Atmospheric Sciences 101
Homework Assignment #7 Solutions and Discussion

First, a disclaimer: every mid-latitude cyclone is different, and even experienced meteorologists have a difficult time locating frontal positions and predicting the behavior of some of these storms. What we tried to emphasize in the class was the *idealized* structure and behavior of mid-latitude cyclones. Realize that what we have discussed are the *typical* characteristics of wave cyclones and their associated fronts, but that a wide amount of variation is possible in the size, shape, intensity, and time evolution of these systems.

2. Answer the following questions about this cyclone using both Figure 1 and the satellite image:
(a) Examining the different stages in the formation of a mid-latitude cyclone that we discussed in class (or in Chapter 8), identify the stage which most resembles the situation in Figure 1.
This wave cyclone is in the "open wave" or "mature" stage of development. The low pressure center is well defined, the warm front and cold front are both well developed and easily identifiable, and the occlusion process has not yet begun. If you examine the sequence of pressure maps on the web, you can tell that the low pressure center reached its minimum (lowest) value in about twelve hours, about the same time that the occlusion process began.

(b) What cloud structures do you see in the vicinity of the cold front on the satellite image? Are these the types of clouds you expect to see associated with a cold front? Explain.
There is a relatively small band of low- and medium-height clouds slightly *behind* the position of the cold front at the surface. Because a cold front represents a boundary between cold, dense air and warm, moist air, these clouds are probably convective clouds like cumulus, altocumulus, or even cumulus congestus formed by uplift near the frontal boundary. This particular cold front does **not** exhibit the typical tall convective clouds (e.g. cumulonimbus) that we expect to find directly over the cold front. Since there are no tall clouds, we would not expect the jet stream to shear off the tops of the clouds to form cirrus clouds over the warm sector. Be aware that although the precipitation associated with the cold front was rather weak at 12 p.m. on October 17th, a squall line of large cumulonimbus towers developed over this cold front over the next 24 hours which spawned several tornadoes in the Ohio River valley as the cold front moved eastward (you can see this development by examining the sequence of satellite pictures on the web).

(c) What cloud structures can you see ahead of the warm front? Is this what you expect? Why?
The warm front over the upper Midwest has a large amount of intense precipitation and cloudiness associated with it. Note the particularly high cloud top over Wisconsin, which is probably associated with a strong supercell thunderstorm. This is rather unusual, since we would typically expect the warm front to be associated with milder precipitation and shallower clouds than the cold front. Apparently the atmosphere was unusually unstable in the upper Midwest at this time, so the small amount of lifting present near the warm front was strong enough to trigger intense deep convection. On the other hand, the atmosphere in the vicinity of the cold front was probably rather stable at this time, such that the lifting by the cold front did not trigger much convective activity.

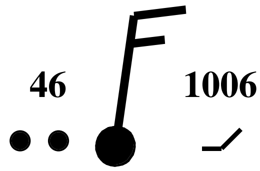
(d) Note the presence of some non-frontal clouds in the warm sector between the two fronts (e.g. over Illinois) and in the cold air mass behind the cold front (e.g. over Colorado and Wyoming). What types of clouds do you think these are? Why?
These are probably fair weather cumulus clouds, which can develop into deeper convective clouds and even thunderstorms if the conditions are right. However, this convection is generally isolated and is usually not as well organized as the convection associated with fronts. In the warm sector, the warm, moist surface air might become buoyant and form convective clouds if it is lifted away from the surface by weak low-level convergence, orographic lifting, or another lifting mechanism (in

Illinois, a sea breeze associated with Lake Michigan could possibly the lifting mechanism). In the cold sector, clear weather behind the cold front could lead to warming of the surface and the near-surface air by solar radiation during the day. This warm surface air would then be located under a rather cold atmosphere behind the cold front, and with a small amount of lifting could also develop into fair-weather cumulus clouds or possibly more intense convection. (in Colorado and Wyoming, this lifting could be provided by the Rocky Mountains)

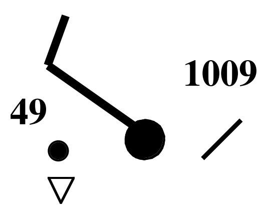
3. On a separate sheet of paper, <u>draw the surface station</u> information for the following cities: Lincoln, Nebraska; Kansas City, Missouri; and Green Bay, Wisconsin. Include the following data: (use the surface station model introduced in class and reproduced in Appendix C)

-surface temperature in °F (note that Figure 1 is in °C)
-surface pressure (use millibars instead of the abbreviated notation)
-pressure tendency (just the "line", not the numerical value)
-wind direction and speed (full barb = 10 knots, half barb = 5 knots)
-present weather <u>and</u> sky cover (use the satellite image and your knowledge of frontal precipitation)
(You do not need to indicate the 3-hour surface pressure change or the dewpoint temperature on your surface station diagrams.)

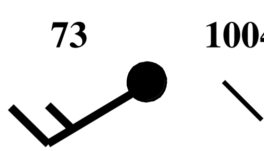
Example: Fargo, ND



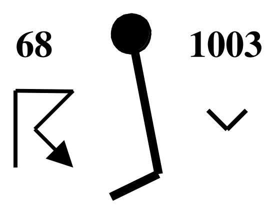
Lincoln, Nebraska



Kansas City, Missouri



Green Bay, Wisconsin



5. <u>Write</u> a short forecast for Little Rock, Arkansas for the next 36 hours. Be sure to mention the pressure, temperature, cloudiness, chance of rain, the direction and strength of the wind.
Little Rock is in the warm sector of this mid-latitude cyclone, with a cold front approaching from the west that will reach central Arkansas in approximately 12 hours. The weather in Little Rock will probably be pleasant for the next 12 hours, followed by the cold front passage which might be associated with severe weather. Afterwards, we would expect clearing and colder temperature as the cold air behind the cold front moves into the area.
Forecast for the next twelve hours: Decreasing barometric pressure; southwesterly winds at the surface at about 15 knots, possibly changing as the cold front approaches; temperature remaining relatively constant between 20-25°C (although it might decrease slightly as the cold front approaches); possibly some low fair-weather cumulus clouds in the sky, but no precipitation.
Forecast for the cold front passage (about 12 hours from now): Barometric pressure will fall to below 1008 mb; winds will suddenly shift from southwesterly to westerly to northwesterly; intense convection and severe weather (heavy rain, lightning, hail) is possible (note that although the cold front does not have any severe weather associated with it at the moment, as it approaches Arkansas it could encounter warmer, moister air and deep convection could form in a short period of time, so it would be wise to predict the possibility of severe weather).
Forecast for the 24 hours following the frontal passage: Temperature decreasing rapidly by 10°C or more; barometric pressure rising steadily; winds holding steady from the northwest and possibly increasing in speed; cloudiness and precipitation rapidly diminishing; possibly a few low cumulus clouds, but clear skies are most likely.