

4. Doppler Weather Radars- Science & Technology

Doppler weather radars now cover 87% of India's total area. India has significantly expanded its weather surveillance capabilities, with 47 Doppler Weather Radars (DWRs) now covering 87% of the country to track extreme events like cyclones and heavy rainfall in real-time. These radars utilise the Doppler effect to measure not just precipitation intensity but also the speed and direction of wind and storm systems.

Current Status of Weather Surveillance in India

Expansion- India has significantly strengthened its weather monitoring capabilities and now possesses a network of 47 Doppler Weather Radars (DWR).

Coverage- These radars cover approximately 87% of the country's geographical area.

Utility- The network aids in the real-time tracking of extreme weather events, including cyclones, heavy rainfall, and snowfall, enhancing disaster preparedness.

About Doppler Radars

Definition- Doppler radars are advanced radar systems that utilize the Doppler Effect to measure both the speed and direction of moving objects, such as rain droplets, hail, and wind.

Mechanism- Unlike standard radars that primarily detect intensity, Doppler radars transmit radio waves and analyze the frequency shift in the reflected signal to detect motion dynamics.

Doppler Weather Radars Work

The operation of a DWR involves a systematic process

Transmission of Radio Waves- The radar emits short pulses of microwave radio waves into the atmosphere.

Scattering by Precipitation- Atmospheric targets like raindrops, snow, or hail intercept these waves and reflect part of the signal back to the radar as "echoes."

The Doppler Effect Application- If the target (rain/clouds) is moving, the frequency of the returned signal changes.

Moving Toward- Frequency increases.

Moving Away- Frequency decreases.

Velocity Calculation- The radar measures this frequency shift to accurately determine wind speed and direction inside a storm.

Distance & Intensity Estimation

Distance- Calculated based on the time delay of the returned echo.

Intensity- Determined by the strength of the returned signal (stronger echo = heavier rain).

Data Display- The processed information is visualized on colour-coded maps, showing precipitation intensity and the direction of storm movement.

Advantages of Doppler Radar

Motion Detection- Unlike conventional radars, DWRs can detect the movement of weather targets, not just their presence.

Phase Shift Tracking- They track the phase shift (change in wave pattern) between the transmitted and received signals.

Velocity Vector- This capability allows for the precise calculation of the speed and direction of rain or storm systems (whether they are moving toward or away from the radar site).

Understanding the Doppler Effect

Definition- The Doppler effect is the change in frequency or wavelength of a wave relative to an observer who is moving relative to the wave source.

Origin- Named after Christian Doppler, a 19th-century Austrian physicist.

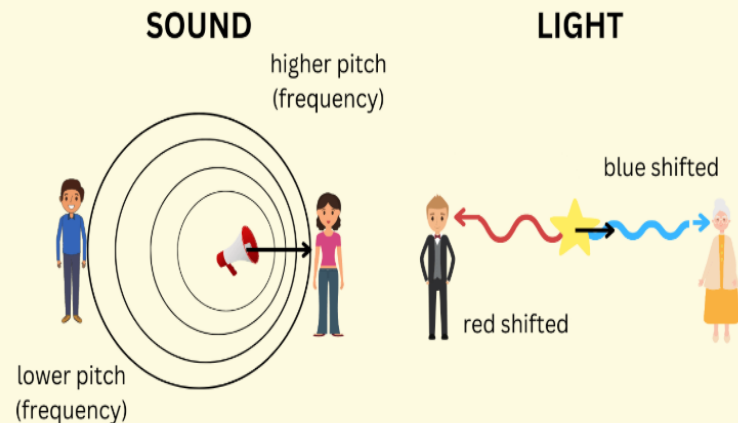
The Phenomenon

Towards Observer- When the source moves closer, the waves compress, leading to an increased observed frequency.

Away from Observer- When the source moves away, the waves stretch, leading to a decreased observed frequency.

Doppler Effect

The Doppler effect is the shift in the frequency of a wave in relation to an observer due to relative motion of the wave source and observer.



Broader Applications- Beyond weather, this principle is used in-

Astronomy- Measuring Red shift/Blue shift to track stars.

Medical Field- Ultrasound imaging (blood flow).

Law Enforcement- Speed detection guns.

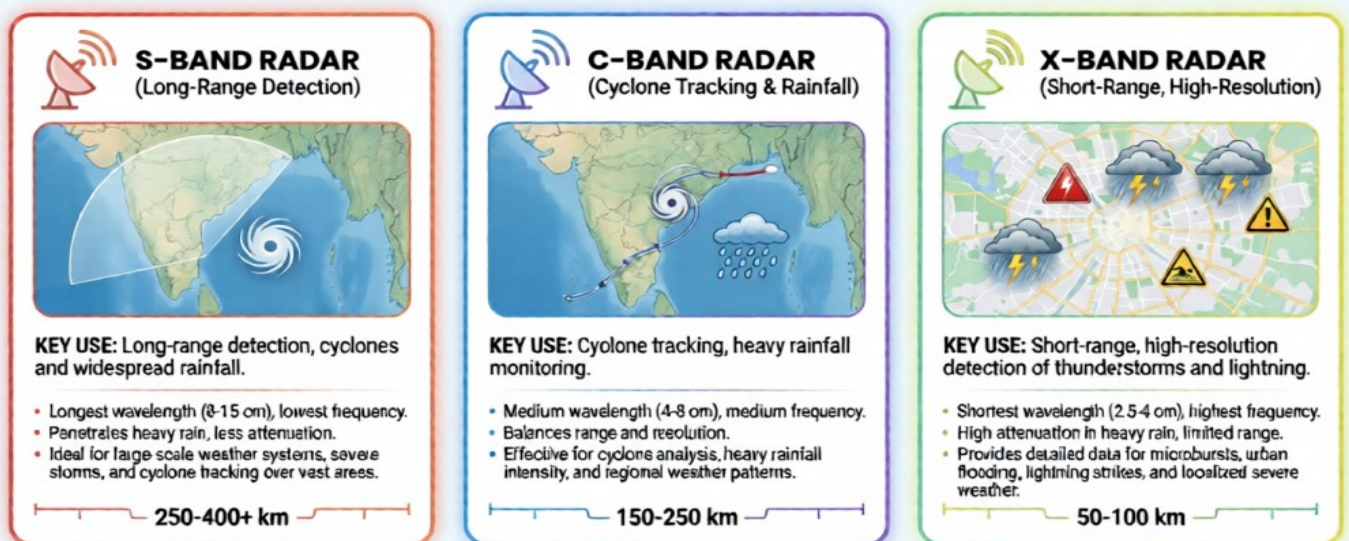
Types of Doppler Radars Used in India

The India Meteorological Department (IMD) utilizes DWRs of varying frequencies to track weather systems. These radars typically have a coverage radius of about 500 km.

Radar Band	Primary Use Case	Characteristics
S-band	Long-range weather monitoring	Operates at lower frequencies; less attenuation; best for seeing through heavy rain to detect distant storms.
C-band	Cyclone tracking and rainfall measurement	Operates at medium frequencies; balances range and sensitivity; standard for non-extreme rainfall.
X-band	Local storm detection	Operates at high frequencies; highly sensitive to smaller particles; ideal for detecting thunderstorms, lightning, and local storms.

TYPES OF DOPPLER WEATHER RADARS USED IN INDIA (IMD)

India Meteorological Department primarily operates three radar bands for atmospheric monitoring.



Source: India Meteorological Department (IMD). Note: Ranges are approximate and vary by specific radar model and conditions.

Source- <https://indianexpress.com/article/explained/explained-sci-tech/doppler-weather-radars-india-10429115/>