OBSERVING THE ATMOSPHERE

GEOG/ENST 3331 – Lecture 7

Ahrens: Chapters 13 and 11; A&B: Chapters 13 and 9

Agenda

- Lecture: **Observing the Atmosphere**
- **Welcome Anna Gutman at 0930**
  - Lakehead University's Media and Environmental Justice Movements course in Ecuador this spring.
- Discussion of **Assignment 1 (A1)** and **A 2** on Friday

Lecture outline

- **Weather observation**
  - Observation tools
- **Air masses and fronts**
  - Migration
  - Identification
- Midlatitude cyclones
  - Surface features
  - Upper air divergence

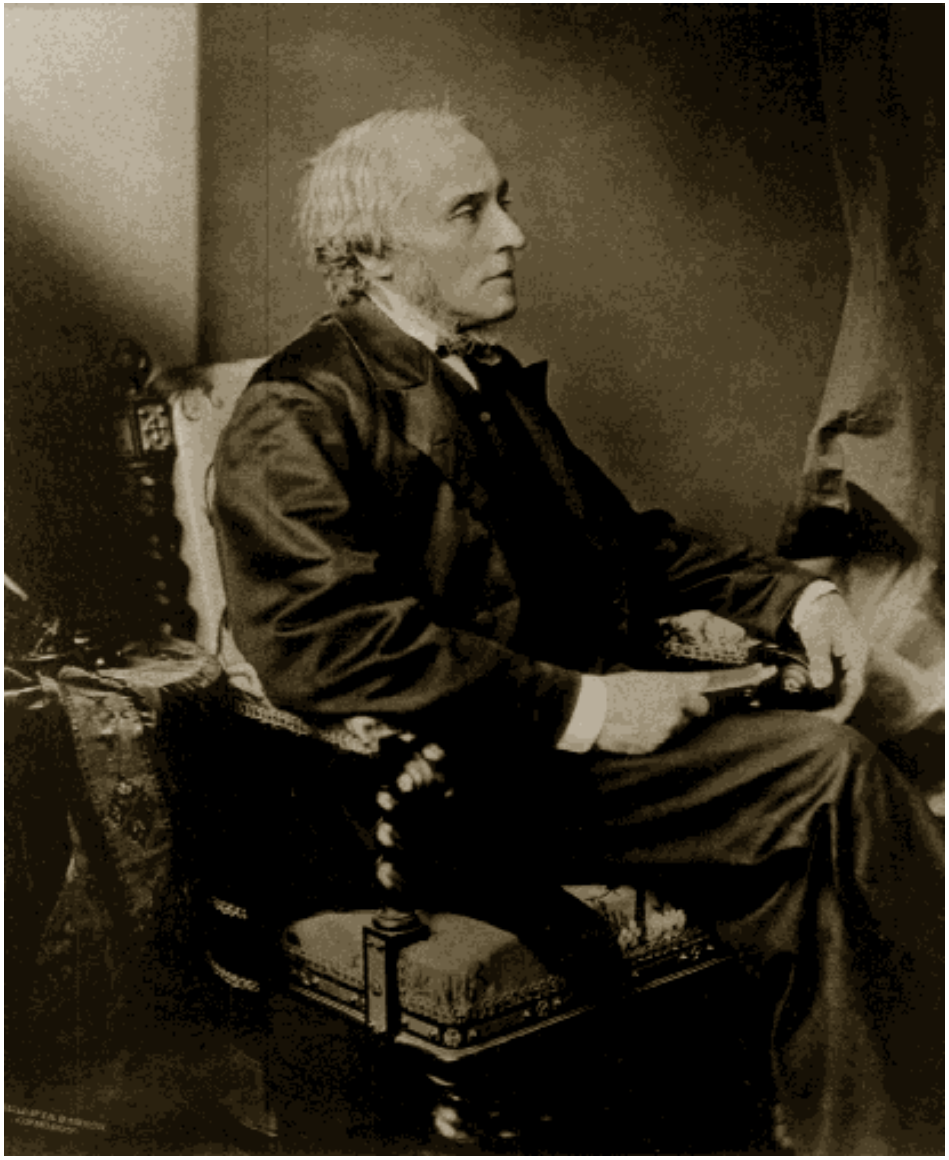
World Meteorological Organization

- WMO
- UN Body that oversees data collection
  - 185 nations and 6 territories
- All weather data is sent to three WMO Centres:
  - Melbourne, Australia
  - Washington, D.C.
  - Moscow, Russia
- From here these data are sent to national centres.

Canadian Weather Service (CWS)

1871 CWS started by George Kingston

- Budget: $5000
- Set up national weather office and observing network
- Observation stations
  - Ottawa
  - Halifax
  - Fredericton
  - Saint John



Canadian Weather Service

- 1873
  - "Great Nova Scotia Cyclone"
  - Category 2 hurricane off Nova Scotia
  - Over 500 people killed
- 1876
  - Telegraph lines set up to every major city in Eastern Canada.

Meteorological Services

Canada: Meteorological Service of Canada

www.msc.ec.gc.ca

U.S.: National Weather Service

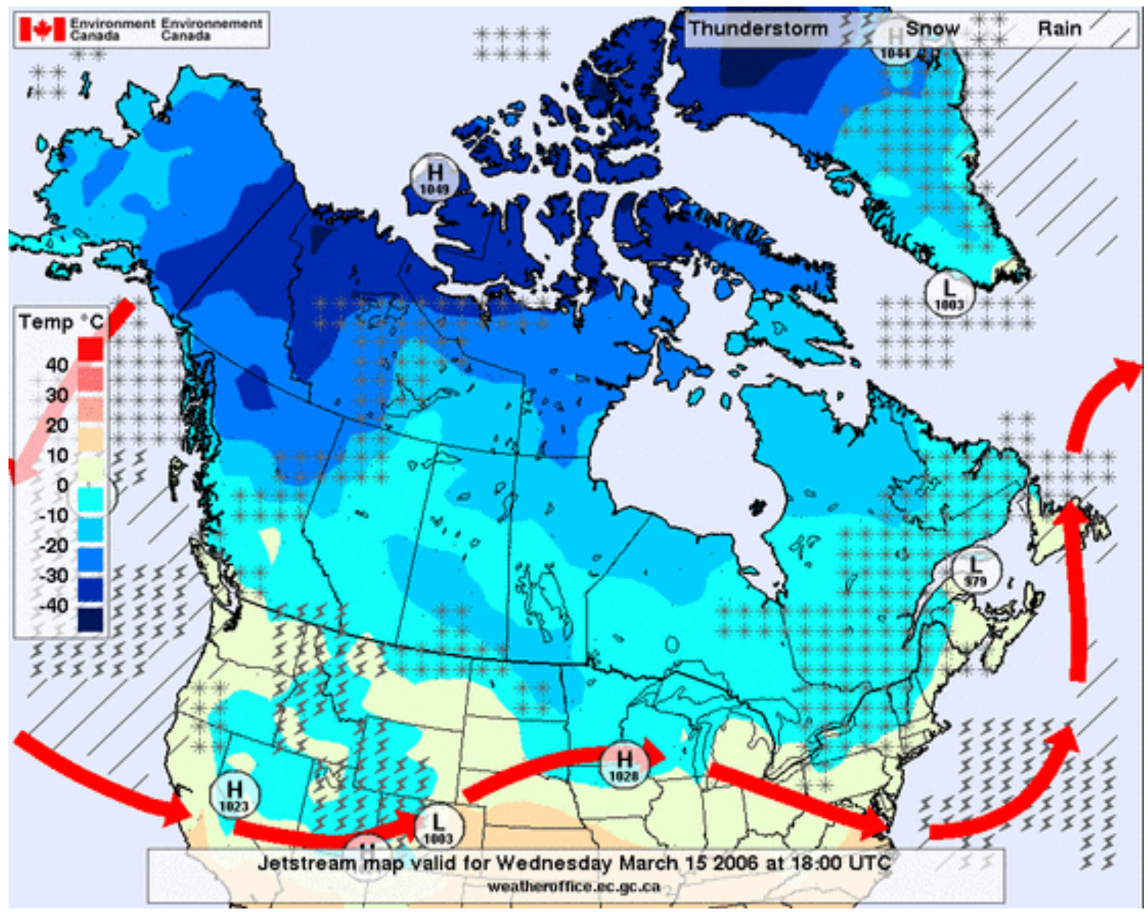
www.nws.noaa.gov

Products

- Current state of the weather
- Forecast of future weather
- Record keeping – climatology
- Education
- Warning system

Meteorological Service of Canada

- Over 60 000 observations processed daily by Environment Canada computers
- Regional weather offices turn these observations into 1300 daily local weather forecasts
- Also monitors air quality, ice cover, water levels and more.



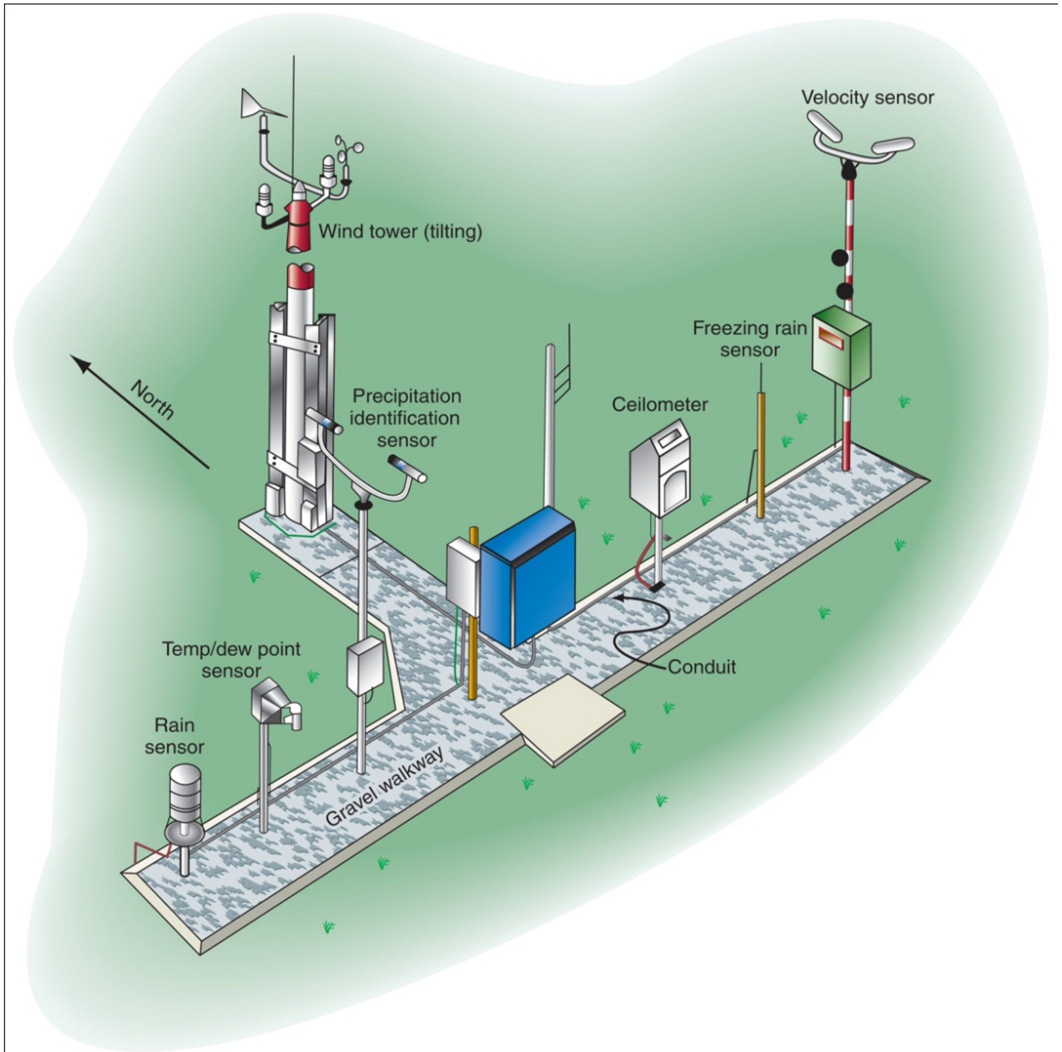
Instrumentation

Instrument	Variable
Thermometer	Temperature
Barometer	Pressure
Hygrometer	Humidity
Rain gauge	Precipitation
Anemometer	Wind speed
Wind vane	Wind direction
Radiometer	Radiation

Data Collection

Surface observations

- Hourly
  - Temperature
  - Pressure
  - Pressure tendency
  - Humidity
  - Sky condition
  - Precipitation
- WMO: 10,000 ground stations worldwide



