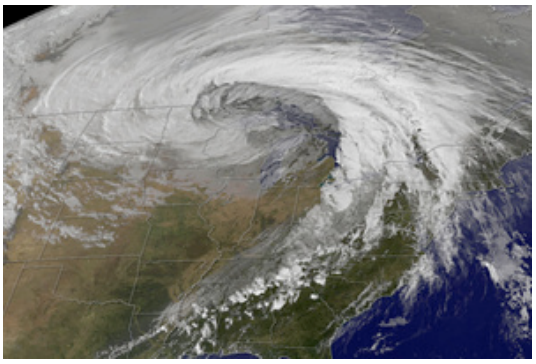
<u>Midlatitude Cyclones</u> – Identifying High/Low Pressure Areas and Warm/Cold Fronts

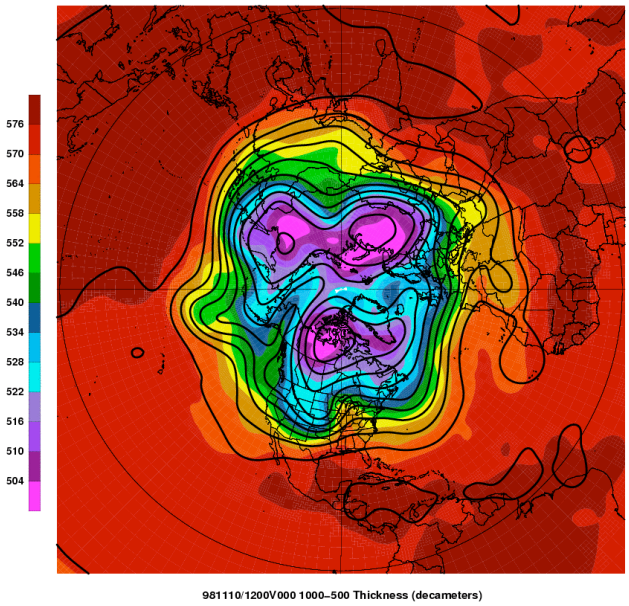
What is a Midlatitude Cyclone?

Midlatitude cyclones are the result of baroclinic waves in the upper atmosphere, which act to lessen earth's equator-to-pole temperature gradient.



-In more detail, midlatitude cyclones occur because of the energy imbalance between the equator and the poles. The temperature gradient that results from the energy imbalance (warm in the tropics, cold at the poles) tilts pressure surfaces and produces the westerly jet in the midlatitudes. Waves within the jet induce convergence and divergence higher in the atmosphere, which then lead to areas of high and low pressure at earth's surface. The eddies, or midlatitude cyclones, within the jet explain much of our wintertime weather.

- Think of the north-south temperature gradient as a source of potential energy. Midlatitude cyclones convert this energy to kinetic energy as they develop and allow the atmosphere to lower its center of mass.



November 10, 1998

This activity will allow us to look more closely at a specific midlatitude cyclone from November 10, 1998. This particular storm brought strong winds and heavy rain and snow to much of the central United States.

-Sioux Falls, South Dakota received 12.6 inches of snow in 24 hours. That is the largest snowfall ever recorded on a single November day in Sioux Falls. Strong winds (50-60mph gusts) followed to create blizzard conditions.

-Wave heights of 15-20 feet were recorded in Lake Michigan and several Michigan towns experienced wind gusts of up to 95mph. High winds from this storm caused 10 deaths, 34 injuries, and over $40 million in damages.

