NUMERICAL SIMULATION OF THUNDERSTORM AND LIGHTNING WITH WRF-ELEC OVER ODISHA, INDIA

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Motivation

- **Odisha, on India's eastern coast, is highly susceptible to lightning due to its unique climate and topography.**
- **Lightning endangers human life, disrupts infrastructure, and threatens agriculture.**
- **Precise, timely lightning forecasts are crucial.**
- **WRF-Elec has shown promise in regions with similar conditions to Odisha.**
- **Model credibility supported by successful application in Bangladesh (Rabbani et al., 2022).**
- **Research aims to adapt WRF-Elec for Odisha, improving lightning prediction and mitigation.**


Asia > India

Record 61,000 lightning strikes in two hours kill 12 people

Government announces £3,827 in compensation for families of each killed in lightning strikes

Alisha Rahaman Sarkar • Monday 04 September 2023 14:12 • Comments

Events

For this Study, 4 events recorded by IMD and INSAT 3D/3DR has been chosen. A 3 km resolution nested domain is set over entire Odisha to capture the following events :-

- **15 JUNE 2019**
- **24 JUNE 2020**
- **27 JULY 2020**
- **08 AUG 2021**

Table 1. Events Observation from LIS and IMD Station Data

Events	Flash Count (LIS)	Rainfall (peak)	Station
15 JUNE 2019	143	46.3 mm	PAIKMAL
24 JUNE 2020	240	115.1 mm	NAWARANGPUR
27 JULY 2020	159	88.6 mm	BHUBANEASWAR
08 AUG 2021	282	55.8 mm	KEONJHAR

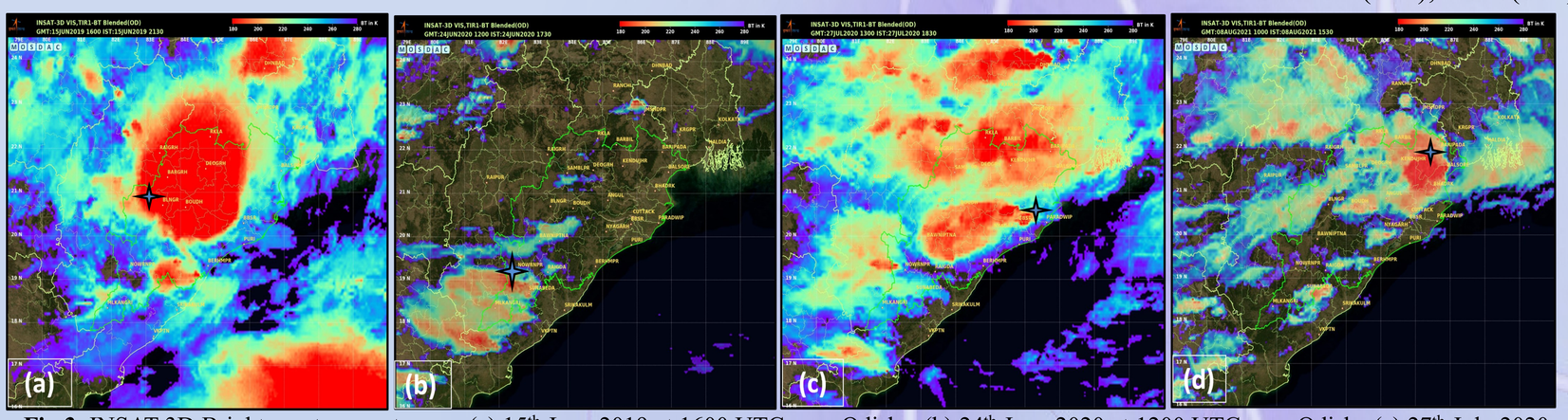


Fig 3. INSAT-3D Brightness temperature on (a) 15th June 2019 at 1600 UTC over Odisha. (b) 24th June 2020 at 1200 UTC over Odisha (c) 27th July 2020 at 1300 UTC over Odisha (d)08th August 2020 at 1000 UTC over Odisha; Stars represent Peak Rainfall Stations(Source: ISRO-MOSDAC)

Model Description and Methodology

- WRF-ELEC calculates electric potential and lightning rates (Rabbani et al., 2022; Mansell et al., 2005).
- Uses inductive and non-inductive charging mechanisms (Mansell et al., 2005).
- Adheres to charge conservation and includes mass exchange among hydrometeors (Mansell et al., 2005).
- Employs 3D Poisson equation and BoxMG solver for computing electric potential (Mansell et al., 2005).
- Initiates lightning at grid points with electric field above 120 kV/m; centres discharges in a 6 km radius cylinder (Rabbani et al., 2022; Fierro et al., 2013).
- Data - NCEP-FNL 6 Hourly 0.25
- Resolution - 9:3 Km (Nested)
- Microphysics - NSSL 2-Moment
- Cumulus - Grell 3D(d01), None(d02)