Data Collection

Radiosonde

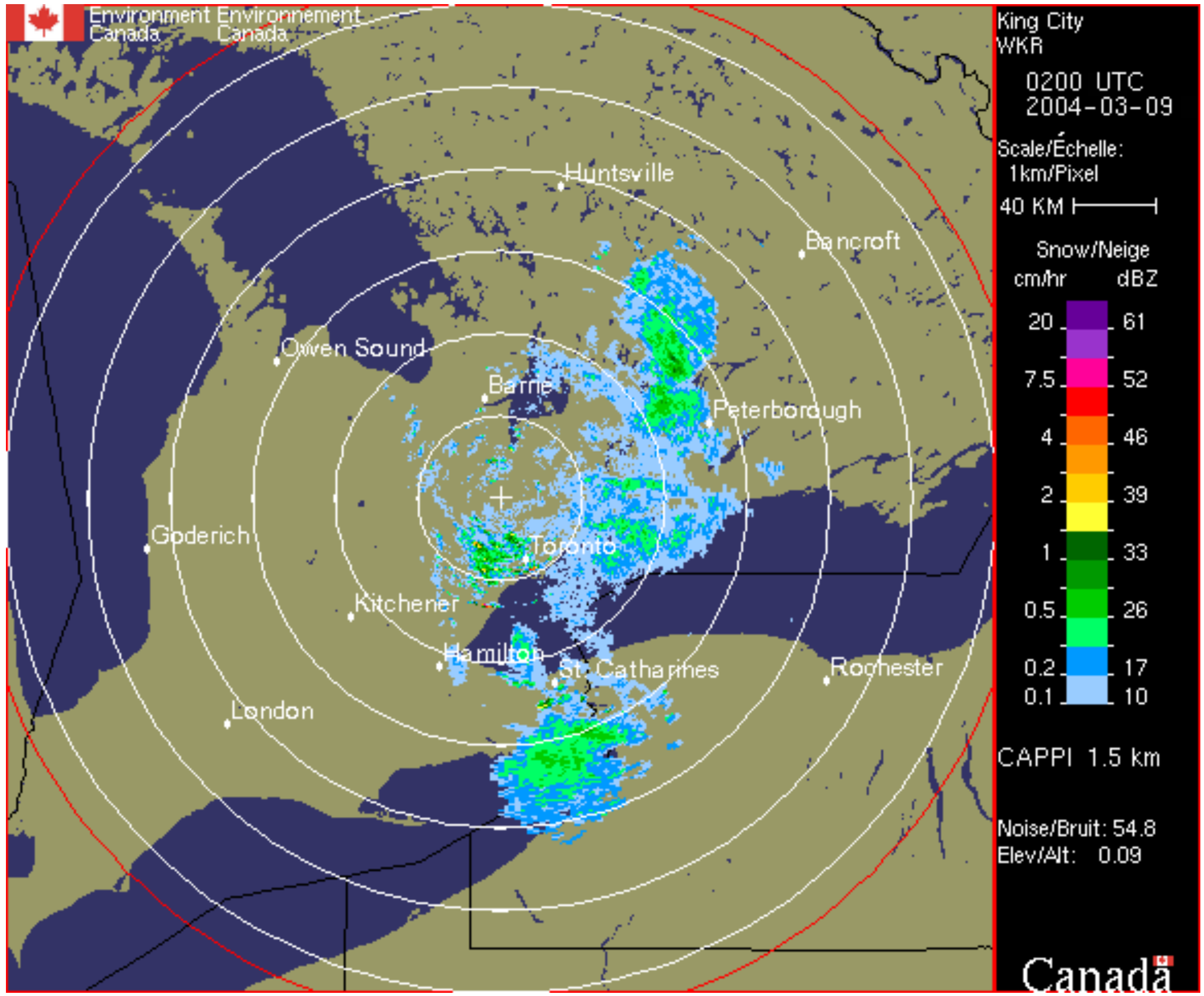
- Weather balloons launched twice daily (0 and 12 UTC)
- Temperature, pressure, humidity, wind
- Generally 'pop' around 30 km (halfway through the stratosphere)
- 34 in Canada, 750 worldwide

A&B: Figure 13-4

Data Collection

Radar

- Continuous monitoring
  - Rainfall rate
  - Wind speed
  - Tornado detection



Data Collection

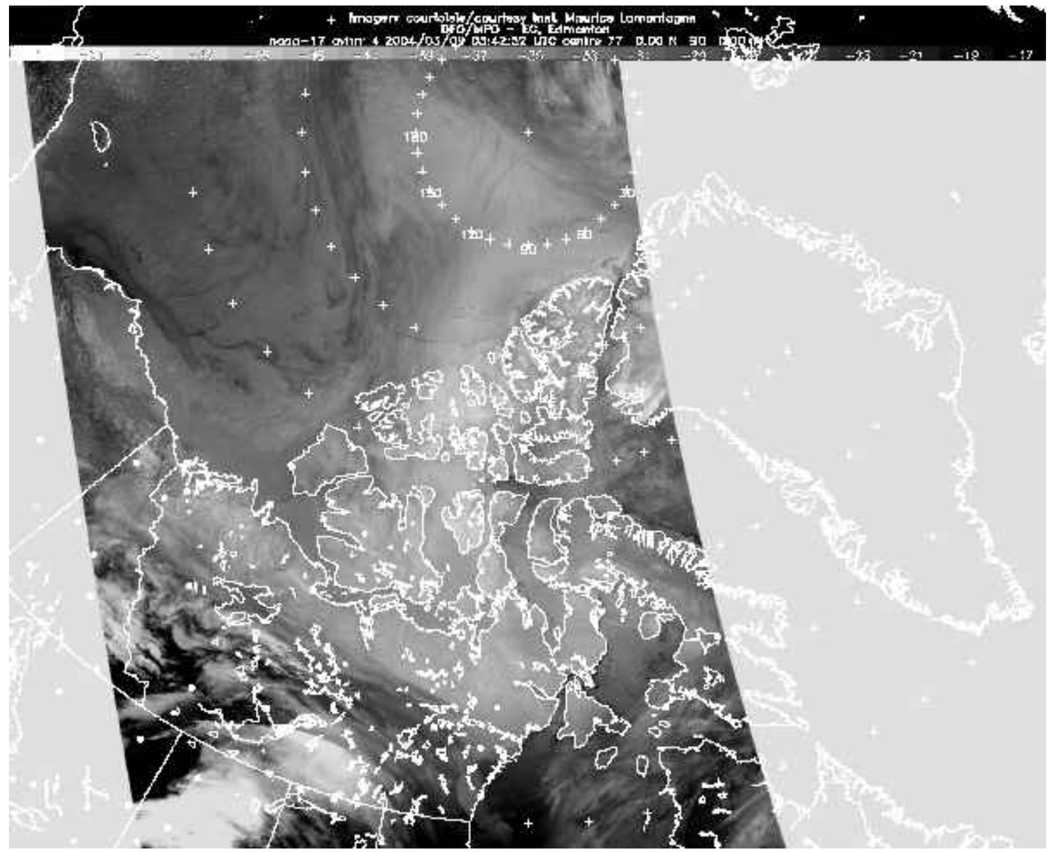
Satellite

- Continuous monitoring
  - Cloud cover
  - Cloud temperatures
  - Surface temperatures
  - Ice conditions
- Two main types
  - Polar orbiting
  - Geostationary

Satellite Data

Polar orbiting

- First launched in 1960 (TIROS-N)
- Passes over both poles
- *Sun synchronous*
- 800 km above the earth
- Excellent resolution.



Satellite Data

Geostationary

- Fixed relative to the earth
- Altitude: 37,000 km
- Latitude: 0°
- Continuous monitoring of atmospheric conditions

Data Collection

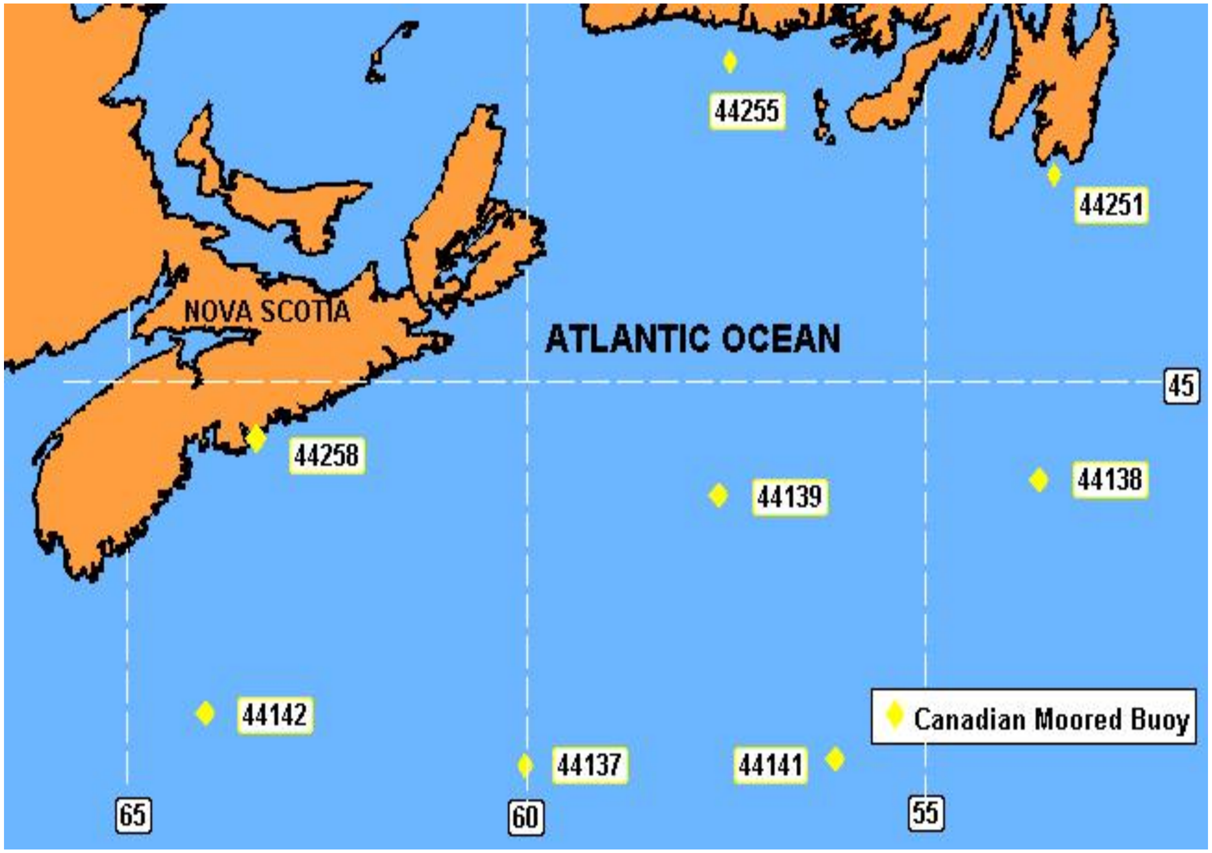
Rocketsonde

- Two per week
- Higher altitudes than radiosondes
- Stratospheric data
  - Temperature
  - Ozone concentration

Data Collection

Other methods

- Ships (7000 worldwide)
- Buoys (300)
- Aircraft (*dropsonde*).



Data Assembly

The Canadian Meteorological Centre

- Dorval, Québec

There are six regional centres:

- Vancouver
- Edmonton
- Winnipeg
- Toronto
- Montréal
- Halifax

Data Assembly

Current weather conditions, satellite imagery and computer weather forecasts are sent to these centres where regional forecasts are made.

Meteorological offices are typically located and maintained at airports.

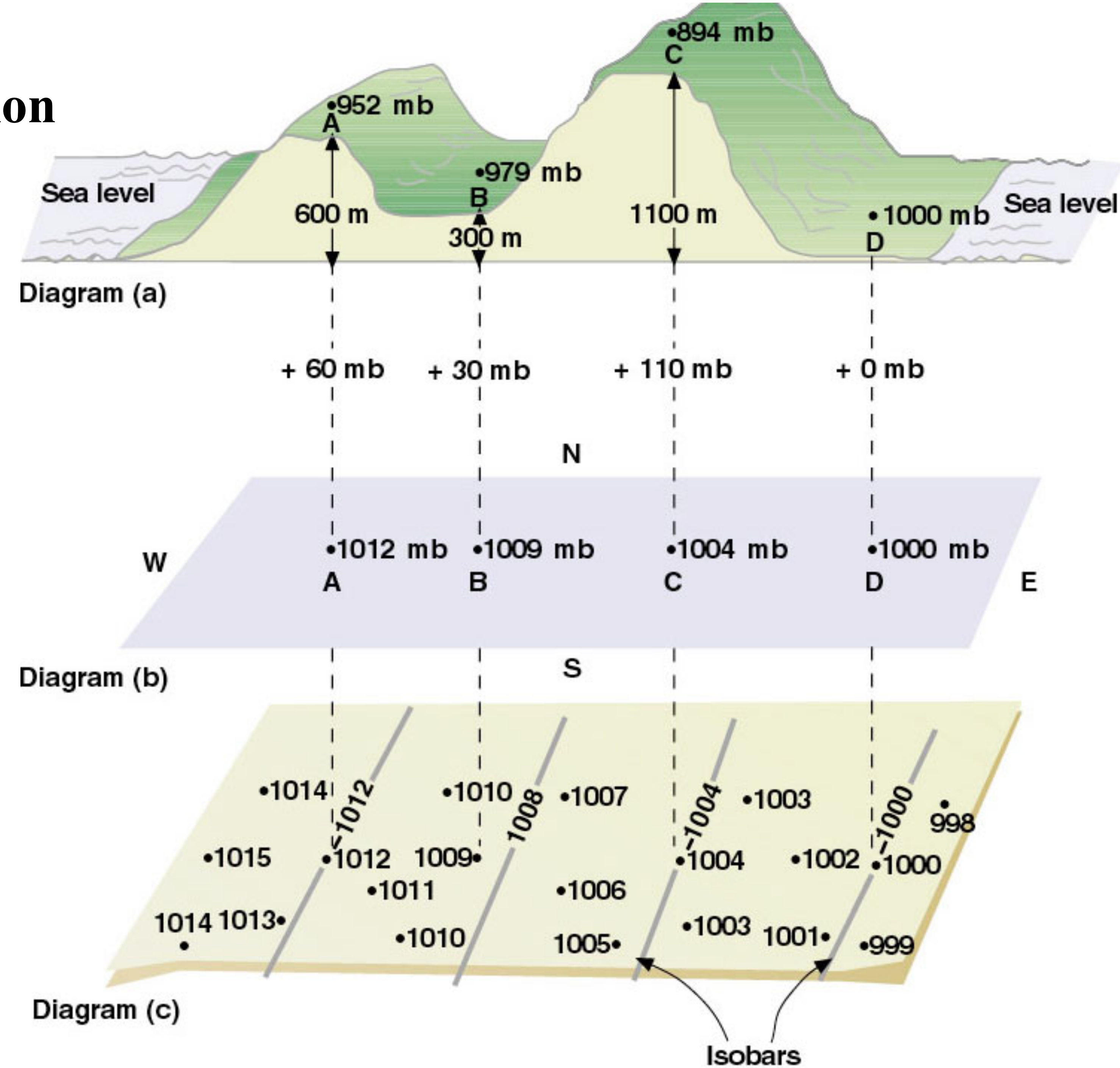
Data Analysis

- Surface charts (near 1000 hPa)
- Pressure correction to sea level is needed in order to compare pressures and temperatures from surface observations.

