The role of tides in arctic ocean/ice climate

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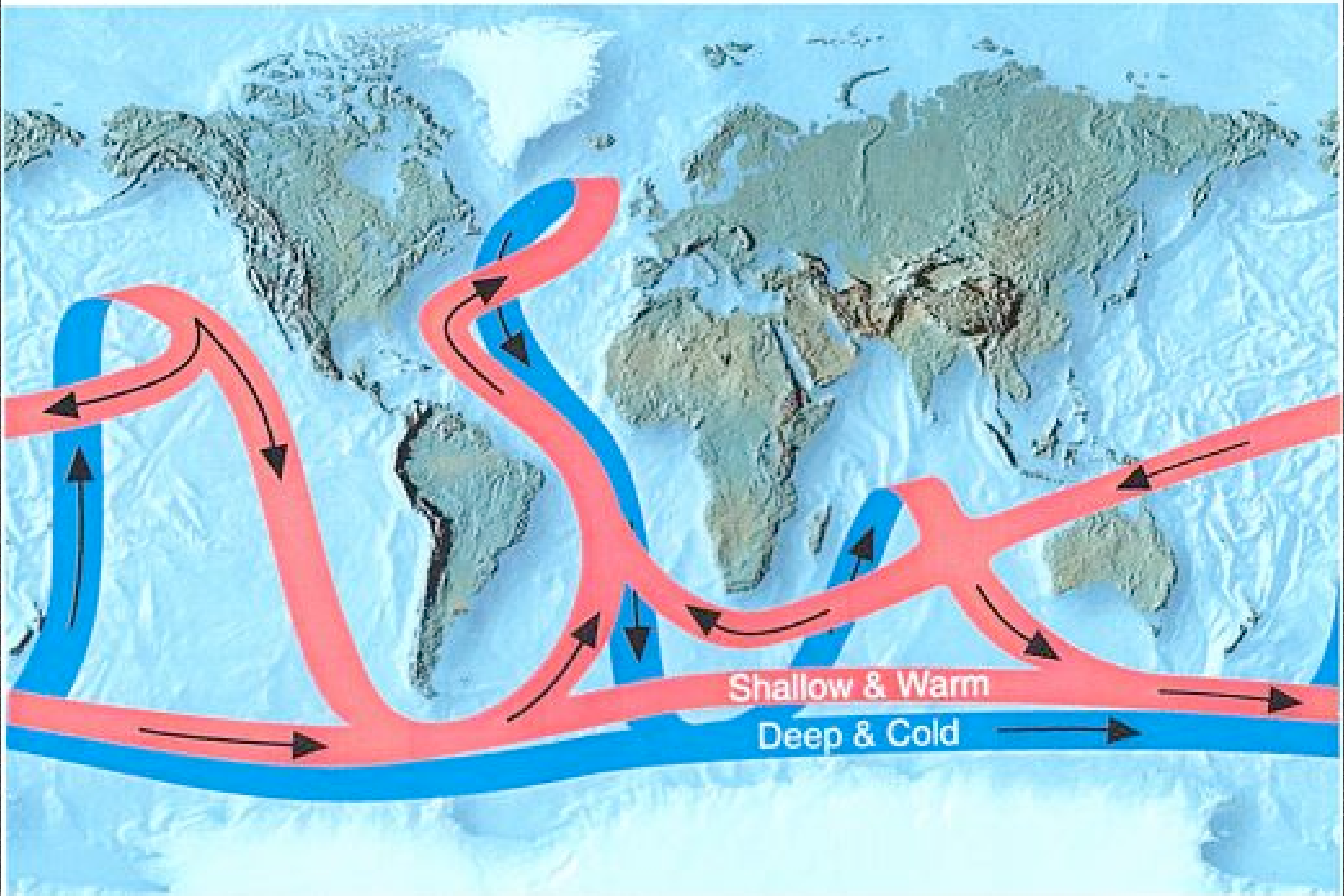
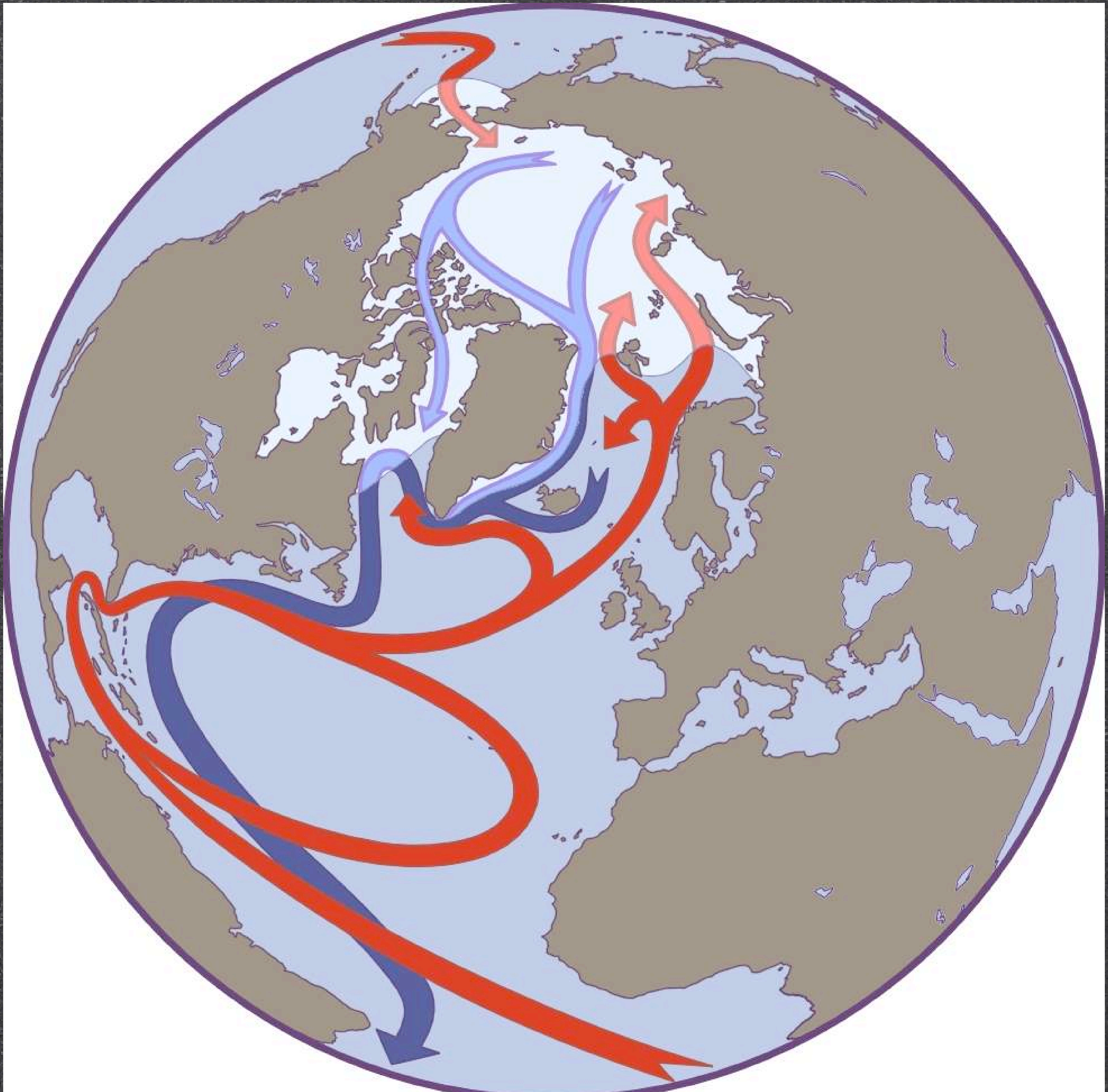
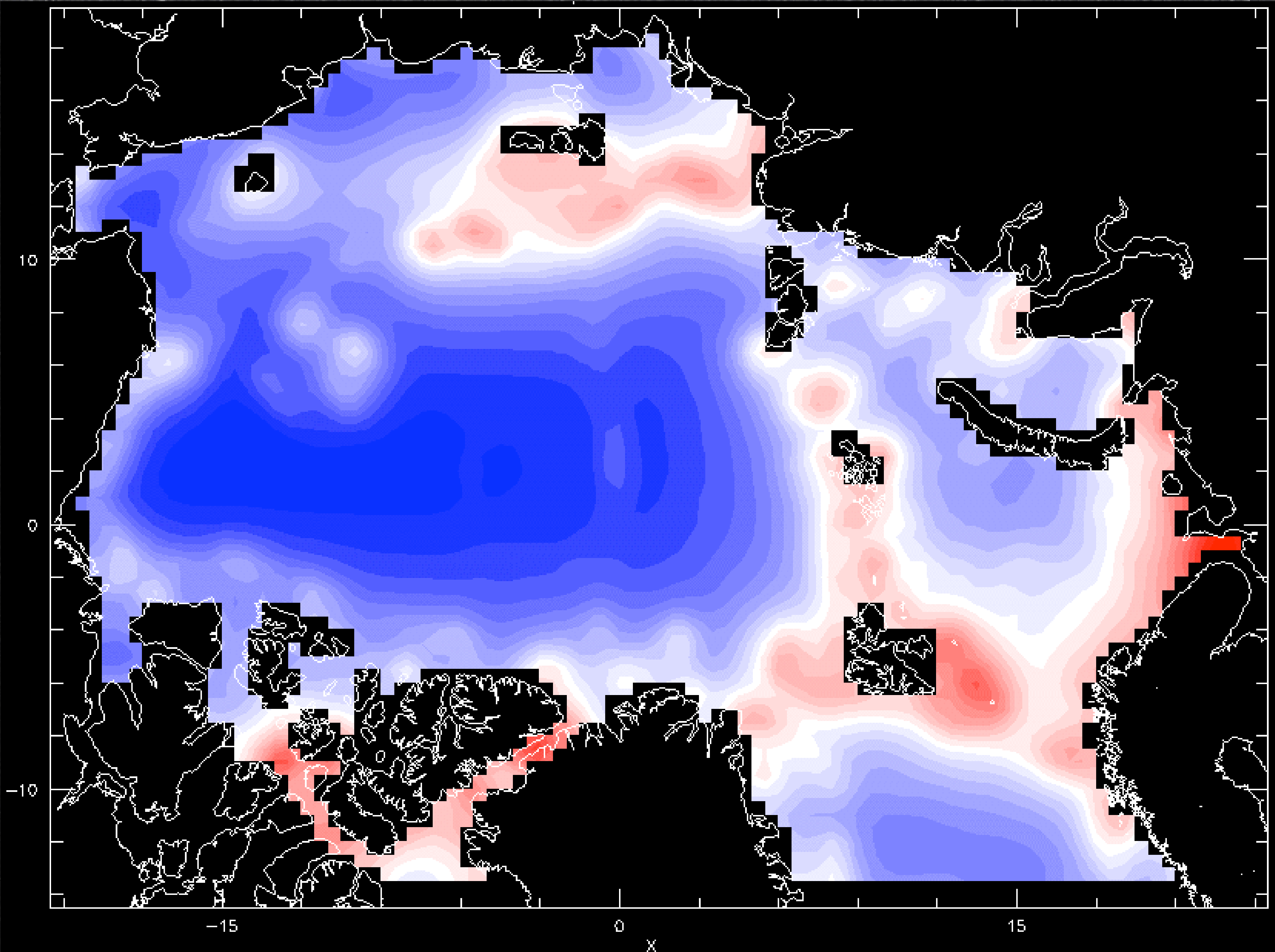
following

