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PRELIMINARY INVESTIGATION OF LIGHTNING ACTIVITY AND MICROPHYSICS OVER THE WESTERN HIMALAYAS USING THE WRF MODEL

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Keywords

Lightning, Himalayan Region, WRF Model, Model Evaluation

Abstract

Lightning is a highly destructive atmospheric phenomenon, capable of causing fatalities and extensive damage to infrastructure in a short time. Although the overall frequency of lightning occurrences is relatively low in the North Indian Himalayan region, the consequences can be severe when such events do occur. To better understand lightning activity in this region during 2023, we utilized data from both the Lightning Imaging Sensor (LIS) aboard the International Space Station (ISS) and the Indian Lightning Location Network (ILLN). Since LIS provides observations only at 10:00 (121 flashes/hour) and 18:00 (421 flashes/hour) UTC, high-temporal-resolution ILLN data were essential for detailed analysis. To complement the observations, we conducted high-resolution simulations using the Weather Research and Forecasting (WRF) model, focusing on three microphysics (MP) schemes: Thompson (MP=8), Morrison (MP=10), and WDM5 (MP=14). Convective Available Potential Energy (CAPE) simulations revealed that the Morrison scheme produced a broader and more intense region of instability, aligning well with the spatial patterns of observed lightning activity. The WDM5 scheme simulated more intense but spatially confined lightning occurrences. Additionally, each microphysics scheme generated distinct ice cloud characteristics: Morrison resulted in widespread and relatively stable cloud formations; Thompson produced deep convective structures; and WDM5 yielded vertically extensive, fragmented cloud layers. When compared with ILLN observations, the Morrison scheme demonstrated the best agreement in terms of spatial lightning distribution, whereas WDM5 tended to underestimate the coverage and suggested that further refining will be helpful to capture the lightning activities in the complex Himalayan region.

1. INTRODUCTION

Lightning is a frequent pre-monsoon phenomenon in India, causing significant damage. Mishra et al. (2024) reported 101,309 deaths (1967–2020), averaging 1,876 lightning-related fatalities annually. Lightning forms mainly in cumulonimbus clouds due to uplift mechanisms like surface heating, frontal lifting, and orographic forcing (Kumar et al., 2024). In thunderstorms, charge separation produces strong electric fields (~1 MV/m^2), initiating stepped leaders (~50 m/µs) that propagate downward (Rakov, 2013). As these leaders near the ground, they induce upward-moving positive streamers. When they connect, a bright return stroke rapidly travels upward (~100 µs), neutralizing the charge and producing intense lightning (Wallace & Hobbs, 2006). Additional electrons flow from the cloud's negatively charged regions via K or J processes, leading to dart leaders and subsequent return strokes (Dwyer & Uman, 2013).

- **Scope and Significance of Study**

This study provides a comprehensive understanding of lightning activity over the complex terrain of the North Indian Himalayan region using satellite, ground-based, and model-simulated data for the year 2023. By integrating high-resolution ILLN and LIS observations with WRF model simulations under different microphysics schemes (Thompson, Morrison, WDM5), the research highlights the strengths and limitations of each scheme in capturing lightning-related processes. The findings emphasize the Morrison scheme's better spatial agreement with observed lightning, underscoring its potential for operational forecasting. This work aids in improving lightning prediction in mountainous regions, which is critical for disaster preparedness and risk mitigation.

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2. RESEARCH OBJECTIVE

In this research work, we successfully addressed our target objectives: 1) to study the spatial variation of lightning activities over Uttarakhand using model simulations, ground-based, and satellite observations, 2) to investigate the variation of cloud hydrometeors responsible for intense lightning activities over Uttarakhand.

3. LITERATURE REVIEW

In the Indian subcontinent, lightning hotspots are primarily located over the foothills of the Himalayas, as well as in the southeastern (SE) and southwestern regions. Different regions exhibit distinct lightning-dominant mechanisms. The northwestern (NW) and northeastern (NE) Himalayan foothills experience intense lightning due to deep convection, the convergence of moist and warm air masses, and orographic uplift. These processes enhance lightning activity compared to forested regions in the north. In contrast, coastal regions experience lightning primarily due to low-pressure systems, depressions, and cyclonic activity (Kamra and Kumar 2020; Unnikrishnan et al., 2021). Cloud microphysics critically governs lightning activity through interactions in the mixed-phase region. Interactions between graupel and ice crystals in mixed-phase zones drive charge separation. This non-inductive charging drives electrification, leading to lightning once electric fields surpass a threshold.

Updrafts and turbulence, especially in multi-cell storms, enhance hydrometeor growth and charge separation, forming lightning-prone regions known as "lightning bubbles (Sherwood 2006; Williams et al., 2002; Saunders, 2008). Accurate lightning prediction requires incorporating these parameters, though it remains computationally challenging despite recent advancements. (Zepka et al., 2014; Kumar et al., 2022). In the early 20th century, researchers began employing empirical techniques to estimate lightning activity (Price and Rind, 1992; Boccippio et al., 2002).

Over the Indian region, several studies have applied statistical and binary logistic regression approaches using meteorological parameters such as CAPE, convective rainfall, evaporation, temperature, and humidity to predict lightning and thunderstorm occurrences (Mukhopadhyay et al., 2003; Rajeevan et al., 2010). In parallel, other researchers have adopted dynamic numerical approaches like the WRF model to evaluate microphysics schemes across NE, SW, and western India (Rajeevan et al., 2010; Halder and Mukhopadhyay, 2016; Kumar et al., 2022). he WRF model, using PR92 and hydrometeor-based schemes, effectively simulates IC, CG, and total lightning by representing mesoscale processes and storm-height relationships (Price and Rind, 1992). To simulate lightning activity, the Price and Rind (1992) (PR92) scheme, grounded in cloud-top dynamics, has been extensively employed for robust regional modeling and validation efforts (Wong et al., 2013).

