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F10.7 Solar Radio Flux Prediction using a Multi-Stage Self-Organizing Map-Autoencoder-LSTM Model

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F10.7 is a solar radio flux measured at a wavelength of 10.7, which represents the vital proxy of solar activity. In this study, the impact of solar ultraviolet (UV) radiation on the upper atmosphere of Earth is considered by F10.7. This study aims to develop a predictive system for solar radio flux at F10.7 for short-term prediction from 1 to 3 days ahead. We implemented a multi-stage learning model to improve the short-term forecast of solar radio flux at F10.7. In the previous study, we explored a total solar irradiance forecast using a self-organizing map-autoencoder-LSTM model. In this study, we extend this approach to forecast solar radio flux at F10.7 using the same self-organizing map-autoencoder-LSTM model. We applied a self-organizing map (SOM) to cluster and segment the solar image features of continuum images, magnetograms. The μ maps represent the heliocentric angular parameter as an additional input channel alongside continuum images and magnetograms to account for center-to-limb variation and spatial projection effects across the solar disk. This model generates the feature map that serves as input to the autoencoder (AE) model. The encoder is used to reduce feature dimension and extract the compressed features. The compressed latent features are further integrated with the lagged solar radio flux at F10.7 to represent the input of a long short-term memory (LSTM) network to perform the prediction of solar radio flux at F10.7 for a few days ahead.

To the best of our knowledge, this study represents the first implementation of a SOM-AE-LSTM framework to forecast solar radio flux at F10.7. The proposed hybrid data-driven framework complements the existing F10.7 solar radio flux reconstruction and modeling approaches by integrating image-based solar information with lagged solar radio flux at F10.7.

We evaluated the performance of this model using the mean squared error (MSE), the root mean squared error (RMSE), the correlation coefficient (R), the determination coefficient (R2), and the mean absolute percentage error (MAPE) as performance metrics. We execute the forecast performances with the baseline and benchmark models, and conduct the ablation study to quantify the contribution of each component of the proposed architecture for this study.

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