OCEAN 200: Physical Oceanography

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   a) What are its properties?

   b) Why does it occur?

   c) When and where does it occur?

2. Read Talley Section 5.8 and answer the following questions:

   a) What is the difference between wind and wind stress?

   b) Using Figure 5.16a in Talley, describe generally the spatial structure of the annual mean wind stress over the ocean (for simplicity you can describe it as a function of latitude in the middle of the Pacific).

   c) Imagine the usual Cartesian coordinate system in which x is eastward and y is northward placed over the map of wind stress and keep thinking about the middle of the Pacific. Given the shading of the zonal component of wind stress over the Pacific, what is the sign of $\frac{\partial \tau^{(x)}}{\partial y}$ at a latitude of about 30N? What about around 40S?

   d) Identify 2 regions in the northern hemisphere where the wind stress curl is positive and 1 region where it is negative. Identify 3 regions in the southern hemisphere where the wind curl is positive. You can copy the figure from the book or find a similar figure elsewhere (e.g., Fig. 4.4a from Stewart at https://ocean.tamu.edu/academics/resources/ocean-world/resources/Stewart_PObook.pdf; also posted on our class website) and then circle the regions with positive or negative wind stress curl.

3. Ekman Solution (Talley section 7.5.3 and Stewart Chapter 9.2). Assume a northward wind (with a wind stress of 0.1 N/m^2) blows over the ocean at the latitude of Santa Cruz.

   a) Assume that the vertical eddy viscosity is 0.01 m^2/s. Take equations 9.9 in Stewart book (see link in Problem 2 or class website) and plot u(z) and v(z) down to a depth of 90 m. What is the direction of the surface velocity?

   b) Determine the formula for the absolute speed ($U(z) = \sqrt{u^2 + v^2}$) as a function of z and find the level where its value has decreased to 1/e of its surface value.

   c) If you used a value for the viscosity of 0.0001m^2/s (i.e., molecular viscosity), at what depth would the absolute velocity be reduced to 1/e its surface value? Given that observed responses to wind fields often extend over several tens of meters in the upper ocean, which value of the viscosity is more consistent with the data, molecular or eddy?

   d) What is the net mass transport per meter of wind stress (units of $\frac{kg\ s^{-1}}{m}$) driven by this wind stress, and in what direction? Answer this for both the eddy and molecular viscosity

values. What about the volume transport per meter of wind stress (units of $\frac{m^3\,s^{-1}}{m} = m^2 s^{-1}$)?

e) In general, how does the Ekman transport depend on the value of the eddy viscosity?

3. Thoughts on turbulence

a) In one sentence, what is the immediate effect of turbulence in the ocean on local water properties?

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Due: Thursday Nov. 14, 2019

1. Read Talley Section 4.2.2-4.2.4, 7.3.2 and 7.4 (you might also or instead look at the supplemental version of Chapter 7 posted on our class web site) and describe what a surface mixed layer is in terms of:

a) What are its properties?

b) Why does it occur?

c) When and where does it occur?

2. Read Talley Section 5.8 and answer the following questions:

a) What is the difference between wind and wind stress?

b) Using Figure 5.16a in Talley, describe generally the spatial structure of the annual mean wind stress over the ocean (for simplicity you can describe it as a function of latitude in the middle of the Pacific).

c) Imagine the usual Cartesian coordinate system in which x is eastward and y is northward placed over the map of wind stress and keep thinking about the middle of the Pacific. Given the shading of the zonal component of wind stress over the Pacific, what is the sign of $\frac{\partial \tau^{(x)}}{\partial y}$ at a latitude of about 30N? What about around 40S?

d) Identify 2 regions in the northern hemisphere where the wind stress curl is positive and 1 region where it is negative. Identify 3 regions in the southern hemisphere where the wind curl is positive. You can copy the figure from the book or find a similar figure elsewhere (e.g., Fig. 4.4a from Stewart at https://ocean.tamu.edu/academics/resources/ocean-world/resources/Stewart_PObook.pdf; also posted on our class website) and then circle the regions with positive or negative wind stress curl.

3. Ekman Solution (Talley section 7.5.3 and Stewart Chapter 9.2). Assume a northward wind (with a wind stress of 0.1 N/m^2) blows over the ocean at the latitude of Santa Cruz.

a) Assume that the vertical eddy viscosity is 0.01 m^2/s. Take equations 9.9 in Stewart book (see link in Problem 2 or class website) and plot u(z) and v(z) down to a depth of 90 m. What is the direction of the surface velocity?

b) Determine the formula for the absolute speed ($U(z) = \sqrt{u^2 + v^2}$) as a function of z and find the level where its value has decreased to 1/e of its surface value.

c) If you used a value for the viscosity of 0.0001m^2/s (i.e., molecular viscosity), at what depth would the absolute velocity be reduced to 1/e its surface value? Given that observed responses to wind fields often extend over several tens of meters in the upper ocean, which value of the viscosity is more consistent with the data, molecular or eddy?

d) What is the net mass transport per meter of wind stress (units of $\frac{kg\ s^{-1}}{m}$) driven by this wind stress, and in what direction? Answer this for both the eddy and molecular viscosity

values. What about the volume transport per meter of wind stress (units of $\frac{m^3\, s^{-1}}{m} = m^2 s^{-1}$)?

e) In general, how does the Ekman transport depend on the value of the eddy viscosity?

3. Thoughts on turbulence

a) In one sentence, what is the immediate effect of turbulence in the ocean on local water properties?

b) Describe 3 factors that can increase turbulence in the ocean.

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