Examining the Potential of Satellite Precipitation Product for Monitoring Extreme Urban Precipitation Events across Contiguous United States

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Urban environments modify local weather through land-surface change, thermal circulations, and atmospheric composition. Impervious surfaces, sparse vegetation, and dense building geometry alter roughness, wind flow, and boundary-layer structure, affecting precipitation and strengthening the urban heat island (UHI). The UHI in turn changes thermodynamic and dynamic conditions, influencing where convection develops within and around cities. Urban structures also act as mechanical barriers that reorganize storm motion, shift precipitation location, intensify precipitation intensity, and increase flood risk. Recent extreme precipitation in major U.S. cities highlights growing vulnerability; for example, parts of New York City recorded over 50 mm of rain in a day in October 2025, causing severe flash flooding. From 2020–2024, flooding produced roughly $15 billion in losses in the U.S. highlighting the need for accurate, high-resolution near-real-time monitoring. Therefore, this study will evaluate near-real-time (NRT) satellite precipitation product (SPP) performance for urban extremes (2021–2025) across diverse U.S. cities differing in population, urban extent, geography, and climate. To this end, we will analyze extreme precipitation events across diverse climatic and land-cover regimes using observational benchmarks from the Automated Surface Observing System (ASOS) and Global Precipitation Measurement (GPM) Ground Validation (GV) sites across the U.S. Extreme urban precipitation events will be evaluated using the NRT Integrated Multi-satellitE Retrievals for GPM (IMERG) product, which provides half-hourly estimates at ~10 km resolution.

The primary objectives of our work are: (1) Quantification of biases in the magnitude of urban extreme precipitation observed via IMERG through the intercomparison framework; (2) Evaluation of the performance of IMERG in capturing the timing and intensity of city-specific extreme precipitation regimes; and (3) Evaluate long-term trends in urban extreme precipitation using ground observations and assess how well IMERG reproduces them. The satellite estimates will be systematically compared with ASOS and GPM-GV gauges to quantify biases and uncertainties in precipitation magnitude, timing, and location. Evaluating SPP performance during urban extreme precipitation will quantify biases and improve confidence in their use for flood forecasting and mitigation, strengthening monitoring, real-time assessment, nowcasting, early-warning systems, and climate-resilient risk management across U.S. cities.