15. Frontal Depressions

15.1 Formation of a frontal depression

A depression, also known as a low, appears on a meteorological chart as a region of relatively low pressure with closed isobars. They are generally circular or oval in shape.

A team of Norwegian meteorologists developed a frontal theory of the formation, growth, and decay of depressions in mid-latitudes. It relates the life of a depression to the frontal zone separating two distinct air masses. The recognised zone is known as the *Polar Front*, which separates cold surface air of Polar origin from warm moist air of Tropical origin.

The polar front is approximated, continuous and shifts north and south with the seasons, forming waves. Since there are large differences in temperature and moisture content between the Polar and Tropical air masses, depressions most frequently form in the Western North Atlantic and Western North Pacific, particularly in winter. Southern Hemisphere depressions have similar qualities.

For a depression to form at the Polar Front an essential condition is that the warm air should be moving to the eastward at a greater speed than the cold air or in the opposite direction.

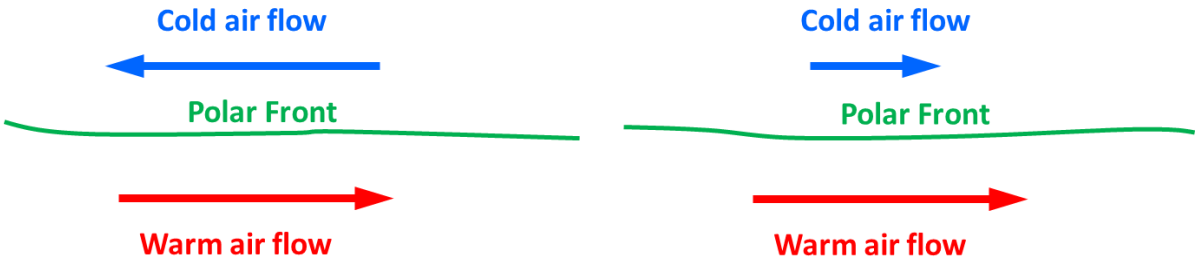


Fig. 15.1 – Initial conditions necessary for the formation of a depression.

In general, a depression begins as a small wave-like disturbance on a frontal surface. As it develops a circulation, it becomes a larger system and moves away to the E or NE in the Northern Hemisphere.

The figures on the next page represent successive stages in the development of a depression. The warm air overrides the cold air at the warm front and the cold air undercuts the warm air at the cold front. Simultaneously, a fall of pressure occurs over the centre i.e. the depression *deepens*.

Along with the process of development, there is a general motion of the system as a whole with the approximate direction and speed of the warm air in the warm sector.

The centre of low pressure is surrounded by roughly concentric isobars that run more or less straight and parallel to each other between the fronts within the warm

sector. The isobars show an abrupt change in direction at the fronts. The wind circulation is anti-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

The features shown represent the surface conditions, it must be appreciated that depressions are three-dimensional phenomena often extending upwards throughout the troposphere and having a structure which will usually vary with height.

