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

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Objective

・GSMaP interpolates the gaps in precipitation observation network from multiple Passive Microwave (PMW) satellites using Geostationary Meteorological Satellites (GMS).

・The current GSMaP has a spatial resolution of 0.1° (approximately 10 km), which is insufficient for accurately estimating basin-scale precipitation.

・Therefore, the objective of this study is to super-resolve GSMaP using a machine learning model.

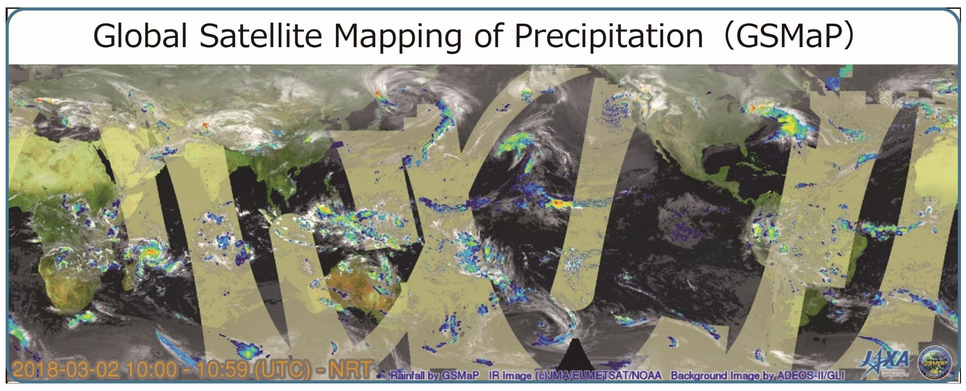


Fig. 1: A snapshot of GSMaP_MVK

Data

・In this study, we conducted a super-resolution experiment using machine learning to enhance the spatial resolution of GMI satellite precipitation observation data from 0.05° to 0.01°.

Input data	GPM GMI surface precipitation
Traning ground truth	XRAIN (ground-based radar observation)
Auxiliary data	land–sea mask data, elevation data, and Himawari-8 infrared multi-band observation data
Target period	May 2025 – October 2025
Improvement of spatial resolution	From the GMI of 0.05° (approximately 5 km) To 0.01° (approximately 1 km)

