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Conceptual Constraints on Polar MOCs

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Tsubouchi et al., 2012

Pressure (dbar)

Davis Strait

Belgica Bank

Fram Strait

Bear Island

Barents Sea Opening (BSO)

Bering Strait

Potential Temperature (˚C)

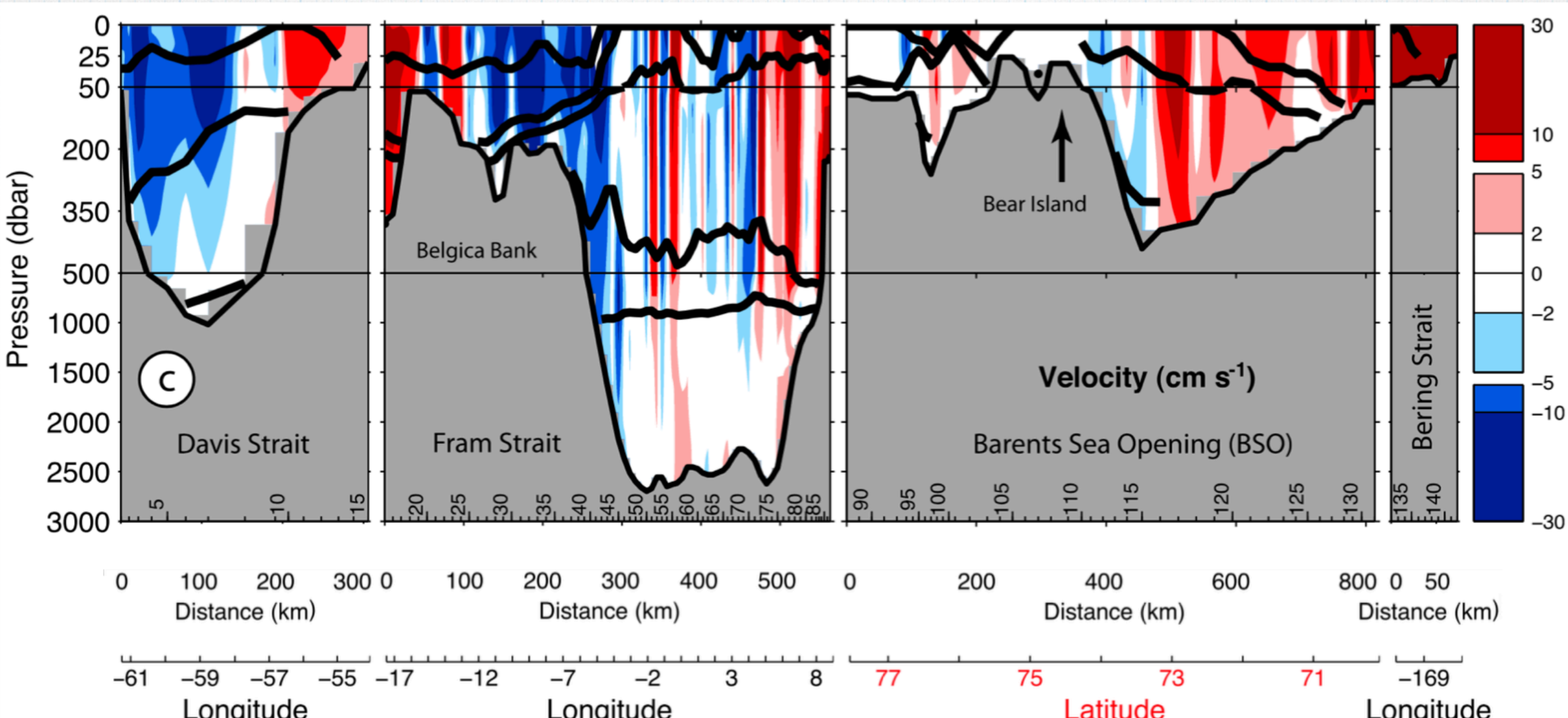
Salinity

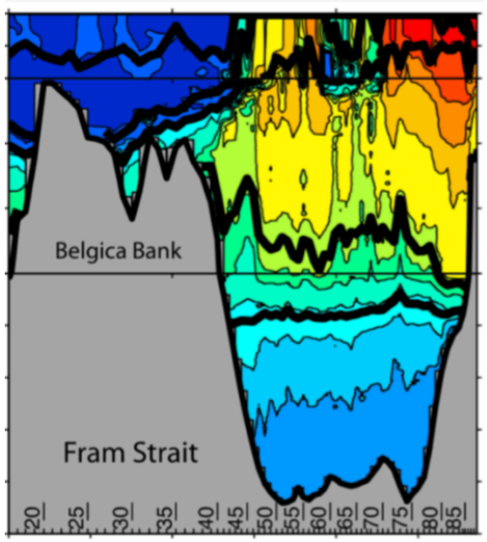
Distance (km)

