LOW PRESSURE SYSTEM

Mid-Latitude Cyclones
Low Pressure

**CHARACTER**

- Warm air rises
- Clockwise in SH
- Air moves into a LP
- Precipitation

- Associated with the meeting of warm and cold air masses.
- Do not mix readily as they have different densities, separated by a ‘front’. (Think of War, enemies are separated by a front.)
- See video.
- Warm front found where warm air is advancing and overriding cold air. (Hot air always rises)
- Cold front occurs when advancing cold air undercuts a body of warm air.
- Diameters of mid-latitude cyclones range from 1000km to 4000km. (Distance from Pretoria to Cape Town is 1450km)
- Occur all year round, but in SA their influence is strongest in winter bringing the familiar ‘cold fronts’ which bring rain.
- Cyclogenesis (development or strengthening of cyclonic circulation in the atmosphere) occurs as a result of an imbalance in energy between the polar and tropical regions.
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GLOBAL AIR CIRCULATION PATTERN

- Very hot
- Ascending air
- LOW PRES

- Warm & cold air meet
- LOW PRES

- Very cold
- Descending air
- HIGH PRES

- Air from Equator sinks
- HIGH PRES

Winds deflect to the RIGHT in NH and to the LEFT in SH
Mid-latitude cyclones move from west to east - Because they develop in the mid-latitudes - westerlies.
Conditions Necessary for MLCs

- Two large high-pressure systems (anti-cyclones) are in contact on the polar front.
- The warm, subtropical high pressure contains a warm, moist maritime air mass. (Water fuels the cyclone, petrol in a car)
- The polar high pressure contains a cold, dry air mass.
- The airflow converges from opposite directions on the two sides of the polar front.
- Disturbances on the polar front result in an unstable situation, creating a local low pressure into which air will flow and around which air will circulate.
Activity 1 Corrections:
1. Weather is the condition of the atmosphere on a specific day at a specific place in terms of the different weather elements like temperature, humidity, wind, air pressure and cloud cover. Climate refers to the long-term average of seasonal weather conditions of geographical regions.
2. In the Southern hemisphere as in Figure 36:
   • North-westerly winds from the subtropical HP: these air masses are warm and moist; mostly maritime air
   • South-easterly winds from the polar HP: these air masses are cold and dry; mainly Antarctic air.
3. Mid-latitude cyclones generally move from West to East, in the mid-latitudes. The oldest mid-latitude cyclone of such a family of fronts will therefore always be furthest to the East.
4. Two air masses flow towards each other in the mid-latitudes. They are separated by the polar front. The air mass from the subtropical HP flows in a south-easterly direction and the air mass from the polar HP in a north-westerly direction along the polar front.
Stages of Development

The lifecycle of a Mid-latitude Cyclone is approximately 2-7 days

STAGES
- Initial
- Development
- Mature
- Occluded
- Dissipating
Initial Stage

- At approx. 60° S
- Friction between:
  - the cold polar easterlies (from the polar HP) and
  - The warm Westerlies (from the Sub Tropical HP)
- Causes a kink/discontinuity/disturbance to develop in the polar front
Development or wave stage

- Disturbance occurs on the polar front due to:
  - 1. Accelerated movement in fronts.
  - 2. Frictional drag between the different air masses.
  - 3. Disturbances in the westerly wind belt.
  - 4. Uneven surfaces or shape of coastline.
  - Temperature difference.
Mature Stage

- Fronts are well developed
- Clear warm front
- Clear cold front
- Clockwise airflow
- If warm sector to the north
  - southern hemisphere
- If warm sector to the south
  - northern hemisphere
MID-LATITUDE CYCLONE: Synoptic weather map

- Cold front
- Warm sector
- Isobar
- Cold sector
- Wind rotation clockwise
- 1008 hPa
- 1006 hPa
MID LATITUDE CYCLONE: Cross Sections

**WARM FRONT**
- Advancing Warm Air Behind Warm Front
- Receding Cold Air Ahead of Warm Front
- Cloud Development Because of Frontal Lifting of Warm Moist Air
- Direction of Frontal Movement