Table. 1: List of data used in the machine learning model

The super-resolution model architecture

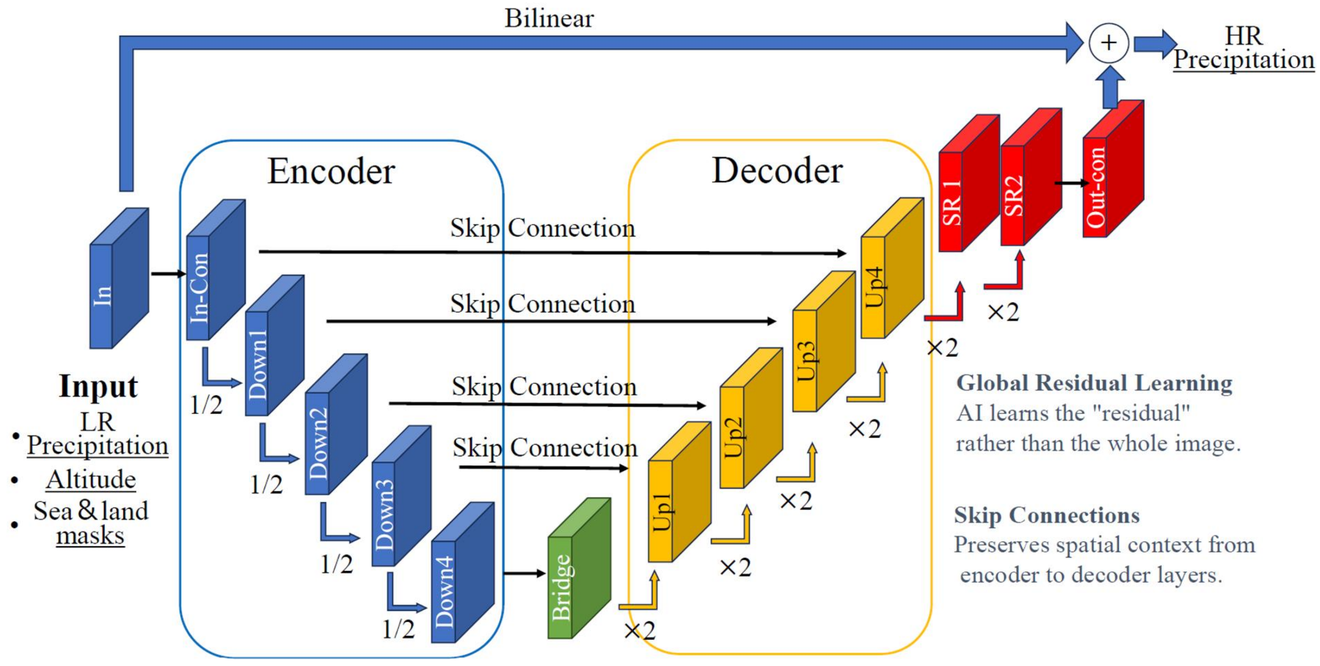


Fig. 2: Schematic diagram of the U-Net architecture for generating the initial field