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Despite advances in lightning research, limited studies exist for the western Himalayas, especially Uttarakhand, where complex terrain increases lightning risk (Gautam et al., 2022). This study presents the first simulation of a severe lightning event on 23 May 2023, which caused significant lightning activity and livestock losses. Using WRF with three microphysics schemes (MPS), we assess the ability to capture spatial lightning distribution and storm dynamics. The study compares simulated lightning with ISS-LIS and ILLN observations. Data and methodology are detailed in the following section.

4. RESEARCH METHODOLOGY

The research design was descriptive in nature. The researchers collected data from interns who completed their internship from Social Science and Humanities Stream and Science and Technology Streams through Microsoft Forms. The researcher used convenience sampling to collect data from 105 respondents. 58 respondents belonged to Social Science and Humanities Stream and 47 members belonged to Science and Technology Stream. The questionnaire consisted of demographic and Likert Scale questions on a 5-point scale, where strongly disagree equals 1 and strongly agree equals 5. The period of data collection was February 2025.

- **Model Configuration**

To simulate lightning over the western Himalayas, we employed the WRF-ARW model (version 4.5), developed by NCAR (Skamarock et al., 2008). The model uses a terrain-following hydrostatic pressure coordinate system on an Arakawa-C grid with third-order Runge–Kutta time integration. A nested domain setup (27 km, 9 km, and 3 km) was used, focusing on the innermost 3 km domain for analysis (Figure 1). WRF has been effectively applied in similar studies over NE India, Western Ghats, and the Indo-Gangetic Plains (Choudhury et al., 2020; Mohan et al., 2021).

- **Data**

To identify suitable lightning events for simulation, we analyzed data from NASA Earthdata and GHRC portals. Space-based lightning data from the ISS-LIS instrument (temporal resolution ~2 ms, spatial ~4–8 km) were used alongside ground-based observations from the Indian Lightning Location Network (ILLN), which consists of 92 sensors, including three in Uttarakhand. The ILLN operates using the Time-of-Arrival (TOA) technique within a 1 Hz–12 MHz frequency range. It detects both CG and IC flashes with ~90% and ~50% efficiency, respectively. These datasets helped evaluate WRF model performance using various microphysics and cumulus schemes. Model inputs were sourced from NCEP (1° × 1°) as described by Mohan et al., (2021).

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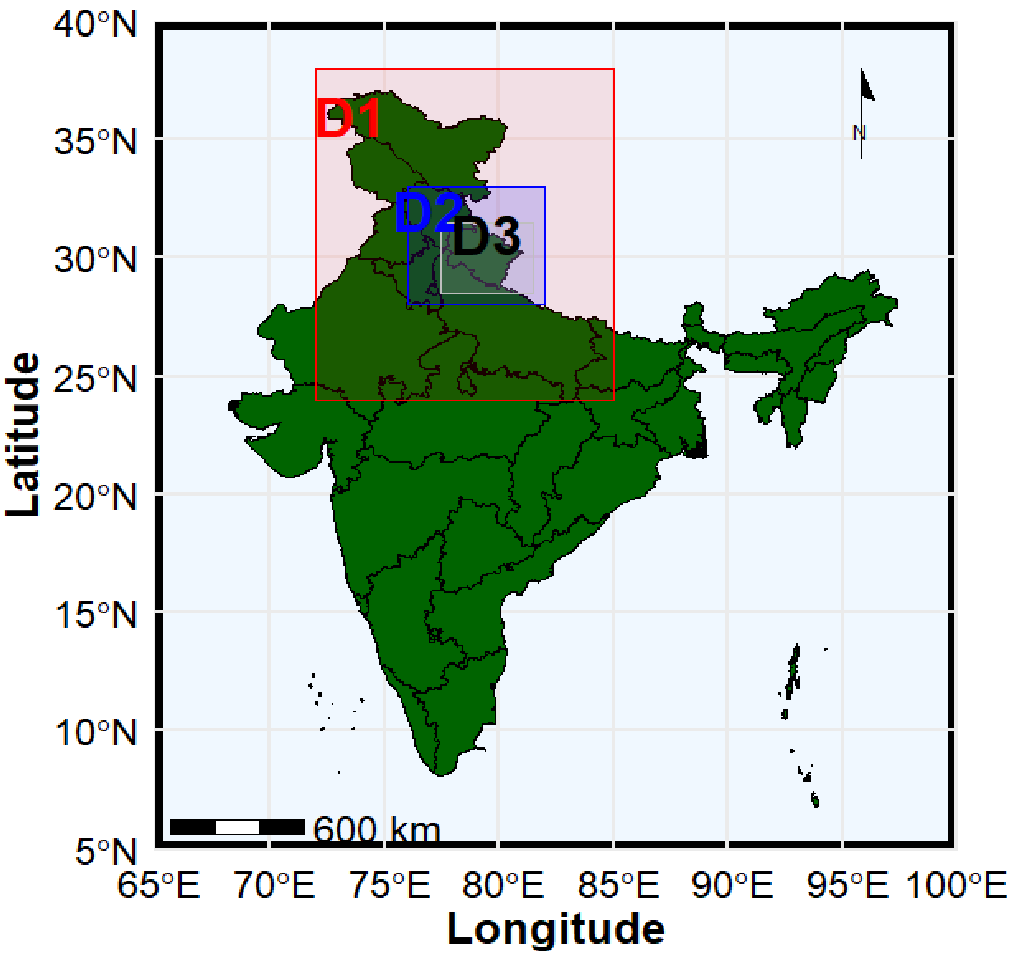

Figure 1: WRF model domain configuration (D1:27 km; D2:9km & D3:3km)

Table 1: Model configuration

Parameters	Description	References
Domains Size	27km, 9km, 3km	
No. of vertical resolutions	34	
Microphysics (MP) Options	**Scheme**	**Reference**
mp_physics=8 mp_physics= 10 mp_physics=14	Thompson microphysics Morrison 2-mom WRF Double-moment 5-class (WDM5)	Thompson et al. (2008) Morrison et al., (2009) Lim and Hong, (2010)
Cumulus Options	**Scheme**	**Reference**

