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Tropospheric influence on dropped calls in mobile networks

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Abstract

It is common knowledge that tropospheric variables affect signals, thereby distorting coverage. Since the major factor affecting dropped calls is coverage and the penetration depth of the signal strength transmitted by a wireless system determines its coverage, therefore, there is a tendency for tropospheric variables to affect dropped calls. This research investigates the effects of relative humidity, wind speed, rainfall and temperature on dropped calls for four mobile networks (MTN, Airtel, Globacom and 9mobile) in Cross River State, Nigeria. Six years data of weather variables collected from the Nigerian Meteorological Agency (NiMet), Cross River State and six years Drop Call Rate (DCR) data obtained from the telecommunications regulatory body, Nigerian Communication Commission (NCC), was used for this study, both spanning from January 2015 to December 2020. From the collected data, graphs were plotted and, in each case, the DCR of the mobile networks were the dependent variables while the tropospheric variables were the independent variables. Also, regression models were obtained to forecast the DCR of each network, provided the tropospheric variable at each given period is known. Finally, the variables were correlated to give a picture of how each tropospheric variable related to the DCR of the mobile networks. For MTN and 9mobile networks, a low positive correlation was obtained for rainfall and relative humidity, a highly positive correlation was obtained for wind speed while a lowly negative correlation was obtained for temperature. For Airtel network, a moderately negative correlation exists between DCR and relative humidity/temperature while a low positive relationship existed for rainfall. However, a low negative relationship was observed for wind speed. For Globacom network, a moderately negative and a moderately positive relationship was obtained for rainfall and relative humidity respectively while a highly positive and a lowly negative correlation was obtained for temperature/wind speed against DCR. This result will be very useful to the meteorologist, mobile network planners and the network operators.

Keywords: Drop Calls; Drop Call Rate; Tropospheric Variables; Mobile Networks; Service Retainability; Quality of Service

1. Introduction

The increasing poor Quality of Service (QoS) rendered by telecommunication operators in Nigeria is worrisome and frustrating. Cellular network subscribers' resort to purchasing Subscribers Identity Module (SIM) cards of all existing cellular network operators, as one cannot predict when one will obtain good QoS from any of the telecommunication operators. To judge mobile network QoS, regulatory authorities and telecommunication operators, use Key Performance Indicators (KPIs), which hinges on the end user's perspective [1]. These KPIs are classified into service reliability [2], service integrity [3], service accessibility, service mobility and service retainability [4].

One major KPI investigated under service retainability is the drop call. A drop call is a call that aborts prematurely before being released normally by either the caller or called party. That is, the call is dropped before the exchange of Released

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Message "RL_M" and Released Complete Message "RLC_M" in the signaling flow. An appraisal of the aggregate of dropped calls is termed the Drop Call Rate (DCR), which is the amount of dropped calls divided by the sum total of call attempts [5]. Dropped calls are effectuated by degraded signal quality around the precincts of a mobile phone [6], instability in received signal strength [7] and coverage [8].

Telecommunication providers deploy voice services using radio signals and the network is dispersed over large areas known as cells. Each cell has a minimum of a fixed location transceiver, usually called a base station. These transceivers furnish the cells with the network coverage usually relied upon for voice transmission. To ensure good QoS and to outmanoeuvre interference, distinct set of frequencies from the neighbouring cells are used for signal propagation [9]. This cellular network provides signal strength to a mobile phone and these strengths fluctuate with weather [10].

Varying weather conditions affect major KPIs such as service accessibility and retain ability and this causes drastic degradation in system performance [11], leading to lack of coverage, distortion in link quality and therefore, poor QoS [12-13]. In order to achieve good QoS, minimal fluctuations in signal is required to avert higher rate of dropped calls [10]. Therefore, it is essential to explore the factors affecting radio link quality in order to attenuate their influence [14].

The technical factors affecting the QoS of mobile networks have been investigated [15-18]. The effect of tropospheric parameters on telecommunication signals have also been studied [19-24] and its impact has been analyzed [25-42]. Since the knowledge of atmospheric characteristics for service retainability is necessary, the International Telecommunication Union Radio Communications (ITUR) maintains a database for atmospheric characteristics around the world and this is used to estimate weather attenuations and other parameters [35].