**COLD FRONT**
- Advancing Cold Air Behind Cold Front
- Receding Warm Air Ahead of Cold Front
- Cloud Development Because of Frontal Lifting of Warm Moist Air
- Direction of Frontal Movement

Warm Front Map Symbol
Cold Front Map Symbol
(a) Cold front: cold air mass advances

(b) Warm front: warm air mass advances

- Warm air mass
- Cool air
- Moderate, steady precipitation

Cold air mass

Heavy precipitation
Warm front
Source: Lutgens and Tarbuck, 2004
Overhead view vs. Cross section
Mid-latitude Cyclone Size

- Cold front
- Cumuliform clouds
- Stratocumulus clouds
- Warm front
- Warm stratiform clouds
- Showers
- Precipitation
- 2,000 kilometres

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The diagram shows a warm front advancing from west to east. As the warm front moves, it lifts the cold air, causing it to condense and form cloud layers. The cloud layers indicate different types of clouds:

- **Nimbostratus (nimbos)**: Cloud layer associated with continuous precipitation, often leading to rain.
- **Altostratus (alto)**: Cloud layer that covers the sky but allows some sunlight to penetrate, leading to overcast skies.
- **Cirrus (cirrus)**: High-altitude clouds, often indicating weather changes.

The front moves from ground to the point marked as X, causing rain to fall as it encounters the cold air mass.
Occluded Stage

- The Cold Front has caught up with the warm front
- This is because;
  - it displaces warm air easily
  - it travels horizontally and does not use energy to rise

- There are two types of occluded fronts, namely cold front and warm front occlusions:
In a cold occlusion, the cold air mass overtaking the warm front is colder than the cool air ahead of the warm front, and plows under both air masses.
Cold Front Occlusion

Cold Front

Cold Occlusion
The warm sector air mass has been uplifted above the ground surface.

Warm Front

Cold polar maritime air

Cool polar maritime or polar continental air
In a warm occlusion, the cold air mass overtaking the warm front is warmer than the cool air ahead of the warm front, and rides over the cooler air mass while lifting the warm air.
Warm Front Occlusion

The warm sector air mass has been uplifted above the ground surface.

Cool polar maritime air

Cold polar maritime or polar continental air
Dissipating Stage

- Cold air completely isolates warm air from the ground.
- Vertical mixing of warm and cold air therefore there is no pressure differences and the system “dies”/dissipates.
- This stage occurs soon after occlusion has occurred.
SUMMARY: MID-LATITUDE CYCLONE DEVELOPMENT

1 INITIAL STAGE

2 DEVELOPMENT STAGE

3 MATURE STAGE

4 OCCLUSION

FAMILY OF CYCLONES
Summary of stages in both Hemispheres

Northern Hemisphere

1. Easterly winds
2. Polar front
3. Cold front, Warm front
4. Outer area

Southern Hemisphere

1. Easterly winds
2. Polar front
3. Warm front, Cold front
4. Outer area
Summary of stages in both Hemispheres
Satellite image of a cold front approaching

Late morning satellite image (11 July 2018)
Weather Changes Associated with a Passing Cold Front

