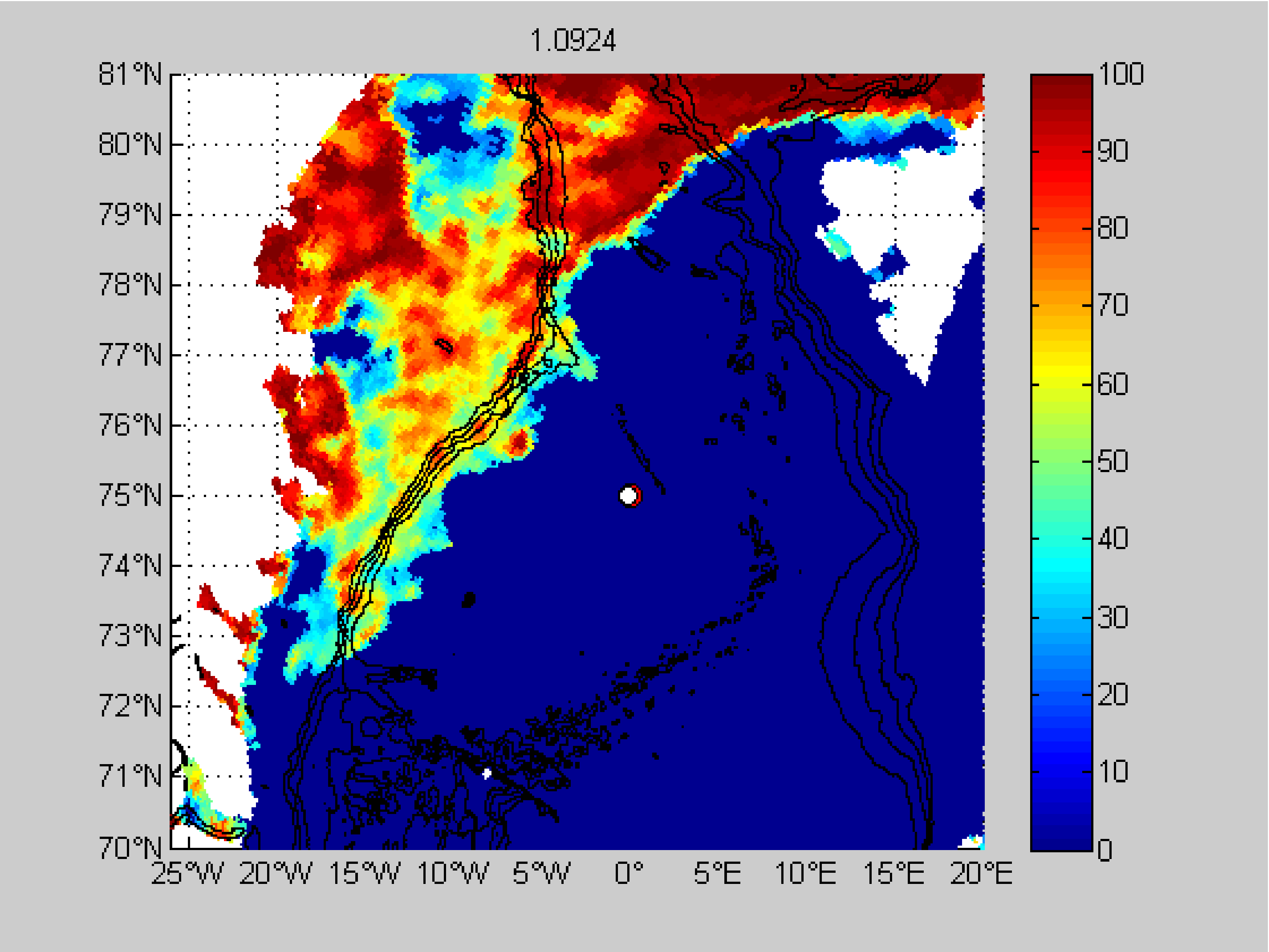


N. Serra, pers cummunication, 2010:
Snapshot, MITgcm, 4 km hor resolution
vel 500m depth, pot Vorticity red-positiv, blue-negative

