



Lightning Analysis for the GMRT Using IITM Data : Studying Antenna problems Due to Lightning

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The Upgraded Giant Metrewave Radio Telescope (uGMRT) in Khodad, Pune, India, consists of thirty fully steerable 45-meter diameter parabolic radio antennas operated by the NCRA. Fourteen antennas are arranged in a central square area of approximately 1 km x 1 km, while the rest are distributed over a 30 km diameter in a Y-shape. The telescope operates at frequencies ranging from 120 to 1500 MHz with multiple RF sub-bands and an instantaneous bandwidth of 100-400 MHz. When the upgraded BAND-2 (120-150 MHz) feed is directed towards the sky, its dual-ring structure due to large size near lightning arresters can induce lightning currents, causing malfunctions in the receiver chain and other antenna-base systems. To address this, a Lightning Warning and Alarm tool is being developed to notify and mitigate risks by adjusting the BAND-2 feed before severe lightning.

Using five years of Lightning Location Network (LLN) data from 2018 to 2022, provided by the Indian Institute of Tropical Meteorology (IITM, Pune¹), we aimed to determine the optimal sampling time interval (ΔT) for detecting consecutive lightning strikes. Sampling intervals of 1, 5, 10, 15, 20, 30, and 60 minutes were tested. Analysis covered **4×4** and **40×40 km-square** areas centered at the C03 antenna and radial distances of **0.5 and 5 km** from individual GMRT antennas using the Haversine formula. We found that, on average, 85-98% of lightning was detected over a year with a maximum sampling interval of 1 hour.

Key findings include: **(i)** Optimal sampling time converged to ~15 minutes, covering 5-10% of maximum detection at 1 hour. **(ii)** A 5 km radial distance is preferred, reducing average operational downtime to 22.11 hours per year, compared to 48.8 hours for a 40×40 km area. **(iii)** Total lightning detection is more informative than cloud-to-ground only, as in-cloud lightning indicates storm intensity and potential severity.

Lightning statistics from five years show: **(i)** Total lightning occurrence is detected on 34 days (5 km radial distance) and 50 days (40×40 km area) per year. Cloud-to-ground lightning is less than 10 days in both cases. **(ii)** Annual lightning strike counts vary widely, from 2126 to 10755, with no predictable average. **(iii)** The ratio of cloud-to-ground to in-cloud lightning averages 10-30%. **(iv)** Average intensities are -44 K Amp for negative and +70 K Amp for positive lightning, with strong positive strikes of +232 to +255 K Amp causing significant antenna issues in October 2022.

Correlation of IITM lightning data with GMRT issues shows central-square and arm antennas are most affected when the BAND-2 feed is directed skyward. In general, electrical problems such as Vacuum circuit breaker bottle failed during heavy lightning, AC stabilizer faults are noticed. The Servo system of GMRT showed failures of Azimuth or Elevation encoder card faulty, MCB tripped, and encoder transceiver system gone bad due to the lightning. In the Front-electronic system, majorly LNA (ATF-54143) found faulty at a time for many antennas during the lightning. Accordingly, we implement a lightning warning and alarm tool for the GMRT with a 15-minute sampling interval and a 5 km radial distance from individual antennas to provide timely warnings and alarms.

1. Lightning Detection and Warning - Anirban Guha, Yakun Liu, Earle Williams, Carina Schumann, and Hugh Hunt, *Lecture Notes in Electrical Engineering*, Volume 780, Springer.
2. National Centre for Earth Science Studies, Ministry of Earth Sciences, Govt. of India
<https://www.ncess.gov.in/research-groups/atmospheric-science-group/laboratories/lightning-detection-network.html>

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