Name: _____

NATS 101 Introduction to Weather and Climate, Section 54, Fall 2005
Homework #4: Due at beginning of lecture **Tuesday**, 22 November 2005.

Global Atmosphere-Ocean Interactions [18]

1. Explain why the thermocline in the eastern tropical Pacific levels out during **El Niño**. Describe the air-sea interaction processes involved, including the shift of the surface pressure systems, the resulting winds and the effect on the ocean. [6]

The thermocline in the east Pacific levels out during El Nino because of a series of linked events. 1) The normal surface pressure difference across the tropical Pacific, from high over the cold tongue to low over the warm pool, decreases in conjunction with warm water moving eastward, shrinking the cold tongue region. 2) This smaller pressure difference results in weaker trade winds in the east Pacific. 3) As the winds reduce, the upwelling off the eastern coast of the Pacific is also reduced. This is because the northeasterly trades cause off-shore transport of surface waters due to the Coriolis force pushing the currents to the right of the wind. 4) Finally, a reduction in the upwelling results in a flattening of the thermocline, the strong change in temperature with depth in the ocean that separates the surface layer from the deep ocean. Normally, upwelling pushes this layer upwards in the east Pacific relative to the west Pacific where no upwelling occurs.

2. During the **positive** phase of the Pacific Decadal Oscillation, describe how the north Pacific surface ocean temperature is different from normal. What effect does this have on the Aleutian Low and the north Pacific storm track? [6]

During the positive phase of the PDO, the north Pacific ocean temperatures are colder than normal, while the ocean temperatures off the west coast of the US, Canada, and Alaska are warmer than normal.

This temperature pattern is coincident with a deeper Aleutian Low, which intensifies the north Pacific storm track located on the south side of this low pressure region. The storm track also tends to shift south, causing more storms in California and fewer storms in the Pacific Northwest US.

3. During the **negative** phase of the North Atlantic Oscillation, describe how the Icelandic Low and Bermuda High are different from normal. What effect does this have on the Atlantic storm track? What effect does this have on the trade winds off Africa? Upwelling off the coast of Africa? [6]

During the negative phase of the NAO, the Icelandic Low and the Bermuda High are both weaker than normal. The weaker pressure gradient results in weaker and less frequent storms within the Atlantic storm track. The weaker Bermuda High also weakens the trade winds off Africa, which are located on the south side of this high pressure region. Since the trade winds cause upwelling off the west coast of continents, upwelling is also reduced during this phase of the NAO.

Air Masses [4]

4. Define the four types of air masses discussed in class and give their abbreviations. [4]

continental polar (cP) - cold, dry air originating from polar land regions

continental tropical (cT) - warm, dry air originating from southern land regions

marine polar (mP) - cold, moist air originating from polar ocean regions

marine tropical (mT) - warm, moist air originating from tropical or subtropical ocean regions

Fronts [37]

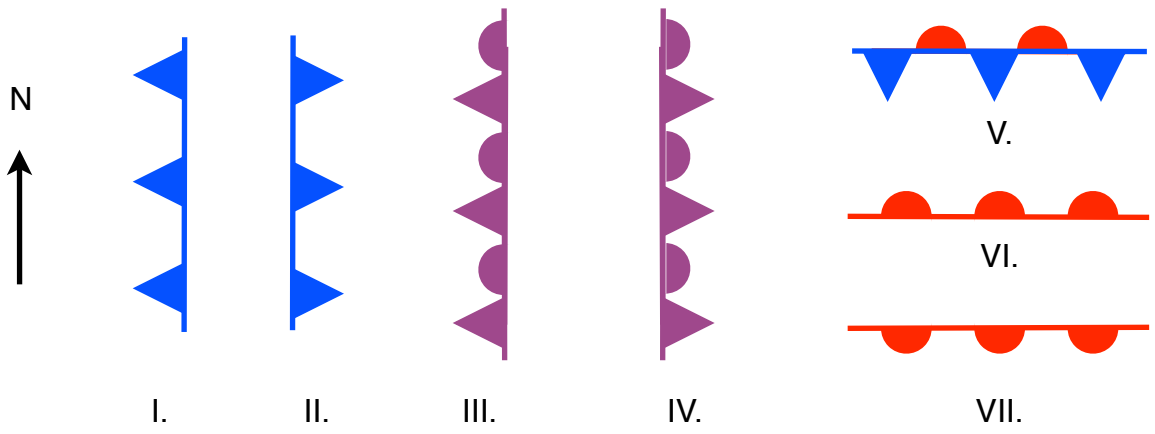
5. Match the roman numeral to the correct definition. (You will not need all the roman numerals.) [4]

a. cold front moving east __II__

b. warm front moving north __VI__

c. stationary front __V__

d. occluded front moving east __IV__



6. Name **three** ways of finding (locating) a front on a weather map. [3]

sharp temperature difference over short distance
sharp moisture difference over short distance
shift in wind direction
pressure changes
clouds and precipitation patterns

__c__7. A **cold** front moves _____ than a **warm** front and has a _____ leading edge. [5]
a. faster, more gradual
b. slower, more gradual
c. faster, steeper
d. slower, steeper

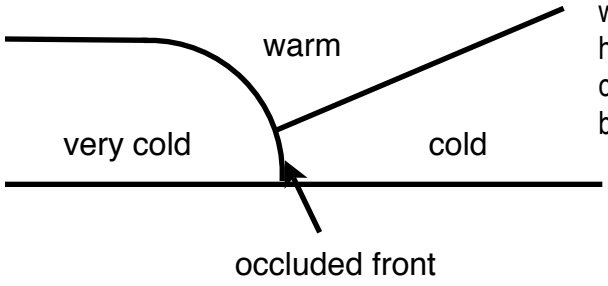
__d__8. The air within a **warm** air mass is typically _____, causing _____ upon lifting over a **cold** air mass. [5]
a. stable, fair weather
b. absolutely unstable, precipitation and cloud formation
c. conditionally unstable, fair weather
d. conditionally unstable, precipitation and cloud formation

