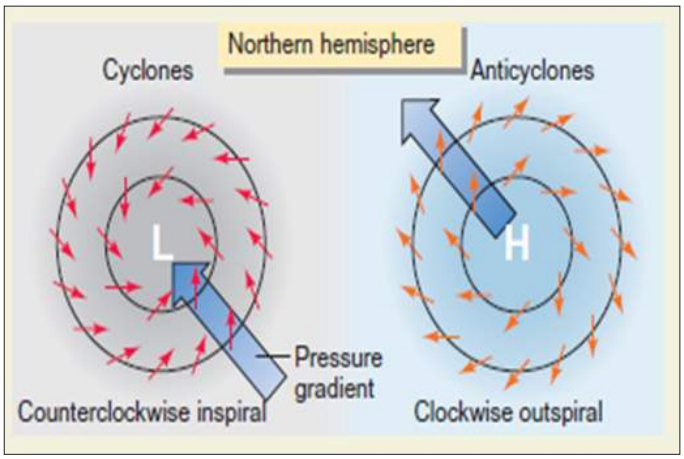
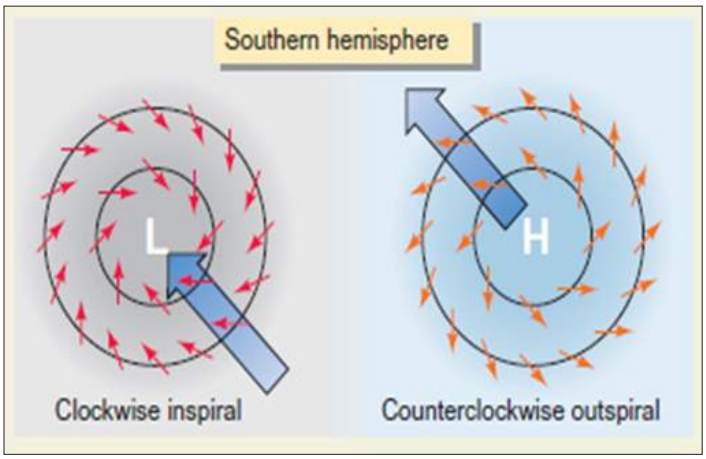
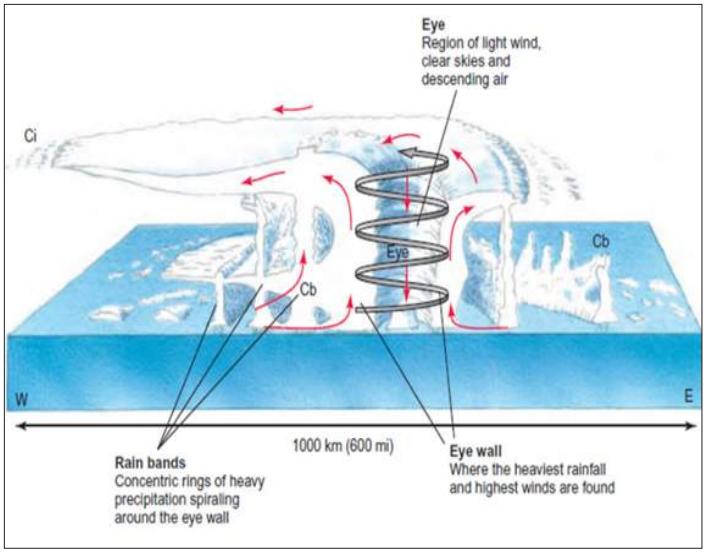
CYCLONES & JET STREAMS

Coriolis Force, Frictional Force

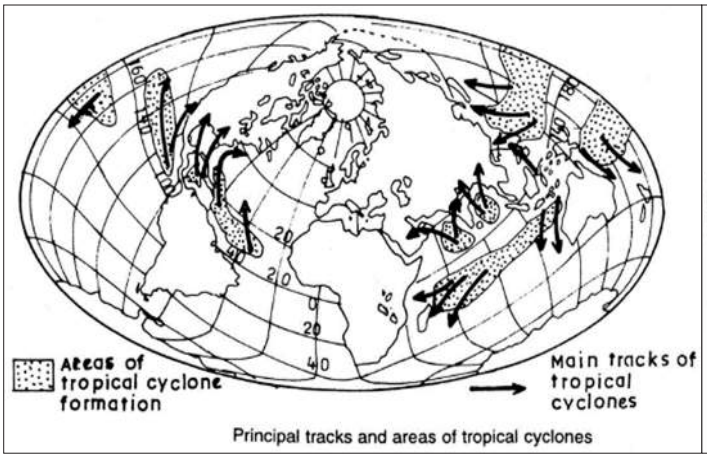


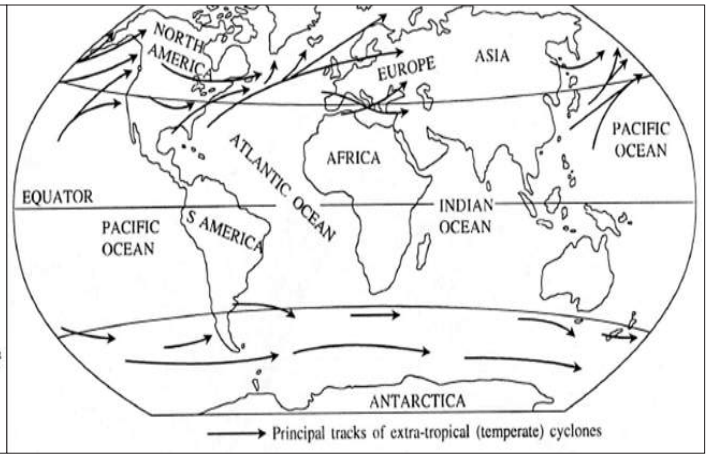


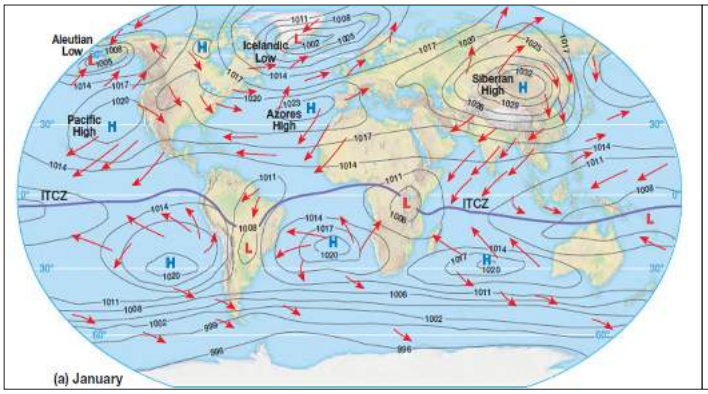
Cyclones



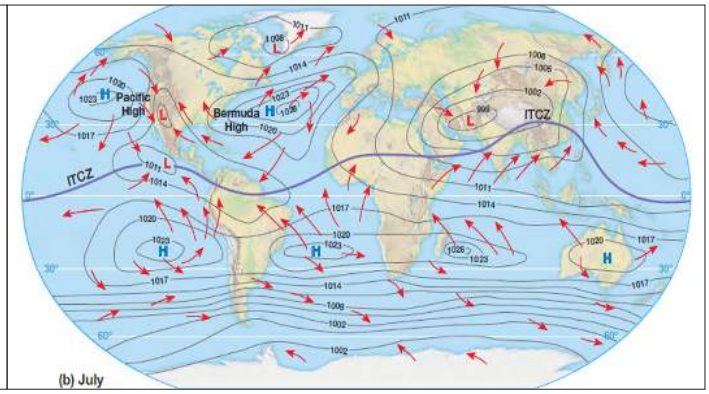
- The term cyclone refers to the **circulation around any low-pressure center,** regardless of its size or intensity.
- Hence, **hurricanes and midlatitude cyclones** are two types of cyclones.
- Whereas **"extratropical cyclone"** is another name for a midlatitude cyclone, the name **"tropical cyclone"** is often used to describe a hurricane.
- **Anticyclones**
- Most tropical cyclones form between the **latitudes of 5° and 20° over all the tropical oceans** (except in the South Atlantic and the eastern South Pacific.)
- Tropical **do not develop within about 5°** of the equator because the **Coriolis force is too weak** in that region.