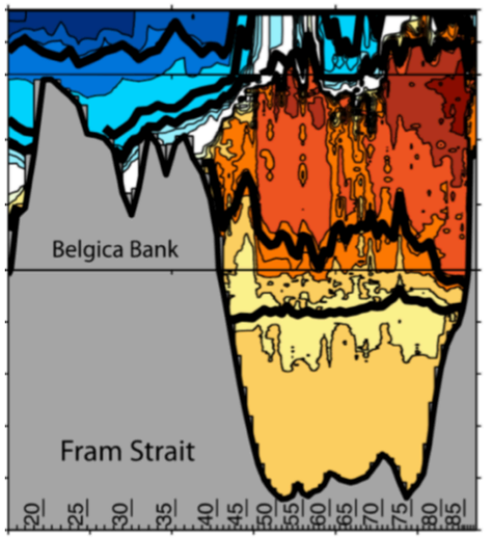
Longitude

Latitude

Tsubouchi et al., 2012




Belgica Bank
Fram Strait
20
25
30
35
40
45
50
55
60
65
70
75
80
85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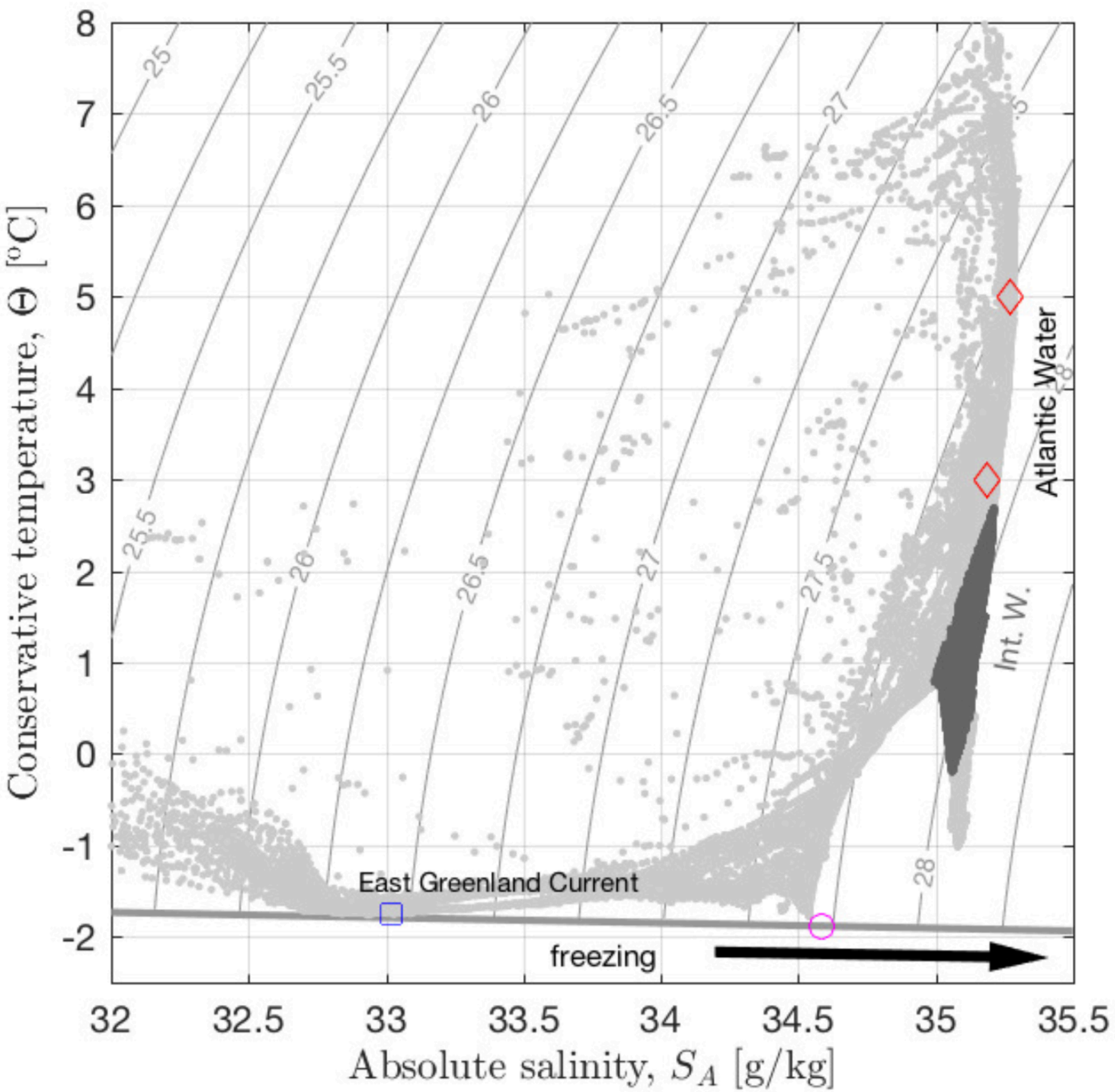
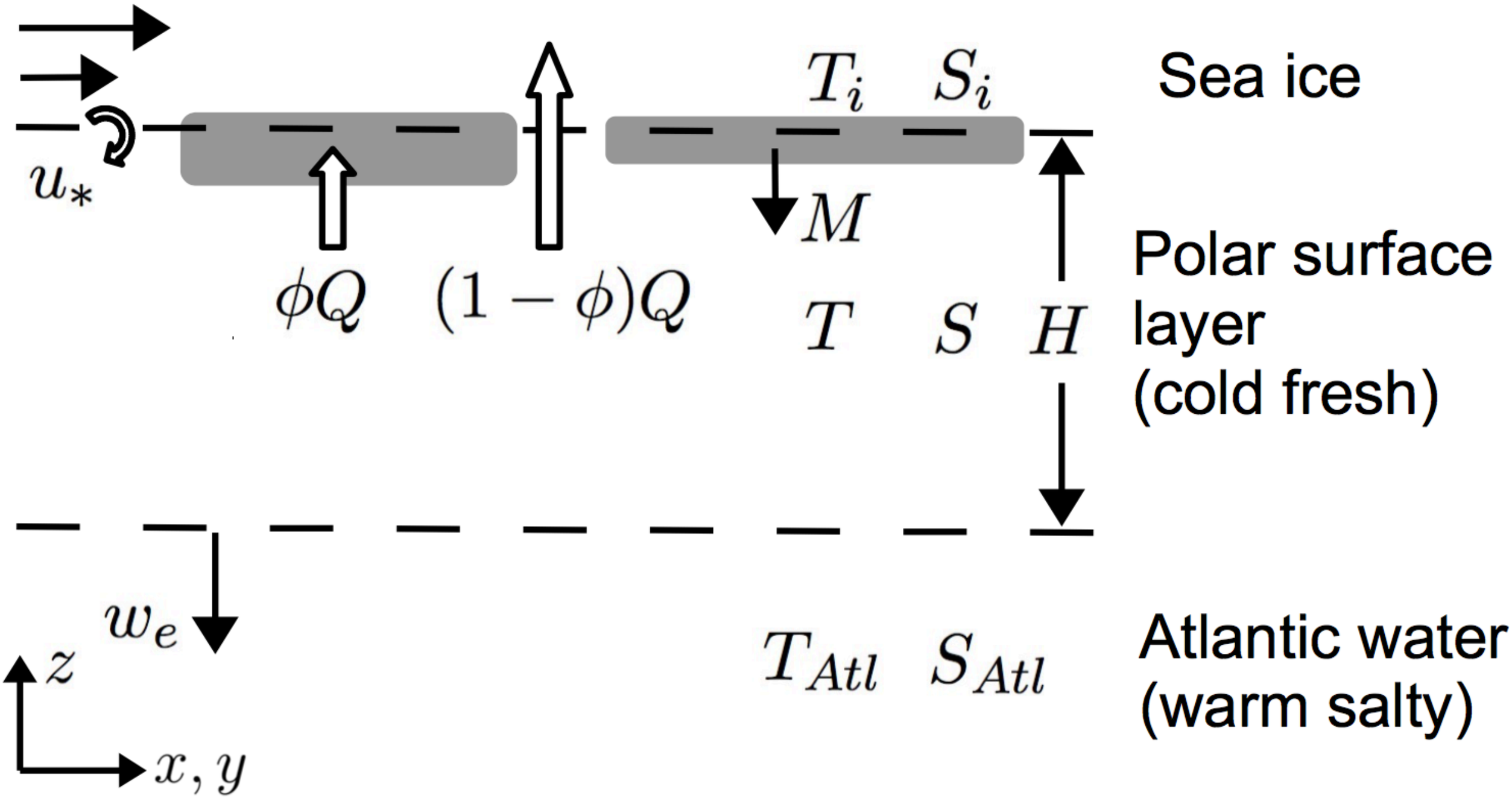
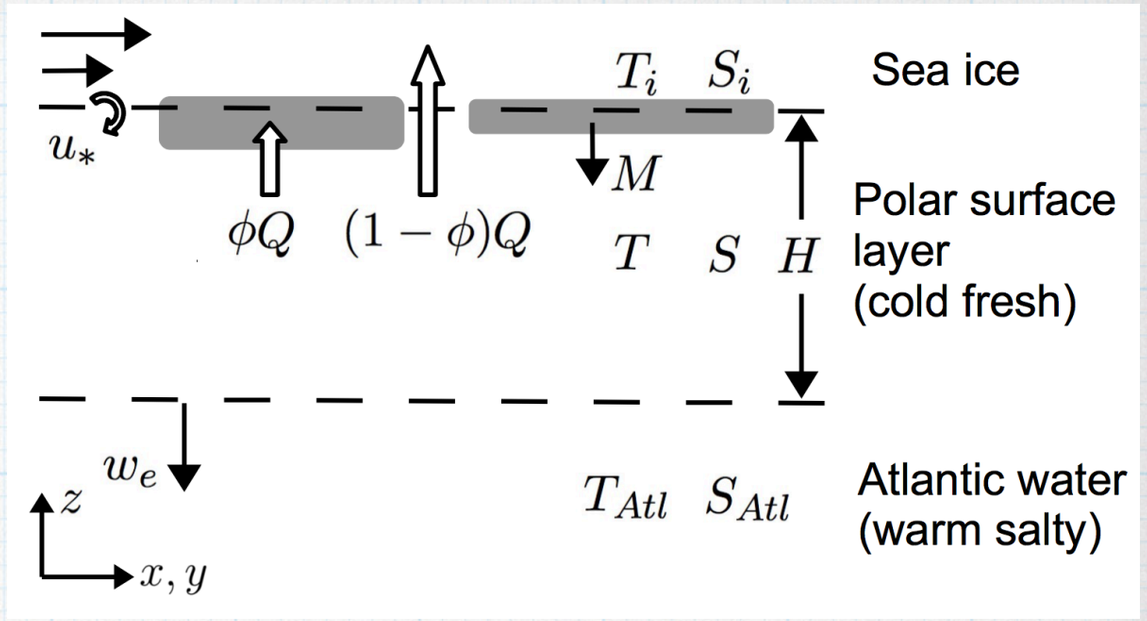