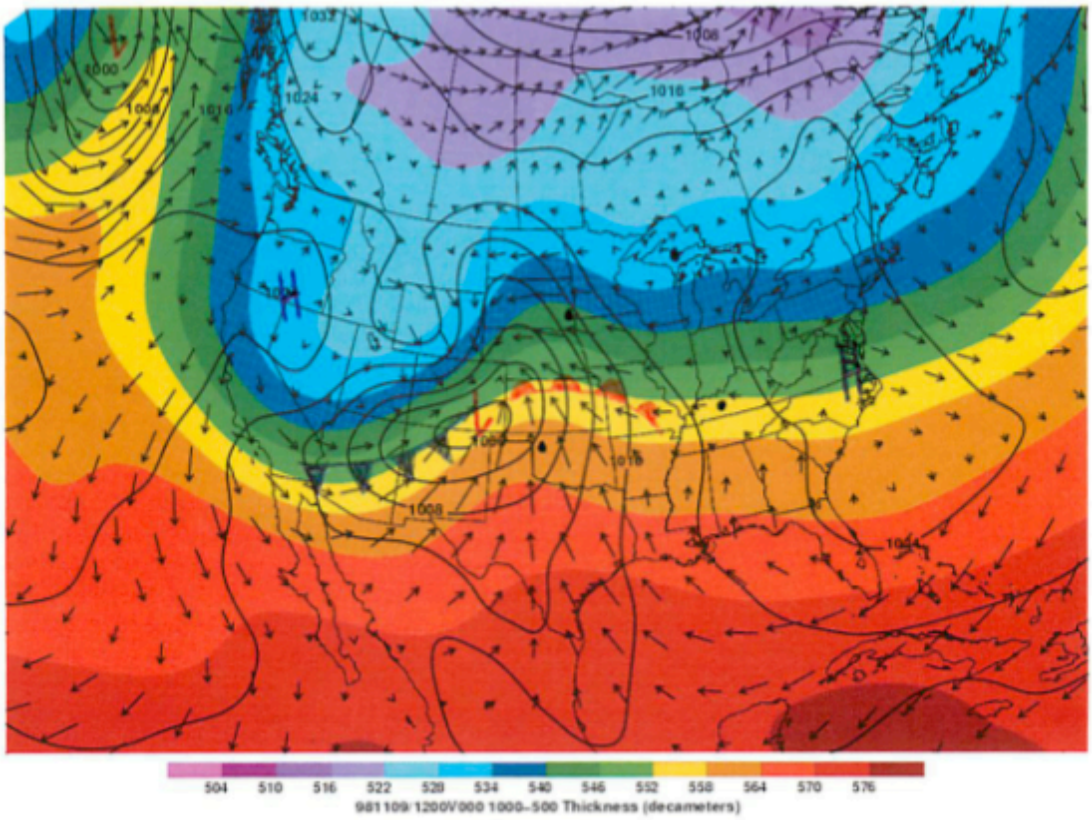
-Minnesota set a state record for low pressure with readings of 963mb. Pressures that low are recorded in Category 3 hurricanes. The speed with which the pressure dropped is astounding. In general, storms are referred to as "bombs" if the central pressure drops more than 24mb in 24 hours (1mb/hour). Storms like "The Perfect Storm" of 1993 fall into this category. The November 1998 storm dropped 30mb in only 18 hours!

This case is unusually intense, but typifies many features of midlatitude cyclones.

Part 1: Interpreting a Basic Weather Map

As we begin to look at the November 1998 storm it will be helpful to understand the most common data and symbols found on weather maps.

The map below contains three main variables: pressure, temperature, and wind.



-PRESSURE: The solid black lines indicate isobars (or lines of constant pressure). The numbers associated with these lines indicate the pressure in mb (i.e. 1006mb).

-TEMPERATURE: The different colors on the map indicate temperature. You may notice that the key below the map indicates that the "thickness" of the 1000mb-500mb layer is being shown. For all intents and purposes this can be thought of as temperature. The warm colors indicate higher temperatures (or thicker layers) and the cool colors indicate colder temperatures (or thinner layers). Atmospheric scientists often use thickness as a measure of temperature because it is a better indicator of the mean temperature of an air mass, which could be different from temperature measurements taken just at the surface.

-WIND: The arrows indicate wind direction and speed. The longer the arrow the greater the wind speed. Refer to the wind direction as the direction the wind has COME from. For example, → would be a westerly wind.

Other symbols contained on this map include:
- HIGH pressure center (local area of highest pressure)

H

- LOW pressure center (local area of lowest pressure)

L

- COLD front

- WARM front

Common symbols not found on this map include:
- STATIONARY front (winds blow parallel to the front; thus, the front does not move)

- OCCLUDED front (occurs when the cold front catches the warm front)

Part 2: Identify and Label the Midlatitude Cyclone

The goal of this section is to increase your understanding of the life cycle of a midlatitude cyclone. You will make use of your weather map skills to identify the midlatitude cyclone (central low pressure with the associated warm and cold fronts) as it develops on November 10, 1998.

Important Characteristics of Cold and Warm Fronts

A COLD FRONT is associated with

- Rapid temperature change (cooing)
- Precipitation (rain and/or snow) - can be of high intensity
- Cumulus (convective) clouds along the front
- A wind shift: winds are S/SW ahead of the front and gusty W/NW behind the front
- Being located along a kink in the pressure lines
- Dry, clear air behind the front
- Pressure falling ahead of the front, rising behind the front
- Fast movement (speed of 10-50mph)

A WARM FRONT is associated with

- Temperature Change (warming)
- Light precipitation or fog well ahead of front
- Stratus clouds well ahead of the front
- A wind shift: winds are E/NE ahead of the front and non-gusty S/SW behind the front
- Pressure falling
- Slow movement (Speed of 5-10mph)

1) On each of the following maps from November 10, 1998, identify the area of lowest pressure and mark with the low pressure symbol. (Hint: Focus on the black isobars. Wind arrows may help as well).

2) On each of the following maps locate the warm and cold fronts and label with the appropriate symbols. Feel free to refer back to the characteristics of warm and cold fronts.