Global Pressure Patterns and Winds (January)

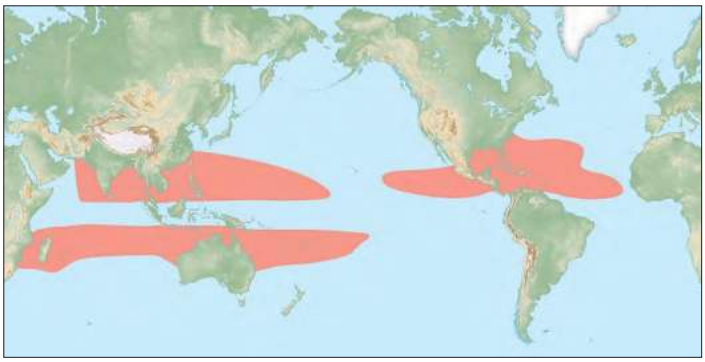


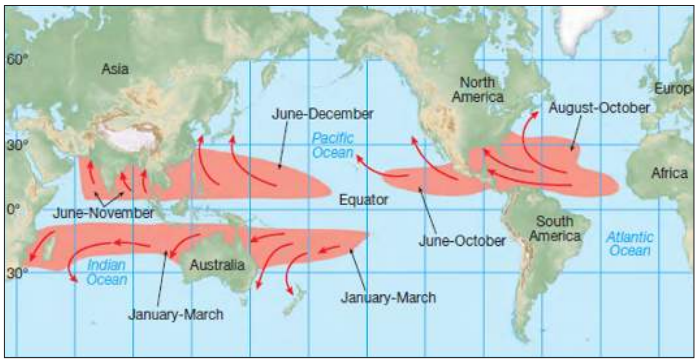
Global Pressure Patterns and Winds (July)

Characteristics

- Because warm surface ocean temperatures (SST>26^{0}C) are necessary for hurricane formation, hurricanes **seldom form poleward of 20^0 latitude nor over the cool waters of the South Atlantic and the eastern South Pacific.**
- By **international agreement,** a hurricane has **sustained wind speeds of at least 119 kilometers (74 miles) per hour and a rotary circulation.**
- Mature hurricanes average **about 600 kilometers (375 miles) across,** although they can range in diameter from 100 km up to about 1500 km.
- From the outer edge of a hurricane to the center, **the barometric pressure** has sometimes **dropped 60 millibars, from 1010 to 950 millibars.**

Principal tracks and months of occurrence





Death or decay of Tropical Cyclone

Tropical Cyclone diminish in intensity whenever they :

(1) Move over ocean waters that cannot supply warm, moist tropical air;

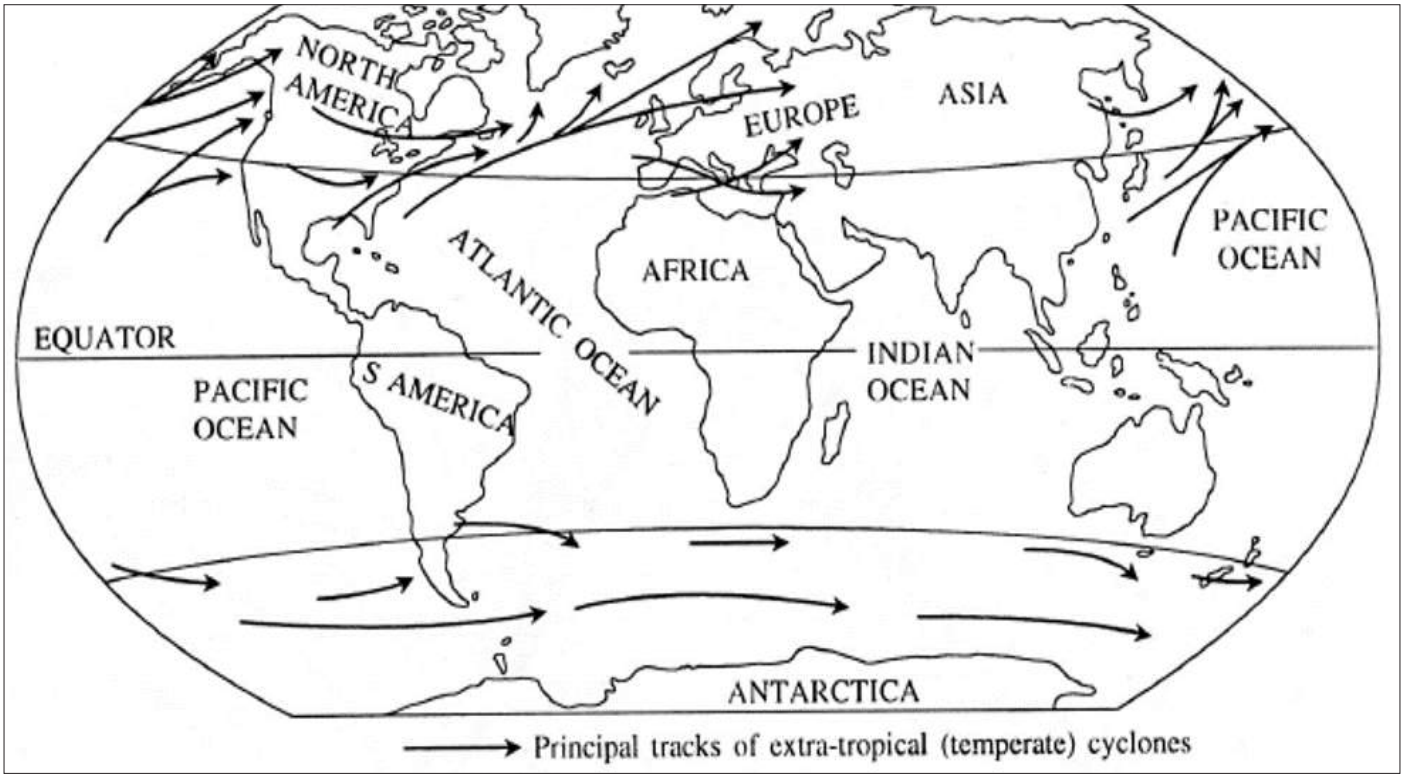
(2) Move onto land (make Landfall) or

(3) Reach a location where the large-scale divergence flow aloft is unfavorable.

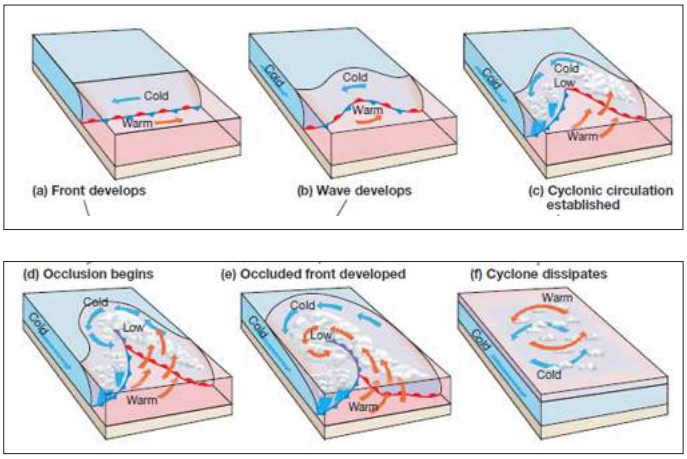
Temperate/Extra Tropical Cyclones

Temperate Cyclones

- Genesis
- Life Cycle
- Structure



6 Stages of Temperate Cyclone



Distribution of Temperate Cyclones

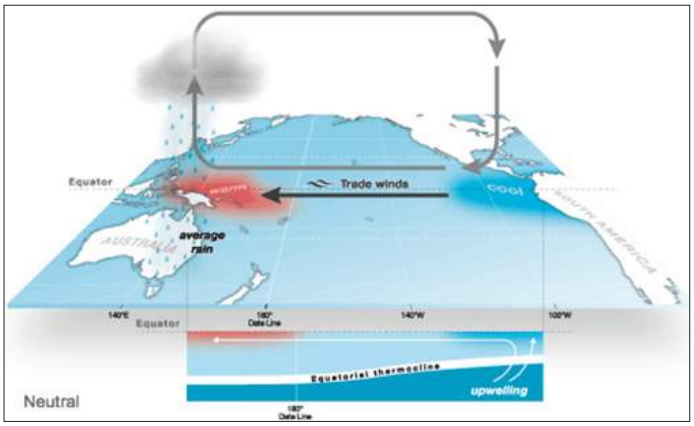
- Temperate cyclones are generally found between 300 and 600 north and south in the westerly belt. As a result temperate cyclones travel from west to east. Cyclone belt shifts towards equator during winter and towards poles during summer.
- Unlike tropical cyclones, temperate cyclones are formed both over land and sea. Important source regions of cyclone include

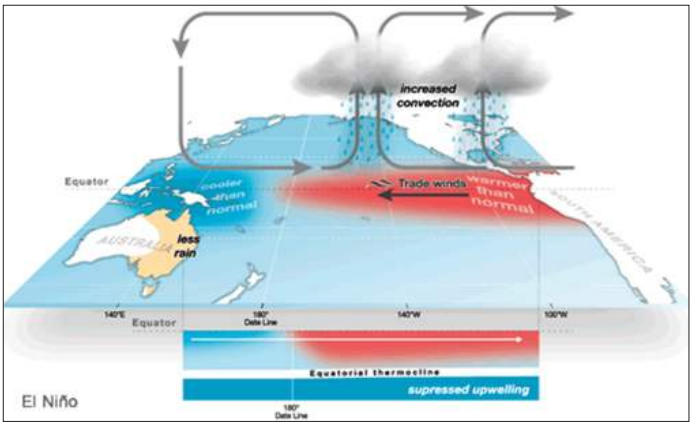
1. East of Sierra Nevada
2. East of Collarado
3. East of Canadian Rockies
4. Great lake region
5. West of Appalachian
6. Iceland and Barrent sea
7. Around Baltic sea in continental Europe