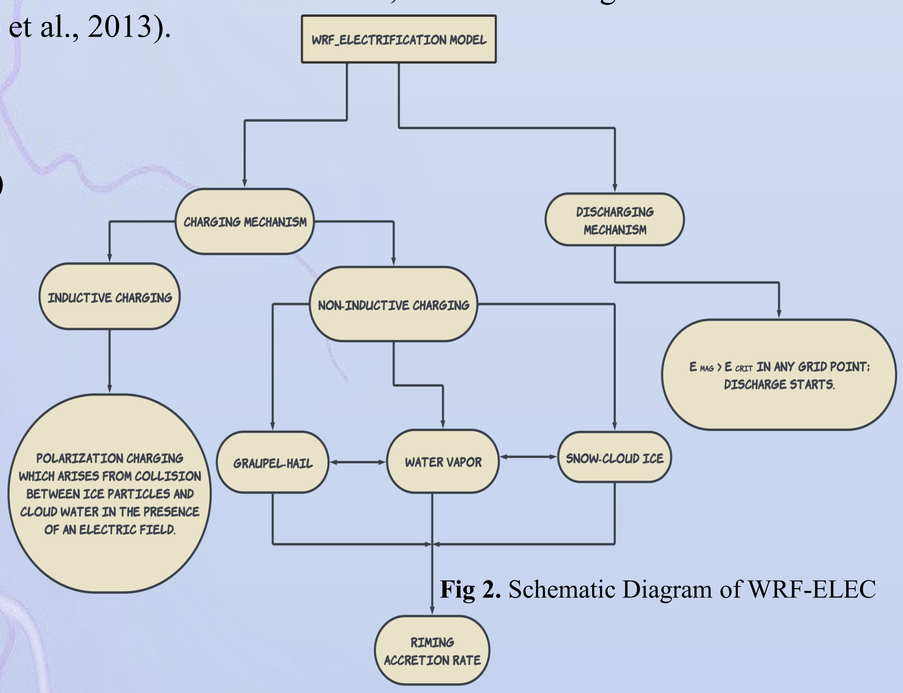
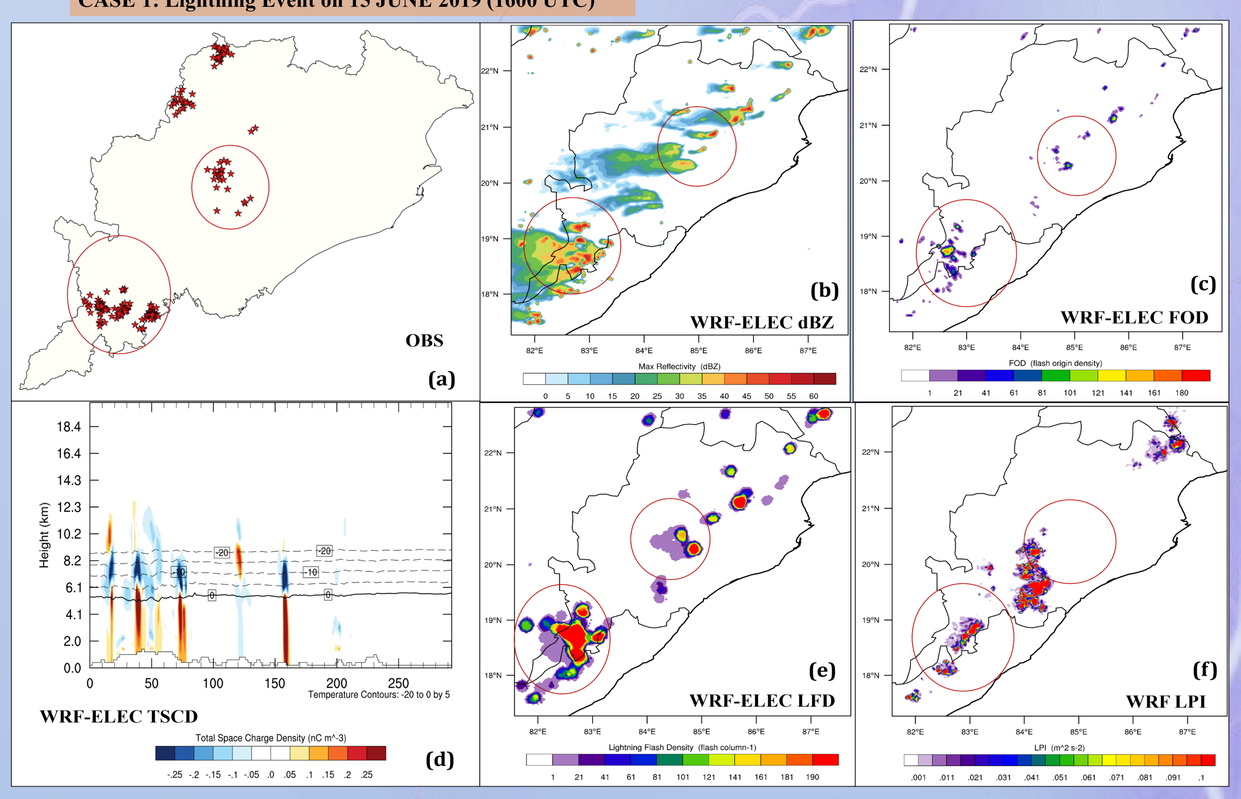