Conservative temperature, Θ [°C]
Absolute salinity, S_A [g/kg]
8
7
6
5
4
3
2
1
0
-1
-2
32
32.5
33
33.5
34
34.5
35
35.5
25
25.5
26
26.5
27
27.5
28
Atlantic Water
Int. W.
East Greenland Current
freezing

Simple conceptual upper ocean model of Atlantic Water melting sea ice, e.g., in the Eurasian Basin



Fluxes of heat and freshwater



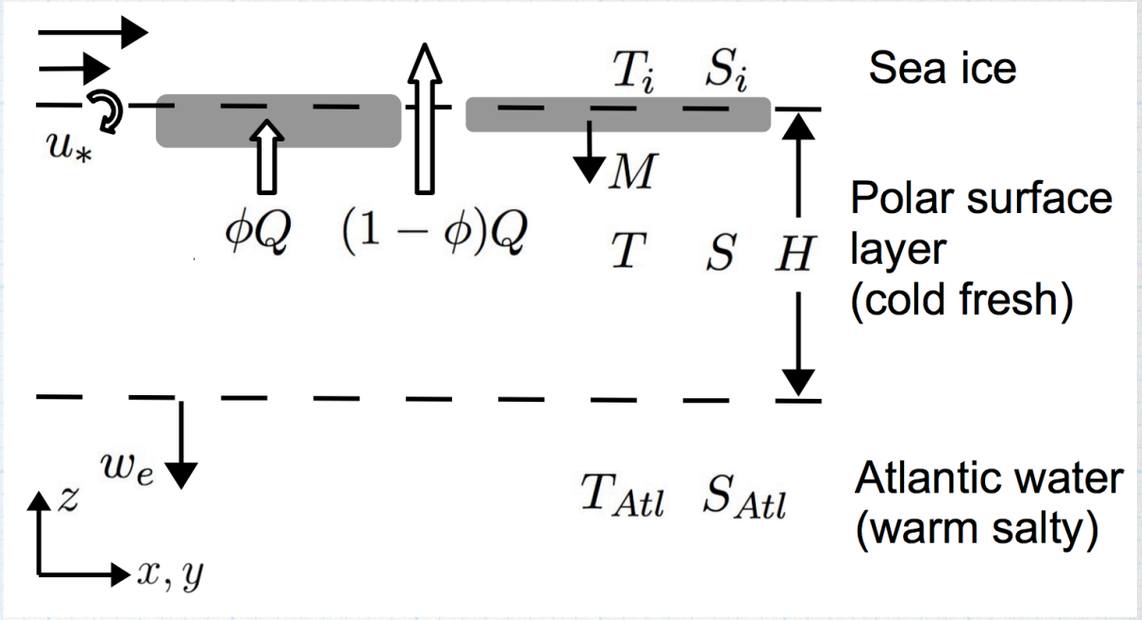
$$Q = Q_a + \rho_i M_i \left[L + c(T - T_f) + c_i(T_f - T_i) \right]$$

$$\mathcal{F} = -\frac{\rho_i}{\rho} M_i (S - S_i)$$

$$M = (\rho_i / \rho) M_i$$

$$M = \phi \frac{Q}{\rho \left[L + c(T - T_f) + c_i(T_f - T_i) \right]}$$

Evolution equations:



$$\begin{aligned}
\frac{dH}{dt} &= w_e + M, \\
H\frac{dT}{dt} &= w_e \Delta T - \frac{Q}{\rho c}, \\
H\frac{dS}{dt} &= w_e \Delta S - M(S - S_i)
\end{aligned}$$