AIRMASSES & FRONTS

What is El Nino

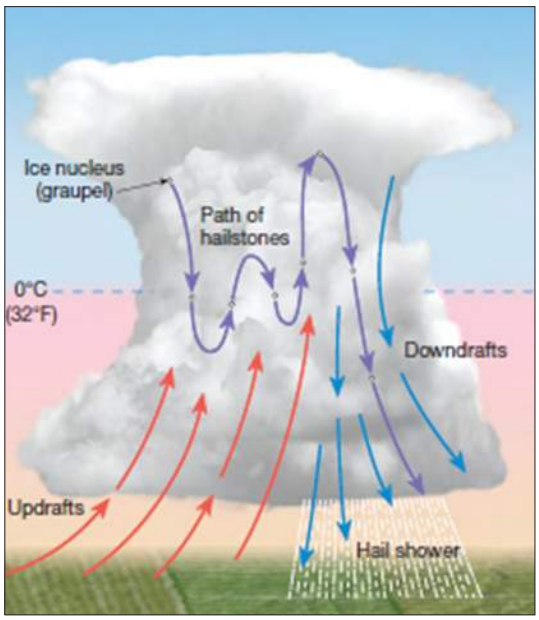
- El Nino, means **'little boy' in Spanish.**
- It is a weather system which re-emerges after **a gap of about two to five years** in the Pacific Ocean and **its effects last for about 12 months on an average.**
- El Nino **leads to warming of sea surface temperatures,** which in turn **affects wind patterns** and triggers both floods and droughts in different parts of the world.

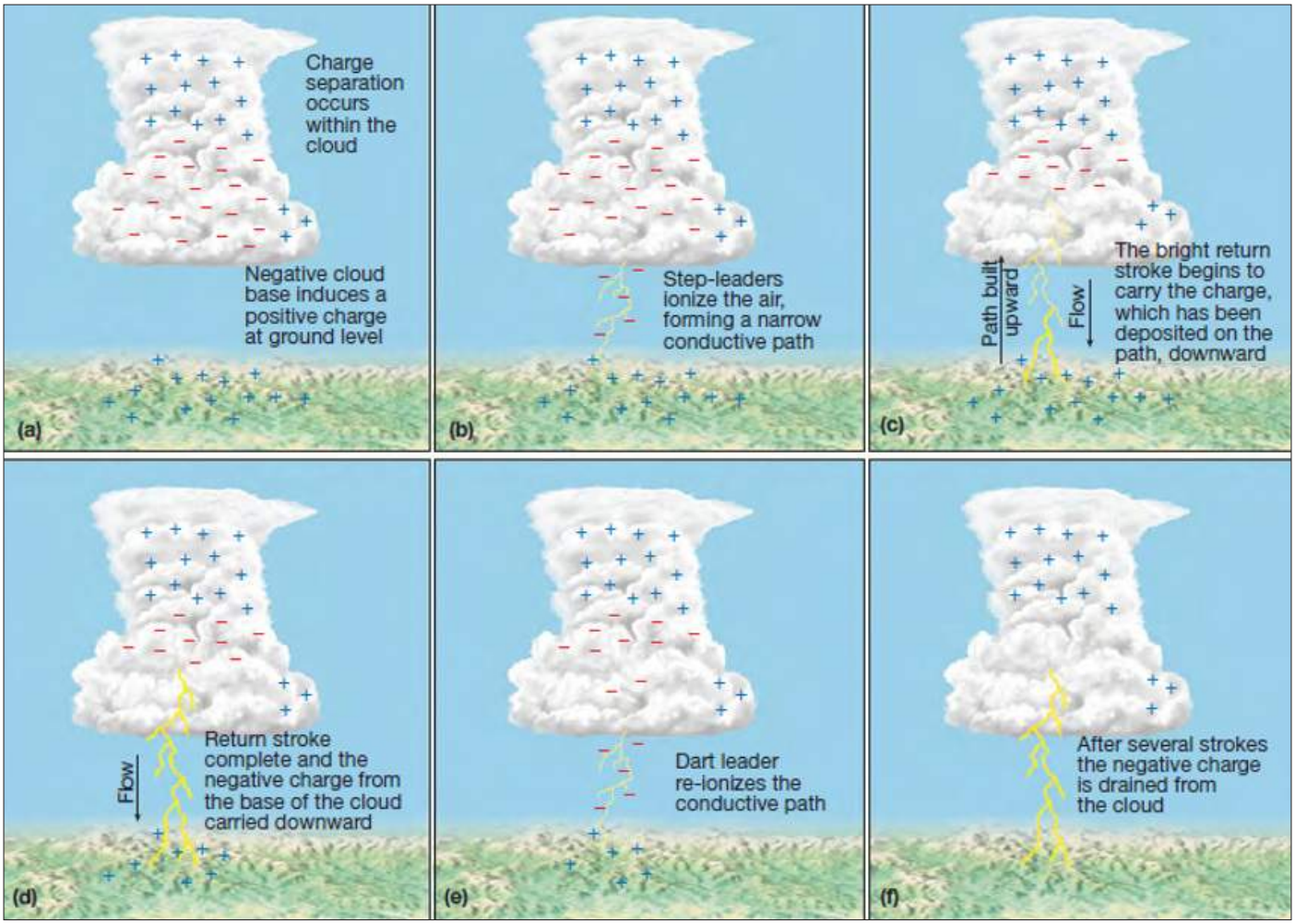




Thunder Storm

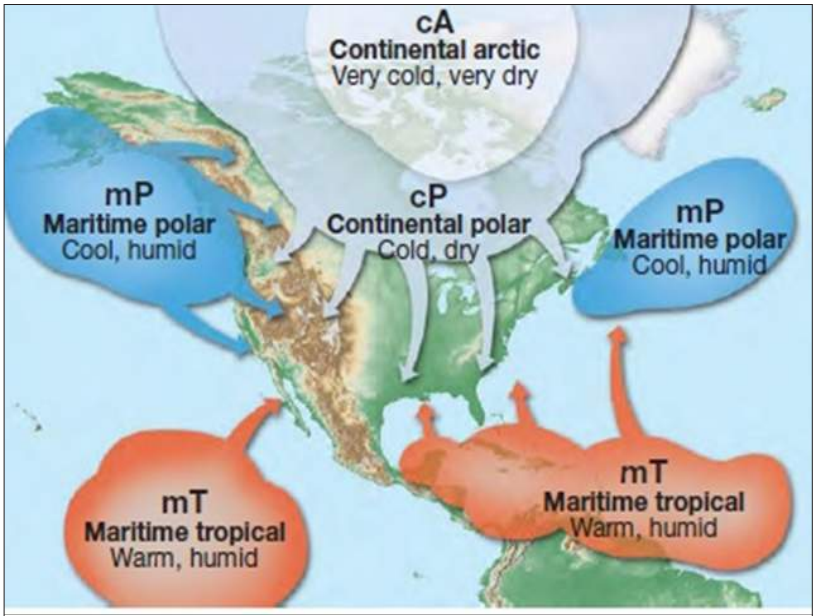
- The thunderstorm, a much more familiar weather event, hardly needs to be distinguished from tornadoes, hurricanes, and midlatitude cyclones.
- Unlike the flow of air about these storms, the circulation associated with thunderstorms is **characterized by strong up-and-down movements.**
- Winds in the vicinity of a thunderstorm **do not follow the inward spiral of a cyclone,** but they are typically variable and gusty.
- The **heat from lightening bolt** raises the temperature of the surrounding air to around **27,000 C^0.**
- As **the heated air expands,** the pressure drops, the air cools, and it contracts. The **result is a shock wave,** with a **loud, booming burst of noise** sent in every direction.





