ESS206a. Problem set #3

Due at the beginning of class on Thursday, February 5th.
Use SI units, state your assumptions, and show all your work.
Please begin each problem on a separate page.

1 RINGS

The Gulf Stream is located at the boundary between the warm subtropical gyre and the cold subpolar gyre in the North Atlantic. As the current detaches from the coastal region around Cape Hatteras, it starts meandering and eventually form some rings. Look at the web page `http://www.classzone.com/books/earth_science/terc/content/investigations/es2403/es2403page06.cfm?chapter_no=investigation` to understand how this process works. In the figure, red indicates warm water an d green colder water. Check the animations to see the formation of a cold core ri ng and of a warm core ring. Those rings have typically max velocity of about $1 m/s$, occuring at about $100 km$ from the center. Their vertical extension is much much deeper than the mixed layer depth (i.e. their horizontal velocity is different from zero down to more than 1000m). To simplify the visualization of those structure, we can approximate the density in this region of the ocean to be independent of x and y, below the mixed layer. With this assumption the only horizontal variations of density are confined to the surface mixed layer. Those rings are extremely coherent, meaning that there is very little mixing of the inner water with the ambient water. They can survive, without mixing, for several months. Think and briefly comment on the following things.

a) The relative position of warm core rings with respect to the position of the Gulf Stream.

b) How good an approximation geostrophic balance is for those rings (neglect surface friction).

c) The sea surface elevation anomaly in a cold and in a warm core ring.

d) The thickness of the mixed layer in a cold and in a warm core ring.

e) If we want to catch some fish, do you think it's a good idea trying to chase rings?

Those of you who are interested in knowing a bit more about those features, can read a review paper by Donald Olson (1991) "Rings in the ocean", Annual Review of Earth and Planetary Sciences, 19: 283-311.

2 Problem 10.4 of Marshall and Plumb's book (section 10.7).

3 Problem 10.5 of Marshall and Plumb's book (section 10.7).