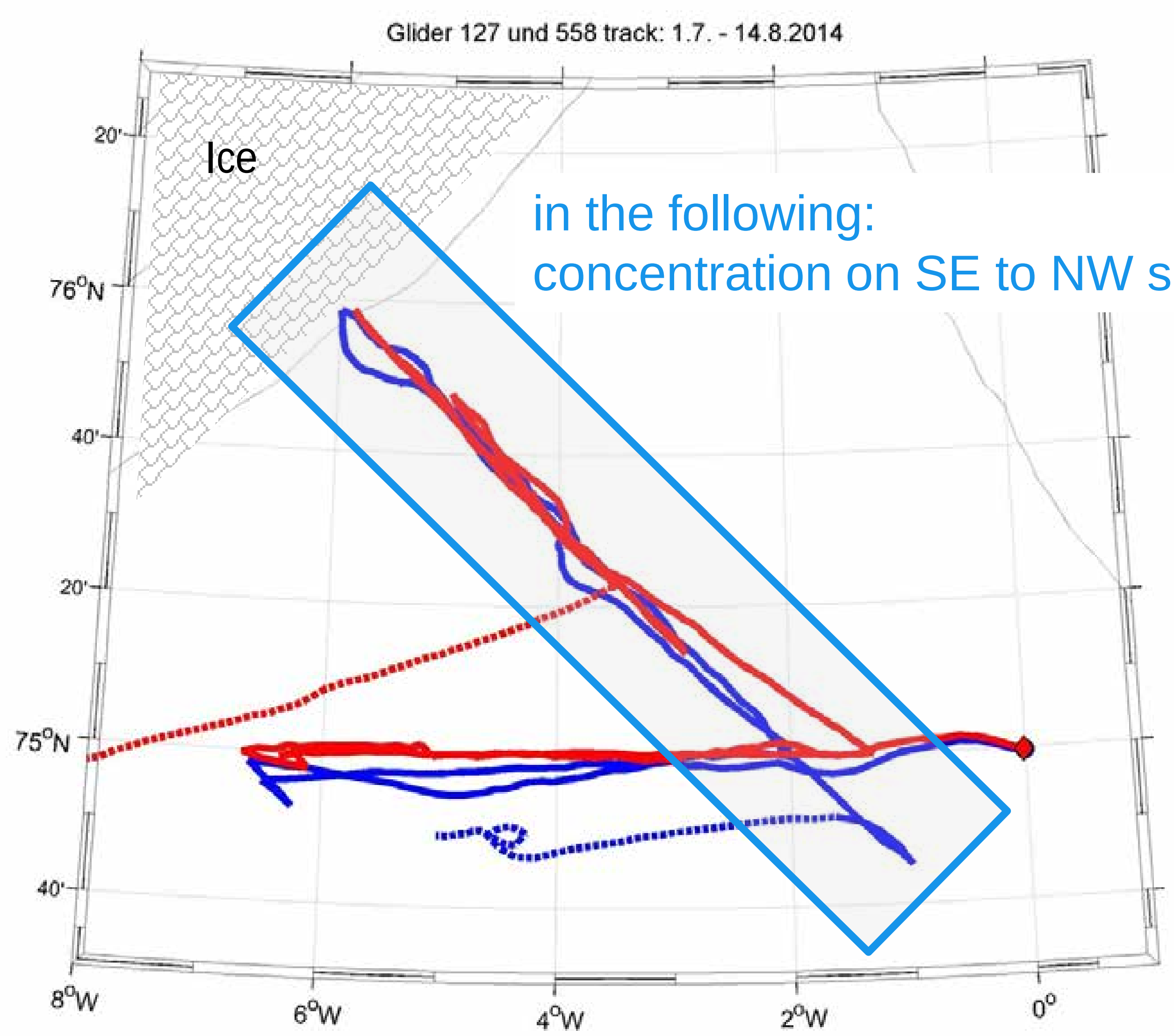
Glider measurements at the Polar Front – Western Greenland Sea





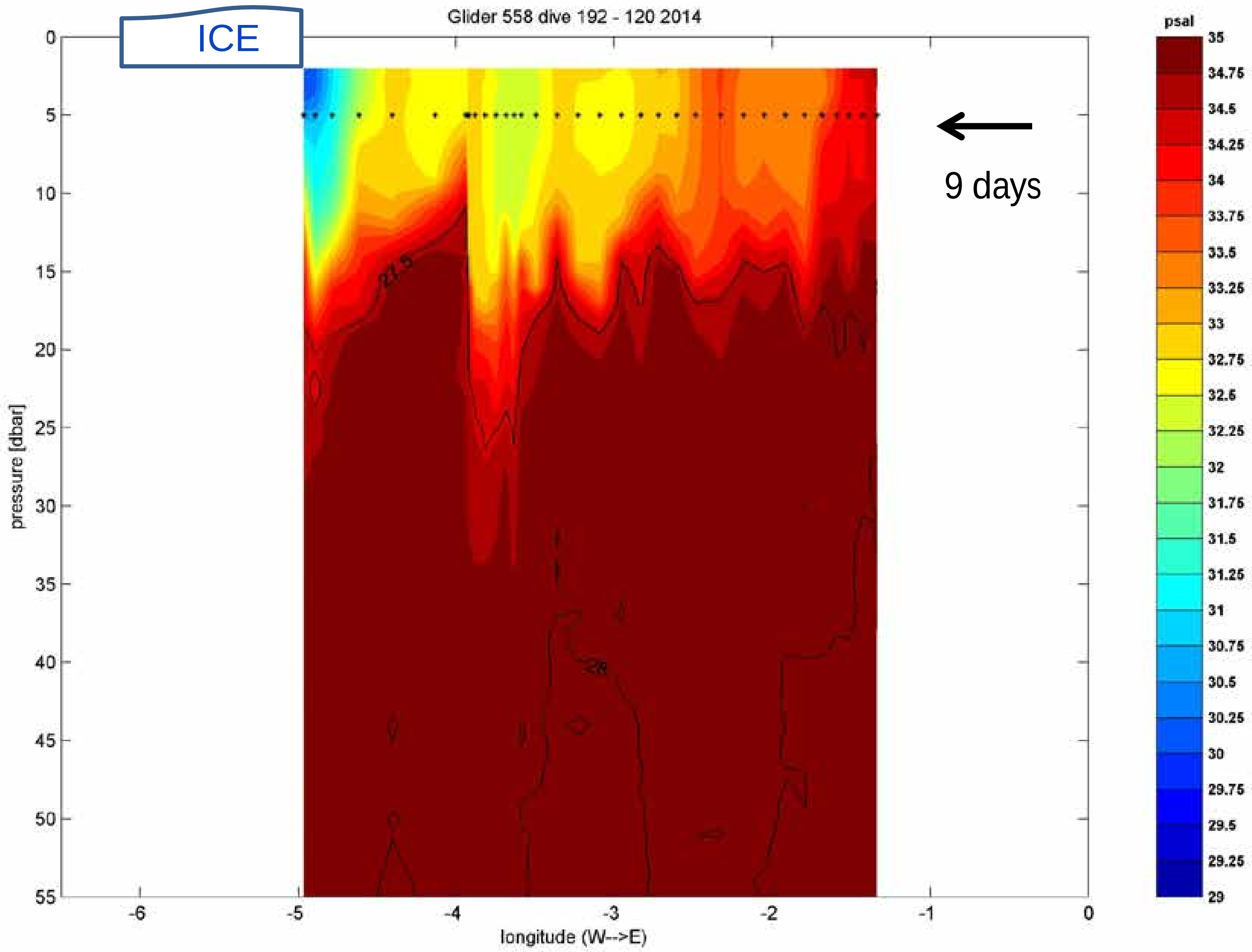

1.0924
81°N
80°N
79°N
78°N
77°N
76°N
75°N
74°N
73°N
72°N
71°N
70°N
25°W
20°W
15°W
10°W
5°W
0°
5°E
10°E
15°E
20°E
100
90
80
70
60
50
40
30
20
10
0