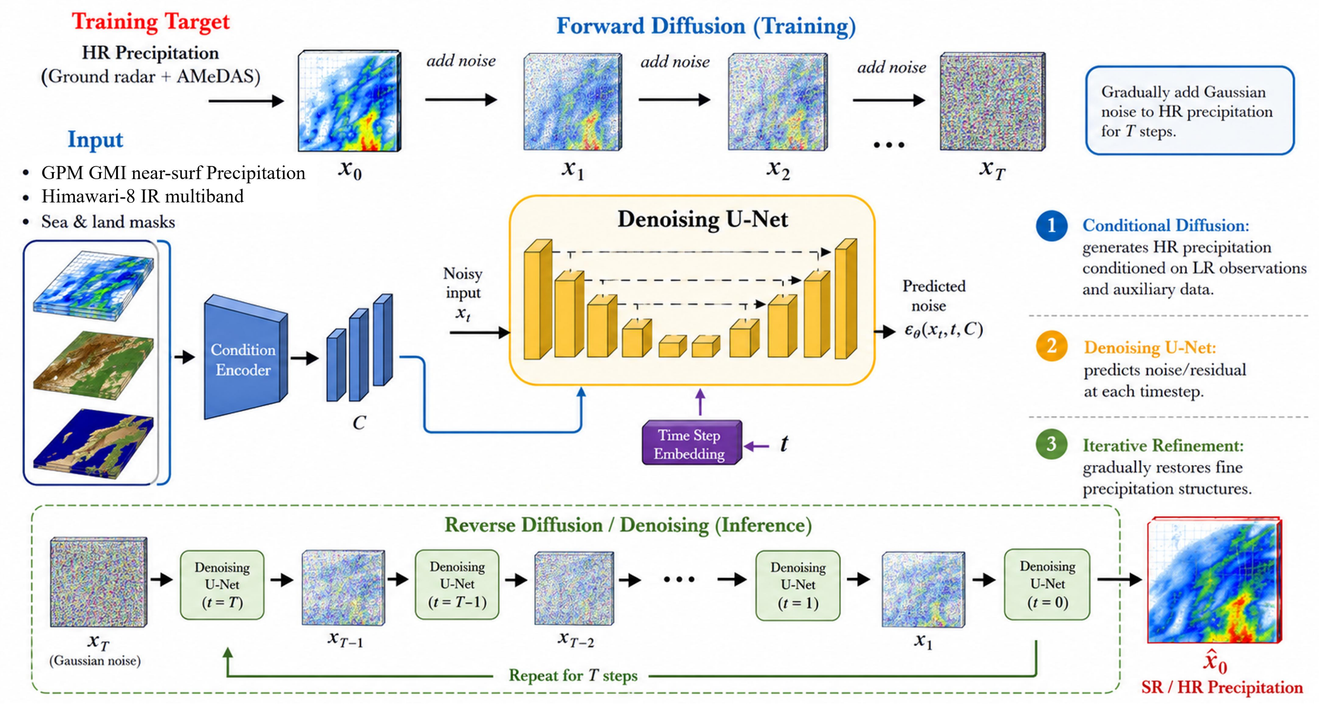


Fig. 3: Schematic diagram of the overall model structure including the diffusion model

Figure 4 shows the super-resolved result.

Input data were generated using U-net, and a diffusion model was applied.

The spatial resolution was improved from 0.05° to 0.01°.

The result was qualitatively in good agreement with the XRAIN ground truth.

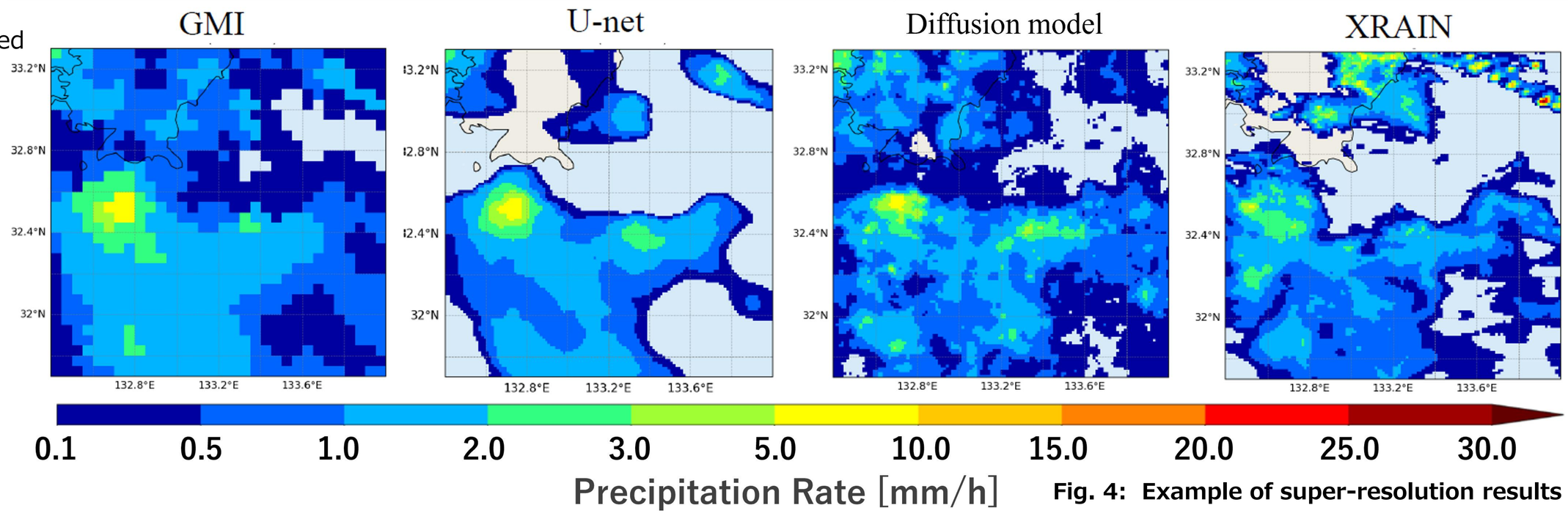


Fig. 4: Example of super-resolution results

Statistical Accuracy Evaluation for a Selected River Basin

Figure 5 evaluates the estimation accuracy of basin-scale precipitation.

The results show that the RMSE improved from 4.89 to 3.13, while the correlation coefficient improved from 0.47 to 0.65.

Figure 6 shows the results of comparing the power spectra, indicating that fine-scale precipitation structures were reproduced through super-resolution.