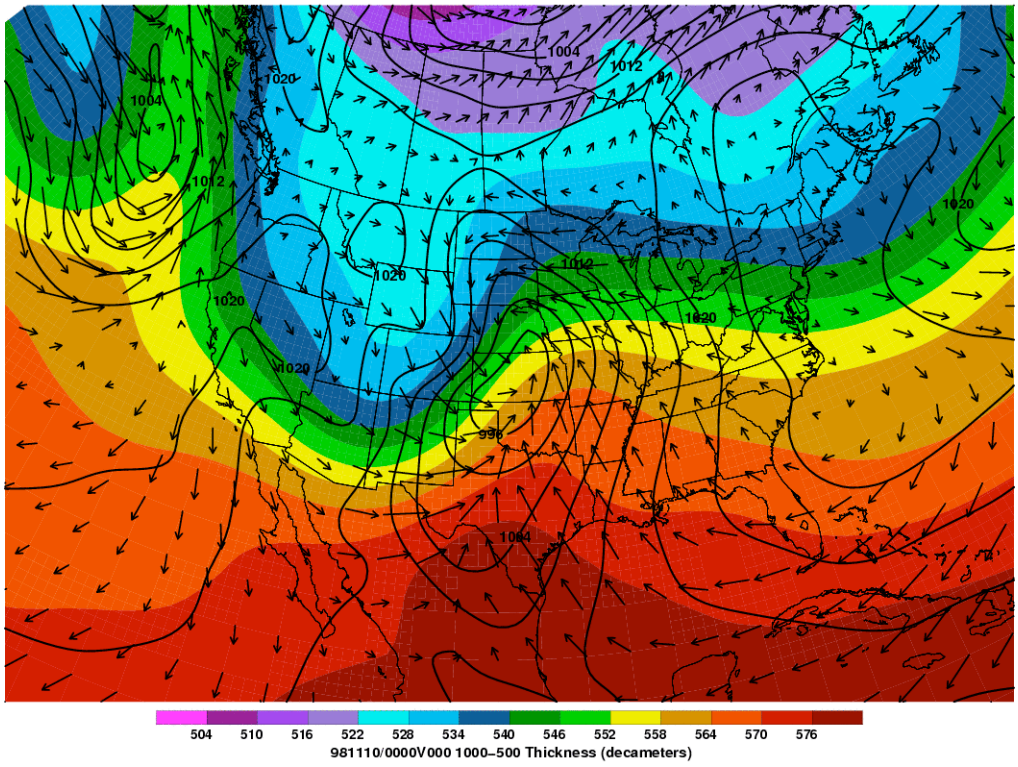
3) Look at the progression of maps and what you have drawn. What do you notice?

4) Can you identify the cold and warm sectors of the midlatitude cyclone? Please label.

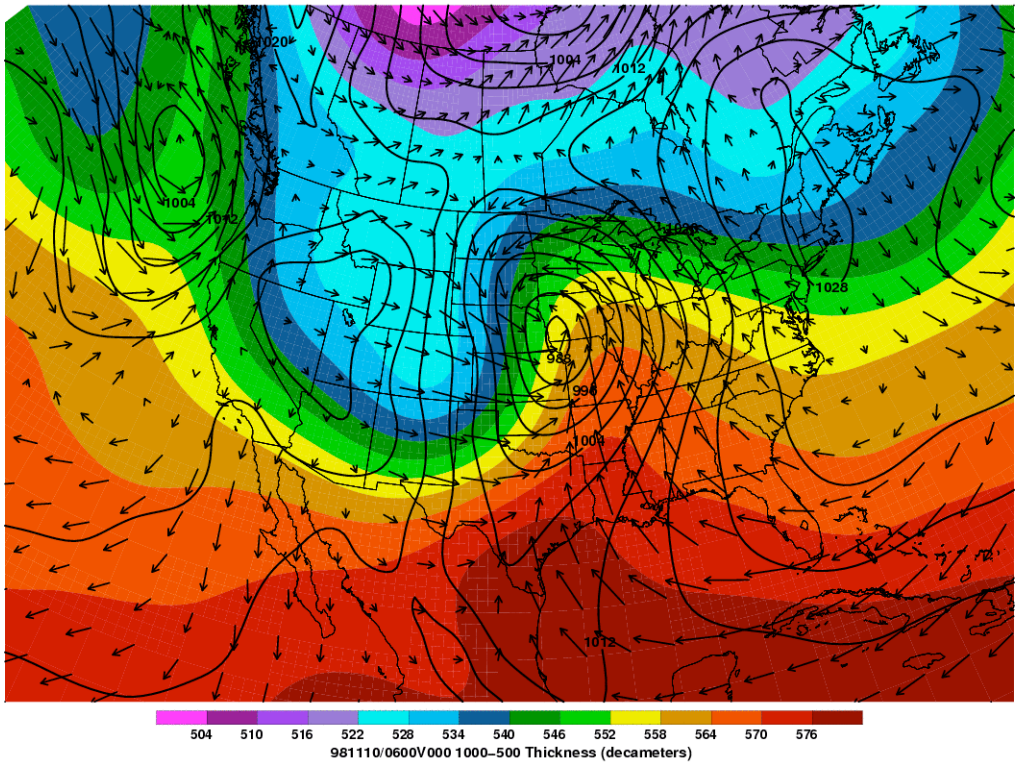
In which direction (north or south) is each of these sectors moving?

