PROBLEM SET #3

LARGE-SCALE OCEAN CIRCULATION

1. Consider an equation of state for seawater,

$$\rho = \rho_0[1 - \alpha(T-T_0)+\beta(S-S_0)-\gamma(T-T_0)^2]$$

where ρ_0=1027 kg/m^3, T_0=10^{o}C, S_0=35 ppt, and where we take α=0.0002/^{o}C, β=0.001/ppt.

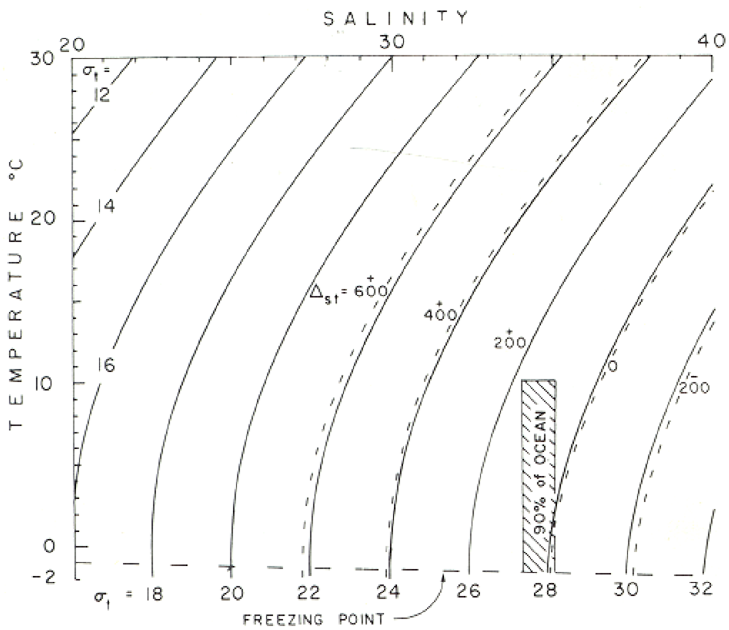


FIG. 2.1 *Values of density (as σ_t) and thermosteric anomaly ($\Delta_{s,t}$) as functions of temperature and salinity over ranges appropriate to most of the oceans. (90% of the world ocean has temperature and salinity values within the shaded rectangle.)*

Assume γ=0.

a. What *type* of equation of state (in a word) does this yield?

b. What is the sigma-t value for seawater with (i) $T=T_0$, $S=S_0$, (ii) T=20^{o}C, S=37ppt, (iii) T=0^o C, S=33ppt. How do these values compare with the true values of sigma-t for these temperatures and salinities (neglecting any pressure dependence)?

c. Suppose that you mix equal volume samples of seawater with the properties of (ii) and (iii) so that the temperature and salinity of the new mixture take on the average values of the two samples. What is the resulting sigma-t value?
$T_{mix}=10^{o}C$, $S_{mix}=35$ ppt.

Now, assume that $\gamma=0.00001/\,^{o}C^{2}$.

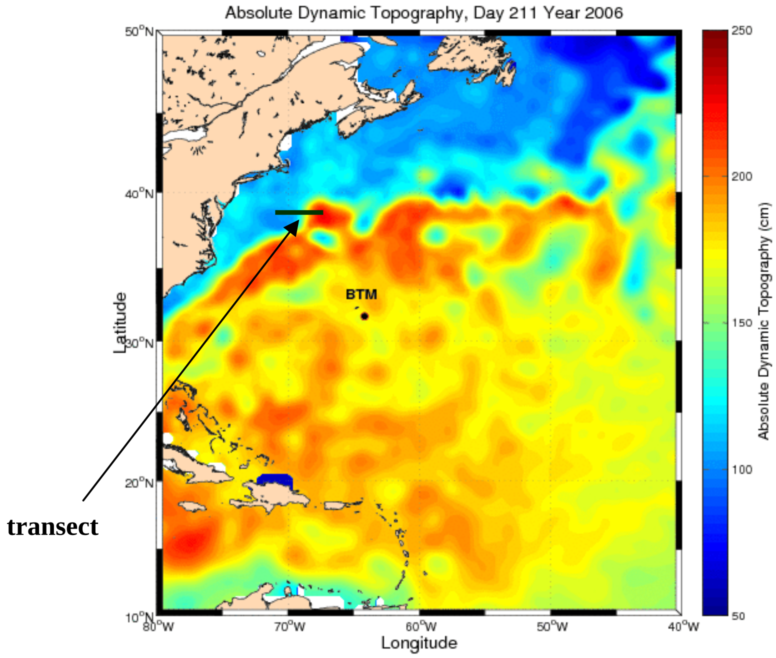
d. What *"type"* of equation of state does this yield?

