Homework #3

Introduction to physical oceanography

(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.

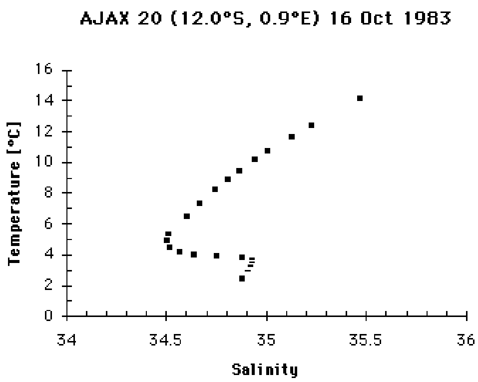
   (b) The average density from the surface to a depth of 2000 decibars at hydrographic station A in the North Atlantic near 35 deg N was observed to be 1027.00 kg/m^3. At station B, 250 km northwest of station A, the average water density from the surface to a depth of 2000 decibars was observed to be 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 $g = 9.8 m/s^2$). 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 the equal salinity)? Looking downstream at a point midway between A and B, what is the direction to warm water?

2. Heat fluxes and heat budget: The error in the estimation of heat fluxes through the sea surface in the equatorial Pacific is about 35 W/m^2. Assume the 35 W/m^2 warms the mixed layer for one year (only the mixed layer, no heat leaks down). If the mixed layer in the eastern equatorial Pacific is 50 m deep, calculate the change in temperature of the mixed layer after one year.

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



∗ Where in the South Atlantic is the station located (relative to land or prominent bottom features)?
∗ 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).
∗ 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.
∗ What are the names of the water types? (use one of the course textbooks for help with water mass names if needed).

p.s. Here is another kind of TS diagram that is used: a "volumetric" histogram of temperature and salinity of cold water in the oceans. Height is proportional to volume. Height of highest peak corresponds to a volume of 26 million cubic kilometers per bivariate class of 0.1°C and 0.01 psu. From Worthington (1981).