Glider measurements at the Polar Front – Western Greenland Sea

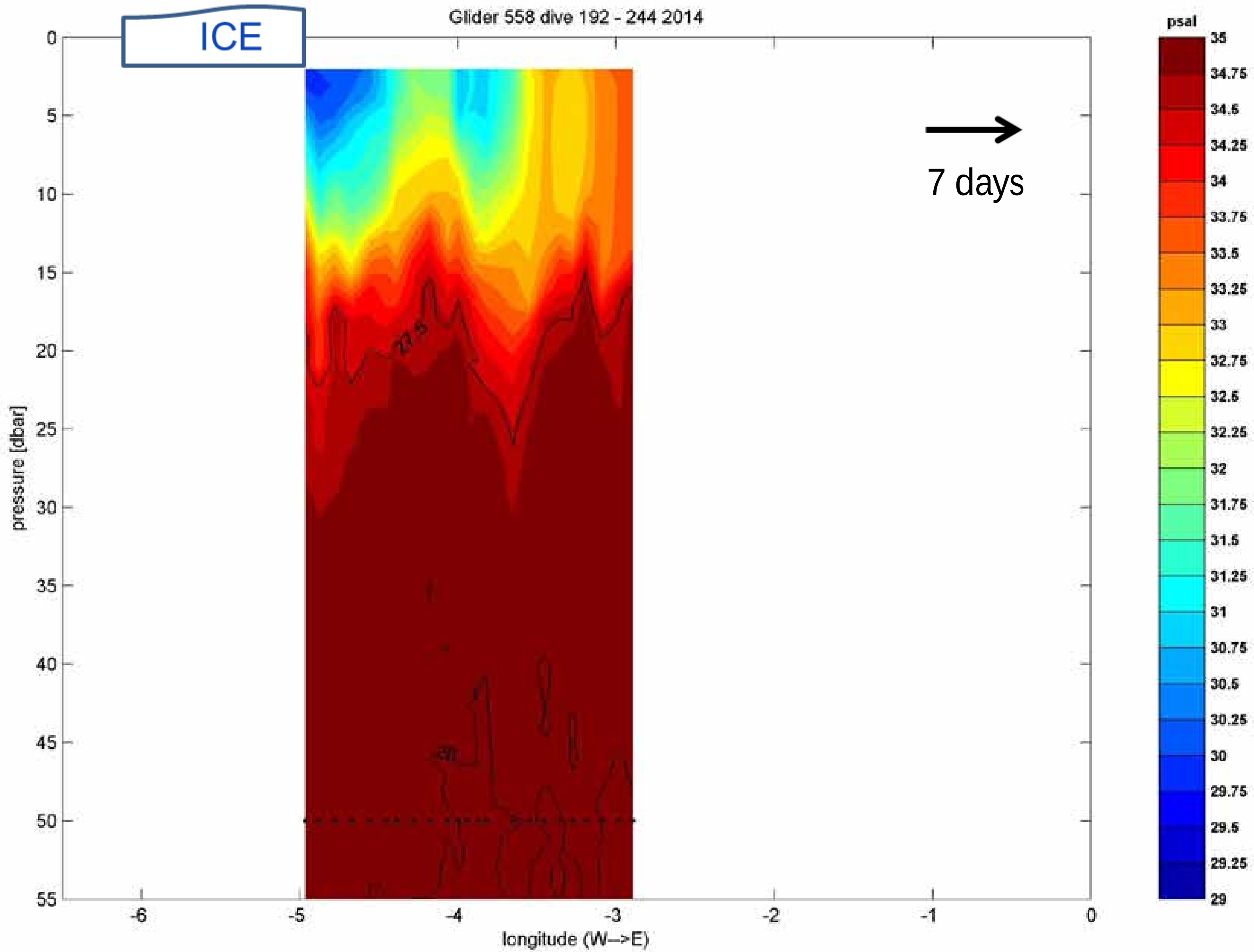


60 days of mission
with 2 gliders
700 dives
(0-500m or 0-1000m)

