Temperate cyclone

Temperate Cyclones

A temperate cyclone is referred as mid-latitude depressions, extra-tropical cyclones, frontal depressions and wave cyclones. Temperate cyclones are active above mid-latitudinal region between 35o to 65o latitudes in both hemispheres. The direction of movement is blow from west to east and more pronounced in the winter seasons. It is in these latitude zones the polar and tropical air masses meet and form fronts.

Most of these cyclones form at wavelike twist or perturbation on these fronts. On weather map, cyclones are shown as a low pressure area enclosed by a number of isobars circular or elliptical in shape. It is also referred as cyclone or depression. When these isobars take an elongated shape, the pressure system is called as trough. These cyclones are mainly observed in Atlantic Ocean and northwest Europe. These cyclones have characteristics to develop over both oceanic and land surface. Much of the highly variable and cloudy weather come across in the temperate zone. Since mid-latitude is an area of convergence of different air masses, it leads to the formation of fronts as well as the cyclonic conditions are bound to happen.

Fronts

They have similarity in terms of air pressure, horizontal temperature and moisture distribution. Based on temperature characteristics, air masses are of two types – warm and cold. Both of the air masses march forward and both of them converge. The convergence is known as fronts

Chritchfield defined front as "sloping boundary surface between contrasting air masses". Strahler and Strahler have defined the front as "sharply defined boundary between itself and a neighbouring air mass". According to Oliver and Hidor front is "identified as a zone of transition between airs of different properties". In a very simple term, front is a narrow zone between two air masses like a frontier when the armies of two countries come to fight each other.

As mentioned before, air masses are of two types – warm and cold, two types of fronts with distinct characteristics are formed in the process of marching forward and getting interacted with each other. Latter on the intermingling of the two gives birth to another one known as – occluded front.

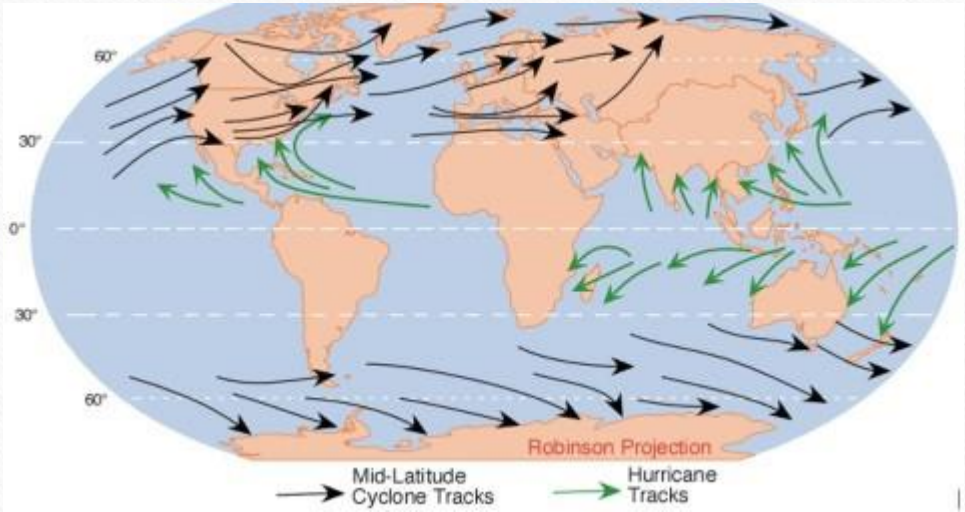
Warm Front: In the northern hemisphere, the warm front (Figure 4) develops to the southeast; to the right side of the moving direction of warm air mass. In southern hemisphere, it develops to the southeast; to the left side of the moving direction of warm air mass. The warm front development is caused and modified due to the interaction of the air masses. On the warm front, the effect of warm air mass is pronounced, and hence, it is named so.

Cold Front: In the northern hemisphere, the cold front (Figure 4) develops to the northwest; to the right side of the moving direction of cold air mass. In southern hemisphere, it develops to the southwest; to the left side of the moving direction of cold air mass. The development is caused and modified due to the interaction of the air masses. On the cold front, the effect of cold air mass is marked, and hence, it is named as cold front.

Occluded Front: Occlusion means the blocking or sealing the existence and with respect to fronts. It signifies the removal of the fronts from the ground. Occlusion of the fronts occurs when the cold air mass occupy the ground space surrounding the hairpin turned clubbed warm and cold

Favorite Breeding Grounds for Tropical Cyclones

USA and Canada – extend over Sierra Nevada, Colorado, Eastern Canadian Rockies and the Great Lakes region,
the belt extending from Iceland to Barents Sea and continuing over Russia and Siberia,
winter storms over Baltic Sea,
Mediterranean basin extending up to Russia and even up to India in winters (called western disturbances) and the Antarctic frontal zone.