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Cumulus physics cu_physics=11	Tiedtke	Tiedtke (1989) Zhang et al., (2011)
Land Surface, boundary layer and radiation model Options	**Scheme**	**Reference**
Boundary layer scheme bl_pbl_physics=1	Yonsei University Scheme	Hong et al., (2006) Choudhury et al., (2020)
Land surface model sf_surface_physics=2 sf_sfclay_physics=1	Noah LSM	Niu et al., (2011)
Radiation ra_la_physics=4 ra_sw_physics=4	Rapid Radiative transfer model	Iacono et al., (2008)
Time Steps	15 Sec	
Lightning Options	**Scheme**	**Reference**
Lightning_option = 1	Price and Rind	Price and Rind (1992)

Lightning Options: Price and Rind 1992: The PR92 scheme is a commonly applied parameterization method used to estimate lightning flash rates based on storm height characteristics.

$$F_{rc} = 3.44X10^{-5}H_s^{4.9} \quad \text{..........} \quad (1)$$

Where F_{rc}: Flash rate (Flash/min), H_s: Strom Height

4.1 Identification of lightning event day by using ground-based and satellite observation: For the identification of peak hours of lightning activity, we analysed a complete year hourly ISS-LIS dataset and found only two lightning events occurring at 10:00 (121 Flashes) and 18:00 (421 Flashes/hour) UTC on 23 May 2023 (Figure 2ab). Due to this limited temporal coverage, we further utilized high-resolution (300 m) ground-based lightning data from the ILLN to understand lightning activity over the study region (Figure 2a-b). Following this period, a declining trend in lightning activity was observed, as shown in Figure 2, likely due to the dissipation of thunderstorms. The elevated lightning activity during late evening and night is primarily governed by the convergence of moisture in the foothill regions, driven by radiative cooling processes. A similar diurnal pattern of lightning activity was reported by Pawar et al. (2015) over the Guwahati observatory, located in the foothills of the Northeast Himalayas, during the pre-monsoon season.

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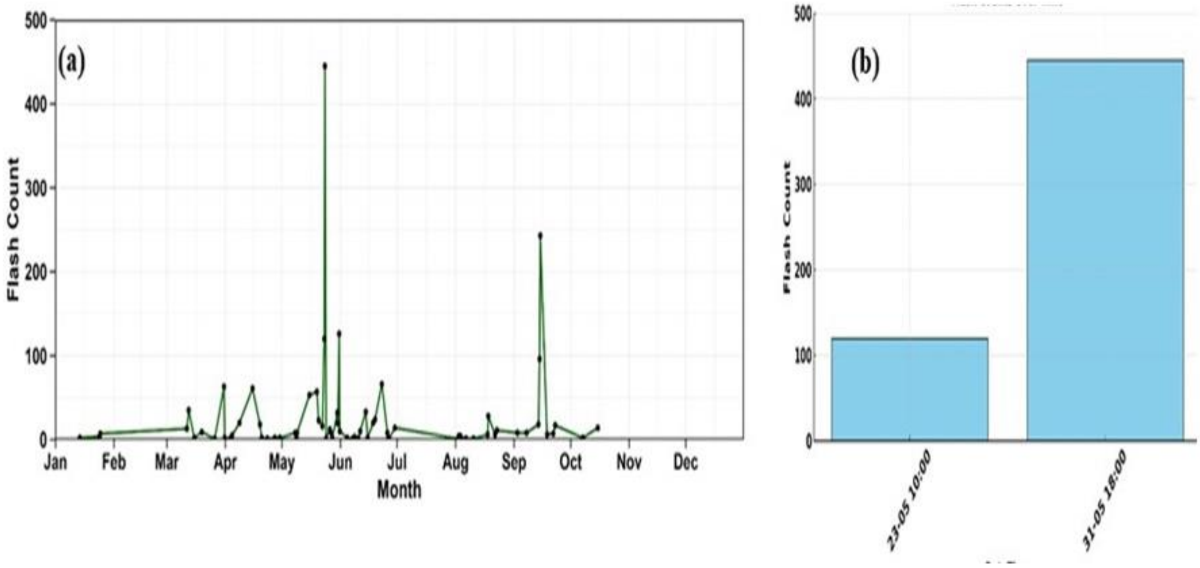

Figure 2: Hourly flash rate (flashes/hour) over the Uttarakhand region: (a) diurnal variation for year 2023, (b) hourly flash rate (flashes/hour) on 23 May 2023 observed by ISS-LIS.

4.2 Spatial variation of model and observed normalised flash rate (flashes/hour): We have analyzed the spatial variation of lightning activity using both ILLN observations and model-simulated results (Figure 3). The ILLN dataset represents 24-hour accumulated observed and modelled lightning flash rate (flashes/hour). Observations from ILLN clearly indicate intense lightning activity over the foothills of the Himalayas, including regions such as Dehradun, Haridwar, Pauri Garhwal, Udham Singh Nagar, and surrounding areas of Uttar Pradesh. Four lightning hotspots were identified in these regions, with normalised flash rate (NFR) values ranging from 0.8 to 1.0 (Kumar et al., 2024). Additional lightning activity with NFR values around 0.4 was also reported over the NW and NE parts of Uttarakhand. The highest observed lightning flash rate was 40 flashes/hour, recorded by the ILLN, while the Thompson microphysics scheme in the WRF model reported a very close value of 41.27 flashes/hour. The Thompson scheme successfully captured the spatial pattern of lightning activity over the Himalayan foothills but failed to predict lightning events in SW areas and successfully indicated the absence of lightning activity in the NE parts. Moreover, the model showed significant overestimation in the region between 28.0–28.5°N and 77.5–78.5°E. The Morrison microphysics scheme also performed reasonably well, predicting lightning activity with NFR values ranging from 0.4 to 0.6. Unlike the Thompson scheme, Morrison captured events in both the NW and NE regions of Uttarakhand, though it tended to overestimate lightning occurrence. The WDM5 scheme captured lightning activity only in limited areas such as Dehradun, Uttarkashi, and adjacent foothill regions. It failed to estimate the lightning hotspots identified by the ILLN.