Airmasses

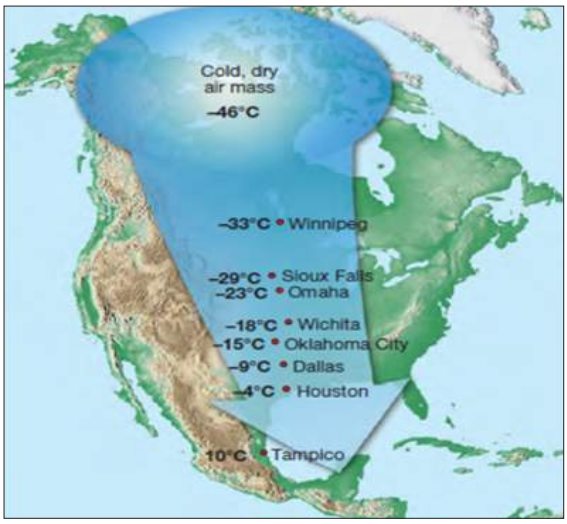
- **An air mass,** as the term implies, is **an immense body of air,** usually 1000's kilometers or more across and perhaps several 100 kilometers thick, which is **characterized by homogeneous physical properties** at any **given altitude.** (They extend **upto TROPOPAUSE.**)
- Most **mid-lat/ temperate phenomena** like temperate cyclones, blizzards, coldwaves etc. Can be **understood using the concept of AIRMASSES.**
- Areas in which **air masses originate** are called **source regions**. The nature of the source region largely determines **the initial characteristics** of an air mass.

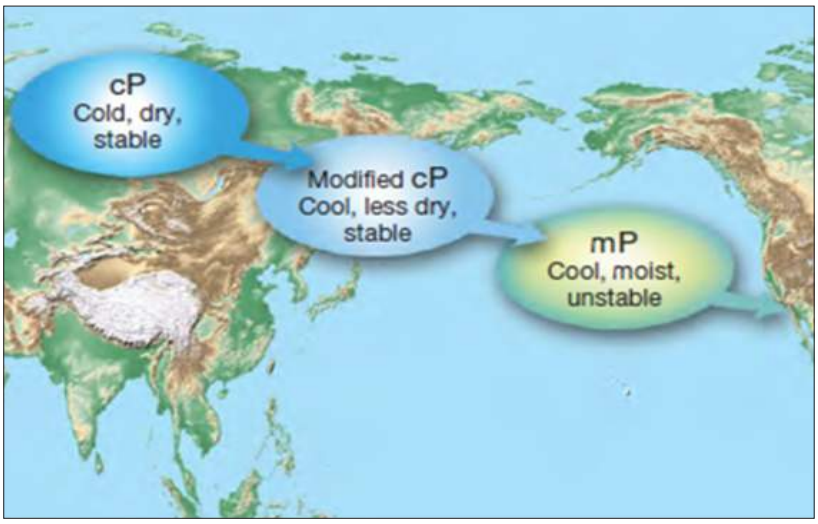


Play a great role in
GLOBAL HEAT EXCHANGE.

- Development of **Airmass requires time (7-10 days)**

Airmasses in Action

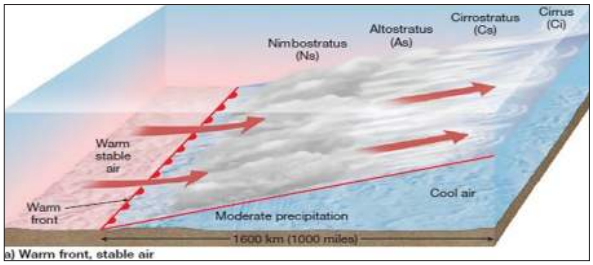


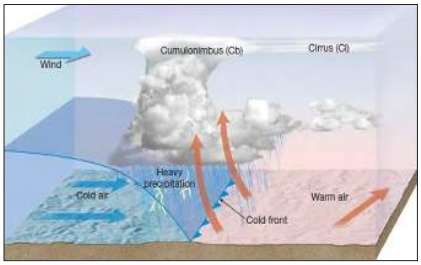


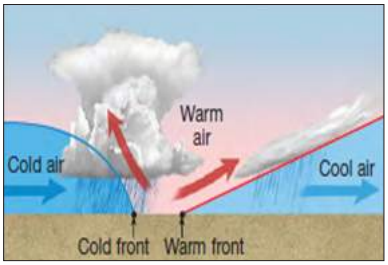
Fronts

- **Fronts** are **boundary surfaces that separate air masses** of different densities—one of which is usually warmer and contains more moisture than the other.
- However, fronts can **form between any two contrasting air masses**.
- When the vast sizes of air masses are considered, the zones (fronts) that separate them **are relatively narrow** and are **shown as lines on weather maps**.
- Frontal Interaction helps in maintaining **Heat Budget of the planet Earth**.
- **There are 4 Types of Fronts :**