Why do you think that is?

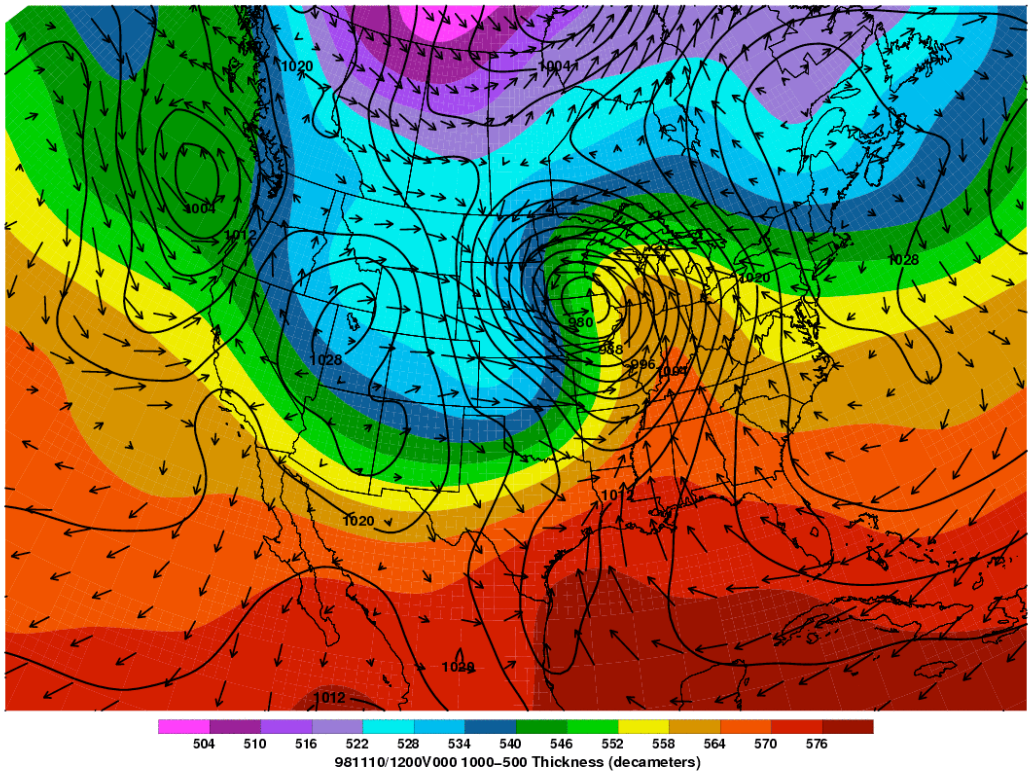
MAP 1



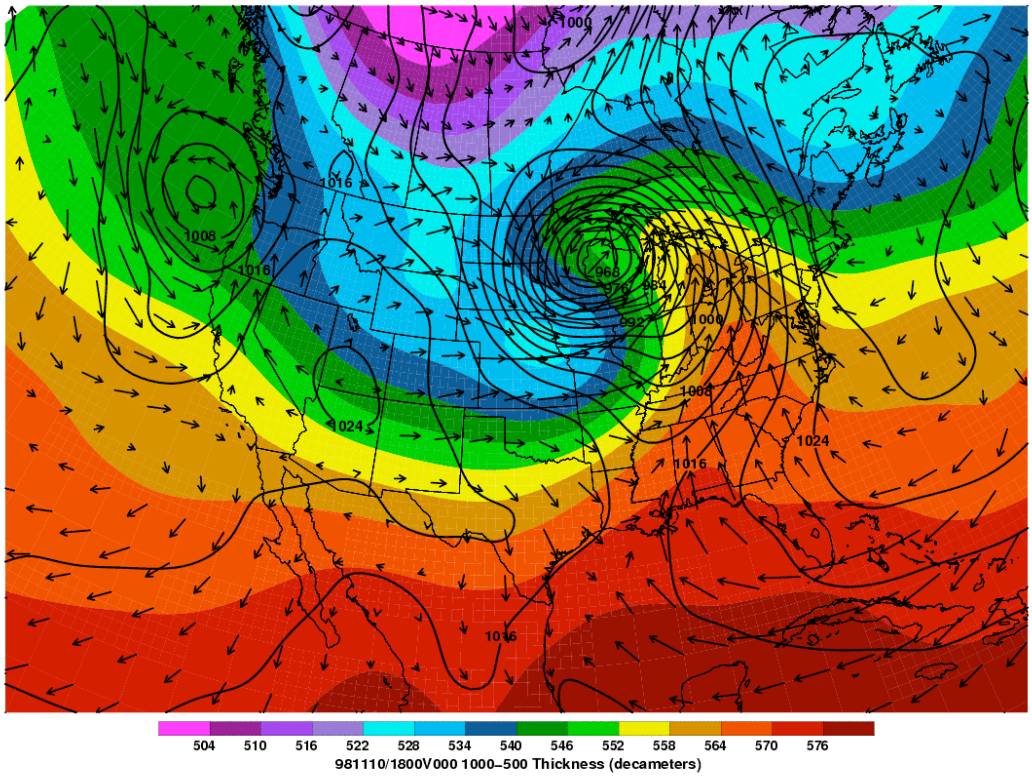
MAP 2: 6 Hours Later



MAP 3: 6 Hours Later



MAP 4: 6 Hours Later



Part 3: Forecast Weather Associated with a Midlatitude Cyclone
This exercise began by describing the weather associated with the November 10, 1998 midlatitude cyclone. You may know what types of weather to expect from this storm, but do you know where and when?

Let's be weather forecasters! We will focus on forecasting for four different cities:

Gage, Oklahoma

Bowling Green, Kentucky

Sioux Falls, South Dakota

Marquette, Michigan

We will be making two forecasts for each of these locations. One forecast for MAP 1 and one forecast for MAP 4 (18 hours later). You can mark each of these cities on your MAP 1 and MAP 4 by using the map on page 3 as a reference. Each city is marked with a small black dot.

Based on what you have learned about midlatitude cyclones and the tendencies in pressure, temperature, and wind associated with warm and cold fronts make a prediction at each time for:

Precipitation (Rain, Snow, or None)

Wind (Direction)

Temperature (Rising, Falling, or Steady) – Initial value given

Pressure (Rising, Falling, or Steady) – Initial value given

1) Fill in the table below.

LOCATION	MAP 1	MAP 4 (18 HOURS LATER)	HAS A FRONT PASSED? IF SO, WHAT KIND?
1 Gage, OK	*Precipitation* *Wind* *Temperature* 50°F *Pressure* 996mb	*Precipitation* *Wind* *Temperature* *Pressure*	
