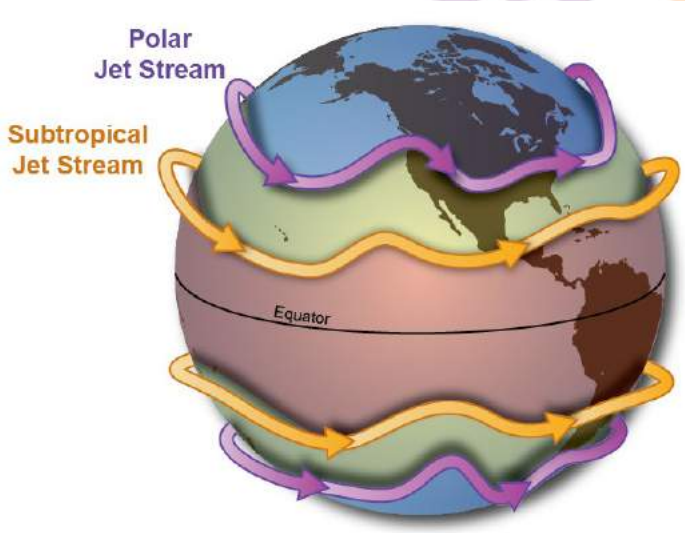
Jet Streams

[UPSC Notes]

What are Jet Streams?

Jet streams are fast flowing, narrow, meandering air currents in the atmospheres. They are located near the altitude of the tropopause and are westerly winds. Jet Streams are bands of strong wind that generally blow from west to east all across the globe. The winds blow from west to east in jet streams but the flow often shifts to the north and south. Jet streams form when warm air masses meet cold air masses in the atmosphere. The greater the difference in temperature, the faster the wind velocity inside the jet stream.
Jet Streams extend from 20 degrees latitude to the poles in both hemispheres. On Earth, there are four main jet streams: two polar jet streams and two subtropical jet streams. They form in the atmosphere where warm air masses meet cool air masses.
Jets streams play a key role in determining the weather because they usually separate colder air and warmer air. When the jet streams are warmer, their ups and downs become more extreme, bringing different types of weather to areas that are not accustomed to climate variations.



Genesis of Jet Streams

The genesis of the Jet-Streams is provided by three kinds of gradients:

- The pressure gradient between pole and equator
- The pressure gradient between surface and subsurface air over the poles.
- The thermal gradient between pole and equator.

Factors Influencing Jet Streams

The Coriolis effect and landmasses are two factors that influence the flow of the jet streams. The flow of the jet is disrupted by landmasses due to friction and temperature differences and the meandering movement of the jet streams is due to the earth's spinning nature. As the meandering sections of the stream interact with landmasses, they create a state of flux. This results in temperature differences.

The strength and position of the stream can also be affected by the temperature of the stratosphere in the winter. The stronger the jet stream, the cooler the polar stratosphere. The strength and amplitude of the jet streams can also be affected by the warmth of the landmasses and oceans.

Types of Jet Streams

The Jet Streams are of the following types:

Polar Front Jet Streams

- They are present in the convergence zone of the surface polar cold air mass and tropical warm air mass (sub-polar low-pressure belt), somewhere between 40 degrees and 60 degrees latitude.
- Polar Front Jet Streams have a more variable position than the subtropical jets and move in an easterly direction.

Polar Night Jet Streams

- They develop in the winter season due to the steep temperature gradients in the stratosphere around the poles.
- During the winter months, when the nights are much longer, the air high above the poles becomes much colder than the air over the Equator.
- The polar night jets, which move eastwards at an altitude of about 48 kilometers, are created by extreme air pressure differences in the stratosphere. These, when combined with the Coriolis effect, produce extreme air pressure differences in the stratosphere.
- During the summer, the polar night jet travels at a higher altitude of about 24,000 meters.

Subtropical Westerly Jet Streams

- They are best developed in winter and early spring, and their maximum speed approaches 300 knots, which is associated with the merger with polar-front jets.
- They move from west to east.
- They move north of the subtropical high-pressure belt in the upper troposphere in both hemispheres, above 30 degrees to 35 degrees latitude.
- Also known as stratospheric subpolar jet streams. They are produced by the earth's rotation and flow for the majority of the year.
- Their circulation is more regular than the polar front jet stream.

