The role of tides in Arctic ocean-ice climate

Strong tides occur in several regions, peak speeds > 1 m/s

Tidal effects include
1) enhanced mixing within the water column
2) breaking and mobilizing sea ice cover

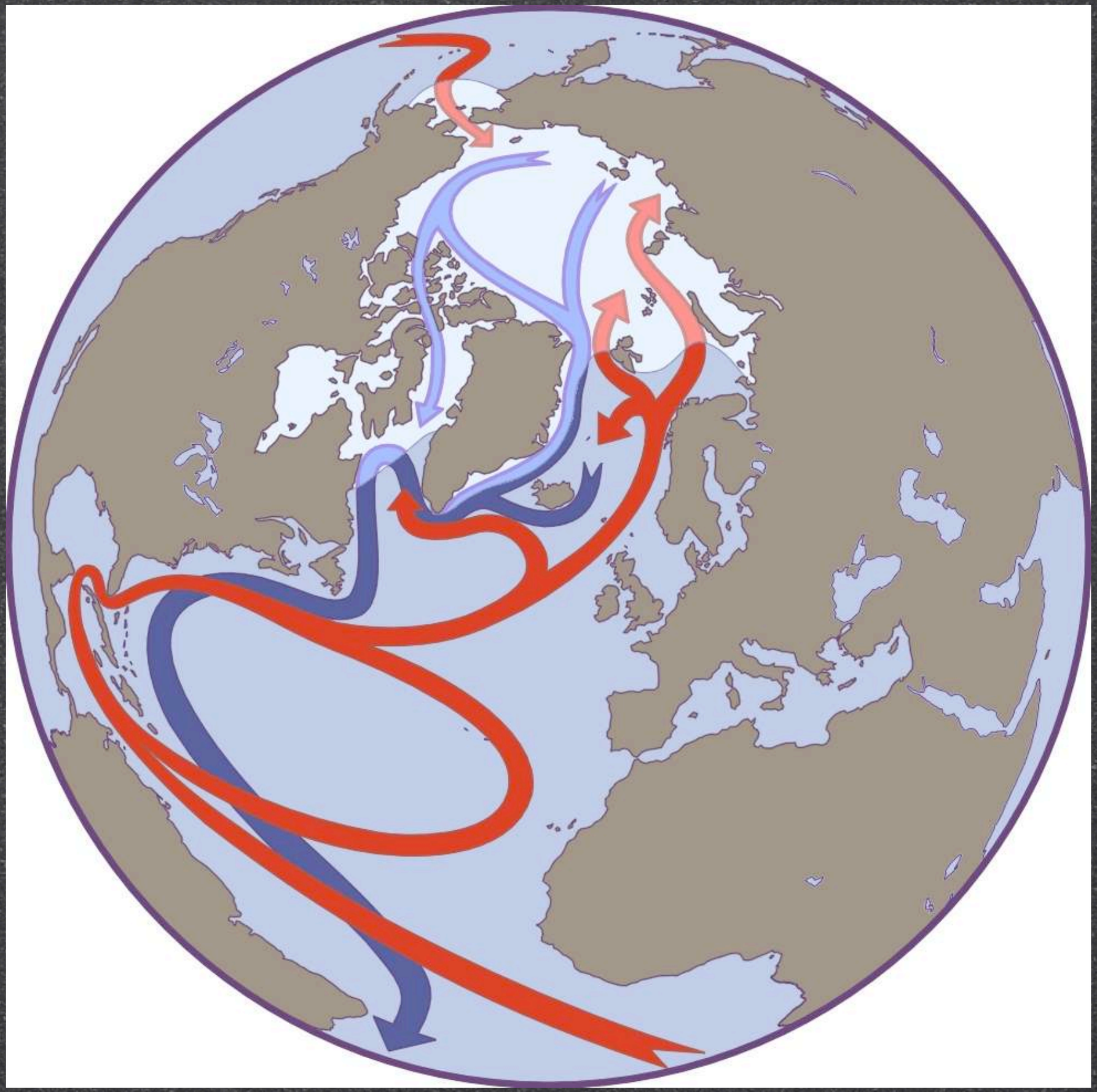
May be important for Arctic ocean/ice climate
-- and (possibly) for global ocean THC

peak tidal speed

10
0
−10
Y

−15
0
15
X

0.25
24.76
49.27
73.79
98.30
122.81
cm/sec



Step 1: Estimate energy dissipation rate from tides

An upper bound (strong tide, shallow water) may be U^3/D

From Kowalik & Proshutinsky 1994 get U_{peak} then $U^3 \approx 0.35\ U_{peak}{}^3$

(N.b., this does not count topog scatter to internal wave breaking.)

Step 2: Fraction of dissipation available to vertical mixing ~ 0.2

Step 3: Upper bound vertical mix coef: $K \approx 0.07\,\rho U_{peak}{}^3 / g\,\delta\rho$

