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

Source: TH

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.

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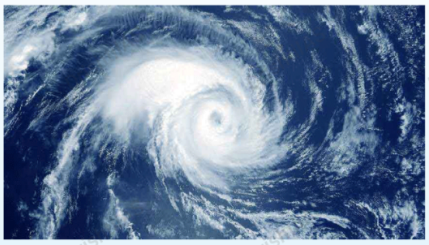
CYCLONE

Drishti IAS

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

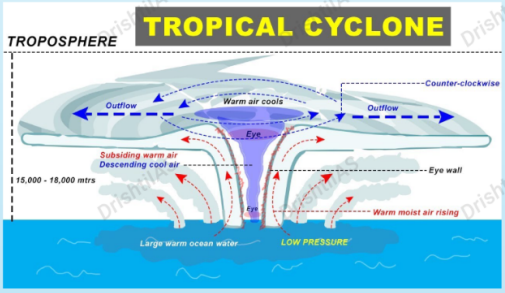


Cyclone v/s Anticyclone

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° 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

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.

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

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.

Read more...

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 10ºC 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)**