Kowalik and Proshutinsky,1994: The Arctic Ocean tides. In: The Polar Oceans and Their Role in Shaping the Global Environment, Geophys Monograph, Amer Geophys Union, 85, pp. 137-158.

The Global Ocean Conveyor Belt







tidal dissipation

From tidal model, averaged over periods from 8 constituents, obtain mean values for

1) watercolumn total dissipation, εD

2) magnitude horizontal divergence, $\delta = |\nabla \cdot U|$

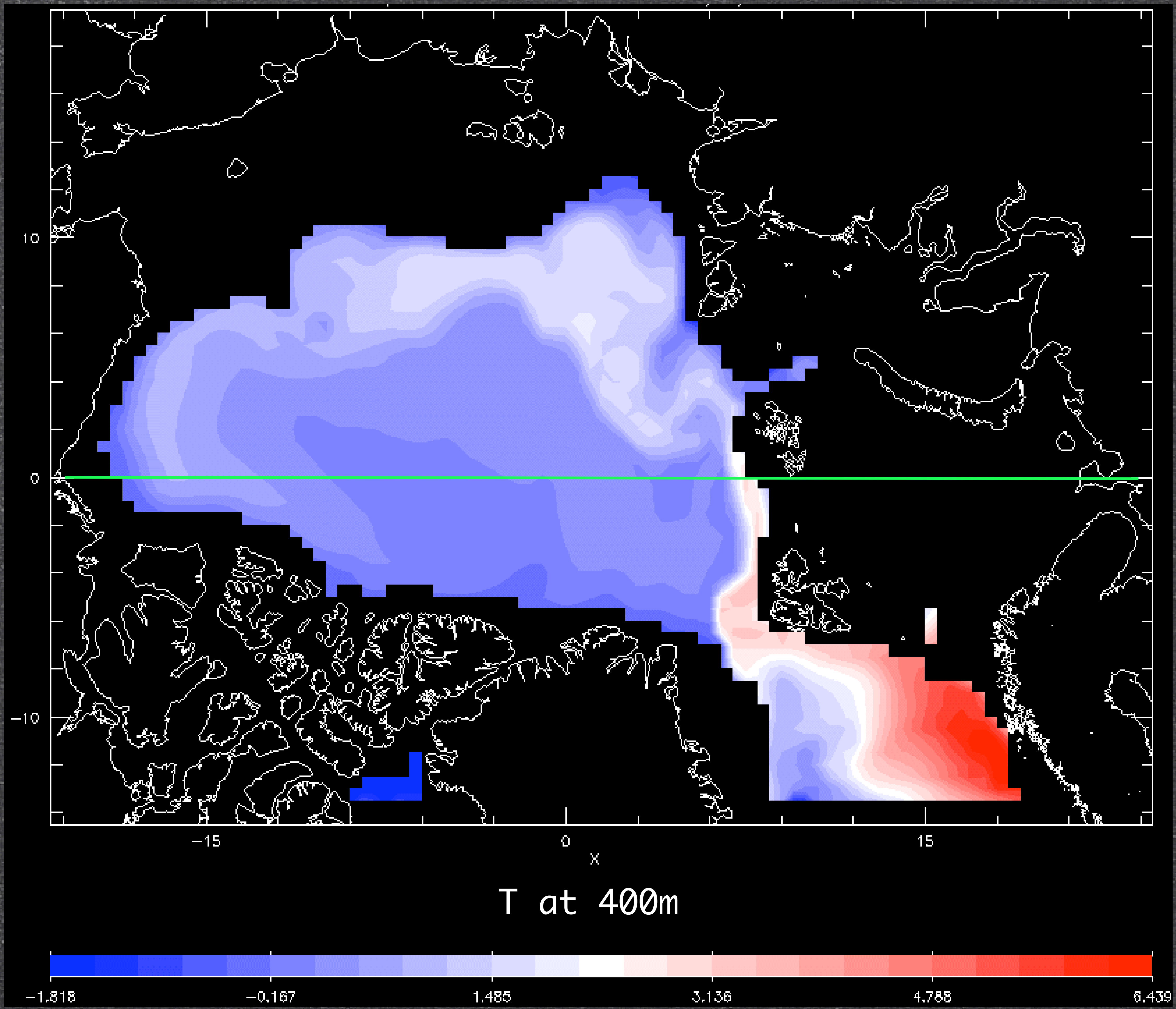
Estimate a reference diffusivity, $K_o = \Gamma\varepsilon / N^2$, where Γ =0.2 is efficiency of conversion to mixing and N^2 is watercolumn averaged stratification. Assume actual K decays upward from the bottom, $K = K_o \exp\{(z - z_b)/Z\}$ with Z a dissipation scale height