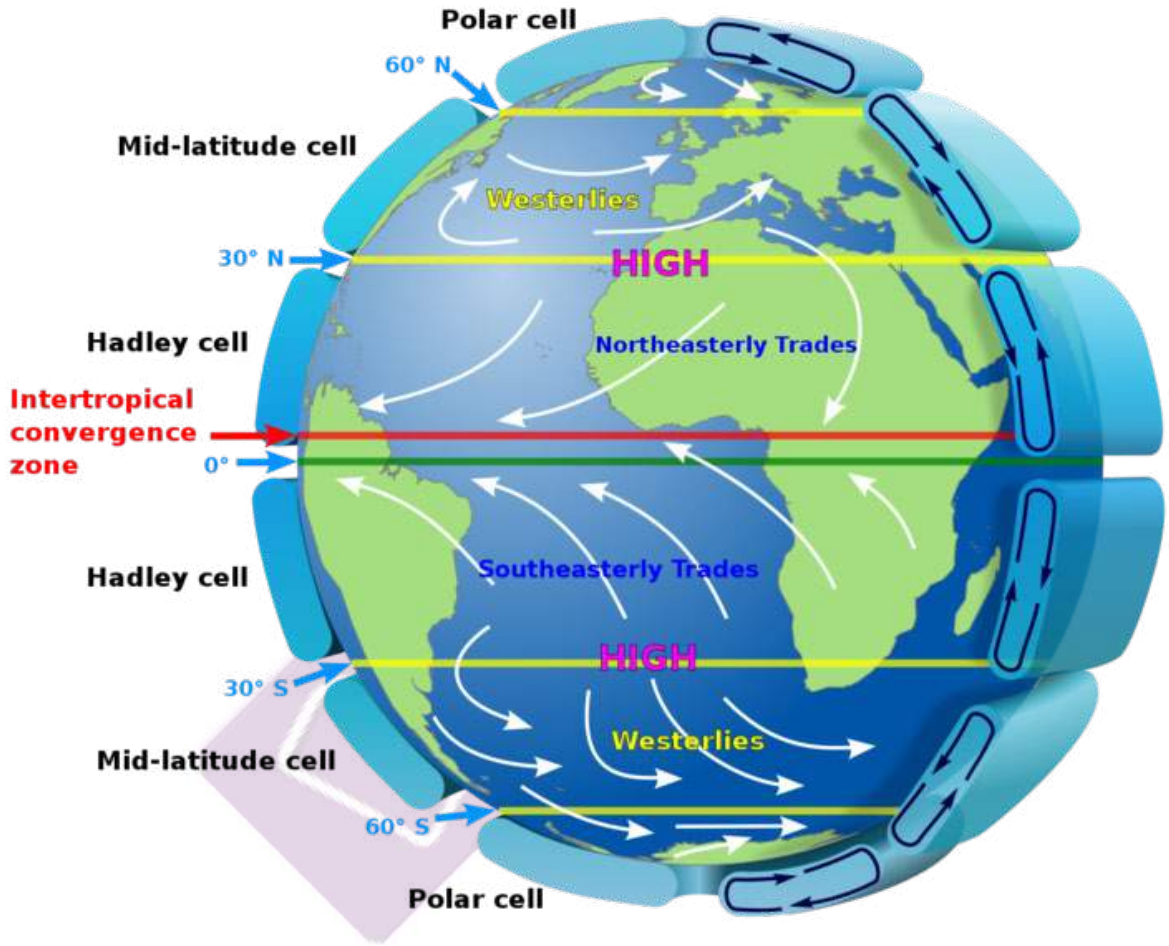
Tropical Easterly Jet Streams

- They are upper-level easterly winds that originate in late June and last until early September.
- The jet's strongest development occurs about 15 kilometers above the Earth's surface, over the Indian Ocean, with wind speeds of up to 40 meters per second.

- They occur near the tropopause in Southeast Asia, India, and Africa during summer.
- The difference in heating and cooling of winds, along with the pressure gradient is the reason behind this jet.

Local Jet Streams

- They are formed locally as a result of local thermal and dynamic conditions.
- They have limited local importance.



Characteristics of Jet Streams

Jet Streams are high-velocity winds (400-500km/hr). This high velocity is due to great thermal contrast creating a powerful pressure gradient force. The effect of Earth's rotation causes Jet streams to circulate from west to east. The other characteristics include:

- They are circumpolar, i.e., they move around the poles in both hemispheres.
- Their circulation path is wavy and curving.
- The flow of the jet streams is 3-dimensional and it develops crests and troughs.
- They have seasonal variations and shift with the apparent movement of the sun.

How Jet Streams Affect the Indian Climate

The Indian climate is predominantly influenced and dominated by Sub Tropical Jet Streams (STJ). The northward movement of the subtropical jet is the first indication of the onset of the monsoon over India. The monsoon's onset and withdrawal are often predicted by the Jet Stream's periodic movement.

- The onset of the monsoon season in India is signaled by the subtropical stream moving northward.
- During the summertime, there is increased solar heating of the Indian subcontinent, which results in a tendency to form a cyclonic monsoon cell situated between the Indian Ocean and southern Asia.
- The STJ deflects northwards and crosses over the Himalayan Range. The altitude of the high mountains initially disrupts the jet but once the STJ crosses the high summits, it is able to reform again over central Asia.
- Warmth and moisture are fed into the cell by a lower-level tropical jet stream which brings with it air masses laden with moisture from the Indian ocean. As these air masses are forced upward by north India's mountainous terrain the air is cooled and compressed, it easily reaches its saturation vapor point and the excess moisture is dissipated in the form of monsoon rains.
- The easterly winds become very active in the upper troposphere and they are associated with westerly winds in the lower troposphere. This results in a more active southwest monsoon and heavy rainfall are caused.
- The end of the monsoon season is brought about when the atmosphere over the Tibetan Plateau begins to cool, this enables the STJ to transition back across the Himalayas.
- The winter subtropical westerly Jet Stream blows from the west to the east in the entire west and middle of Asia and is divided by the Himalayan ranges and Tibetan Plateau.
- One of the branches blows parallel to the plateau from the north while the other moves towards the east in the south of the Himalayas.

South Asia's monsoon is largely influenced and controlled by jet streams. In India, the southwest monsoon is linked to the tropical easterly stream, which can be found between 8 and 35 degrees north latitude. The subtropical westerly Jet Stream, which blows between 20 and 35 degrees latitude in both hemispheres during the winter, is linked to the northeast monsoon.

Significance of Jet Streams

Jet Streams have a significant impact on the local and regional weather patterns, and when they collide with surface wind systems, they result in severe storms.

- Temperate cyclones and jet streams have a close relationship in terms of intensity.
- The Jet Streams help in providing a relatively clear picture of the occurrence of El Nino and La Nina events.
- Pilots take the help of the jet streams when they have to fly in the direction of the jet stream's flow. It makes the movement smooth.