= Cyclogenesis =

Cyclogenesis is the development or strengthening of cyclonic circulation in the atmosphere (a low @-@ pressure area) . Cyclogenesis is an umbrella term for at least three different processes , all of which result in the development of some sort of cyclone , and at any size from the microscale to the synoptic scale .

Tropical cyclones form due to latent heat driven by significant thunderstorm activity , and are warm core .

Extratropical cyclones form as waves along weather fronts before occluding later in their life cycle as cold core cyclones .

Mesocyclones form as warm core cyclones over land , and can lead to tornado formation . Waterspouts can also form from mesocyclones , but more often develop from environments of high instability and low vertical wind shear .

The process in which an extratropical cyclone undergoes a rapid drop in atmospheric pressure (24 millibars or more) in a 24 @-@ hour period is referred to as explosive cyclogenesis , and is usually present during the formation of a nor 'easter . The anticyclonic equivalent , the process of formation of high pressure areas , is anticyclogenesis . The opposite of cyclogenesis is cyclolysis .

= = Meteorological scales = =

There are four main scales , or sizes of systems , dealt with in meteorology : the macroscale , the synoptic scale , the mesoscale , and the microscale . The macroscale deals with systems with global size , such as the Madden ? Julian oscillation . Synoptic scale systems cover a portion of a continent , such as extratropical cyclones , with dimensions of 1 @,@ 000 @-@ 2 @,@ 500 km (620 @-@ 1 @,@ 550 mi) across . The mesoscale is the next smaller scale , and often is divided into two ranges : meso @-@ alpha phenomena range from 200 @-@ 2 @,@ 000 km (125 @-@ 1 @,@ 243 mi) across (the realm of the tropical cyclone) , while meso @-@ beta phenomena range from 20 ? 200 km (12 @-@ 125 mi) across (the scale of the mesocyclone) . The microscale is the smallest of the meteorological scales , with a size under two kilometers (1 @.@ 2 mi) (the scale of tornadoes and waterspouts) . These horizontal dimensions are not rigid divisions but instead reflect typical sizes of phenomena having certain dynamic characteristics . For example , a system does not necessarily transition from meso @-@ alpha to synoptic scale when its horizontal extent grows from 2 @,@ 000 to 2 @,@ 001 km (1 @,@ 243 mi) .

= = Extratropical cyclones = =

= = = Norwegian Cyclone Model = = =

The Norwegian Cyclone Model is an idealized formation model of cold @-@ core cyclonic storms developed by Norwegian meteorologists during the First World War . The main concept behind this model , relating to cyclogenesis , is that cyclones progress through a predictable evolution as they move up a frontal boundary , with the most mature cyclone near the northeast end of the front and the least mature near the tail end of the front .

= = = Precursors for development = = =

A preexisting frontal boundary , as defined in surface weather analysis , is required for the development of a mid @-@ latitude cyclone . The cyclonic flow begins around a disturbed section of the stationary front due to an upper level disturbance , such as a short wave or an upper @-@ level trough , near a favorable quadrant of the upper level jet . However , enhanced along @-@ frontal stretching rates in the lower troposphere can suppress the growth of extratropical cyclones .

= = = Vertical motion affecting development = = =

Cyclogenesis can only occur when temperature decreases polewards (to the north , in the northern hemisphere) , and pressure perturbation lines tilt westward with height . Cyclogenesis is most likely to occur in regions of cyclonic vorticity advection , downstream of a strong westerly jet . The combination of vorticity advection and thermal advection created by the temperature gradient and a low pressure center cause upward motion around the low . If the temperature gradient is strong enough , temperature advection will increase , driving more vertical motion . This increases the overall strength of the system . Shearwise updrafts are the most important factor in determining cyclonic growth and strength .

= = = Modes of development = = =

The surface low could have a variety of causes for forming . Topography can force a surface low when dense low @-@ level high pressure system ridges in east of a north @-@ south mountain barrier . Mesoscale convective systems can spawn surface lows which are initially warm core . The disturbance can grow into a wave @-@ like formation along the front and the low will be positioned at the crest . Around the low , flow will become cyclonic , by definition . This rotational flow will push polar air equatorward west of the low via its trailing cold front , and warmer air will push poleward low via the warm front . Usually the cold front will move at a quicker pace than the warm front and ? catch up ? with it due to the slow erosion of higher density airmass located out ahead of the cyclone and the higher density airmass sweeping in behind the cyclone , usually resulting in a narrowing warm sector . At this point an occluded front forms where the warm air mass is pushed upwards into a trough of warm air aloft , which is also known as a trowal (a trough of warm air aloft) . All developing low pressure areas share one important aspect , that of upward vertical motion within the troposphere . Such upward motions decrease the mass of local atmospheric columns of air , which lower surface pressure .