Note1: after playing at taking decay also downward from underside of ice, I've set this aside for the present.

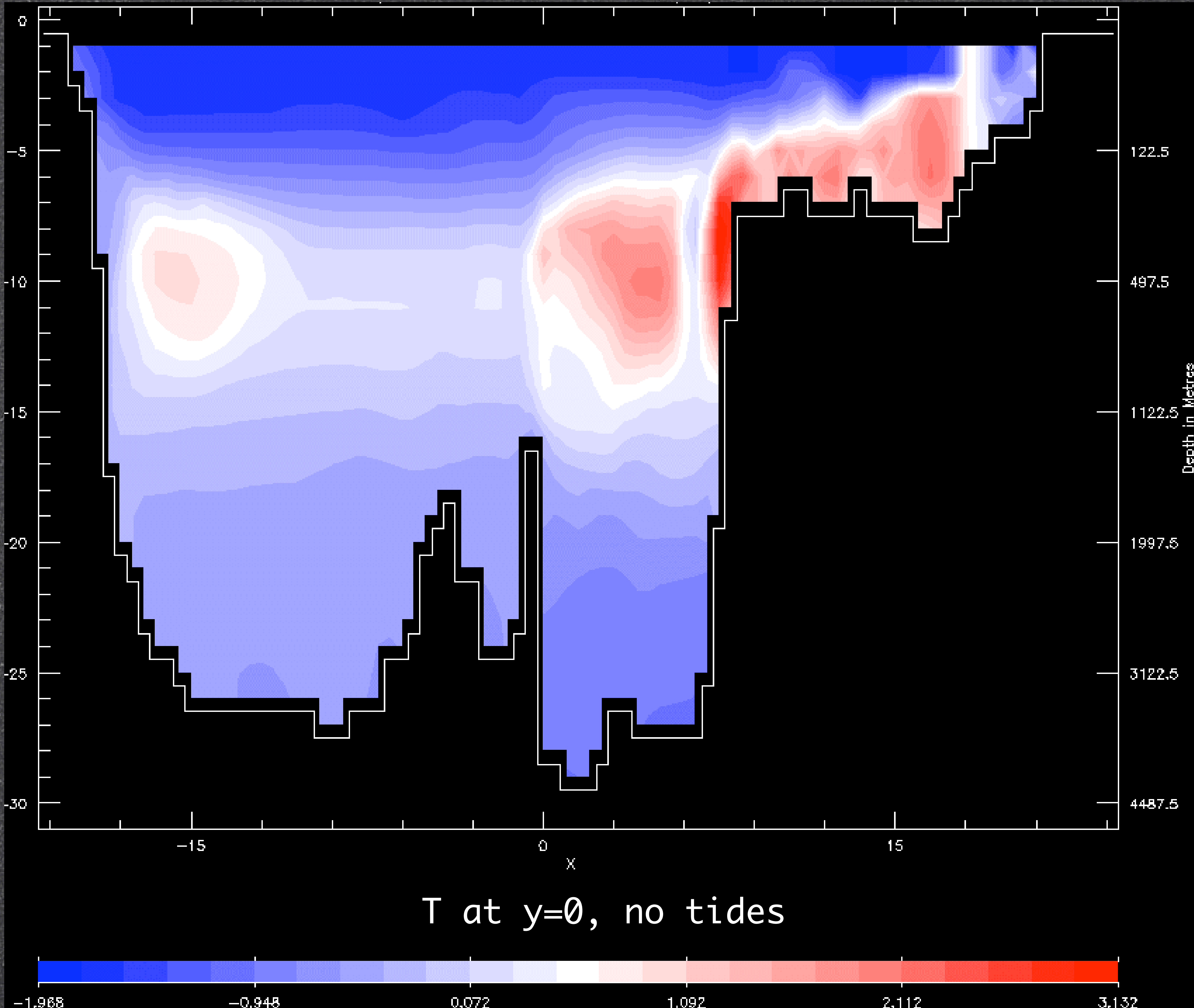
Note2: I ignore entirely topog scattering barotropic => baroclinic => internal wave breaking.

Periodic divergence breaks the ice cover, growing, ridging and mobilizing sea ice. Treat this in terms of "effective" area fraction, A. At every timestep with usual dynamics / thermodyn, reduce A by $\exp\left\{-F\delta dt \exp\left\{-\frac{h}{H} - \frac{1-A}{p\delta}\right\}\right\}$, where F is for Fudge-it, h is cell-average ice thickness, H is an ice-thickness (strength) scale, and p is quarter-period semi-diurnal (= 3 hr).

