Department of Earth & Climate Sciences NAME__________________________
San Francisco State University ERTH 260

Inclass Exercise 12 Key
Geostrophic Flow in the Atmosphere and the Ocean
100 points (Due Friday 4 May 2018)

Part I. You are provided the 500 mb analysis (without data plots) for 12 UTC 9 February 2005. Note the station in southeastern Oklahoma (indicated by the square). The line segment shown is a portion of the "n" axis (normal to the flow) at that location, with the segment length shown there (delta n) = 300 km.

The geostrophic wind speed can be calculated from the expression

$$V_g = -{}^{g}/_{f}\ {}^{\Delta z}/_{\Delta n}$$

where g is gravity, 9.8 m s^{-2} , f is the Coriolis parameter, numerically equal to approximately 10 X 1 0^{-5} s^{-1} at around the latitude of the station shown, delta z is the difference in 500 mb heights normal to the flow measured along the increment delta n (remember, to estimate a gradient, take the value at location 2, furthest along the positive directon of the given axis, and subtract from it the value at location 1.)

1. Estimate the value of the geostrophic wind in meters per second, kilometers per hour and knots at the location shown;

2. Plot the value with conventional weather map symbols for wind direction and wind speed (knots) on the map. Lay out all steps on a separate sheet, show all expressions. 1 knot=0.514 m s^{-1}

   Caution, Caution: *the challenge here will be to keep units consistent initially. Please remember that when you solve for the geostrophic wind speed using the above expression, your result will initially be in meters per second. You will need to convert that to kilometers per hour and knots. Remember that a nautical mile is 6040 feet.*

3. With a long arrow/streamline drawn right on the chart, locate the position of the fastest current (the polar jet stream).

Describe the Problem

The task is to compute the speed of the geostrophic wind speed at a point located on the 500 mb surface at 12 UTC 9 Feburary 2005. We are given the 500 mb map that shows the topography of the 500 mb surface. We are also given the increment over which the wind speed is to be evaluated, delta n= 300 km.
The expression to be used is the version of the simplified equation of motion known as the geostrophic wind relation, given above. The expression contains the acceleration of gravity and the value for the Coriolis Parameter at the given location. The values of these two constants are:
$g = 9.8\ m\ s^{-2}$
$f = 10\ X\ 10^{-5}\ s^{-1}$
delta n = 300 km

The problem also involves evaluation of $\Delta z/\Delta n$ centered at the location given. To evaluate this, one needs to read the values of the 500 mb heights at either end of the interval given. In this case $z_2 = 5580$ m and $z_1 = 5700$ m.

2. Plan the Solution
The solution involves a so-called "finite difference" approximation of the expression $\Delta z/\Delta n$.

Step 1: This can be expanded out: $(z_2 - z_1)$/ ?n.

Step 2: Once this is computed a simple multiplication of the quantity -g/f will give the desired result.

3. Implement the Plan
Making the appropriate substitutions and using consistent uints we get:

Step 1: $\Delta z/\Delta n = -(5580m-5700m)/3.0\ X\ 10^{5} m = -\ 4.0\ X\ 10^{-3}$