Types of Fronts

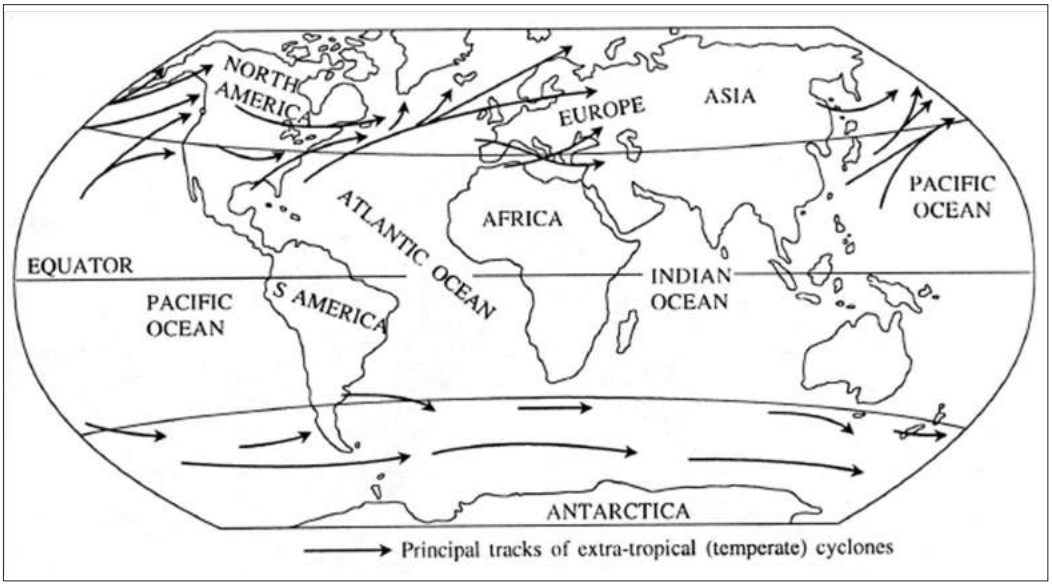






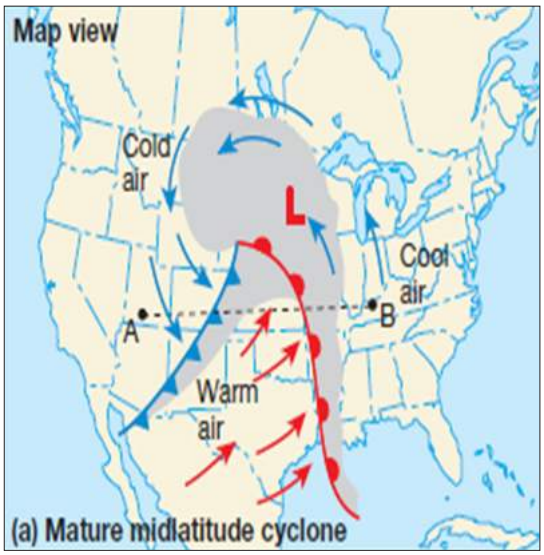
Cyclones

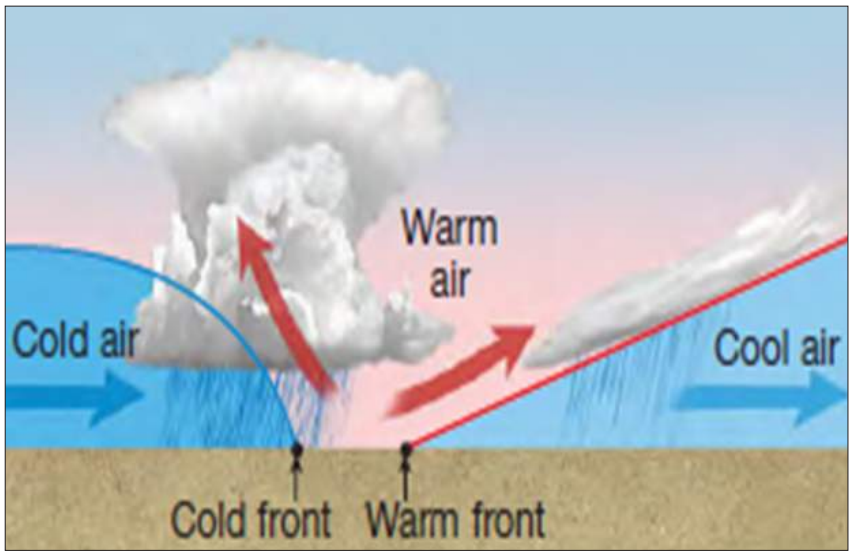
Temperate Cyclone



JET STREAM

Temperate Cyclone





Cyclones

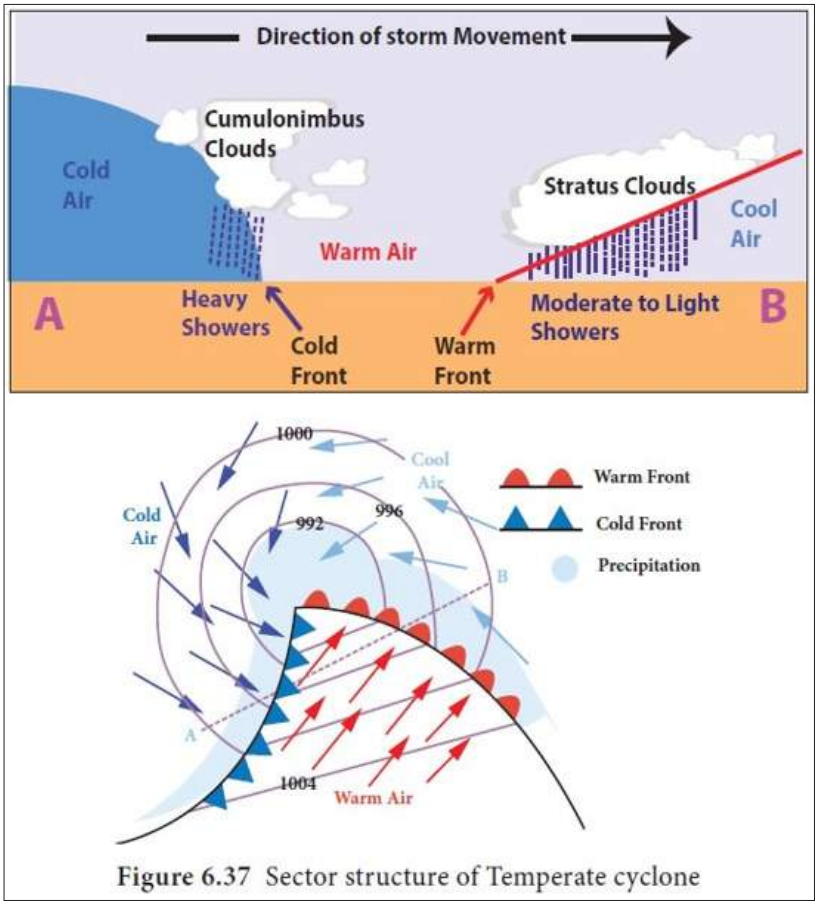
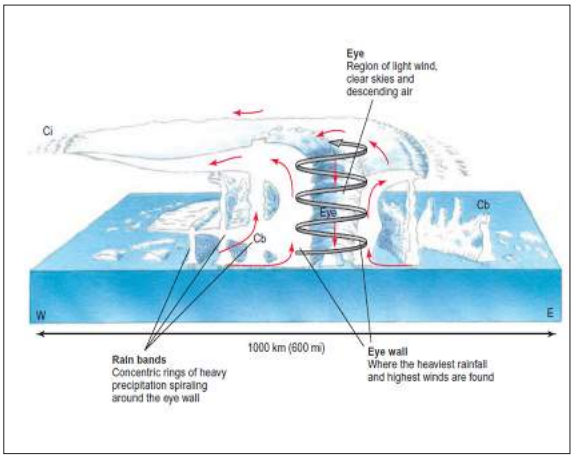
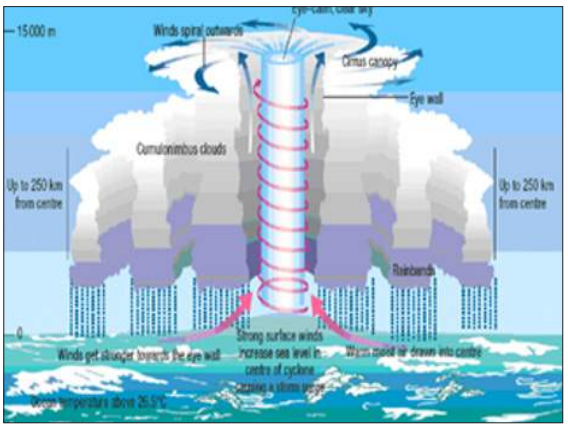


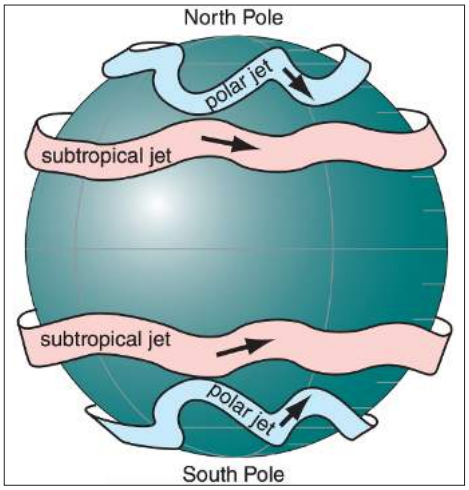
Figure 6.37 Sector structure of Temperate cyclone

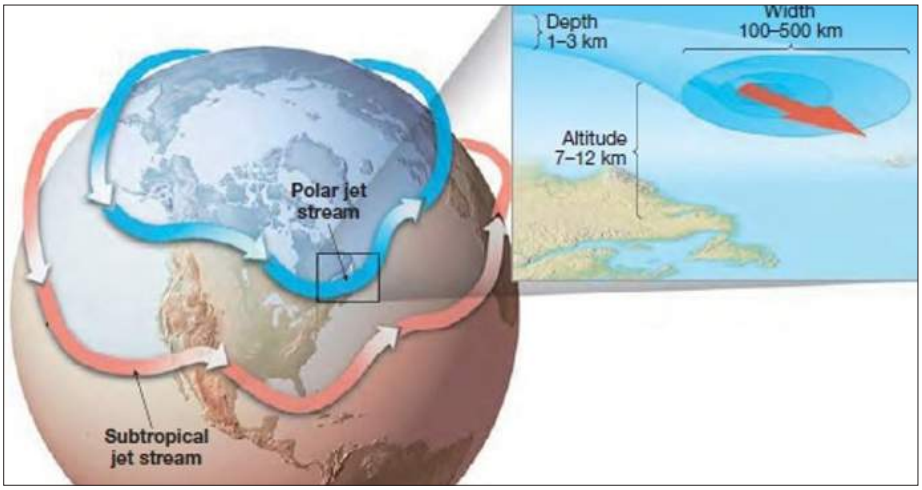


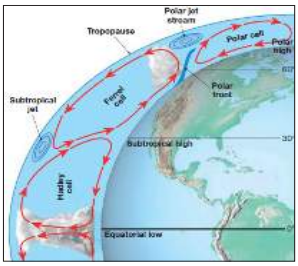


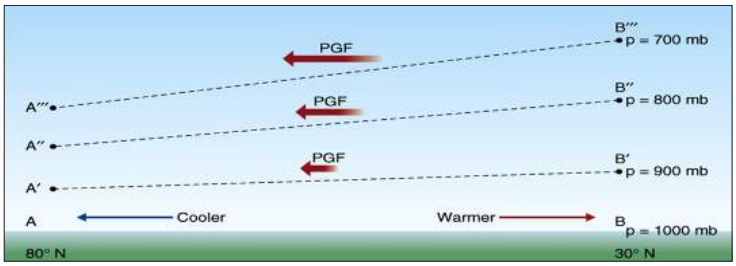
Permanent Jet Streams

- Jet streams in the real atmosphere look very much like the **thin ribbons of fast-moving air.**
- Jet vertical thickness (order of 1 to 5 km) is much smaller than their horizontal width (order of 100 to 500 km).







