ESS130 HOMEWORK 6 DUE THURSDAY March 12th, 3:30 p.m.

1 TIDES [50]

What would be the direction and approximate magnitude of the lunar tide-producing forces at

(a) the Earth's center? [10]

(b) a point on the Earth's surface represented by point X on figure 1? [10]

(c) What motion does the tide producing force calculated in part (b) induce on the water at location X? Explain [10]

(d) Using a value of 40000 km for the Earth's circumference and a period of 24h50' (the lunar day), calculate the speed at which the two tidal bulges in the figure would have to move relative to the Earth's surface along the Equator, in order to 'keep up' with the Moon and so maintain an equilibrium tide. (Assume for simplicity that the Moon is directly overhead at the Equator, and that the Earth is an aquaplanet) [10]

(e) How deep would the oceans have to be to allow the tidal bulges to travel as waves at the speed you calculated in part (d)?[10]

2 WIND STRESS [30]

At 45 N off the coast of Oregon, the direction of the near-surface wind is southward during the summer months. Suppose two buoys are moored along an east-west line. Buoy L is located at the coast and buoy M is placed 20 km offshore. The wind stress is $-4.4 \cdot 10^{-2} kg\ m^{-1} s^{-2}$ at buoy L and $-6.7 \cdot 10^{-2} kg\ m^{-1} s^{-2}$ at buoy M.

(a) What is the wind stress curl ($curl \tau = \partial\tau_y/\partial x - \partial\tau_x/\partial y$) between buoy L and buoy M? [10]

(b) What is the Ekman velocity averaged in the Ekman layer, which is 50 *m* deep, at buoy L? And at buoy M? (Magnitude and direction) [10]

(c) What is the vertical velocity at the base of the Ekman layer (magnitude and direction), as driven by the Ekman pumping, between buoys L and M? [10]

3 SVERDRUP BALANCE [20]

The Sverdrup balance is defined by $\beta M_y = curl\ \tau$, where β is the latitudinal change in the Coriolis parameter, M_y is the vertically integrated mass north-south transport per unit width ($M_y = \int_z \rho v dz$, where ρ is density of water which is assumed to be constant and v is th north-south component of velocity), and τ is the surface wind stress. Along 30 N in the Atlantic ocean (where 1 degree Longitude is equal to 96km, and $\beta = 2 \cdot 10^{-11} m^{-1} s^{-1}$), $curl\ \tau = -15 \cdot 10^{-8} N m^{-3}$ and $curl\ \tau$ is constant along the 70 degrees longitude width of the Atlantic Ocean.

(a) What are the magnitude and direction of the longitudinally integrated north-south volume transport (i.e., $(1/\rho)(\int_x M_y dx)$ (in units of Sv) computed from wind stress curl? [10]

(b) Assume that the volume transport of the Gulf Stream at 30 N is equal to

50 Sv. Compare the Gulf Stream volume transport (magnitude and direction) and the volume transport (magnitude and direction) that you computed in (a). Based on your understanding of the subtropical gyre circulation, explain why or why not you were expecting the result that you obtained. [10]