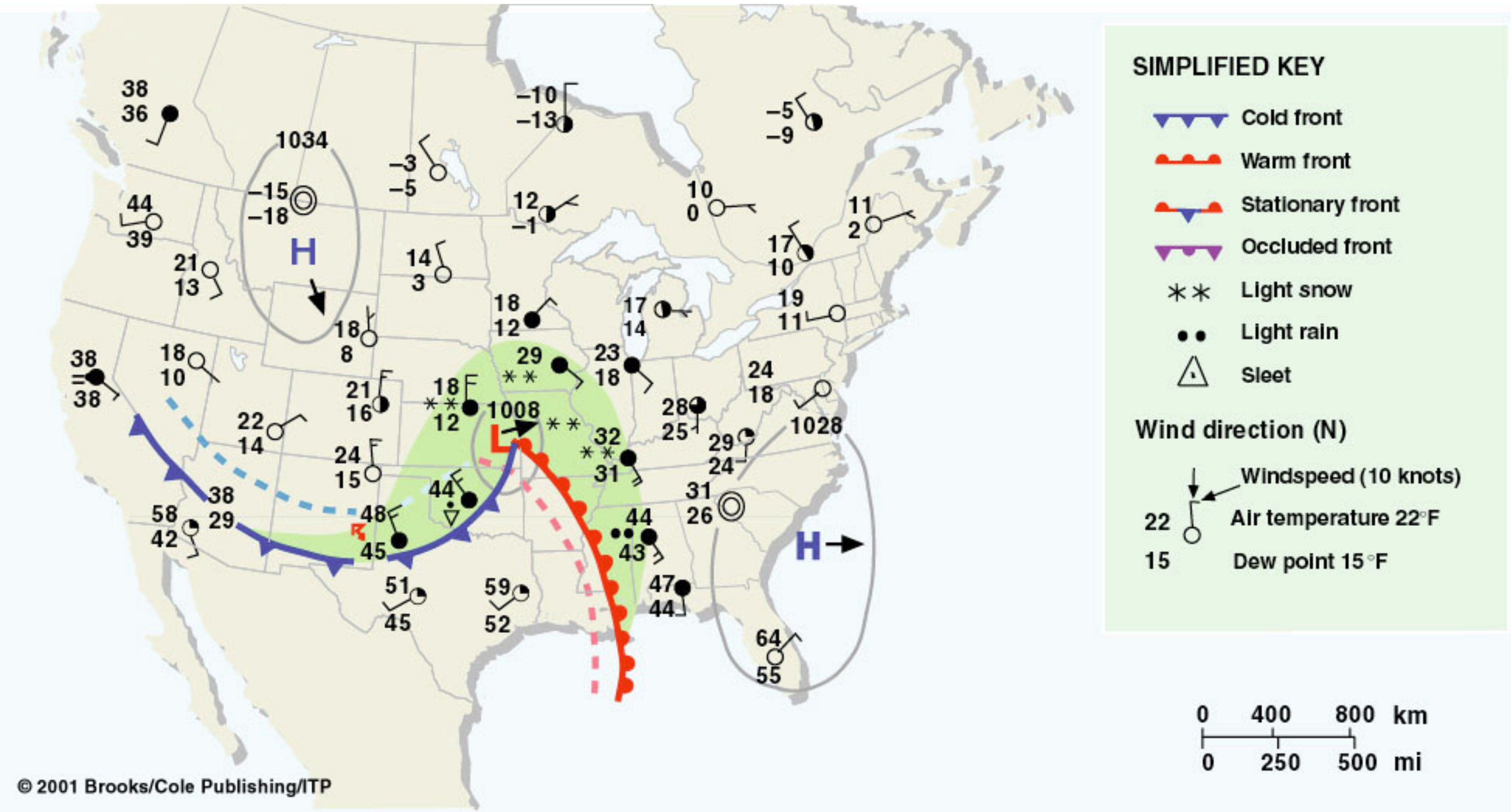
Pressure reduction to sea level

Rule of Thumb Correction:

10 hPa / 100 m

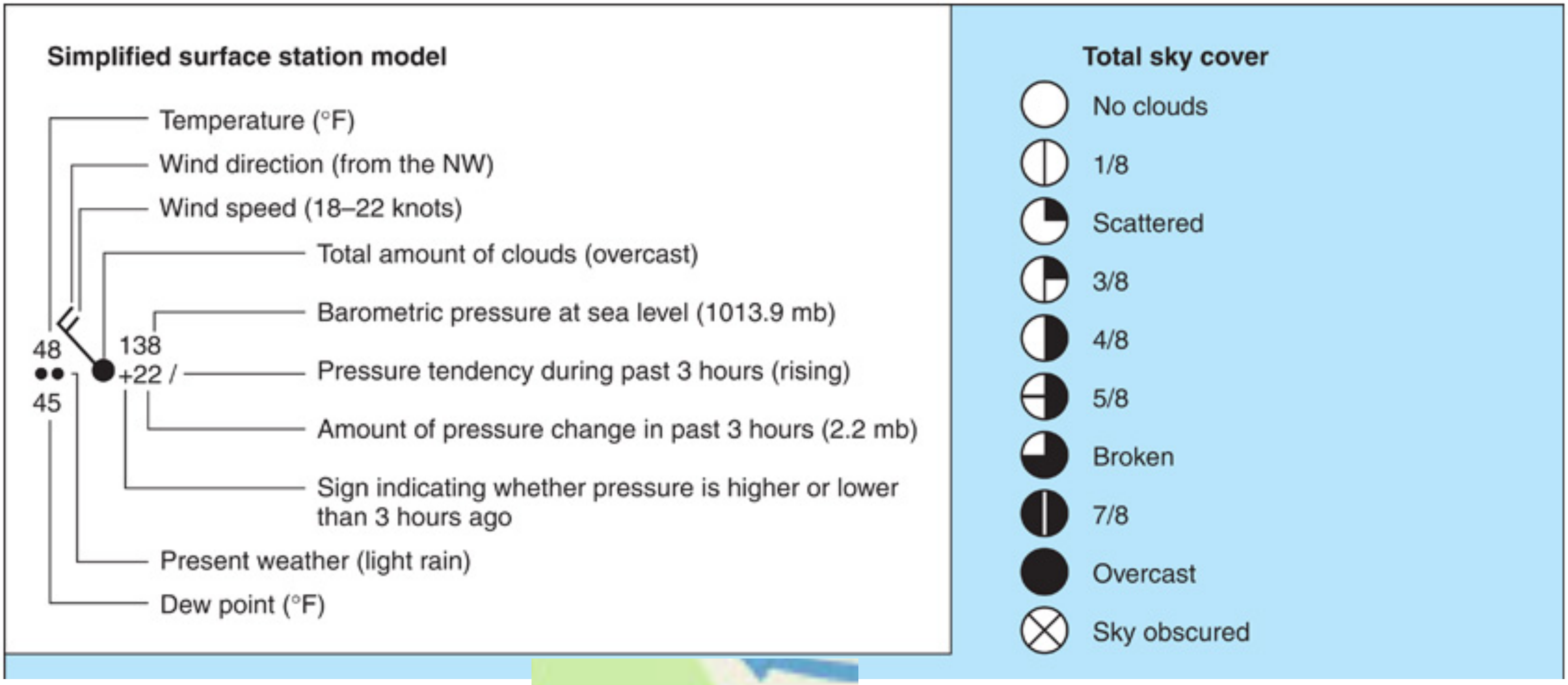


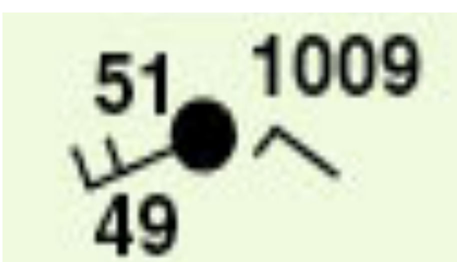
Surface charts: the station model



Ahrens: Figure 13.12

Station Model





A&B: Figure 13-12

Wind entries

	Miles (statute) per hour	Knots	Kilometers per hour
	Calm	Calm	Calm
	1–2	1–2	1–3
	3–8	3–7	4–13
	9–14	8–12	14–19
	15–20	13–17	20–32
	21–25	18–22	33–40
	26–31	23–27	41–50
	32–37	28–32	51–60
	38–43	33–37	61–69
	44–49	38–42	70–79
	50–54	43–47	80–87
	55–60	48–52	88–96
	61–66	53–57	97–106
	67–71	58–62	107–114
	72–77	63–67	115–124
	78–83	68–72	125–134
	84–89	73–77	135–143
	119–123	103–107	144–198

Pressure tendency

- Rising, then falling
- Rising then steady; or rising, then rising more slowly
- Rising steadily or unsteadily
- Falling or steady, then rising; or rising, then rising more quickly

(Barometer now higher than 3 hours ago)

- Steady, same as 3 hours ago
- Falling, then rising, same or lower than 3 hours ago
- Falling, then steady; or falling, then falling more slowly
- Falling steadily, or unsteadily
- Steady or rising, then falling; or falling, then falling more quickly

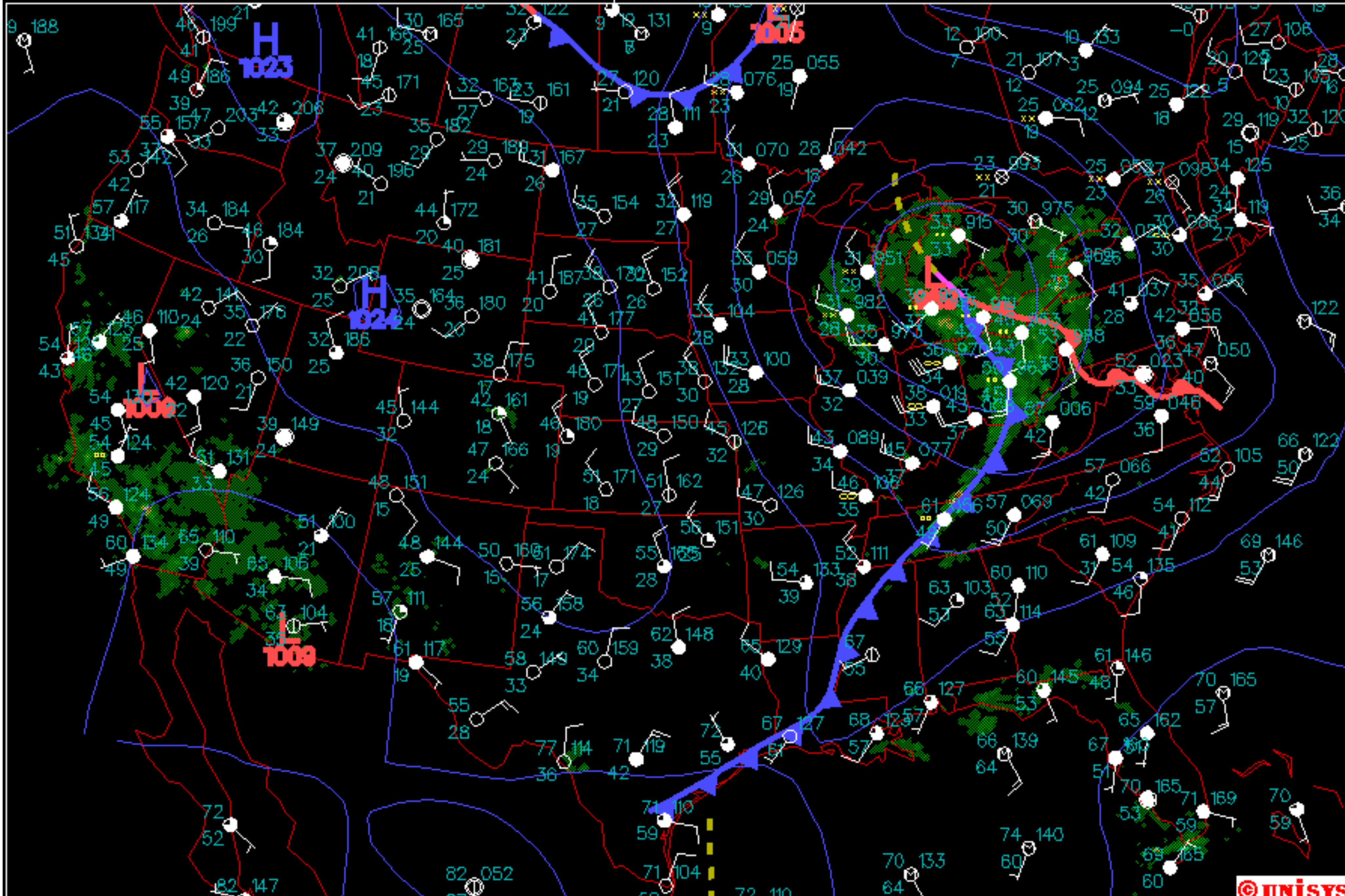
(Barometer now lower than 3 hours ago)

Common weather symbols

Light rain	Freezing rain
Moderate rain	Freezing drizzle
Heavy rain	Rain shower
Light snow	Snow shower
Moderate snow	Fog
Heavy snow	Haze
Light drizzle	Smoke
Ice pellets (sleet)	Thunderstorm
	Hurricane

A&B: Fig. 13-12

Surface data plot for 00Z 21 FEB 04



Intensities (Dbz): 20 30 40 45 50 55

Fronts at 00Z

Upper air charts

- Pressure levels
- Height: Isoheight or isohypse
- Temperature: Isotherm
- Vorticity
- Wind speed: Isotach
- Pressure tendency: Isallobar

- Essential for forecasting
- What should we look for?

Pressure Surface	Approximate Altitude
850 hPa	1.5 km
700 hPa	3 km
500 hPa	5 km
250 hPa	10 km

Air mass

A large body of air whose properties of temperature and moisture are fairly uniform in any horizontal direction at any given altitude.