2 Bowling Green, KY	*Precipitation* *Wind* *Temperature* 55°C *Pressure* 1016mb	*Precipitation* *Wind* *Temperature* *Pressure*	
3 Sioux Falls, SD	*Precipitation* *Wind* *Temperature* 43°C *Pressure*	*Precipitation* *Wind* *Temperature* *Pressure*	
4 Marquette, MI	*Precipitation* *Wind* *Temperature* 35°C *Pressure*	*Precipitation* *Wind* *Temperature* *Pressure*	

2) Pick one city and compose a forecast for November 10, 1998. Write your forecast as if it would be read over the radio or on television.

City:
Forecast:

<u>Midlatitude Cyclones</u> – Identifying High/Low Pressure Areas and Warm/Cold Fronts

******KEY***********************************

Part 2: Identify and Label the Midlatitude Cyclone

1) On each of the following maps from November 10, 1998, identify the area of lowest pressure and mark with the low pressure symbol. (Hint: Focus on the black isobars. Wind arrows may help as well). *See maps*

2) On each of the following maps locate the warm and cold fronts and label with the appropriate symbols. Feel free to refer back to the characteristics of warm and cold fronts. *See maps*

3) Look at the progression of maps and what you have drawn. What do you notice?

The midlatitude cyclone is . . .

- *moving northeastward*
- *becoming stronger/the pressure is dropping*
- *has become occluded*
- *gradients in pressure and temperature are increasing (lines and colors are more tightly packed as time goes on)*
- *etc.*

