



Interplay of Heat Waves, Anticyclones and Global Warming

For Prelims: [El Niño](#), [India Meteorological Department](#), [Heatwave](#), [Climate change](#), [Greenhouse Gases \(GHG\)](#).

For Mains: Global warming and the heat waves, Early warning systems, Impact of anticyclones on Indian weather patterns

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Why in News?

As the world grapples with the **waning phase of the strong El Niño of 2023**, the [India Meteorological Department](#) has warned of severe **heatwave conditions affecting extensive areas of eastern India and the Gangetic Plain**.

- This highlights the challenge of understanding how [global warming](#) affects local weather. Additionally, the presence of **anticyclones** further complicates the situation, exacerbating the severity of heat waves in affected areas.

What Role Do Heat Waves Play in Global Warming?

- Heat waves result from [climate change](#), caused by the burning of [fossil fuels](#) that add [Greenhouse Gases \(GHG\)](#) to the atmosphere.
 - These **gasses trap more heat energy**, increasing average and extreme temperatures.
- GHG emissions from human activities have [heated the planet by about 1.2 degrees Celsius](#) since pre-industrial times.
 - That warmer baseline means higher temperatures can be reached during extreme heat events.
- Global warming causes **uneven temperature changes across regions**, leading to **local variations in heat waves**.
 - Despite some areas experiencing cooler temperatures, **global warming can create conditions that intensify heat waves locally**, influenced by land use and geography.
- Understanding these local effects is important for accurate forecasting and effective heat wave mitigation.

What is an Anticyclone?

- **High-Pressure Systems:** Anticyclones are areas of high atmospheric pressure, the opposite of cyclones (low pressure).
- **Wind Circulation:** Winds blow **clockwise** around an anticyclone in the Northern Hemisphere and **counterclockwise** in the Southern Hemisphere due to Earth's rotation ([Coriolis Effect](#)).
- **Clear Skies and Calm Weather:** Anticyclones bring stable, calm conditions with little wind and clear skies.
- **Dry Air:** Sinking air in anticyclones warms up and dries out, leading to less rain and humidity.

- **Summer vs. Winter Effects:** Summer anticyclones can be hot and sunny, while winter anticyclones can be cold and clear with morning frost.

CYCLONE



Cyclones are rapid **inward** air circulation around a **low-pressure** area.

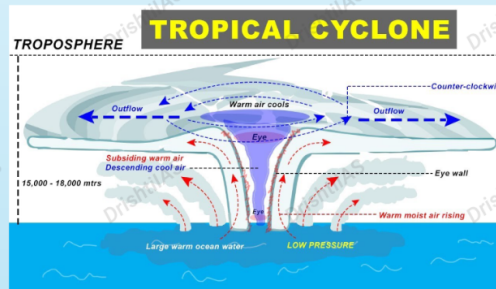


Cyclone v/s Anticyclone

Pressure System	Pressure Condition at the Center	Pattern of Wind Direction	
		Northern Hemisphere	Southern Hemisphere
Cyclone	Low	Anticlockwise	Clockwise
Anticyclone	High	Clockwise	Anticlockwise

Classification

- **Tropical Cyclones;** originate between the **Tropics of Capricorn and Cancer**
- **Extra Tropical/ Temperate Cyclones;** originate in the **Polar Regions**



Conditions for Formation

- Large sea surface with temperature $>27^{\circ}\text{C}$.
- Presence of the **Coriolis force**
- Small **variations in the vertical wind speed**
- **A pre-existing weak low- pressure area**
- **Upper divergence** above the sea level system

Different Names for Tropical Cyclones

- **Typhoons** - Southeast Asia and China
- **Hurricanes** - North Atlantic and eastern Pacific
- **Tornados** - West Africa and southern USA
- **Willy-willies** - Northwest Australia
- **Tropical Cyclones** - Southwest Pacific and Indian Ocean

Nomenclature

- Nodal Authority - **World Meteorological Organization (WMO)**
- Indian Ocean Region - **Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand** contribute to naming cyclones that occur in this region.

Cyclones in India

- **Bi-annual Cyclone Season** - March to May and October to December
- Recent Cyclones - **Tauktae, Vayu, Nisarga and Mekanu** (in Arabian Sea) and **Asani, Amphan, Fani, Nivar, Bulbul, Titli, Yaas and Sitrang** (in Bay of Bengal)

What Links Anticyclones to Heat?