Step 4: Intensity diminishes away from bottom as $\exp(z - D/Z)$

Step 5: Overall intensity diminshes as $\exp(-D/Z)$

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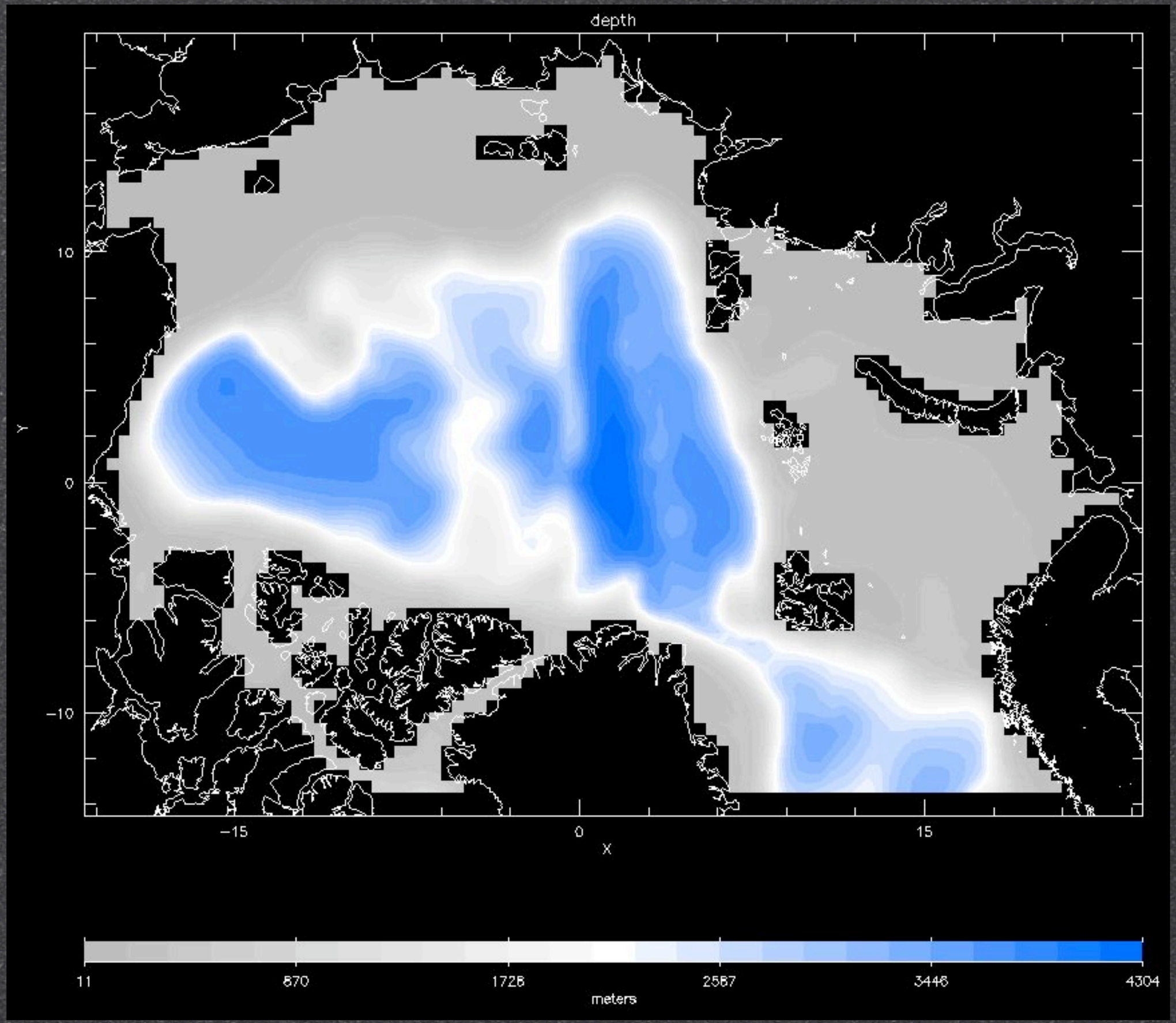
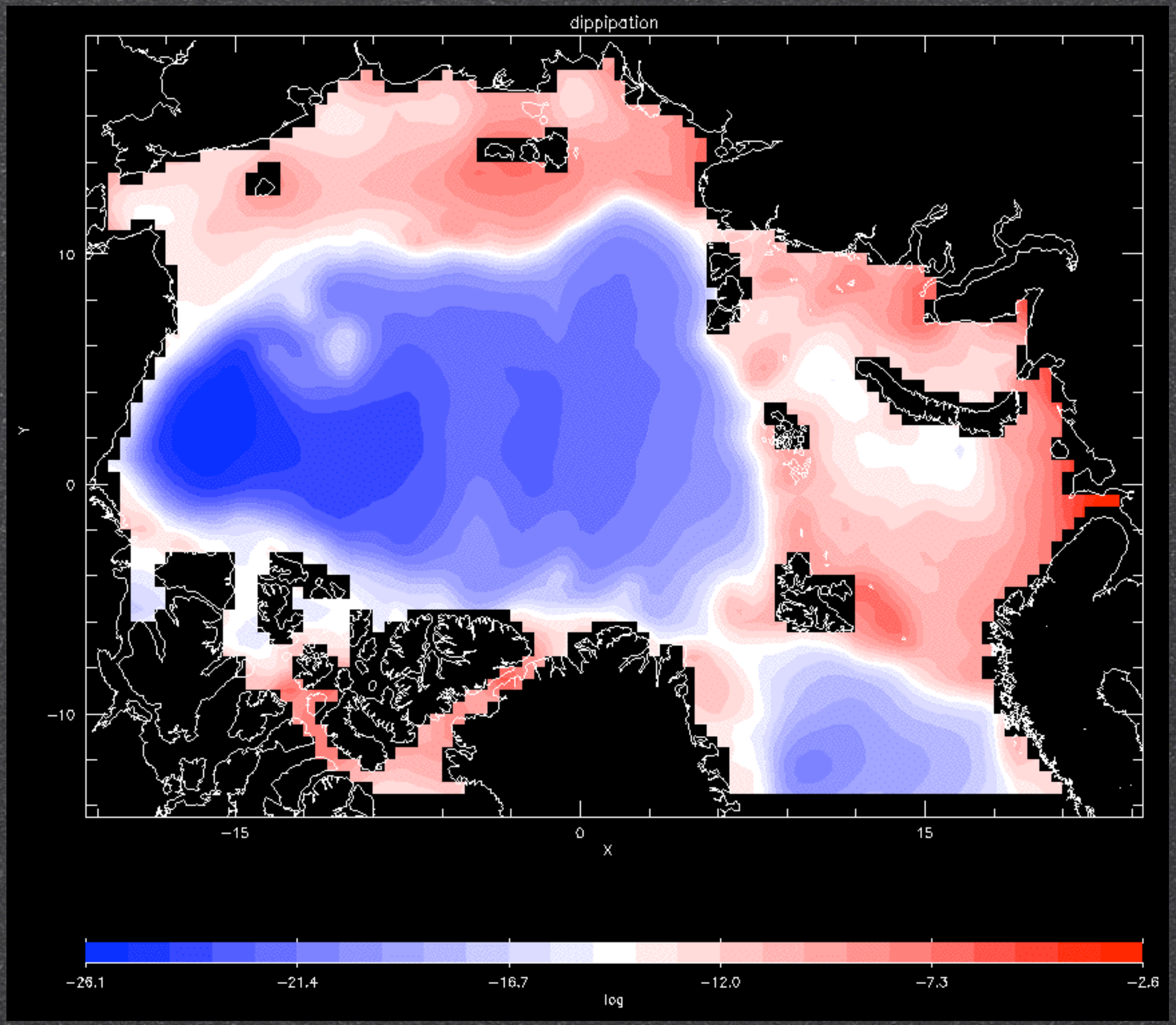
N.b., fudge factor Z 50m? 100m? more?