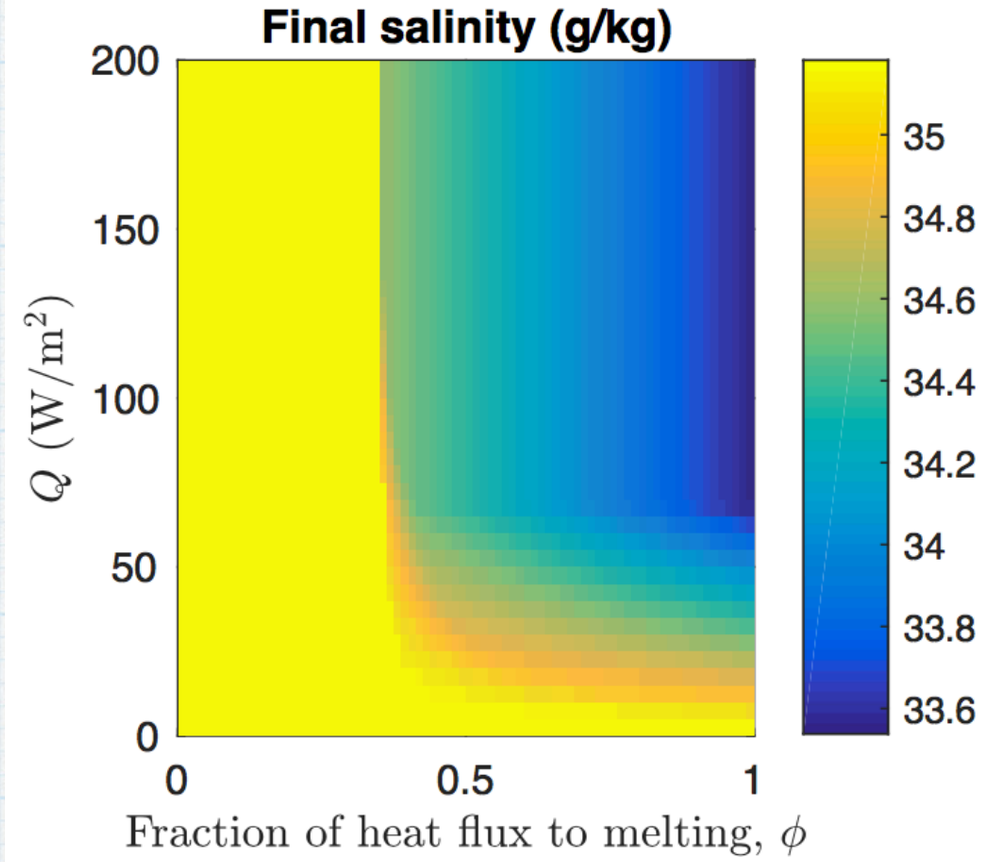
$$\Delta\rho = \rho(T_{Atl}, S_{Atl}) - \rho(T, S)$$

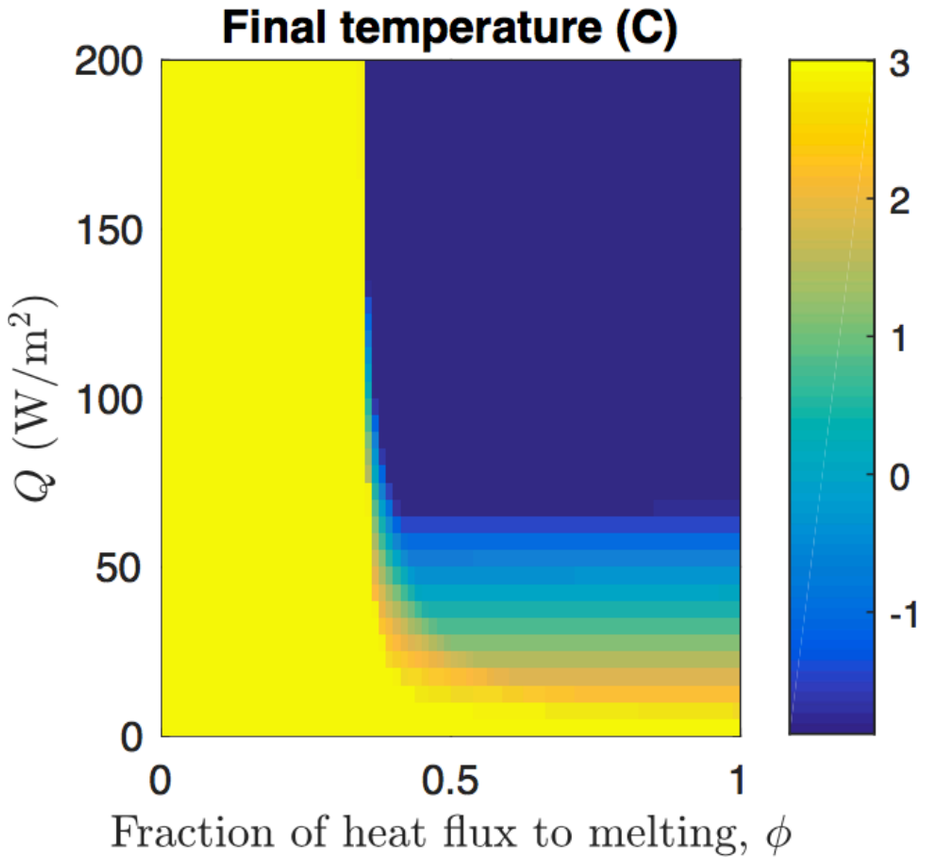
$$\begin{aligned}
w_e &= \frac{\rho}{g\Delta\rho}\left(\frac{2m_0 u_*^3}{H} - \epsilon B\right) \\
\epsilon &= \begin{cases} 1 \text{ for } B \geq 0, \\ 0.05 \text{ otherwise.} \end{cases}
\end{aligned}$$