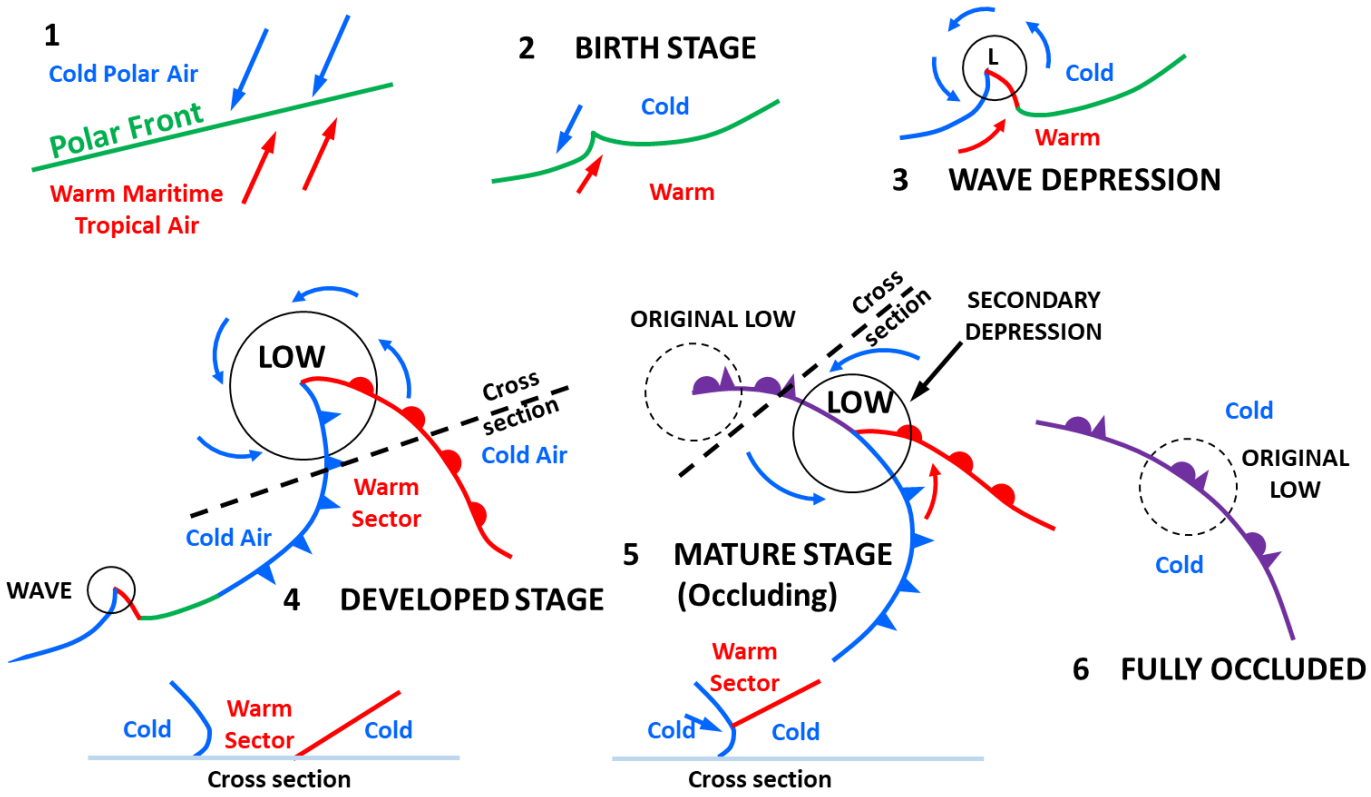


Fig. 15.2 - Life cycle of a depression.

Fronts are named with respect to the temperature of the air behind the front when compared to the temperature ahead of it.

The life cycle of a depression is summarised as follows:

(1) On the western side of the ocean cold polar air meets warm tropical air on the Polar Front; the warm air moves eastward at a greater speed than the cold air or in the opposite direction.

(2) This creates a disturbance on the frontal boundary and cold air makes incursions into the warm air and vice versa. This creates a wave on the front which travels eastward.

(3) Pressure falls at the crest of the wave and circulation develops as the wave continues to move easterly. The warm and cold fronts form the wave.

(4) At the developed stage the depression continues to move east; the cold front travels at the geostrophic wind speed and the warm front travels more slowly at about 2/3 the geostrophic wind speed.

(5) At the mature stage the air in the warm sector starts to be lifted above the surface from the centre of the depression going southwards as the system moves easterly. This is termed the *occlusion* process. Occlusion continues as the system continues to move eastwards.

(6) Eventually the depression becomes fully occluded and the system decays; often a secondary depression might form on the remaining trailing edge of the cold front of the first, see *family of depressions*.

15.2 Typical depression movement

Depressions can move in any direction but generally they will develop and decay as the system moves easterly along the Polar Front; the warm and cold fronts themselves creating the wave pattern in the Polar Front.

