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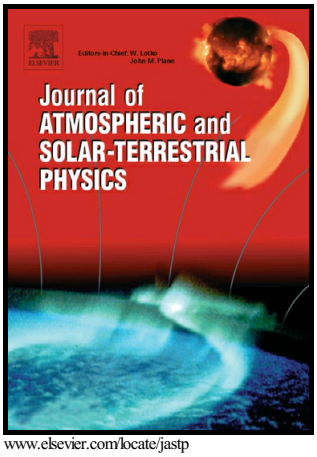

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Quantification of scaling exponents and dynamical complexity of microwave refractivity in a tropical climate

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Abstract

Radio refractivity index is used to quantify the effect of atmospheric parameters in communication systems. Scaling and dynamical complexities of radio refractivity across different climatic zones of Nigeria have been studied. Scaling property of the radio refractivity across Nigeria was estimated from the Hurst Exponent obtained using two different scaling methods namely: The Rescaled Range (R/S) and the detrended fluctuation analysis(DFA). The delay vector variance (DVV), Largest Lyapunov Exponent (λ_1) and Correlation Dimension (D_2) methods were used to investigate nonlinearity and the results confirm the presence of deterministic nonlinear profile in the radio refractivity time series. The recurrence quantification analysis (RQA) was used to quantify the degree of chaoticity in the radio refractivity across the different climatic zones. RQA was found to be a good measure for identifying unique fingerprint and signature of chaotic time series data. Microwave radio refractivity was found to be persistent and chaotic in all the study locations. The dynamics of radio refractivity increases in complexity and chaoticity from the Coastal region towards the Sahelian climate. The design, development and deployment of robust and reliable microwave communication link in the region will be greatly affected by the chaotic nature of radio refractivity in the region.

Keywords: delay vector variance, radio refractivity, recurrence quantification analysis, Hurst exponent, tropical climate, climate change
2010 MSC: 00-01, 99-00

1. Introduction

Natural time series show complex dynamics which available linear tools could not explain. The postulate of Weber et al. (1995) that the atmosphere might be governed by low dimensional chaotic attractors led to the quest to understand the dynamics of our atmosphere by several researchers using diverse tools. Low dimension chaos has been found and reported in several natural time series such as temperature (Ray et al., 2016b), rainfall (Sivakumar et al., 2006), boundary layer dynamics (Campanharo et al., 2008; Mukherjee et al., 2013), El-Nino (Kawamura et al., 1998), sunspot (Panchev & Tsekov, 2007), solar radiation (Ogunjo et al., 2015), wind speed (Samet & Marzbani, 2014) etc. These results gives better insight into understanding our atmosphere. However, much attention has not been paid to the dynamics of atmospheric parameters such as rainfall, temperature and humidity in the tropical region. Dynamical complexity of weather parameters in the tropics will give better understanding into the rapidly changing and dynamical complex systems contributing to driving the tropical climate.

Nigeria is a tropical country located in West Africa between latitude $4^o - 14^oN$ and longitudes $2^o - 15^oE$. The climate of Nigeria can be regarded as a microcosm of West African climate with the major climatic zones represented. It is bounded by the Atlantic Ocean, Cameroon, Benin Republic and Niger Republic in

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