

Chapter 12: Middle-Latitude Cyclones

Definition

Examples from history

Polar front theory

Life cycle

Typical paths of lows and highs

Where and why storms start

Vertical structure of storms

Conveyor belt model

Nor'easters

Polar lows

Mid-latitude Cyclones

- Cyclone = low pressure area, hundreds of miles in size, with “cyclonic” circulation, i.e., counterclockwise (CCW) in the Northern Hemisphere, clockwise (CW) circulation in the Southern Hemisphere. Synonym: storm.
 - ◆ Either mid-latitude or tropical
 - ◆ This chapter focuses on mid-latitude cyclones.
- Older meaning of cyclone is tornado, as in Iowa State Cyclones, named in 1895. We are not using this sense here.
- Anticyclone = high pressure area with “anti-cyclonic” circulation (CW/CCW in N/S Hem)

Examples of Important Mid-latitude Storms in History (not in book)

- 1588: Spanish Armada defeated partly by English navy with superior armaments and tactics and later by bad storm. 150 Spanish ships started, only 65 returned.
- March 1776: Storm caused British to cancel assault on US troops under Washington at Dorchester Heights.
- 6 June 1944: D-Day invasion of France in WW II: Allied forecasters correctly forecasted break in storm, allowing invasion, when Germans thought storm would continue.

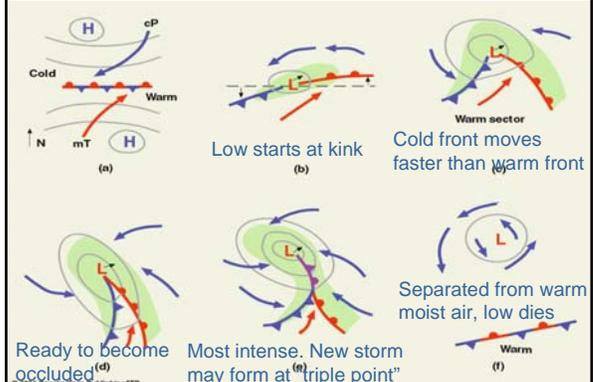
Development of concept of a front

- Basic concepts developed by Norwegian team, published in 1919 & 1922. Team members:
 - ◆ Vilhelm Bjerknes (leader, physics professor)
 - ◆ Jakob (Jacob, Jack) Bjerknes, son of Vilhelm and chief author. (22 years old in 1919. 30 years later, he did fundamental El Nino research at UCLA.)
 - ◆ Halvor Solberg
 - ◆ Tor Bergeron (Swedish pioneer of ice crystal process of rain formation, p. 193 of Ahrens.)
- Don't memorize their names, but these guys had good ideas in several areas of meteorology! Example of 80-20 rule: 80% of ideas and productivity come from 20% of workers.

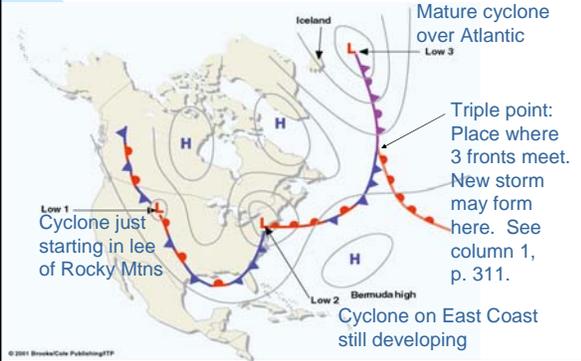
Polar Front Theory (pp. 310-312)

- Mid-latitude storms develop where there is strong horizontal temperature contrast.
- Most cyclones start on existing fronts because of large temperature contrast.
- Mid-latitude storms are strongest in winter when north-south temperature contrasts are greatest.
- Initial source of energy: temperature contrast with warm air rising and cold air sinking. Other sources: release of latent heat during precipitation, and air being pushed from high toward low pressure.
- Cyclogenesis = development or strengthening of a mid-latitude cyclone.