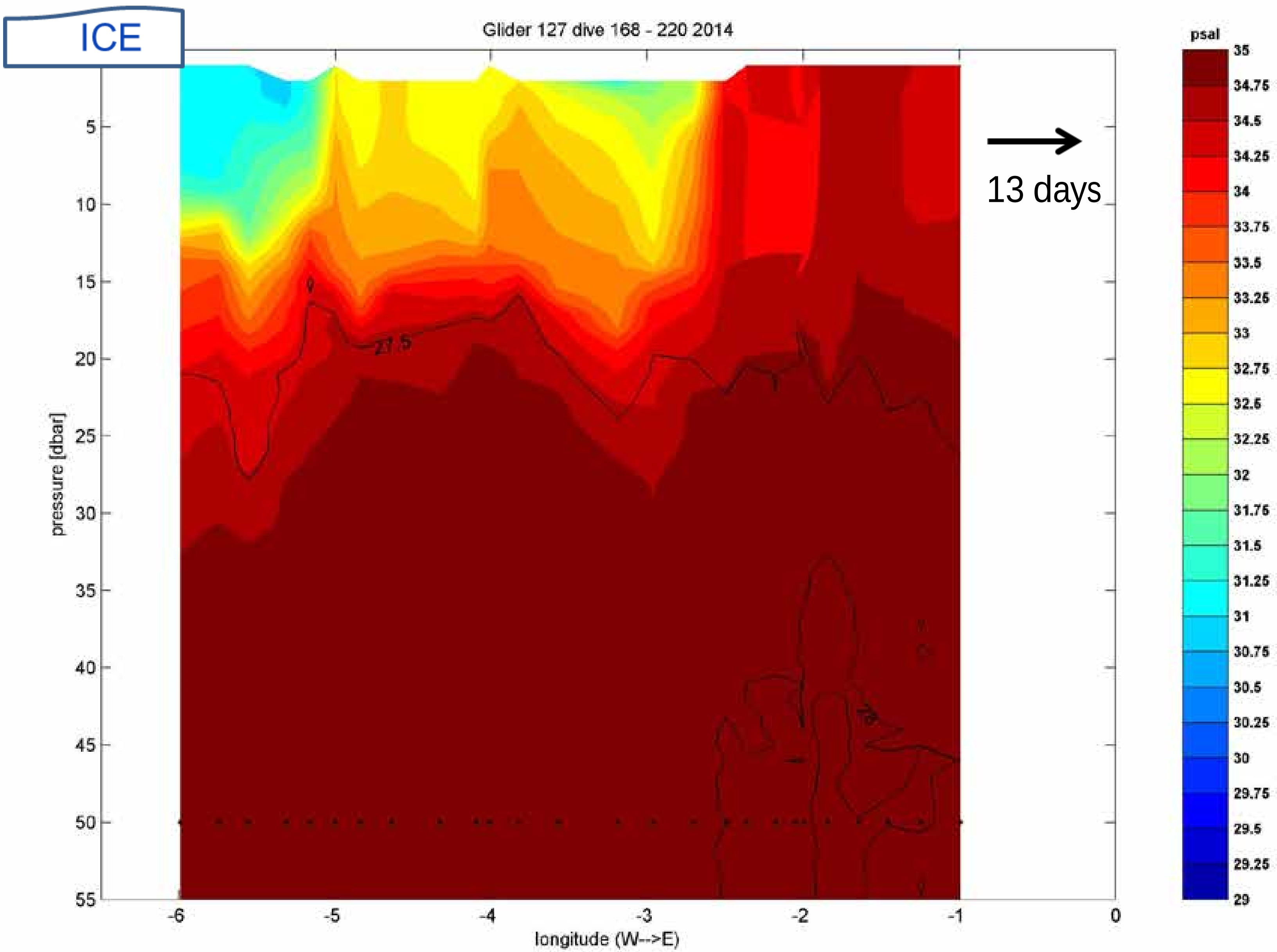
4 E to W-sections
6 SE to NW sections



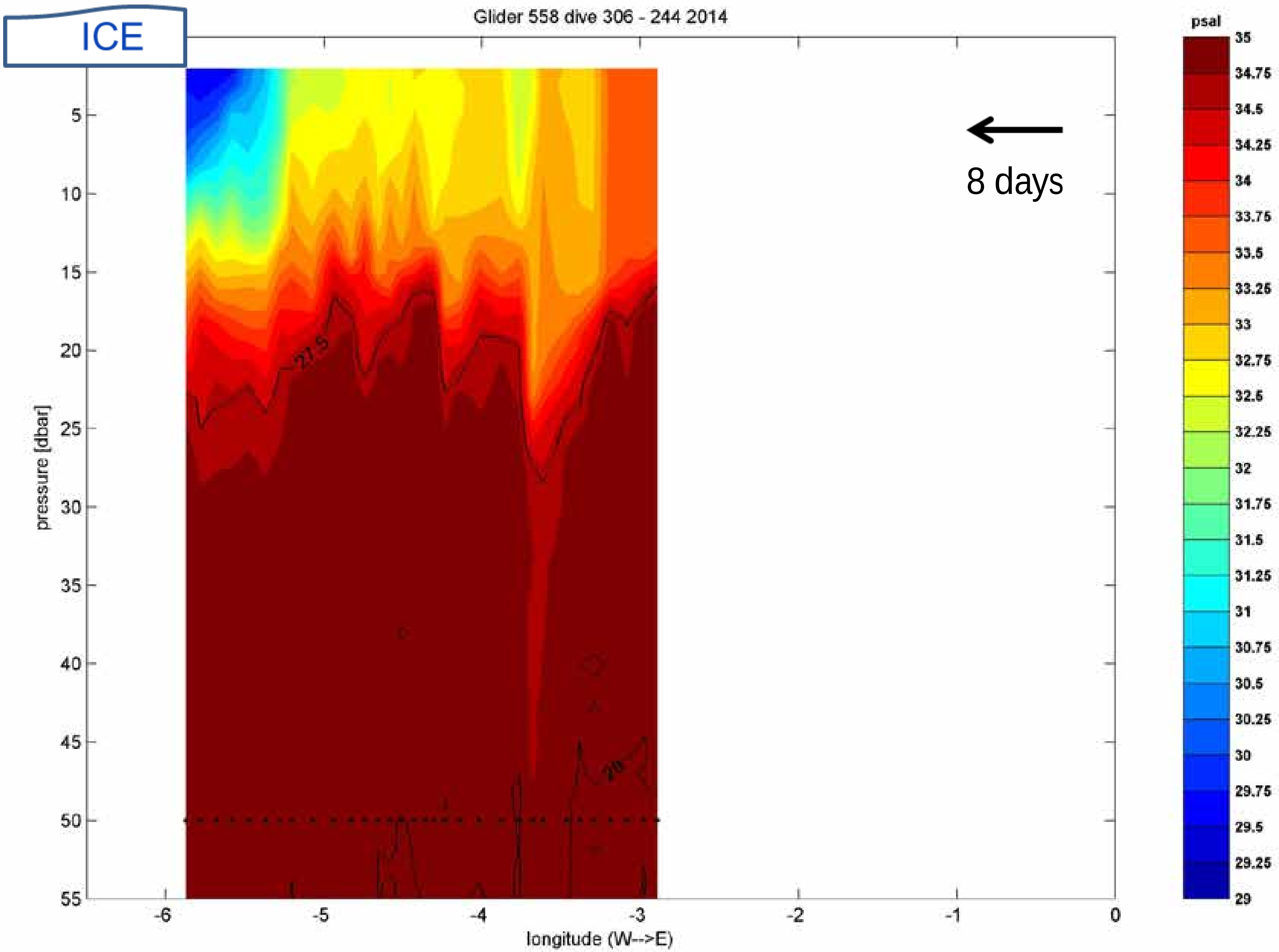
Glider 558 dive 192 - 120 2014
ICE
9 days
pressure [dbar]
longitude (W-->E)
psal
35
34.75
34.5
34.25
34
33.75
33.5
33.25
33
32.75
32.5
32.25
32
31.75
31.5
31.25
31
30.75
30.5
30.25
30
29.75
29.5
29.25
29