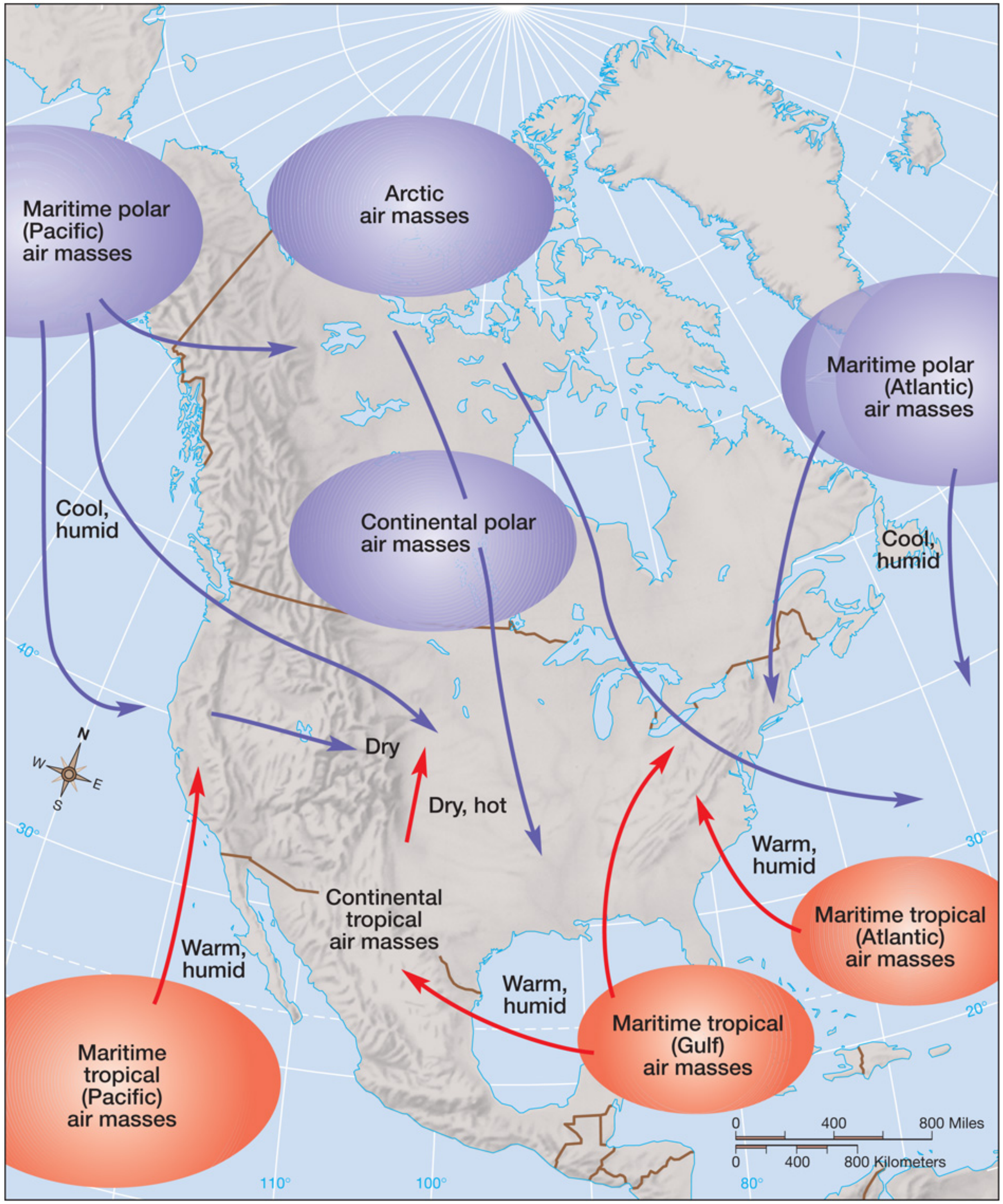
Typically air masses cover many thousands of square kilometres

Source regions

- Air masses form in regions that are horizontally uniform
  - Oceans
  - Plains and tundra
  - Plateaus
- Midlatitudes are not usually source regions
  - Too many synoptic weather systems mixing things up

Air mass classification

Type	Source	Properties
Continental Arctic (cA)	Russia, Canada, Alaska, Greenland, Antarctica	Extremely cold and very dry Extremely stable
Continental Polar (cP)	High-latitude continental interiors	Cold and dry Very stable
Maritime Polar (mP)	High-latitude oceans	Cold and damp Somewhat unstable
Continental Tropical (cT)	Low-latitude deserts	Hot and dry Very unstable
Maritime Tropical (mT)	Subtropical oceans	Warm and humid Unstable, saturated


Maritime polar (Pacific) air masses
Arctic air masses
Maritime polar (Atlantic) air masses
Continental polar air masses
Cool, humid
Cool, humid
Dry
Dry, hot
Warm, humid
Continental tropical air masses
Warm, humid
Warm, humid
Maritime tropical (Atlantic) air masses
Maritime tropical (Gulf) air masses
Maritime tropical (Pacific) air masses
N
W
E
S
40°
30°
30°
20°
110°
100°
80°
0 400 800 Miles
0 400 800 Kilometers

A&B: Figure 9-1

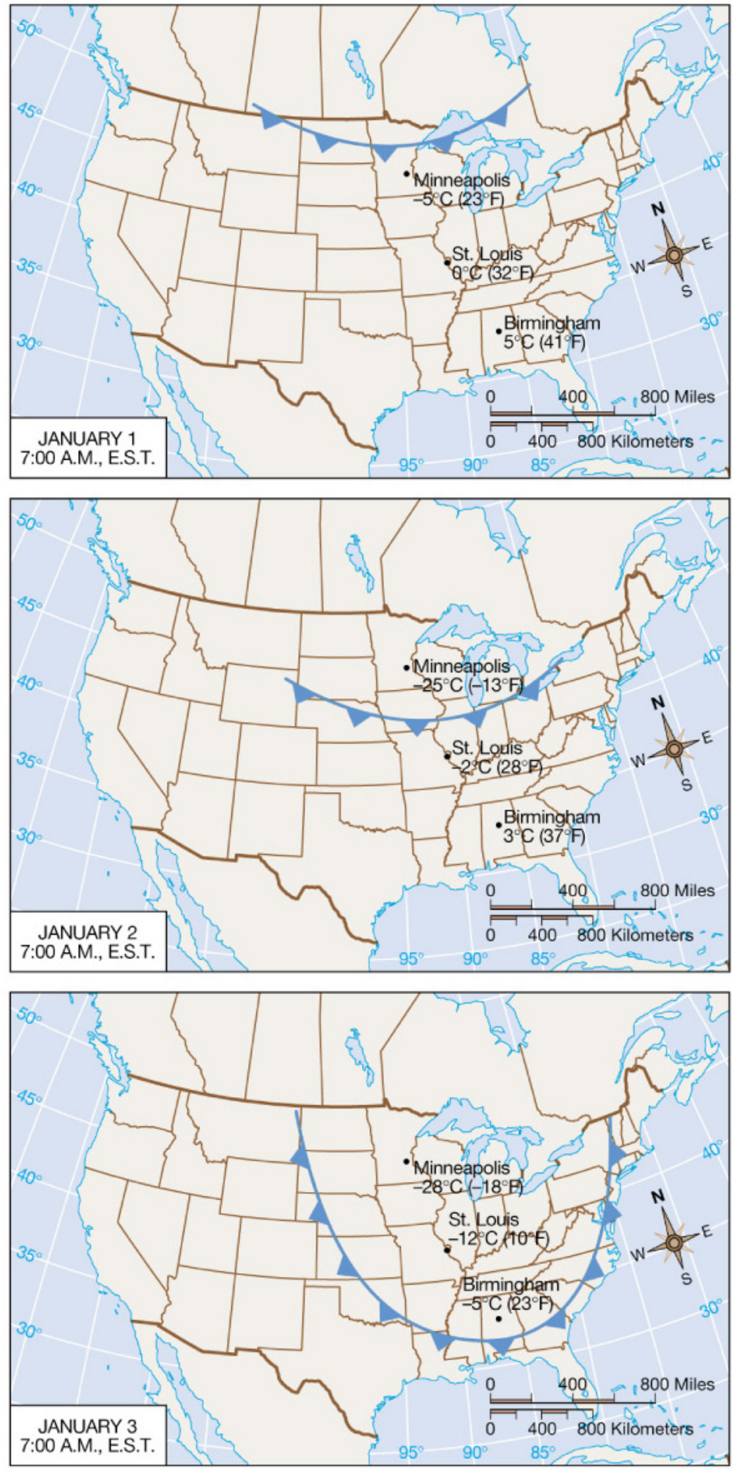
Air masses

- Air masses are not confined to their source regions and move around, which causes:

1. The region to which the air mass goes causes a major change in temperature and humidity
2. The air mass itself becomes more moderate

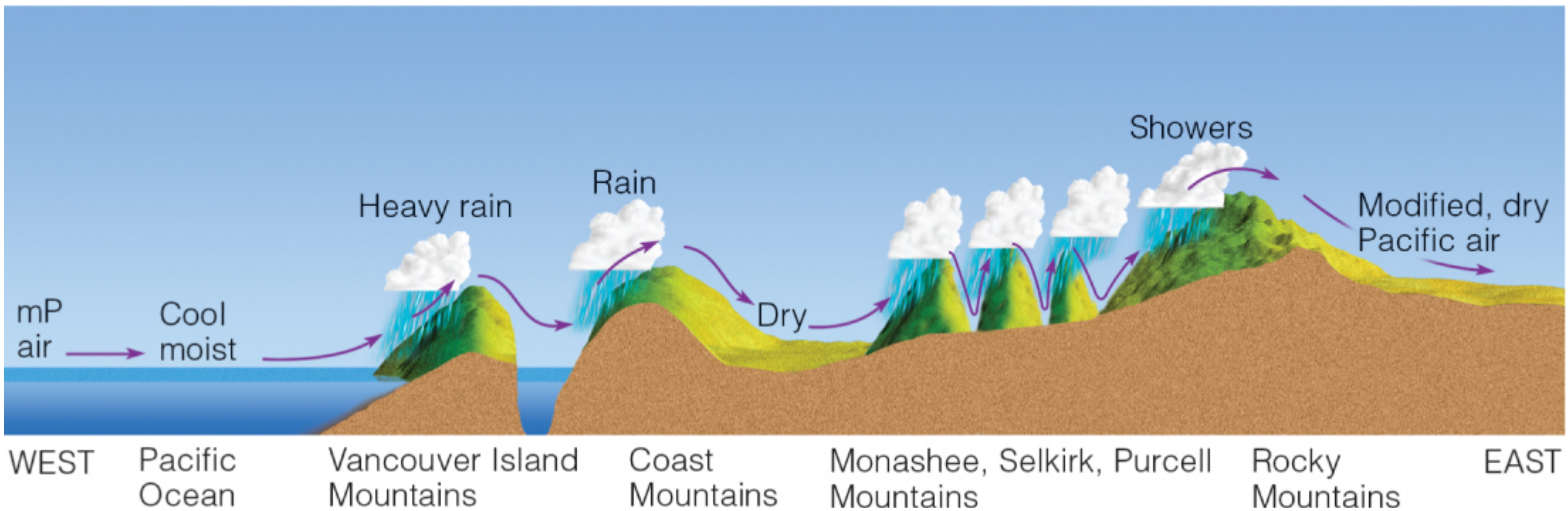
Modifying air masses

- As the air mass moves south, it cools the surrounding surface area
- Air mass itself becomes warmer