Favorite Breeding Grounds for Tropical Cyclones

Atlantic-Arctic Front and Cyclone: The north Atlantic is much warmer while the Arctic air mass is very cold. When both of them are coming into contact with each other, the strong temperature contrast is created and strong low pressure formation is resulted. It causes to move the cyclone towards northeast direction and reaches to the Western Europe

North America-Polar Front and Cyclone: The air mass of North America and the north polar air mass convergence cause the cyclone to develop, particularly in the Great Lakes region and move towards northeast direction (Figure 8). Mediterranean Front and Cyclone: The third important area of the development of temperate cyclones in northern hemisphere is the Mediterranean-Caspian front region. Huge expanse of the continental areas to the north of Mediterranean-Caspian parts and relatively warmer air mass over these seas create front. Along this front, the extra-tropical cyclone is generated and moves in the general wind patterns of the region. The light shower in the winter over north-western parts of India is caused by the western disturbances coming from this zone.

Extra-tropical Cyclone in Southern Hemisphere: The southern hemisphere does not have big landmass for creating temperature contrast, hence, there is no specific regions of the development of extra-tropical cyclone. They are developed with lesser intensity between 350 to 650 south latitudes and travel in south-easterly direction.

Figure

Characteristics of Temperate Cyclones

Size and Shape

The temperate cyclones are asymmetrical and shaped like an inverted 'V'.
They stretch over 500 to 600 km.
They may spread over 2500 km over North America (Polar Vortex).
They have a height of 8 to 11 km.

Wind Velocity And Strength

The wind strength is more in eastern and southern portions, more over North America compared to Europe.
The wind velocity increases with the approach but decreases after the cyclone has passed. The temperate cyclones are formed over a very large areas. The development of low pressure is not very intense. The isobars are relatively wideapart and therefore, the pressure gradient is smaller and hence, the velocity is moderate around 30 to 40 km per kour.

Frequency: Since the temperate cyclones are formed due to fornt formmation, they are occuring throughout the year. Therefore, they are not confined to any particular season but are slightly their frequency is less during summer in comparison to winter.

Areal Coverage: The temperate cyclones develop over a very large areas occupying more than 1500 or even sometime more than 2000 km in diameter. Its vertical dimensions reaches upto tropopause limit.

Characteristics of Temperate Cyclones

Location: Temperate cyclones exhibts wide variety of characteristics. They are formed between to 35˚ to 65˚ north and south latitudes in the sub-polar frontal zone and this is a result of interaction between cold polar mass and warm tropical air masss in the westerly wind belt. This type of cyclone is more pronounced in northern hemisphere due to greater temperature contrast created by land-water distribution. Climatologies suggest that, globally, mid-latitude cyclones predominantly form in one of two locations: downwind of major mountain ranges and near the eastern coastlines of continents.

Structure

The north-western sector is the cold sector and the north-eastern sector is the warm sector (Because cold air masses in north and warm air masses in south push against each other and rotate anti-clockwise in northern hemisphere).

Formation: The formation of temperatte cyclone is predominaently controlled and dominated by the formation of the fronts after coming into the contacts of two different air masses warm and cold. Thermal contrast of the two types of air masses is the genesis for the development of low pressure center and finally the creation of temperate/ extra-tropical cyclone. Their occurrence are possible over large arreas characterized by land or water or at the joining places of the two.

Air Pressure: As mentioned before, the pressure gradient in temperate cyclone is gentle as the isobars are widespread. Hence, the intensity of the winds in this type of cyclones are moderate. Generally the isobaric difference varies between 10 to 15 mb.

Characteristics of Temperate Cyclones

Orientation And Movement

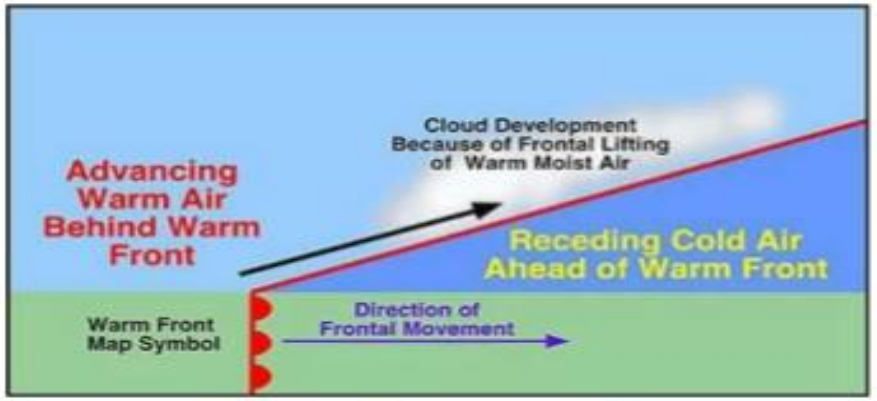
Jet stream plays a major role in temperate cyclonogeneis.