depth
10
0
−10
Y
−15
0
15
X
11
870
1728
2587
3446
4304
meters


dippipation
10
0
−10
Y
−15
0
15
X
−26.1
−21.4
−16.7
−12.0
−7.3
−2.6
log

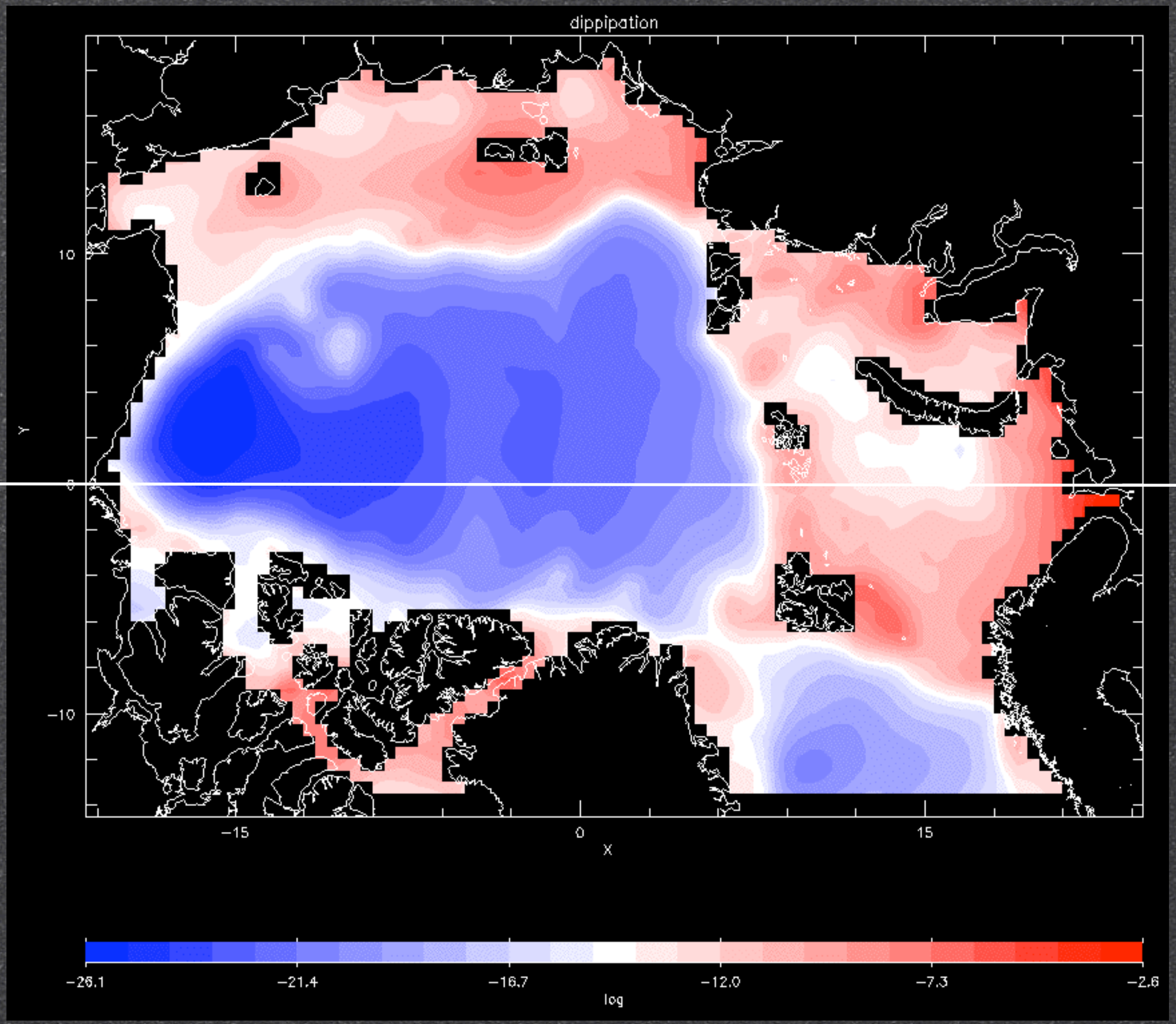
and ...

Tides break ice cover, opening & reclosing leads. Ocean heat escapes. New thin ice forms (during freezing) and is ridged to thicker ice => overall ice volume grows. How?