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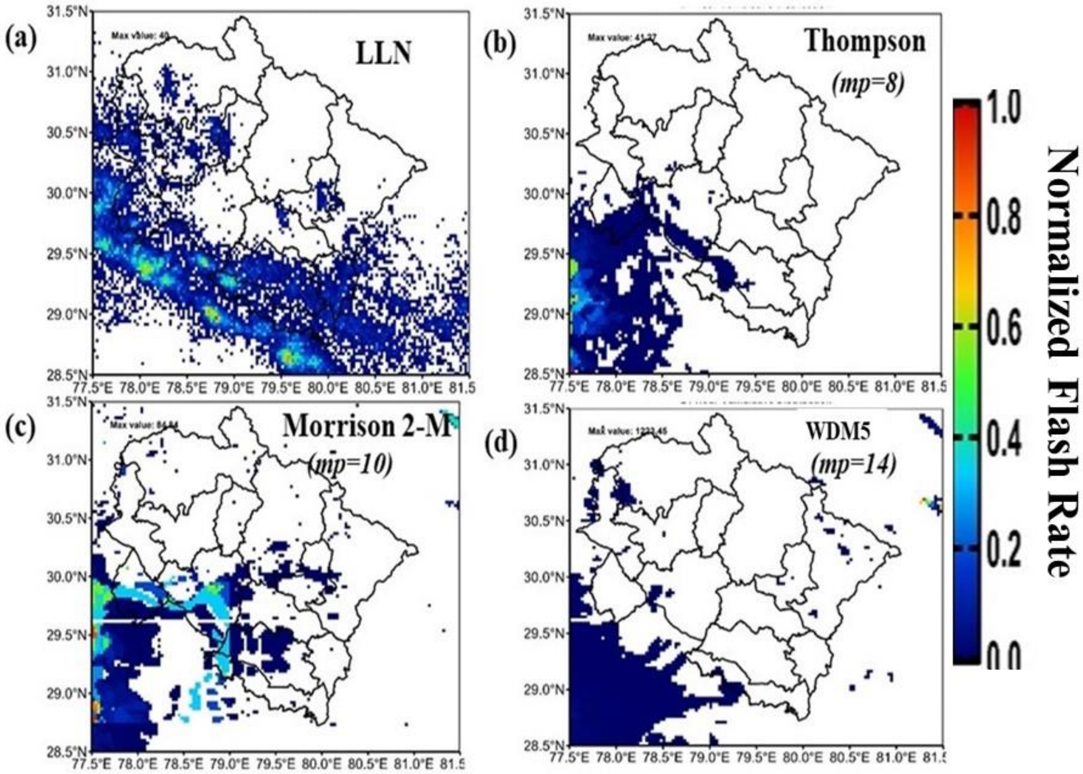

Figure 3: Normalised flash Rate (NFR; Flashes/hour) variation of Indian Lightning Location Network (ILLN) (a), Thompson (b), Morrison (c) and WDM5 over the 3 km domains.

4.3 Comparative Analysis of CAPE Simulations Across MPS: Figure 4 represents the simulation of Convective Available Potential Energy (CAPE) using the Thompson microphysics scheme (MP=8) across the Uttarakhand region. Figure 4a shows the spatial distribution of CAPE at 850 hPa. The highest CAPE values (150–200+ J/kg), represented by yellow to orange shades, are concentrated along the southern boundary around 28.5°N, particularly in the SE region. The northern areas exhibit significantly lower CAPE values (0–50 J/kg), shown in blue to purple. This north–south gradient reflects regions of atmospheric instability, a key precursor for thunderstorm development and lightning generation. Figure 4b presents the hourly vertical profile of CAPE across pressure levels and corresponding altitudes. Significant CAPE concentrations are observed below 2 km altitude during hours 8–13 (UTC), with peak values exceeding 100 J/kg, indicated by green to yellow colours. Additionally, CAPE magnitudes (maximum ~200 J/kg) also show similarities with observed lightning activities in the south east and south west. The CAPE in the NW part of India is not a prime contributor of lightning, as observed by Kumar et al., (2024), showing a Pearson's correlation (r = 0.34). Whereas in another study, in the NW and the

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Himalayan foothills region, intense solar heating, the availability of precipitable water, convective cloud clustering, and orographic influences from the Himalayas contribute to strong pre-monsoon thunderstorms and lightning activity (Kamra and Kumar, 2020).