From the available literature, no work has been done on the effect of tropospheric variables on mobile network KPIs, except on received signal strength. Again, we deduced that the received signal strength of a cellular system, defines the network penetration level and therefore, its coverage [43-44]. Studies further reveal that voice services of the cellular system depends on network coverage. Since the major factor affecting drop calls is coverage and the penetration depth of the signal strength transmitted by a wireless system determines its coverage, therefore, there is a tendency for tropospheric variables to have effects on drop calls.

It is therefore indispensable to traverse the innumerable factors influencing the link quality in cellular communication systems in order to take the necessary measures and adaptation options to alleviating and controlling its effects. In this study, we are looking into drop calls and how it is affected by four tropospheric variables; wind speed, temperature, relative humidity and rainfall.

2. Material and methods

This work investigates how relative humidity, wind speed, rainfall and temperature affect dropped calls in mobile networks. Four mobile networks are investigated in this study; they are MTN network, 9mobile network, Glo network and Airtel network.

The research is carried out in Cross River State, Nigeria. 72 months radiosonde data for Cross River State, obtained from the Nigerian Meteorological Agency (NiMet), is used for this study. These data contain monthly tropospheric data that spans from January 2015 to December 2020.

Furthermore, drop calls data measured through sophisticated counters embedded in the base stations of mobile networks in Cross River State were obtained from the Nigerian Communication Commission. These data spans from January 2015 to December 2020.

The obtained tropospheric and DCR data were then subjected to statistical analyses to obtain a relationship between both variables. A correlation analysis was done to obtain the degree of relationship between the variables investigated while a regression analysis was done to establish a relationship between the variables investigated, as well as to enable us predict and forecast when to expect drop calls or not.

3. Results and discussion

This section is divided into four parts. We shall first analyze the effect of relative humidity on call setup for the four networks, followed by the effect of wind speed, rainfall and finally, temperature.

3.1. Effects of Relative Humidity on Drop Calls

In this part, figure 1 shows a graph of DCR against relative humidity plotted for MTN network. A weak positive correlation value of 0.11 was obtained. A regression model to predict possible call setup was obtained as D = 0.01R – 0.34 for MTN users. A graph of DCR against relative humidity for Airtel network was revealed in figure 2. A moderately negative correlation value of – 0.55 was developed with a regression model D = - 0.02R + 2.25 for Airtel users to forecast when it is accurate to make calls. Figure 3 sets forth a graph of DCR against relative humidity for Globacom network. A regression equation, D = 0.17R – 13.40 and a moderately positive correlation value, 0.34 were obtained. A graph of DCR against relative humidity for 9mobile network is presented in figure 4, with a weak positive correlation value of 0.28 and regression equation of D = 0.03R – 1.70. In each regression model developed, D depicts DCR while R stands for relative humidity. Therefore, at a known value of relative humidity, it is possible to predict the probability of having dropped calls.