$dA/dt = \ldots - \mu A$ where $\mu = U_{peak} \exp(-h/H)/R$

with A & h = ice area & thickness, H & R = fudge factors

$H \sim$ 1 m, $R \sim$ fewx10 to 100 km


dippipation
10
Y
0
−10
−15
0
15
X
−26.1
−21.4
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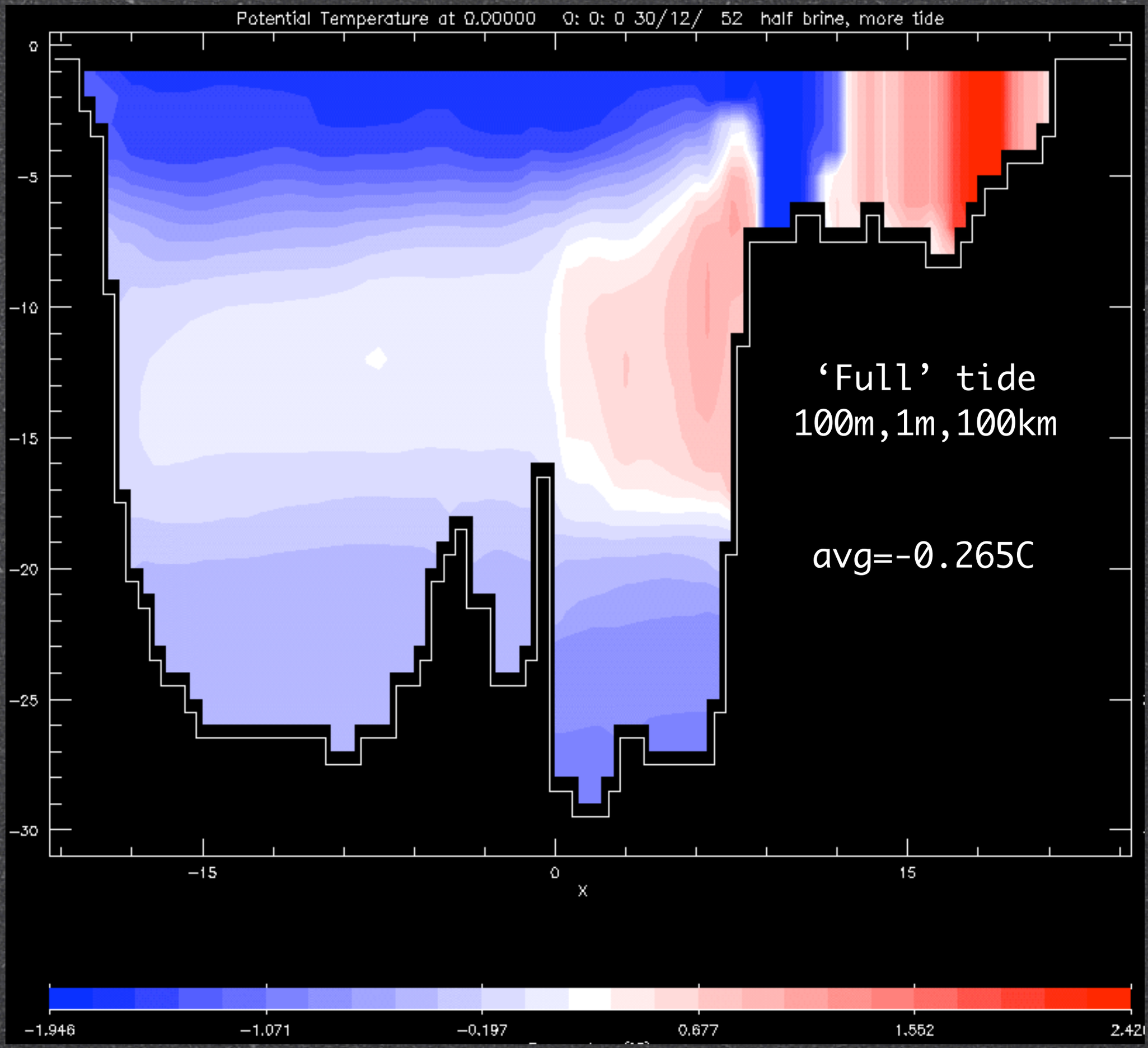
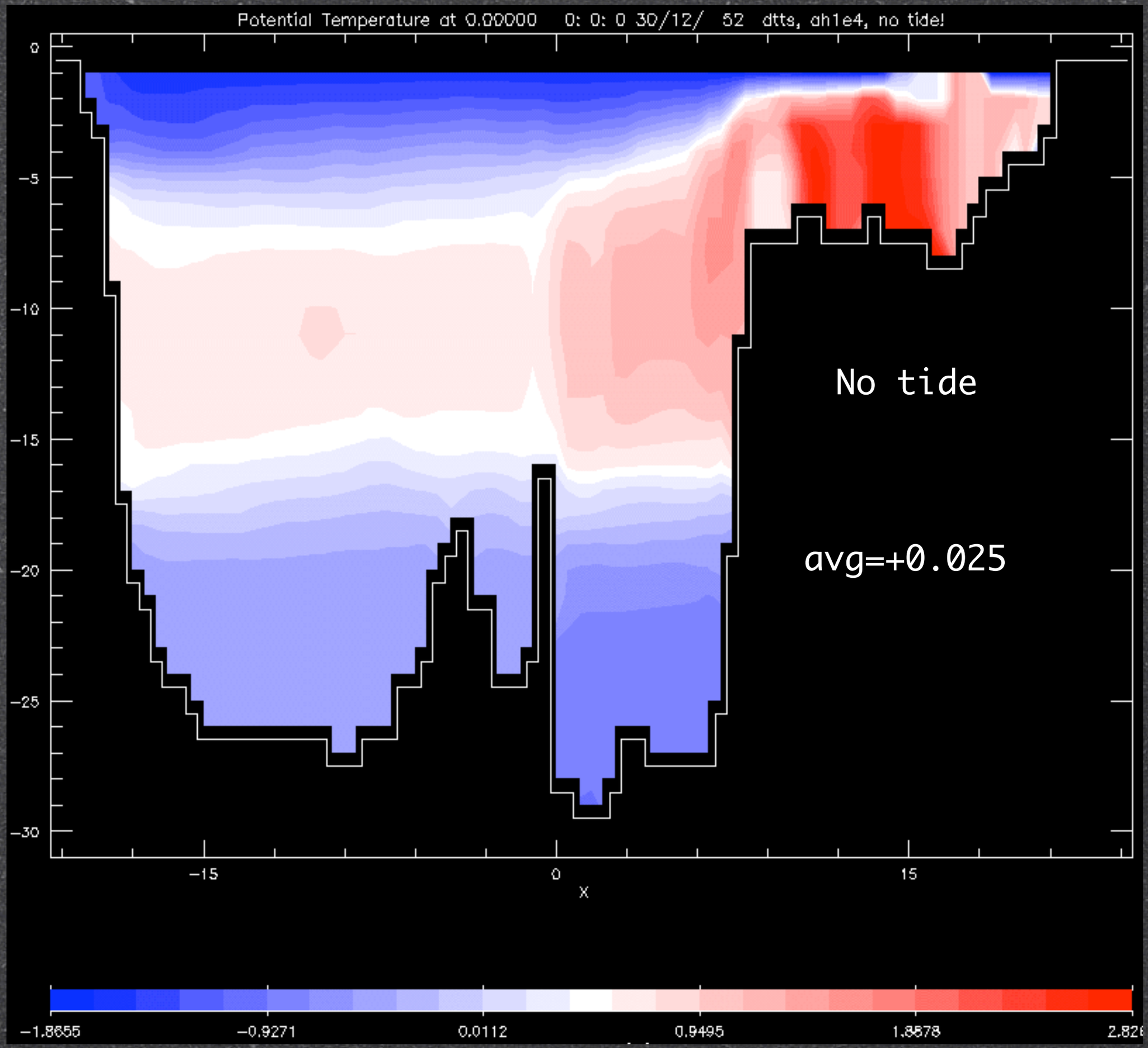
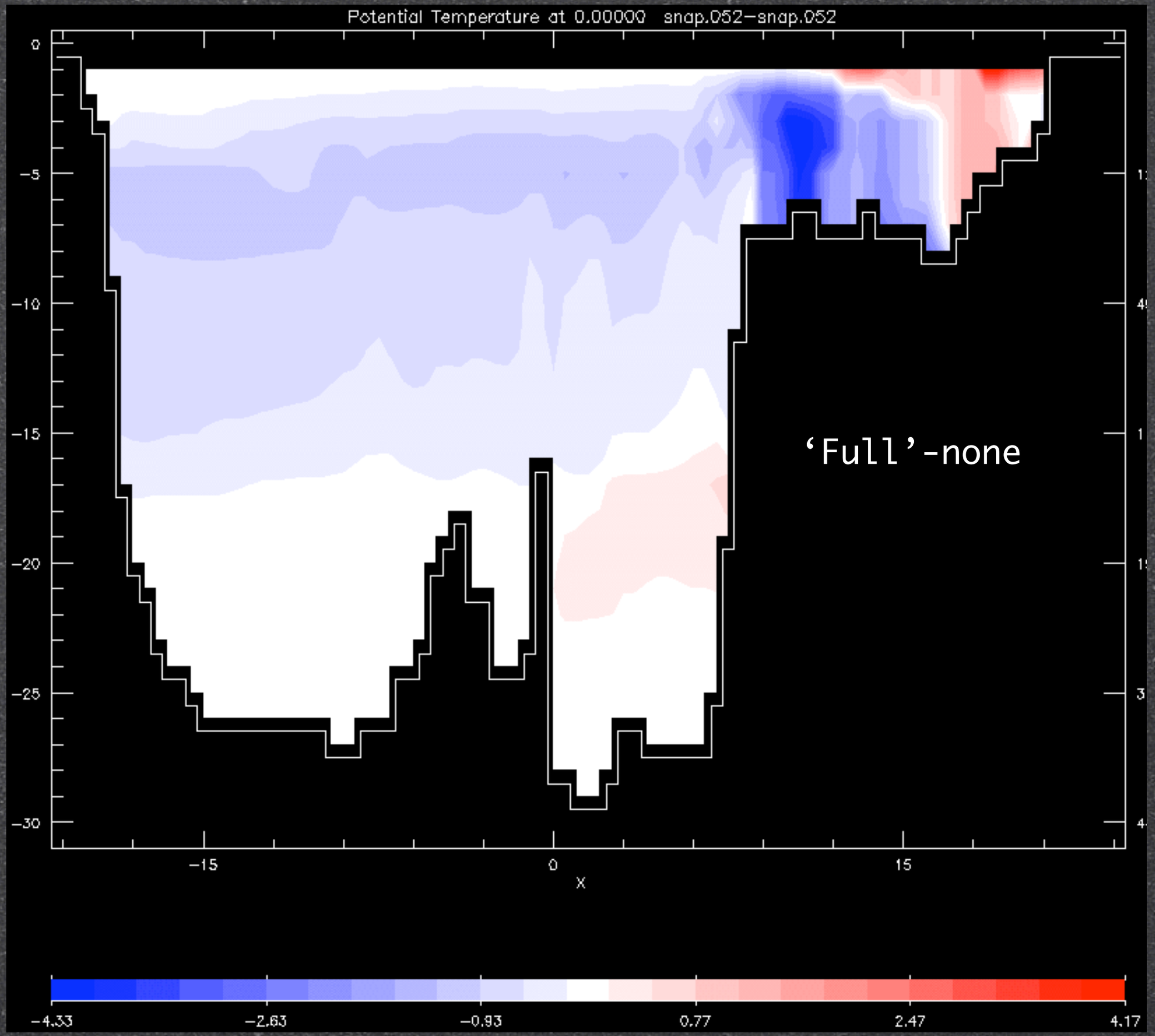
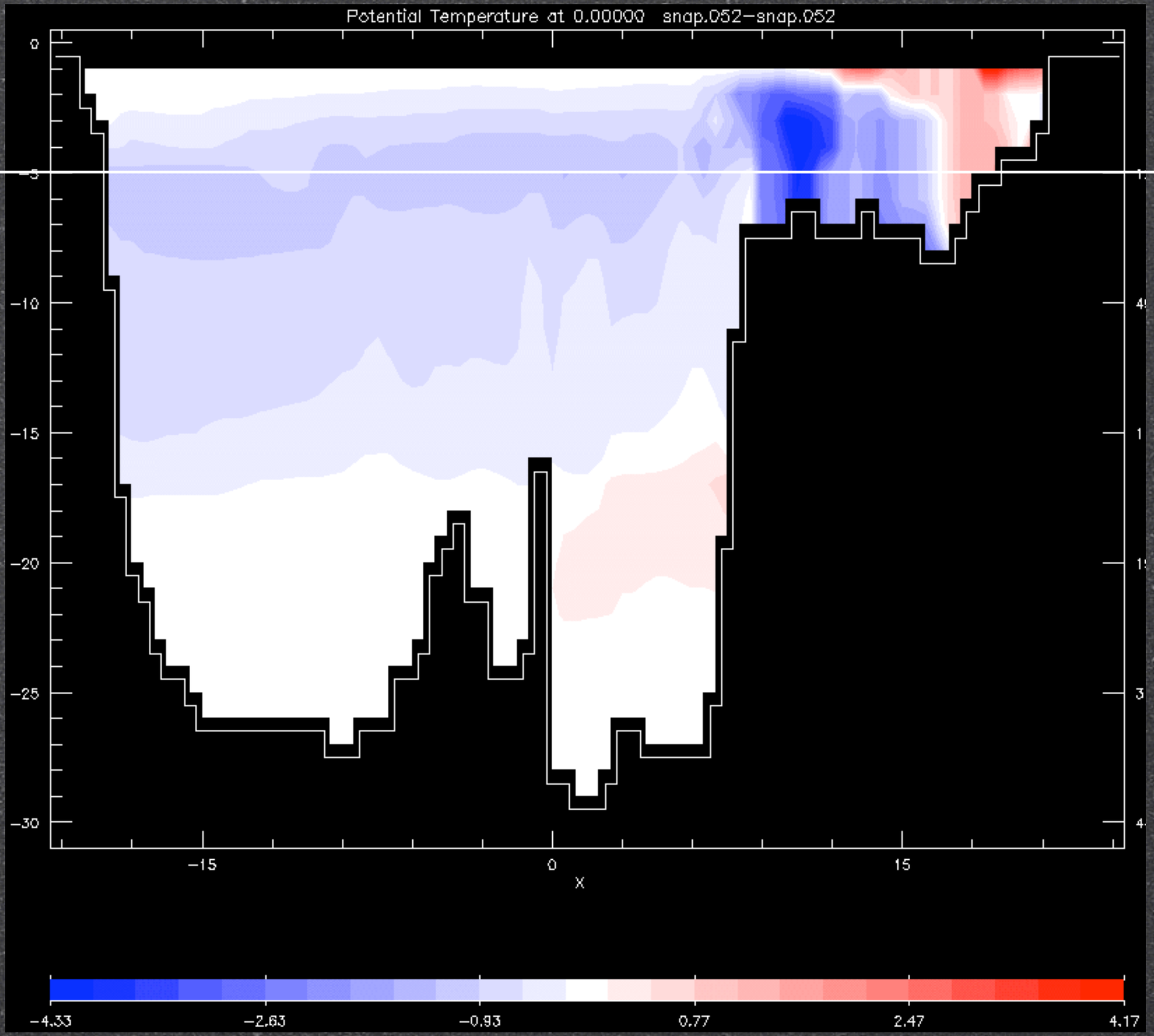
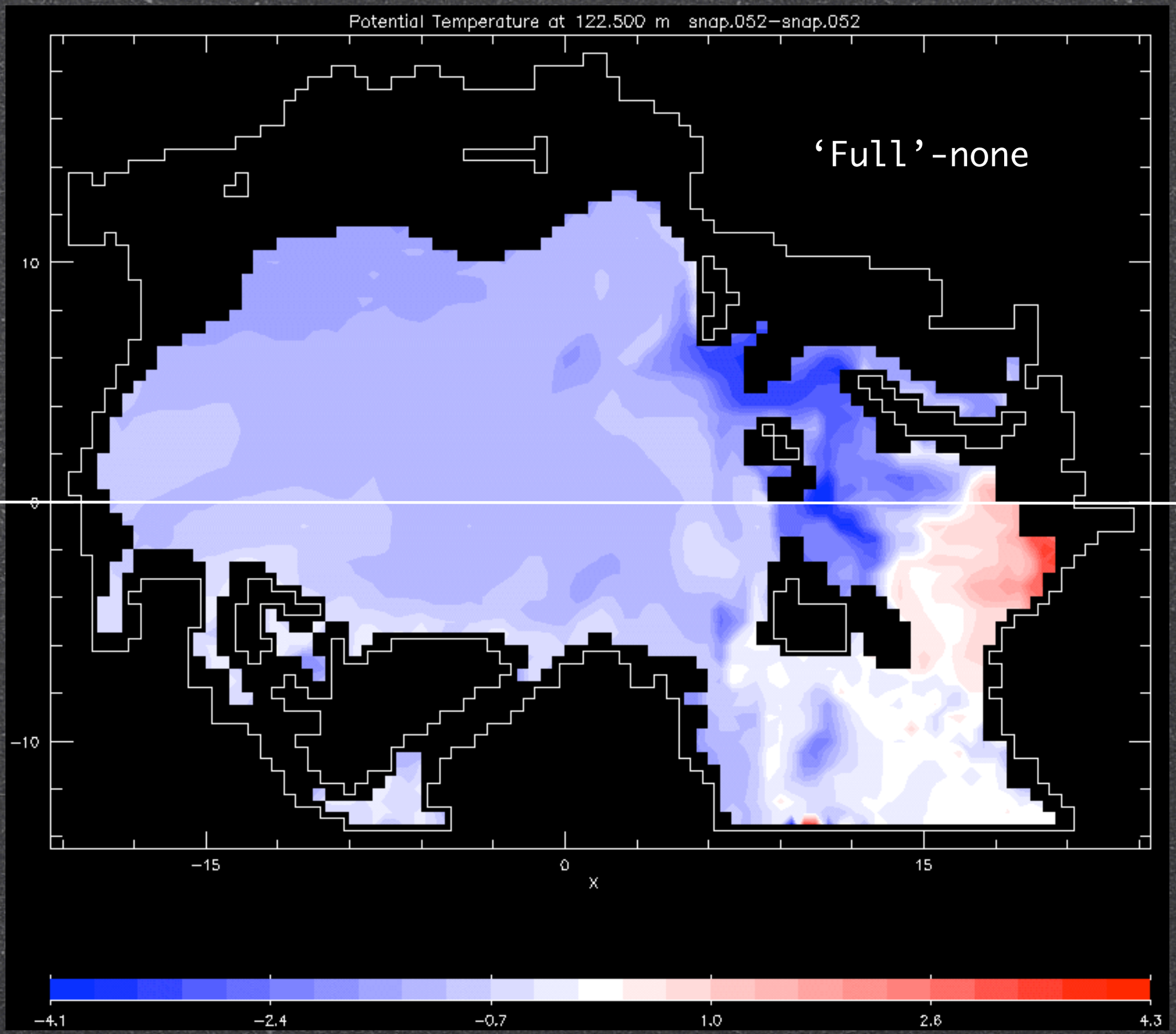
−12.0
−7.3
−2.6
log