= = = Maturity = = =

Maturity is after the time of occlusion when the storm has completed strengthening and the cyclonic flow is at its most intense . Thereafter , the strength of the storm diminishes as the cyclone couples with the upper level trough or upper level low , becoming increasingly cold core . The spin @-@ down of cyclones , also known as cyclolysis , can be understood from an energetics perspective . As occlusion occurs and the warm air mass is pushed upwards over a cold air airmass , the atmosphere becomes increasingly stable and the centre of gravity of the system lowers . As the occlusion process extends further down the warm front and away from the central low , more and more of the available potential energy of the system is exhausted . This potential energy sink creates a kinetic energy source which injects a final burst of energy into the storm 's motions . After this process occurs , the growth period of the cyclone , or cyclogenesis , ends , and the low begins to spin down (fill) as more air is converging into the bottom of the cyclone than is being removed out the top since upper @-@ level divergence has decreased .

Occasionally , cyclogenesis will re @-@ occur with occluded cyclones . When this happens a new low center will form on the triple @-@ point (the point where the cold front , warm front , and occluded front meet) . During triple @-@ point cyclogenesis , the occluded parent low will fill as the secondary low deepens into the main weathermaker .

= = Tropical cyclones = =

Tropical cyclones exist within a mesoscale alpha domain . As opposed to mid @-@ latitude cyclogenesis , tropical cyclogenesis is driven by strong convection organised into a central core with no baroclinic zones , or fronts , extending through their center . Although the formation of tropical cyclones is the topic of extensive ongoing research and is still not fully understood , there are six

main requirements for tropical cyclogenesis : sea surface temperatures that are warm enough , atmospheric instability , high humidity in lower to middle levels of the troposphere , enough Coriolis force to develop a low pressure center , a pre @-@ existing low level focus or disturbance , and low vertical wind shear . These warm core cyclones tend to form over the oceans between 10 and 30 degrees of the equator .

= = Mesocyclones = =

Mesocyclones range in size from mesoscale beta to microscale . The term mesocyclone is usually reserved for mid @-@ level rotations within severe thunderstorms , and are warm core cyclones driven by latent heat of its associated thunderstorm activity .

Tornadoes form in the warm sector of extratropical cyclones where a strong upper level jet stream exists . Mesocyclones are believed to form when strong changes of wind speed and / or direction with height (" wind shear ") sets parts of the lower part of the atmosphere spinning in invisible tube @-@ like rolls . The convective updraft of a thunderstorm is then thought to draw up this spinning air , tilting the rolls ' orientation upward (from parallel to the ground to perpendicular) and causing the entire updraft to rotate as a vertical column .

As the updraft rotates , it may form what is known as a wall cloud . The wall cloud is a spinning layer of clouds descending from the mesocyclone . The wall cloud tends to form closer to the center of the mesocyclone . It should be noted the wall clouds do not necessarily need a mesocyclone to form and do not always rotate . As the wall cloud descends , a funnel @-@ shaped cloud may form at its center . This is the first stage of tornado formation . The presence of a mesocyclone is believed to be a key factor in the formation of the strong tornadoes associated with severe thunderstorms .

= = Tornadoes = =

Tornadoes exist on the microscale or low end of the mesoscale gamma domain . The cycle begins when a strong thunderstorm develops a rotating mesocyclone a few miles up in the atmosphere , becoming a supercell . As rainfall in the storm increases , it drags with it an area of quickly descending air known as the rear flank downdraft (RFD) . This downdraft accelerates as it approaches the ground , and drags the rotating mesocyclone towards the ground with it .

As the mesocyclone approaches the ground , a visible condensation funnel appears to descend from the base of the storm , often from a rotating wall cloud . As the funnel descends , the RFD also reaches the ground , creating a gust front that can cause damage a good distance from the tornado . Usually , the funnel cloud begins causing damage on the ground (becoming a tornado) within minutes of the RFD reaching the ground .

= = Waterspouts = =

Waterspouts exist on the microscale . While some waterspouts are strong (tornadic) like their land @-@ based counterparts , most are much weaker and caused by different atmospheric dynamics . They normally develop in moisture @-@ laden environments with little vertical wind shear along lines of convergence , such as land breezes , lines of frictional convergence from nearby landmasses , or surface troughs . Their parent cloud can be as innocuous as a moderate cumulus , or as significant as a thunderstorm . Waterspouts normally develop as their parent clouds are in the process of development , and it is theorized that they spin up as they move up the surface boundary from the horizontal wind shear near the surface , and then stretch upwards to the cloud once the low level shear vortex aligns with a developing cumulus or thunderstorm . Weak tornadoes , known as landspouts , across eastern Colorado have been witnessed to develop in a similar manner . An outbreak occurred in the Great Lakes in late September and early October 2003 along a lake effect band . September is the peak month of landspout and waterspout occurrence around Florida and for waterspout occurrence around the Great Lakes .

= = Related terms = =

Cyclogenesis is the opposite of cyclolysis , which concerns the weakening of surface cyclones . The term has an anticyclonic (high pressure system) equivalent ? Anticyclogenesis , which deals with the formation of surface high pressure systems .