P-76

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Advancing Extreme Precipitation Modeling Using Data Fusion and Machine Learning

■ Introduction

Climate change intensifies extreme precipitation events, posing severe risks to water-stressed subtropical regions. This study develops an integrated framework combining multi-source precipitation data fusion, machine learning-based downscaling, and physically consistent hydrological modeling. First, a high-resolution precipitation product (0.1° ×0.1°) is generated by merging ground observations with ERA5 reanalysis, significantly improving spatial accuracy and temporal consistency compared to leading satellite datasets. Next, satellite-gauge fusion supports the downscaling of climate model outputs using machine learning techniques, enabling the robust simulation of flood dynamics through SWAT+. The proposed workflow offers actionable insights for climate risk assessment and water resource management in vulnerable subtropical environments.

■ Research Activity

1. Data

The newly produced product (NPP) was validated against five widely used SPPs (IMERG, CHIRPS, PERSIANN-CDR/PDIR, SM2Rain-ASCAT) to assess its effectiveness in capturing extreme precipitation events across various spatial and temporal scales. Similarly, the fusion of PERSIANN-CCS with observed data supports downscaling of climate model outputs.

2. Methods

Developed a Novel Precipitation Product (NPP) by fusing satellite data with in-situ meteorological observations using Cressman interpolation method. To assess NPP's ability in capturing extreme precipitation events across various spatial and temporal scales eleven extreme precipitation indices were used.

Two machine learning models, Artificial Neural Networks (ANN) and Recurrent Neural Networks (RNN) were used to downscale precipitation from high resolutions GCMs in flood-prone region (Jiang et al., 2020). Machine learning models were trained and tested with respect to NPP.

Finally, these outcomes were then used as inputs for SWAT+ model to simulate streamflow and assess runoff responses. (Mishra et al., 2025).

■ Contribution of the study

Results highlight the superior performance of sequence-based models in capturing the magnitude, timing, and spatial variability of extreme events. The proposed workflow offers actionable insights for climate risk assessment and water resource management in vulnerable subtropical environments.

■ References

Jiang et al., (2020) Sequence-based statistical downscaling and its application to hydrologic simulations based on machine learning and big data https://doi.org/10.1016/j.jhydrol.2020.124875 J. Hydrology.

Debasish Mishra, et al., 2025 Advanced hydrological assessment with SWAT+ under climate change: An integrated framework over large climate-sensitive and reservoir-regulated watershed, Science of The Total Environment, Volume 994, 2025,180062,ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2025.180062.

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