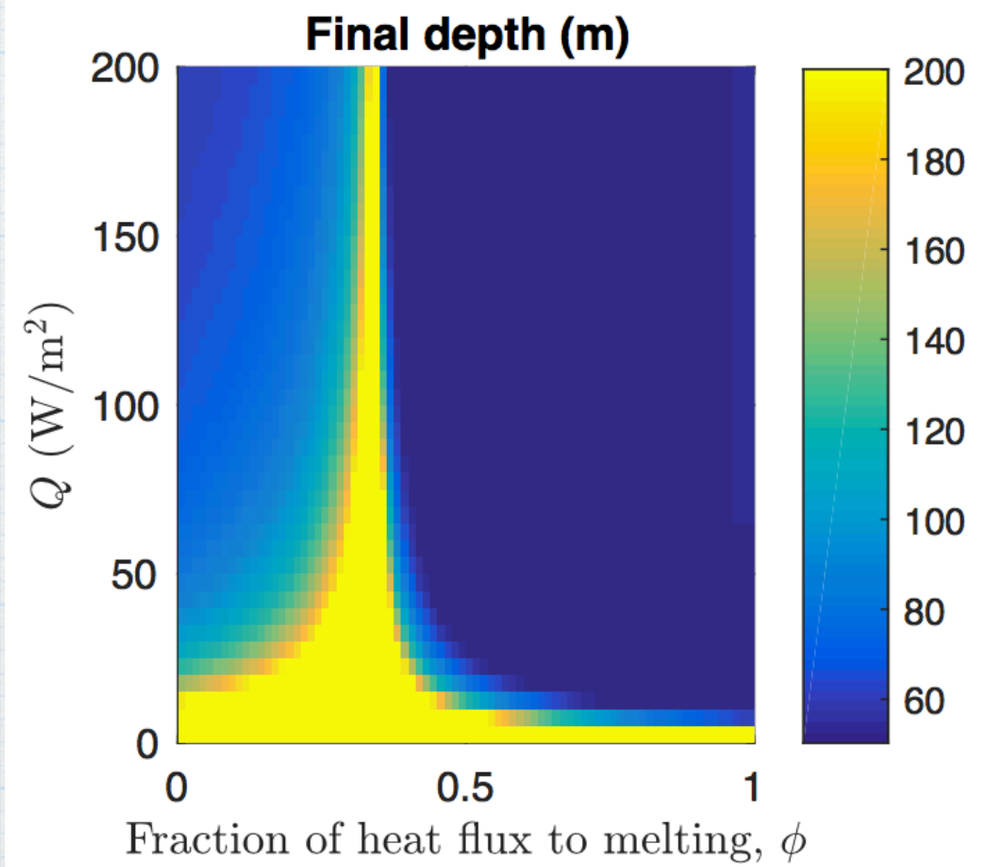
$$B = g\left[\frac{\alpha Q}{\rho c} + \beta M\,(S - S_i)\right]$$

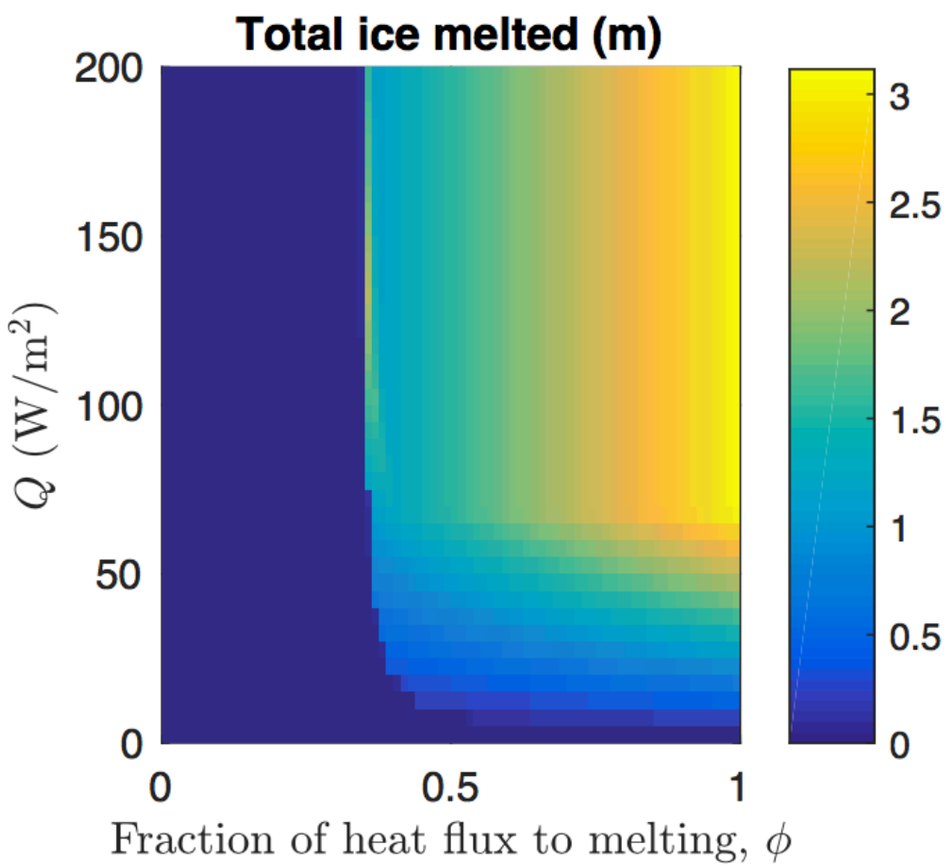
Solutions:

[For many (phi, Q) pairs]