A&B: Figure 9-3

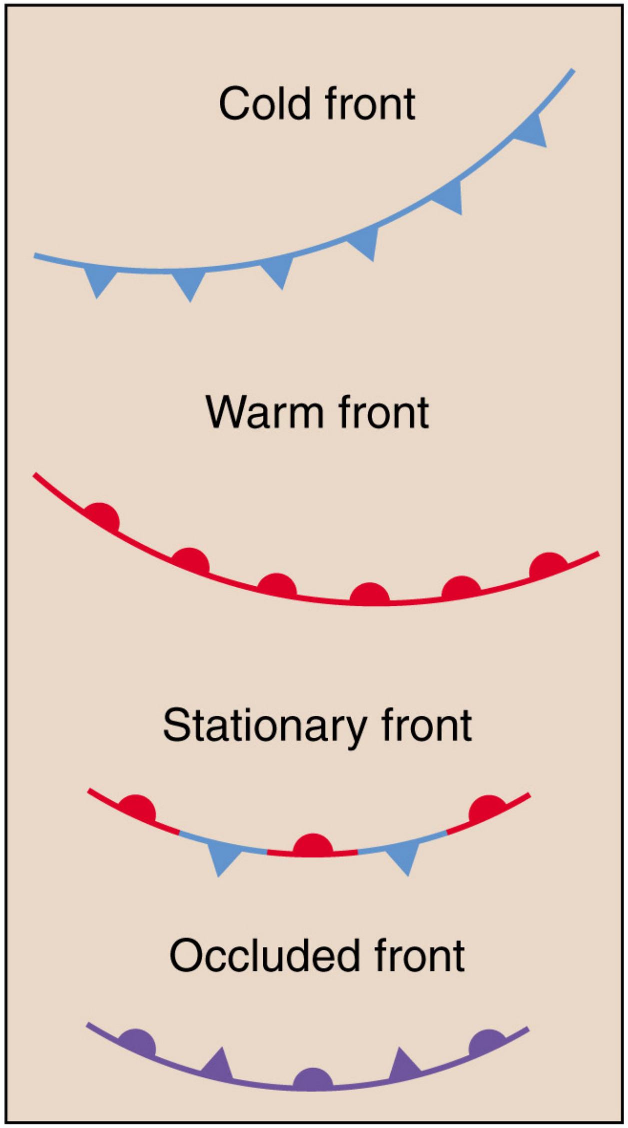
Modifying Air Masses



Ahrens: Figure 11.7

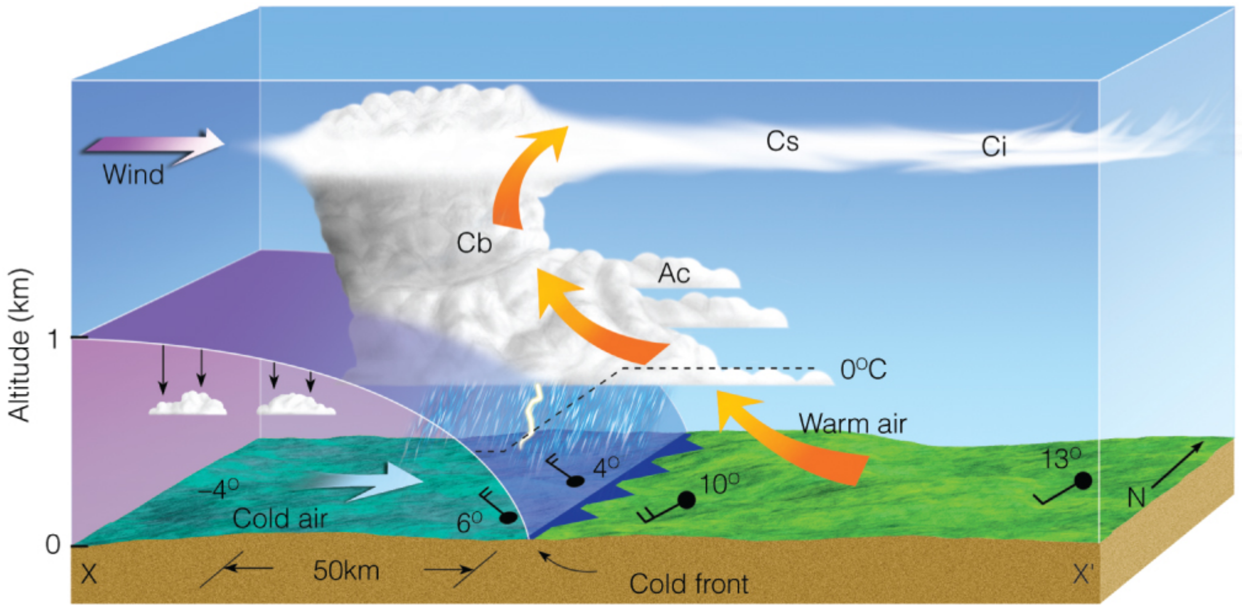
Fronts

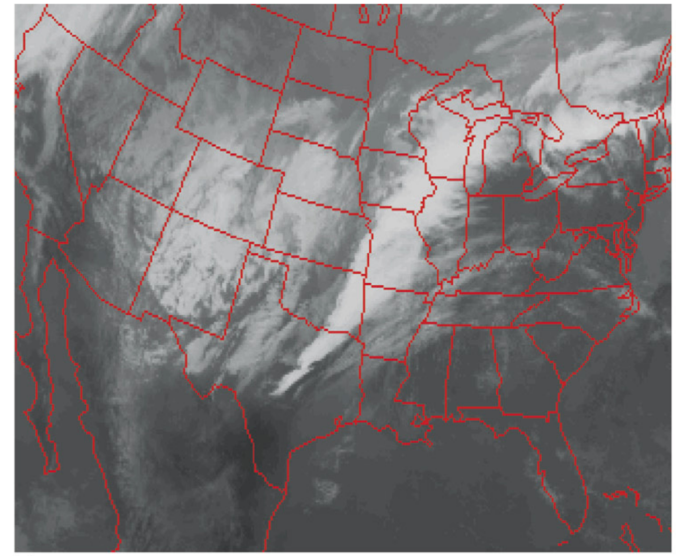
- Boundaries between air masses of different densities



A&B: Figure 9-4

COLD FRONTS





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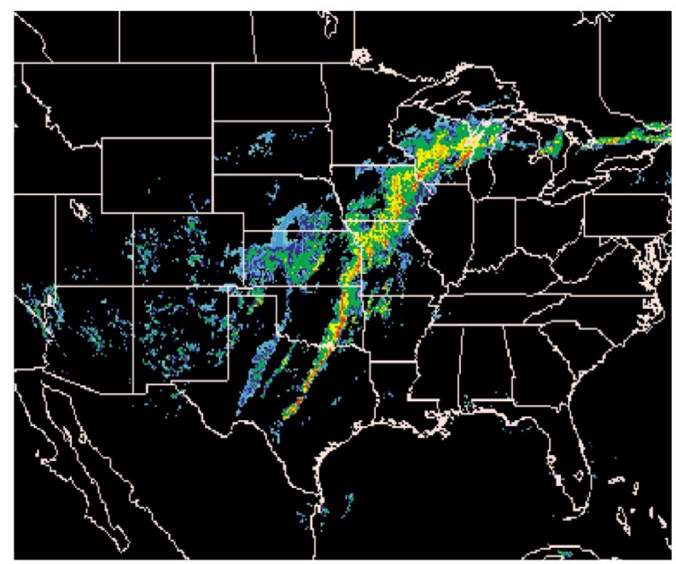


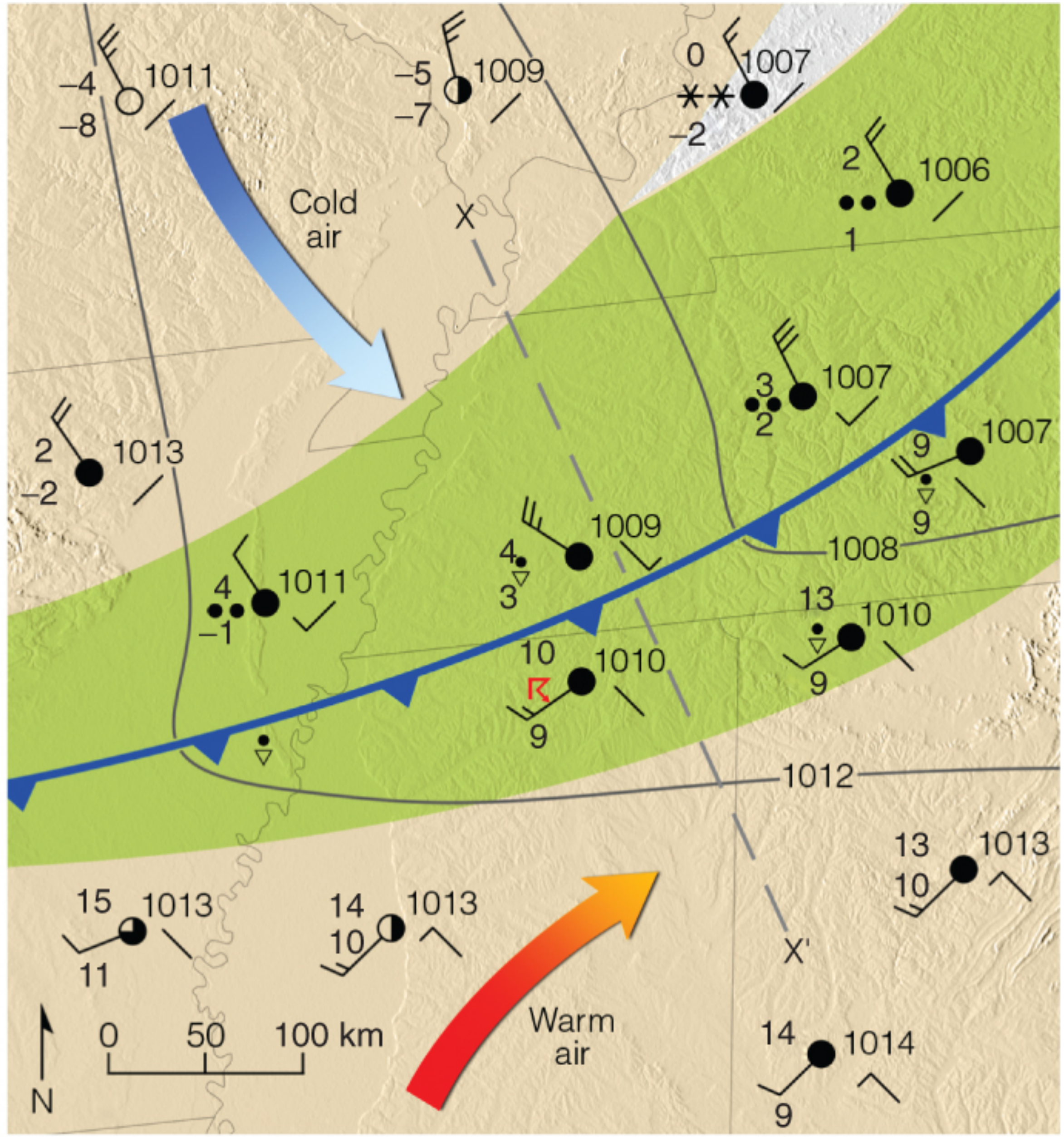
(b)

Ahrens: Active Fig. 11.15

The vertical displacement of air along a cold front boundary; steep profile (1:50 to 1:100)

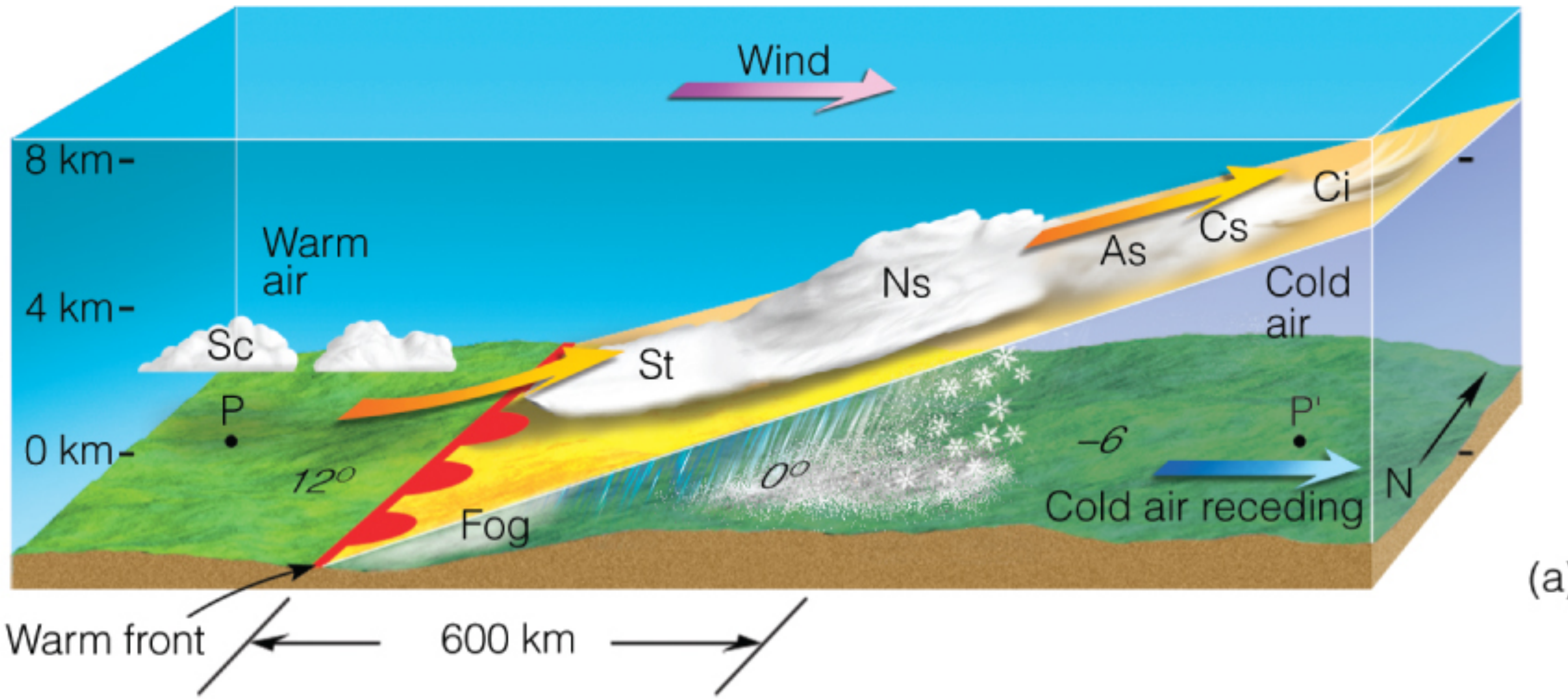
Identifying cold fronts

- Strong temperature gradient
- Humidity change
- Shift in wind direction
- Pressure change
- Clouds and precipitation patterns



Ahrens: Fig. 11.13

WARM FRONTS

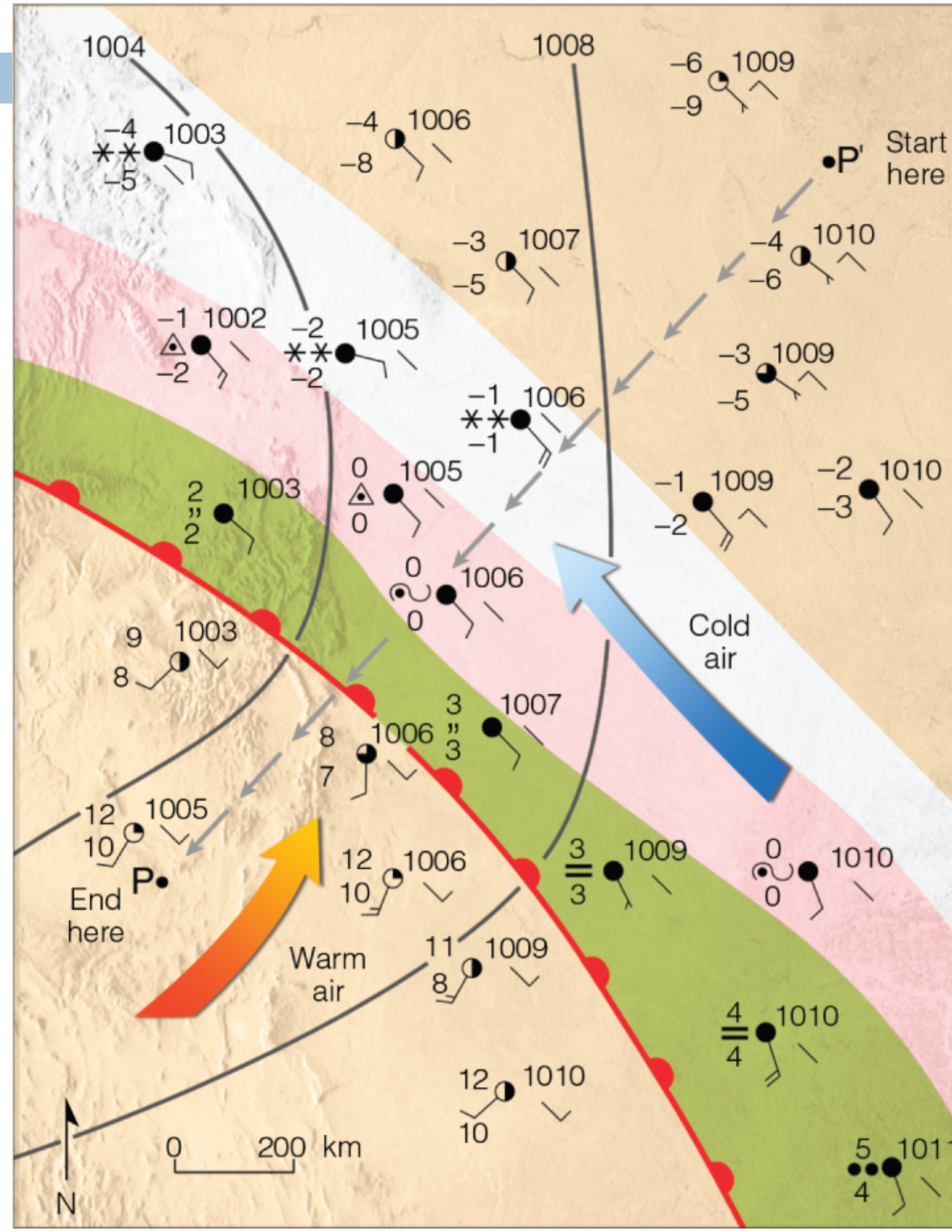


Overrunning leads to extensive cloud cover along the gently sloping surface of cold air.