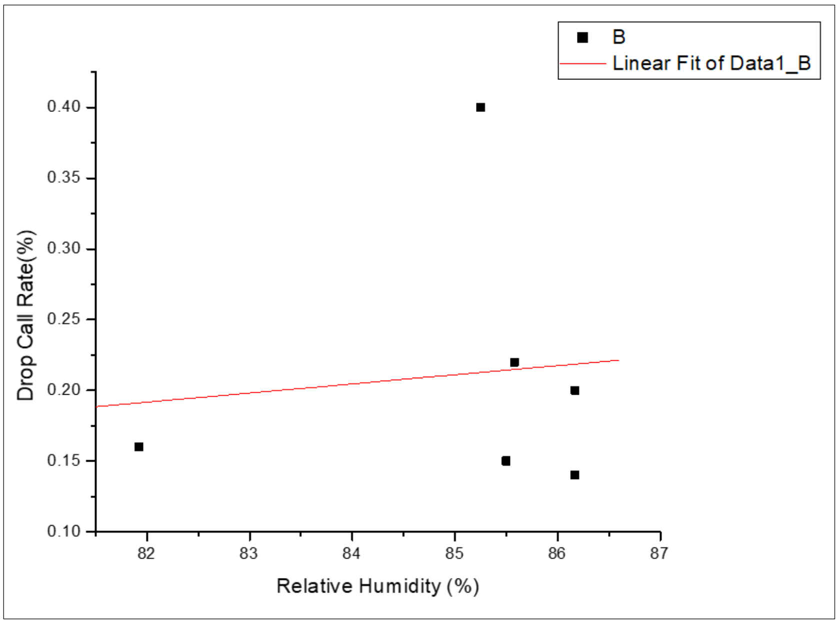

Figure 1 Graph of DCR against Relative Humidity for MTN Network

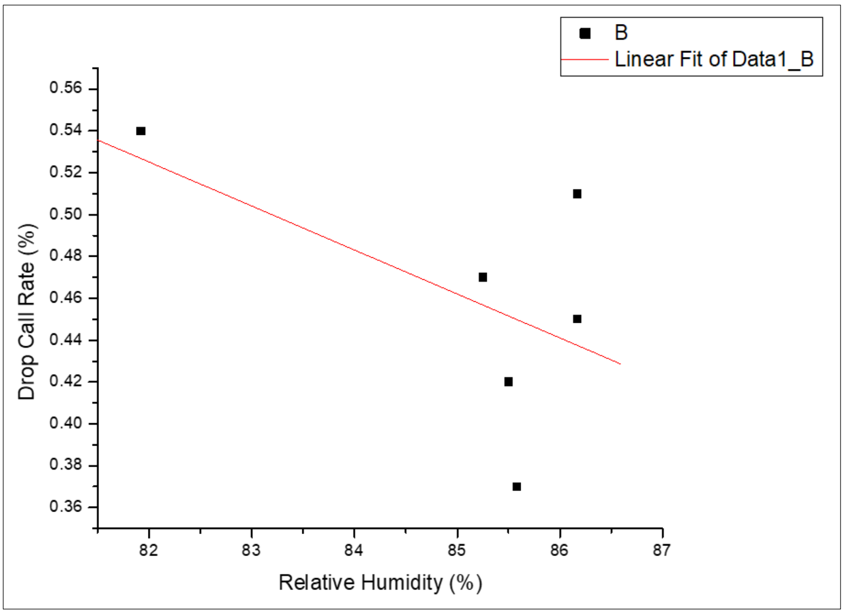

Figure 2 Graph of DCR against Relative Humidity for Airtel Network

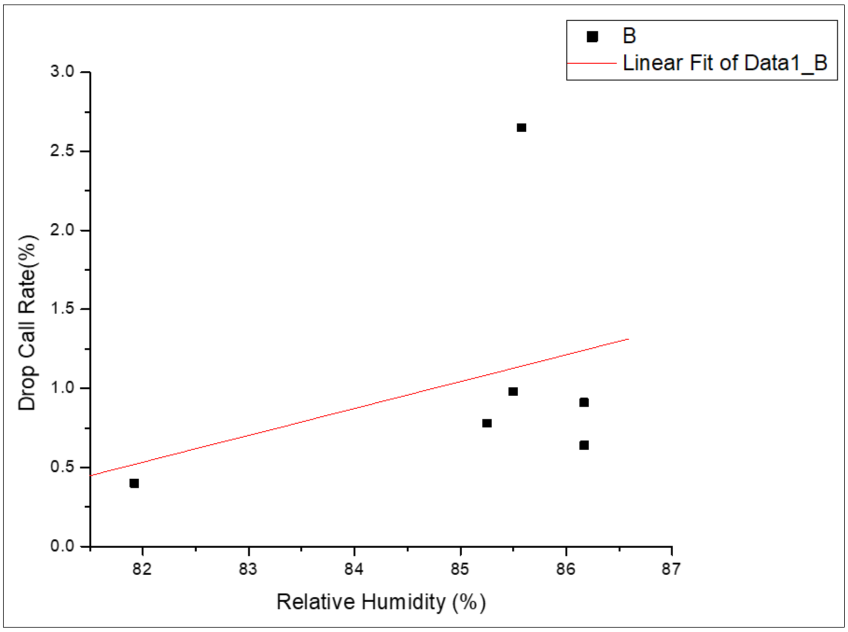

Figure 3 Graph of DCR against Relative Humidity for Globacom Network

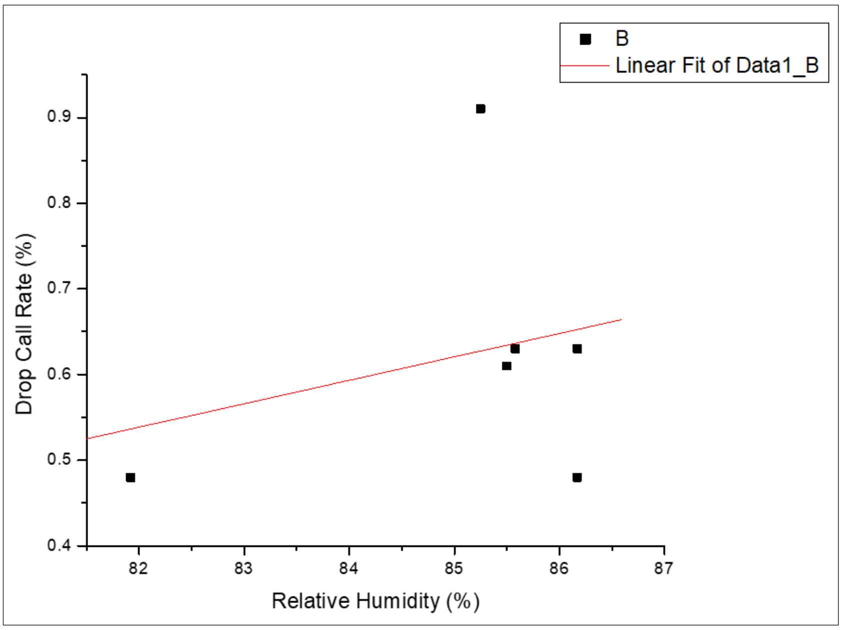

Figure 4 Graph of DCR against Relative Humidity for 9Mobile Network

3.2. Effects of Wind Speed on Drop Calls

In this section, figure 5 to 8 flaunt graphs of DCR against wind speed for MTN, Airtel, Globacom and 9mobile network respectively. For MTN network, a high negative correlation of 0.99 was obtained with regression equation D = 0.02W - 0.85. A regression model D = 0.01W + 0.55 and a low negative correlation value of - 0.13 was obtained for Airtel network. For Globacom network, a low positive correlation of 0.10 was obtained with a derived regression equation D = 0.02W + 0.18. For 9mobile network, a regression model D = 0.03W – 0.99 along with a very strong correlation value of 0.93 was obtained. In each case, D represents DCR while W represents the wind speed.

