DEVELOPING A HIGH-RESOLUTION GRIDDED PRECIPITATION DATASET FOR SRI LANKA BASED ON GRID SENSITIVITY TO STREAMFLOW ESTIMATIONS UNDER CLIMATE VULNERABILITY

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ABSTRACT

Developing a High-Resolution Gridded Precipitation Dataset for Sri Lanka based on Grid Sensitivity to Streamflow Estimations under Climate Vulnerability

Ground-based rain gauges remain the benchmark for accurate precipitation measurement; however, their sparse spatial distribution limits the representation of rainfall heterogeneity. Satellite-based precipitation products (SPPs) provide consistent spatial coverage but are often affected by retrieval errors and regional biases, restricting their direct use in local-scale hydrological applications. To overcome these limitations, precipitation data merging (PDM) techniques integrating gauge and satellite observations have gained prominence. This study introduces a novel machine learning framework, GraphIDW, which combines Graph Neural Networks (GNNs) with Inverse Distance Weighting (IDW) interpolation to explicitly incorporate spatial autocorrelation into the merging process, addressing a major limitation of traditional ML-based PDM approaches. The framework was evaluated across the Wet Zone of Sri Lanka from 2001 to 2015 using two state-of-the-art SPPs (IMERG and CHIRPS) together with ground observations. IMERG data (0.1°) were first downscaled to 0.05° using CHIRPS, after which the downscaled product was merged with gauge observations through GraphIDW. A total of 60 gauges (70%) were used for training and 28 (30%) for validation. Results show that GraphIDW outperforms conventional machine learning algorithms, including Random Forest, Artificial Neural Network, Support Vector Regression, and XGBoost. It achieved the highest probability of detection (0.97) and reduced root mean square error (RMSE) and mean absolute error (MAE) by 13-41% and 9-36%, respectively, compared with the original SPPs. The results demonstrate that explicitly accounting for spatial dependence through graph-based learning significantly improves precipitation estimation, particularly in regions characterised by strong spatial heterogeneity. By embedding spatial autocorrelation directly into the merging process, GraphIDW provides a robust and computationally efficient framework for generating high-resolution rainfall datasets that are better suited for hydrological analysis in complex climatic and topographic settings.

Keywords: **CHIRPS; GNN; IMERG; precipitation data merging; spatial autocorrelation**

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AMW	Active microwave
ANN	Artificial neural networks
BS	Bias score
CHIRPS	Climate hazards group infrared precipitation with stations
CMORPH	Climate prediction center morphing technique
CPC	Climate prediction center
CSI	Critical success index
DEM	Digital elevation model
DL	Deep learning
DML	Double machine learning
ELM	Extreme learning machines
GBDT	Gradient boosting decision tree
GCN	Graph convolutional network
GNN	Graph neural networks
GSMaP	Global satellite mapping of precipitation
GWL	Groundwater level
GWR	Geographically weighted regression
IDW	Inverse distance weighting
IM	Inter monsoon
IMERG	Integrated multi-satellite retrievals for GPM
KED	Kriging external drift
KNN	K-nearest neighbour
LSTM	Long short-term memory
LST	Land surface temperature
LSTday	Daytime land surface temperature
LSTnight	Nighttime land surface temperature
MAE	Mean absolute error
MGWR	Multiscale geographically weighted regression
ML	Machine learning

MLP	Multilayer perceptron
MPE	Multi-sensor precipitation estimation
MSWEP	Multi-source weighted-ensemble precipitation
NDVI	Normalised difference vegetation index
NEM	Northeast monsoon
OCK	Ordinary cokriging
OK	Ordinary kriging
PCC	Pearson’s correlation coefficient
PERSIANN	Precipitation estimation from remotely sensed information using artificial neural networks
PERSIANN-CCS	PERSIANN cloud classification system
PMW	Passive microwave
POD	Probability of detection
PRISM	Parameter-elevation regression of independent slopes model
RB%	Relative bias
RBF	Radial basis function
RF	Random forest
RFSI	Random forest spatial interpolation
RMSE	Root mean squared error
SPPs	Satellite-based precipitation products
SR	Success ratio
SVM	Support vector machines
SVR	Support vector regression
SWM	Southwest monsoon
TH	Thiessen polygon
TMPA	TRMM multi-satellite precipitation analysis
TPS	Thin plate splines
UK	Universal kriging
VIS/IR	Visible and infrared
XGBoost	Extreme gradient boosting