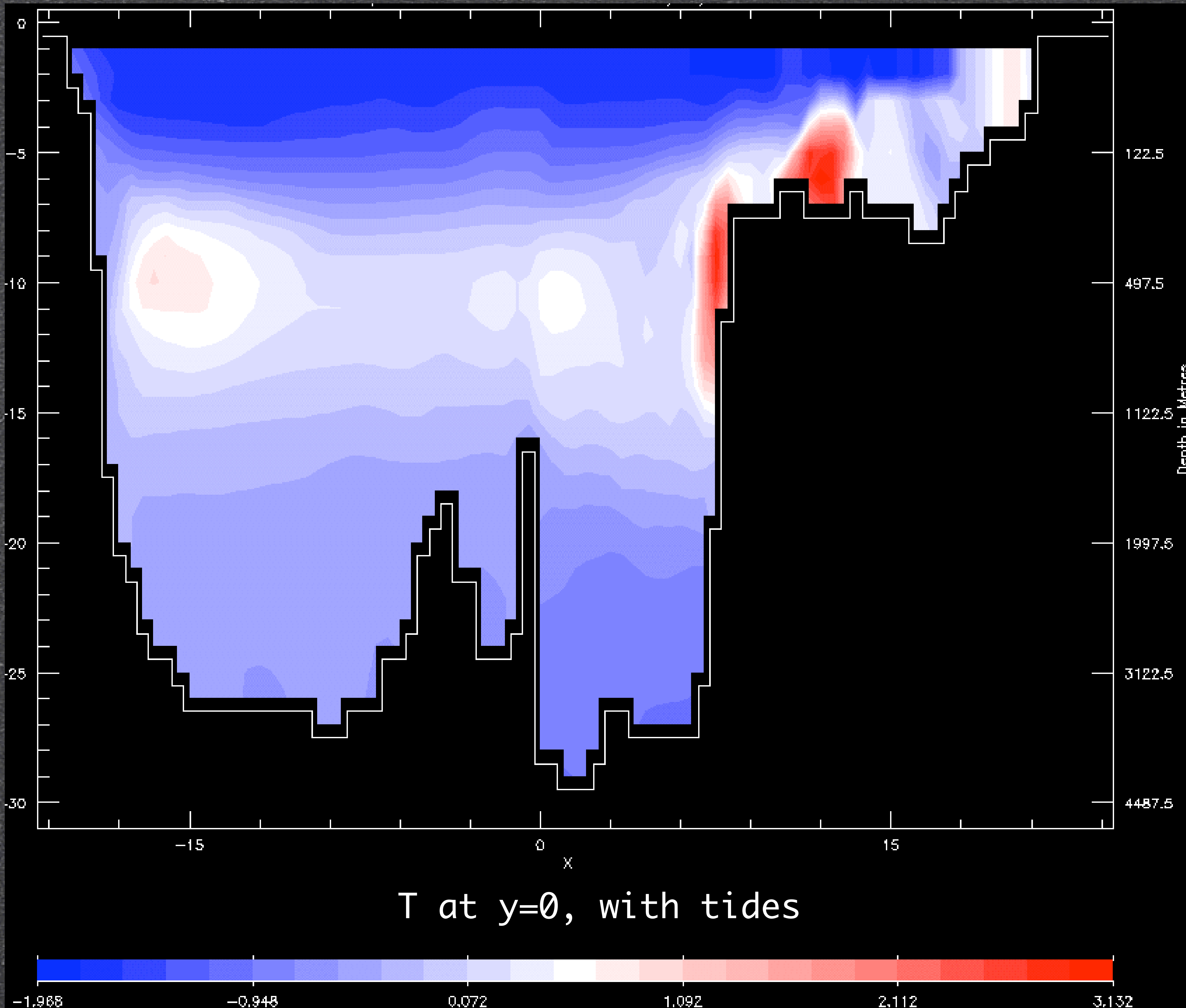
Fudge factors: Γ, Z, F, H and p. Really these are **three**: Z, F, H.



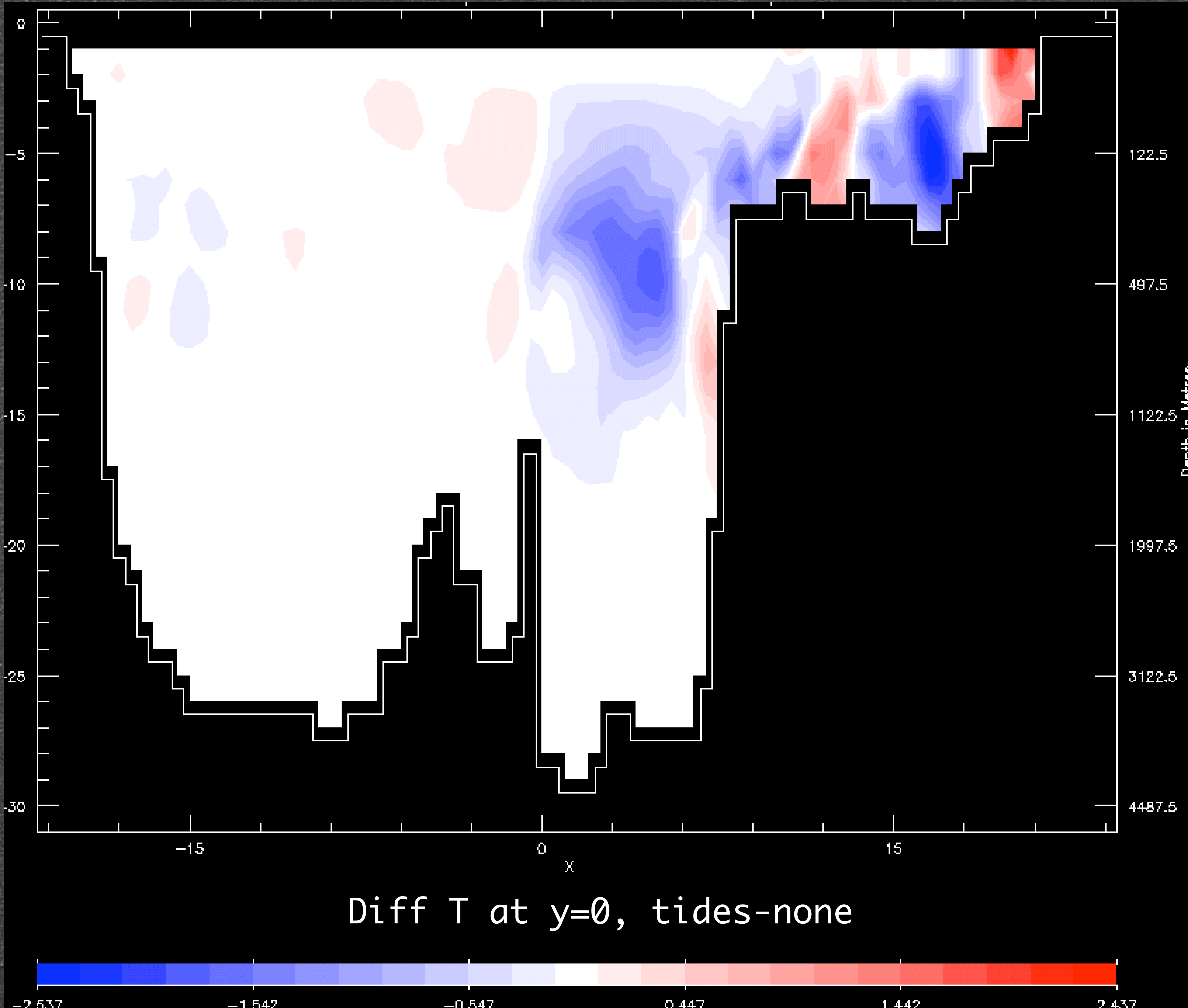
10
0
−10
−15
0
15
X
T at 400m
−1.818
−0.167
1.485
3.136
4.788
6.439