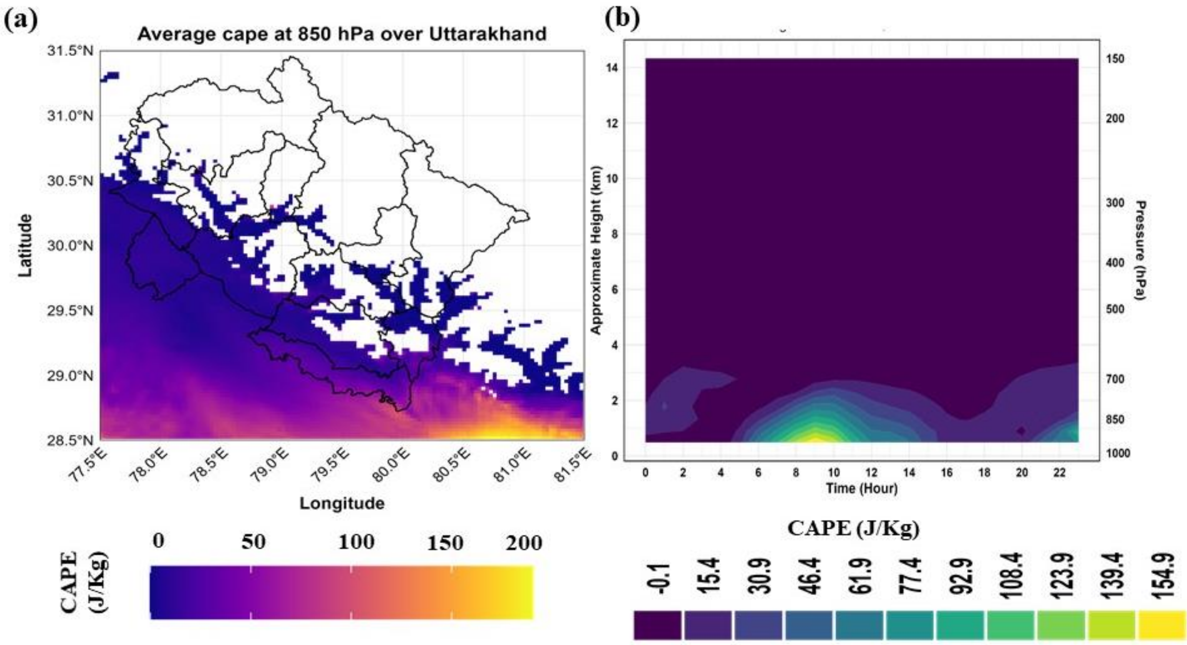

Figure 4: Spatial distribution of CAPE (a) over Uttarakhand and hourly vertical profiles of CAPE (b) at different pressure levels and heights over the region by using the Thompson microphysics scheme (MPS).

Figures 5 represent CAPE simulations from the Morrison (MP=10) MPS over Uttarakhand, allowing for direct comparison with the previously discussed Thompson scheme (Figure 4). The Morrison scheme shows significantly higher CAPE values along the southern boundary, with intense concentrations (200+ J/kg) extending farther west than in the Thompson simulation. This enhanced instability at 28.5°N creates a sharper north-south gradient and covers more area with higher CAPE values. The southwestern corner displays particularly intense CAPE, which aligns with the areas where the Morrison scheme produced more concentrated lightning in previous spatial comparison maps. The vertical CAPE profile shows strong values concentrated below 3 km from the ground level, with peak intensity during hours 8-12 (Figure 5b). The maximum CAPE values reach approximately 140 J/kg (yellow), with high values extending longer throughout the day compared to Thompson. Notably, the Morrison scheme produces elevated CAPE values in the lowest atmospheric layer (0-1 km), creating favorable conditions for sustained convection.

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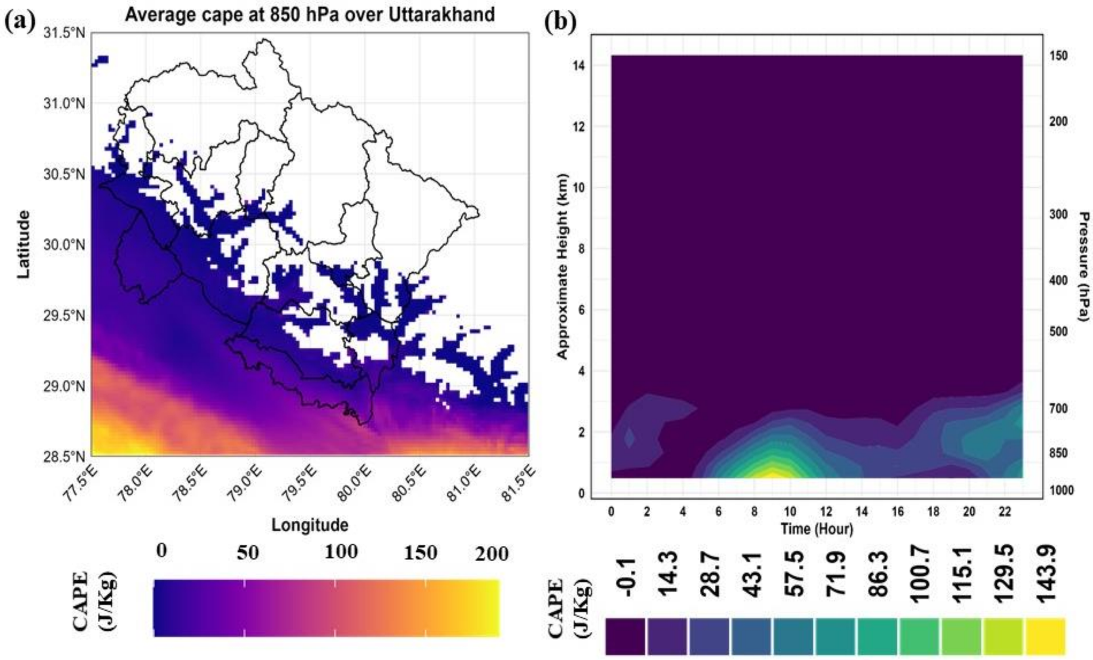

Figure 5: Spatial distribution of CAPE (a) over Uttarakhand and hourly vertical profiles of CAPE (b) at different pressure levels and heights over the region by using Thompson MPS.

The WDM5 simulation shows the spatial distribution of CAPE, with higher values (100-150 J/kg) concentrated primarily in the SE corner (Figure 6a). The intense values don't extend as far westward as in the Morrison scheme, creating a more localized area of instability. The WDM5 scheme shows more limited spatial coverage of lightning activity observed in earlier simulations. The WDM5 vertical profile displays a similar temporal pattern but with slightly lower maximum CAPE up to 135 J/kg (Figure 6b). The high-CAPE region appears more compact and concentrated around hours 8-10, with a narrower vertical extent than the Morrison scheme. This more constrained temporal-vertical CAPE distribution explains WDM5's tendency to produce intense but limited lightning activity. Morrison's more sustained elevated CAPE values throughout the vertical profile correlate with its relatively higher lightning flash rate and better spatial coverage. WDM5's more constrained shows the highest values up to more than 100 flashes/hour, but with intense but limited spatial coverage, as seen in Figure 3. Leena et al. (2019) observed that CAPE increases approximately six hours before thunderstorm events. They also evaluated the evolution and development of thunderstorms using radiometer-derived products and the WRF model over Maharashtra. In the upper Himalayan region, due to complex terrain, the model was not able to resolve the issue and reported poor model simulation.