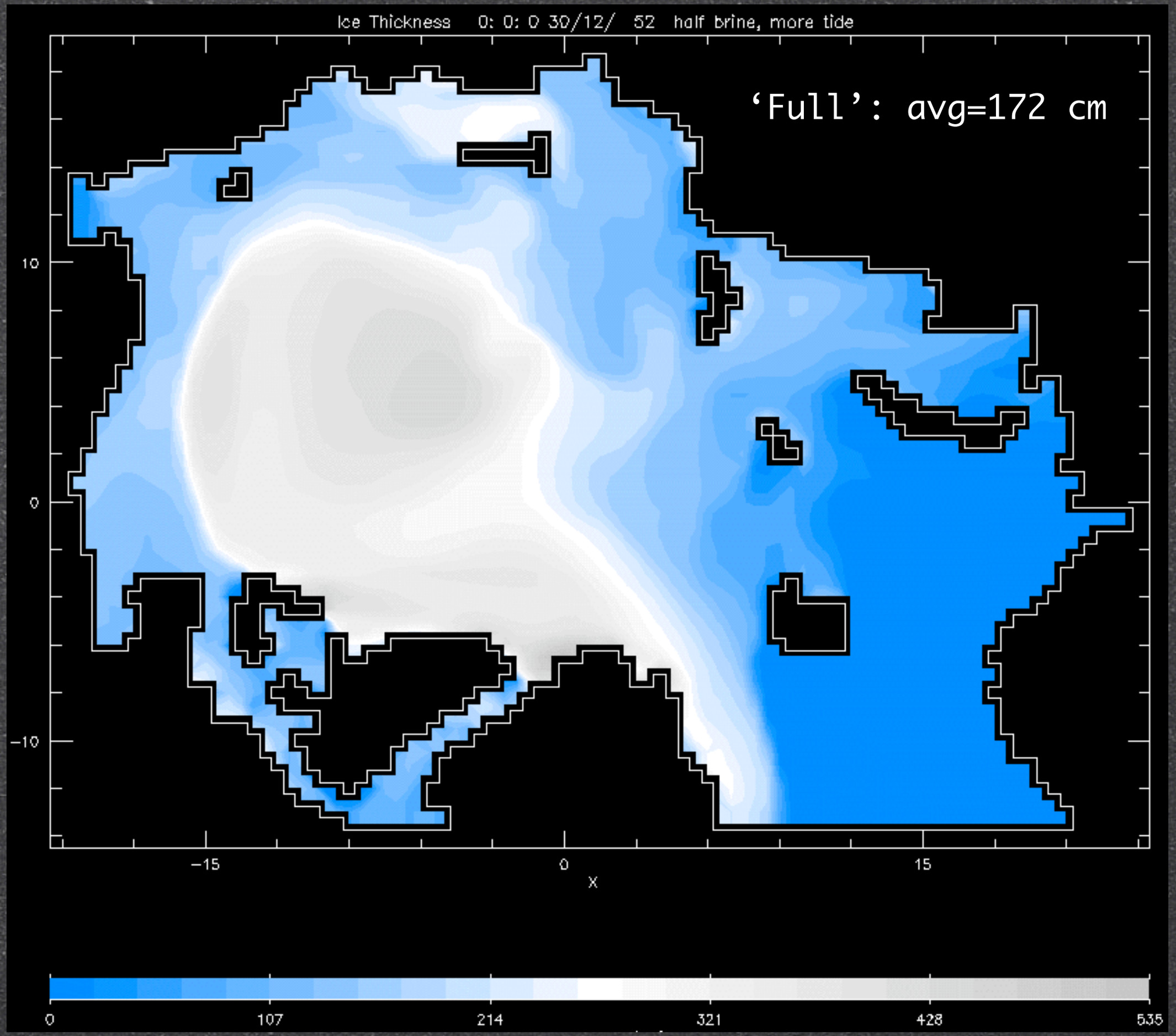

Potential Temperature at 0.00000 0: 0: 0 30/12/ 52 half brine, more tide
0
-5
-10
-15
-20
-25
-30
-15
0
15
X
‘Full’ tide
100m,1m,100km
avg=-0.265C
-1.946
-1.071
-0.197
0.677
1.552

