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Electrical Alignment Signatures in Storms Using Dual-polarized Phased Array Radar

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Ice crystals in the upper parts of thunderstorms could be vertically aligned by strong in-cloud electric fields. The maximum alignment with the electric field is reached just before the lightning discharge, followed by a quick reorientation in the horizontal plane due to the dominant atmospheric forces [1, 2]. Using an X-band Multi-Parameter Dual-Polarized Phased Array Weather Radar (MP-PAWR) which performs a whole-sky volume scan with 110 elevations at a temporal resolution of 30 seconds, the electrical alignment signatures within an evolution of an isolated thunderstorm have been investigated.

By introducing the composite K_{DP} and negative K_{DP} volume [3, 4], an electrification process inferred by the electrical alignment signatures of ice crystals is explored within an isolated thunderstorm evolution. During the early developing stage of the storm, the average composite K_{DP} on the top of the storm decreased from positive to negative values or from negative to more negative values before the first IC lightning flash. Subsequently, the average composite K_{DP} increased following it. Specifically, the average composite K_{DP} above the -10 ℃ isothermal layer started to decrease from a positive value to a negative value about 7 minutes before the first IC lightning flash, and the average composite K_{DP} above the -30 ℃ layer reached the minimum negative value 30 seconds before the first IC lightning flash. Meanwhile, the negative K_{DP} volume above the -10 ℃ layer appeared about 7 minutes before the first IC lightning flash, lagging behind the formation of graupel indicated by 40 dBZ volume above the -10 ℃ layer for about 5 minutes. These signatures probably suggest that the electric field established and accumulated in the top parts of the storm, potentially contributing to the initiation of the first IC lightning flash. Before the end of the mature stage, there is a tendency for the increased IC lightning rate as the decrease in average composite K_{DP} in the middle and upper parts of the storm, with an increasing negative K_{DP} volume above the -10 ℃ layer. It indicated that the electric field accumulated and intensified within the thunderstorm. During the end of the mature stage, the IC lightning flash rate continued to increase to its maximum value and then decreased, while the negative K_{DP} volume decreased and the average composite K_{DP} increased. It probably suggests that the electric field weakened due to a large amount of IC lightning discharges, which is probably a precursor to the dissipation stage of the thunderstorm.

By employing the electrical alignment signatures, this study explored the evolution of the radar-inferred electric field which corresponded with the electrification process of the isolated thunderstorm, including the initiation, intensification, and decay. The results indicate that the MP-PAWR has the potential to perform instantaneous observation of the radar-inferred electrification process within the evolution of thunderstorms.

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3. Wang, S., Wada, Y., Hayashi, S., Ushio, T., and Chandrasekar, V, "Electrical alignment signatures of ice particles before intracloud lightning activity detected by dual - polarized phased array weather radar," *Journal of Geophysical Research: Atmospheres*, **129**, 7, 2024, doi: 10.1029/2023JD039942.

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