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Author: Ms. Manar Anwer Abusirdaneh
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates, u18102992@sharjah.ac.ae

Dr. Muhammad Mubasshir Shaikh
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates, mshaikh@sharjah.ac.ae
Mr. Abdollah Darya
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates, adarya@sharjah.ac.ae
Mr. Sultan Suhail
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates, shalawa@sharjah.ac.ae
Prof. Ilias Fernini
Sharjah Academy for Astronomy, Space Sciences and Technology (SAASST), United Arab Emirates, ifernini@sharjah.ac.ae

RECONSTRUCTION OF INCOHERENT SCATTER RADAR VERTICAL ELECTRON DENSITY PROFILES USING REGRESSION TREES

Abstract

The key point to understanding the ionospheric variability caused by the solar and geomagnetic space weather is the ability to rapidly determine accurate electron density profiles wherever necessary across the globe. However, developing a high-predictability model that accurately predicts electron density is still challenging. This study proposes a technique to reliably reconstruct ionospheric vertical electron density profiles for corrupted and missing incoherent scatter radar (ISR) data using a machine-learning-based technique, particularly regression trees (RT). The technique is built using an extensive dataset that includes observations from the Jicamarca ISR ranging from 1966 to 2020, collocated GNSS radio occultation data during 2007 - 2020, and collocated ground-based vertical incidence sounding (ionosonde) data. For training and validation, we have used data from 1966 to 2019, whereas the 2020 data has been used as a test data set. To include the solar and geomagnetic activity information, we have used the F10.7 (solar radio noise flux at 10.7 cm wavelength) index and the disturbance storm time (Dst) index. Only data from geomagnetically quiet times are considered in this work.
Regression trees (RT), boosted RT and bagged RT are the three models used in this work. The proposed machine learning model best suited for our technique is the bagged RT. Our initial results show that the minimum root mean square error (RMSE) was obtained when using bagged RT with a value of 0.1023. Furthermore, the R-squared values for the three different models were within the range (0.60 - 0.65), with 0.63 for the bagged RT. However, after applying Bayesian optimization on the bagged RT, the R-squared value increased to 0.70. These initial findings indicate the ability of the proposed model to reconstruct ionospheric vertical electron density profiles in a considerably accurate manner. However, further optimizations and enhancements in the hyperparameters selection are being done. Therefore, the results of our model are expected to improve significantly.