__b__9. A **fast** moving cold front will more likely produce _____ clouds, while a **slow** moving cold front will more likely produce _____ clouds. [5]
a. stratus, cumulonimbus
b. cumulonimbus, nimbostratus
c. fog, nimbostratus
d. cumulonimbus, cumulus

10. Define the term **overrunning** in the context of a warm front. Which cloud types are most likely to form in this situation? [5]

Overrunning is the process in which a warm, less dense air rises up over colder, more dense air. In a warm front the warm air overruns receding cold air. Warm fronts have more gradual slopes than cold fronts and move more slowly. In general, the lifting is not as vigorous and typically produces layer clouds such at stratus and nimbostratus clouds ahead of the front's surface boundary.

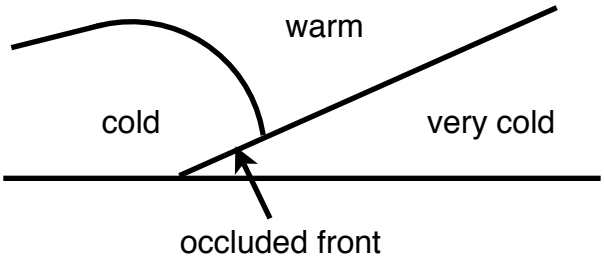
11. Use a diagram to explain **cold occlusion**. [5]



Cold occlusion is when a cold front catches up with a warm front, pushing the warm air over the cold air behind the cold front, as well as pushing the relatively cooler air in front of the warm front over the colder air behind the cold front.

12. Use a diagram to explain **warm occlusion**. [5]

A warm occlusion occurs when a cold front meets a warm front but the cold air in front of the warm front is colder than the cold air behind the warm front, forcing the cold front over the cold air in front of the warm front. The warm air remains above both cold air masses.



Mid-latitude Cyclogenesis [13]

_**c**__ 13. The polar front could also be considered a _____ front. [5]
a. cold
b. warm
c. stationary
d. occluded

14. Steps to cyclogenesis:

a. What direction do the winds blow on either side of the polar front? How does this encourage the development of a localized low pressure within the front? [2]

Winds flow from the northeast on the north side of the polar front and from the southwest on the south side of the polar front, causing convergence at the front. The flow parallel to the front is cyclonic (counter-clockwise), in the same direction as flow around a low pressure system in the northern hemisphere. This flow pattern encourages development of a low within the polar front.

b. Once the localized low develops within the front, how does the front change structure? What new fronts form and what motion develops on either side of the low due to these fronts? [2]

Once a low develops, a cold front is set up to the west of the low in front of the northerlies, and a warm front is set up to the east of the low, in the southerlies. The cold front then starts to turn cyclonically around the low towards the warm front.

c. What role does cold front and warm front movement play in the developing low pressure region? [2]

The cyclonic movement of the cold front towards the warm front deepens (intensifies) the low pressure region.

d. What final frontal system results from this motion prior to the dissipation of the low and the re-establishment of the original type of front (named in 13.)? [2]

Once the cold front meets the warm front, an occluded front forms. This is the final, most intense stage for the cyclone. At this point, there is cold air on either side of the occluded front and the cyclone starts to dissipate. Once the low separates, the stationary front reforms.

Thunderstorms and Lightning [28]

__**c**__15. Air _____ and _____ determine air density. [5]

a. pressure, temperature
b. speed, pressure
c. temperature, humidity
d. humidity, pressure

16. During the growth stage (cumulus stage) of a developing ordinary thunderstorm, what allows the cloud to grow upwards? What process creates downdrafts? [5]

As the cloud develops, the air aloft is moistened by the warm, moist air from the surface being lofted to higher levels. As the cloud air becomes more moist, parcels of air can reach higher levels within the cloud, permitting the cloud to grow upwards.

Downdrafts are created from falling precipitation particles and entrainment of relatively colder, drier air from the environment into the cloud.

17. During the mature stage of an ordinary thunderstorm, how does the gust front act to encourage the lifetime of the storm? [5]

The gust front is the leading edge of the colder, drier (denser) downdraft air from the ordinary thunderstorm. As this dense air flows down out of the cloud and along the ground, it forces warmer, moister air up into the cloud, intensifying the updraft and thus prolonging the life of the storm.

18. During the growth of a severe thunderstorm, how does vertical wind shear help to encourage the lifetime of the storm? [5]

The vertical wind shear (both directional and speed shear) helps to prolong the life of the storm by separating the downdraft from the updraft region. This keeps cold, dry downdraft air out of the updraft for longer periods of time than in an ordinary thunderstorm where these regions can mix more effectively over time, causing the dissipation of the cloud.

19. If you see lightning strike and then hear the thunder 20 seconds later, how far away is the thunderstorm? [3]

330 m/s x 20 s = 6,600 m or 6.6 km

1100 ft/s x 20 s = 22,000 ft or 4.2 miles

20. What elements are electrically charged (positive or negative) in a thunderstorm cloud? Why is it a bad idea to sit under a tall tree in an open field during a thunderstorm? [5]

hail and ice crystals become charged within the cloud

A lightning strike develops after a leader, generally negatively charged, reaches down towards the ground. As the leader extends out of the cloud towards the ground, it draws positive charge at the ground towards it. Build up of positive charge at the ground is most likely to occur around tall, narrow objects like a tree. This will be the first place the lightning will strike and subsequent strikes are also likely to go through the same channel. Thus, it is best to stay away from tall objects in an open field.