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Short-term Precipitation Nowcasting Using Satellite Data and Deep Learning

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Short-term precipitation nowcasting is critical for meteorological disaster prevention, yet it remains a challenging task in operational forecasting. This study introduces the development and validation of a deep learning-based nowcasting system that leverages multi-source observational data from the Fengyun-4B (FY-4B) and GK-2A geostationary satellites. A full-stack implementation has been designed, covering data preparation, model training, and real-time forecast. The training model employs a spatiotemporal deep learning architecture based on Convolutional Long Short-Term Memory (ConvLSTM) method. Input features include temporally aligned Level 1 data from FY-4B visible and infrared channels, FY-4B cloud type products, GK-2A cloud physical retrievals, and surface precipitation observations with high spatiotemporal resolution of 4 km and 15 minutes. The model takes 3-hour continuous data as input and generates 1-hour precipitation forecasts. A key innovation is the design of a weighted loss function (Weighted Huber Loss) that incorporates precipitation-intensity-based adaptive weights and spatial consistency constraints to improve forecast skill, particularly for moderate-to-heavy precipitation events. The system architecture, code implementation, and debugging have been completed. Performance will be evaluated using several typical precipitation cases in China. Quantitative verification against observed precipitation will be conducted using the Fraction Skill Score (FSS), Threat Score (TS), Probability of Detection (POD), and False Alarm Ratio (FAR). The system is expected to demonstrate improved capability in capturing the intensity, location, and evolution of heavy precipitation cores. This work provides a comprehensive technical framework for the quantitative application of high-temporal-resolution satellite data.

Keywords: Precipitation Nowcasting, Satellite, Deep Learning, ConvLSTM

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