

Nonlinear Interdependence features in Solar wind parameters influencing geomagnetic activity during geomagnetic storm

Oludehinwa Irewola^{1,1}, Olusola Isaac^{1,1}, Segun Bolaji^{2,2}, and Olumide Odeyemi^{1,1}

¹University of Lagos

²Ionospheric and Space Physics Laboratory, Department of Physics, University of Lagos, Nigeria.

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Abstract

In this study, we examine the nonlinear interdependence between the parameters of the solar wind influencing geomagnetic activity (proton density and solar wind dynamic pressure, IMF Bz and solar wind dynamic pressure) and geomagnetic activity (AE and SYM-H) during pre-storm, storm and post-storm of intense, major, moderate and minor geomagnetic storms. Nonlinear analytical tools comprising cross recurrence plot (CRP) and Recurrence Rate (RR) was used to capture the features of nonlinear interdependence in the time series data of the solar wind parameter (solar wind dynamic pressure, IMF Bz and proton density) and geomagnetic indices (AE and SYM-H). The pearson correlation coefficient was also used to reveal the features of linear dependence between the parameters of the solar wind during the different categories of geomagnetic storms. Our result shows that during the storm, the CRPs of the solar wind parameters investigated pictured a strong deterministic structure of CRP which is an indication of strong interdependence. In particular, the results of our analysis showed that the solar wind dynamic pressure and proton density depicted very strong interdependence features. On the other hand, during pre-storm and post-storm, the CRP of solar wind dynamic pressure in relation to IMF Bz and proton density pictured a rare deterministic structure signifying weak interdependence. Furthermore, the values of RR were very high (an indication of strong interdependence between the parameters of the solar wind) during the storm while at pre-storm and post-storm, the values of RR declined significantly in most of the periods which further strengthened the evidence of weak interdependence in the parameters of solar wind. The CRP and RR of the geomagnetic indices (AE and SYM-H) reveals no significant difference between pre-storm, storm and post-storm of the different categories of geomagnetic storms. However, strong interdependence between the geomagnetic indices were observed in most of the periods investigated. Finally, the pearson correlation coefficient reveals high values of linear dependence between the solar wind parameters without any significant difference between pre-storm, storm and post-storm periods during intense, major, moderate and minor geomagnetic storms.

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In this study, we examine the nonlinear interdependence between the parameters of the solar wind influencing geomagnetic activity (proton density and solar wind dynamic pressure, IMF Bz and solar wind dynamic pressure) and geomagnetic activity (AE and SYM-H) during pre-storm, storm and post-storm of intense, major, moderate and minor geomagnetic storms. Nonlinear analytical tools comprising cross recurrence plot (CRP) and Recurrence Rate (RR) was used to capture the features of nonlinear interdependence in the time series data of the solar wind parameter (solar wind dynamic pressure, IMF Bz and proton density) and geomagnetic indices (AE and SYM-H). The pearson correlation coefficient was also used to reveal the features of linear dependence between the parameters of the solar wind during the different categories of geomagnetic storms. Our result shows that during the storm, the CRPs of the solar wind parameters investigated pictured a strong deterministic structure of CRP which is an indication of strong interdependence. In particular, the results of our analysis showed that the solar wind dynamic pressure and proton density depicted very strong interdependence features. On the other hand, during pre-storm and post-storm, the CRP of solar wind dynamic pressure in relation to IMF Bz and proton density pictured a rare deterministic structure signifying weak interdependence. Furthermore, the values of RR were very high (an indication of strong interdependence between the parameters of the solar wind) during the storm while at pre-storm and post-storm, the values of RR declined significantly in most of the periods which further strengthened the evidence of weak interdependence in the parameters of solar wind. The CRP and RR of the geomagnetic indices (AE and SYM-H) reveals no significant difference between pre-storm, storm and post-storm of the different categories of geomagnetic storms. However, strong interdependence between the geomagnetic indices were observed in most of the periods investigated. Finally, the pearson correlation coefficient reveals high values of linear dependence between the solar wind parameters without any significant difference between pre-storm, storm and post-storm periods during intense, major, moderate and minor geomagnetic storms.