Ahrens: Fig. 11.19

Warm front identification

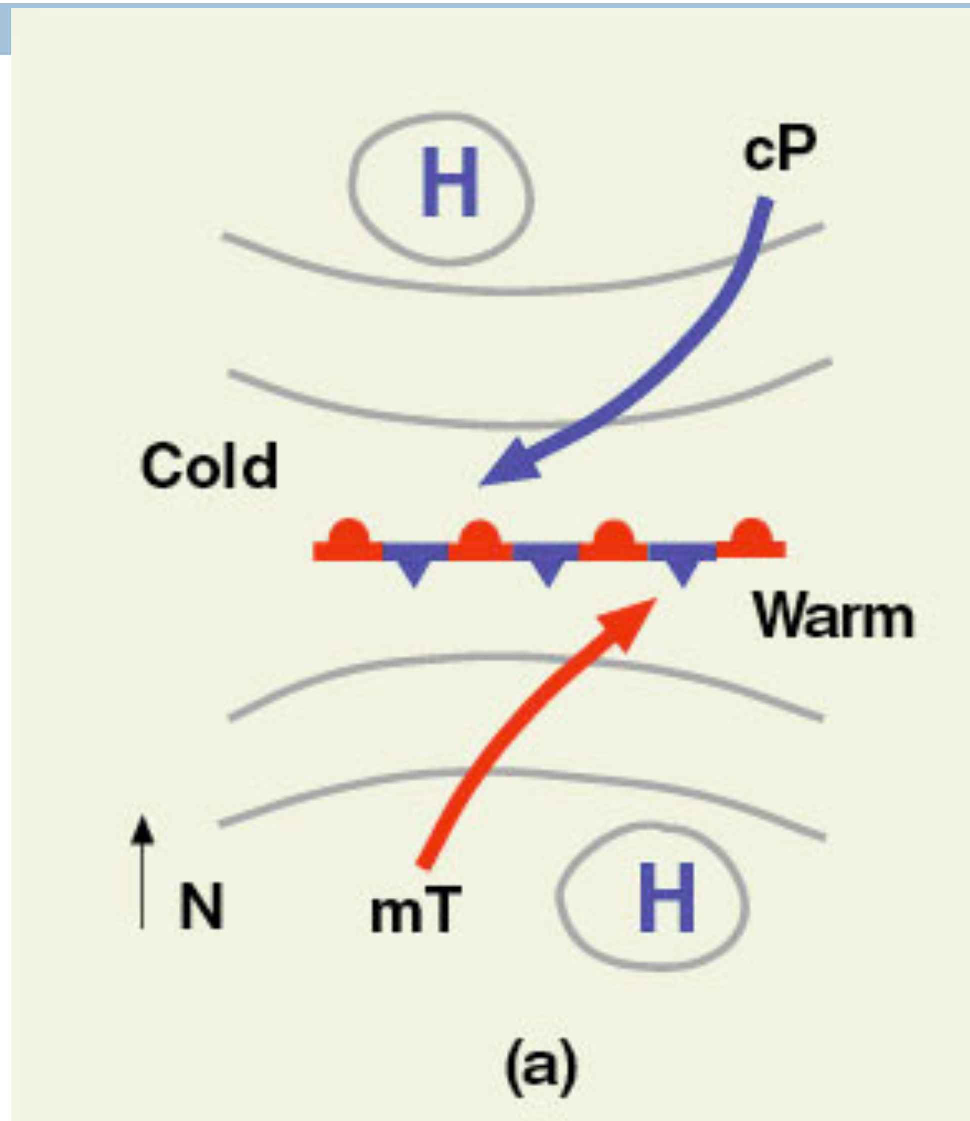
- Here, mT overrides mP
- Profile 1:150 - 1:300
- Gentle precipitation (drizzle)

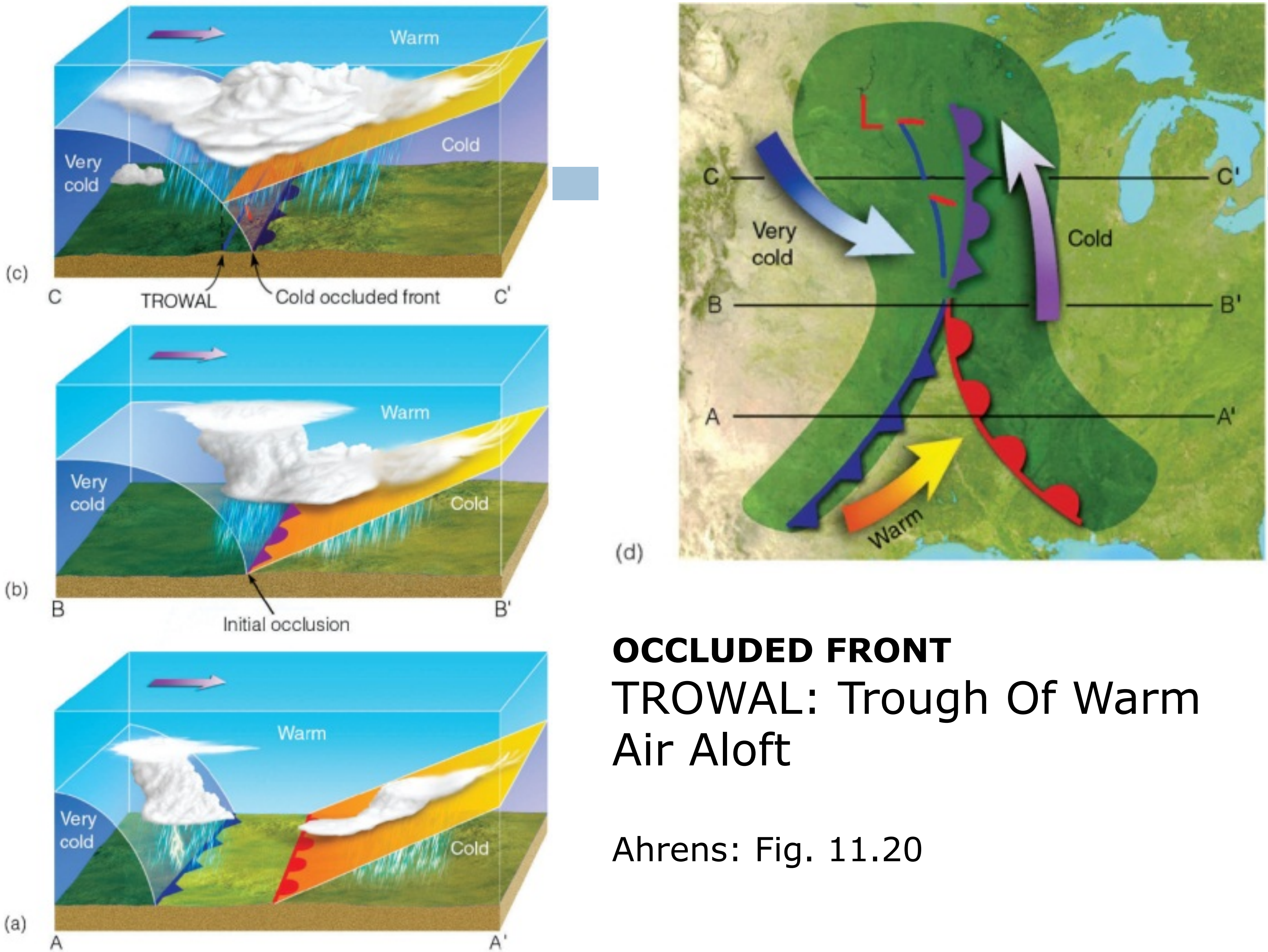


Ahrens: Active Fig. 11.18

Stationary fronts

- Boundary between fronts stalls
- Stable but with strong horizontal wind shear
- Quite common along the Polar Front
  - Boundary between Polar and Ferrel cells





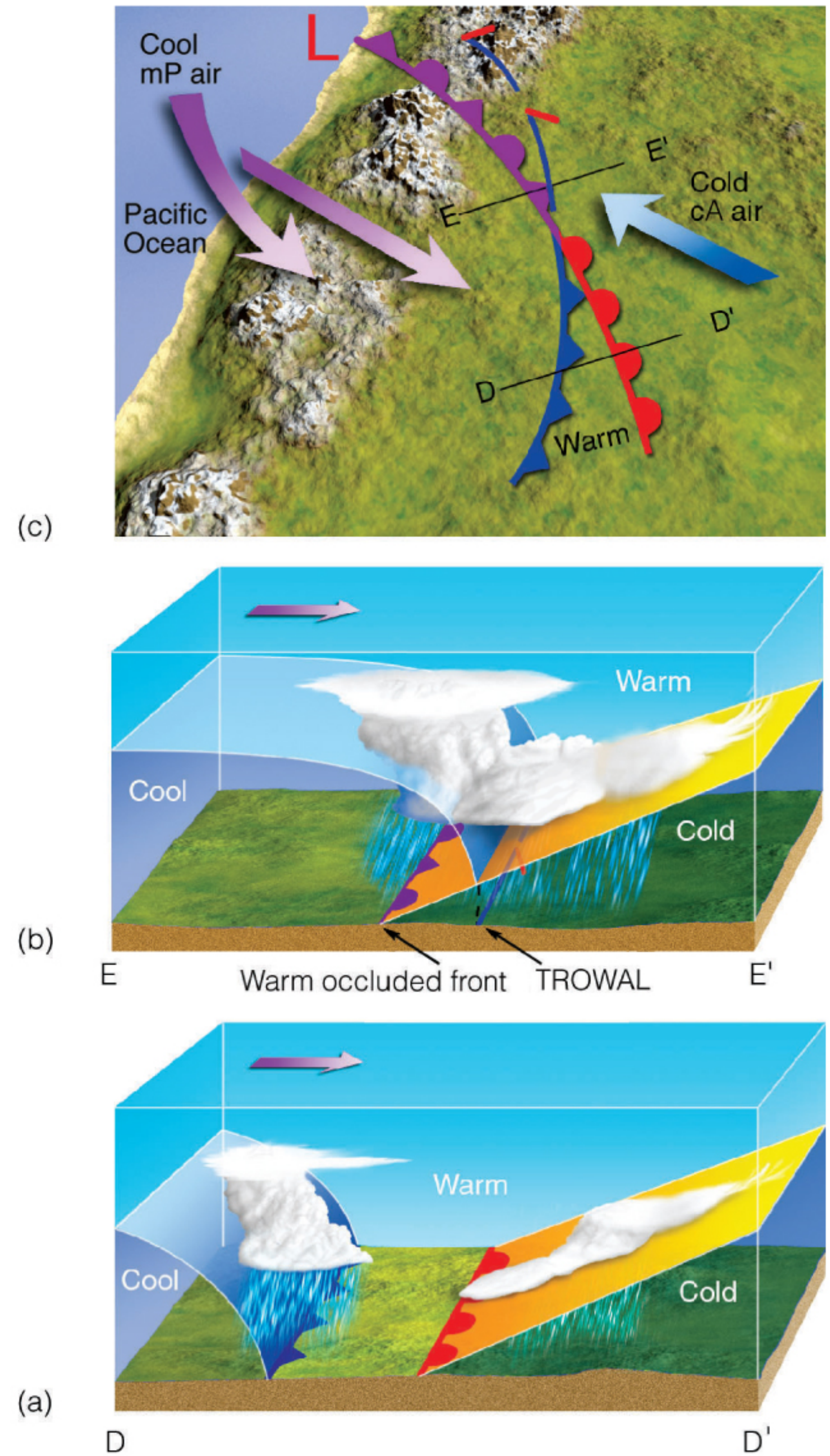
OCCLUDED FRONT

TROWAL: Trough Of Warm Air Aloft

Ahrens: Fig. 11.20

Warm occluded front

- More common in Europe, British Columbia
- Advancing cool air slides on top of cold air mass
  - Similar to warm front
- TROWAL is ahead of the surface front

