Homework #4

Introduction to physical oceanography

(First two questions taken from Dr. Robert Stewart's on-line course)

1. Geostrophy and thermal wind:

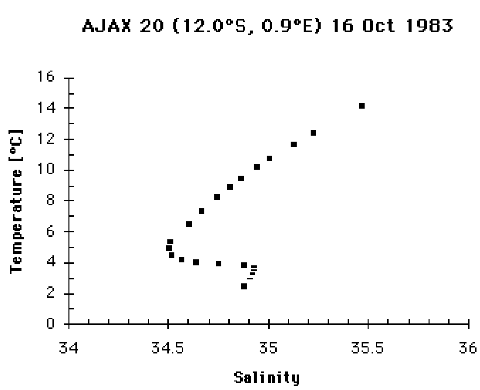
   (a) A satellite altimeter observed that sea level relative to the geoid (the oceanic topography) increased by 1.0 m over a distance of 200 km as the satellite track crossed a current at 35 deg N. If the satellite track is northwest-southeast, and if sea level increases toward the southeast, what can you say about the velocity (magnitude and direction) of the surface geostrophic current? Please give a quantitative answer.

   (b) The average density from the surface to a depth of 2000 decibars at hydrographic station A in the North Atlantic near 35 deg N was observed to be 1027.00 kg/m^3. At station B, 250 km northwest of station A, the average water density from the surface to a depth of 2000 decibars was observed to be 1027.80 kg/m^3. What is the slope of the sea surface midway between A and B assuming the slope is constant between the two stations and that the 2000 decibar surface is a level surface? (that is, 2000 decibar is assumed to be a level of no motion) (Use $g = 9.8m/s^2$). What is the velocity of the surface geostrophic current calculated from this hydrographic data?

   (c) Calculate the velocity at 2000 decibars perpendicular to the line between A and B without assuming that the 2000 decibar level is flat. Use the satellite surface height measurements and the density measurements from the two last questions. What is the speed and direction of the current? Why does the current differ from what you assumed in the previous problem? (This is how altimeter satellite data of sea surface height is used to solve the problem of level of no motion).

   (d) Using the information above, which station has warmer water (assuming that station A and B have the same salinity)? Looking downstream at a point midway between A and B, what is the direction to warm water?

2. T-S diagram and water mass mixing: Using the T-S plot below, which is based on hydrographic data collected from the South Atlantic:



   (a) Where in the South Atlantic is the station located (relative to land or prominent bottom features)?

(b) Assuming mixing occurs along straight lines, draw best-fitting straight lines through the water masses in the figure. Use the intersections of the straight lines to determine water types (temperatures and salinities).

(c) Do the observed data on the Temperature-Salinity curve fit the idea of water masses being formed by the mixing of waters from different water types, e.g. is the fit excellent, good, poor, or very poor? explain.

(d) What are the names of the water types? Very briefly, what are the salinity and temperature of each water mass? Where are they formed (sink from the surface to the deep ocean)? At what depth and geographical areas are they found? (use one of the course textbooks for help with water mass names if needed).

3. Buoyancy oscillations and the thermal expansion coefficient in equation of state: we wrote the linearized equation of state for the density as

$$\rho(T,S) = \rho_0(1 - \alpha(T - T_0) + \beta(S - S_0)) \tag{1}$$

where $\alpha = |(1/\rho_0)\partial\rho/\partial T|$ and $\beta = (1/\rho_0)\partial\rho/\partial S$; look at a table of the equation of state (file equation-of-state-Table.pdf in the supporting material directory under the course home page), to deduce the values of α and β as function of temperature. Now, consider a vertical temperature profile in two cases: (a) the temperature changes from 1 degree at a depth of 200 meters, to 3 degrees at the surface; (b) the temperature changes from 21 degrees at a depth of 200 meters, to 23 degrees at the surface. Assume the salinity is uniform and equal to 35ppt. For each of these two cases,

(a) calculate and plot the density profile.

(b) calculate the Brunt Vaisala frequency in units of $\sec^{-1}$;

(c) calculate the period of buoyancy oscillations in units of seconds and in units of hours.