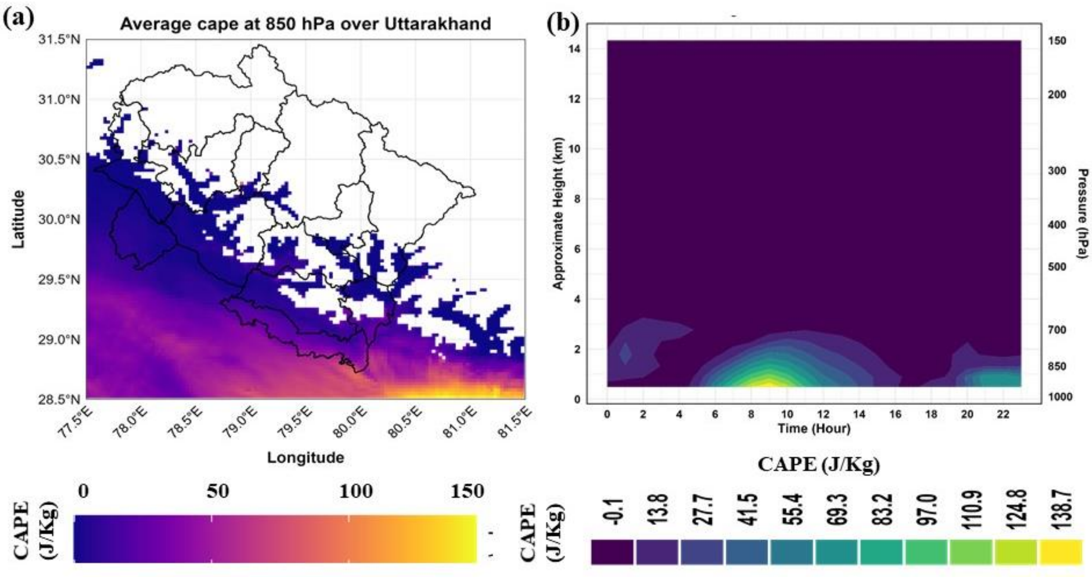

Figure 6: Spatial distribution of CAPE (a) over Uttarakhand and hourly vertical profiles of CAPE (b) at different pressure levels and heights over the region by using WDM5 MPS.

4.4 Vertical and Temporal Distribution of Rainwater (qrain) and Ice Mixing Ratio (qice): Cloud microphysical properties play a crucial role in influencing lightning activity. The interaction between graupel and cloud ice particles through collisions enhances cloud electrification, ultimately leading to intense lightning events (Hazra et al., 2013; Williams et al., 2002; Chaudhury et al., 2020). Therefore, understanding and evaluation of cloud microphysics schemes is essential for improving lightning prediction. In the present study, we have investigated the temporal and vertical distribution of rainwater mixing ratio (qrain) and ice mixing ratio (qice) simulated over the Uttarakhand region (Figure 7a & b). The simulation using the Thompson scheme exhibits a delayed yet intense convective episode. In the Thompson scheme, qice begins forming around 09 UTC, with a sharp, vertically confined peak between 9 and 11 km altitude, reaching a maximum of approximately 2.9×10^{-6} kg/kg (Figure 7a). This pattern suggests a convective core-type structure where strong updrafts rapidly generate deep ice clouds. The scheme emphasizes deposition and riming processes for ice growth, leading to vertically deep but short-lived convective events. Whereas rainwater formation begins around 16 UTC (21:30 IST), followed by a rapid intensification phase that peaks near 19 UTC (00:30 IST). During this peak, the maximum qrain values exceed 5.8×10^{-6} kg/kg (Figure 7b). The core of qrain is concentrated around 3 km altitude and extends vertically up to approximately 4.5 km, indicating the development of deep convection likely driven by late-evening atmospheric instability and orographic lifting (Pawar et al., 2015). The delayed onset of precipitation in the Thompson scheme suggests that it requires stronger vertical motion and sufficient hydrometeor growth to trigger rainfall. This behavior is consistent with the scheme's emphasis on ice-phase processes and auto conversion thresholds, which play a key role in the initiation of convective precipitation and associated lightning activity.