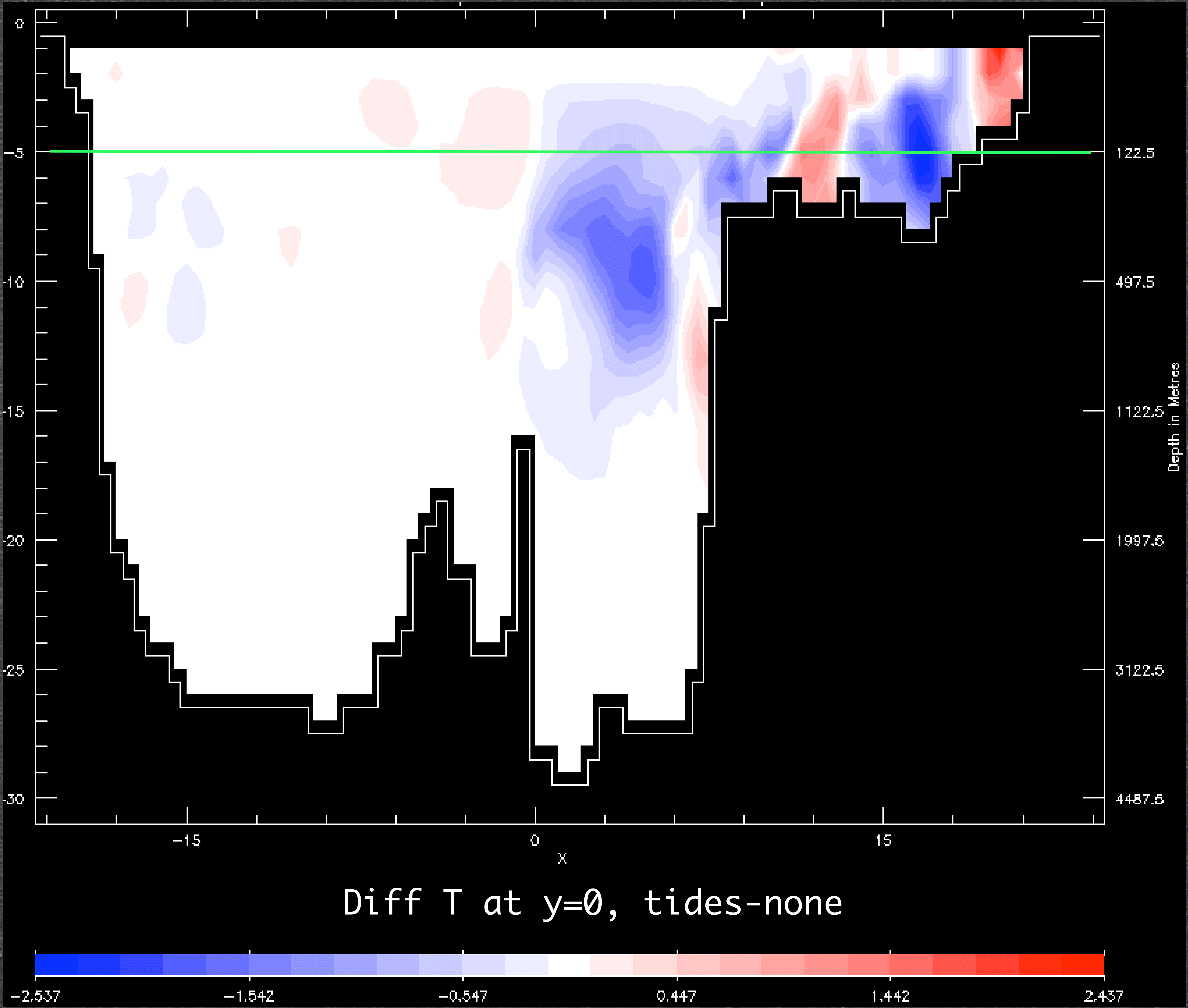
T at y=0, no tides



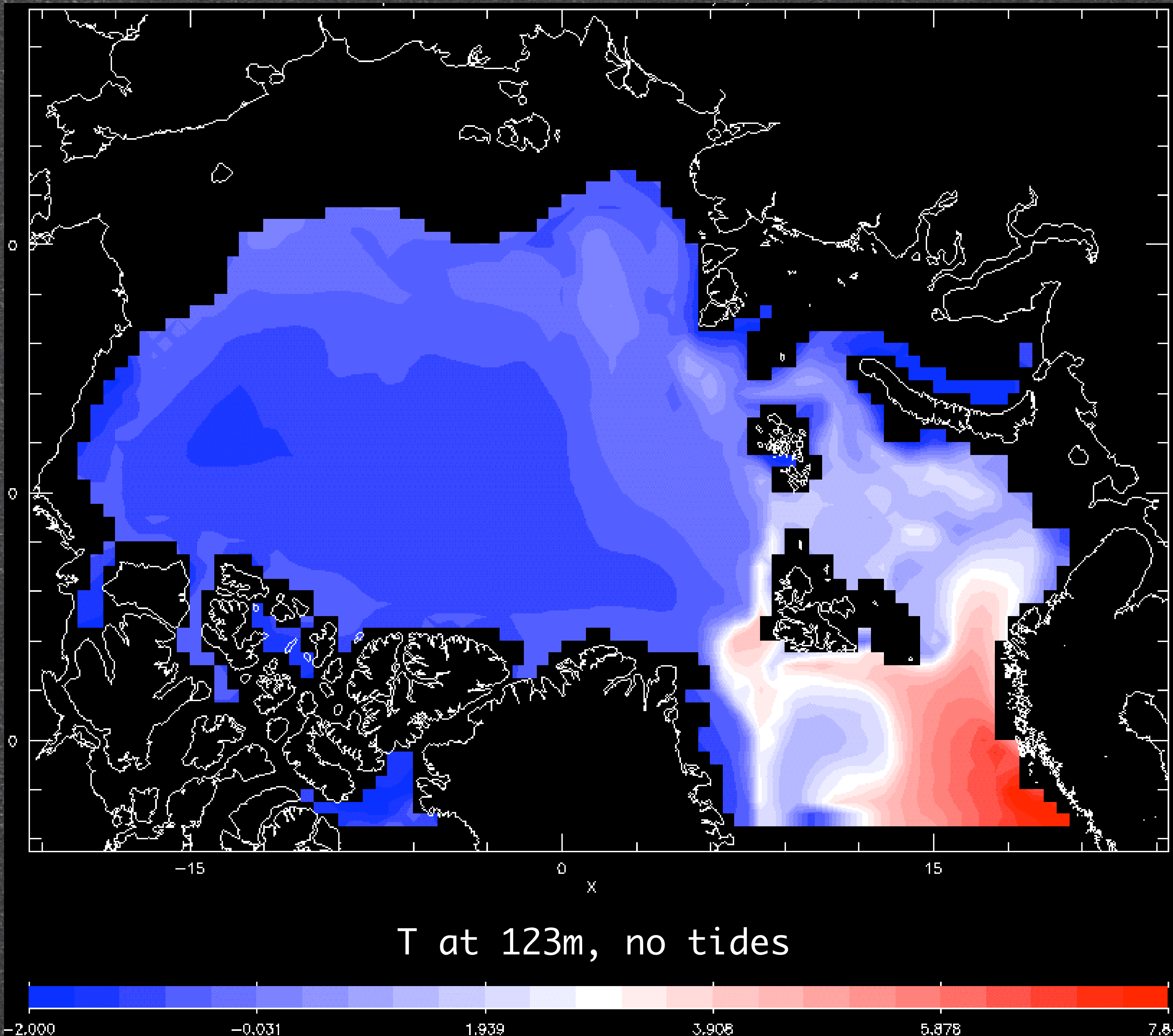
T at y=0, with tides



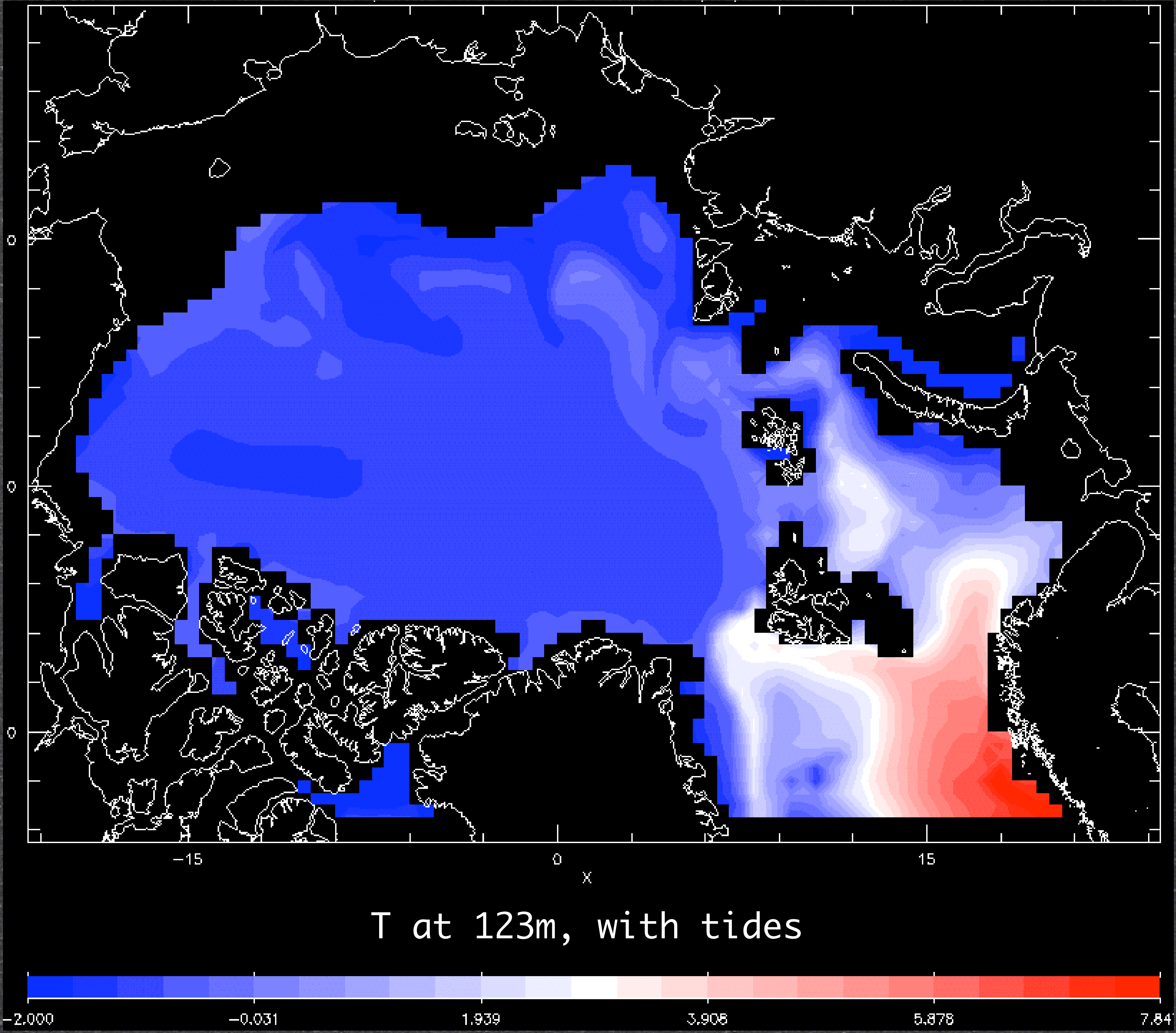
Diff T at y=0, tides-none



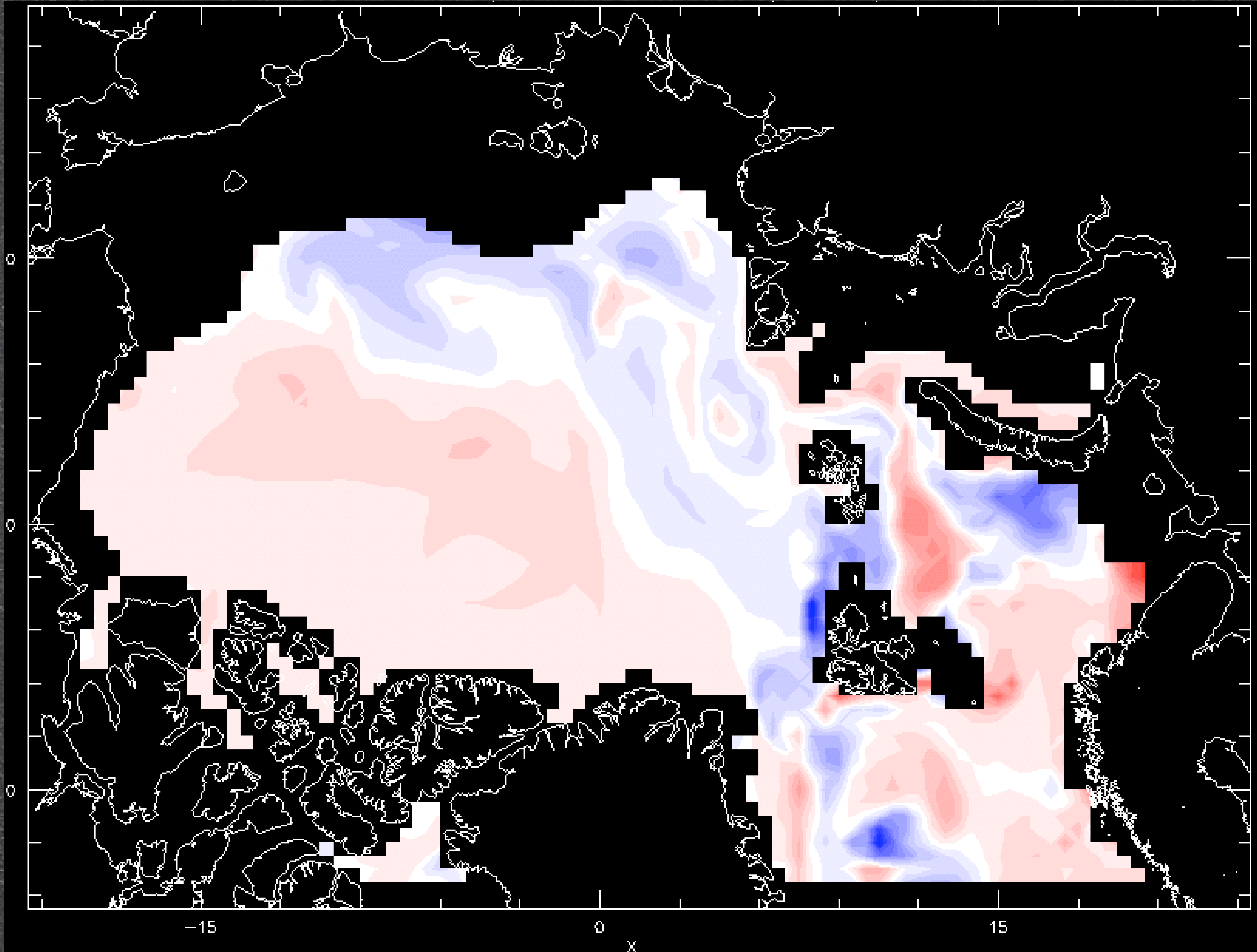