Jet streams also influence the path of temperate cyclonesDirection of Movement: Since, the temperate cyclones are developed in the mid-latitudes areas where the westerlies are prominently blowing, the direction is, in general, from west to east. Due to Coriolis effects, the direction is not straight from west to east but follow the path from southwest to northeast in northern hemisphere. In southern hemisphere, it is from northwest to southeast direction. Therefore, they move from mid-latitude areas to high latitude areas. The direction of the tracks of this type of cyclone is governed by the surface roughness and the characteristics of the areas from where they pass. In general, it is curvilinear direction that they follow. With the passage of the cyclonic tracks, they get reduced, fronts weakened and finally they dissipate. In case the storm front is directed southwards, the center moves quite deep southwards-even up to the Mediterranean region [sometimes causing the Mediterranean cyclones or Western Disturbances (They are very important as they bring rains to North-West India – Punjab, Haryana)].

Characteristics of Temperate Cyclones

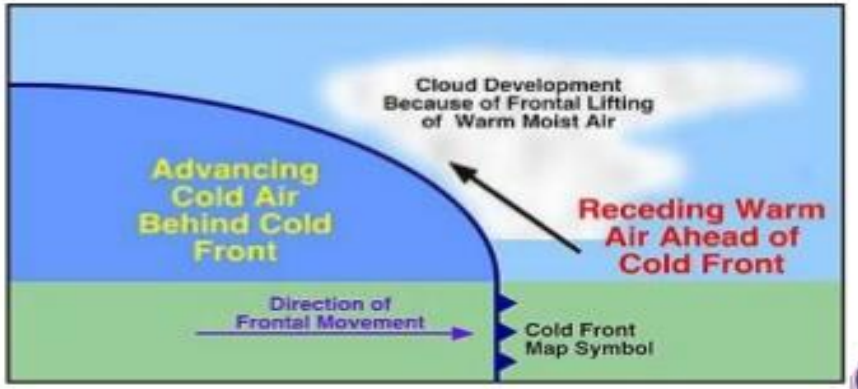
1.The Extra-Tropical Cyclones are storm systems emerging in the mid and high latitudes, away from the tropics.
2.They are low-pressure systems with associated cold fronts, warm fronts, and occluded fronts.
3.These cyclones are formed along the polar front.
4.In the beginning, the front is stationary.
5.Extra-tropical cyclones are also known as mid-latitude storms or baroclinic storms.
In the Northern hemisphere, cold air blows from the north of the front and warm air blows from the south.
When the pressure descents along the front, the cold air move towards the south, and the warm air moves northwards setting in motion an anticlockwise cyclonic circulation.
5.The cyclonic circulation results in a well-built extratropical cyclone, with a cold front and a warm front.
6.There are pockets of warm air compressed between the forward and the rear cold air.
7.The warm air climbs over the cold air and a series of clouds appear over the sky ahead of the warm front and cause rainfall.
8.The cold front approaches the warm air from behind and pushes the warm air up.
9.As an outcome, cumulus clouds develop along the cold front.
10.The cold front moves faster than the warm front eventually surpassing the warm front.
11.The warm air is entirely lifted and the front is occluded and the cyclone dissipates.
12.They can originate over the land and sea and cover a larger area.66

MID LATTITUDE CYCLONES: CONCEPTS



WARM FRONT

COLD FRONT



Warm Front: In the northern hemisphere, the warm front (Figure 4) develops to the southeast; to the right side of the moving direction of warm air mass. In southern hemisphere, it develops to the southeast; to the left side of the moving direction of warm air mass. The warm front development is caused and modified due to the interaction of the air masses. On the warm front, the effect of warm air mass is pronounced, and hence, it is named so.

Cold Front: In the northern hemisphere, the cold front (Figure 4) develops to the northwest; to the right side of the moving direction of cold air mass. In southern hemisphere, it develops to the southwest; to the left side of the moving direction of cold air mass. The development is caused and modified due to the interaction of the air masses. On the cold front, the effect of cold air mass is marked, and hence, it is named as cold front.