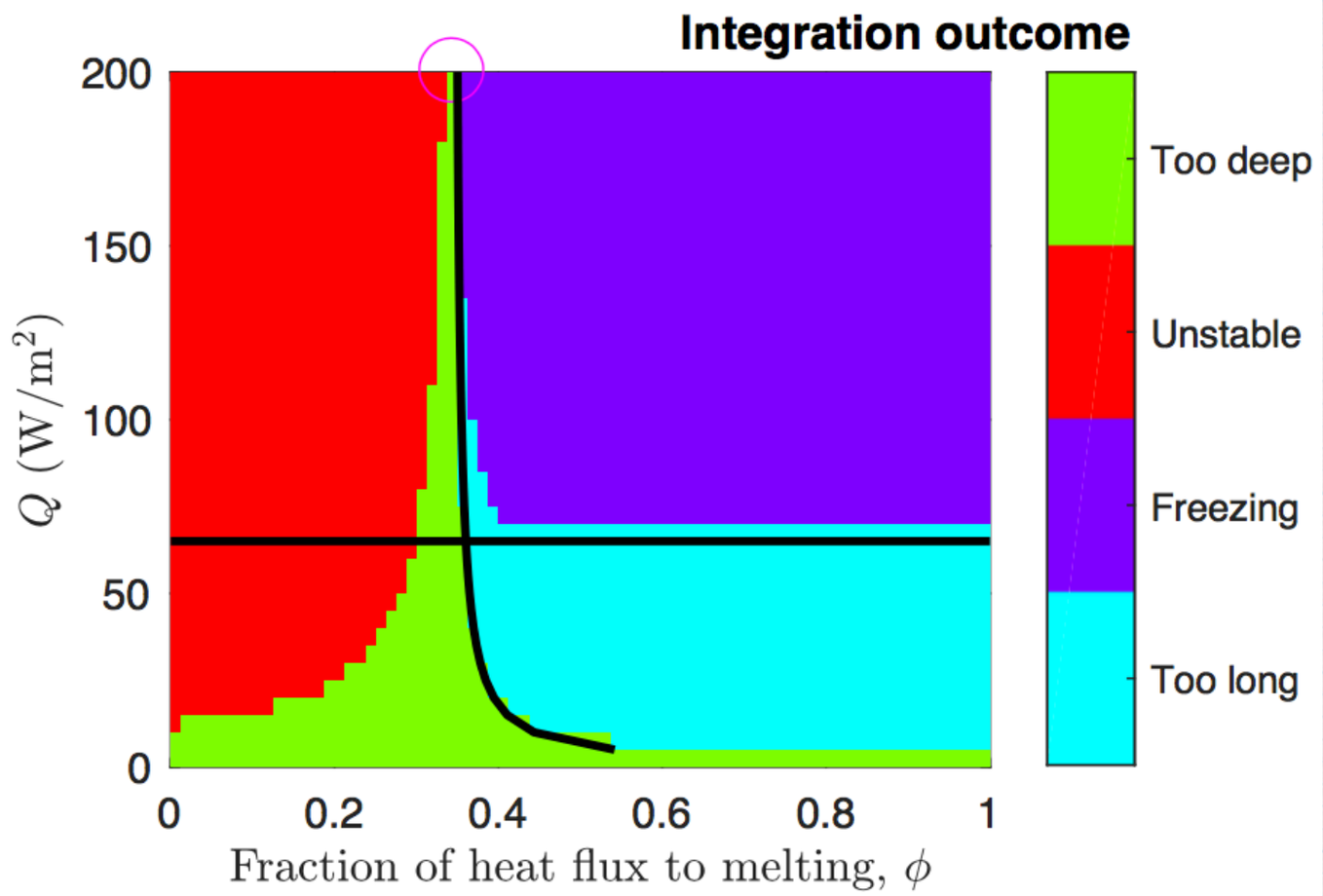


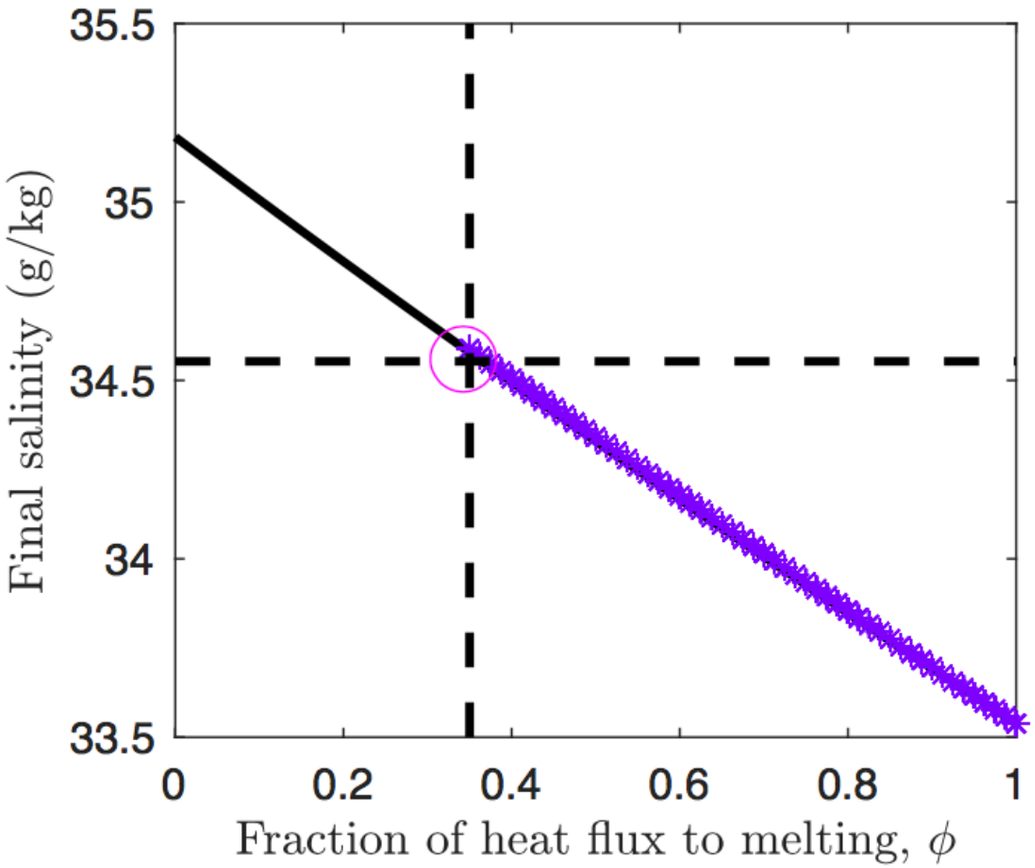