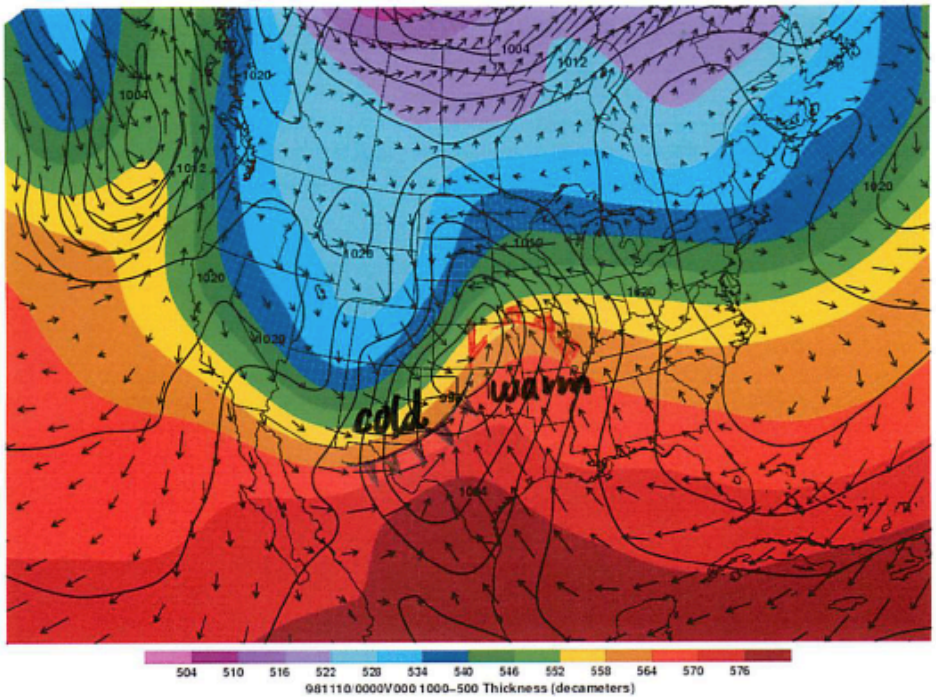
4) Can you identify the cold and warm sectors of the midlatitude cyclone? Please label. *See maps*

In which direction (north or south) is each of these sectors moving?

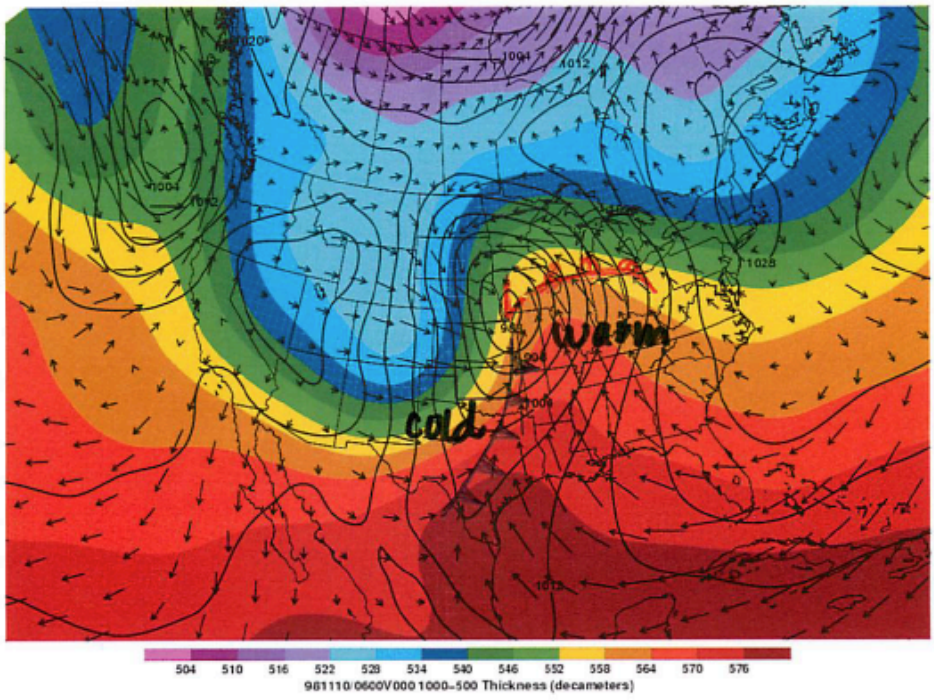
Cold – moving south
Warm – moving north
Why do you think that is?

The cyclone is doing its job of balancing the energy discrepancy between the pole and equator. It is moving arm air northward and cold air southward.