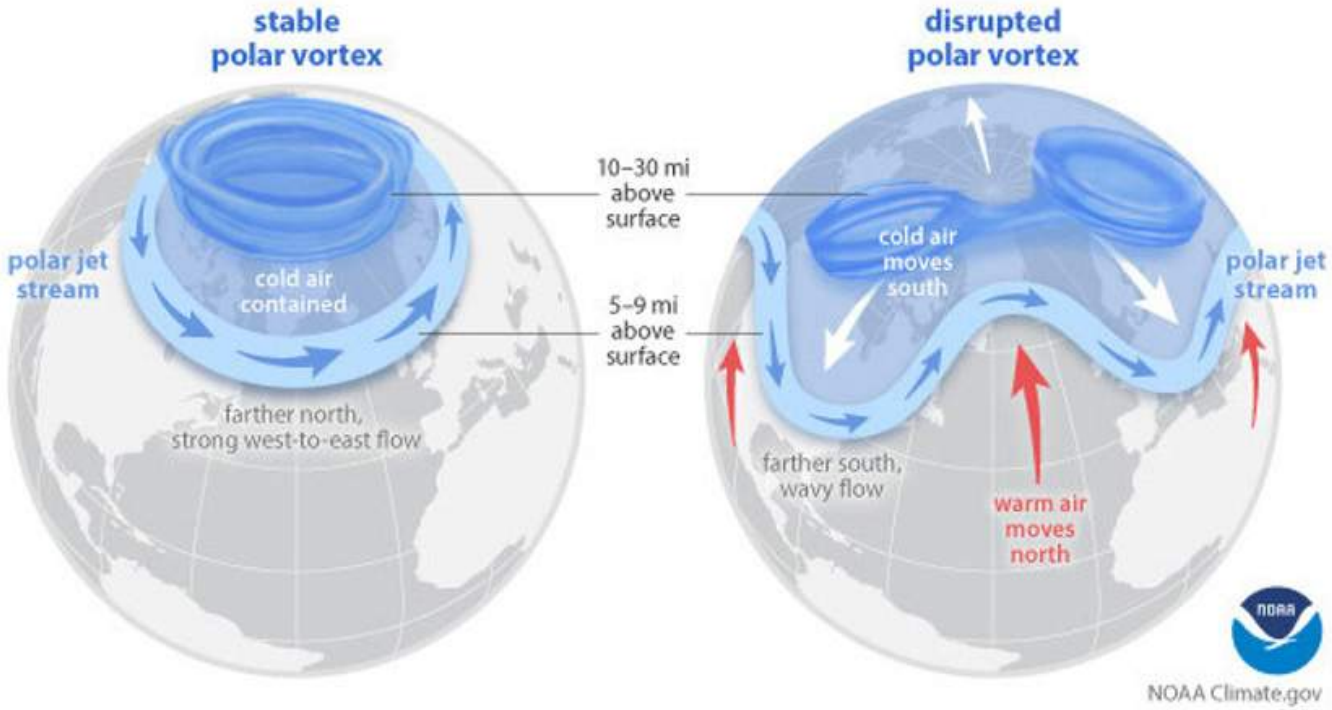


Understanding the polar vortex

The Arctic polar vortex is a strong band of winds in the stratosphere, surrounding the North Pole 10–30 miles above the surface.

The polar vortex is far above and typically does not interact with the polar jet stream, the flow of winds in the troposphere 5–9 miles above the surface. But when the polar vortex is especially strong and stable, the jet stream stays farther north and has fewer "kinks." This keeps cold air contained over the Arctic and the mid-latitudes warmer than usual.

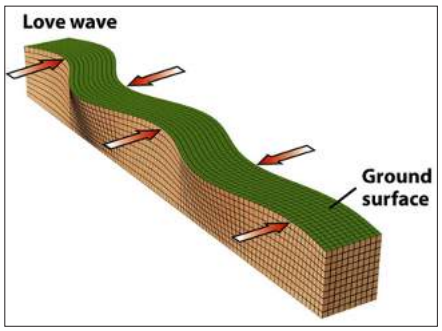
Every other year or so, the Arctic polar vortex dramatically weakens. The vortex can be pushed off the pole or split into two. Sometimes the polar jet stream mirrors this stratospheric upheaval, becoming weaker or wavy. At the surface, cold air is pushed southward to the mid-latitudes, and warm air is drawn up into the Arctic.

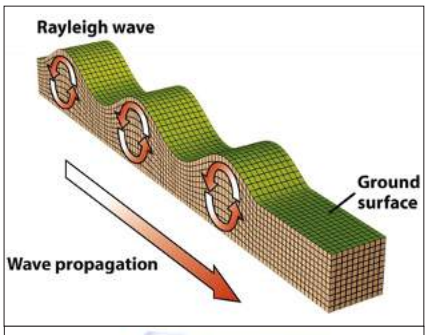


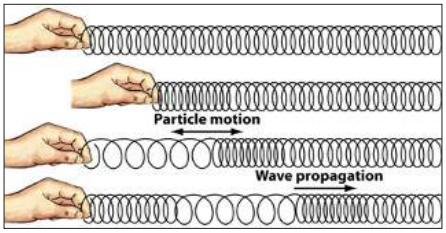
EARTHQUAKES & SEISMICITY

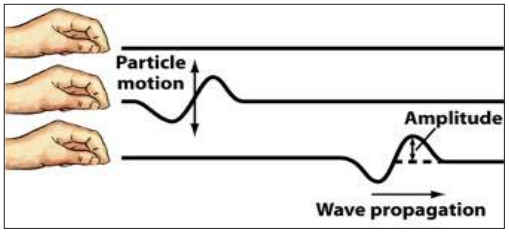
Earthquakes

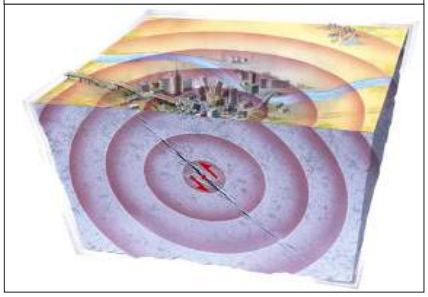
- Earth shaking caused by a rapid release of energy
- Seismicity (earthquake activity) occurs due to:
  1. Tecto Volcanic causes
  2. A sudden change in mineral structure
  3. Meteorite impacts.
  4. Nuclear detonations











- When rocks break, stored elastic strain is released.
- This energy radiates outward from the hypocenter.
- The energy, as waves, generates vibrations.

Earthquake Size

- **Magnitude** – The amount of energy released.
- Magnitude is measured by **Richter scale.**
- Magnitude scales are **logarithmic.** (Increases of 1 unit = 10-fold increase in ground motion.)
- Two of the strongest earthquakes in **southeastern Türkiye, of 7.8 and 7.7 magnitude,** occurred on Monday 6 February, 2023.
- **Intensity** – The amount of energy released.
- Magnitude is measured by **Mercali scale. (I-XII)**

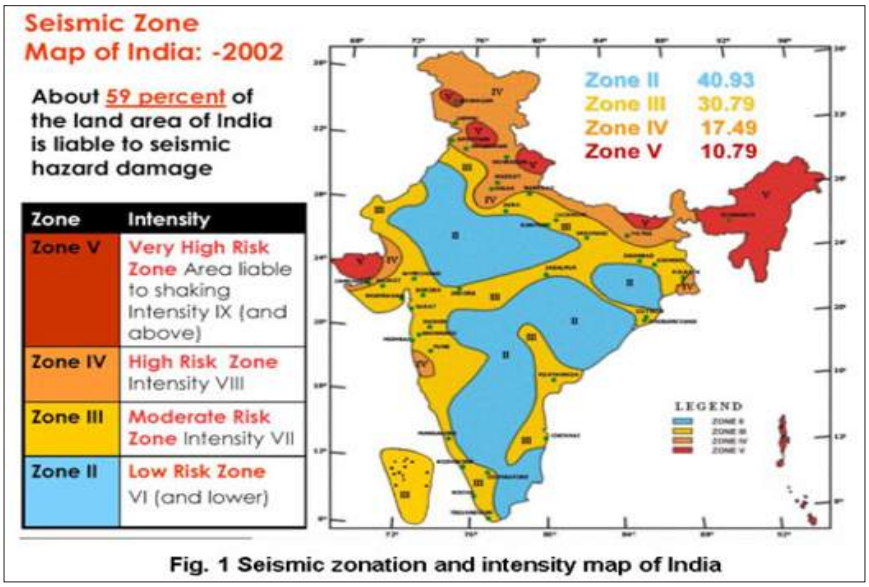
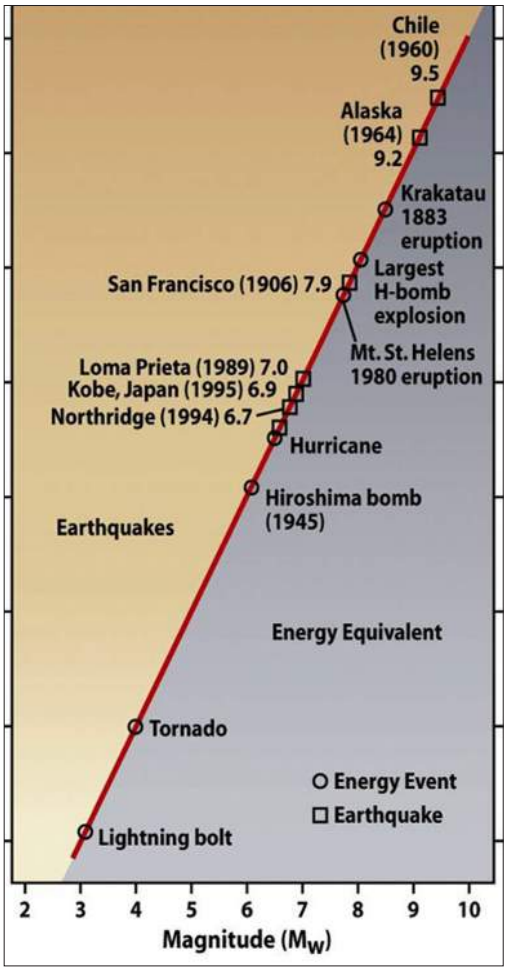
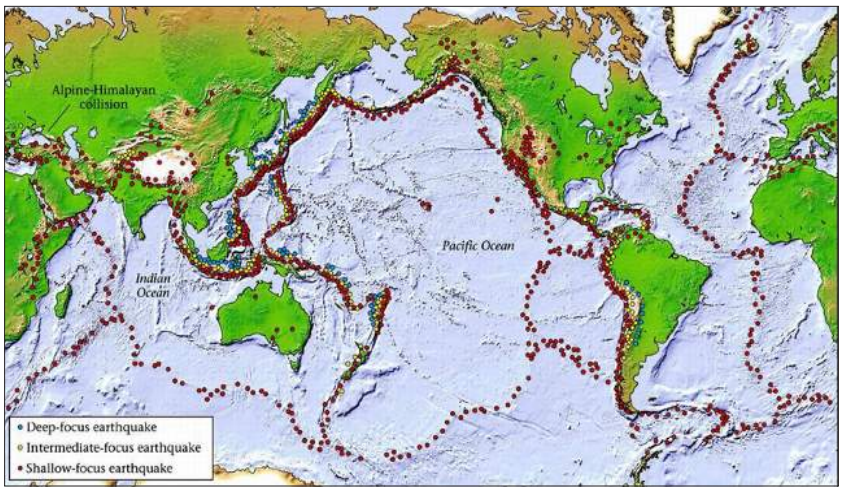