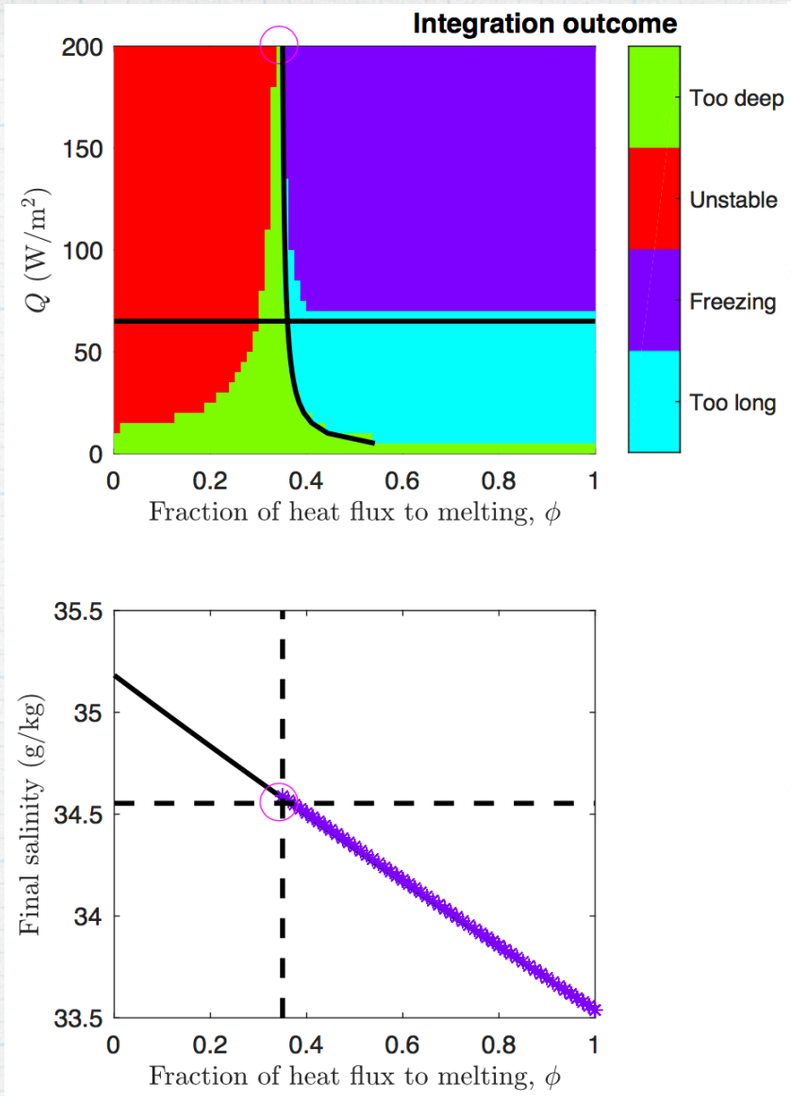


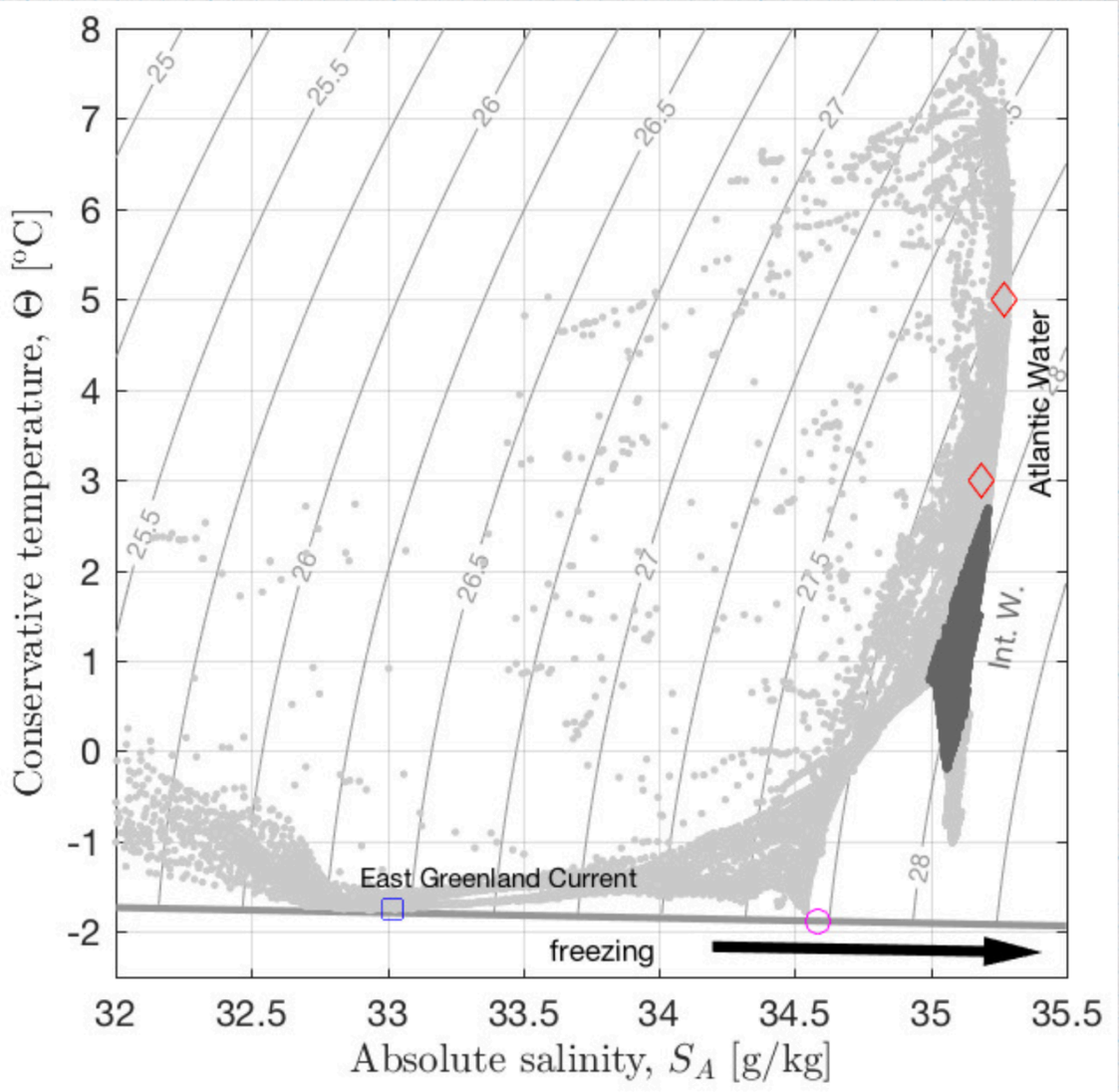
Solution categories:





