PHYS 2265: Intro to GFD
Modeling Project 5

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In this project, we develop a toy model to describe the wind-driven circulation. Assume that we are considering a rectangular basin 100 km wide (x), 100 km long (y), and 4 km deep (z). The wind forcing over the region can be characterized by:

$$\vec{\tau}(x,y) = \left[0.1 \sin\left(\frac{y}{33 \text{ km}}\right) \sin\left(\frac{y}{18 \text{ km}} - 10\right) \text{ N/m}^2\right]\hat{x}$$

For the following calculations, you may assume that f is of order 10^{-4} s^{-1}, β is of order 10^{-11} m^{-1}s^{-1}, and the background density if 10^3 kg m^{-3}.

1. Plot the wind stress and the corresponding mass transport. What is the orientation between the wind stress and the mass transport? In two to three sentences, describe why this is the case. Additionally, comment on how the wind-induced circulation varies with depth; does it have the same orientation as the mass transport you just calculated?

2. Based on your plots presented in 1., indicate where you expect Ekman upwelling and Ekman downwelling to occur. Please provide a few sentences of explanation.

3. Using your experience from our field trip, and what you learned in class, speculate where on your map you would expect to see high chlorophyll levels. Give a several sentence explanation.

4. Calculate and plot the Sverdrup transport stream function assuming that there is a continent along the zonal edges, $x = 0$ and $x = 100$ km. Superimposed on the stream function, plot the depth-integrated flow as vectors (with components U and V). In one to two paragraphs, describe the circulation pattern.

5. While your plot in 4. closely resembles the wind-driven gyres, there is a noticeable issue at the Western boundary. In two to three sentences explain why. Then, replicate your plot from 4., with additional arrows drawn on at the Western boundary (however you want to draw them is fine, don't worry about making it look nice) so that mass conservation is satisfied. How does the magnitude of these Western Boundary Currents compare with the currents elsewhere in the gyres?

6. The Great Pacific Garbage Patch is a collection of marine debris in the North Pacific Ocean. The Patch (which is actually composes of two patches, one in the West and another in the East) is located inside the North Pacific Subtropical Gyre. Using the plot of the toy model gyre circulation you created in 4., explain why, once marine garbage is in the Patch, it doesn't leave.

When you have completed the project, please assemble your results (figures and answers to questions) and a copy of the code into one file for submission.