Fig 2. Schematic Diagram of WRF-ELEC

Results (a) Model Prediction



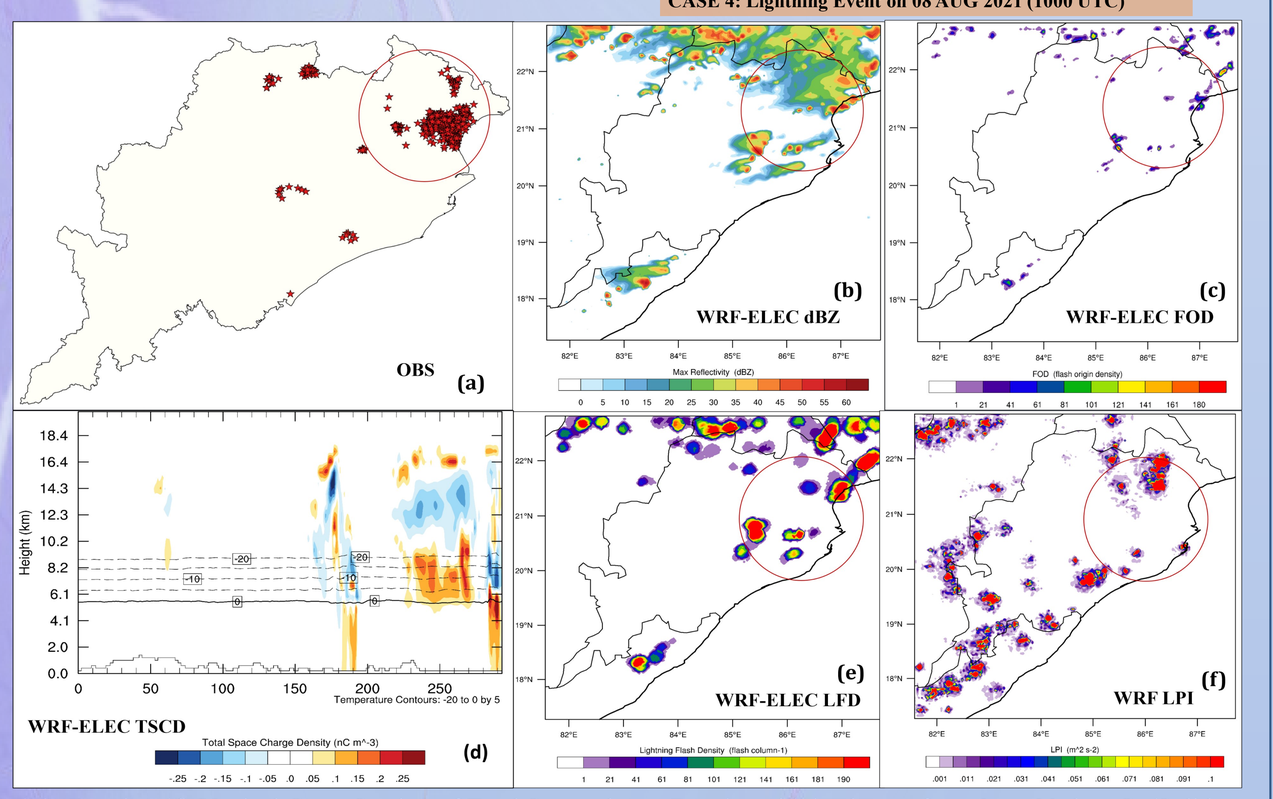


Fig 4. (a) IITM Accumulated Ground Based Lightning Flash Count (IC+CG), (b) Max Reflectivity (dBz), (c) Flash Origin Density, (d) Vertical Cross Section of Total Space charge Density with isotherms from 0 to -20 deg. C (Solid line shows 0 deg. C), (e) Lightning Density, (f) Lightning Potential Index (LPI) .