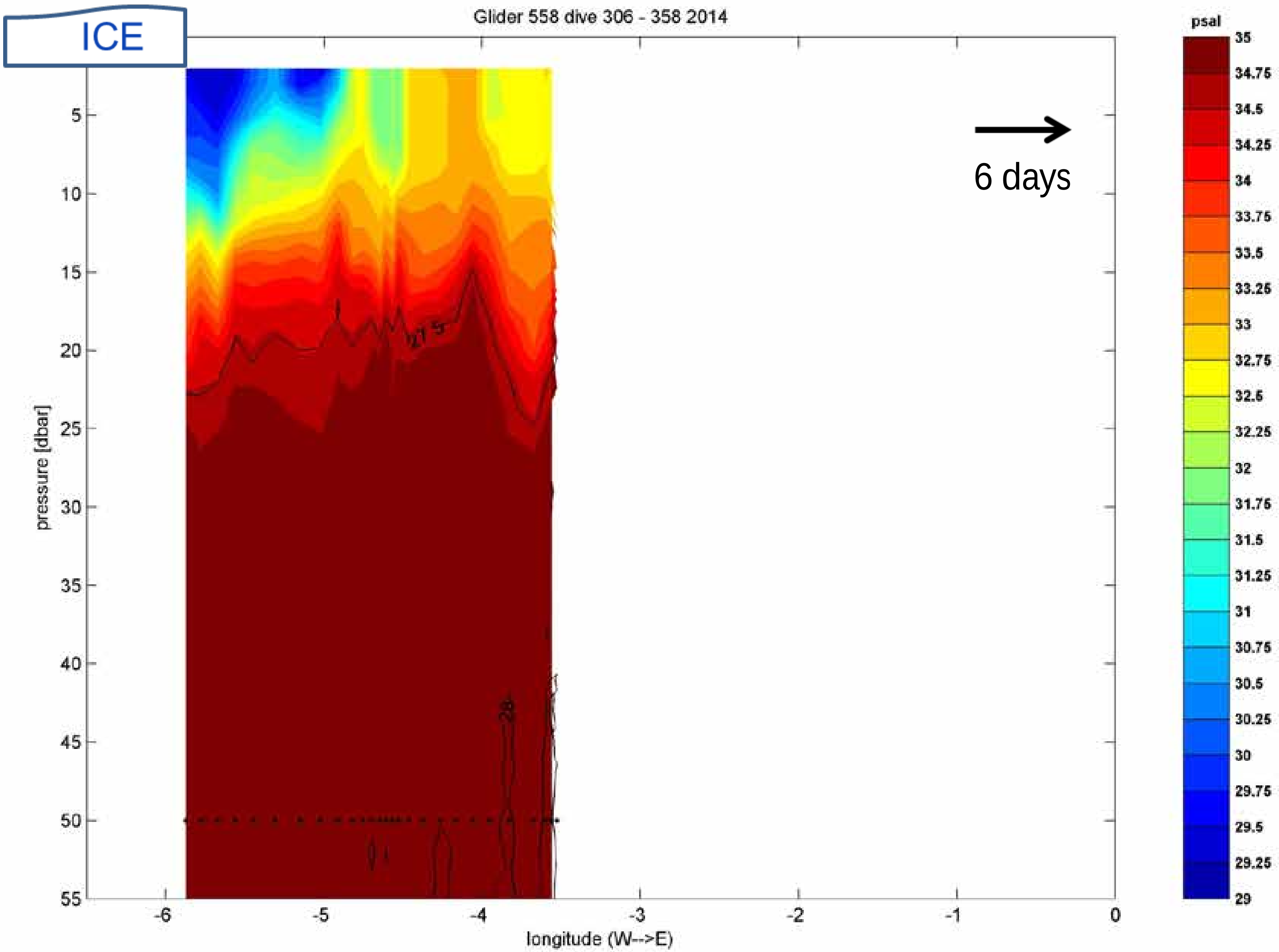
Glider 558 dive 192 - 244 2014
ICE
7 days
pressure [dbar]
longitude (W-->E)
psal
27.5
27



ICE
Glider 127 dive 168 - 220 2014
13 days
pressure [dbar]
longitude (W-->E)
psal
27.5



ICE
Glider 558 dive 306 - 244 2014
8 days
pressure [dbar]
longitude (W-->E)
psal
35
34.75
34.5
34.25
34
33.75
33.5
33.25
33
32.75
32.5
32.25
32
31.75
31.5
31.25
31
30.75
30.5
30.25
30
29.75
29.5
29.25
29



ICE
Glider 558 dive 306 - 358 2014
6 days
psal
35
34.75
34.5
34.25
34
33.75
33.5
33.25
33
32.75
32.5
32.25
32
31.75
31.5
31.25
31
30.75
30.5
30.25
30
29.75
29.5
29.25
29
pressure [dbar]
5
10
15
20
25
30
35
40
45
50
55
-6
-5
-4
-3
-2
-1
0
longitude (W-->E)

