

Leveraging Passive Microwave Observations for Precipitation Nowcasting

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Satellite observations provide unique capability for real-time precipitation monitoring in regions lacking continuous radar coverage, making them critical for operational meteorology and hazard response. Current near-real-time precipitation products rely primarily on geostationary infrared observations because of their continuous temporal sampling. However, these measurements are only indirectly related to surface precipitation, as they mainly sense cloud-top properties, which fundamentally limits achievable retrieval accuracy.

To address this limitation, we present a machine-learning precipitation retrieval that fuses geostationary observations with polar-orbiting passive microwave (PMW) measurements. The proposed framework integrates information across sensors and time, allowing the retrieval to exploit PMW overpasses even when they occurred earlier. The retrieval is based on a convolutional neural network specifically designed to combine multi-spectral observations from multiple timesteps and heterogeneous sensors.

We evaluate the algorithm against gauge-corrected ground-radar precipitation estimates. Through systematic sensor-withholding experiments, we demonstrate that the retrieval remains robust under sparse observation conditions and can effectively utilize PMW information with time lags of up to three hours in some cases. Comparisons with single-sensor and single-timestep baselines show clear benefits from both temporal memory and cross-sensor information synergy. Although demonstrated using GOES observations over the Americas, the approach is globally applicable.

By enabling the effective use of intermittent PMW observations in real time, the proposed retrieval overcomes a key limitation of existing geostationary-only algorithms and improves exploitation of satellite information for precipitation monitoring. The algorithm will be released publicly to facilitate community adoption and further development.