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Geog 133 - Tropical Meteorology

Lab 3 – General Circulation of the Tropics

1: Tropical atmospheric circulation in the troposphere occurs in Hadley cells. The vertical velocity (Omega) assumes negative values for rising air and positive values for sinking air. Go to the CDC NOAA website (http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl) and plot the zonally averaged climatological vertical velocity (Omega) for both January and July.

Which variable? ____ (choose **Omega**)

Beginning month of season: ____ Ending month: ____ (choose Jan for both)

OR Enter range of years: ____ (choose 1979 to 2008)

Color? ____ (choose color)

Shading: ____ (choose Shaded w/overlying contours)

Map projection: ____ (Choose Latitude by Height)

Lowest lat: ____ (choose -30)

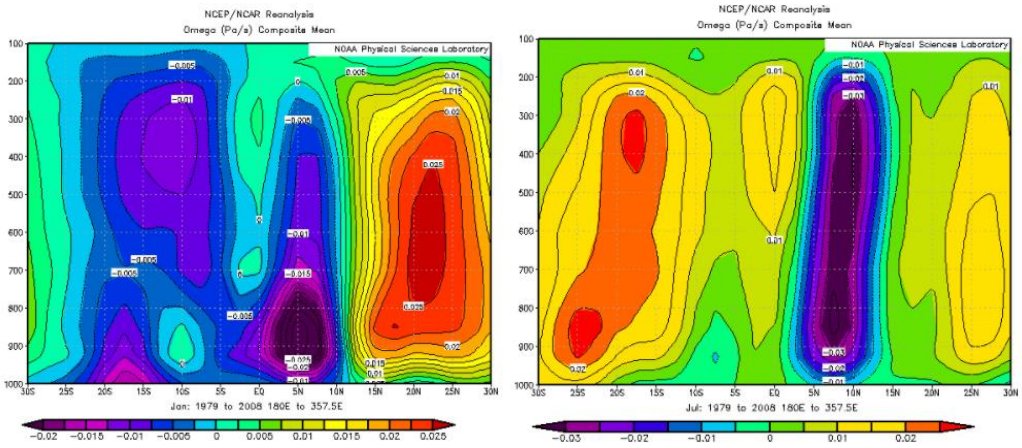
Highest lat: ____ (choose 30)

Western-most longitude: ____ (choose 0)

Eastern-most longitude: ____ (choose 360)

Upper level ____ (choose 100mb)

Now, repeat the procedure for July. (2pts – 1pt for each plot)



a. Is the equator a zone of **convergence or divergence**, and what **consequences do this have for air pressure**? (2 pts.)

Convergence, resulting from low-level atmospheric pressure, forcing areas of high pressure in the subtropics.

b. What drives this large-scale atmospheric motion at the equator? (1 pt. main reason)

Warm air convection from surface sources, such as warm ocean water.

c. **What is the difference** between the equatorial branches of the Hadley cell during January and July and what **cause these differences**? (2 pts)

The equatorial branches change in geographic position depending on the month and will be more present during summer months. Since the equatorial zone receives more insolation on average, it will always be present more poleward during summer months.

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2: Go to the CDC NOAA website (http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl) and plot the zonally averaged climatological Zonal Wind and Meridional Wind for both January and July. For Zonal Wind, negative values are easterly winds and positive values are westerly winds. For Meridional Wind, negative values are northerly winds and positive values are southerly winds.

Which variable? ____ (choose **Zonal Wind**)

Beginning month of season: ____ Ending month: ____ (choose Jan for both)

OR Enter range of years: ____ (choose 1979 to 2008)

Color? ____ (choose color)

Shading: ____ (choose Shaded w/overlying contours)

Map projection: ____ (Choose Latitude by Height)