e. Repeat (b) above.

f. Repeat (c) above

g. Discuss (briefly) the implication of the comparison between (c) and (f) for the formation water masses in the ocean.

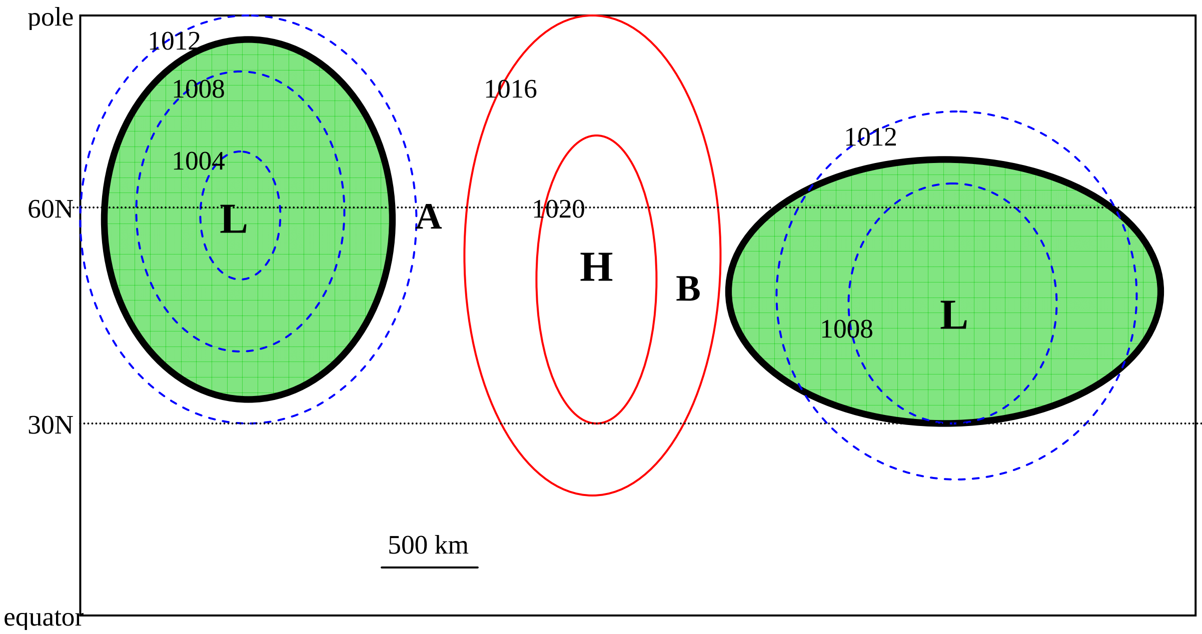
2. Consider the *dynamic topography* map:



a. Sketch the path of the Gulf Stream north of 30N on this particular date.

b. Using the transect shown (which has approximate length 300km), estimate the speed of the Gulf Stream at 38N.

3. Consider this hypothetical Northern Hemisphere:



Ignoring the effects of surface friction:

a. Qualitatively sketch the wind field surrounding points A and B (use arrows whose relative direction qualitatively indicates the direction of the wind).

b. Estimate the Ekman Transport (magnitude and direction) at Points A and B.

c. Would you expect coastal upwelling near point A and/or B? Why or why not?