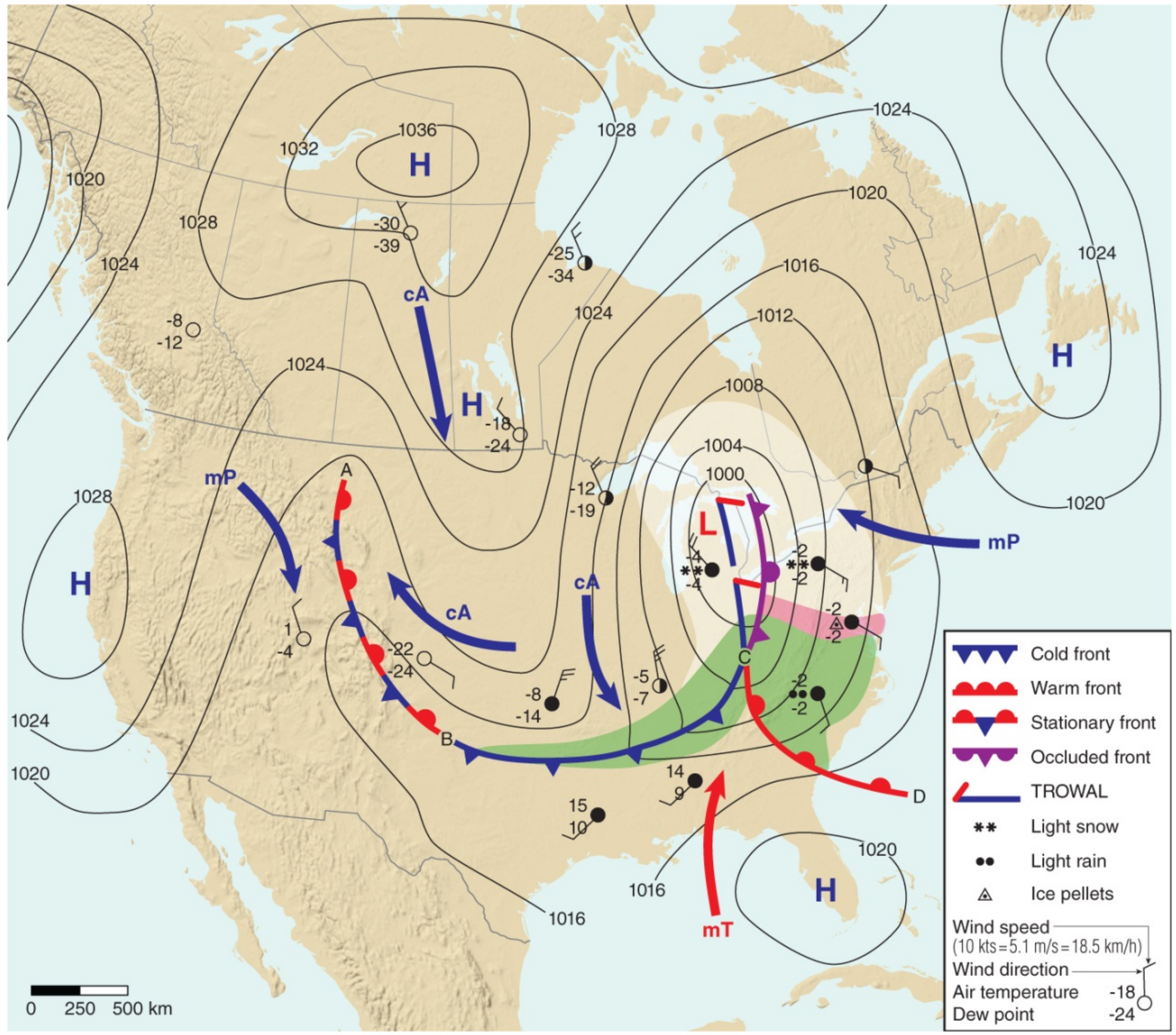


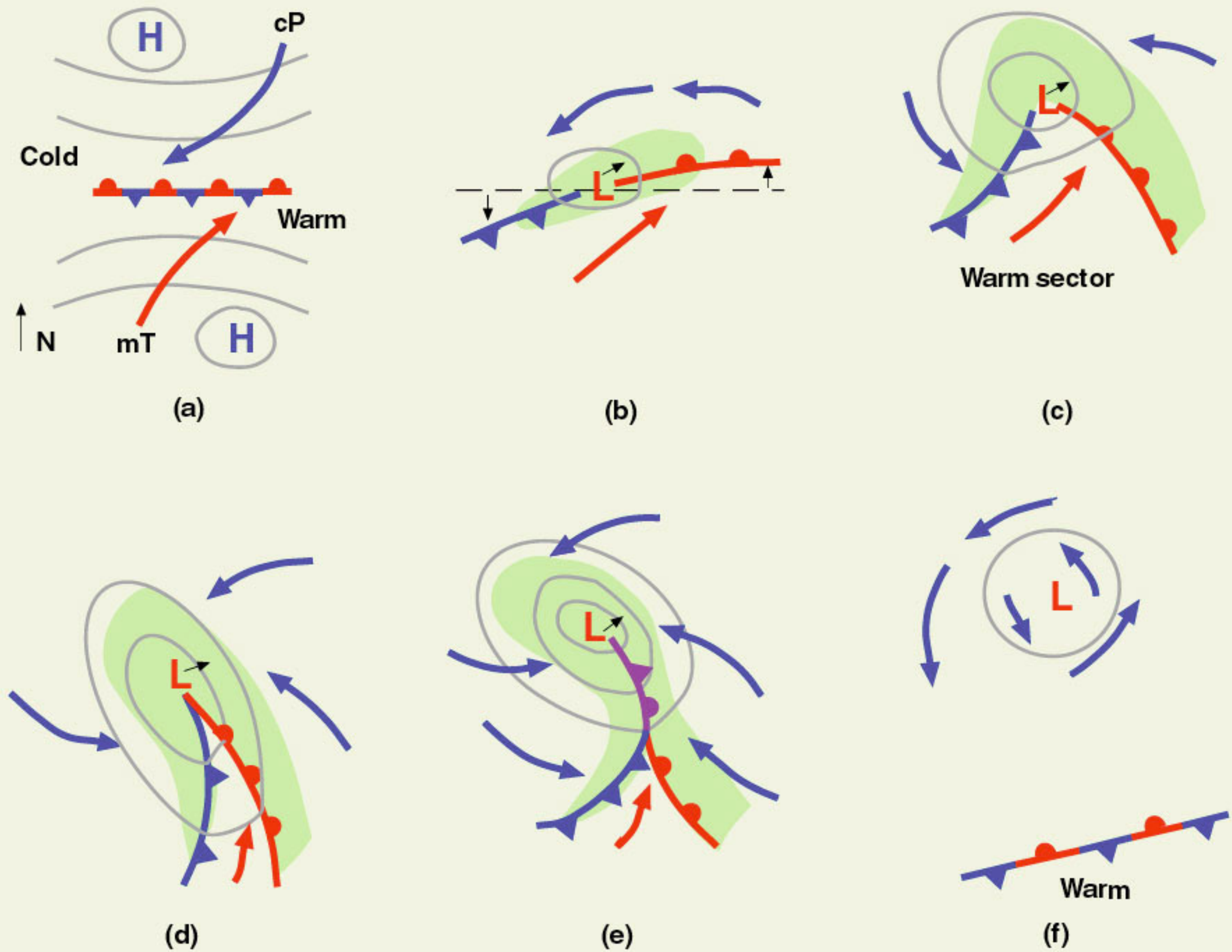
Midlatitude cyclone

Kink in the polar front

Cold and warm fronts rotate around a central low

Wedge of warm air to the south



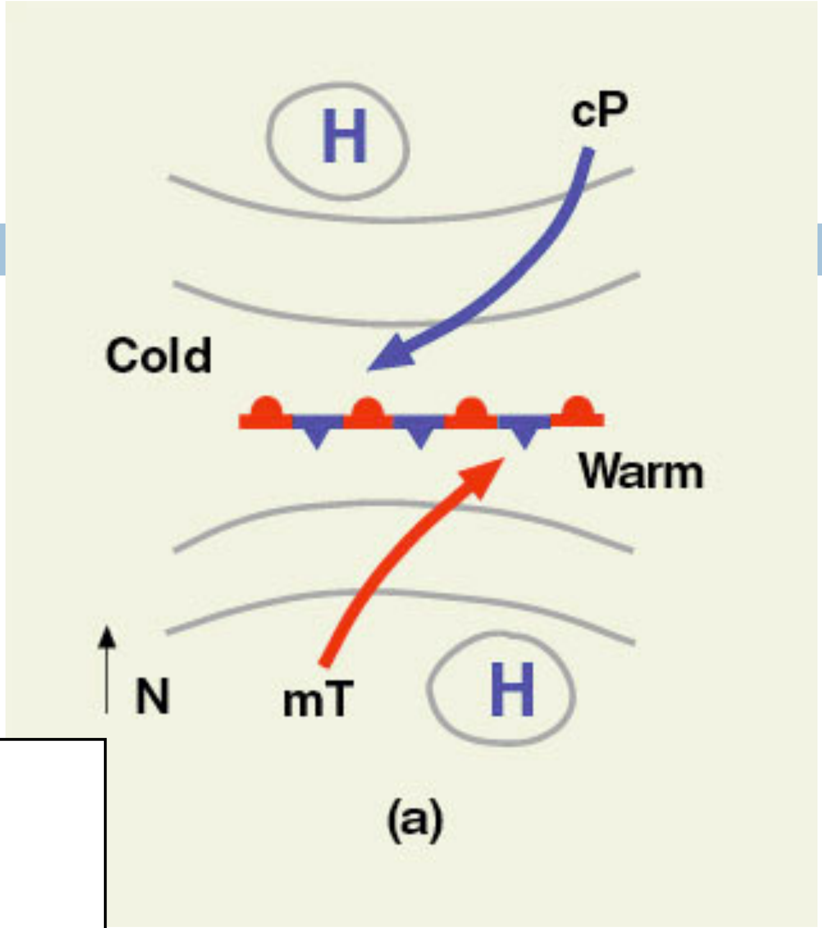


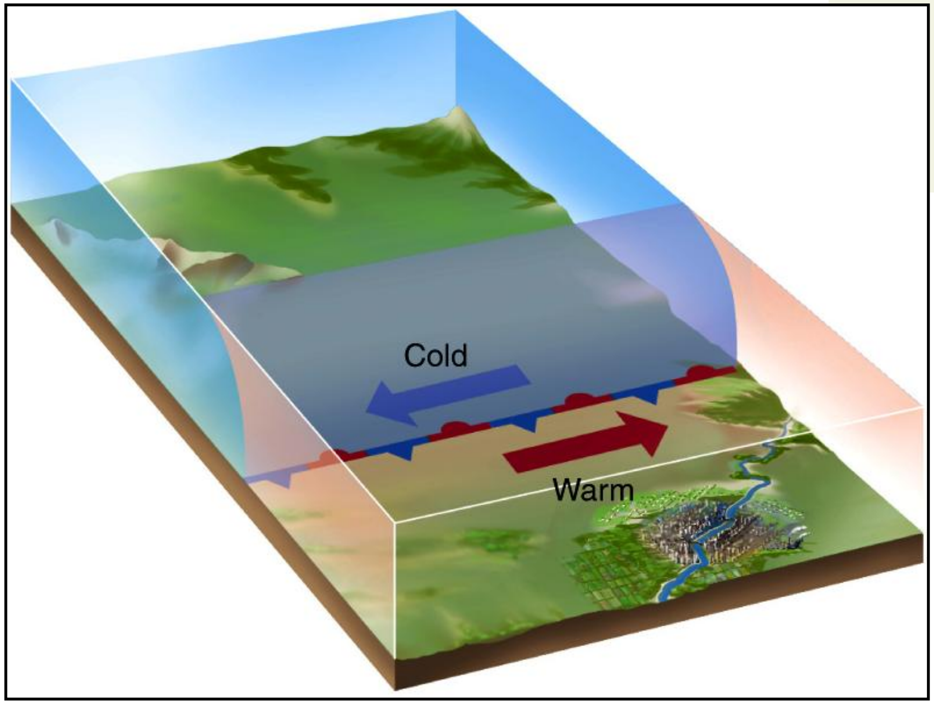
Ahrens: Figure 12.1

Stationary front

Step One

Stationary front with a strong horizontal wind shear



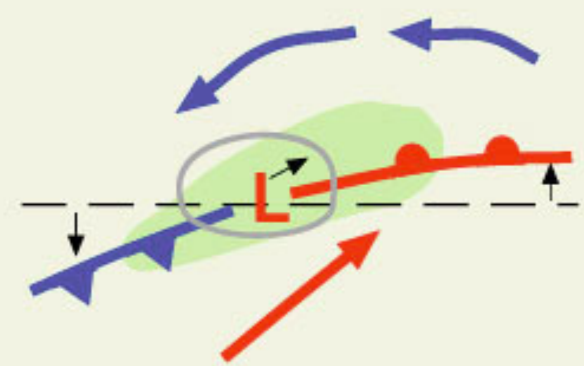


A&B: Figure 10-1

Cyclogenesis begins

Step Two

Under certain conditions a kink or small disturbance forms along the polar front



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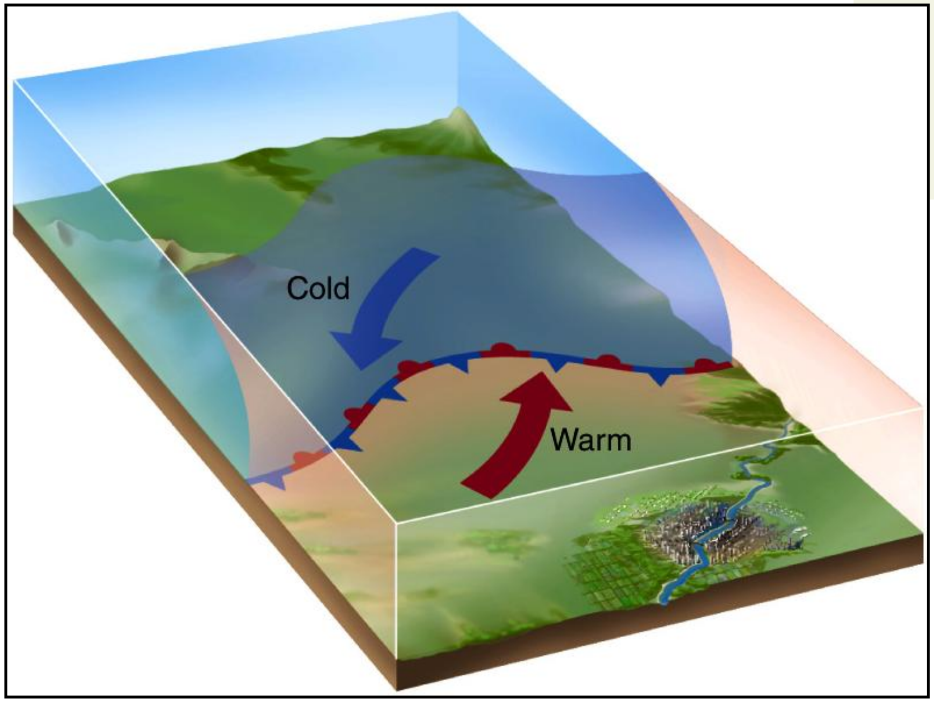