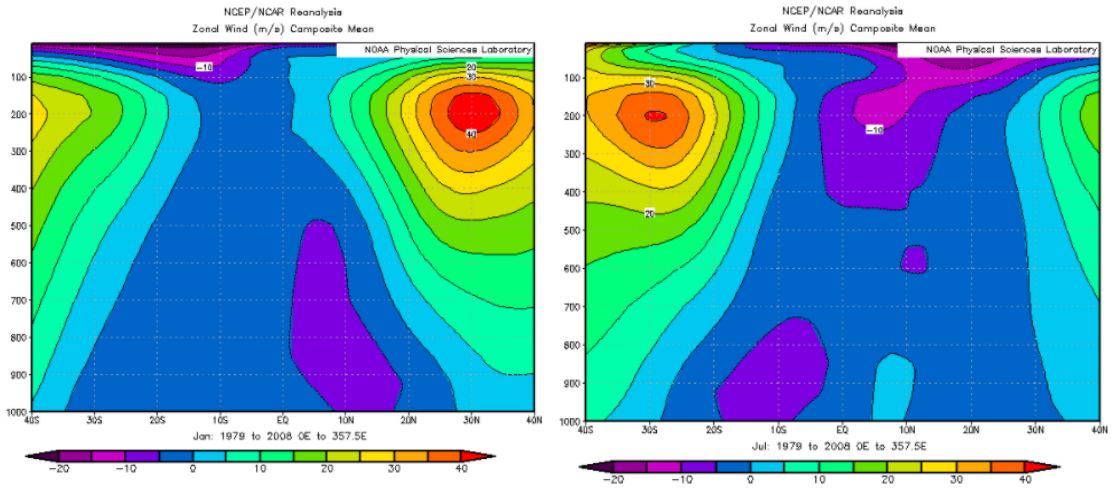
Lowest lat: ____ (choose -40)

Highest lat: ____ (choose 40)

Western-most longitude: ____ (choose 0)

Eastern-most longitude: ____ (choose 360)

Now, repeat the procedure for **July**. **(2pts – 1pt for each plot)**



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Which variable? ____ (choose **Meridional Wind**)

Beginning month of season: ____ Ending month: ____ (choose Jan for both)

OR Enter range of years: ____ (choose 1979 to 2008)

Color? ____ (choose color)

Shading: ____ (choose Shaded w/overlying contours)

Map projection: ____ (Choose Latitude by Height)

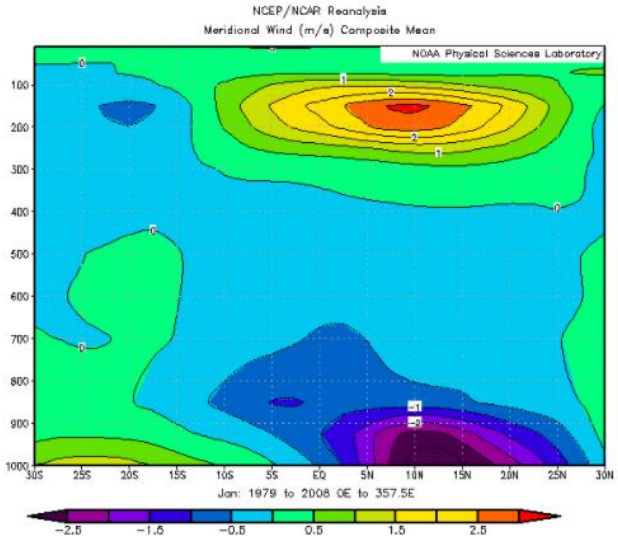
Lowest lat: ____ (choose -30)

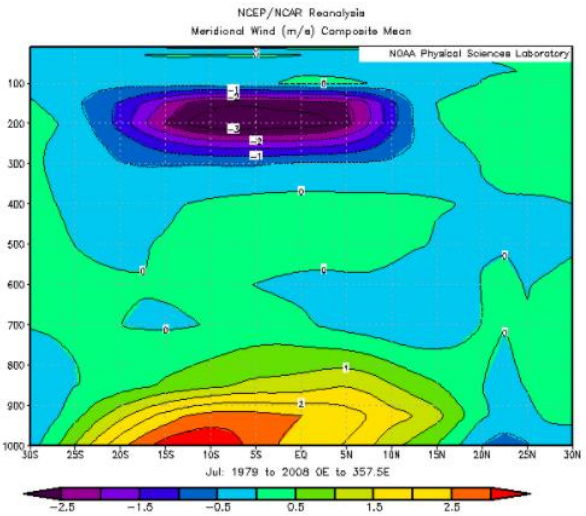
Highest lat: ____ (choose 30)

Western-most longitude: ____ (choose 0)

Eastern-most longitude: ____ (choose 360)

Now, repeat the procedure for **July**. **(2pts – 1pt for each plot)**





a. What are some of the roles that Hadley cells play in maintaining the global energy balance? (4 pts for four main roles)

   Rising heat and moisture in limbs, upper branch redistribution of heat in upper atmosphere to high latitudes, kinetic energy transportation, and generating angular momentum.

b. Earth's angular momentum is greater at the equator than at the poles. How do Hadley Cells assist in exporting excess angular momentum away from the equator, to help maintain Earth's energy balance? (2 pts; Hint: what's the difference between the angular momentum in the lower latitudes compared to higher latitudes)

In lower latitudes, angular momentum is positive, but the regions do not speed up faster than higher latitudes. The excess momentum is transported to high latitudes by the upper branches of the Hadley cell to balance out.

c. Considering both meridional and zonal components of the wind, discuss how do maximum wind velocities change throughout the year? In other words, **when are maximum wind velocities located in the northern hemisphere (1),** and **when are they located in the southern hemisphere (1)**? **What causes the shift (2)**? (4 pts total)

Northern Hemisphere maximum wind speeds occur between December and February.