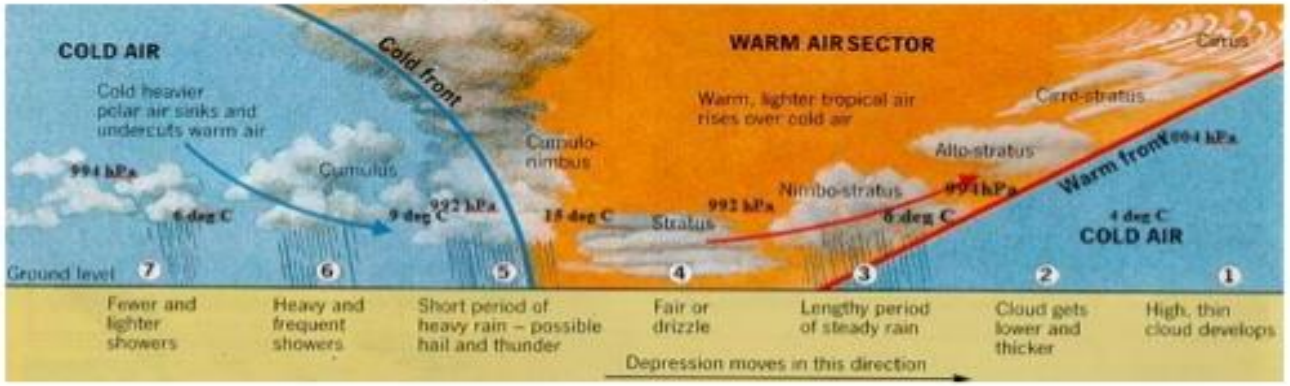
Occluded Front: Occlusion means the blocking or sealing the existence and with respect to fronts. It signifies the removal of the fronts from the ground. Occlusion of the fronts occurs when the cold air mass occupy the ground space surrounding the hairpin turned clubbed warm and cold
fronts. This type of fronts do existbut for short time. Theyremain onsuspension in the sky. It is termed as occluded front

Cross section through a cold and warm front

WEATHER	Behind cold front	Cold front passing	Warm sector	Warm front	Cyclone approach
Air pressure	increase continues at a slower rate	sudden increase	remains steady	decrease stops	steady decrease
Wind direction	south	backing from west to southwest	west	backing from north-west to west	northwest
Wind speed	gusty, decreases slowly	very strong to gale force	decreases	strong	increases slowly
Temperature	cold, around 5 °C	sudden decrease	warm to mild, around 12 °C	sudden rise	cool, around 8 °C
Relative humidity	rapid fall	high during precipitation	steady and high	high during precipi-tation	slow rise
Cloud cover	decreasing in succession cumulonimbus to cumulus	very thick and towering cumulonimbus clouds	low stratus clouds, with clear patches in-between	low and thick nim-bostratus	high and thinner clouds altostratus, cirrostratus and cirrus
Precipitation	heavy and later soft, persistent showers	short period of heavy rain or hail	intermittent drizzle or stop	continuous rainfall – steady and quite heavy	none
Visibility	very good, but poor in showers	poor, especially in showers and fog	often poor	decreases rapidly	good, but decreasing with nearing front

FIGURE 44 Cold and warm front conditions at the Earth's surface in the Southern Hemisphere with explanatory notes on weather changes

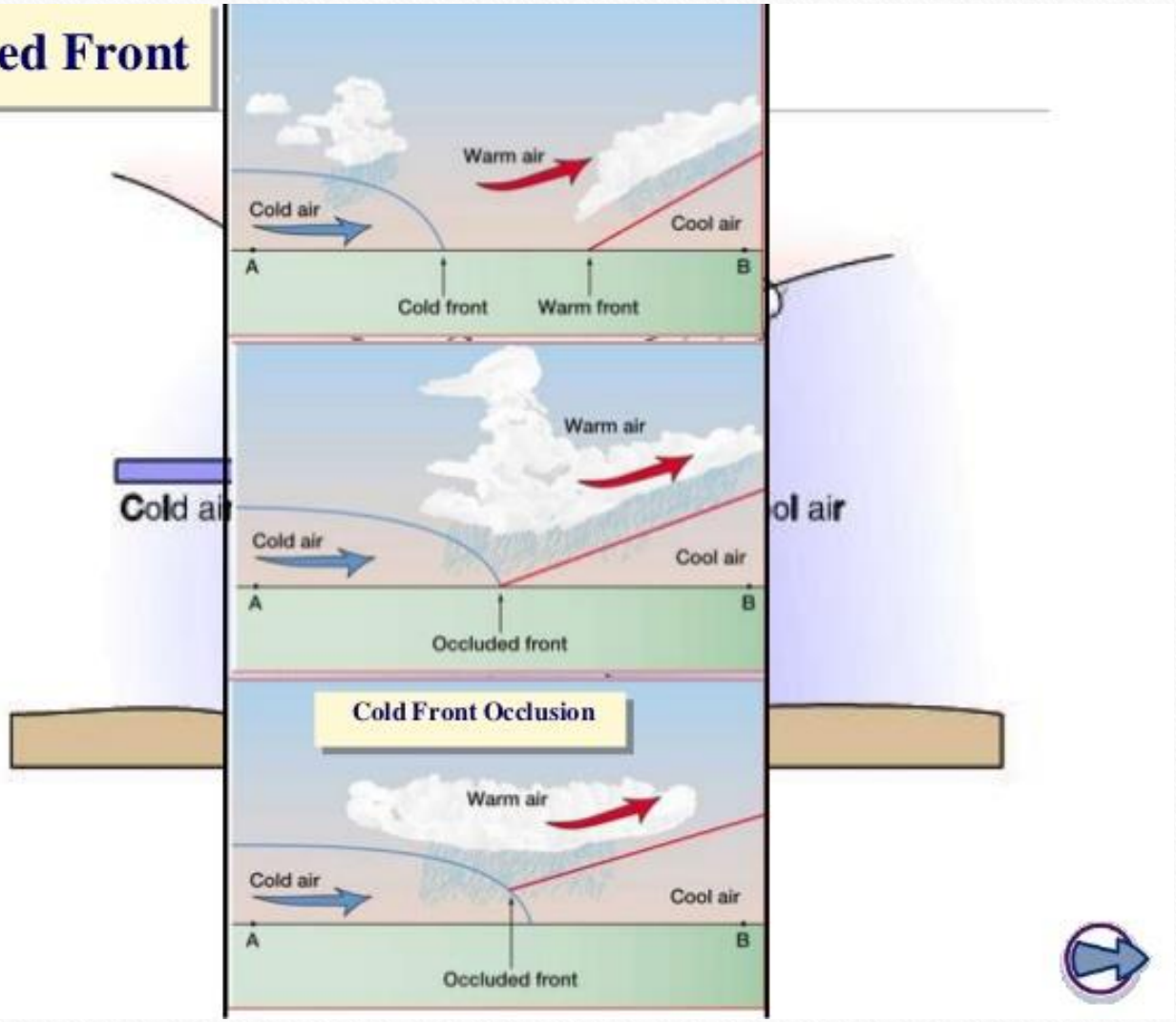
Cross section through a cold and warm front