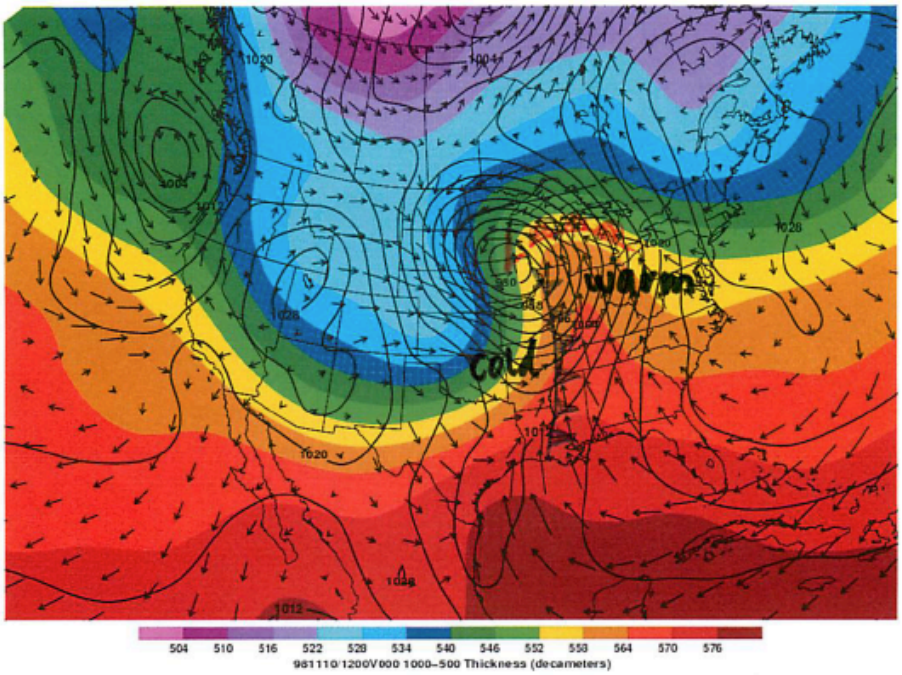
MAP 1



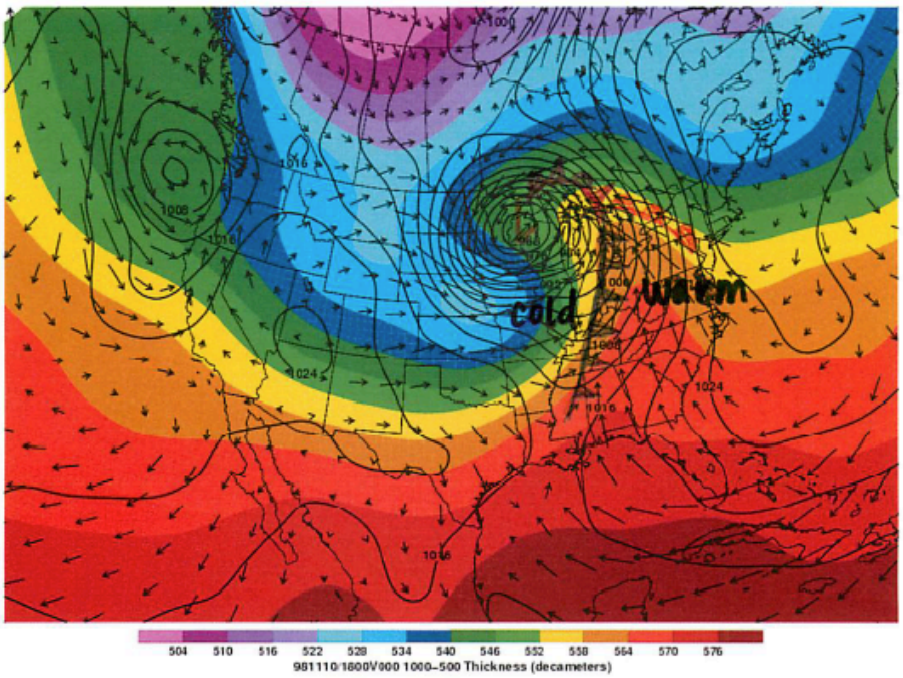
MAP 2: 6 Hours Later



MAP 3: 6 Hours Later



MAP 4: 6 Hours Later



occluded front present

Part 3: Forecast Weather Associated with a Midlatitude Cyclone

1) Fill in the table below.

LOCATION	MAP 1	MAP 4 (18 HOURS LATER)	HAS A FRONT PASSED? IF SO, WHAT KIND?
1 Gage, OK	*Precipitation* Rain (Moderate) *Wind* SW or NW (depends on where the front has been drawn; front is either about to pass or just has) *Temperature* 50°F *Pressure* 996mb	*Precipitation* None *Wind* W *Temperature* Falling *Pressure* Rising	Yes, Cold
2 Bowling Green, KY	*Precipitation* Fog or light rain *Wind* E/SE *Temperature* 55°C *Pressure* 1016mb	*Precipitation* None (Or, if cold front has reached KY, moderate rain) *Wind* S (Or, if cold front has reached KY, W) *Temperature* Rising (Or, if cold front has reached KY, falling) *Pressure* Falling (Or, if cold front has reached KY, rising)	Yes, Warm (Or, if cold front has reached KY, warm and cold)

3 Sioux Falls, SD	*Precipitation* Rain (moderate) *Wind* E *Temperature* 43°C *Pressure* 1002mb	*Precipitation* Snow (moderate) *Wind* NW *Temperature* Falling *Pressure* Falling	No, this location has always been on the western side of the midlatitude cyclone; colder air has moved into the area from the north
4 Marquette, MI	*Precipitation* None *Wind* E *Temperature* 35°C *Pressure* 1018mb	*Precipitation* Rain (moderate) *Wind* SE *Temperature* Steady rise then fall *Pressure* Falling	Yes, Occluded