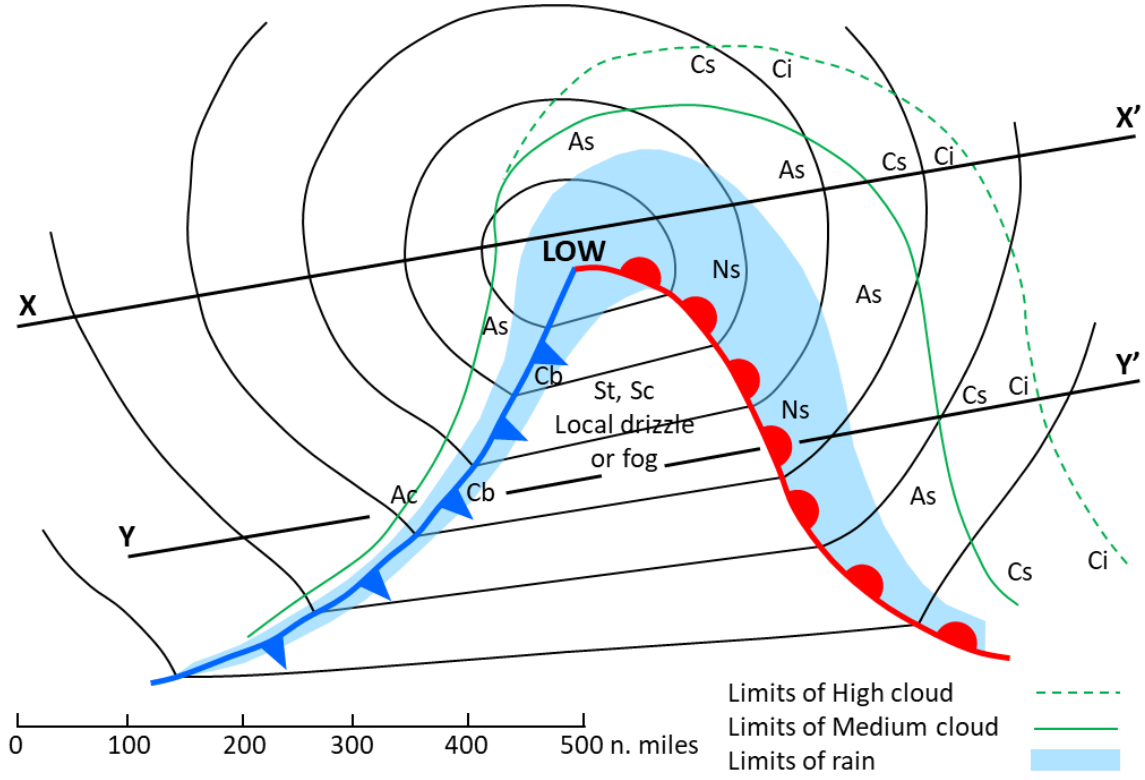
Speed of movement can vary widely as with direction but as a guide the speed of the fronts themselves may be estimated as being as follows:

- The speed of a warm front may usually be taken as about two-thirds of the geostrophic wind speed.
- The speed of a cold front is usually the same as, or slightly greater than, the geostrophic wind speed.
- The speed of an occlusion is best assumed to be equal to the geostrophic wind speed.

The direction of movement of each front may be assumed to be in a direction that is normal (90°) to the part of the front being considered but this is only a rough guide.

15.3 The features of a depression at the developed stage

Figure 15.3 shows a fully developed stage depression.



High cloud: Cirrus (Ci), Cirrostratus (Cs)
Medium cloud: Altostratus (As), Altocumulus (Ac), Nimbostratus (Ns)
Low cloud: Stratus (St), Stratocumulus (Sc), Cumulonimbus (Cb)

Fig. 15.3 - Plan of a mid-latitude depression at the fully developed stage.

Figures 15.4 and 15.5 show the sections through the depression (XX' and YY').

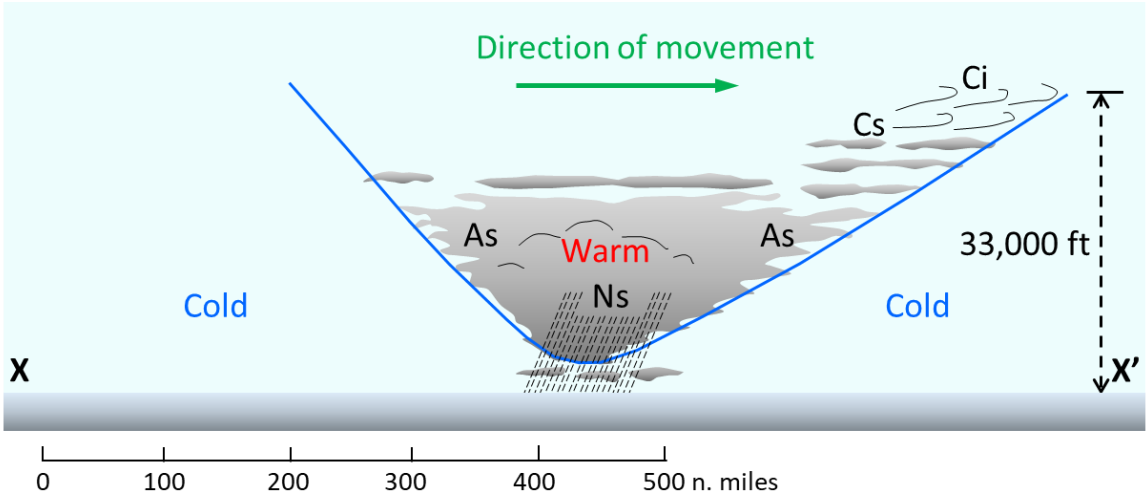


Fig. 15.4 - Section of a mid-latitude depression along XX'.