<table>
<thead>
<tr>
<th>Cold sector</th>
<th>Cold front</th>
<th>Warm Sector (Variable width)</th>
<th>Warm front</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropopause</td>
<td></td>
<td>Warm light Tm air forced to rise gently</td>
<td>Ac = Altocumulus</td>
</tr>
<tr>
<td>Cb</td>
<td></td>
<td></td>
<td>Cs = Cirrostratus</td>
</tr>
<tr>
<td>As</td>
<td></td>
<td></td>
<td>As = Altostratus</td>
</tr>
<tr>
<td>Cu</td>
<td></td>
<td></td>
<td>Ns = Nimbostratus</td>
</tr>
<tr>
<td>Cold dense Pm air</td>
<td></td>
<td>Warm light Tm air forced to rise steeply</td>
<td>Cu = Cumulus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>St = Stratus</td>
</tr>
<tr>
<td>Cool dense Pc air</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sunny intervals, possibly showers</th>
<th>Cloudy, bursts of moderate or heavy rain, possible thunder.</th>
<th>Warm sector</th>
<th>Dull with more continuous moderate rain</th>
<th>Cloudy with light intermittent rain and drizzle</th>
<th>Dull</th>
<th>Bright, some watery sunshine</th>
<th>Hazy sunshine</th>
<th>Sunny, cool and dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunny intervals, increasing cloud.</td>
<td>Sunny, warm and humid</td>
<td>Cloud clearing, warm and humid</td>
<td>Dull with more continuous moderate rain</td>
<td>Cloudy with light intermittent rain and drizzle</td>
<td>Dull</td>
<td>Bright, some watery sunshine</td>
<td>Hazy sunshine</td>
<td>Sunny, cool and dry</td>
</tr>
<tr>
<td>Decreasing wind</td>
<td>Direction change</td>
<td>Wind increasing</td>
<td>Change in wind direction</td>
<td>Increasing wind</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
WEATHER CHANGES DUE TO COLD FRONTS

Key:
- **Cold front**
- **Warm front**
- **SW Wind**
- **NW Wind**

Map notes:
- Weak pressure gradient
- Isobars far
- Steep pressure gradient
- Isobars close

Areas of interest:
- Namibia
- Grootfontein
- Bulawayo
- Windhoek
- Pretoria
- Bloemfontein
- Durban
- Maputo
- Antananarivo
- E

Legend:
- H
- L
- L
- 1022
- 1020
- 1012
- 1000
- 998
- 980
- 500 km
- 0°
NB! When a cold front passes…

• Temperature decreases
• Humidity decreases
• Pressure increases
• Cb clouds at front, cumulus after
• Heavy rain at front, little rain after
• Wind “backs” to SW in S.H and (“veers” in N.H.)
• Wind speed increases
Effect on SA’s Weather

• They occur throughout the year, but only affect SA in Winter when the sub-tropical HP’s have moved North - Cold snaps on plateau in Winter
• Snow on Cape Fold Mountains
• Rain in Western and Southern Cape
• Cause Berg Winds (next chapter)
Characteristics of a Mid-latitude Cyclone evident on a synoptic chart

- Low pressure system
- Large features approx. 2000 km on average
- Travel in Westerly Wind belt
- Occur in families (if they touch); groups if they are not touching
- Causes a pre-frontal Low (coastal LP) to develop
- Has fronts

And lasts about 6 days
Characteristics of a Mid-latitude cyclone on a synoptic weather map

- **Circular isobars**
- **Cold sector**
- **Winds blow clockwise**
- **Low Pressure < 1000hPa**
- **Western winds push system from west to east**

- **Cold front**
- **Mature stage**
- **Warm sector**
- **Warm front**
Typical Exam Questions

- Label the system - a MLC
- Label the parts of a MLC – fronts and sectors
- Label warm, cool and cold sectors
- Where did system originate – polar Front
- Alternative names for the system
- Stage of development system is in
- Draw a cross section across mature/occluded stage/cold front
Typical Exam Questions

- What are the expected weather changes in PE/CT/Mossel Bay in the next 24 hours?
- Typical characteristics of MLC apparent on synoptic chart
- Which MLC is older? – occluded or one further south east.
Synoptic Chart 1
Synoptic Chart 2
Synoptic Chart 3
Remember!

Northern Hemisphere and Southern Hemisphere are opposites of each other in many aspects.
Mid-Latitude Cyclone in Northern Hemisphere (UK)

Warm sector at the bottom on map

Circulation anti-clockwise (Low Pressure in NH)
UK Synoptic weather map
(Northern Hemisphere)
Activity 2: Interpret a cross section of a mid-latitude cyclone, p.61

- 1a) Mid-latitudes, between 30° and 60 °N
- 1b) Warm, moist South-westerly winds AND cold, dry north-easterly winds
- 1c) Mature (Warm sector) stage. The air masses do not mix, well developed cold and warm fronts. Rain along the cold front.
- 1d)
• 1e) Warm sector narrows, cold front overtakes warm front, Cold air isolates warm air from the surface, this forms an occlusion front
• 1f) C is called the warm sector
• 1g) B = cold air 6°C, Cloudy, Rain (Heavy along the cold front)
    D = Cool air 9 °C, Cloudy, Rain (scattered)

2a) The **coldest air** is behind the cold front. If it was a warm front occlusion the coldest air would be in front of the warm front.