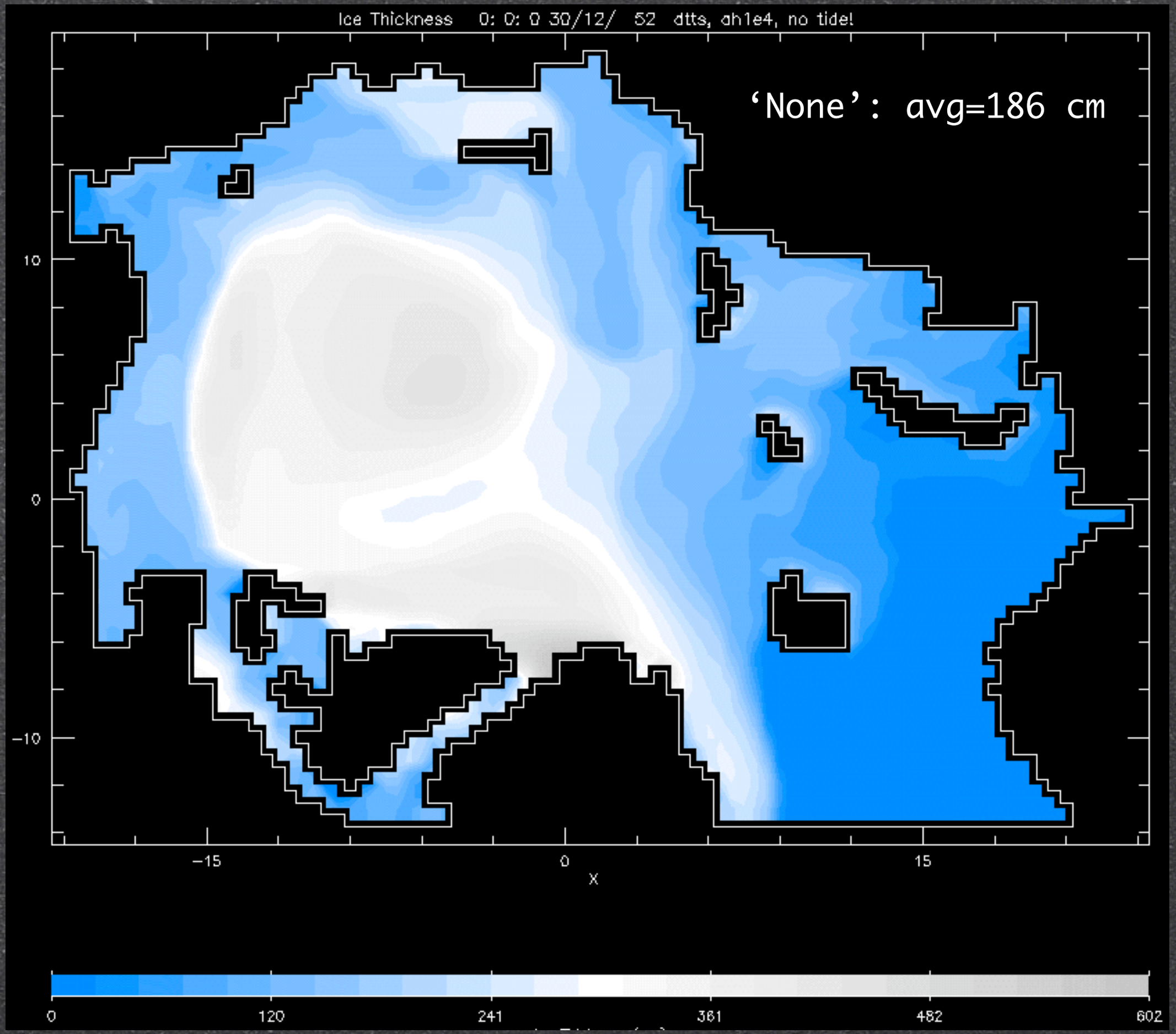

Potential Temperature at 0.00000 0: 0: 0 30/12/ 52 dtts, ah1e4, no tide!
0
-5
-10
-15
-20
-25
-30
-15
0
15
X
No tide
avg=+0.025
-1.8655
-0.9271
0.0112
0.9495
1.8878
2.826