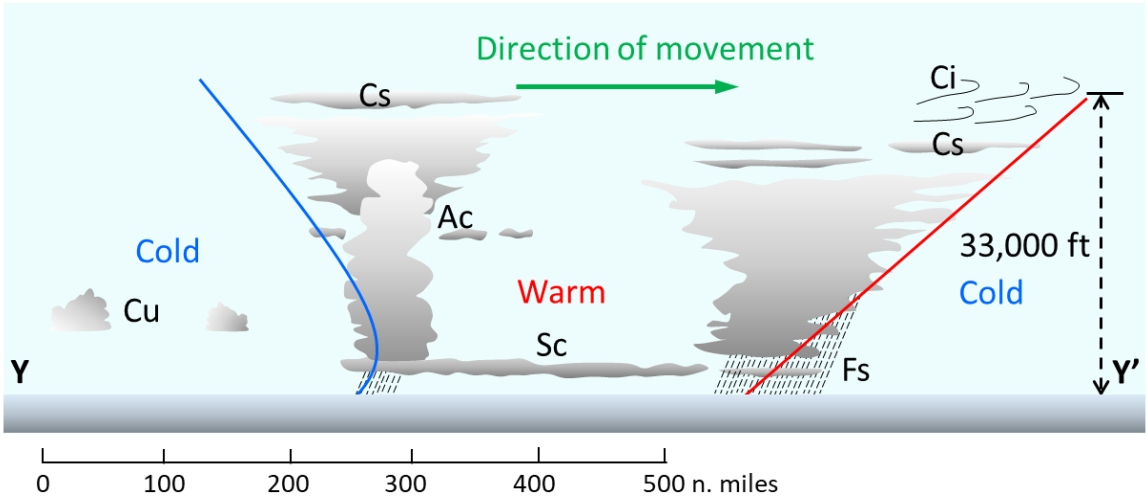


Fig. 15.5 - Section of a mid-latitude depression along YY'.

Note

It must be noted that the depression and fronts as depicted can vary greatly in structure and movement; the description given is an idealised situation.

15.4 Typical sequence of weather as a depression approaches

It must be understood that the following is an approximation of the likely sequence of weather events but in the absence of up to date weather information and charts it provides a good guide.

Depressions in middle latitudes can bring changeable and bad weather conditions at any time of the year and are of great significance to the mariner.

Note the following terms with respect to change of wind direction:

Backing is when the wind direction changes in an *anticlockwise direction* i.e. from W to SW or NE to N for example.

Veering is when the wind direction changes in a *clockwise direction* i.e. from W to NW or NE to E for example.

15.4.1 Signs of an approaching depression

Depressions are usually preceded by a ridge of high pressure. An observer to the eastward (i.e. in the path) of an advancing depression will therefore experience the following phenomena as the ridge passes to the eastwards:

(1) Wind backing round to a generally southern sector.

(2) Falling pressure.

(3) Increasing cloud cover from the west with a lowering of the cloud base.

These three signs taken together may be taken as evidence of an approaching depression.

Treated separately the following general rule may be used with a fair degree of reliability:

- **one sign** *possible* approach of a depression.
- **two signs** *probable* approach of a depression.
- **three signs** *certain* approach of a depression.

In addition to the above, the presence of a Halo around the Sun or Moon viewed through Cs cloud is a reliable indicator of imminent rain.

Fig. 15.6 – Typical halo effect of the Sun see through a layer of cirrostratus cloud.
https://www.metoffice.gov.uk/learning/clouds/high-clouds/cirrostratus

Although Buys Ballot's Law will indicate the approximate direction of the centre of the depression, it does not indicate the path of the centre of the depression relative to an observer.

15.4.2 Typical frontal weather events

The following tables describe the typical sequence of weather likely to be experienced by an observer at sea as a depression approaches and passes.

Table 15.1 is for an observer that is in a position where the centre of the Low passes to the north in the northern hemisphere OR passes to the south in the southern hemisphere (**YY'**).

Table 15.2 is for an observer that is in a position where the centre of the Low passes to the south in the northern hemisphere OR passes to the north in the southern hemisphere.

Study the diagrams when working through the sequence of events in each case; this is a popular examination question!