- **Anticyclones and Heat:**
 - Anticyclones are linked to heat through their **persistence and strength**.

- During the pre-monsoon season, the **Indian Easterly Jet (IEJ)** and a **strong westerly jet** can generate an anticyclonic pattern over the Indian Ocean and the Indian subcontinent.
 - A strong anticyclone can bring dry and hot weather over many parts of India, while a **weak anticyclone produces milder weather**.
 - IEJ is a narrow belt of strong easterly winds in the mid-troposphere that blows over peninsular India and the adjoining south Indian Ocean during the **pre-monsoon season (March-May)**.
 - It is weaker and smaller than the well-known **African Easterly Jet (AEJ)**.
 - AEJ occurs in the **lower troposphere over West Africa**. It is characterized by easterly winds and is most prominent during the summer months.
 - It is formed due to the temperature contrast between the hot [Sahara Desert](#) and the cooler [Gulf of Guinea](#).
- **Impact of Anticyclones on Weather Patterns:**
 - Strong IEJ years lead to **higher near-surface temperatures** and drier conditions in India, while weak IEJ years result in cooler and wetter conditions.
 - The strength of the anticyclone in a particular year is a key factor in determining whether it is related to heat waves and global warming.
 - The impact of **El Niño on the Indian subcontinent** tends to **produce stronger and more persistent anticyclones**, leading to longer-lasting and more intense heat waves.
 - Understanding the background state of cool seasonal temperatures and strong, persistent anticyclones is essential for **accurate weather predictions and early warnings**.
- **Recent Impact of Anticyclones:**
 - The recent **anticyclonic circulations over the North Indian Ocean** were responsible for **abnormal rainfall in Odisha in March 2024**. Anticyclones, characterized by clockwise winds and sinking air, can create **high-pressure heat domes**.
 - This phenomenon may have also contributed to [floods in Dubai](#) in April 2024.

Early Warning Systems

- Accurate early-warning systems for global warming use a **three-step approach called the 'ready-set-go' system**.
- The approach is part of the **'Subseasonal-to-Seasonal Predictions (S2S)' project** of the **World Climate Research Program** under the [World Meteorological Organisation](#).
 - **India is part of this project** and has invested heavily in S2S predictions.
- The three-step approach is important for guiding the [National Disaster Management Agency \(NDMA\)](#) to function efficiently and effectively.
 - The 'ready' step provides a **seasonal outlook based on external factors** such as global warming and El Niño.
 - The 'set' step involves sub seasonal **predictions for weeks two to four**, contributing to resource allocations and identifying potential hotspots.
 - The 'go' step is based on **short- and medium-range forecasts** and involves managing disaster response efforts.
- However, the challenge lies in **enhancing local-level weather predictions**. Efforts are underway to forecast weather trajectories over a 10-year span.
 - Coordination and early warning mechanisms are being developed at different levels, requiring training and engagement of governments, departments, and the public.
- The success of these systems is crucial for India's sustained economic development.

Drishti Mains Question:

Q. Explain how anticyclones exacerbate heat wave conditions and contribute to the complexity of weather patterns, particularly in the context of the Indian subcontinent.

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UPSC Civil Services Examination Previous Year's Questions (PYQs)

Prelims:

Q. Consider the following statements: (2020)

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

Ans: (c)

Exp:

- Jet Stream is a geostrophic wind blowing horizontally through the upper layers of the troposphere, generally from west to east, at an altitude of 20,000 - 50,000 feet.
- Jet Streams develop where air masses of different temperatures meet. So, usually surface temperatures determine where the Jet Stream will form.
- Greater the difference in temperature, faster is the wind velocity inside the jet stream. Jet Streams extend from 20° latitude to the poles in both hemispheres. **Hence, statement 1 is not correct.**
- Cyclones are of two types, tropical cyclone and temperate cyclone. The center of a tropical cyclone is known as the 'eye', where the wind is calm at the center with no rainfall.
- However, in a temperate cyclone, there is not a single place where winds and rains are inactive, so the eye is not found. **Hence, statement 2 is correct.**
- The eye of a tropical cyclone is warmer, not colder, and it is this warmer temperature that drives the storm. **Hence, statement 3 is not correct.**

Mains

Q. Tropical cyclones are largely confined to the South China Sea, Bay of Bengal and Gulf of Mexico. Why? (2014)

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