Ocean 420 Physical Processes in the Ocean
Project 3: Force Balance and Ekman Transport
Due: Thursday, February 1st

To get started

a) Login
   Username: Ocean Class (click on the icon)
   Password: *ocwaves*
b) Start up MATLAB
c) At the MATLAB prompt, type: *cd c:\classes\ocean420* to change to the Ocean 420 directory
d) 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.

(Note: we use the atmosphere as example in this exercise)

Force Balance (do not turn this one in)

In this exercise, you will examine the resulting flow field under different force balances. After you have selected *Force Balance* from the list of demonstrations you will see a plot of the mean January sea level pressure over the North Pacific. This demo will calculate the flow field based on the force terms selected. Before selecting terms, press *Display Real Wind* to see the mean January surface wind over the North Pacific. You will use this to evaluate how well the various force balances are doing at predicting the real flow.

You will need to look at 5 different balances to answer the questions.

a) Pressure gradient force balancing Coriolis force.
   How well does the geostrophic balance hold for the surface winds in the North Pacific? Where does it not hold?

b) Acceleration balancing pressure gradient force.
   In this case, the pressure gradient is specified. What happens over time (i.e. what direction and how big is the flow)? Why?

c) Acceleration balancing Coriolis force.
   Look at the magnitude and direction of the wind over time. Describe what you see. (Try looking at only one vector.)

d) Friction balancing acceleration.
   In this case, the initial condition is the geostrophically balanced flow. Try both with large and small values of friction. Does the flow slow down more quickly with larger or smaller friction? Why? Does the direction of the flow change with time? Why?

e) Friction balancing pressure gradient force.
   What direction is the flow? How does the magnitude of the flow depend on friction? Why?

2. Ekman transport.

Download wind data for the Pacific from the web page. In the plots you create below, only show results for 10N to 50N. The file is wind.dat and it contains the zonal (east-west) wind in m/s as a function of latitude. Turn in the plots and be sure to say what the units are for each quantity.

a) Plot the wind as a function of latitude.
b) Plot the stress as a function of latitude. You may use a drag coefficient of 1×10^{-3} and an air density of 1.3 kg/m^3.
c) Calculate *f* as a function of latitude and plot it (be sure to calculate it using the correct units, degrees or radians, for the latitude).
d) Calculate the Ekman volume transport per unit distance as a function of latitude and plot it.
e) For a basin 100 degrees wide for all latitudes, what would the total Ekman volume transport be at each latitude?
f) We discussed in class that if the Ekman transport changes spatially, we would expect that to cause an upwelling or downwelling. We know that to conserve mass we must have (for no flow in the zonal direction)

$$\frac{\partial v}{\partial y} = -\frac{\partial w}{\partial z}$$

If we integrate vertically from the base of the Ekman layer to the surface, we get

$$\frac{\partial V}{\partial y} = -w_{top} + w_{bottom},$$

where V is the meridional Ekman volume transport per unit distance. The flow through the surface is zero so

$$\frac{\partial V}{\partial y} = w_{bottom}.$$

Using this formula, calculate the vertical velocity at the base of the Ekman layer and plot it.