After the cold front passes (See no. 7)	During the warm sector (See no. 4)	2) As warm front passes (See no. 3)	Weather conditions
6 deg	16 deg	6 deg C	Temperature
994 hPa	992 hPa	994 hPa	Pressure
Cumulus	Sratus	Nimbostratus	Cloud type
Light showers	Drizzle or no rain	Rain	Precipitation

Go into editing mode and fill in the missing information!

Occluded Front



STAGES OF FORMATION

(a) **FIRST STAGE:** This involves the convergence of two air masses of contrasting physical properties and directions. Initially, the air masses (warm and cold) move parallel to each other and a stationary front is formed. This is **called initial stage.**

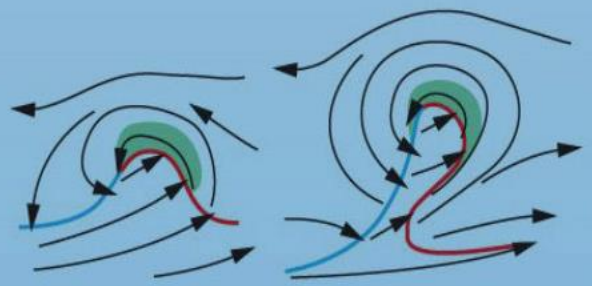
(b) **SECOND STAGE**: It is also called as **'incipient stage'** during which the warm and cold air masses penetrate into the territories of each other and thus a **wave-like front is formed.**

(c) **THIRD STAGE**: It is the **mature stage** when the cyclone is fully developed and isobars become almost circular.

(d) **FOURTH STAGE**: Warm sector is narrowed in extent due to the advancement of cold front than warm front, as cold front comes nearer to warm front.

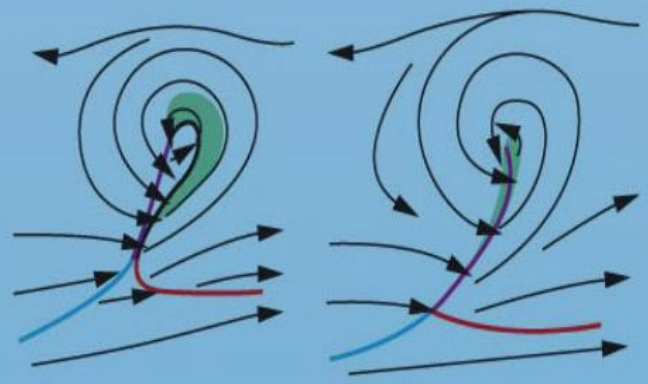
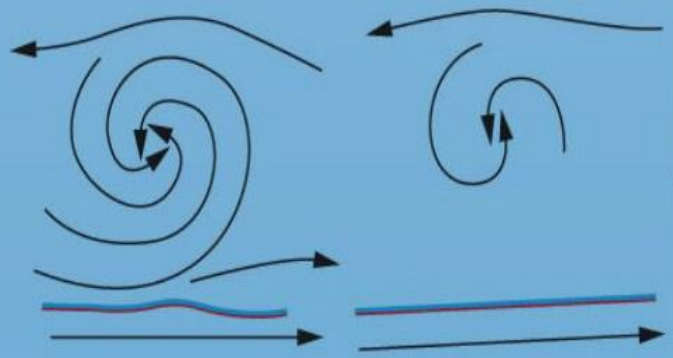
(e) **FIFTH STAGE:** Starts with the **occlusion of cyclone** when the advancing cold front finally overtakes the warm front and an occluded front is formed.

