Radar-Guided Machine Learning Super-Resolution for Improved GSMaP Precipitation Estimates

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Keyword : Super-resolution, Precipitation estimates, Satellite remote sensing

Satellite-based precipitation products such as the Global Satellite Mapping of Precipitation (GSMaP) are widely used in hydrological and meteorological applications; however, their native spatial resolution remains insufficient for analyses requiring fine-scale rainfall variability. This study develops an AI-driven super-resolution framework to enhance the spatial detail of GSMaP while maintaining physical consistency.

A major challenge in precipitation super-resolution is the amplification of false rainfall signals, particularly under weak or intermittent conditions. To address this issue, the proposed machine learning model selectively enhances precipitation-related structures while suppressing non-precipitating patterns. The training process incorporates precipitation-sensitive features and ground-based weather radar precipitation data over Japan as high-resolution reference information. By learning rainfall-specific characteristics from radar observations, the framework effectively reduces spurious precipitation signals commonly introduced during high-resolution reconstruction.

Beyond spatial refinement, the super-resolution process improves the spatiotemporal consistency of GSMaP fields. Discontinuities associated with satellite overpass gaps and retrieval transitions are mitigated as the model learns coherent precipitation evolution across space and time. The resulting super-resolved product exhibits smoother spatial transitions and more continuous temporal behavior without excessive smoothing of intense rainfall events.

Evaluation over selected regions in Japan demonstrates that machine learning–based super-resolution can enhance both spatial realism and overall product quality. Future work will extend the framework to broader regions and additional datasets to assess its general applicability.

Acknowledgment
This work was supported by the 4th Research Announcement on the Earth Observations of the Japan Aerospace Exploration Agency (JAXA) (ER4GPF008).