Glider sections between Polar Front and central Greenland Sea

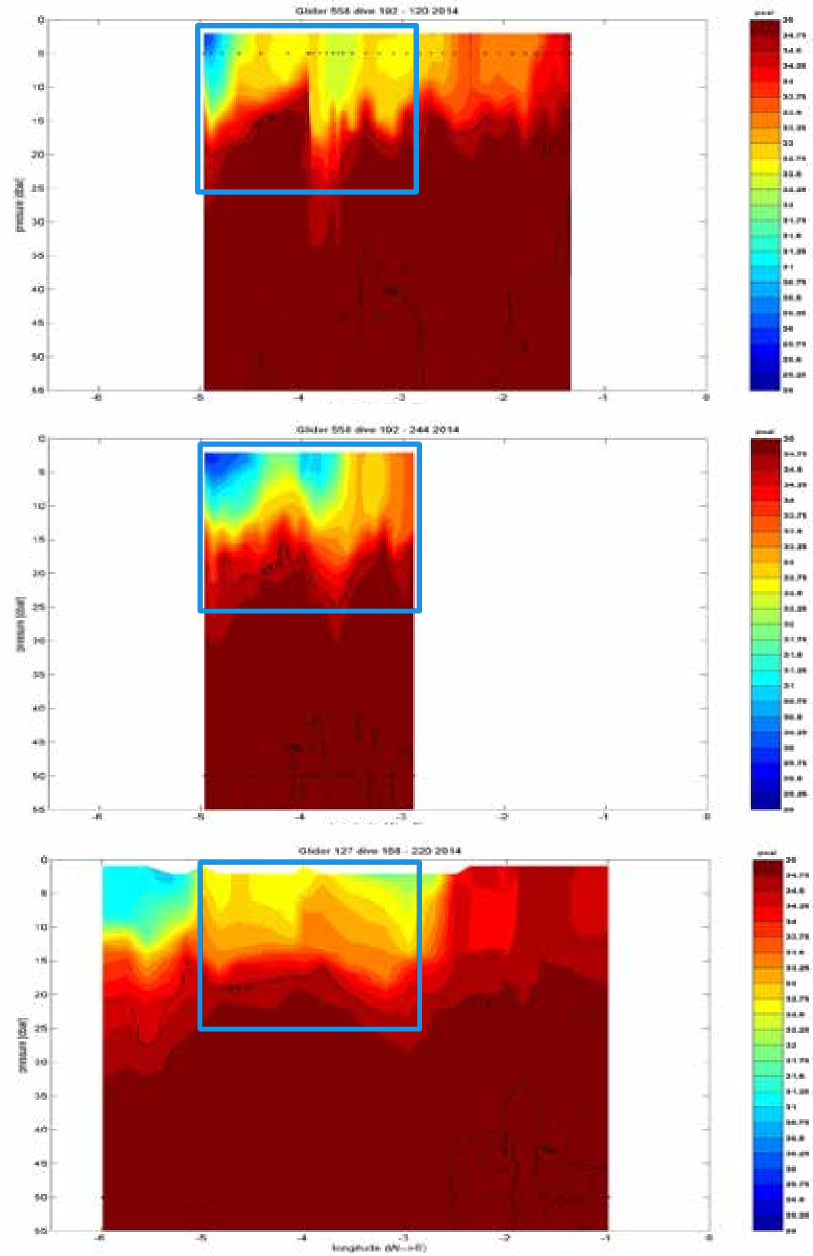
Smean (surface to sigma 27.5) = 33.0

~ 7 days S: -0.18

Smean (surface to sigma 27.5) = 32.82

~ 9 days S: +0.37

Smean (surface to sigma 27.5) = 33.19



Glider sections between Polar Front and central Greenland Sea

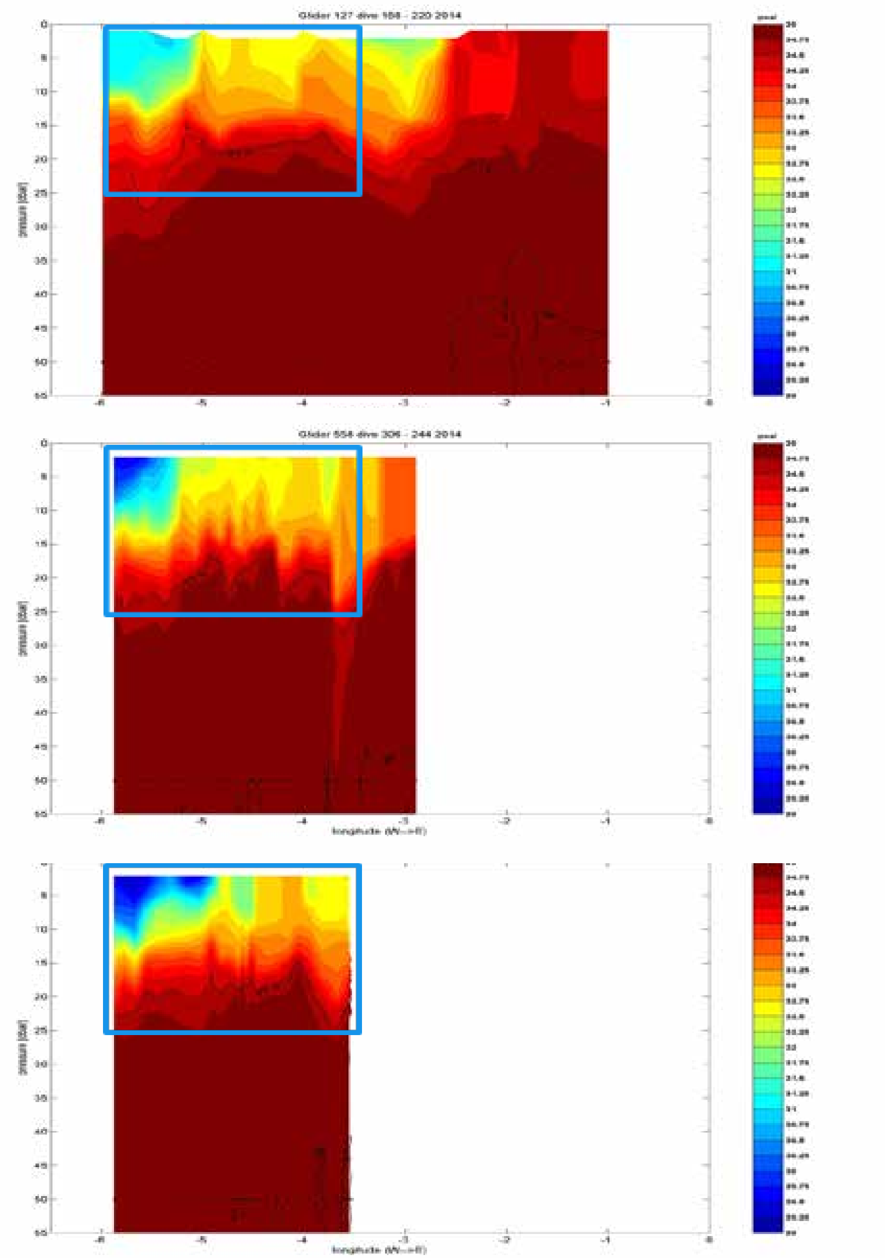
Smean (surface to sigma 27.5) = 33.00

