

**Supplementary Material**

**I. Prediction Assessment:**

We provided the evaluation findings of four models—GA-MLP, EFO-MLP, PSO-MLP, and AAEO-MLP—selected for their proficiency in forecasting monthly groundwater level (GWL). We employed four commonly used metrics (MAE, RMSE, R, NNSE) to assess accuracy and consistency. The assessment encompassed two datasets, IMD and IMERG, for the Bajpe and Surathkal wells, with the objective of assessing the models' adaptability across diverse data sources. Each model underwent ten runs with optimized parameters, and the average metric values, showcased in Table 1, present a comprehensive overview of their predictive performance, capturing the variability in their effectiveness.

Table 1 The mean results of performance metrics of all models in forecasting monthly GWL at Bajpe and Surathkal wells using IMD and IMERG datasets.

Well	Precipitation Data	Model	Train				Test			
			MAE (m)	RMSE (m)	R	NNSE	MAE (m)	RMSE (m)	R	NNSE
Bajpe	IMD	AAEO-MLP	0.740	1.012	0.907	0.838	1.627	2.042	0.870	0.708
		EFO-MLP	0.750	1.019	0.908	0.836	1.796	2.284	0.818	0.661
		GA-MLP	0.781	1.050	0.900	0.828	1.621	2.030	0.888	0.710
		PSO-MLP	0.935	1.220	0.853	0.781	1.724	2.135	0.830	0.690
	IMERG	AAEO-MLP	0.784	1.062	0.902	0.824	1.660	2.161	0.863	0.685
		EFO-MLP	0.775	1.044	0.908	0.829	1.681	2.239	0.836	0.669
		GA-MLP	0.846	1.112	0.889	0.811	1.586	2.015	0.906	0.713
		PSO-MLP	1.042	1.333	0.819	0.749	1.600	1.976	0.855	0.722
Surathkal	IMD	AAEO-MLP	0.407	0.721	0.854	0.755	1.366	1.950	0.480	0.502

# EGU General Assembly 2024

EGU24-14765: [Session HS 3.4]

<https://doi.org/10.5194/egusphere-egu24-14765>

		EFO-MLP	0.420	0.733	0.848	0.748	1.332	1.882	0.552	0.521
		GA-MLP	0.454	0.760	0.831	0.734	1.192	1.659	0.721	0.579
		PSO-MLP	0.588	0.870	0.733	0.679	1.178	1.579	0.713	0.603
	IMERG	AAEO-MLP	0.439	0.740	0.838	0.745	1.275	1.692	0.677	0.568
		EFO-MLP	0.436	0.740	0.840	0.745	1.266	1.696	0.683	0.569
		GA-MLP	0.457	0.768	0.824	0.730	1.135	1.579	0.785	0.602
		PSO-MLP	0.597	0.899	0.711	0.664	1.128	1.548	0.762	0.612

## II Model Stability:

The standard deviation quantifies the diversity in the model's performance, revealing how consistent its predictions are. Smaller standard deviation figures suggest a more reliable model with less fluctuation in outcomes. Table 4 displays standard deviation values for metrics like MAE, RMSE, R, and NNSE. It presents these values for each model utilizing both IMD and IMERG datasets for the Bajpe and Surathkal wells.

Table 2 The standard deviation of the performance metrics of all models forecasting monthly GWL at Bajpe and Surathkal wells using IMD and IMERG datasets.

Well	Precipitation Data	Model	Train				Test			
			MAE (m)	RMSE (m)	R	NNSE	MAE (m)	RMSE (m)	R	NNSE
Bajpe	IMD	AAEO-MLP	0.028	0.033	0.008	0.009	0.107	0.180	0.035	0.036
		EFO-MLP	0.054	0.052	0.012	0.014	0.248	0.374	0.072	0.070
		GA-MLP	0.031	0.026	0.007	0.007	0.100	0.131	0.021	0.026
		PSO-MLP	0.065	0.073	0.023	0.020	0.200	0.269	0.094	0.053
	IMERG	AAEO-MLP	0.029	0.025	0.007	0.007	0.195	0.311	0.073	0.061
		EFO-	0.030	0.025	0.008	0.007	0.186	0.340	0.094	0.065

# EGU General Assembly 2024

EGU24-14765: [Session HS 3.4]

<https://doi.org/10.5194/egusphere-egu24-14765>

		MLP								
		GA-MLP	0.021	0.023	0.006	0.006	0.127	0.190	0.029	0.039
		PSO-MLP	0.123	0.117	0.037	0.033	0.231	0.387	0.100	0.074
Surathkal	IMD	AAEO-MLP	0.017	0.011	0.008	0.006	0.148	0.292	0.197	0.075
		EFO-MLP	0.019	0.013	0.009	0.007	0.193	0.321	0.227	0.081
		GA-MLP	0.015	0.006	0.007	0.003	0.091	0.163	0.134	0.046
		PSO-MLP	0.068	0.056	0.049	0.028	0.113	0.169	0.091	0.051
	IMERG	AAEO-MLP	0.023	0.014	0.009	0.007	0.046	0.081	0.041	0.023
		EFO-MLP	0.022	0.016	0.010	0.008	0.131	0.173	0.130	0.049
		GA-MLP	0.007	0.006	0.004	0.003	0.058	0.072	0.047	0.021
		PSO-MLP	0.052	0.043	0.033	0.021	0.075	0.110	0.057	0.033

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