Southern Hemisphere maximum wind speeds occur between June and August.

The shift is caused by a weak lower branch of the Hadley cell that stays within subsequent winter seasons.

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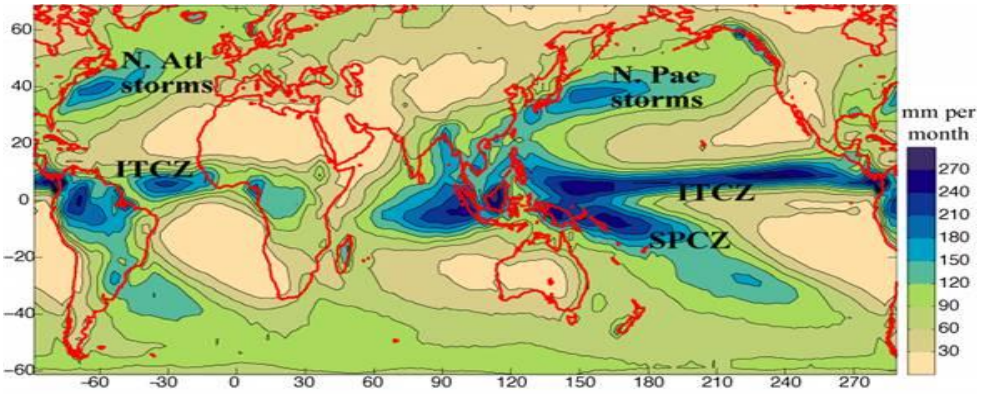

Figure for questions 3 & 4

3. Why is the ITCZ known as the "zone of equatorial cloudiness"? What causes the cloudiness at the ITCZ? (4 pts. Describe the process that produces the cloudiness of the ITCZ)

The cloudiness in the ITCZ is produced by air convergence, caused by slowing wind or changes in wind direction, where the air piles up and rises. The convergence is supported by warm surfaces, which factors into large-scale convection, forming clouds and rain.

4. Why does the ITCZ reach its maximum northward position in the northern hemisphere autumn when ocean temperatures are at a maximum? (4 pts. **State the main reason** - one or two sentences)

Ocean temperatures affect surface level air more than continental surface temperatures. The ITCZ covers areas of mass air convergence and warm temperatures, thus when ocean temperatures are maxed, the extent of the ITCZ also reaches its maximum position.

5. Examine the figure below (Figure 5.1 in your textbook). Why is the boundary between the tropical and mid-latitude atmospheres oriented in a *slantwise* direction? (2 pts, main reason)

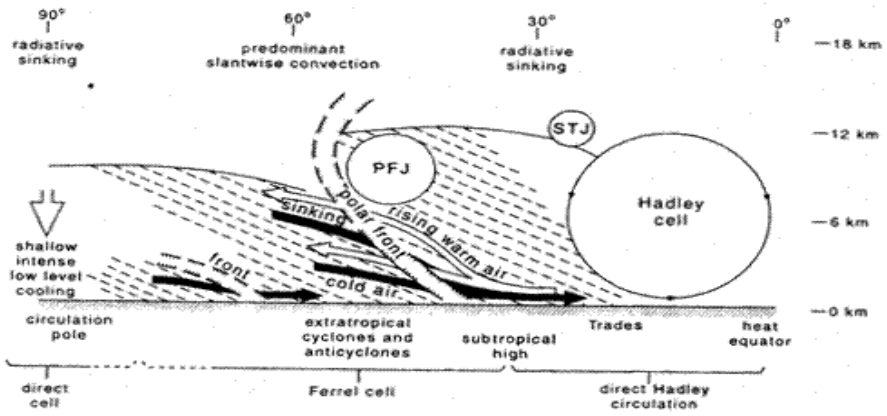

Figure 5.1 Cross-section of general circulation. STJ is subtropical jet; PFJ is polar front jet. Modified from Palmen and Newton (1969)

Cold air subducts under warm air in a gradual downslope, the boundary between the tropical and mid-latitude atmospheres matches this air-density system

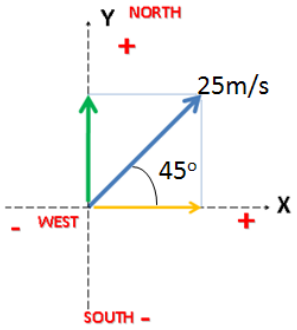

Figure for question 6

6. Calculate the zonal and meridional components of a southwesterly wind with magnitude 25m/s (hint: calculate zonal and meridional components using Pythagorean or trigonometric relationships) (2 pts; provide numerical answer for each "leg")