Fig. 1 Seismic zonation and intensity map of India



Earthquake Occurrence

- Earthquakes linked to plate tectonic boundaries.
- Shallow – Divergent and transform boundaries.
- Intermediate and deep – Convergent boundaries.



Earthquakes in continental crust.

- Continental transform faults (San Andreas, Anatolian).
- Continental rifts (Basin and Range, East African Rift).
- Collision zones (Himalayas, Alps).
- Intraplate settings (ancient crustal weaknesses).
- 5% of earthquakes are not near plate boundaries.

Earthquake Prediction

- Prediction would help reduce catastrophic losses.
- Can we predict earthquakes? Yes and no.
  - ✔ They CAN be predicted - long-term (10-100s of years).
  - ✔ They CANNOT be predicted - short-term (hours-months).
- Seismic hazards are mapped to assess risk.

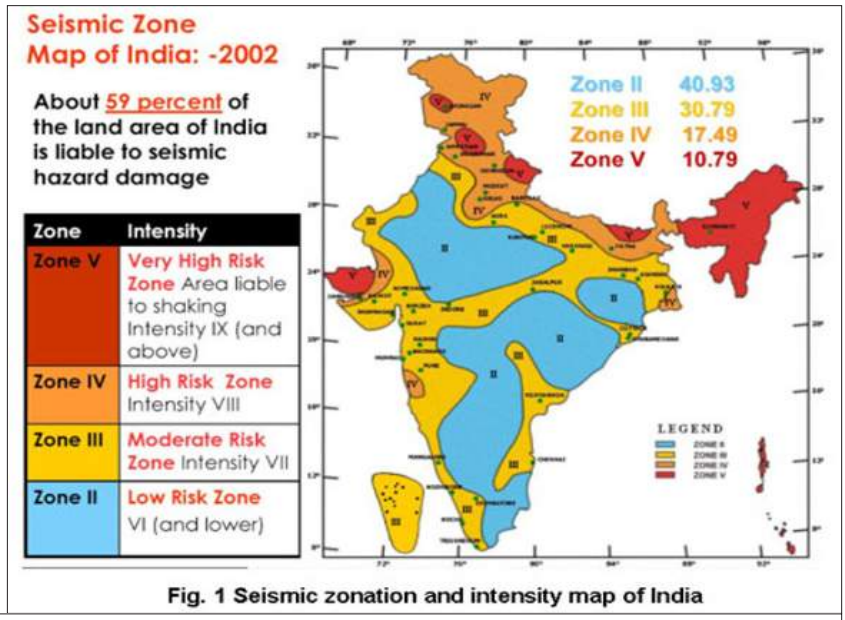
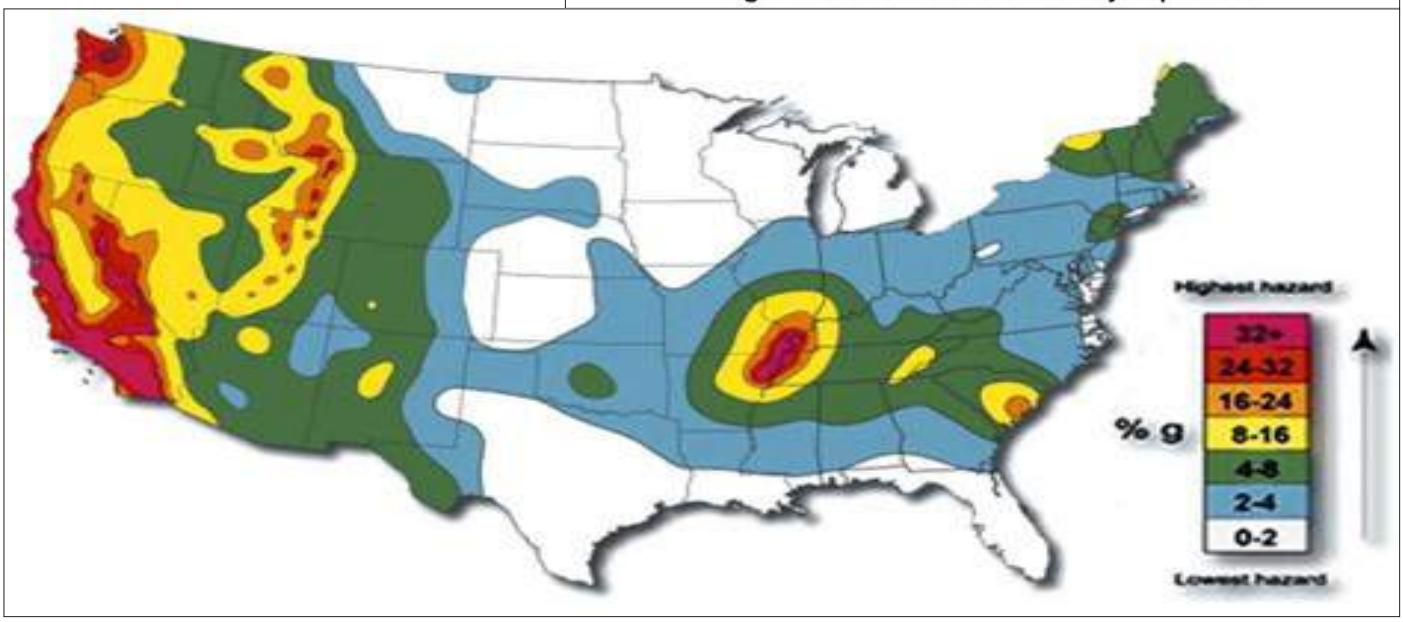


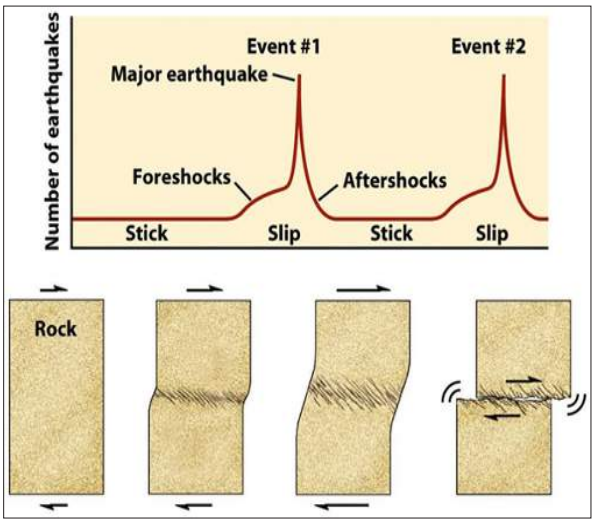
Fig. 1 Seismic zonation and intensity map of India



Earthquake Preparedness

We can't stop them **but we can be ready for them:**

- Understand what happens during an earthquake.
- Map active faults and areas likely to liquefy from shaking.
- Develop construction codes to reduce building failures.
- Regulate land use to control development.



Earthquakes do have precursors.

