PREDICTION OF TOTAL ELECTRON CONTENT OVER SOUTH AFRICA USING GLOBAL POSITIONING SYSTEM AND NEURAL NETWORKS

John Bosco Habarulema[a,b,c], Lee-Anne McKinnell[a,b], Pierre Cilliers[a], Ben Opperman[a]

[a] Hermanus Magnetic Observatory, 7200 Hermanus, South Africa
[b] Department of Physics and Electronics, Rhodes University, 6140 Grahamstown, South Africa
[c] NASSP, University of Cape Town, 7201 Rondebosch, Cape Town, South Africa

1. INTRODUCTION

The Global Positioning System (GPS) makes it possible to study the dynamics of the ionosphere by supplementing ionospheric studies carried out using various techniques including ionosondes, incoherent scatter radars and low earth orbit satellites. Total electron content derived from GPS data (GPS TEC) is a key parameter characterising the ionosphere. Its time evolution provides an indication of ionospheric variability. Temporal and spatial total electron content (TEC) variations have significant effects on radio communications, applications involving navigational systems, GPS surveying and space weather. The analysis presented in this paper compared predicted Neural Network predictions of TEC with TEC values from the IRI-2001 version of the International Reference Ionosphere (IRI), validating GPS TEC with ionosonde TEC (ITEC) and assessing the performance of the NN model during equinoxes and solstices.

2. NEURAL NETWORKS

Neural Networks are information processing systems which permit the modelling and prediction of complex nonlinear systems such as the various interlinked elements of space weather which result in the variability of TEC [1]. In the study to be presented in this paper, NN are used for the prediction of South African GPS derived TEC. The input space for the NN was developed from the parameters that we know to affect GPS TEC such as seasonal variation, solar activity, magnetic activity, diurnal variation and geographic position of the GPS receiver. A model has been developed to predict the GPS TEC at a single location, at a particular time (10h00 UT). The seasonal and diurnal variations are represented by the day number (DN) and hour (HR). The magnetic activity is represented by an index derived from K-index recorded by the Hermanus Magnetic Observatory in South Africa. The solar activity is represented by the Sunspot Number (SSN). The output of the NN was the GPS TEC. The NN was trained with GPS TEC data derived from the South African network of GPS receivers for the period 200-2004. The optimum NN was determined by minimising the Root Mean Square Error (RMSE) between the predicted and measured GPS TEC of the training set.

3. RESULTS

The results obtained with the 10h00 UT model, as shown in Figure 1, indicate that NNs are very suitable for predicting the GPS TEC values at locations within South Africa. Our results show that within the confines of our input space, NNs predict GPS TEC more accurately than the IRI at South African GPS locations for the period 2000-2004 [2].

4. REFERENCES

[1] Haykin S. Neural Networks, A Comprehensive Foundation. Macmillan College Publishing Company, 1994.
[2] Habarulema J-B, McKinnell L-A, Cilliers PJ, Prediction of global positioning system total electron content using Neural Networks over South Africa, Journal of Atmospheric and Solar-Terrestrial Physics 69 (2007), 1842–1850.

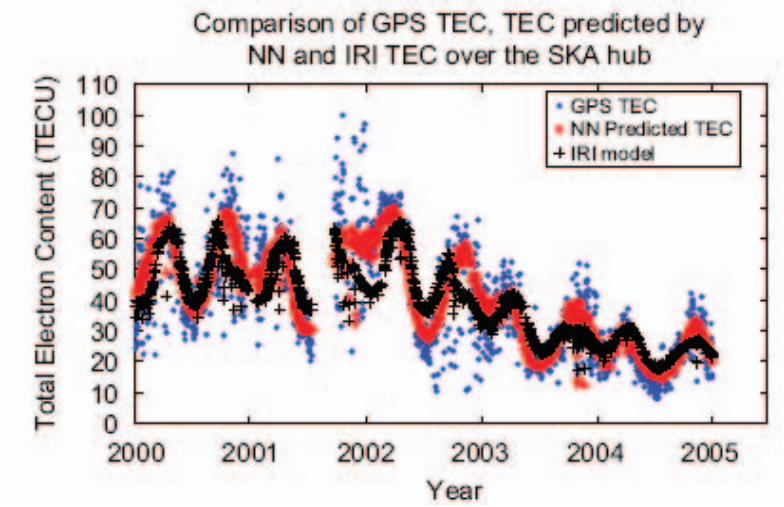

Figure 1. Variation of local noon GPS TEC, IRI TEC and TEC predicted by the NN. The comparison is in terms of TEC in TEC units (1 TECU = 10^{16} electrons/m^2) with day number for the period of five years (2000–2004).