Diff T at y=0, tides-none



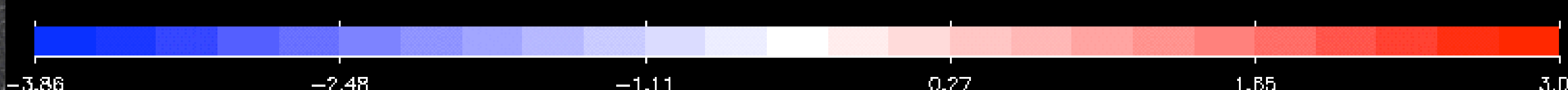
T at 123m, no tides

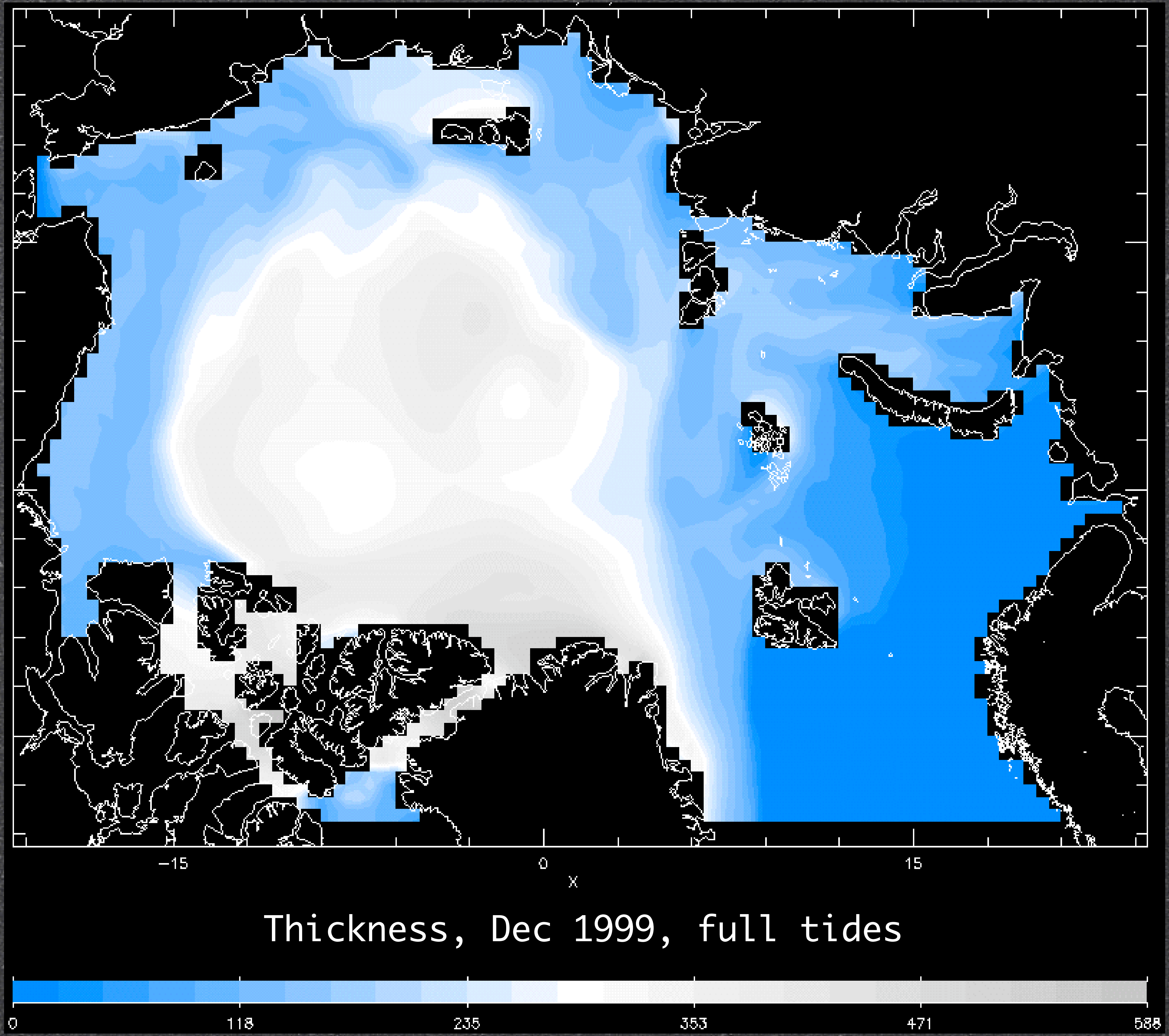


T at 123m, with tides

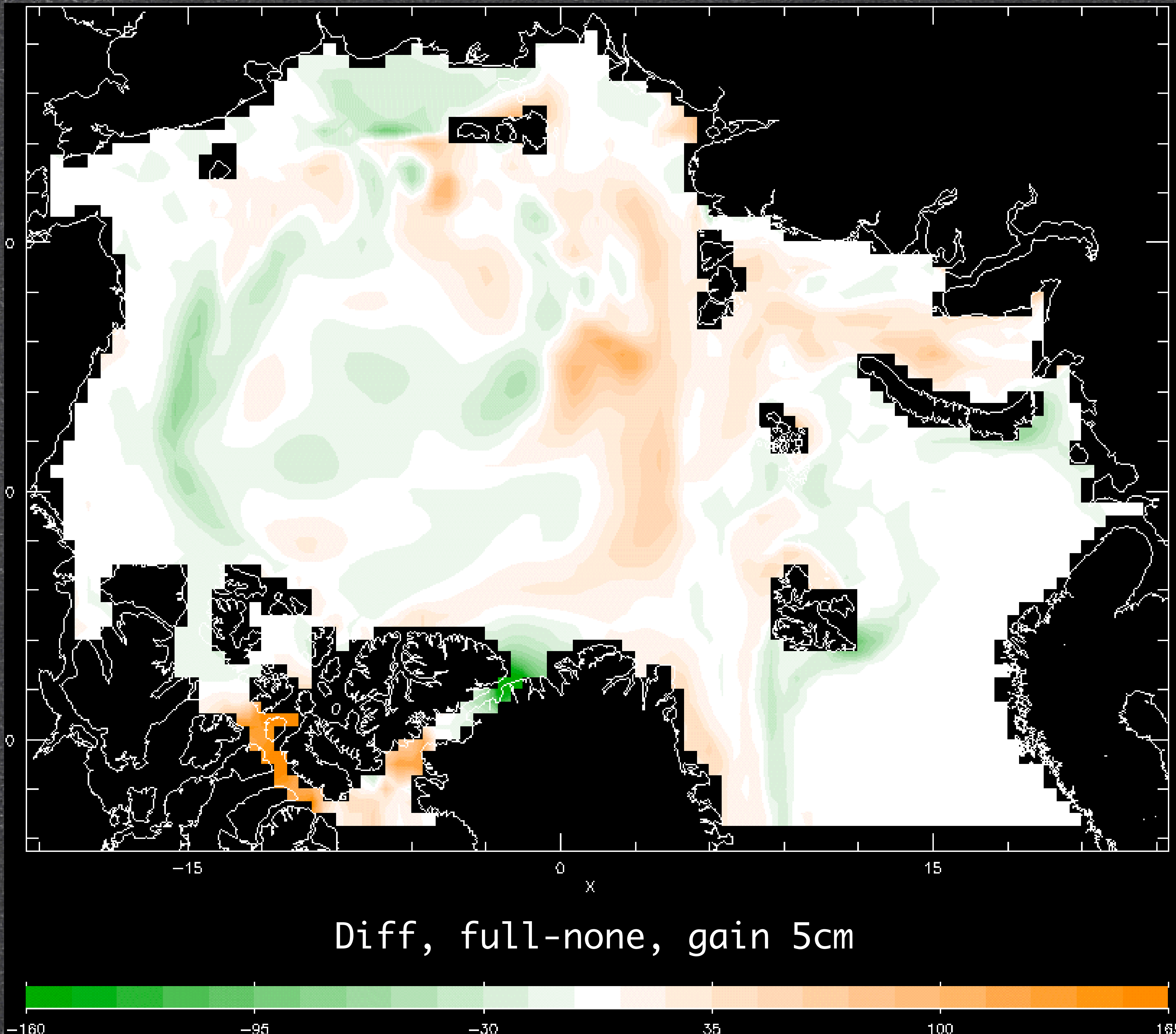


Diff T at 123m, tides-none