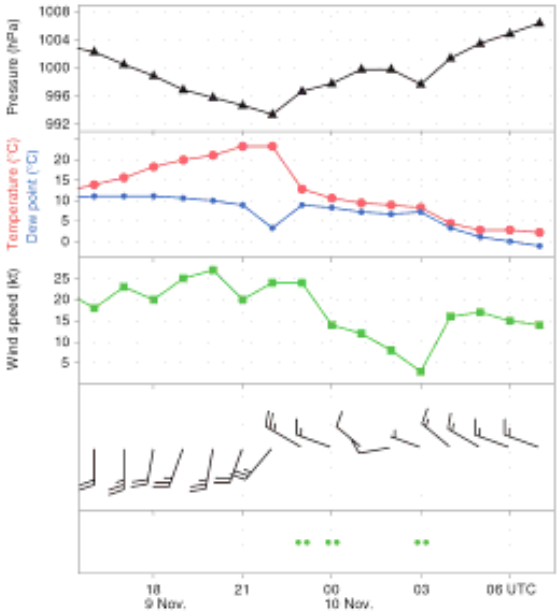
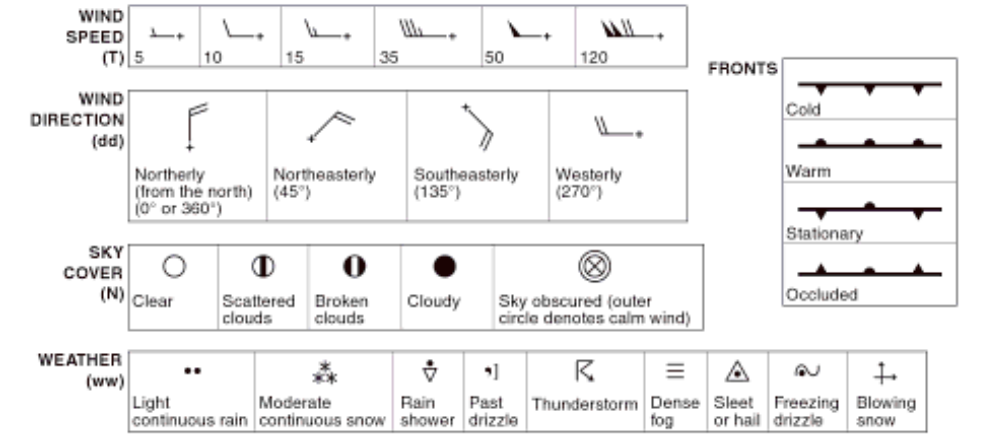


Fig. 8.10 Hourly surface observations at Gage, Oklahoma (KGAG in Fig. 8.36) showing the passage of the primary and secondary cold fronts. The locations of Gage and the other stations for which time series of hourly station observations are shown are indicated in Fig. 8.36 at the end of Section 8.2. [Courtesy of Jennifer Adams, COLA/IGES.]



Plotting model		Example 1		Example 2		Example 3	
TT dd PPP ww N ±ppa T_dT_d RR		21 247 10 +8/		−1 037 −1		17 936 15 M	
T	Wind speed (kt)	T	15	T	Calm	T	5
dd	Wind direction	dd	320	dd	—	dd	070
TT	Temperature (C)	TT	21	TT	−1	TT	17
T_dT_d	Dew point (C)	T_dT_d	10	T_dT_d	−1	T_dT_d	15
PPP	Pressure	PPP	1024.7	PPP	1003.7	PPP	993.6
±ppa	Pressure tendency	±ppa	0.8 (rising, then steady)	±ppa	1.8↓	±ppa	3.0 (fall, then larger rise)
N	Sky cover	N	Clear	N	Sky obscured	N	Cloudy
ww	Weather	ww	None	ww	None	ww	Thunderstorm in past hour
RR	6h precipitation (in.)	RR	None	RR	0.15	RR	Missing

2) Pick one city and compose a forecast for November 10, 1998. Write your forecast as if it would be read over the radio or on television.

These responses are very open-ended and can vary greatly.

City: *Gage, OK*
Forecast: *Anticipate moderate rain, strong westerly winds, and falling temperatures this morning as a cold front moves through the area. Things should clear later in the day and westerly winds will prevail, along with rising pressure.*

City: *Bowling Green, KY*
Forecast: *(Written as if the cold front has not yet reached town) Anticipate light drizzle as a warm front moves towards us this morning. As the rain recedes temperatures will rise and winds will come from the south.*

City: *Sioux Falls, SD*
Forecast: *Expect a great deal of precipitation today. Moderate rain in the beginning of the day will transition to snow as colder air moves in from the north. Expect snowfall amounts near 12" and high winds. Beware of blizzard conditions.*

City: *Marquette, MI*
Forecast: *Easterly winds and warmer temperatures early in the day will give way to south-easterly winds and quickly falling temperatures as an occluded midlatitude cyclone moves over the region today. Moderate rain can be expected later in the day.*