(f) **SIXTH STAGE**: Warm sector completely disappears, occluded front is eliminated and ultimately **cyclone dies out.**

Stage	Weather Map Depiction of Norwegian Cyclone Model	Typical Satellite Image of Life-Cycle Stage	Typical Sea-Level Pressure at Cyclone Center	Corresponding Dates of *Edmund Fitzgerald* Cyclone
Birth (frontal wave)			1000-1010 mb	November 8, 1975
Young adult (open wave)			990-1000 mb	November 9, 1975

Source: Meteorology: Understanding the Atmosphere (4th ed.) by S. Ackerman and J. Knox

Figure 7B: Idealized View of the Successive Stages of Temperate Cyclone

Stage	Weather Map Depiction of Norwegian Cyclone Model	Typical Satellite Image of Life-Cycle Stage	Typical Sea-Level Pressure at Cyclone Center	Corresponding Dates of *Edmund Fitzgerald* Cyclone
Mature (occluded cyclone)			960-990 mb	November 10–11, 1975
Death (cut-off cyclone)			Slowly rising from 960-990 mb up to 1010 mb	November 11–15, 1975

Source: Meteorology: Understanding the Atmosphere (4th ed.) by S. Ackerman and J. Knox

Polar Front Theory

According to this theory, the warm-humid air masses from the tropics meet the dry-cold air masses from the poles and thus a polar front is formed as a surface of discontinuity.

Such conditions occur over sub-tropical high, sub-polar low pressure belts and along the Tropopause.

The cold air pushes the warm air upwards from underneath. Thus a void is created because of lessening of pressure. The surrounding air rushed in to occupy this void and coupled with the earth's rotation, a cyclone is formed which advances with the westerlies (Jet Streams).

In detail

temperate cyclone -occluded front formation animation Temperate Cyclone-polar front theory path of temperate cyclone.In the northern hemisphere, warm air blows from the south and cold air from the north of the front.

When the pressure drops along the front, the warm air moves northwards and the cold air move towards south setting in motion an anticlockwise cyclonic circulation (northern hemisphere). This is due to Coriolis Force.

The cyclonic circulation leads to a well-developed extra tropical cyclone, with a warm front and a cold front.There are pockets of warm air or warm sector wedged between the forward and the rear cold air or cold sector. The warm air glides over the cold air and a sequence of clouds appear over the sky ahead of the warm front and cause precipitation.

The cold front approaches the warm air from behind and pushes the warm air up. As a result, cumulus clouds develop along the cold front. The cold front moves faster than the warm front ultimately overtaking the warm front. The warm air is completely lifted up and the front is occluded (occluded front) and the cyclone dissipates.

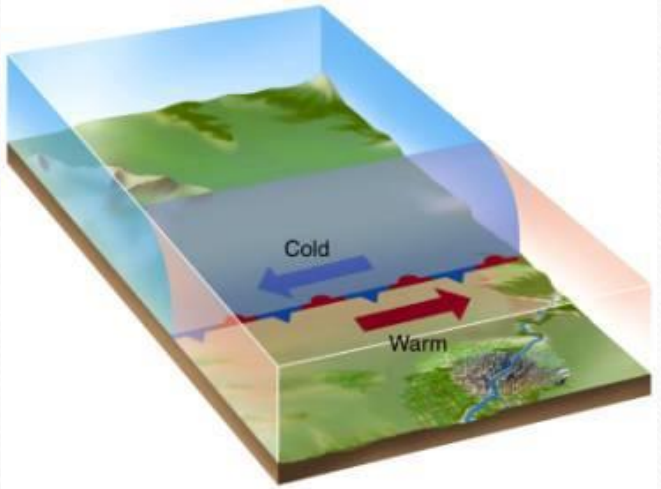
The processes of wind circulation both at the surface and aloft are closely interlinked.

So temperate cyclone is intense frontogenesis involving mainly occlusion type front. (Occluded front explained in detail in previous posts).

Normally, individual frontal cyclones exist for about 3 to 10 days moving in a generally west to east direction.

