Name: _____

NATS 101 Introduction to Weather and Climate, Section 54, Fall 2005
Homework #3: Due at beginning of lecture Thursday, 27 October 2005.

1. Suppose the rate of rotation of the Earth was increased. What effect would this have on the Coriolis force and the strength of the geostrophic wind? [E.C.]

From Appdx B the geostrophic wind is given by - $V_g = \frac{\Delta P}{\rho \cdot d \cdot 2\Omega \sin\phi} = PGF \cdot \frac{1}{f}$

where f is simply replacing $2\Omega\sin\phi$. So, f is what will increase if you increase the rate of rotation, Ω. We also now see that V_g will decrease if f increases, answering part of the question. For the first part about the CF we have to recall the geostrophic balance, PGF=CF. To get this relationship from the geostrophic wind equation above we just multiply both sides by f giving us,

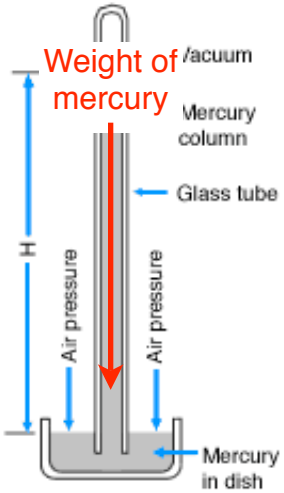
$f \cdot V_g = PGF$ or that $f \cdot Vg = CF = PGF$ for geostrophic balance.

So, now we can get the second part, since f increases and V_g decreases, CF must stay the same to balance the PGF, not affected by increasing Ω.

2. What vertical air motion would you expect above a low pressure center in which the surface pressure is falling. Explain.

As the pressure drops, more air will converge around the low at the surface. To accomodate this incoming air, air at the center of the low pressure will rise.

3. Using the diagram, describe how a mercury barometer works.



The barometer works by removing all the air in a tube (creating a vacuum) and then filling it with mercury and setting it in a tub of mercury open to the outside air. The air excerts a force on the mercury in the tub, equivalent to the outside air pressure. This pushes the mercury in the tube up until the weight of the mercury in the tube balances that of the external air pressure.

Mercury is chosen for this type of instrument because it is very dense and heavy. A liquid such as water would require a much taller tube in order to get enough water to balance the external air pressure.

4. Explain how each of the following affect the Coriolis force:

(a) Wind speed.

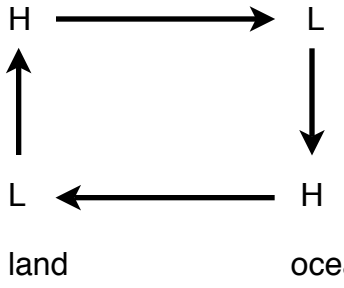
(b) Latitude (northern and southern latitudes)

(a) The Coriolis force increases with increasing wind speed, all else being equal.

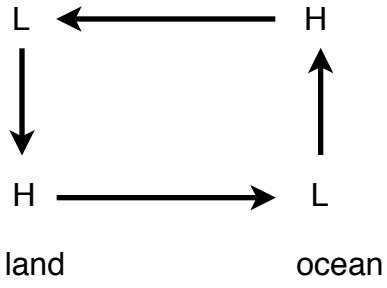
(b) The Coriolis force is zero at the equator. As an object like an air mass moves poleward, the amount the object appears to be sent off in a different direction increases with increasing latitude, with the most change in apparent direction occurring at the north and south poles. If the air mass heads to the north pole, the apparent force will make it look as if the wind goes to the right. If headed to the south pole, the apparent force will make it look as if the wind goes to the left.