2b) In a warm front occlusion (Fig 44b), the air ahead of the warm front is colder (4 °C) than the air behind the advancing cold front. As the cold air catches up with the warm air (12 °C), the advancing cool air rises above the colder air ahead of the warm front. The warm air in the warm sector is forced to rise above the warm front occlusion. As the warm moist air cools, condensation takes place, nimbostratus clouds form and precipitation takes place.
Worksheet: Mid Latitude cyclone cross section

**Mid-Latitude Cyclones: Worksheet**

Refer to the following diagrams, which illustrates Mid-Latitude Cyclones in certain stages of development and answer the questions that follow:

1. Draw a cross section from west to east to illustrate the mature stage of a mid-latitude cyclone as shown above. Indicate the fronts, air masses, direction of movement, Clouds and precipitation.  
   (7x2) (14)

2. Draw a cross section for a cold front occlusion as illustrated above. Indicate the fronts, the different air masses and clouds on your drawing.  
   (7x2) (14)
Worksheet Answers

1. [Diagram of cold front and warm front with cumuliform and stratiform clouds, showing showers and precipitation.]

2. [Diagram of cold front and warm front, illustrating cold occlusion with warm sector air mass uplifted above the ground surface.]
Activity 3: Analyse a satellite image and synoptic weather map

1) The synoptic chart is oldest, because the cold front is further east than on the satellite image.
2) Mid-Latitude Cyclone
3) Direction of movement: West TO East
4) Low pressure. Evidence: There is a big L in the centre of the system, and the pressure at the centre is the lowest at 998hPa. The pressure decreases towards the centre, the movement is clockwise around the LP
5) Wind speed decreases, because the isobars spaced further from each other as you move north.
6) A = Coldfront ; B = Warm front
7) A Cold front is the leading edge of a forward moving cold air mass. It forms the boundary between advancing cold air mass and the warm (sector) air mass. The cold air undercuts the warm air, forcing it to rise. MAP: Air temperatures behind the cold front is colder than in front of it. (Weather stations). SATELLITE IMAGE: Clouds appear white with high humidity. Formed when cold air forced warm air to rise, condensate and form clouds.
• 9) There is no indication of an occlusion front on the synoptic weather map.
• 10) Dissipating stage: Cold air completely isolates warm air from the ground, all the warm air has been lifted high above the ground. Isobars become more even as the low pressure starts to increase and level out. Rainfall decreases and eventually stops.
Case Study 1: “The worst Cape Winter Storm” p.64

- 1) Marion Island and Gough Island
- 2) Clockwise air movement around the centre, pressure decreases towards the centre
- 3) Subtropical High Pressure belt; Warm moist air
- 4) A local decrease in pressure develops at the disturbance. Cold and warm air starts to move in a clockwise direction, with the cold front following the warm front. Warm air rises above the cold air in front of it.
- 5) A front is the transitional zone between two different air masses
• 6) A=Cold front, B= Warm front, C= Occlusion front
• 7) Behind front A (Cold front) the air is colder than in front of front A. The air in front of front B (Warm front) is colder than the air behind front b.
• 8) Occluded front develops when the warm sector starts to narrow because the cold front catches up with the warm front and forces the warm air to rise, completely isolating it from the ground.
• 9) The ship is in the warm sector. 8/8 overcast (It will be thick cumulonimbus clouds will form from which heavy rain will fall) , 40 knots wind speed, wind direction is Southerly (From North to south).
10) Wind direction changes from west to south, wind speed is going to increase when cold front passes, then decrease, Sudden drop in temperature, humidity increase, it will start to rain (heavy rain and thunderstorms)

11) SE is older, the system moves from west to east

12) D = South Atlantic High pressure system

13) False. Anticyclone: air moves anticlockwise and downward