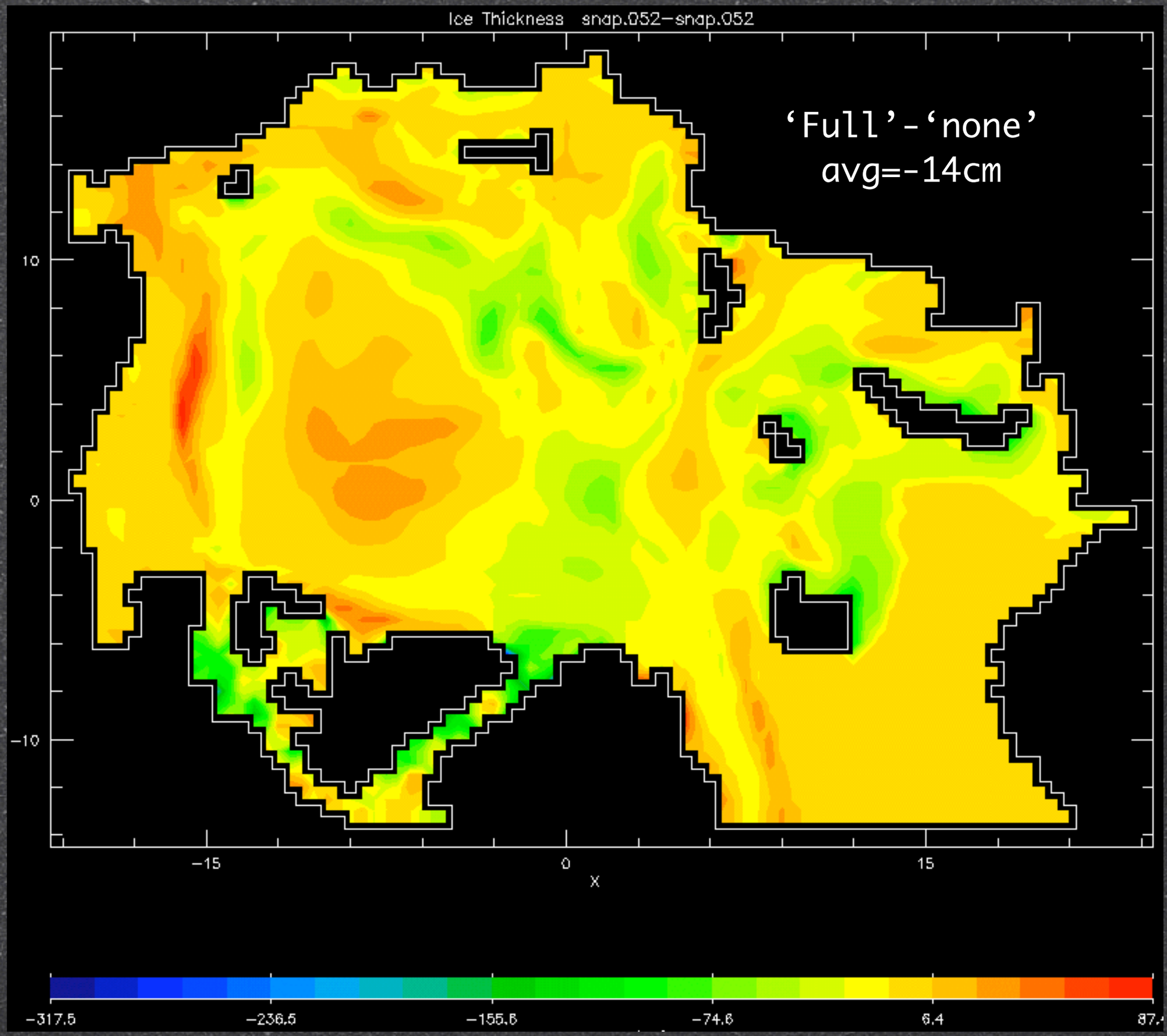

Potential Temperature at 0.00000 snap.052-snap.052
0
-5
-10
-15
-20
-25
-30
-15
0
15
X
'Full'-none
-4.33
-2.63
-0.93
0.77
2.47
4.17

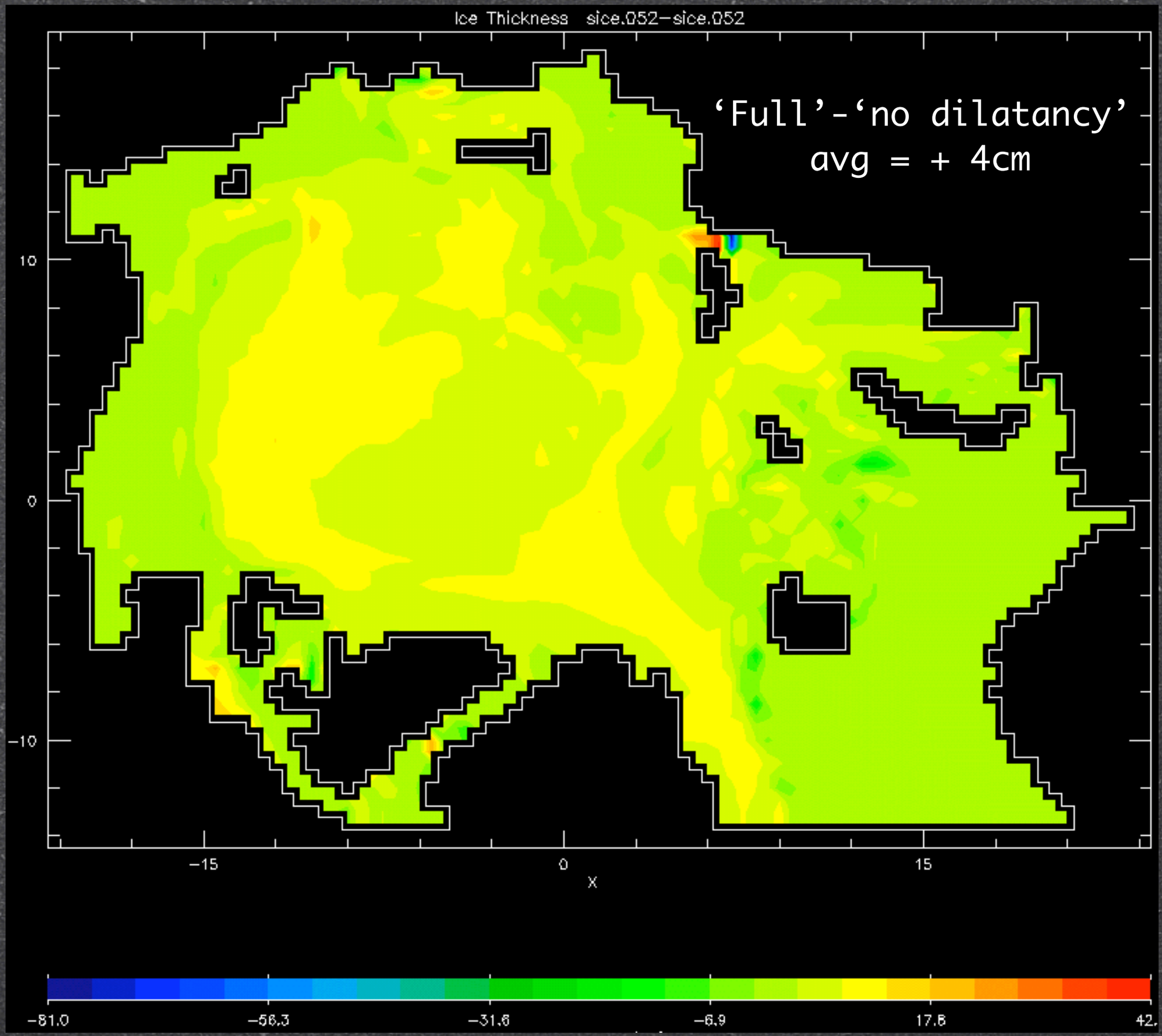

Potential Temperature at 0.00000 snap.052-snap.052
0
−5
−10
−15
−20
−25
−30
−15
0
15
X
−4.33
−2.63
−0.93
0.77
2.47
4.17


Potential Temperature at 122.500 m snap.052–snap.052
'Full'-none
10
0
−10
−15
0
15
X
−4.1
−2.4
−0.7
1.0
2.6
4.3


Ice Thickness 0: 0: 0 30/12/ 52 half brine, more tide
'Full': avg=172 cm
10
0
-10
-15
0
15
X
0
107
214
321
428
535


Ice Thickness 0: 0: 0 30/12/ 52 dtts, dh1e4, no tide!
'None': avg=186 cm
10
0
-10
-15
0
15
X
0
120
241
361
482
602


Ice Thickness snap.052-snap.052
'Full'-'none'
avg=-14cm
10
0
-10
-15
0
15
X
-317.5
-236.5
-155.6
-74.6
6.4


Ice Thickness sice.052−sice.052
‘Full’-‘no dilatancy’
avg = + 4cm
10
0
−10
−15
0
15
X
−81.0
−56.3
−31.6
−6.9
17.8
42.

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Given this uncertain, exploratory study with poorly known (but plausible?) parameter values, suggestions are ----------

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Enhanced ocean heat flux reduces total ice volume

Tidal fracturing mobilizes ice and grows volume

but (for present scheme) net effect is to reduce ice volume