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Lightning Nowcasting Using GLM and GOES-ABI Data in a High-Resolution Machine Learning-Based Predictive Model

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Lightning is a critical hazard affecting infrastructure, public safety, and operational sectors, including aviation and energy. Accurate nowcasting of lightning remains a challenge due to the rapid development of convective storms and limitations in current forecasting systems. This study proposes a novel, high-resolution lightning nowcasting model that leverages satellite-derived data from the Geostationary Lightning Mapper (GLM) and the Advanced Baseline Imager (ABI), both aboard NOAA's GOES-16 and GOES-19 satellites. By utilizing machine learning techniques, particularly linear models, the proposed method aims to provide interpretable and operationally feasible forecasts up to 120 minutes in advance. This research addresses the need for globally scalable and radar-independent forecasting systems, especially in data-sparse regions. GLM provides continuous, full-disk lightning detection, while ABI captures multispectral imagery indicative of cloud dynamics. Key features such as cloud-top cooling rates, brightness temperature differences (BTDs), and lightning flash density are extracted and processed on a unified 10 km spatiotemporal grid. Feature engineering incorporates both temporal evolution and local spatial context to enhance model sensitivity to convective initiation. The study prioritizes interpretable models, such as logistic regression and regularized linear classifiers, over deep learning methods, which, while powerful, are often computationally intensive. These linear models are trained to classify the likelihood of lightning occurrence and predict flash rates using a spatiotemporal block cross-validation strategy, ensuring robustness across different regions and meteorological conditions. The results include probabilistic nowcast maps, performance comparisons, and a detailed analysis of feature importance. By isolating the contributions of each satellite-derived variable, the study aims to clarify the physical processes associated with lightning occurrence and enhance early warning capabilities. This research proposes a scalable, explainable, and efficient nowcasting tool that enhances global lightning risk management. It aligns with international initiatives for satellite-based severe weather monitoring and promises significant operational benefits, particularly in regions with limited radar or ground-based lightning detection coverage.