~ 0 days S: -0.05

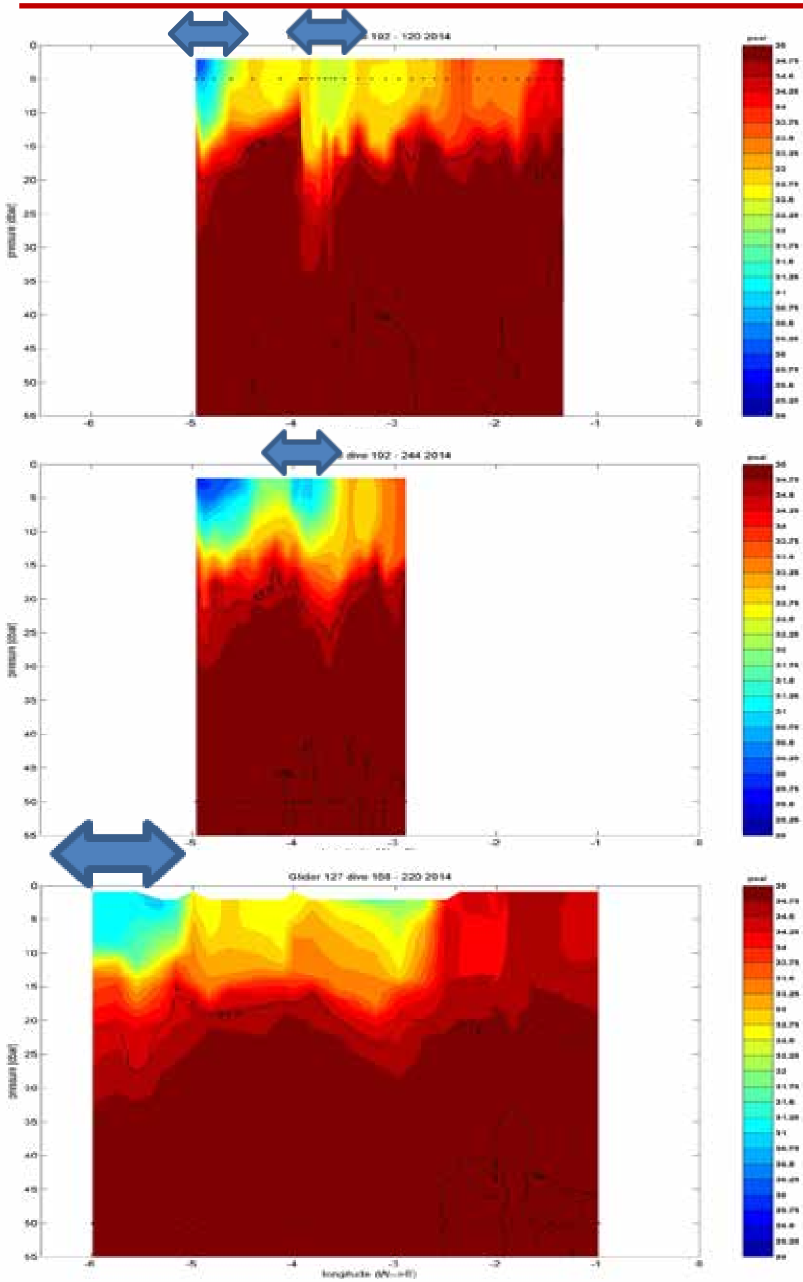
Smean (surface to sigma 27.5) = 32.95

~ 6 days S: -0.09

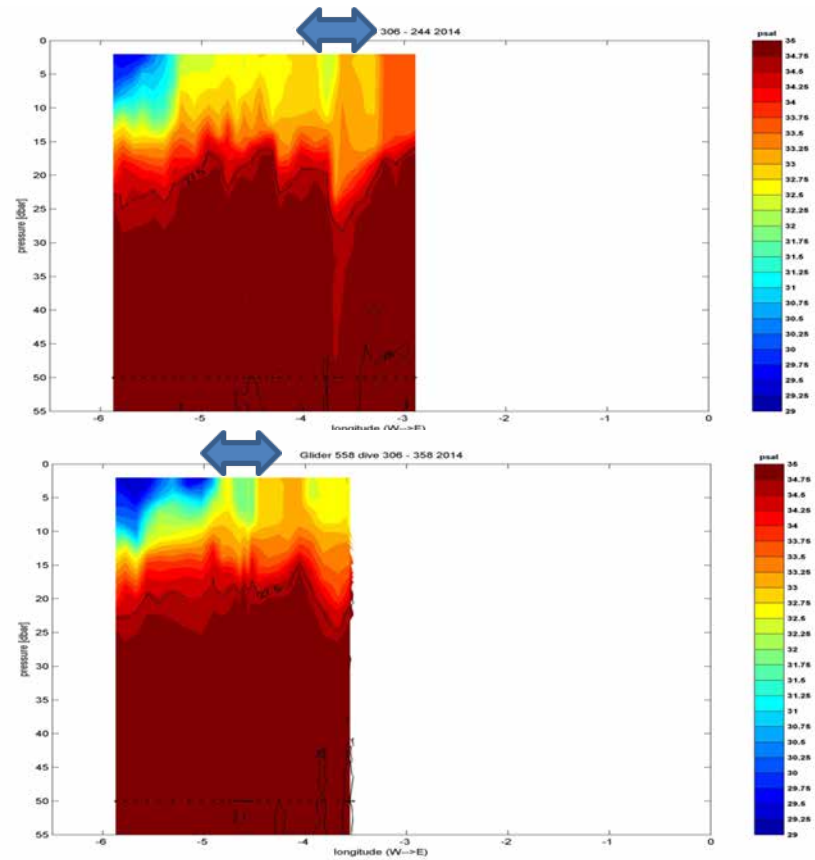
Smean (surface to sigma 27.5) = 32.86



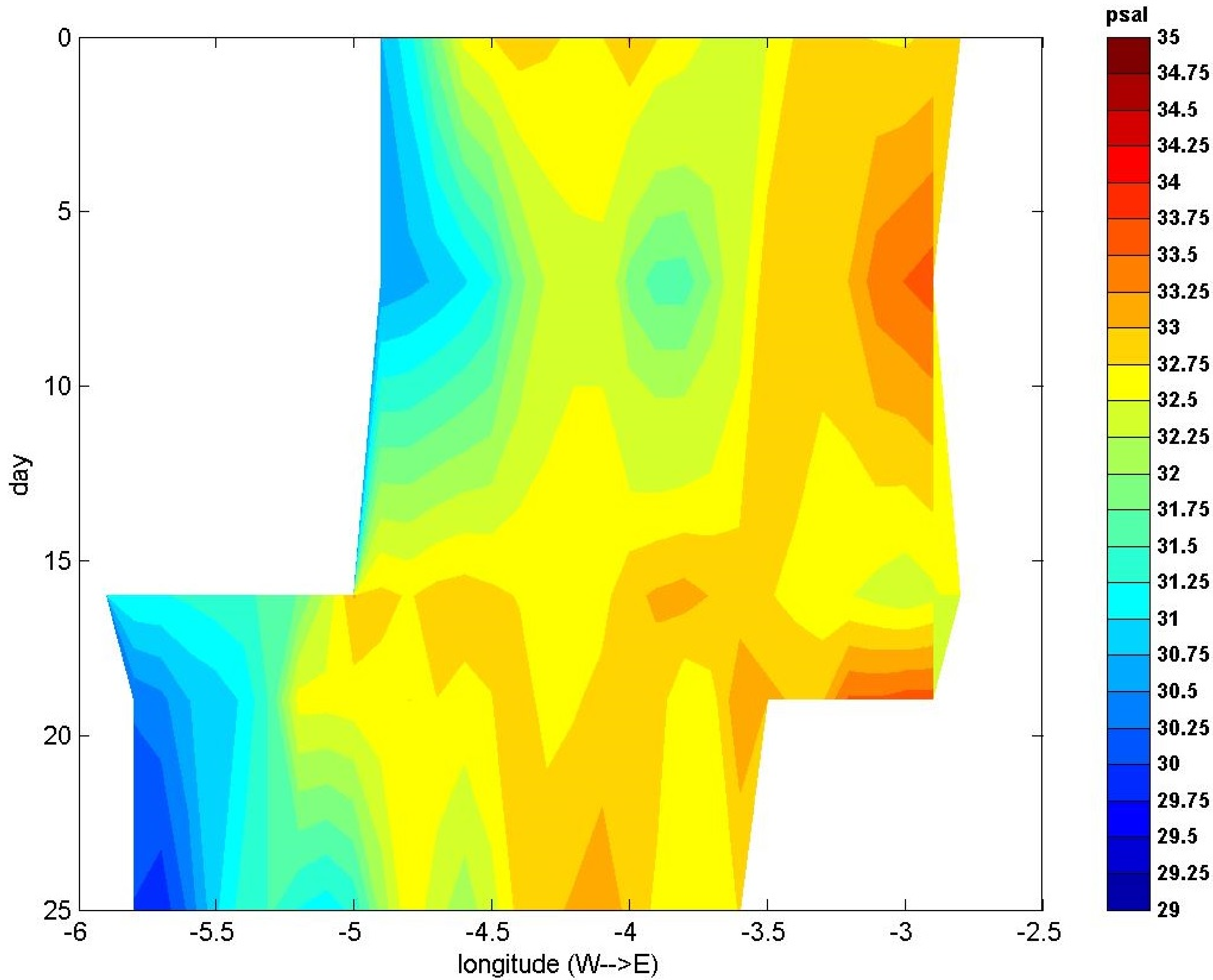
Glider sections between Polar Front and central Greenland Sea



„freshwater features“ have horizontal scales of 10 to 40 km
matches well with the baroclinic Rossby-Radius



Hovmüller diagram build from the glider sections



14 years of Argo float measurements in the Nordic Seas enable to observe long term and large scale development of the system.

The combination with observations from below 2000m and with observations with higher resolution in space and time opens the perspective for interpretation.

end

I. freshwater in the surface layer: