

**Ocean 420 Physical Processes in the Ocean  
Project 2: Force Balance and Geostrophy  
Due: Thursday, January 25th**

**To get started**

1. Login  
    Username: Ocean Class (click on the icon)  
    Password: *ocwaves*
2. Start up MATLAB
3. At the MATLAB prompt, type: `cd c:\classes\ocean420` to change to the Ocean 420 directory
4. Type: `ocean420` to begin running program – you will see a small window pop up with Ocean 420 in the title bar, from here you can choose a demonstration.

**1. Geostrophic Shear**

From the list of demonstrations, choose *Geostrophy* and then *Geostrophic Shear*. In this exercise, the Margules equation is used to calculate the geostrophic velocities between two stations. Density profiles with depth at both stations are shown in the leftmost panel. On the right, choose 2 layers, with the reference layer at the bottom and a reference velocity of zero. Hit the *Apply* button. In the middle panel, an interface between the two layers is drawn which is a line of constant density (isopycnal) and the velocities normal to the page are displayed. Note: positive is out of the page as in this case we are looking at zonal (east/west) velocity. The velocity profile with depth is also plotted in the rightmost panel. Convince yourself that the correct solution is displayed. Remember: the Margules equation says the velocity shear is proportional to the slope of the isopycnals.

Answer the following questions.

- a. Choose a 5-layer model with the reference velocity of zero at the bottom (layer 5). Write down the equations for the  $u$  velocity in each layer starting from the bottom. Why does the velocity increase with height? What is the difference between the maximum and minimum velocities?
- b. Now switch the reference layer to be the uppermost layer (layer 1). What happens to the velocity profile? What is the difference between the maximum and minimum velocities?
- c. Next try with the reference layer in the middle layer (layer 3). What happens to the velocity profile?
- d. Finally, with the reference layer at the bottom, choose a reference velocity of 0.1 m/s. How does this change the velocity profile? What is the difference between the maximum and minimum velocities? Is this different from that in the cases with a zero reference velocity?

**2. Geostrophic Velocity in the North Atlantic Subtropical Gyre**

(Do not turn this one in)

From the list of demonstrations, choose *Geostrophy*, then *North Atlantic Subtropical Gyre*. The top left panel shows the mean density at 1000 m off the northeast coast of the United States. Stations A and B on the red line are locations where density profiles have been measured. The upper right panel shows the corresponding density/depth section. Density sections like this one can be used to calculate the relative geostrophic velocities.

Click on the top right *Display* button to see the geostrophic velocity at 1000 m relative to the sea surface (calculated assuming zero velocity at the sea surface). Do the geostrophic currents look like you might expect?

Display the sea surface height *Display* button. This sea surface height can be used to calculate the geostrophic velocity at the sea surface. Click on the button to display the sea surface velocities.

The surface velocities can then be used as the reference surface velocities (as zero surface velocity was not really a good assumption!) Display the total velocity at 1000 m.

### 3. Geostrophic flow in the Southern Ocean

On the next page is a density section from the southern ocean, with an idealization of the density section on the following page. You may assume that the latitude of the section is 55S. Because the isopycnals never really become flat, the reference level is not necessarily at the bottom.

- a) If the reference level is at the bottom (layer 4 has no velocity), what direction is the geostrophic flow?
- b). If the reference level is at the bottom, draw a quantitative picture of the sea surface height as a function of distance from the beginning of the section. Give units and sizes.
- b). If the reference level is at the bottom, what is the velocity in each layer? Be quantitative. Make a drawing of the velocity profile.
- c). If the reference level is at the bottom, what is the total transport of the current (units of  $\text{m}^3/\text{s}$ )? (hint to find the area of a trapezoid, go to [http://argyll.epsb.ca/jreed/math9/strand3/trapezoid\\_area\\_per.htm](http://argyll.epsb.ca/jreed/math9/strand3/trapezoid_area_per.htm))
- d). Now assume that the flow in the bottom layer is 5 cm/s. What is the velocity in each of the other layers?
- e) Draw a quantitative picture of the sea surface height assuming a 5 cm/s flow in the bottom layer.
- f) What is the total transport of the current with flow of 5 cm/s in the bottom layer?

CTDI-P16  
Sigmals 0-2-4 (kg/m<sup>3</sup>)

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