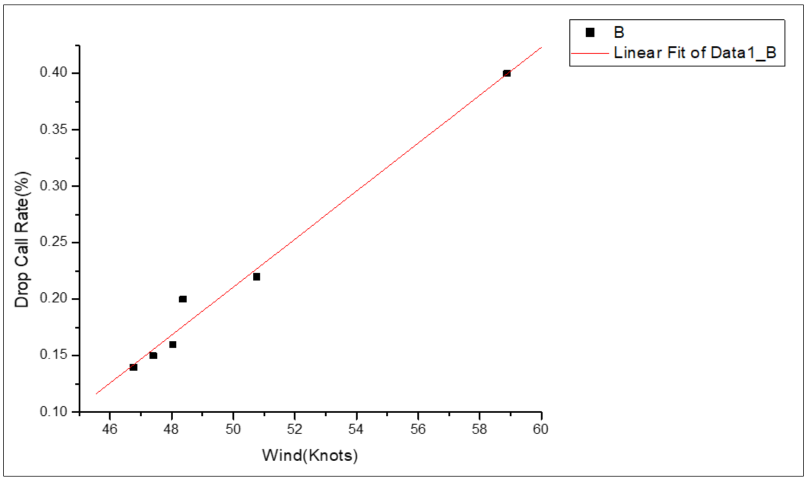

Figure 5 Graph of DCR against Wind Speed for MTN Network

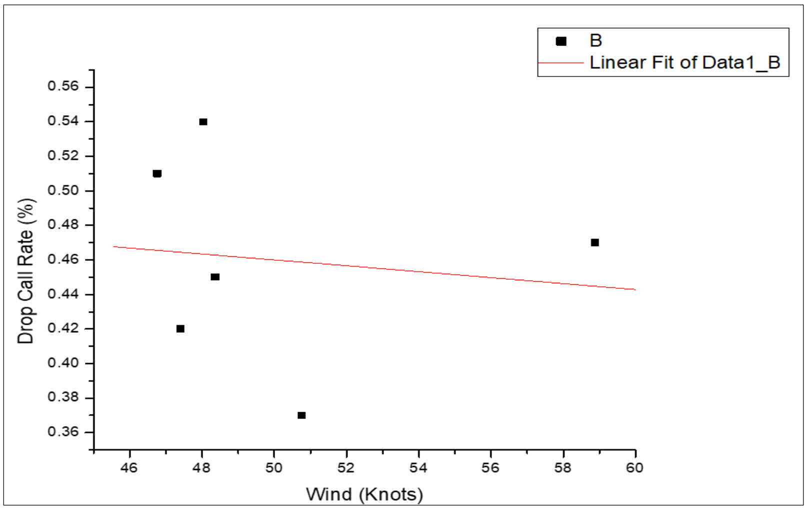

Figure 6 Graph of DCR against Wind Speed for Airtel Network

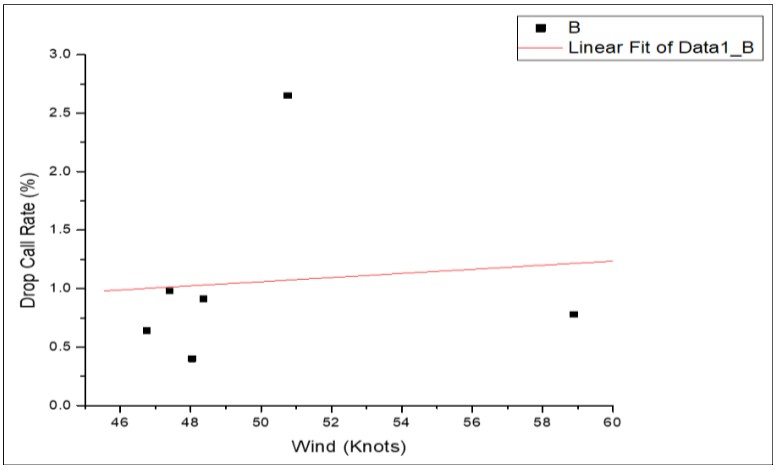

Figure 7 Graph of DCR against Wind Speed for Globacom Network

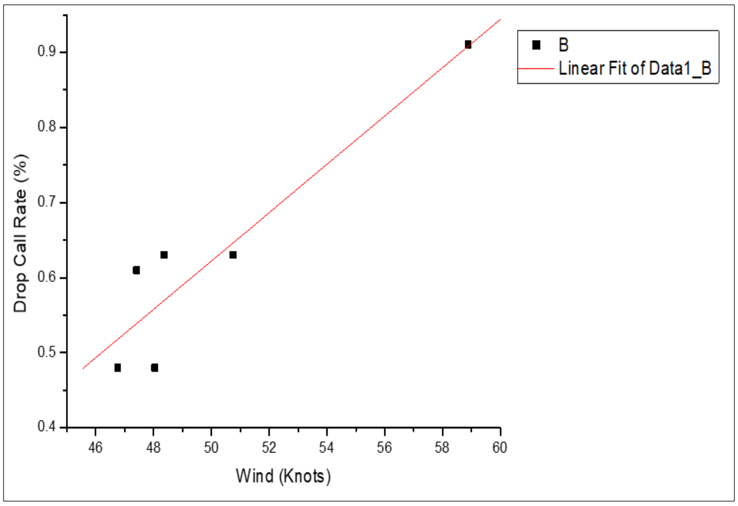

Figure 8 Graph of DCR against Wind Speed for 9mobile Network

3.3. Effects of Rainfall on Drop Calls

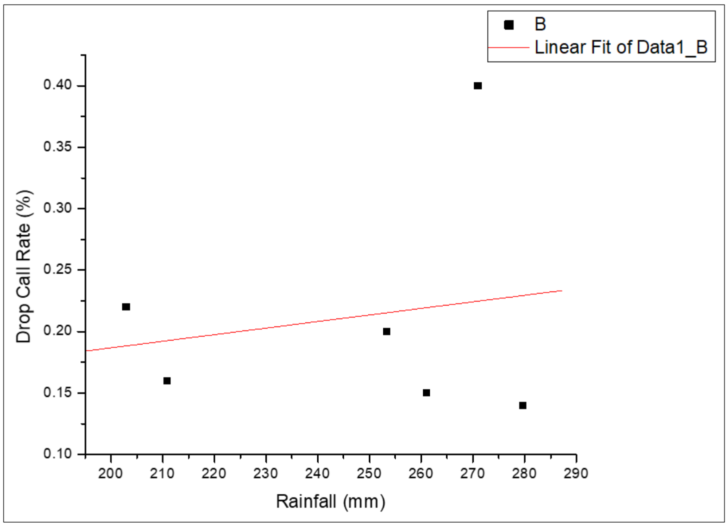

Figure 9 Graph of DCR against Rainfall for MTN Network

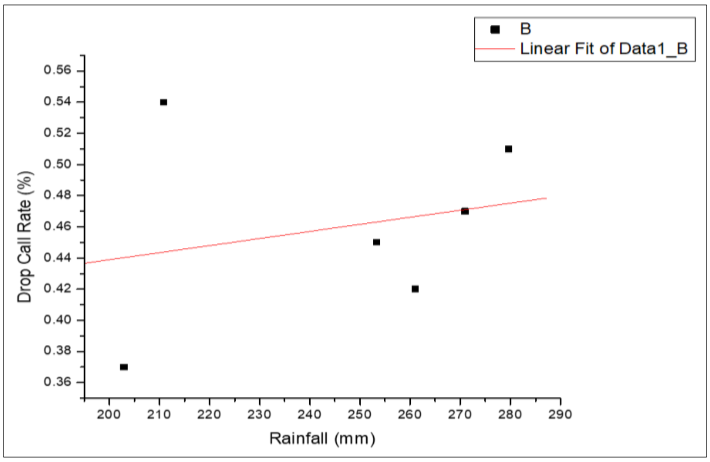

Figure 10 Graph of DCR against Rainfall for Airtel Network

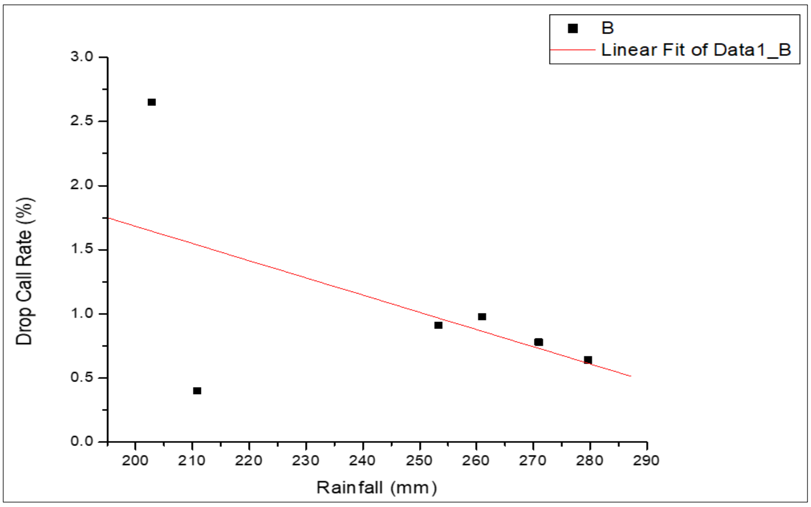