This then needs to be multiplied by

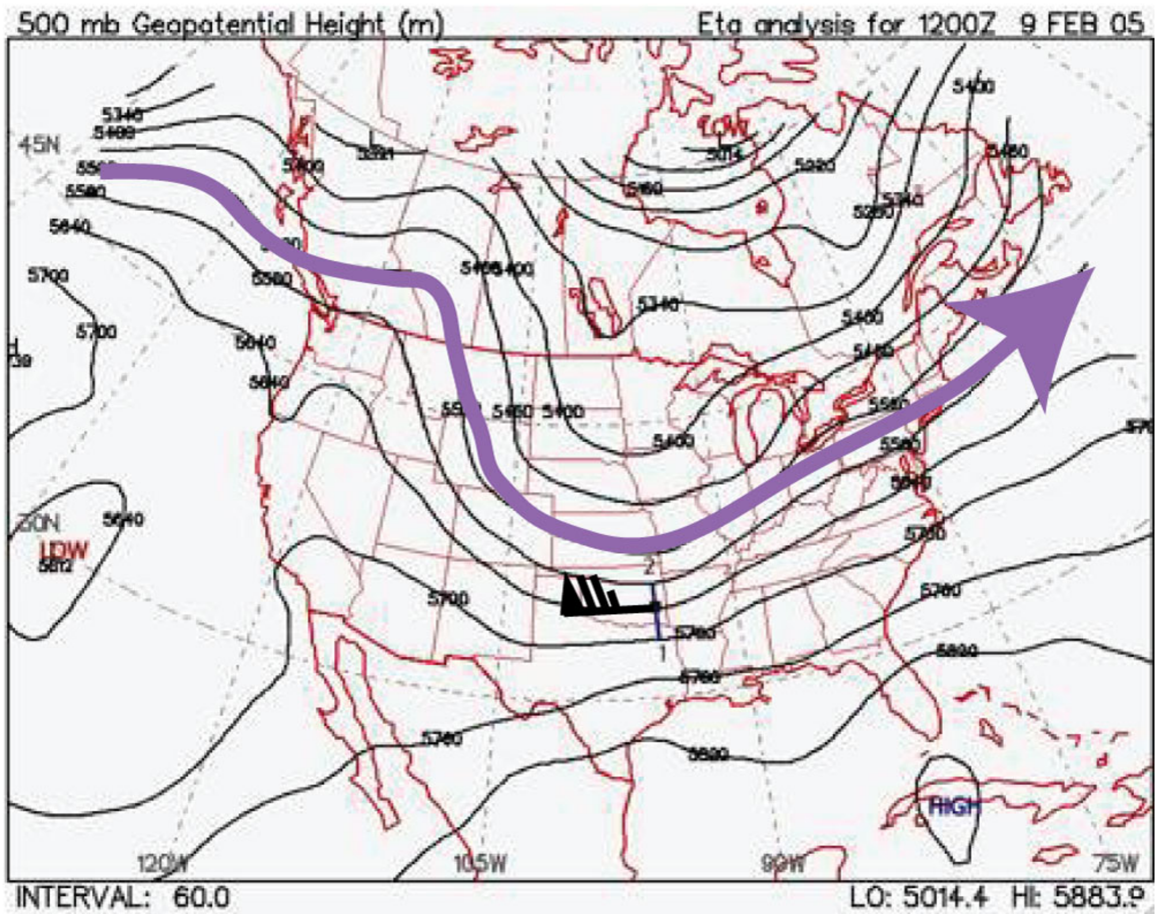
*Step 2: $V_g = -\ [(\ 9.8\ m\ s^{-2})/10\ X\ 10^{-5}\ s^{-1}]\ [-\ 4.0\ X\ 10^{-3}]$ = **39.1 m s^{-1}=141.1 km h^{-1}***

*(39.1 m s^{-1}) X 100 cm/m X 1 inch/2.54 cm X 1 foot/12 in X 1 nautical mile/6040 ft X 3600 s/h = **77.1 knots***

*Answers: **77.1 knots=39.1 m s^{-1}=141.1 km h^{-1}***

2. With a long arrow/streamline drawn right on the chart, locate the position of the fastest current (the polar jet stream).

Fig. 1: 500 mb chart for 1200 UTC 9 February 2005



Part II. You are provided with the time-averaged topography of the ocean (cm) relative to mean sealevel for the period 1992–2002 Note the two locations at 40N in the eastern and western Pacific. The line segment shown is a portion of the "n" axis (normal to the flow) at that location, with the segment length shown there $\Delta n = 300$ km.

The speed of the geostrophic current can be calculated from the expression

$$V_g = -{}^{g}/_{f}\,{}^{\Delta z}/_{\Delta n}$$

where g is gravity, 9.8 m s^{-2} , f is the Coriolis parameter, numerically equal to approximately 10 X 10^{-5} s^{-1} at 40N, Δ z is the difference in sea-surface height topography normal to the flow measured along the increment Δn (remember, to estimate a gradient, take the value at location 2, furthest along the positive directon of the given axis, and subtract from it the value at location 1.) In this case, Δn=300 km.