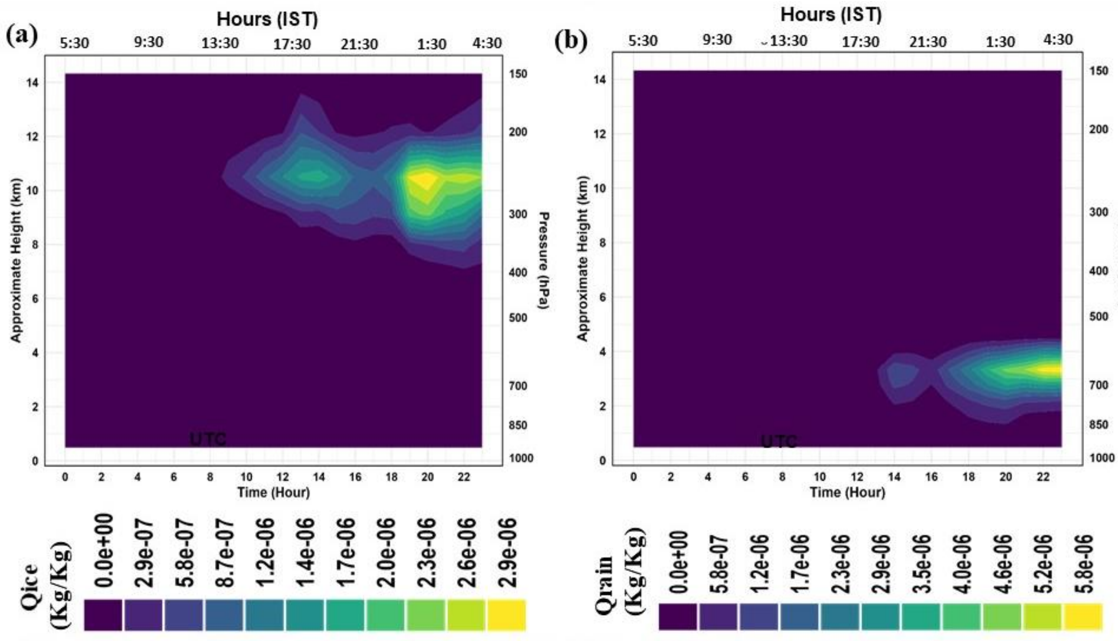

Figure 7: Temporal distribution and vertical distribution of cloud ice (qice) and rainwater mixing ratio (qrain) over Uttarakhand using the Thompson MPS.

The Morrison scheme initiates qice formation earlier, around 08 UTC, and produces a more extensive and sustained ice cloud layer (Figure 8a). The peak values are observed at similar altitudes (9–11 km), but with significantly higher mixing ratios, reaching up to 2.7×10^{-5} kg/kg. The vertical profile remains relatively stable over time, indicating stratiform or anvil-type cloud structures. The Morrison scheme's double-moment approach simulates both mass and number concentrations of ice particles, enhancing broader and longer-lasting cloud development through deposition and aggregation processes. The Morrison scheme exhibits a more complex and temporally extended precipitation pattern. Initial qrain formation begins as early as 13 UTC (18:30 IST), indicating earlier convective development compared to other schemes (Figure 8b). A peak qrain value of approximately 1.9×10^{-6} kg/kg is observed around 3.5 km altitude, followed by a second, broader convective episode occurring between 17 and 20 UTC. During this period, qrain consistently exceeds 1.5×10^{-6} kg/kg, with vertical growth reaching up to 4.5 km and distribution reflects the Morrison scheme's capacity to simulate sustained convection, supported by its detailed representation of ice-phase processes, including ice growth, sedimentation, riming, and melting process (Choudhury et al., 2020).

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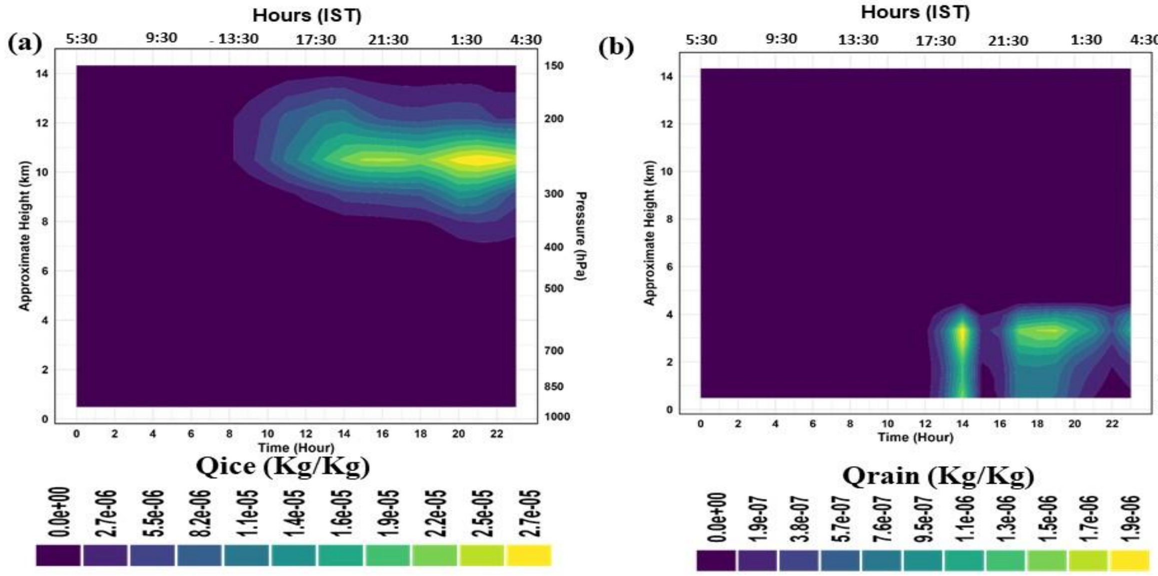

Figure 8: Temporal and vertical distribution of cloud ice (qice) and rainwater mixing ratio (qrain) over Uttarakhand using the Morrison MPS.

WDM5 displays a distinct behavior, with qice onset also occurring around 08 UTC but spanning a wider vertical extent from approximately 4.5 km to 12 km (Figure 9a). Unlike the narrow peaks of Thompson or the smooth layers of Morrison, WDM5 shows multiple localized maxima, with the highest values around 1.9×10^{-5} kg/kg. This irregular vertical distribution suggests layered or intermittent ice cloud structures, likely influenced by the scheme's focus on warm-rain processes and its simplified, single-moment representation of ice microphysics. Its reliance on supercooled water and aerosol activation further contributes to the scattered nature of the ice cloud structure. Overall, these results emphasize how different MPSs influence ice cloud development. The Morrison scheme simulates the most horizontally extensive and temporally stable ice clouds. The Thompson scheme produces intense, vertically deep convective cores, while WDM5 results in patchy and vertically dispersed structures.

