



Support Vector Regression model to predict TEC from GNSS Signals

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Ionospheric Total Electron Content (TEC) predominantly affects the radio wave communication and navigation links of Global Navigation satellite systems (GNSS). The ionospheric TEC exhibits a complex spatial-temporal pattern over equatorial and low latitude regions, which are difficult to predict for providing early warning alerts to GNSS users. Machine Learning (ML) techniques have been proven better for ionospheric space weather predictions due to their ability to process and learning from the available datasets of solar-geophysical data. Hence, a supervised ML algorithm such as the Support Vector Regression (SVR) model is proposed in this paper to predict the ionospheric TEC over northern equatorial and low latitudinal GNSS stations. The vertical TEC data estimated from GPS measurements for the entire 24th solar cycle period, 11 years (2009-2019), were considered over Bengaluru and Hyderabad International GNSS Service (IGS) stations. The performance of the proposed SVR model with Gaussian or Radial Basis Function (RBF) as the kernel is evaluated over the two selected testing periods during the High Solar Activity (HAS) period, 2014 year, and during the Low Solar Activity (LSA) period, 2019 year. The proposed model performance is compared with Neural Networks (N.N.) model, NeQuick-G model, and International Reference Ionosphere (IRI-2016) model during both Low Solar Activity (LSA, 2019) and High Solar Activity (HSA, 2014) periods. It is noticed that the proposed SVR model has well predicted the VTEC values better than N.N. model, IRI-2016 model and NeQuick-G model. The experimental results of the SVR model evidenced that it could be an effective tool for predicting ionospheric space weather over Indian equatorial and low latitude GNSS stations. The results are shown in the table below.

Table 1. Statistical parameters for TEC error analysis from the different models during HSA and LSA periods

Models	Bengaluru -LSA (2019)					Hyderabad -LSA (2019)				
	MAE	MAPE	MSD	R ²	RMSE	MAE	MAPE	MSD	R ²	RMSE
NN	2.14	23.87	9.03	0.88	3.00	2.80	31.02	16.88	0.82	4.09
IRI	3.19	50.08	17.76	0.87	4.03	5.39	52.2	56.68	0.79	7.52
NeQ-G	3.95	74.97	31.71	0.59	5.63	3.86	45.01	30.84	0.67	5.55
SVR	0.21	4.72	0.07	0.99	0.26	0.26	8.72	0.12	0.99	0.17
	Bengaluru- HSA (2014)					Hyderabad- HSA (2014)				
	MAE	MAPE	MSD	R ²	RMSE	MAE	MAPE	MSD	R ²	RMSE
NN	6.93	9.86	81.37	0.84	9.02	7.69	28.67	97.02	0.79	13.14
IRI	8.96	16.5	93.22	0.81	11.96	10.79	70.96	70.77	0.72	14.01
NeQ-G	10.89	13.8	91.52	0.69	13.83	10.72	63.18	93.24	0.71	13.90
SVR	5.35	8.22	80.23	0.85	1.62	1.94	8.01	12.81	0.82	1.79