1. Estimate the value of the geostrophic current meters per second, kilometers per hour and knots at the locations shown. Lay out all steps, show all expressions.

> **Caution, Caution:** *the challenge here will be to keep units consistent initially. Please remember that when you solve for the geostrophic wind speed using the above expression, your result will initially be in meters per second. You will need to convert that to kilometers per hour and knots. Remember that a nautical mile is 6040 feet.*

*1. Same procedure as above. *Note--for delta n of 300 km.*

Eastern Pacific (20 points)

g = 9.8 m s^{-2}
f= 10 X 10^{-5} s^{-1}
delta z/delta n= -(1.0 X 10^{-1}*m-3.0 X* 10^{-1}*m)/3.0 X* 10^{5}*m = -6.7 X* 10^{-7}

V_g *= - [(9.8 m* s^{-2}*)/10 X* 10^{-5} s^{-1}*] [-6.7 X* 10^{-7}*] =* ***0.066 m*** s^{-1}***= .24 km*** h^{-1}

1 knot=0.514 m s^{-1}
0.066 m s^{-1} ***= 0.12 knots***

Western Pacific (20 points)

g = 9.8 m s^{-2}
f= 10 X 10^{-5} s^{-1}
delta z/delta n= -(-1.0 X 10^{-1}*m-3.0 X* 10^{-1}*)/3.0 X* 10^{5}*m = - 1.33 X* 10^{-6}

V_g *= - [(9.8 m* s^{-2}*)/10 X* 10^{-5} s^{-1}*] [-1.33 X* 10^{-6} *] =* ***.13 m*** s^{-1}***= .47 km*** h^{-1}
1 knot=0.514 m s^{-1}
0.13 m s^{-1} ***= 0.26 knots***

2. With a long arrow/streamline drawn right on Fig. 2, locate the position of the fastest current north of the Tropic of Cancer.

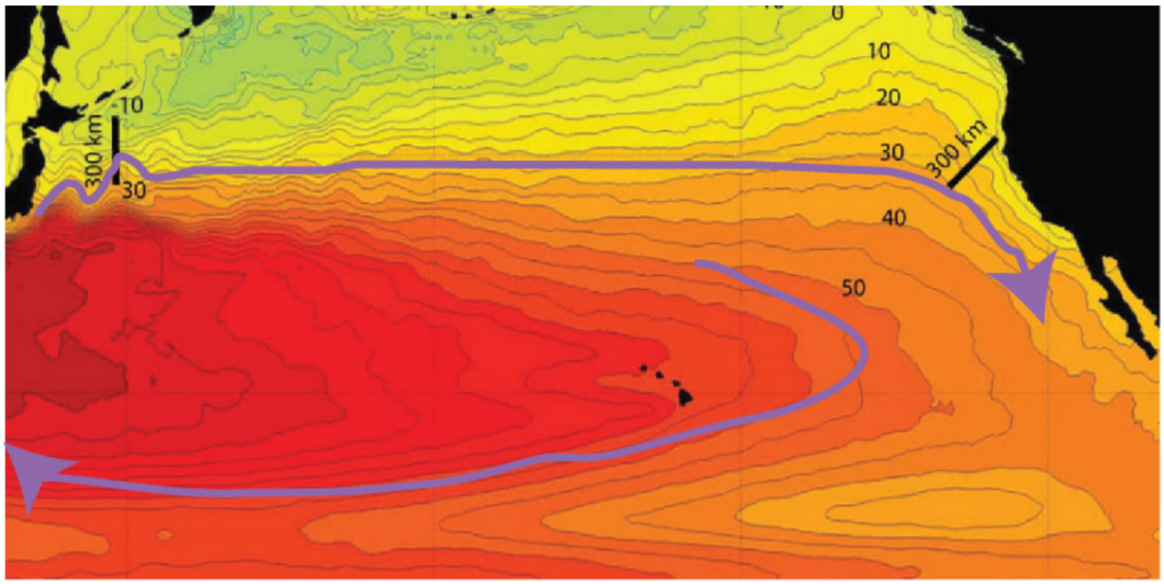


Fig 2: North Pacific Zoom of Fig. 2a