Meridional (y) = 25m/s * sin(45^0) = 17.68 m/s

Zonal (x) = 25m/s * cos(45^0) = 17.68 m/s

7. Why do many subtropical areas have dry climates? Give some examples of dry climates found in tropical latitudes. (4 pts. 2 pts, explain why, and 2 pts for naming two locations)

Colder and Drier air sinks from the upper atmosphere, and because of the Hadley cell, which diverges air at the subtropical surface, leading to a dry climate because of the lack of converging air to produce clouds and rain (subtropical/tropical-easterly jet). The Sahara Desert and Australia are examples of these dry climates.

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8. Go to the CDC NOAA website (http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl) and plot the climatological Vector Wind at the 850mb level for both January and July.

Which variable? ____ (choose **Vector Wind**)

Level? ____ (choose 850mb) ***ATTENTION:** Every time you go back on the web page the level is automatically set to 1000mb*

Beginning month of season: ____ Ending month: ____ (choose Jan for both)

OR Enter range of years: ____ (choose 1979 to 2008)

Color? ____ (choose color)

Shading: ____ (choose Shaded w/overlying contours)

Map projection: ____ (Choose Custom)

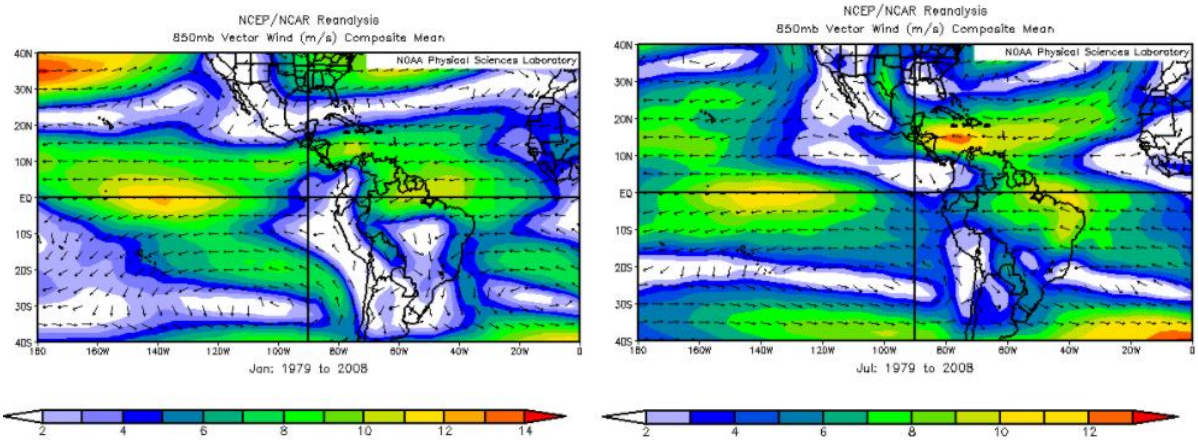
Lowest lat: ____ (choose -40)

Highest lat: ____ (choose 40)

Western-most longitude: ____ (choose 180)

Eastern-most longitude: ____ (choose 360)

Custom projection: ____ (choose cylindrical equidistant)



a. Based on the figures of vector wind in low levels and on the lessons you have learned during this lab, explain the seasonal differences in the low level circulation regarding trade winds and the subtropical highs. (6 pts. 2 pts for the plots, 4pts for describing phenomena)

The positions of subtropical highs moves poleward during summer and equatorial during winter. Trade winds are highest in speed during winter months, in both hemispheres.

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9. Why is global oceanic circulation characterized by a series of gyres instead of global bands? (4 pts)

Ocean circulation is characterized by gyres due to interference from continental lands interrupting circulation cycles, causing current deflection and circular motion.

10. What are the main similarities and differences among the three main convergence zones: SPCZ, SACZ and ITCZ? (4 pts, 1 pts for main similarity, then 3 pts for differences (SPCZ/SACZ vs ITCZ, and SPCZ vs. SACZ)

Each convergence zone represents a region of mass air convergence, rise, cloud coverage, and rainfall. The Southern Ocean convergence zone differ from the ITCZ due to thermal activity. The ITCZ is driven by thermal convection from warm water, whereas the southern convergence zones are driven more by atmospheric processes and trade wind convergence. The South Pacific and Atlantic convergence zones differ in ocean location and both reflect phase changes of the ENSO.