Results (b) Statistical Verification

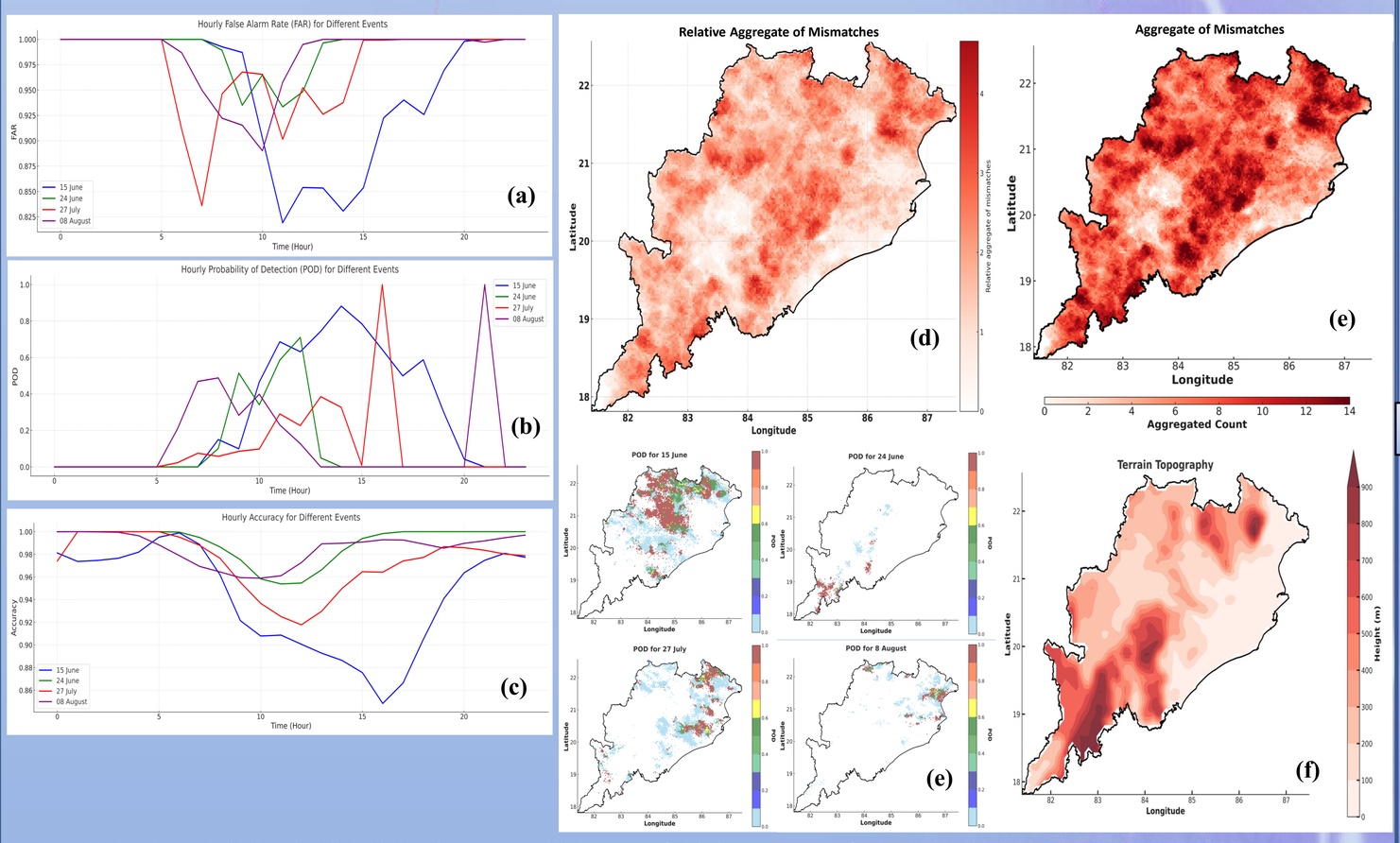


Fig 5. (a) Hourly FAR, (b) Hourly POD, (c) Hourly Accuracy, (d) Heatmap of Relative Aggregate of Mismatches, (e) Grid Point Average POD with IITM obs. Data, (e) Aggregate Geospatial trend of Mismatches, (f) Terrain of Odisha; the binary mismatch and terrain follow quite a resemblance.

Conclusion/Future Work

- The WRF-Elec model outperforms traditional LPI methods.
- Captures key metrics like lightning density and flash count.
- Aligns considerably well with ground-based observational data from IITM.
- The model's discrepancies over complex terrain could be due to either its 3 km resolution limitations in resolving topography or a lack of observational data.
- Future improvements could include data assimilation techniques to refine short-term rainfall and lightning forecasts.
- Exploring the model at a cloud-resolving scale (sub km grid resolution) may provide further insights into its capabilities.

References

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