Life Cycle of Cyclone (fig. 12.1, p. 311)



Chain of Cyclones at Various Stages of Life Cycle (fig. 12.2, p. 312)



Typical Winter Path of Lows: Toward NE (fig. 12.5a, p. 313)

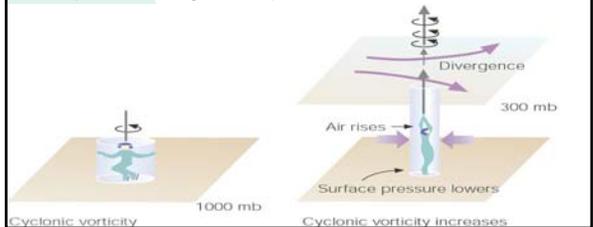


Typical Winter Path of Highs: Toward SE (fig. 12.5b, p. 313)

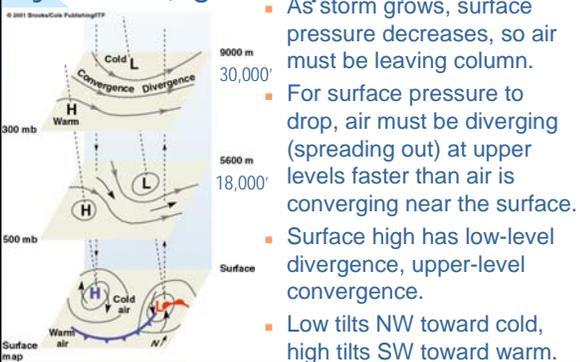


Where and Why Storms Start (p. 313)

- Along East Coast and Gulf Coast in winter: strong temperature contrast between cold land and warm water
- On east side of Rockies: Columns of air are stretched vertically as they descend the mountains. Like a spinning figure skater who extends her arms upward, the column of air will spin faster. Fig. 12.19, p. 326



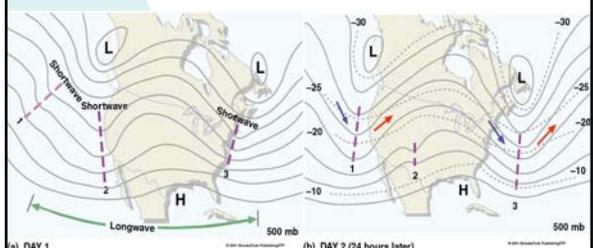
Vertical Structure of Mid-latitude Cyclones (fig. 12.7, p. 315)



- As storm grows, surface pressure decreases, so air must be leaving column.
- For surface pressure to drop, air must be diverging (spreading out) at upper levels faster than air is converging near the surface.
- Surface high has low-level divergence, upper-level convergence.
- Low tilts NW toward cold, high tilts SW toward warm.

Upper level disturbances: Long & Short Waves (fig. 12.9, p. 318)

- Long-wave disturbances in upper-level conditions are nearly stationary
- Short-wave disturbances move eastward more quickly at nearly the speed of the wind, often triggering precipitation.



Simplifications for this course

- The preceding slide is all you need to know about the section on pp. 316-318 titled “Upper-level Waves and Surface Storms”
- You can skip the first part of the next section titled “The Necessary Ingredients for a Developing Wave Cyclone” (pp. 318-321)
- You can skip the special topic on p. 321 (“Jet Streaks and Storms”)
- Resume on p. 322

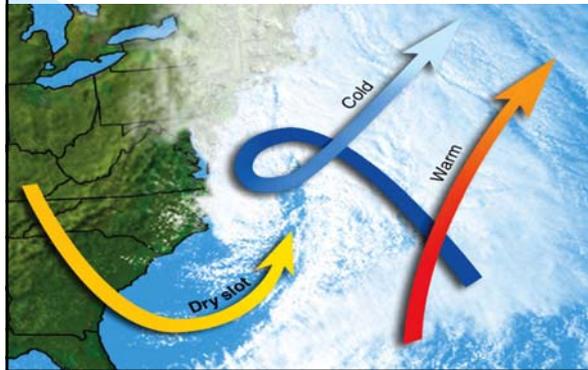
Conveyor Belt Model (pp. 322-323)

- Air rises & sinks in mid-latitude storms on a slant: conveyor belt
- Warm conveyor belt: air in warm sector glides up warm front, produces stratus clouds, turns toward NE or E
- Cold conveyor belt: Wind blows from east below northern part of warm conveyor belt toward surface low, rises, & moves toward NE with jet
- Dry conveyor belt: upper-level dry air to W of storm sinks as it approaches cold front, creating “dry slot” behind cold front