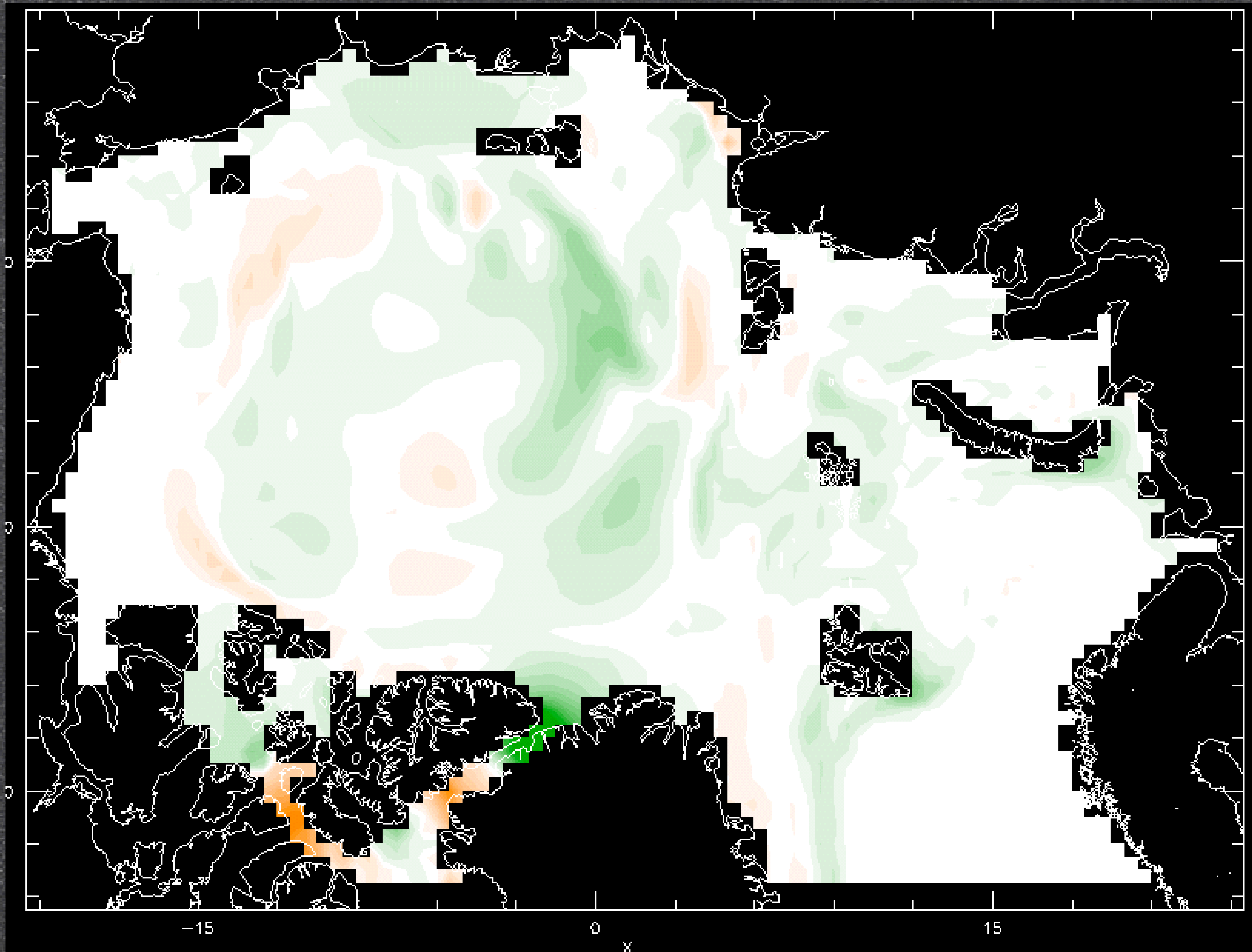




−15
0
15
X
Thickness, Dec 1999, full tides
0
118
235
353
471
588



−15
0
15
X
Diff, full-none, gain 5cm
−160
−95
−30
35
100
165



Diff, ocean only - none, lose 5cm

Where are we?

1. Tidal mixing in ocean
   a) ventilates AW
   b) thins ice

2. Tidal fracturing sea ice
   a) ventilates AW
   b) thickens ice

3. Tides altogether
   a) ventilate AW
   b) ambiguous re ice

4. Tidal (& other) mixing depends on quality advection