DETERMINATION OF AEROSOL SCATTERING ATTENUATION ON TERRESTRIAL FREE-SPACE OPTICAL COMMUNICATION IN SELECTED LOCATIONS IN NIGERIA

AYO-AKANBI, OLAOLUWA ADEDAPO
20PCE02314

MARCH, 2023

DETERMINATION OF AEROSOL SCATTERING ATTENUATION ON TERRESTRIAL FREE-SPACE OPTICAL COMMUNICATION IN SELECTED LOCATIONS IN NIGERIA

BY

AYO-AKANBI OLAOLUWA ADEDAPO
(20PCE02314)
B.Sc Physics and Solar Energy, Bowen University, Iwo

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (M.Sc) INDUSTRIAL PHYSICS (ATMOSPHERIC AND COMMUNICATION PHYSICS) IN THE PHYSICS DEPARTMENT, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA

MARCH, 2023

ACCEPTANCE

This is to attest that this research work is accepted in partial fulfillment of the requirements for the award of the degree of Master of Science (M.Sc) in Industrial Physics (Atmospheric and Communication Physics) in the Department of Physics, College of Science and Technology, Covenant University, Ota, Nigeria.

Miss Adefunke F. Oyinloye
(Secretary, School of Postgraduate Studies) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DECLARATION

I, AYO-AKANBI, OLAOLUWA ADEDAPO (MATRIC NO: 20PCE02314) declare that this research was carried out by me under the supervision of Dr. Olusayo A. Akinwunmi of the Department of Physics, College of Science and Technology, Covenant University, Ota, Nigeria. I attest that this dissertation has not been presented wholly or partially for the award of any degree elsewhere. All sources of data and scholarly information used in this dissertation are duly acknowledged.

AYO-AKANBI, OLAOLUWA ADEDAPO

Signature and Date

CERTIFICATION

We certify that this project titled **"DETERMINATION OF AEROSOL SCATTERING ATTENUATION ON TERRESTRIAL FREE-SPACE OPTICAL COMMUNICATION IN SELECTED LOCATIONS IN NIGERIA"** is an original research work carried out by **AYO-AKANBI, OLAOLUWA ADEDAPO (20PCE02314)** in the Department of Physics, College of Science and Technology, Covenant University, Ota, Nigeria under the supervision of DR. SAYO A. AKINWUMI. We have examined and found this work acceptable as part of the requirements for the award of the degree of Master of Science in Industrial Physics (Atmospheric and Communication Physics).

Dr. Sayo A. Akinwumi
(Supervisor) **Signature and Date**

Prof. Mojisola R. Usikalu
(Head, Physics Department) **Signature and Date**

Dr. Elijah O. Falayi
(External Examiner) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DEDICATION

This research is dedicated to God. I am grateful to Him for his assistance throughout this program.

ACKNOWLEDGEMENTS

I thank God for giving me life, strength, and the impetus to begin and continue my studies. I appreciate the Chancellor of Covenant University, Bishop David Oyedepo, and the entire Board of Regents. I appreciate the Vice-Chancellor and the entire Covenant University Management team. I am grateful to Professor Akan B. Williams, Dean of the School of Postgraduate Studies, Dr. Emmanuel O. Amoo, Sub-dean of the School of Postgraduate Studies, and Professor Timothy A. Anake, Dean of the College of Science and Technology for their selfless efforts. I would like to express my heartfelt gratitude and appreciation to my Head of Department, Professor Mojisola R. Usikalu and the past Dean of the College of Science and Technology, Professor T. V. Omotosho, for their constructive criticisms, contributions, enthusiastic encouragements, reassurances of faith, and useful and timely suggestions throughout the successful completion of my studies.

I am extremely grateful to my supervisor, Dr. Sayo A. Akinwunmi, without whose expertise, kindness, advice, and unwavering support I would not have been able to complete this research work. I am grateful to Professor T. V. Omotosho, Professor M. L. Akinyemi, Dr. Maxwell Omeje, Dr. T. A. Adagunodo, Dr. O. O. Olawale, Dr. K. D. Oyeyemi, Mr Arijaje Theophilus, Mr Araka, Mr Segun Ayanbisi, and Ms Peace Falusi for their assistance and encouragement throughout the program. I also want to thank all of the members of the Department of Physics, faculty, staff, and students who have influenced me and contributed to the success of my studies in various ways. My heartfelt gratitude also goes to my parents, siblings and friends who have contributed financially to this academic program. None of this would have begun or continued without their encouragement and support.

TABLE OF CONTENTS

CHAPTER FIVE

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Free-Space Optics (FSO) is a new technology that allows the transmission of data through the propagation of light in free space. However, it is limited by various atmospheric parameters such as aerosol, temperature and humidity which has significant impact on its design, and attenuates the propagated signals which affects the performance and may lead to unavailability network for wireless communication. The impacts of these atmospheric parameters (visibility, temperature, and relative humidity) on the performance of terrestrial free space optical communication are investigated in this study using the Kim and Ijaz model. The study also looks into the seasonal influence on free space optical communication performance in response to high bandwidth communication demand in selected locations across Nigeria's six geopolitical zones, including Enugu, Lagos, Port Harcourt, Abuja, Kano, and Maiduguri. This study makes use of re-analysed data from the Visual Crossing (VC) archives spanning twenty-one (21) years (2000-2021). The visibility, temperature, and relative humidity of selected locations across Nigeria's six geopolitical zones were collected to determine the aerosol scattering attenuation on terrestrial free space optical communication for the FSO system design. The results show that attenuation values are higher (about 2.87 and 1.84 $dBkm^{-1}$ for 850 and 1550 nm respectively in Kano) in the late dry season (DJF) and lower (about 0.88 and 0.41 $dBkm^{-1}$ for 850 and 1550 nm respectively in Maiduguri) in the late wet season (JJA). During the study period, average visibility shows a decreasing trend during the dry season and an increasing trend during the wet season at all location. Furthermore, as the value of temperature increases, the value of relative humidity decreases. The wavelength of 1550 nm corresponding to a frequency of 193 THz, has the lowest aerosol scattering attenuation in all of the selected locations both in the dry and wet seasons. The findings of this study can be used to determine the suitable location where communication engineers can instal free space optical communication link for optimal performance.

Keywords: Optical wireless communication, Attenuation, Weather condition, Scintillation, Aerosol scattering, Meteorological data.