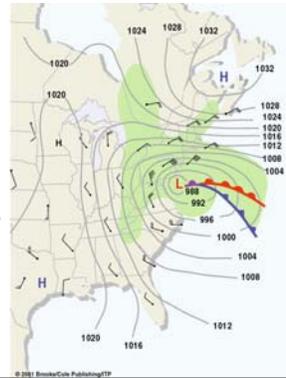
Fig. 12.13, p. 323

Conveyor Belts in Relation to Features in Satellite Picture (Fig. 12. 14, p. 323)



Northeasters = Nor'easters (p. 314)

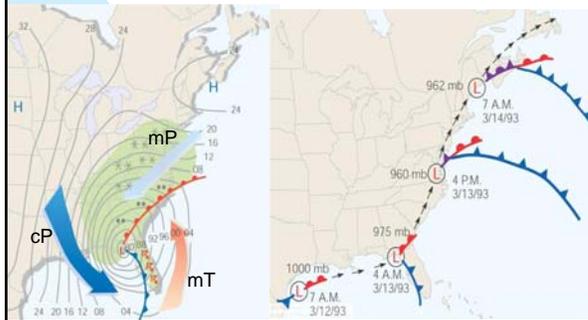
- Mid-latitude cyclones that develop or intensify along the east coast
- Name refers to winds from the NE north of the warm front along the coast
- The nor'easter in this map (11 Dec 1992) caused hundreds of millions of dollars of damage
- Sometimes have hurricane characteristics, such as an eye



Example of Nor'easter: Superstorm of March 1993 (The Storm of the Century)

- References: *Meteorology Today* (our textbook), pp. 323 – 325. www.comet.ucar.edu/resources/cases/c1_11mar93/ www.weathermatrix.net/education/blizzard93/
- Impact on Tallahassee on Saturday, 13 Mar 1993: Snow! Also, lowest pressure ever recorded at Tallahassee.
- National impact
 - ◆ 270 killed (3 times combined death toll of 79 due to Hurricanes Hugo and Andrew)
 - ◆ \$2 billion damage (www.noaa.gov/stories/s334c.htm)
 - ◆ Many records for low temperature and snowfall
 - ◆ Every airport on east coast closed. Only time one storm has ever done that.

Maps of Superstorm of March 1993 Fig. 12.16, p. 324 Arrows denote surface winds.



Color-enhanced infrared photo of Storm of the Century (fig. 12.15, p. 324)

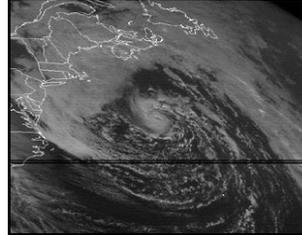
- Compare to surface weather map, fig. 12.16, p.324, for nearly the same time
- Warm front is roughly along the east coast, north of Florida
- Yellow area inland of warm front is light rain & snow from nimbostratus
- Black region crossing Florida indicates high clouds along cold front: thunderstorms & intense precipitation



The Perfect Storm (not in book)

For more info, search Web for "Perfect Storm"

- Officially called the Halloween Nor'easter of 1991
- Strengthened when combined with remnants of Hurricane Grace to form an unnamed hurricane
- Wave heights peaked at nearly 100 feet



Satellite photo of Halloween Nor'easter of 1991 after becoming a hurricane. Photo taken at 1801 UTC, 1 Nov 1991. Note the eye at the center of the storm.

Polar Lows: Arctic hurricanes (pp. 355-356)

- Develop during winter (Nov-March) over water poleward of polar front at "arctic front" where frigid air from land meets much warmer (but still cold) air over water
- Some have comma-shaped cloud band like mid-latitude storms
- Others, as in this photo, have eye like a hurricane & spiral cloud bands

Fig. 12.28, p. 331



Polar Lows: Arctic hurricanes (pp. 331-332)

- Like hurricanes, polar lows:
 - ◆ Have diameter of 300 – 600 miles (smaller than mid-latitude storms)
 - ◆ Are heated by "warm" ocean
 - ◆ Have intense precipitation.
 - ◆ May have an "eye" and spiral cloud bands
 - ◆ Dissipate rapidly when they move over land.
- Differences between polar lows and hurricanes
 - ◆ Polar lows/hurricanes form in the arctic/tropics.
 - ◆ Polar lows/hurricanes form during Nov – March (winter)/June – November (summer and fall).
 - ◆ Polar lows/hurricanes produce snow/rain.