	Approaching warm front	Warm sector	Approaching cold front	At the cold front
Wind (N hemisphere)	Backs to SW or S and freshens	Veers and may freshen	Backs slightly and freshens becoming gusty	Veers markedly to W or NW. May be accompanied by sudden squalls
Wind (S Hemisphere)	Veers N or NW and freshens	Backs and may freshen	Veers slightly and abates	Backs to W or SW. May be accompanied by sudden squalls
Cloud	Thickens and cloud base lowers. Overcast skies obscure the Sun	Medium and high level cloud breaks up. Typically lower level cloud remains	Increase in medium and high level cloud. Often obscured by thickening of low level cloud	Thick bank of cloud breaks up as front clears to the east.
Weather	Intermittent light rain increases moderate to heavy just ahead of the front	Rain eases and may turn to drizzle. Fog banks may develop if sea surface temperature is high compared to dew point temperature	Rain resumes	Moderate or heavy rain followed by clearer conditions as front clears to east. Showers may develop behind the front
Pressure change (tendency)	Increased rate of fall	Rate of fall slows and may become steady	Fall	Sharp rise
Change in temperature	Very slow increase	Sharp increase	Steady	Sharp decrease
Change in dew point	Very slow increase. Higher rate of increase in rain	Sharp increase	Steady. May rise in rain	Sharp decrease
Visibility	Steady reduction as rain increases	Moderate or poor	Moderate	Sudden improvement

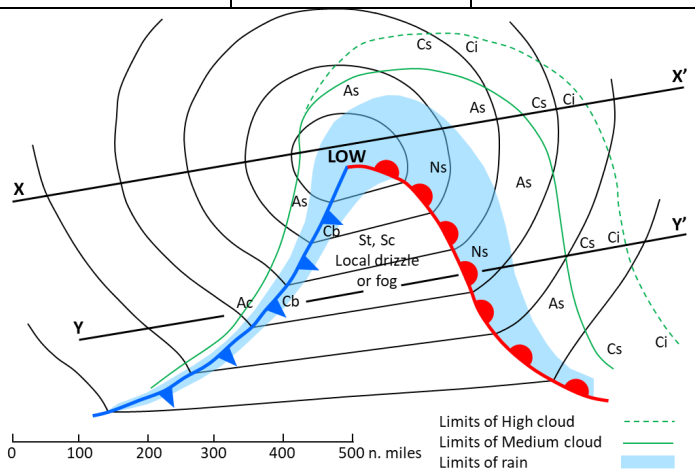


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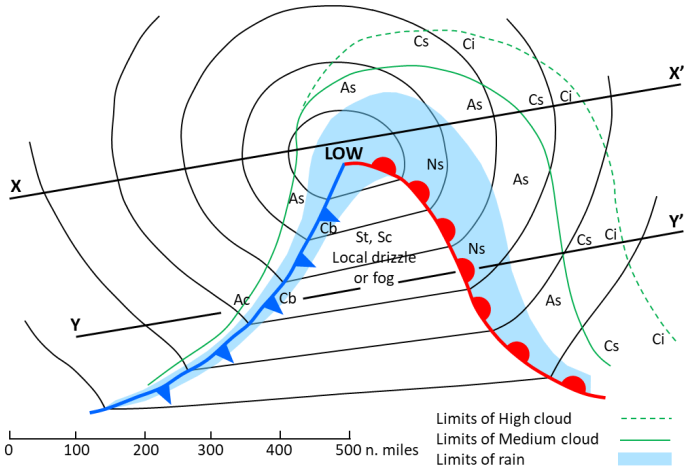
Table 15.1 - Typical weather experienced with passage of a depression approaching from the west (YY') with depression plan view.

	Movement of depression	Ahead of the system	As system passes	Behind system
Wind (N hemisphere)	E or NE	Se backing E then NE	NE backing N	N backing NW
Wind (S Hemisphere)	E or SE	NE veering E then SE	SE veering S	S veering SW
Weather		Skies gradually cloud over. Showers become more frequent and increase in intensity	Long periods of continuous rain with heavy squalls, low cloud and poor visibility	Rain gradually breaks into showers. Visibility improves
Pressure change (tendency)		Increased rate of fall	Sudden drop	Gradual increase



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Note

The winds here are often referred to as cyclonic in forecasts. Changes in wind speed and direction are gradual. Winds may fall light and variable near the centre of the depression before rapid onset of strong or gale force winds.

Table 15.2 - Typical weather experienced with passage of a depression approaching from the west (XX') with depression plan view.