

ESCI 241 – Meteorology
Lesson 16 – Extratropical Cyclones
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Reading: *Meteorology Today*, Chapter 13

CYCLONES

- A *cyclone* technically refers to any cyclonically rotating circulation.
 - Cyclonic rotation is counter-clockwise in the Northern Hemisphere and Clockwise in the Southern Hemisphere
- Cyclonic rotation is associated with low-pressure systems, so that *cyclone* and *low* can be used interchangeably.
- The term *cyclogenesis* refers to cyclone formation.
- Cyclones occurring in the midlatitudes are known as *midlatitude* or *extratropical cyclones*.
- Cyclones forming in the tropics (such as hurricanes) are known as *tropical cyclones*

POLAR-FRONT THEORY OF CYCLONE FORMATION (THE NORWEGIAN MODEL)

- Norwegian meteorologists studies cyclone formation and development during World War I, using mainly surface observations. They formulated what became known as the polar-front theory of cyclone formation.
- Stages of cyclone development
 - Front develops (known as *frontogenesis*).
 - A *wave* develops on the front.
 - A cyclonic circulation (low-pressure) becomes established.
 - The cold front overtakes the warm front, beginning the occlusion.
 - The occluded front continues to develop as the cyclone reaches maturity.
 - The lifetime of the cyclone is roughly 3 – 5 days from the initial wave to the dissipating stage.

CYCLONE ENERGETICS

- The energy that drives the cyclone is derived from the temperature contrast across the front.
 - It is converting potential energy to kinetic energy.
 - After the cyclone has mixed away the temperature contrast across the front there is no longer any potential energy available to keep the cyclone going, so it dissipates.
 - Note that the cyclone is serving to reduce the latitudinal heat imbalance by transporting warm air toward the pole and cold air toward the equator.

CLOUDS AND PRECIPITATION ASSOCIATED WITH MIDLATITUDE CYCLONES

- The cloud pattern associated with the mature cyclone has a *comma* or *wishbone* shape.
- The weather associated with the passage of a midlatitude cyclone depends on where you are relative the center of the low.
- If you are well to the south you will experience the weather associated with a warm front, followed by that of a cold front.
- If you are to the north you will either experience the occluded front, or no front. The weather will be characterized by lots of clouds, precipitation, and wind. This poor weather can last for a day or more, since the low is traveling slower than the fronts themselves.
- During the winter it is the northern area of the cyclone that tends to get the most snow.

VERTICAL STRUCTURE OF MIDLATITUDE CYCLONES

- The midlatitude cyclone begins with a wave developing on the polar front. We would like to know what causes the wave to develop in the first place?
- Often, the wave develops at the surface because there is a trough in the upper atmosphere (called an *upper-level* trough).
- Ahead of the upper-level trough there is upward vertical motion.

- The upward motion requires that there be convergence at the surface.
- The convergence at the surface causes the low-pressure system to develop at the surface.
- In order to continue to develop, the surface cyclone must always be ahead of (downstream from) the upper-level trough.
- Once the upper-level trough moves directly over the surface cyclone there is no longer any divergence aloft. This shuts off any further development, and the surface cyclone begins to weaken and dissipate.

MOVEMENT OF MIDLATITUDE CYCLONES

- Most of the so-called bad weather experienced in the U.S. is associated with warm and cold fronts associated with midlatitude cyclones. Therefore, a key to weather forecasting is not only to predict when a cyclone will develop, but where it will move once it has developed.
- Once a cyclone forms on the polar front it tends to move eastward along the front (much like a wave on a tight string).
 - One reason that the cyclone travels along the front is that it is the temperature contrast across the front that feeds energy to the cyclone.
 - The upper-level winds are sometimes referred to as *steering currents* that push the cyclone along. This is a gross oversimplification. It is true that the cyclone tends to follow the jet stream, but this is because both the cyclone and the jet stream are linked via the polar front. The jet stream doesn't push the cyclone along like a cork in a stream.

ANTICYCLONES

- *Anticyclones* are also known as *high-pressure systems*, or simply *highs*.
- Because anticyclones are associated with surface divergence and sinking air they generally bring good weather with clear skies.
- They are not always associated with pleasant weather.
- In the winter they can bring bitterly cold, dry air masses down from Canada and the Arctic.

- There can be a tight pressure gradient associated with them which causes strong winds. This drastically reduces the wind-chill temperature and causes blowing snow.
- The clear, cold nights can produce *radiation fog*.
- In the summer
 - They can cause very hot weather, resulting in heat stress and other heat related illnesses, as well as draughts.
 - The stagnant air can cause pollution to build to excess levels.
- When a large, vertically stacked anticyclone becomes stationary it can disrupt the entire upper-level wind flow in the atmosphere. In extreme cases it can block storms from moving eastward. It then becomes known as a *blocking high*.