In the qrain, the first event occurs around 14 UTC (19:30 IST), followed by a second peak at approximately 18 UTC, and a third at 21 UTC (Figure 9 b). Each event exhibits qrain values ranging from 3.0×10^{-6} to 3.8×10^{-6} kg/kg, predominantly between 3 and 5 km altitude. The limited vertical extent indicates shallow to moderate convection, potentially influenced by aerosol-induced suppression of droplet growth. While WDM5 captures temporal variability and drizzle-like precipitation, it may underrepresent deeper convective processes in the absence of strong environmental forcing. Despite using the same cumulus parameterization (Tiedtke), the three MPS produce notably different precipitation structures. These distinctions are critical for understanding cloud–radiation interactions, precipitation dynamics, and lightning activity in high-resolution simulations over mountainous regions such as Uttarakhand. Several studies support

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these findings. Hazra et al., (2013) and Unnikrishnan et al., (2021) highlighted the key role of cloud ice and graupel in enhancing lightning through charge separation. Cloud ice, formed via vertical moisture transport and freezing, intensifies convection. Studies over Northeast and Northwest India (Choudhury et al., 2020; Biswasharma et al., 2021) confirm this. Our analysis over Uttarakhand also supports this lightning–ice-phase linkage.

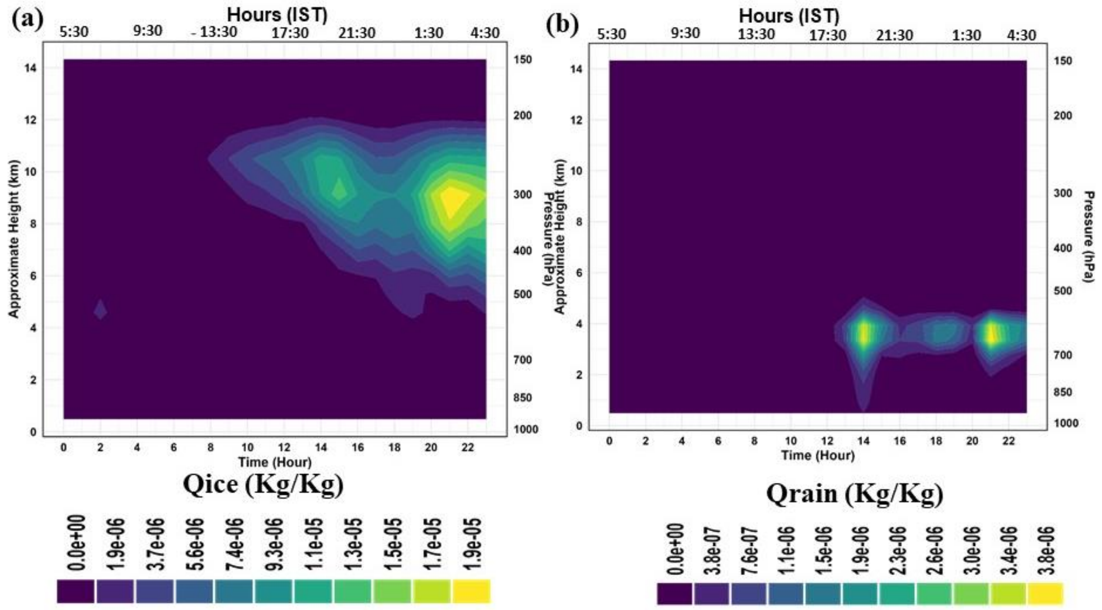

Figure 9: Temporal and vertical distribution of cloud ice (qice) and rainwater mixing ratio (qrain) over Uttarakhand using the WDM5 MPS.

5. SUMMARY, CONCLUSION, AND RECOMMENDATION

Based on the simulation of lightning activities on 23 May 2023 using three MPS, we observed several crucial findings listed below:

i. The highest lightning activity during 2023 was recorded on 23 May, with 421 and 121 flashes/hour detected at 10:00 and 18:00 UTC, respectively, by the LIS-ISS.

ii. Morrison shows broader, stronger instability and better lightning spatial correlation; WDM5 captures intense but localized activity. All schemes predict peak CAPE too early.

iii. Morrison produces widespread and stable ice clouds, Thompson forms deep convective cores, while WDM5 yields scattered, vertically extended layers. These distinctions are crucial for interpreting cloud-radiation interactions, precipitation processes, and storm dynamics in high-resolution simulations over mountainous regions like Uttarakhand.

iv. ILLN observations show extensive southwest coverage. Thompson captures partial patterns. Morrison best matches the spatial distribution. WDM5 severely underestimates coverage despite generating intense lightning.

Kumar Sanjeev, Gautam Alok Sagar, Singh Karan, Sawan, Tomar Anirudh, Amar Deep, Vishwkarma Aman Deep, Panchbhaiya Yasti (2025). *Preliminary Investigation of Lightning Activity and Microphysics over the Western Himalayas Using the WRF Model*. *International Journal of Multidisciplinary Research & Reviews, 4(3), 43-61*

v. The Thompson, Morrison and WDM5 MPS captures the good spatial pattern but is unable to capture lightning variation in the south eastern part of the study region, which clearly highlights the need for more improvement in the model.

6. LIMITATIONS OF STUDY AND FURTHER RESEARCH

(i) All MP schemes predicted CAPE peaks earlier than observed lightning events.

(ii) None of the schemes captured lightning activity well in the SE part of the region.

(iii) WDM5 underestimated spatial lightning coverage despite simulating intense lightning.

(iv) Complex terrain effects may not be fully resolved, limiting accuracy and understanding.

(v) Simplified microphysics assumptions may not fully capture cloud electrification processes.

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8. AUTHOR(S) CONTRIBUTION

Sanjeev Kumar and Alok Sagar Gautam: Conceptualization, methodology development, data analysis, investigation, visualization, and preparation of the original draft. Amar Deep and Karan Singh: Critical review, discussion, and interpretation of results. Anirudh Tomar and Sawan: Support in data processing and analysis.

9. CONFLICTS OF INTEREST

The authors declare that they have no financial or personal relationships that could have influenced the work reported in this manuscript.

10. PLAGIARISM POLICY

All authors declare that any kind of violation of plagiarism, copyright and ethical matters will take care by all authors. Journal and editors are not liable for aforesaid matters.

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