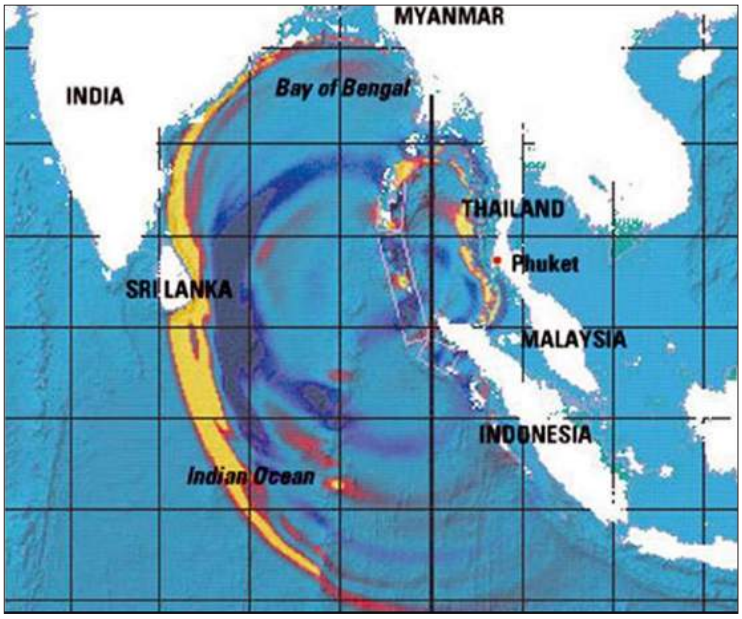
Clustered foreshocks: possibly…

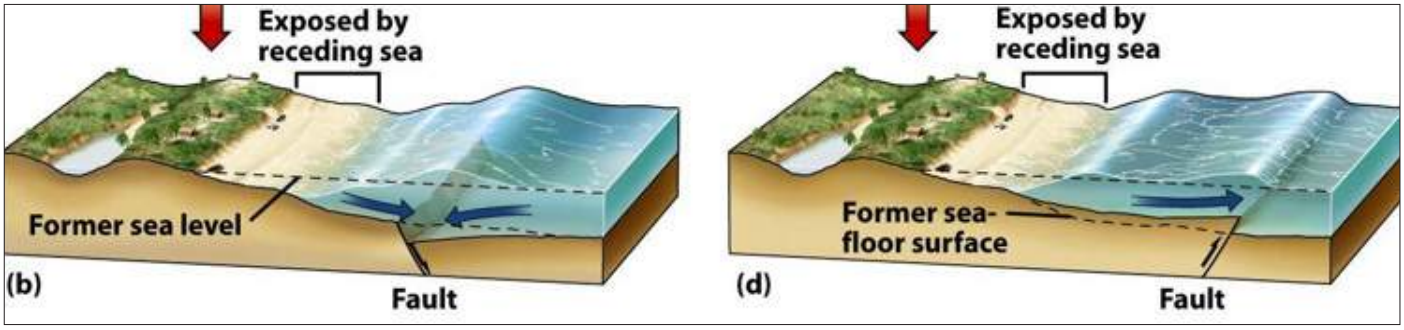
- Water level changes in wells.
- Gases (Rn, He) in wells.
- Unusual animal behavior.

TSUNAMI

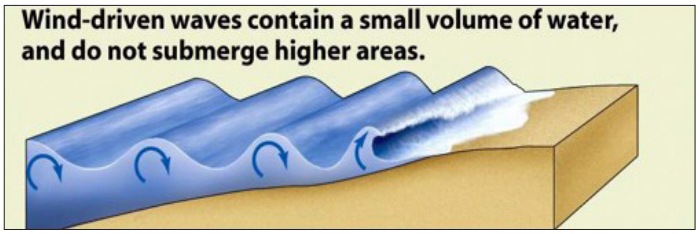
Tsunami/ Seismic Wave (Harbour Wave)

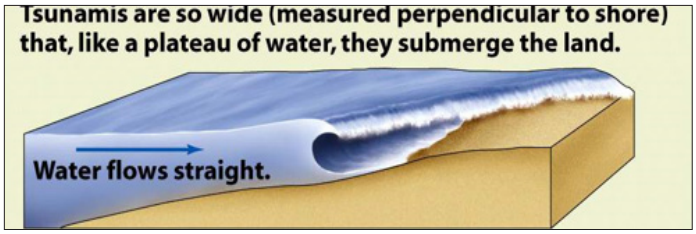
- Tsunamis result when earthquakes change the seafloor.
- Normal faulting drops the seabed; thrusting raises it.
- This displaces the entire volume of overlying water.
- A giant mound (or trough) forms on the sea surface.
- On **December 26, 2004,** a strong megathrust earthquake (M9.0+) originated in the trench to the west of N. Sumatra.
- **Killed nearly 3 lakh people** in **10 countries** surrounding the Indian Ocean.





Tsunami vs. Wind Waves	
Wind Waves	**Tsunami Waves**
Influence the upper ~100 m.	Influence entire water depth
Have wavelengths of several 10s to 100s of meters.	Have wavelengths of several 10s to 100s of kilometers.
Wave height and wavelength related to windspeed.	Wave height and wavelength unaffected by windspeed.
Wave velocity maximum several 10s of kph.	Wave velocity maximum several 100s of kph.
Waves break in shallow water and expend all stored energy.	Waves come ashore as a raised plateau of water that pours onto the land.





PRACTICE QUESTIONS

2015

Q. "Each day is more or less the same, the morning is clear and bright with a sea breeze; as the Sun climbs high in the sky, heat mounts up, dark clouds form, then rain comes with thunder and lightning. But the rain is soon over."

Which of the following regions is described in the above passage?

(a) Savannah
(b) Equatorial
(c) Monsoon
(d) Mediterranean

2020

Q. Consider the following statements:

1. Jet streams occur in the Northern Hemisphere only
2. Only some cyclones develop an eye
3. The temperature inside the eye of a cyclone is nearly 10°C lesser than that of the surroundings.

Which of the statements given above is/ are Correct?

(a) 1 only
(b) 2 and 3 only
(c) (2 only
(d) 1 and 3 only

2019

Q. Why are dewdrops not formed on a cloudy night?

(a) Clouds absorb the radiation released from the Earth's surface.
(b) Clouds reflect back the Earth's radiation.
(c) The Earth's surface would have a low temperature on cloudy nights.
(d) Clouds deflect the blowing wind to ground level.

2015

Q. In the South Atlantic and South-Eastern Pacific regions in tropical latitudes, cyclones do not originate. What is the reason?

(a) Sea surface temperatures are low.
(b) Inter-tropical Convergence Zone seldom occurs
(c) Coriolis force is too weak.
(d) Absence of land in those regions.

2018

Q. Consider the following statements:

1. The Earth's magnetic field has reversed every few hundred thousand years
2. When the Earth was created more than 4000 million years ago, there was 54% oxygen and no carbon dioxide
3. When living organisms originated, they modified the early atmosphere of the Earth

Which of the statements given above is/ are correct?

(a) 1 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

2015

Q. Consider the following statements:

1. The winds which blow between 300 N and 600 S latitudes throughout the year are known as westerlies.
2. The moist air masses that cause winter rains in the NorthWestern region of India are part of westerlies.

Which of the statements given above is/ are correct?

(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

2017

Q. With reference to 'Indian Ocean Dipole (IOD)' sometimes mentioned in the news while forecasting Indian monsoon, which of the following statements is/are correct?

1. IOD phenomenon is characterised by a difference in sea surface temperature between the tropical Western Indian Ocean and the tropical Eastern Pacific Ocean.
2. An IOD phenomenon can influence an El Nino's impact on the monsoon.

Select the correct answer using the code given below:

(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

2018

Q. During a thunderstorm, the thunder in the skies is produced by the:

1. meeting of cumulonimbus clouds in the sky
2. lightning that separates the nimbus clouds
3. violent upward movement of air and water particles

Select the correct answer using the codes given below:

(a) 1 only
(b) 2 and 3
(c) 1 and 3
(d) None

2020

Q. Consider the following statements:

1. Jet streams occur in the Northern Hemisphere only
2. Only some cyclones develop an eye
3. The temperature inside the eye of a cyclone is nearly 10°C lesser than that of the surroundings.

Which of the statements given above is/ are Correct?

(a) 1 only
(b) 2 and 3 only
(c) 2 only
(d) 1 and 3 only

Q. On an average ..... percentage of insolation is directly reflected to outer space.

(a) 14
(b) 17
(c) 35
(d) 26

Q. The pressure and wind belts shift towards the ..... in summer.

(a) Equator
(b) Poles
(c) East
(d) West

Q. The latitudinal extent between 37° North to 37° South is the region of.....

(a) Energy deficit
(b) Energy surplus
(c) Constant energy
(d) Both (a) and (c)

Q. Approximately 99% atmospheric mass is concentrated below ..... kilometers.

(a) 32
(b) 112
(c) 82
(d) 52

Q. When the Sun shines vertically above the Tropic of Cancer it is then ..... in Northern Hemisphere

(a) Spring Equinox
(b) Autumn Equinox
(c) Winter solstice
(d) Summer solstice

Q. Greenhouse effect is the result of the atmosphere's absorption of ..... wave radiations emitted by earth.

(a) Short
(b) Long
(c) Transverse
(d) Longitudinal