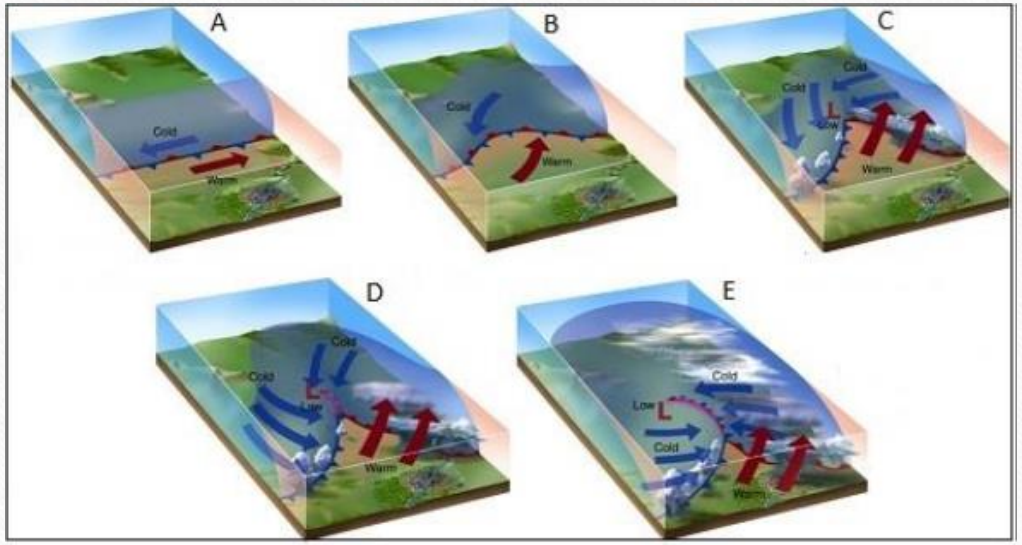
Precise movement of this weather system is controlled by the orientation of the polar jet stream in the upper troposphere.

Stage I: Stationary/ Beginning The cold air mass and warm air mass tend to converge along an axis as shown in Figure 1. The sequential development of temperate cyclone can be seen from Figure 2A to 2E on a three dimensional configuration. In this situation, both of the air masses are almost stable and are in contact with each other. It is also known as the stationary stage of front formation. Though the difference in temperature, moisture and pressureremains marked between two air masses, still it is not that great to create instability at a bigger scale. With passage of time, and with interaction between them particularly in the fringe margin of the contact zone, there starts some push by warm air mass to the eastern side and to the western side, the impacts of cold air mass is distinctly visible. At the latter phase of stage, the straight and flat formed front (Figure 1) is turned by the advancing air masses of their influence (Figure 2B and clearly visible in Figure 3). After this the second stage of the beginning of young adult starts

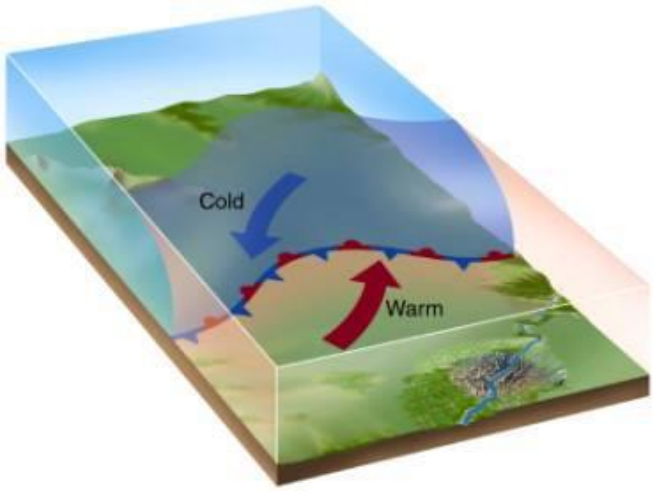


Stage II: Beginning of Young Adult

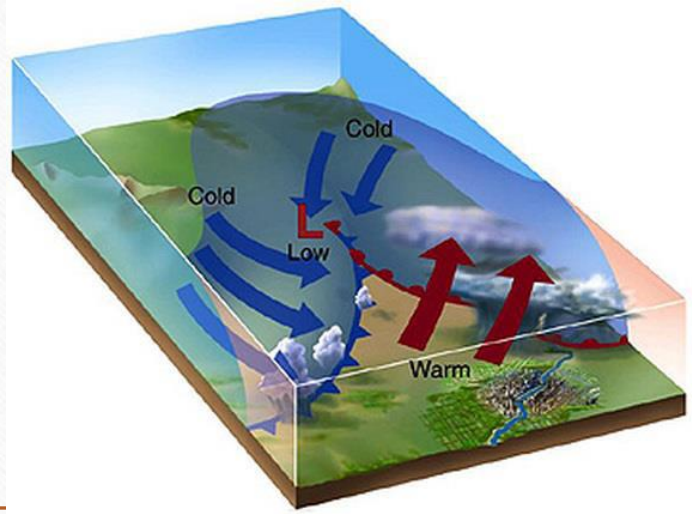
By the end of first stage, the frontiers of two air masses are conspicuously different. First, where the greater impact of warm air is observed, it is warm front and it lays to the eastern part in northern hemisphere. The impact of cold air mass is very significantly seen in the western part in the northern hemisphere. To the north and north-west, the area occupied by cold air mass is known as cold sector (Figure 2B and clearly visible in Figure 3). Opposite to it, i.e. south and south-east, the area is dominated by warm air mass and hence, it is known as warm sector. It is all happening under the general principles of the winds associated with Coriolis Effect and Ferrel's law. A mirror image situation is applicable in the case of southern hemisphere. Figure 2:



