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Analyze thunderstorm events based on the experimental data from LHAASO-WCDA

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Thunderstorms are intense localized convective weather phenomena, typically accompanied by strong lightning, high-energy electromagnetic radiation, and dramatic variations in atmospheric electric fields. Terrestrial Gamma-ray Flashes (TGFs) and Thunderstorm Ground Enhancements (TGE) represent high-energy radiation phenomena generated during thunderstorms. The extreme electric field fluctuations triggered by thunderstorm activity (peaking at -1700 V/cm) can modify the propagation of secondary cosmic particles, altering their arrival times, spatial distributions, and energy spectra at ground level. The Large High Altitude Air Shower Observatory (LHAASO), located in Daocheng County, Sichuan Province, China –a thunderstorm-prone region –hosts the Water Cherenkov Detector Array (WCDA) comprising 3,120 tightly packed detectors covering 78,000 m^2, with a cosmic ray event detection threshold of ˜100 GeV. Data analysis from May 2021 to September 2024 reveals a maximum event rate reduction of 20% during thunderstorms in WCDA observations, exhibiting distinct anisotropic characteristics: systematic discrepancies in reduction magnitude across different azimuthal and zenith angles, with spatial distributions demonstrating temporal evolution as storms develop. Energy-dependent analysis shows more pronounced event rate reductions in the lower energy range compared to higher energies.This paper synthesizes the findings from three years of LHAASO-WCDA cosmic ray data analysis during thunderstorms and discusses potential underlying mechanisms for these anomalies, including electric field modulation of particle transport and possible thunderstorm-induced atmospheric shielding effects.

Collaboration(s)

LHAASO

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