Properties of "EGC" water

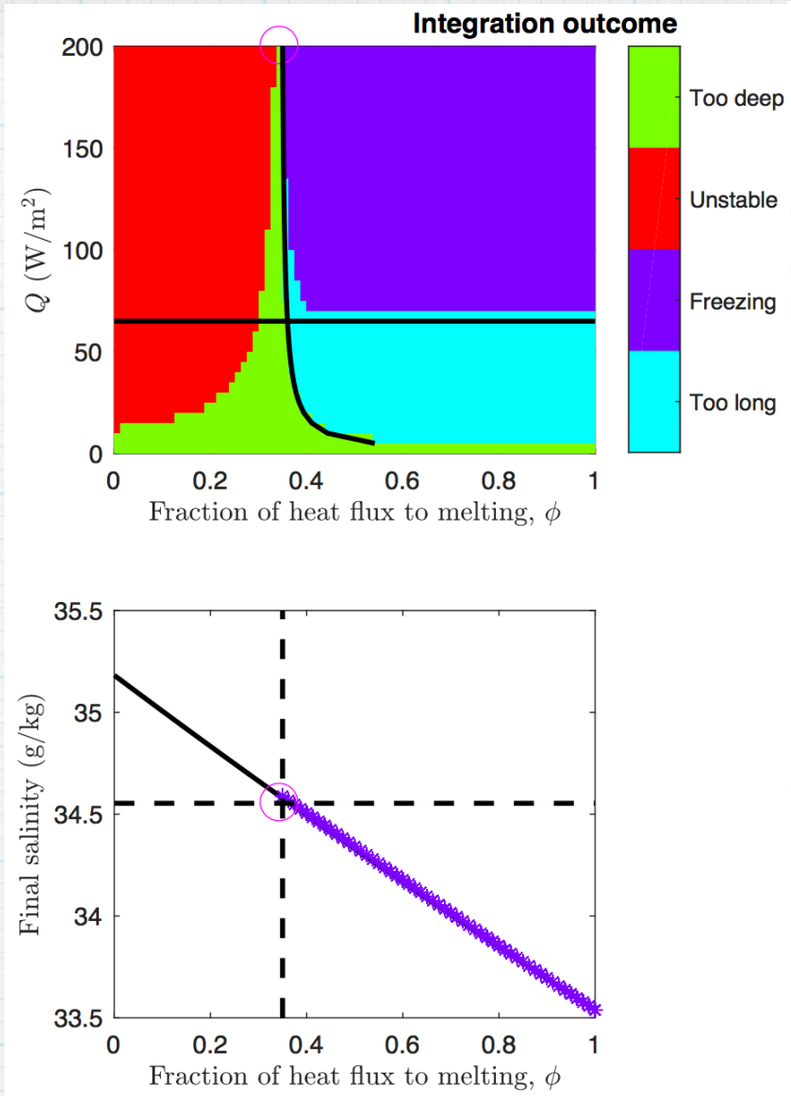


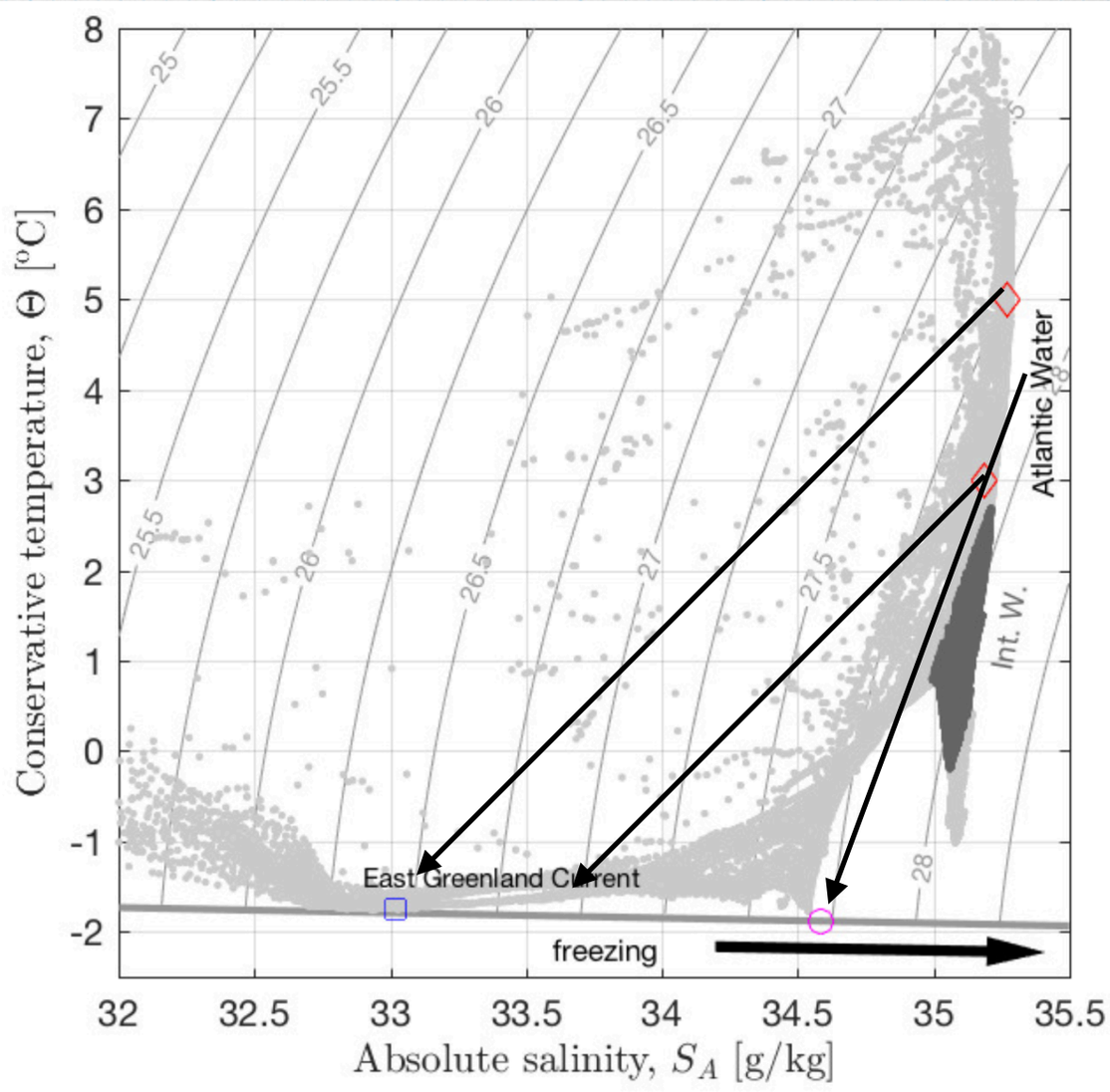


$$S_1 = \frac{\left[L + c_i\left(T_f - T_i\right)\right] S_{Atl} + \phi c (T_{Atl} - T_f) S_i}{\left[L + c_i\left(T_f - T_i\right)\right] + \phi c (T_{Atl} - T_f)} \approx \frac{L S_{Atl}}{L + \phi c (T_{Atl} - T_f)}$$

$$\phi_{min} = \frac{-\alpha\left[L + c(T - T_f) + c_i(T_f - T_i)\right]}{\beta c\left(S - S_i\right)} \approx \frac{-\alpha L}{\beta c S}$$

Properties of "EGC" water





$$S_1 = \frac{\left[L + c_i\left(T_f - T_i\right)\right] S_{Atl} + \phi c (T_{Atl} - T_f) S_i}{\left[L + c_i\left(T_f - T_i\right)\right] + \phi c (T_{Atl} - T_f)} \approx \frac{L S_{Atl}}{L + \phi c (T_{Atl} - T_f)}$$

$$\phi_{min} = \frac{-\alpha\left[L + c(T - T_f) + c_i(T_f - T_i)\right]}{\beta c\left(S - S_i\right)} \approx \frac{-\alpha L}{\beta c S}$$

Remarks

* Conceptual model for properties of EGC (fresh polar outflow) water that fits the data well.
* Comparison with Bert Rudels' formula. Similar fit to data, but different rationale.
* Importance of partial melting of remotely-formed sea ice.
* What sets the properties of the intermediate water?