Figure 11 Graph of DCR against Rainfall for Globacom Network

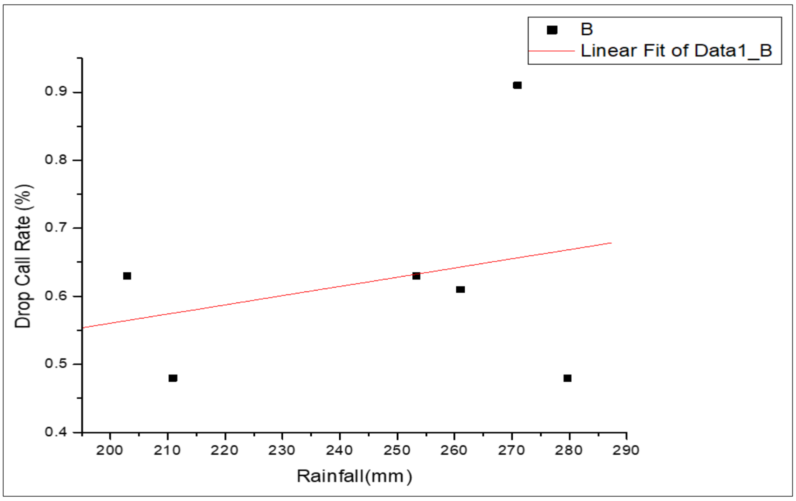

Figure 12 Graph of DCR against Rainfall for 9mobile Network

Here, figure 9 to 12 present graphs of DCR against rainfall for MTN, Airtel, Globacom and 9mobile network respectively. A weak positive correlation of 0.18, a weak positive correlation of 0.24, a moderately negative correlation of - 0.53 and a low positive correlation of 0.28 was obtained for MTN, Airtel, Globacom and 9mobile network, respectively. Furthermore, regression models were obtained for the four networks: D = 0.01RF + 0.08 for MTN network, D = 0.01RF + 0.35 for Airtel network, D = - 0.01RF + 4.37 for Globacom network and D = 0.01RF + 0.29 for 9mobile network. Again, D represents DCR while RF represents rainfall.

3.4. Effects of Temperature on Drop Calls

Lastly, figures 13 to 16 unveil graphs of DCR against temperature for the four networks under study. A low negative correlation value of – 0.22 was obtained for MTN network, a moderately negative correlation value of – 0.65 was realized for Airtel network, a highly positive correlation value of 0.91 was obtained for Globacom network and a low negative correlation of - 0.24 was obtained for 9mobile network. Again, regression equations D = - 0.03T + 1.04, D = - 0.05T + 1.99, D = - 0.88T - 27.07 and D = - 0.04T + 2.04 were obtained for MTN, Airtel, Globacom and 9mobile networks. Here, D stands for DCR while T represents temperature.