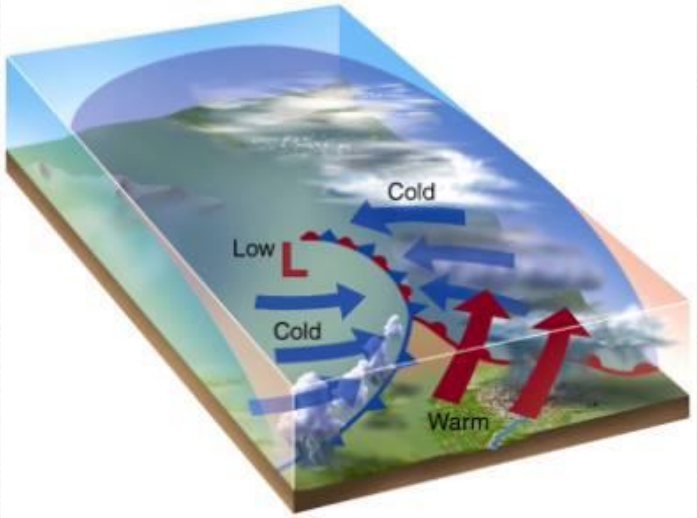
The warm front has more instability because impact of more moisture found with it. Contrary to this, along the cold front, the stability is relative greater as cold air mass has less moisture. Previously, you have already read about the instability in the air. You also know that addition or availability of more and more moisture causes the air to be more and more unstable. At the junction of the two fronts – warm and cold, the instability is greater. The cold air mass tries to push the warm air mass and in this process the junction becomes more and more sharp. The warm sector starts shrinking and the turn of the bend become more sharp (Figure 4). Since the warm air mass is lighter in density and therefore is pushed up on the cold air mass. Rising warm air, with moisture, cools down under the influence of cold air as well as increasing height. The condensation is evident. After the precipitation, latent heat is released and further low pressure is created over the junction of the two fronts. It is the beginning situation of the tropical cyclone formation. Since the cyclonic condition is already initiated by the end of this stage, that is why this stage is known as beginning of young stage of temperate cyclone.



Stage III: Mature By the end of second stage, the low air pressure has already initiated at the junction of the two fronts particularly due to condensation. That low pressure attracts air from the surrounding region and a vertical updraft of the air is observed very significantly. In the third stage, the intensification of the second stage is resulted. Due to intensification, the isobars become closer. The pressure gradient becomes very sharp. Swiftly updraft of the air moves in a whirling manner. The invasion of the cold air mass is greater. Warm sector becomes still smaller and shrinks. More and more sharp turns of the two fronts are seen. That creates the real and advance stage of temperate cyclone. Since the general patterns of the winds are westerlies, the temperate cyclones are in a tendency to march towards eastern side. Therefore, wherever it strikes, it brings changing weather conditions. By the end of this stage, the combinedfrontstarts lifted above (Figure 5) and it is the beginning of the diminishing strength of cyclone.



Stage IV: Beginning of Occlusion The literal meaning of occlusion is constriction or compression. The two distinctly formed fronts are getting compressed because of their diffusion. By the end of third stage, both fronts were coming closer and finally they culminate into merging together which we call the occluded front. In occlusion stage, the cyclone starts declining as the low pressure gets weakened. The intensity is lowered and the wind velocity is on decline. The convergence of the two fronts gets detached from the ground and are still suspended in the sky (Figure 6). Ground level, in the beginning, was occupied by the two different air masses but now after occlusion, it is the occupation of cold air all through on the ground. Clubbed fronts are still hanging in the sky. Warm sector has been shifted above the ground. Discontinuity is still there but in the sky and not on the ground.



Stage V: Late Occlusion or Dissipation

In the beginning stage of the occlusion, the temperate cyclone was still very dynamic and strong, but by the end phase of occlusion it is substantially weakened. In the last stage of cyclone, more and more areas are occupied by cold air mass. It happens so, because it is much dense/ heavy in comparison to warm air. Warm air areas are completely governed by cold air. The pushed up warm air cools down under the impact of cold air as well as by adiabatic cooling. By the end of this stage, the low pressure is completely eliminated and the normal condition is reached. Even the occluded front pushed up is completely removed. All these conditions are the characteristics of the dissipation stage