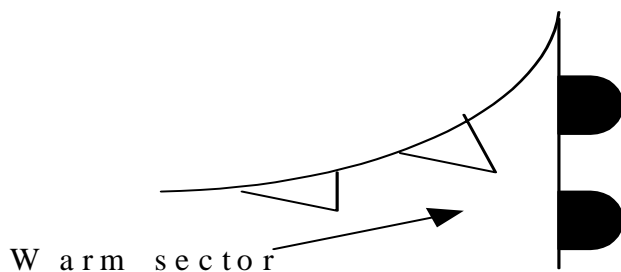


## *Middle Latitude Cyclones*

### *Polar Front Theory*

The largest storms that sweep across the continental U.S. are known as *middle latitude cyclones* or, more generally, as *wave cyclones*. These storms tend to form in one of several source regions and track for long distances before running out of energy. Source regions for storms that sweep across the U.S. include the eastern slope of the Rockies, the Great Basin, the Gulf of Mexico, and the mid-Atlantic coastal region. The location of the polar front is of particular importance in the formation of middle latitude cyclones.

Wave cyclones form along stationary fronts. The process begins with the formation of a kink in the stationary front forming what is called a *frontal wave*. A surface low develops at the center of the boundary between the two air masses. The system is steered east to northeast by winds aloft and develops, within 24 hours, into an *open wave characterized* by organized, cyclonic circulation about the surface low and well-defined cold and warm fronts.



The cold front moves more rapidly than the warm front so the *warm sector*, the region of warm air between the fronts, begins to shrink as the storm develops. As the cold front overtakes the warm front and begins to *occlude*, the storm reaches its peak with clouds and precipitation spread over a wide area. Finally, the cyclone

dissipates as the air on both sides of the occluded front comes to equilibrium and the energy source for the storm diminishes.

The stages of development of a cyclone are known collectively as *cyclogenesis*. Not all open waves develop into large storms. *Stable waves* remain small and never grow into giant weather producers. An extremely important feature in the development of large storms is the vertical profile of the atmosphere. In order for large storms to develop, the vertical profile of the atmosphere must not be "stacked".

### ***Upper Level Waves and Surface Storms***

An examination of a synoptic or larger scale upper level pressure chart reveals a series of elongated troughs and ridges. This *longwave* flow is usually *zonal* (East - West) but, at times, may have a strong *meridional* component. *Short waves* are ripples imbedded in long waves. Long waves "move" slowly eastward or sometimes retrograde (westward). Short waves tend to strengthen when moving towards troughs and weaken when moving toward ridges.

### ***Necessary Ingredients for a Developing Wave Cyclone***

Consider air in the vicinity of the polar front. Near the surface cold air is to the north of the front and warm air to the south. Aloft winds are blowing at high speeds producing strong *wind shear* between the surface and the upper level winds. If a short wave moves into this region *baroclinic instability* results, i.e., regions of rising warm air and sinking cool air now exist. Baroclinic instability leads to intensification of surface pressure systems.

Upper air supports surface pressure features. Cold and warm advection further enhance the process. The advection process intensifies the wave. The advection process also supplies the energy (conversion of potential energy to kinetic energy, latent heat release, etc.) to form a full-blown wave cyclone. The storm will either weaken (surface and upper level lows stacked) or intensify. Most storms weaken as the supply of warm surface air is cut off and cold, dry air is drawn into the surface low, squelching it.

An upper low that breaks from the main flow is called a *cut-off low*. Cut-off lows can produce precipitation for days after the storm has passed.

### ***Role of the Jet Stream***

The region of fastest-moving air in the jet stream is the *jet maximum* or *jet streak*. The jet streak creates areas of intense convergence and divergence which intensify surface features.

### ***Some Conditions for Creating an Intense Wave Cyclone***

- Upper level trough of low pressure west of a surface low.
- Short waves present that disturb the flow aloft creating temperature advection, further intensifying the low aloft
- Polar jet forms a wave that swings south of the developing storm.

Under these conditions, storms may form without the existence of pre-existing fronts.