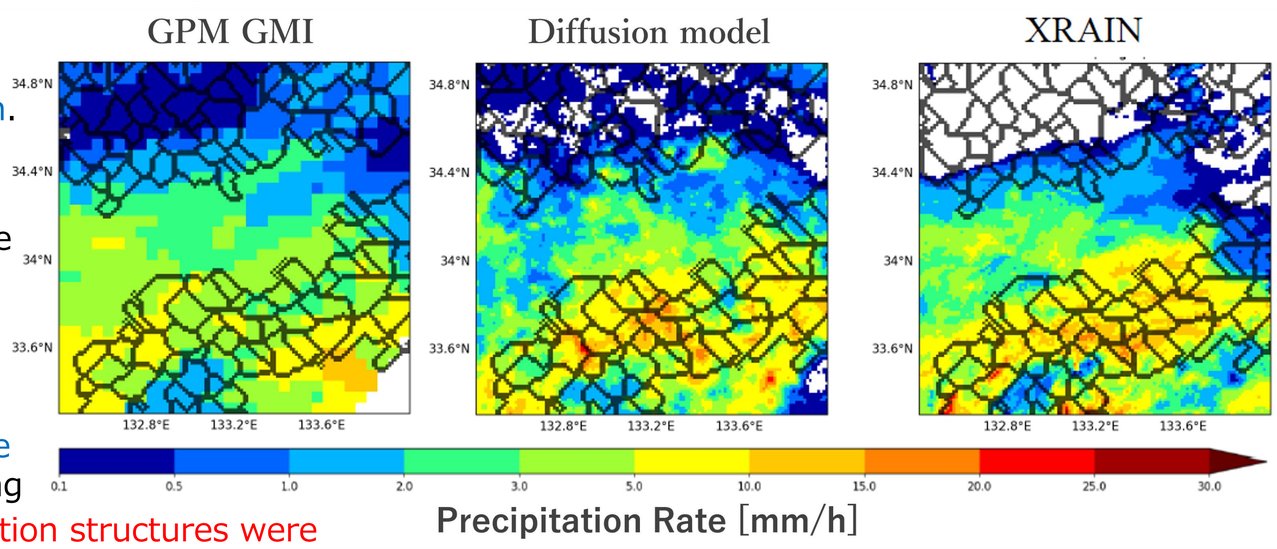
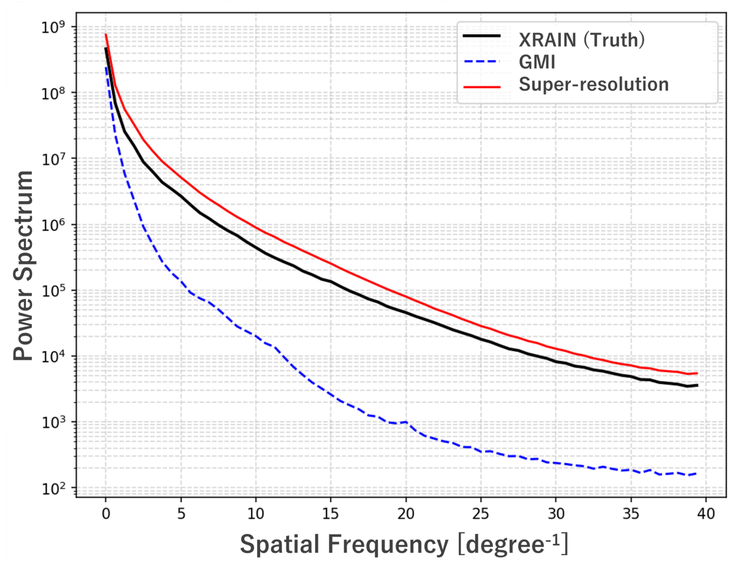


Fig. 5: Comparison results overlaid with a river basin

Fig. 6: Power Spectrum Comparison of results



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