5. With the aid of a simple diagram, describe the sea and land breezes.

Afternoon: Sea Breeze



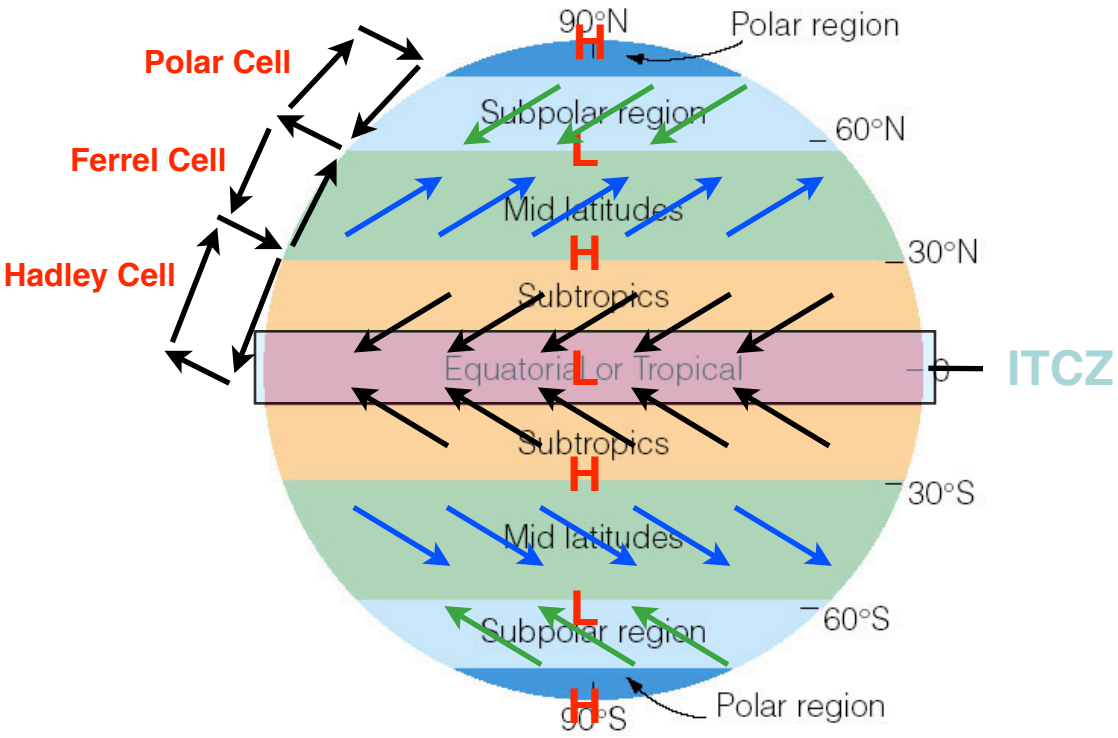
Morning: Land Breeze



In the afternoon the land heats up faster than the ocean. The warm air over land expands, creating a high pressure aloft compared to that at the same level over the ocean. Air moves out to sea at this level, reducing the surface pressure over land, increasing it over the ocean. In response to this surface pressure gradient, air moves onshore, creating a sea breeze.

In the morning the opposite occurs. The ocean is warm compared to the land right before sunrise, so that the column of air over the ocean is expanded relative to that over land. Thus, there is a higher pressure aloft over the ocean than over land at that same level. Air moves onshore at this level, reducing the surface pressure over the ocean and increasing the surface pressure over land. A surface flow develops in response to this developing surface pressure gradient, whereby the air moves offshore, from high to low pressure. This offshore breeze is the land breeze.

6. Using the "water world" below, place the major surface semi-permanent pressure systems and the wind belts of the world at their appropriate latitudes. (Three-Cell Model)



7. In the figure above identify the following:

(a) Trade winds (black arrows)

(b) Intertropical convergence zone (ITCZ) (box along equator)

(c) Westerlies (blue arrows)

(d) Subtropical highs (red H's along 30°N and 30°S)

(e) Subpolar lows (red L's along 60°N and 60°S)

(f) Polar easterlies (green arrows)

(g) Hadley cell

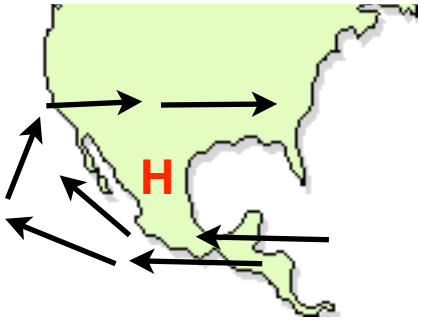
(h) Ferrel cell

(i) Polar cell

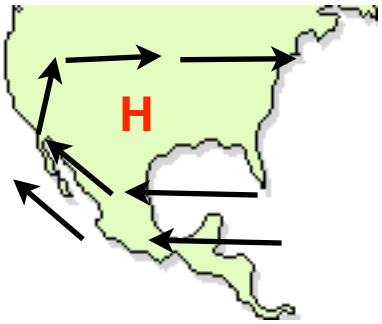
8. Explain why the polar jet stream is stronger in winter than in summer in the northern hemisphere.

The polar jet stream is the result of a subtropic to subpolar temperature difference, where the warm subtropical air sets up a high pressure at upper levels relative to the cold polar air. The temperature difference, and hence the upper level pressure gradient, is strongest during winter, weakest during summer. Thus, the jet stream, responding to the upper level pressure gradient, is strongest during winter.

9. Using the maps below, draw the location of the subtropical high in June and July and the accompanying surface circulation over Mexico and the southern portion of the US.



June



July

10. Explain why Arizona gets heavy rainfall during July and not during June.

After the onset of the North American Monsoon in July, the prevailing winds in the southwest are from the southeast and south, rather than from the west, as seen during June. The southeasterlies bring warm, moist air from the Gulf of Mexico and Pacific Ocean into Mexico and the southwest region. This low density, moist air is easily lifted by mountains or more dense air masses to the north, bringing thunderstorms to Mexico and the southwest region.

11. With a simple diagram, describe the Santa Ana wind system.

A surface high pressure forms over the Great Basin in the western US. The pressure is higher inland over the Great Basin due to the dry air in this region compared to near the coast in the Los Angeles area (dry air is more dense than moist air). The Great Basin is also higher than the Los Angeles area, so as the wind flows towards the coast from high to low pressure, it experiences compressional heating, heating from dry air descending to lower altitudes along a dry adiabat. The relative humidity of the wind is further decreased as the wind is heated on its descent from the plateau. Thus, the Santa Ana winds are warm, dry winds, which can be accelerated when forced through channels in the San Bernardeno and San Gabriel mountains. The wind derives its name from one particular channel, the Santa Ana Canyon, which funnels the wind at particularly high speeds.