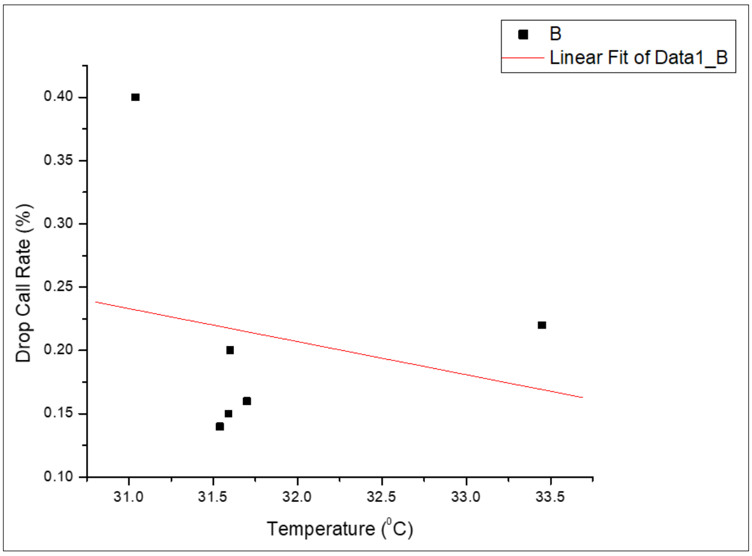

Figure 13 Graph of DCR against Temperature for MTN Network

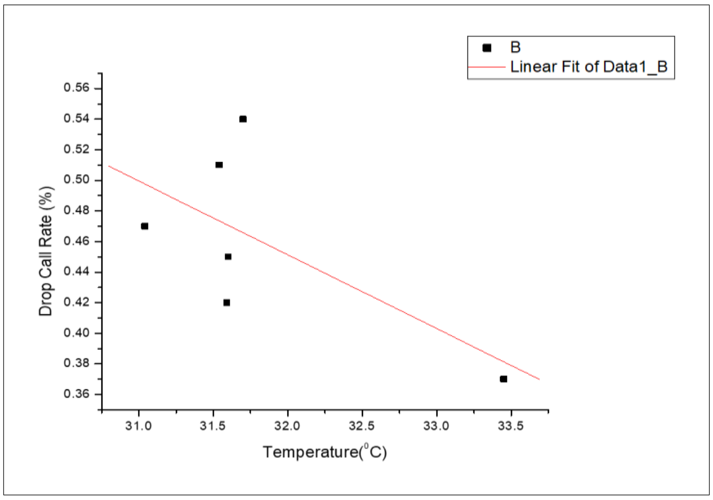

Figure 14 Graph of DCR against Temperature for Airtel Network

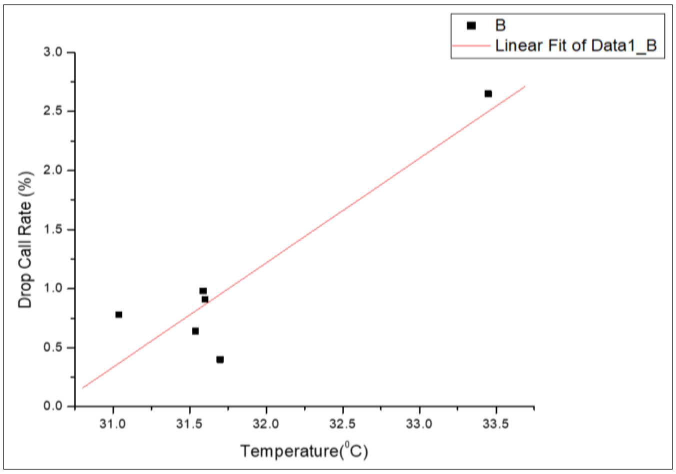

Figure 15 Graph of DCR against Temperature for Globacom Network

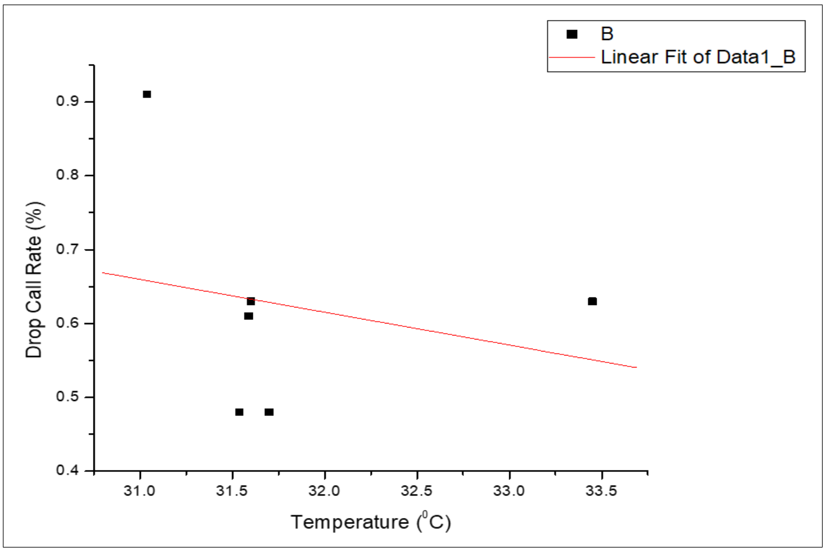

Figure 16 Graph of DCR against Temperature for 9mobile Network

4. Conclusion

The influence of tropospheric variables (relative humidity, wind speed, rainfall and temperature) on drop calls for four mobile networks operating in Cross River State have been studied. The drop calls of the four networks investigated varied with tropospheric variables in an irregular pattern. The results of this study will be useful to RF planners, NCC, the meteorologists and those in academics.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

There was no conflict of interest in this study.

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