

Polar vortex and its impact on the climate

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Manifest Pedagogy

In the backdrop of severe winters in Gangetic plains and peninsular India, climatic phenomenon responsible for severe winters could be asked both at the prelims and mains level. In this topic understanding the linkages of Indian climate with respect to polar vortex, jet streams and western disturbances is the key to understanding the question.

In news

Cold weather in USA due to Polar Vortex

Placing it in the syllabus

Important Geophysical phenomena

Static dimensions

- What is polar vortex?
- Polar vortex and jet stream

Current dimensions

- Polar vortex and cold climatic conditions
- Polar vortex and drop in average temperature in winters in India

Content

What is polar vortex?

The polar vortex is a large area surrounding both the poles of

the Earth with low pressure and cold air. It always exists close to the poles, but in summer it weakens and in winter it strengthens. Each polar vortex is a persistent, large-scale, low-pressure zone less than 1,000 kilometers in diameter, that rotates counter-clockwise at the North Pole. The term 'vortex' refers to the counter-clockwise flow of air that helps keep the colder air near the Poles. The bases of the two polar vortices are located in the middle and upper troposphere and extend into the stratosphere.

Strong Polar Vortex

Strong is the more common state of the polar vortex. When the polar vortex is strong, this creates strong low pressure in the Arctic region. Because of the pressure difference between the Arctic and mid-latitudes, air flows into low pressure and this confines the cold air to high latitudes closer to the Arctic. Therefore it is often mild across the Eastern US, Europe and East Asia during winters when the polar vortex is strong. During strong polar vortex, the air flow is fast and in a direction from west to east.

Weak Polar Vortex

When the polar vortex is weak or "perturbed", the flow of air is weaker and meanders north and south (rather than west to east). This allows a redistribution of air masses where cold air from the Arctic spills into the mid-latitudes and warm air from the subtropics is carried into the Arctic. This mixing of air masses also favors more storms and snow in the mid-latitudes. During a weak polar vortex, high pressure occurs in the Arctic region and is referred to as the negative phase of the Arctic Oscillation (AO).

Air flows away from the high pressure Arctic. The north to south direction of the polar vortex carries cold Arctic air into the mid-latitudes of Eastern US, Europe and East Asia. Therefore it is cold across the Eastern US, Europe and East

Asia during winters when the polar vortex is weak.

Polar vortex and jet stream

- Many times during winter in the northern hemisphere, the polar vortex will expand, sending cold air southward with the jet stream.
- The general assumption is that reduced snow cover and sea ice reflect less sunlight, resulting in increased evaporation and transpiration, which in turn alters the polar vortex's pressure and temperature gradient, causing it to weaken or collapse.
- This becomes apparent when the **amplitude of the jet stream** increases (meanders) across the northern hemisphere, **causing Rossby waves** to spread further south or north, which in turn carries warmer air to the northern pole and polar air to lower latitudes.
- **The amplitude of the jet stream increases with a weaker polar vortex, thus increasing the chance of blocking weather systems.** A blocking event in 2012 emerged when a high-pressure over Greenland steered Hurricane Sandy into the northern Mid-Atlantic states.
- **If this jet stream's circulation is strong, the polar vortex maintains a roughly circular shape** with a centre at or very near to the North Pole.
- Undulations in the circulation of the polar-front jet stream (called Rossby waves) can result from incursions of energy generated by land-ocean contrasts in temperature and air deflected by large mountain ranges into the path of the jet stream in the stratosphere.
- **Disturbances in the jet-stream and the intrusion of warmer air** can disturb this polar vortex sending Arctic air south into middle latitudes.
- The jet stream interacts with the polar vortex, helping bring numbing temperatures further south.

Polar vortex and cold climatic conditions

- Recently, It brought coldest conditions in decades to the midwest US.
 - The phenomenon became widely known to Americans during a particularly frigid spell in 2014, when the media first started using the term “polar vortex”. It was also a factor in the “**bomb cyclone**” that struck the east coast of the US last year.
 - Studies have shown a recent rise in cases where the polar vortex has sprouted into heavily populated areas. Scientists gain a better understanding of why this is happening, with many identifying as influencing climate change.
- **It is assumed that weakening of polar vortex is a result of global warming.**
- The polar vortex is a well-documented, long-existing pattern, but some scientists say climate change could be making it unstable, with potentially serious consequences.
 - It is often mild across the Eastern US, Europe and East Asia during winters when the polar vortex is strong.
 - It is cold across the Eastern US, Europe and East Asia during winters when the polar vortex is weak.

Polar vortex and drop in average temperature in winters in India

- Over the past few decades, the hill states of north India have experienced unusual cold, which is indirectly caused by the Polar Vortex.
- since it is known that arctic cold air blast bottled by the polar jet stream but sudden stratospheric warming events such as strong high pressure riding, intense pacific typhoons and blocking lead to the expansion of the vortex and consequently the frequency and intensity of cold

weather increases.

- This is due to the breakdown of the polar jet stream that allows the expansion of arctic cold air blast that directly affects the global weather system, and country like India is facing the high frequency and intensity of Western disturbances that have led to heavy to moderate snowfall. This can be regarded as Polar Vortex's indirect effect.
- **In fact, it is not the Polar Vortex that affects the climate of India's hilly states, but the weakening of the Western mid-latitude due to the breakdown of the polar jet stream resulting in the Southwest shift of Western Disturbance causing above normal snowfall and precipitation over northern India.**
- Scientist have observed that the Spilling of Arctic Polar Vortex has had an impact on the Indian subcontinent and as a result India has seen increased frequency of western disturbances (Almost double).It also impact on heavy rainfall over western himalaya region.
- The IMD has stated that, increased penetration of cold wave and cold days towards southern peninsula (till Telangana) also has a strong correlation with the Spilling of Arctic Polar Vortex.
- And the frequent western disturbances in the Himalayan region are also responsible for prolonged winters at regular intervals compared to the previous winter.