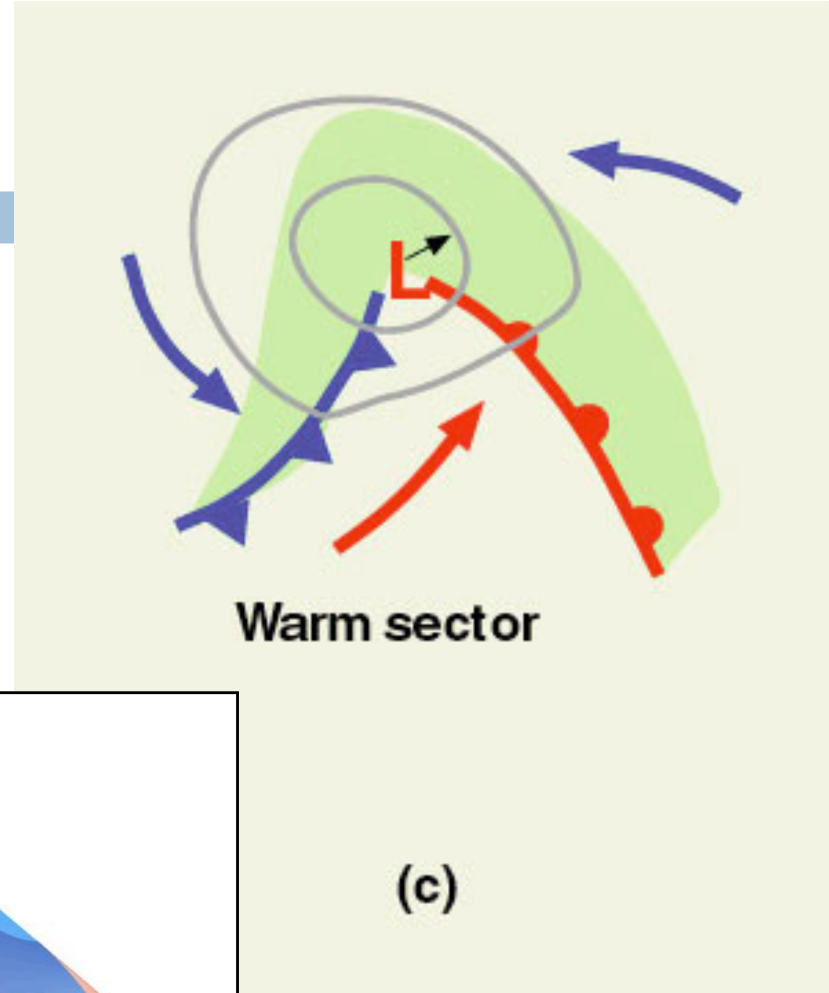
A&B: Figure 10-1

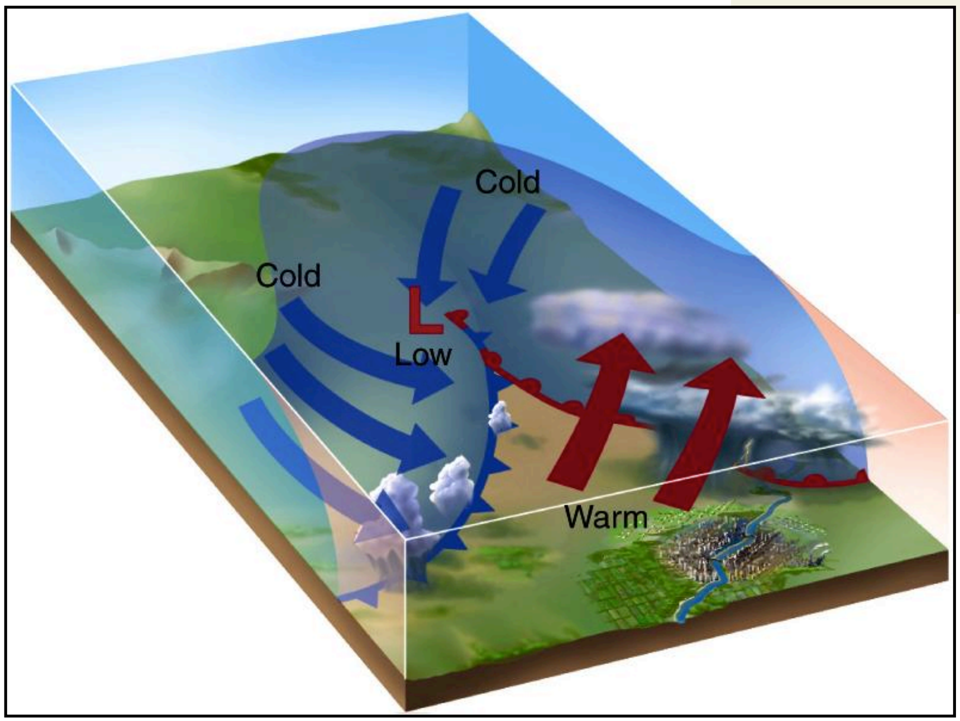
Mature cyclone

Step 3

Fully developed wave

The wave moves east or northeast. It takes 12 to 24 hours to reach this stage of development



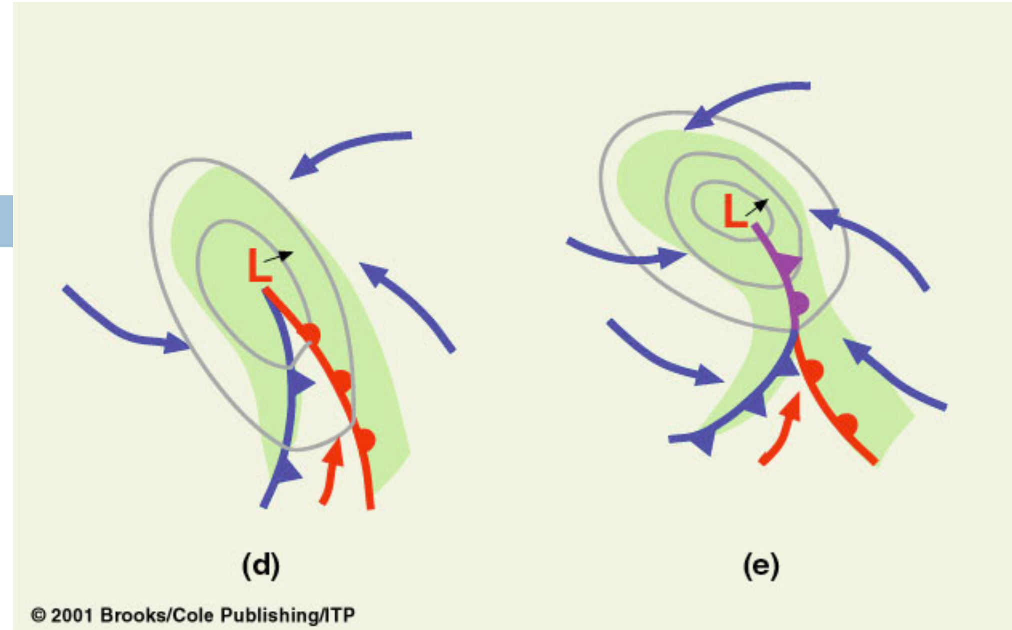


A&B: Figure 10-1

Occlusion

Step 4

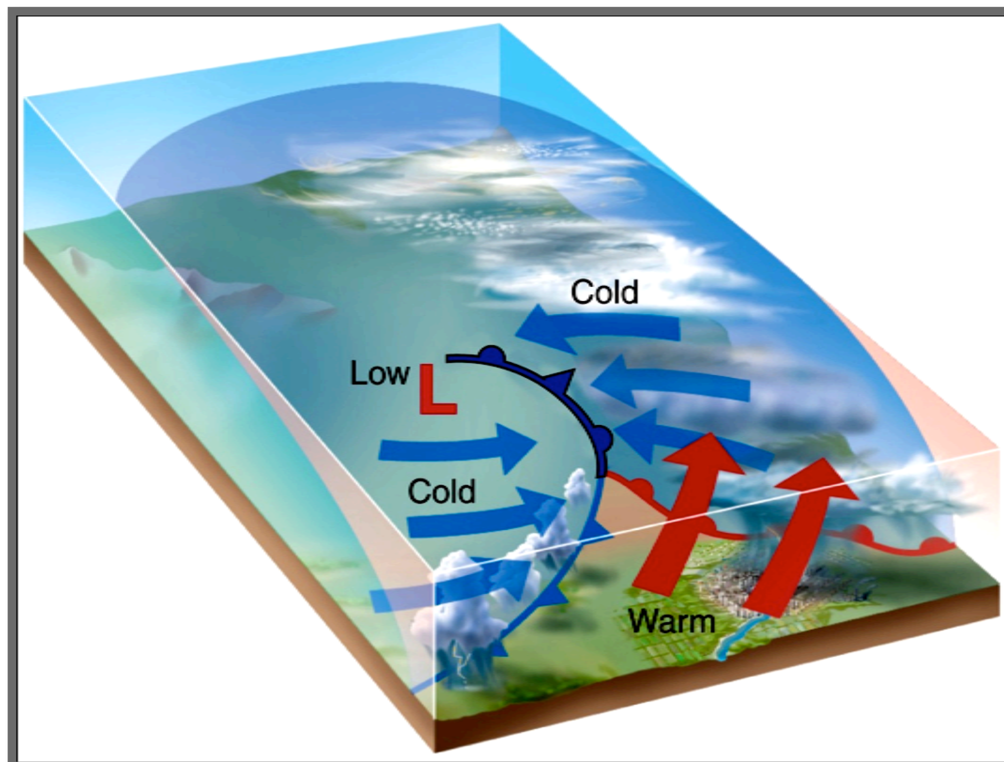
The faster moving cold front catches up with the warm front.



Step 5

Occlusion occurs as cold front catches up with warm front.

Low pulls back from the fronts.

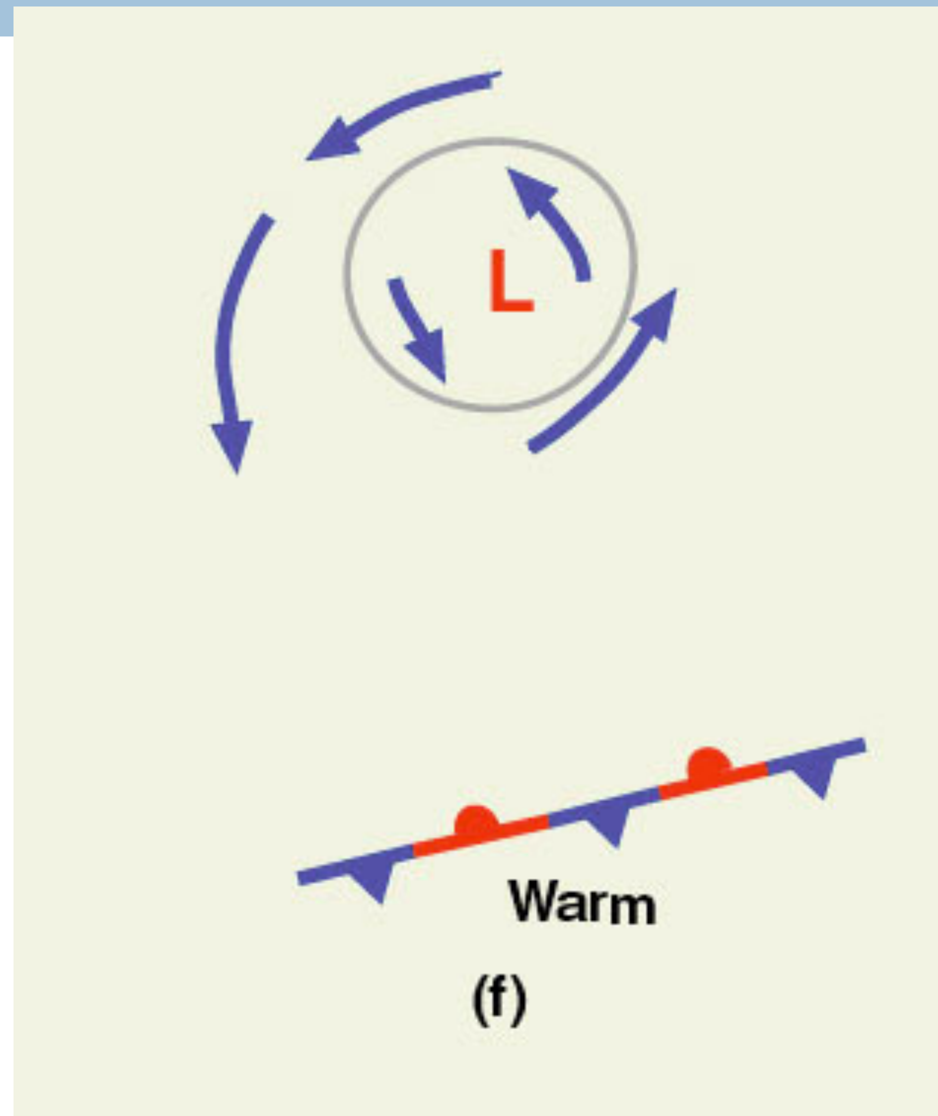


A&B: Figure 10-1

Dissipation

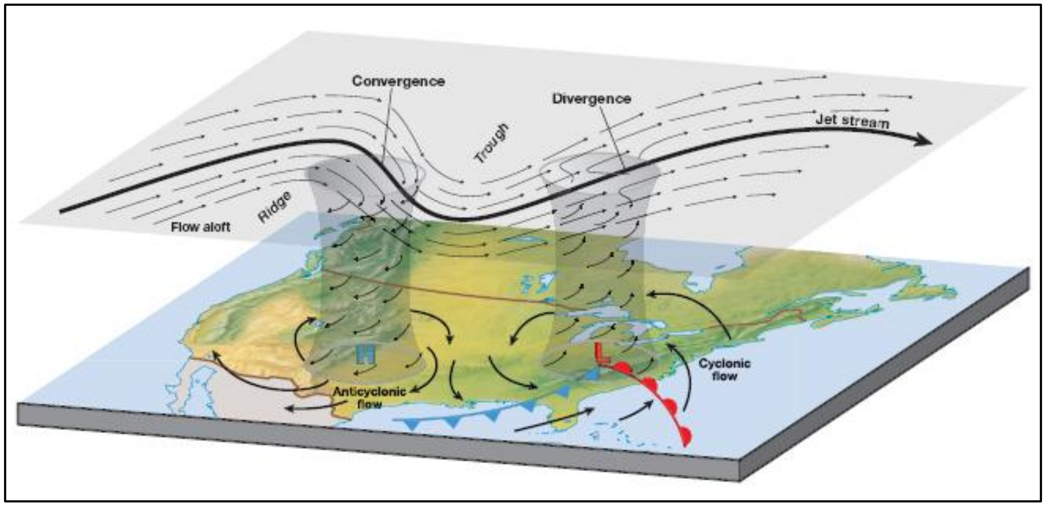
Step 6

Storm dissipates after occlusion.
The source of the energy (rising mT air) has been cut off.



Next on January 29

- The upper troposphere and midlatitude cyclones
- Weather forecasting
- Numerical models
- Long-range forecasts



Welcome Anna Gutman

Lakehead University's Media and Environmental Justice Movements course in Ecuador this spring